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DOE/OR/07-1777/V1&D2
PRIMARY DOCUMENT

Remedial Investigation Report for Waste Area Grouping 27 at the Paducah Gaseous Diffusion Plant Paducah, Kentucky

Volume 1 of 4
Sections 1 through 8

DEPARTMENT OF ENERGY • UNITED STATES OF AMERICA

June 1999

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E031999026ATL / Paducah Covers 2.FH8

Department of Energy
Oak Ridge Operations
Paducah Site Office
P.O. Box 1410
Paducah, KY 42001

June 4, 1999

Mr. Carl R. Froede Jr., P.G.
United States Environmental Protection Agency
Region IV
DOE Remedial Section
Federal Facilities Branch
Waste Management Division
61 Forsyth Street
Atlanta, Georgia 30303

Mr. Michael V. Welch, P.E.
Manager
Hazardous Waste Branch
Kentucky Department for Environmental Protection
14 Reilly Road, Frankfort Office Park
Frankfort, Kentucky 40601

Dear Mr. Froede and Mr. Welch:

REMEDIAL INVESTIGATION REPORT FOR WASTE AREA GROUPING 27 AT THE PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY (DOE/OR/07-1777&D2)

Enclosed for your approval is the subject document. As you are aware, once this Remedial Investigation report is approved, the Waste Area Grouping 27 project will roll into the Groundwater Operable Unit Feasibility Study. In order to maintain our current schedule, your approval is requested by July 7, 1999. If you have any questions or require additional information, please call Myrna E. Redfield at (270) 441-6815.

Sincerely,

Myrna E. Redfield
for Jimmie C. Hodges, Site Manager
Paducah Site Office

Enclosure

cc w/enclosure:
T. Mullins, KDEP/Frankfort
T. Taylor, KDEP/Frankfort
J. Volpe, RCB/Frankfort

CERTIFICATION

Document Identification: **Remedial Investigation Report for Waste Area Grouping (WAG) 27 at the Paducah Gaseous Diffusion Plant (PGDP), Paducah, Kentucky (DOE/OR/07-1777&D2)**

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons directly responsible for gathering the information, the information submitted is to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

U.S. Department of Energy (DOE)
Owner and Operator

Jimmie C Hodges
Jimmie C. Hodges, Paducah Site Manager

6-1-99
Date Signed

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons directly responsible for gathering the information, the information submitted is to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Bechtel Jacobs Company LLC
Co-Operator

Jimmy C. Massey, Paducah Manager of Projects

6/1/99
Date Signed

COMMENT RESPONSE SUMMARY

for Review Comments from
The United States Environmental Protection Agency
and the
Commonwealth of Kentucky Department of Environmental Protection

for the
December 1998

Remedial Investigation Report for
Waste Area Grouping 27
at the Paducah Gaseous Diffusion Plant
Paducah, Kentucky
DOE/OR/17-1777&D1

Prepared by
CH2M HILL, Inc.
Paducah, Kentucky
under General Order 18B-99345C

for the
U.S. Department of Energy
Office of Environmental Management

Environmental Management Activities at the
PADUCAH GASEOUS DIFFUSION PLANT
Paducah, Kentucky 42002
managed by
BECHTEL JACOBS COMPANY LLC
for the
U.S. DEPARTMENT OF ENERGY
Under contract DE-AC05-98OR22700

Remedial Investigation Report for the Waste Area Grouping 27 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky
DOE/OR/07-1777&D2

Comment No.	Section/Page/Para.	State Comment KDEP	Response
	GENERAL COMMENTS		
1		Given the amount of TCE present in UCRS soil at boring 720-002, the Division believes that DNAPL exists within the RGA at this location. The interpretation shown in Figure 4.23 supports this assumption. Section 6-5 of the SMP requires that the maximum depth of contamination be assumed to occur under a DNAPL scenario. If further characterization is not undertaken near boring 720-002 then it must be assumed that DNAPL has entered the RGA at this location. Further characterization could be undertaken as a part of the Treatability Study for WAG 27. If the decision is made not to further characterize the vertical extent of contamination, then any proposed DNAPL source treatment scenario must include both the UCRS and RGA as targeted treatment zones. The D2 WAG 27 RI Report should include a short explanation as to how this issue will be addressed.	Neither the soils data in Boring 720-002 nor the RGA groundwater data in the C-720 area support the interpretation of a DNAPL source in the RGA. The soils data indicate a maximum of 68 ppm in the 20-foot sample. The TCE sample concentration in the next sample, the 25-foot sample, dropped to 32 ppm. By comparison, at SWMU 11 the TCE values in Boring 400-200 were in excess of 11,000 ppm, 160 times more than the 68 ppm at 720-002. At SWMU 001, the highest value encountered was 439 ppm, six times higher than the 68 ppm at 720-002. At SWMU 11 DNAPL is indicated in the RGA; however, at SWMU 001 DNAPL is not indicated in the RGA. With even lower concentrations at C-720, DNAPL in the RGA is even less likely. This interpretation is supported by the RGA groundwater data. At SWMU 11, the TCE concentrations in groundwater exceeded 700 ppm. The highest historical TCE concentrations at SWMU 001 were only 23 ppm in MW-161 and have since dropped to only 37 ppb, indicating no DNAPL in the RGA. At the C-720 area, the highest documented TCE concentration in the RGA is only 12 ppm (Boring P4-H7), with the highest WAG 27 borings being about a factor of

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1	Cont.		10 less than that. The concentrations at C-720 are not generally considered to be indicative of DNAPL. However, to further confirm that TCE DNAPL was or was not present in the UCRS or RGA at the C-720 Complex, additional sample(s) will be collected from the UCRS and RGA during the WAG 28 RI.
2	General	Many of the VOA results listed in Volume 1, Section 4 tables received BL-TJ qualifiers indicating that holding times were exceeded for these samples. A greater effort should be made in the future to assure that samples are analyzed within their required holding times.	Agreed. Holding times are very important for obtaining quality data. DOE will make every effort to ensure that holding times are met in the future.
3	General	Many of the sample numbers listed in Appendix H and in the Section 4 tables are incorrect. A number 1 has been placed in front of nearly all of the boring location codes. For example, boring 001065SA030 is listed as 001165SA030 in Table 4.4. This makes interpreting the data somewhat confusing. These mistakes do not seem to have been transferred onto the sample location maps. Revise the sample numbers where appropriate.	Agreed. The referenced discrepancy between sampling station names and sample identification numbers has been corrected in the D2 WAG 27 RI Report.

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4	General	As noted in previous reviews, at some point a site-wide risk assessment should be performed that includes groundwater, surface water, soils, sediments, and air contamination at the entire site. The risk to receptors (human and ecological) is from the entire contaminant load at the facility. Any remediation plan must attempt to control the total risks to human and ecological health and be based on all chemicals present, even though some are primarily controlled at a given WAG. Therefore, conservative remedial actions and risk management policies ultimately must be developed and implemented.	Agreed. Under the investigation/remediation strategy proposed in the revised Site Management Plan, site-wide risk assessments are to be completed.
5	General	Health risks from exposure to radionuclides found may be underestimated. Many radionuclides were screened out of the risk assessments based on their occurrence below "background" and the PGDP calculated PRGs. The ubiquitous nature of radioactive contamination at the PGDP and the ambiguity surrounding that which is "naturally occurring" or "representative of background" suggest that risks due to radionuclides may not have been adequately determined. In addition, the PGDP radionuclide PRGs were not as conservative as those routinely calculated according to RAGS-B (USEPA, 1991) and we could not reproduce the values using USEPA standard methods for risk assessment. Specific comments below discuss these problems more fully.	Disagree. The procedures used for data evaluation and for derivation of risk-based PRGs are those contained in *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE/OR/07-1586&D1). Additionally, please note that the risk-based PRGs used in this report are more conservative than those that would be determined using RAGS Part B procedures.

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6	General	Background concentrations can be used in deciding risk management remedial actions, but cannot be used as "proof" that risks are not present.	Agreed.
7	General	Kentucky's regulations (401 KAR 224) require that all the waste be tracked to its vertical and horizontal extent in all media. However, in several cases, contaminants were detected at levels of concern in deep soil samples and not sampled further at those locations. Hence, as has been noted in previous reviews, vertical characterization seems questionable at the PGDP.	Granted, there may be specific locations where the extent of contamination was not pursued to non-detect levels. However, the data gathered are sufficient in both quality and quantity to support the development of a Baseline Risk Assessment and to allow the project to proceed to the Feasibility Study. We believe that the extent of contamination at the WAG 27 SWMUs has been adequately delineated to achieve these objectives.
8	General	Interim actions should be considered when contaminants (such as trichloroethylene, TCE, and technetium-99, Tc-99) are migrating or may migrate off-site. A TCE concentration in groundwater of 1.6 µg/l (0.0016 ppm) is equivalent to a 1.0E-06 excess lifetime cancer risk (ELCR) in tap water (USEPA, 1998a). This risk assessment appears to ignore the risks from groundwater contamination until the integrator unit is addressed. Several specific comments below discuss this problem more fully.	Disagree. The risks from use and ingestion of groundwater were taken into account. It is agreed that risk management should consider off-site migration of TCE in groundwater.

Comment No.	Section/Page/Para.	State Comment KDEP	Response
	SPECIFIC COMMENTS		
9	Volume 1; Section 2.3; Page 2-2; Paragraph 4	**Surface and Subsurface Soil Sampling Methods**: The paragraph states that a twice background method was used to screen soil cores but that soil collected from proposed intervals was always submitted for Tc-99 analysis. Please explain in more detail how background was measured at each site. Was off-site soil used as the background source material? Also, include all Tc-99 analytical results in Appendix H. In most instances only gross alpha and gross beta results are presented in this appendix.	Background was determined using the method outlined in the Work Instruction RP-408, "Operation of the Ludlum Model 2221 Scaler/Ratemeter with the Model 44-10 2" NaI Detector". A brief description of the screening process has been added to the text. All Tc-99 analyses are contained in Appendix H. There are more alpha/beta analyses contained in Appendix H than there are Tc-99 analyses because the alpha/beta activity for each sample was measured at both the on-site field lab and the off-site labs. Tc-99 analyses were performed only on samples that were shipped to the off-site labs. Therefore, by design, some samples have alpha/beta analyses reported for which no Tc-99 results are available.

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10	Volume 1; Section 2.5; Page 2-4; Paragraph 4	**Borehole Groundwater Grab Samples**: The second sentence of this paragraph states that all samples, with the exception of VOA samples, were collected at a flow rate of 1L/min. This rate greatly exceeds the 300-ml/min flow rate required in procedure PTER-2010. Use of this higher flow rate may have produced more turbid samples and questionable metal results. Explain why the 300-ml/min standard flow rate was not adhered to in the field.	The referenced PGDP groundwater sampling procedure "PTER 2010" was developed for use by the Groundwater Monitoring Section at the PGDP. During the WAG 27 RI, groundwater sampling was conducted from open boreholes using a QED pump and Micropurge Flow Cell. During the early stages of the project, it was discovered that this pump could not maintain flow rates lower than approximately 1 L/min for a long enough period of time to collect the volume of water necessary for all the non-VOA analyses required of the project. Therefore, a Work Guide was written and implemented; it directed that non-VOA samples were to be collected at a rate of 1 L/min. This higher rate is within the acceptable range for low turbidity sampling (Barcelona, M.J. et al. 1993. *Reproducible Well-Purging Procedures and VOC Stabilization Criteria for Ground-Water Sampling,* Groundwater) and no adverse impact to the sample quality would be expected. The higher than expected metals content in the groundwater is more likely a result of the lack of a filter pack and associated well development process than being the effect of a high sample collection rate.

Comment No.	Section/Page/Para.	State Comment KDEP	Response
11	Volume 1; Section 2.8.3; Page 2-10; Paragraph 2	**Data Validation**: The qualifiers "X", "W", and "N" are associated with some of the results presented in the Section 4 tables. These qualifiers are not defined within this section. Include a definition for these qualifiers in the text.	Agreed. The qualifiers "X," "W," and "N" are EPA qualifiers associated with the fixed-base laboratory. An "X" qualifier designates that a comment concerning the sample analysis is provided in the laboratory narrative. A "W" qualifier denotes that for inorganic samples, the post-digestion spike for AA is out of control limits. The "N" qualifier for inorganic samples means that the spike recovery is not within control limits; for organics an "N" indicates that tentatively identified compounds have been noted, and for radionuclides it means that the spike recovery was poor. A list of laboratory data qualifiers has been added to Section 2.8.2, Fixed-Base Laboratory Methods.
12	Volume 1; Section 2.8.3; Page 2-11; Paragraph 1	**Data Validation**: It is stated that arsenic failed spike recovery criteria and that zinc failed serial dilution criteria in three of four validated data packages. However, the matrices that were most typically involved are not identified. Were these problems generally associated with water or soil samples?	These problems were generally associated with soil samples.

Comment No.	Section/Page/Para.	State Comment KDEP	Response
13	Volume 1, Section 2.8.5.3; Page 2-15; Paragraph 2	**Final Review**: This paragraph indicates that all K-25 laboratory data received for volatile organic analysis received J qualifiers as a result of QA/QC records not being provided by the laboratory. Why was this data not provided? Was this information ever received from K-25?	When the soil "hexane extract" samples were sent to the K-25 laboratory for analysis, the samples were preserved using hexane at PGDP. The K-25 laboratory assumed PGDP would have sent prepared and extracted samples for laboratory quality control samples (such as a matrix spike, matrix spike duplicate, laboratory control sample and method blank). PGDP did not provide extracted quality control samples to K-25. K-25 analyzed some limited quality control samples which consisted of hexane blanks and laboratory duplicates. No additional laboratory quality control information is available to evaluate the quality of the data. Validation guidelines state that if this type of information is omitted, the fact should be noted and the data qualified as being estimated by placing a "J" data assessment qualifier on the affected samples. It should be noted that the affected samples consisted of the 10% confirmation soil samples for the hexane extraction method sent to K-25. All other soil samples for the hexane extraction method were analyzed by the Close Support Laboratory and had all required supporting quality control information for a screening-quality laboratory.

Comment No.	Section/Page/Para.	State Comment KDEP	Response
14	Volume 1; Section 2.9; Page 2-16; Paragraph 3	**Civil Survey**: This paragraph states that the sample grid coordinates were tied to either the NGVD of 1929 or to the NAD83 datum. Why was it necessary to use NGVD29 for some of the coordinates and NAD83 for the rest?	All points were surveyed to both the Kentucky State Plane Coordinate System and the PGDP Plane Coordinate System. The measured locations were then tied to the 1929 National Geodetic Vertical Datum, which is used to reference elevations, and the North American Datum of 1983, which is used for horizontal reference.
15	Volume 1; Section 3.8; Page 3-10; Paragraph 6	**WAG 27 Surface Features, Geology, and Hydrogeology**: This paragraph seems to indicate that only 29 soil borings were completed during the WAG 27 RI. Revise to indicate that 29 borings were completed near the C-720 Complex.	Agreed. The text has been revised to indicate that the 29 borings were drilled around the C-720 Building.
16	Volume 1; Section 4.1; Page 4-1; Paragraph 1	**Introduction**: Lines 4 and 5 indicate that all WAG 27 RI sample results are contained within Appendix H. In fact, all of the C-720 groundwater data for UCRS, RGA, and McNairy groundwater samples is missing from Appendix H. Include this data in the D2 version of the WAG 27 RI Report.	Agreed. During the production of the D1 WAG 27 RI Report, the analytical data for C-720 groundwater were inadvertently omitted. This information has been included in the D2 version of the report (see pages 114 through 206 of the 720 Area section of Appendix H).

Comment No.	Section/Page/Para.	State Comment KDEP	Response
17	Volume 1; Section 4.2.1.5; Page 4-8; Paragraph 3	**Trench Samples-Radionuclides**: No mention is made in this paragraph of the U-235 contaminated alumina pellets found at several locations within the landfarm area. Include a short description of this contamination and indicate that further information can be found in Appendix D of Volume 2.	Agreed. The following paragraph discussing the discovery of alumina pellets in the trench excavations at SWMU 001 has been added to the Trench Samples-Analytical Results, Radionuclides section on page 4-8. "During excavation of the test pits at SWMU 001, a whitish granular material that appeared to be alumina pellets was uncovered. This material was sampled and analyzed. Analytical results indicated that the material contained 295 pCi/g total uranium assayed at 1.062 wt% U-235. A review of the size and activity of the deposits indicated that the source of the material was oil contaminated with alumina that had accumulated in the C-720 Instrument Shop. Detailed information on the origin of the alumina is included in the Geophysical Survey and Excavation Report. This report is included as Appendix F in Volume 2 of this document."
18	Volume 1; Section 4.2.1.5; Page 4-8; Last Paragraph	**Subsurface Soils-Analytical Results**: Soil samples were not collected down to a depth of 50-feet at each of the 73 borings sampled. The second line in this paragraph states that all 73 borings terminated at 50-feet. This statement is misleading. Revise this statement.	Agreed. The first sentence of the Subsurface Soils-Analytical Results section on Page 4-8 has been revised as follows: "...198 soil samples (excluding splits) were collected from 73 borings that ranged in total depth from 5 to 50 ft bgs."

Comment No.	Section/Page/Para.	State Comment KDEP	Response
19	Volume 1; Section 4.2.1.5; Page 4-10; Last paragraph	**UCRS Groundwater-Inorganics**: This paragraph states that the high turbidity of the UCRS groundwater sample collected at 001-073 contributed to the elevated metals concentrations detected in this sample. Why wasn't this sample filtered in the lab or in the field prior to being analyzed? In the future, similar samples must be filtered. Include the sample 001-073 water results in Volume 1 Section 4 tables.	In general, only a small volume of water could be collected from the UCRS and only enough water was collected from this boring to allow either a filtered or an unfiltered sample to be analyzed. Analysis was performed on the unfiltered sample since these results would be more conservative and would provide data required for use in risk calculations. Results for this sample are contained in Volume 4, Appendix H, and the location has been noted in the text.
20	Volume 1; Section 4.2.1.5; Page 4-11; Paragraph 2	**UCRS Groundwater-Radionuclides**: Radionuclide (Tc-99 and total uranium) results for the 001-073 water sample are not reported in Appendix H. Include all radiological sample analysis results for this water sample in Appendix H.	The analytical results for the water sample collected from boring 001-073 are presented on Page 201 of the SWMU 001 section of Appendix H. The identification number for this sample is 001173WA050.

Comment No.	Section/Page/Para.	State Comment KDEP	Response
21	Volume 1; Section 4.2.5.3; Page 4-35; Paragraph 4	**McNairy Flow System-Radionuclides**: Radiological sample analysis results for McNairy groundwater samples are not reported in Appendix H. Include these results in the appendix.	All analytical results for groundwater samples collected at SWMU 001 are contained in Pages 201 through 275 of the SWMU 001 section of Appendix H. Results for the groundwater samples collected at SWMU 091 are presented in Pages 3 through 16 of the SWMU 091 section of Appendix H. Analytical results for groundwater samples collected at the C-720 Complex were inadvertently omitted from the WAG 27 RI D1 Report. These results have been added to the D2 version and are now presented in Pages 134 through 206 of the 720 Area section of Appendix H.
22	Volume 1; Section 4.2.5.3; Page 4-35; Paragraph 4	**McNairy Flow System-Radionuclides**: Line 5 of this paragraph states that elevated Tc-99 was detected in a single C-720 Complex sample. Identify this sample.	Agreed. The text has been revised as follows: "...Tc-99 were reported from a single sample collected at the C-720 Complex in boring 720-010 at 96 ft bgs."
23	Volume 1; Figure 4.4	**Distribution of TCE in UCRS Soil at SWMU 001**: Sample locations 001-051 and 001-067 are not marked as being non-detect for TCE. However, results are not listed on the figure, in Table 4.4, or in Appendix H. Include these sample results at the appropriate locations within the RI report.	Four borings (001-051, 001-063, 001-064, and 001-067) were cone penetrometer test borings. Soil samples obtained from these borings were used to evaluate subsurface soil conditions at the site and were not submitted for laboratory analyses. These four locations have been labeled as CPT borings on SWMU 001 Figures 3.6, 4.3, 4.4, 4.7, and 4.8.

Comment No.	Section/Page/Para.	State Comment KDEP	Response
24	Volume 1; Figure 4.4	**Distribution of TCE in UCRS Soil at SWMU 001**: The crosshatched area depicting the zone of highest TCE soil contamination cannot be assumed to be completely accurate. For example, it is very likely that high levels of TCE soil contamination extend north of boring 001-069 beneath 25-feet. Although numerous borings were placed in this area many of these were shallow (i.e., 0-10 feet). Unless a decision is made to further characterize the soils from 0-50 feet in this area, any remedial action must involve cleanup of a larger region than that shown in this figure.	The distribution of TCE in soil boring 001-069 is concentrated between 40 and 50 ft bgs, which indicates that the TCE encountered at this location represents a smear zone near the top of the water table that has developed along the groundwater plume migration pathway. Therefore, the distribution of the identified contamination appears to be closely related to the groundwater and may best be addressed in the groundwater OU study. During development of the remedial design for the groundwater OU, decisions can be made regarding the need for additional characterization data at SWMU 001.
25	Volume 1; Figure 4.23	**North-South Cross Section A-A Showing TCE Distribution in UCRS Soils**: This profile shows an area of 10,000 μg/kg TCE soil contamination bounded by borings 720-027 and 720-009. There appears to be no sample data that would indicate the presence of 10,000 μg/kg TCE in this area. Explain how this data was contoured.	Agreed. The 10,000 μg/kg contour has been removed from the area between borings 720-009 and 720-027 on Figure 4.23.
26	Volume 1; Figure 4.29	**Maximum Concentration of TCE in RGA Groundwater**: According to the figure legend, all of the borings shown in this figure are UCRS borings. This is not the case and should be corrected. Revise this figure to indicate whether borings were completed in the RGA or the McNairy Formation.	Agreed. Boring location symbols shown in Figure 4.29 have been revised to correctly reflect the depth of the boring as defined in the legend.

Comment No.	Section/Page/Para.	State Comment KDEP	Response
27	Volume 1; Figure 4.31	**Maximum Concentrations of Tc-99 in RGA Groundwater**: According to the figure legend, all of the borings shown in this figure are UCRS borings. This is not the case and should be corrected. Revise this figure to indicate whether borings were completed in the RGA or the McNairy Formation.	Agreed. Boring location symbols shown in Figure 4.31 have been revised to correctly reflect the depth of the boring as defined in the legend.
28	Volume 1; Table 4.9	**Radioactive Isotopes Detected above BG in UCRS Groundwater at SWMU 001**: The uranium result listed for sample 001073WA050 is 0.040 pCi/L. The second paragraph on page 4-11 indicates that uranium was detected at 0.040 mg/L in this sample. Specify the correct units.	The correct value for uranium detected in sample 001173WA050 is 0.04 mg/L as stated in the text on Page 4.11. The uranium value (0.040) reported for this sample in Table 4.9 is also reported in mg/L as noted in the footnote to that table.
29	Volume 1; Table 4.5	**SVOA and PCB Compounds Detected in UCRS Soil at SWMU 001**: This table indicates that 11,000 µg/kg of PCB-1260 was detected in sample 001101SA001. However, the duplicate sample result for this sample is not listed. Include the duplicate result in the table.	All results for PCB detections in samples 001101SA001 and 001101SD001 are presented in Table 4.5. PCB-1260 was not detected in sample 001101SD001. Figure 3.3 in Appendix F has been corrected appropriately.
30	Volume 1; Tables 4.14-4.16	The results listed in Table 4.14 are for sludge, not soil, as the table's title suggests. Results for both sludge and soil samples are listed in Tables 4.15 and 4.16. Revise these tables so that the titles more accurately represent the sample media represented. Also, include sample results for sample 196001SA001 in Appendix H.	Agreed. The titles on Tables 4.14, 4.15, and 4.16 have been revised as requested. Sample 196001SA001 was collected as part of the investigation of potentially contaminated sludge. Analytical results for this sample are presented in Appendix C of the Geophysical Survey and Excavation Report included as Appendix F of this document.

Comment No.	Section/Page/Para.	State Comment KDEP	Response
31	Volume 1; Table 4.20	**Metals Detected above BG in UCRS Soil at C-720 Complex**: Results for borings 720024 and 720027 are not presented in Appendix H. Include these results in the appendix.	Agreed. Analytical results for borings 720-024 and 720-027 were inadvertently omitted from the D1 version of the WAG 27 RI Report. They are included in Pages 114 through 130 of the 720 Area section of Appendix H in the D2 version.
32	Volume 1; Section 5.2; Page 5-2; Paragraph 4	**Conceptual Site Model**: Lines 4 and 5 of this paragraph state that KPDES Outfalls 008 and 009 are intermittent flow outfalls. In fact, these outfalls receive continuous discharge from the plant. KPDES 008 in part receives discharge from the C-615 Sewage Treatment Facility. KPDES 009 receives water from several sources including once-through cooling water. Page 1-46 of the Baseline Risk Assessment indicates that several exposure routes were not quantitatively evaluated due primarily to the assumption that these ditches and KPDES 015 receive only intermittent flow associated with rainfall events. This is a false assumption. Revise the statement found in Volume 1, Section 5.2 and reconsider the decision not to evaluate the exposure routes listed in the Baseline Risk Assessment (see comment #53).	The intent of the statement was to say that the water flow within the surface drainage ditches within the bounds of WAG 27 is intermittent, not that the flow from KDPES Outfalls 8 and 9 is intermittent. The text has been revised to reflect actual site conditions.
33	Volume 1; Section 5.3.2; Page 5-9; Paragraph 3	**Chlorinated VOAs**: The last sentence of this paragraph states that ratios of 1,2-DCE and vinyl chloride to TCE were "favorable" at several sample locations, suggesting that biodegradation is occurring at these locations. Explain at what point these ratios become "favorable".	The word "favorable" has been deleted and the sentence rewritten to indicate that in some areas the ratios of daughter to parent product were less than one or that the daughter to parent ratio was higher in areas away from the source, which would indicate that degradation is occurring as the plume migrates.

Comment No.	Section/Page/Para.	State Comment KDEP	Response
34	Volume 1; Section 5.3.3.1; Page 5-12; Fourth bullet	**Abundant Metals**: PGDP background values for metals in soil are site-specific. The significance of comparing PGDP background values to "generally report literature values" is not understood. Explain what is meant by this comparison.	The statement in the fourth bullet is presented as part of the overall general assessment of the origin of the metals detected in the soil and groundwater at WAG 27. The statement is presented as general information.
35	Volume 1; Page 5-12; Paragraph 2	**Abundant Metals**: In this paragraph it is concluded that metals concentrations for WAG 27 RGA groundwater samples are not indicative of actual RGA groundwater metals concentrations due to the high turbidity of these samples. This problem is likely a result of pumping the wells at rates in excess of 300 ml/min (see comment #10). It is strongly suggested that the 300 ml/min maximum pumping rate be adhered to during all future investigations.	The flow rate of 1 L/min that was used during sample collection is within the acceptable range for low-turbidity sampling and no adverse impact to sample quality would be expected. However, as these water samples were collected from an open borehole, and not from a developed monitoring well containing a designed sand filter, the metals content of the samples would still be expected to exceed actual formation concentrations.
36	Volume 1; Section 5.3.4; Page 5-13; Paragraph 6	**Radionuclides**: Lines 5-6 of this paragraph indicate that the decay chains for U-235 and U-238 are found in Table 5.3. This is not the case. Revise the table or remove this statement.	Agreed. The referenced paragraph has been revised to indicate that Table 5.3 contains the half lives, decay constants, and K_d values for WAG 27 radionuclide COPCs.

Comment No.	Section/Page/Para.	State Comment KDEP	Response
37	Volume 1; Section 5.5.4; Page 5-13; Paragraph 1	**C-720 Complex**: The last sentence in this paragraph states that modeling results suggest that a DNAPL source is present in the RGA near the northeast corner of C-720. The sampling results presented in Figure 4.29 and results for water samples collected from MW203 and from boring P4H7 do not support this conclusion. Using Figure 4.29 as a guide it appears more likely that a source exists just north of the central portion of the building or perhaps even beneath the building. Explain the apparent discrepancy between the sample results and modeling results.	Agreed. The modeled source term encompasses borings 720-018 and 720-017 and so would be more accurately described as being located north, not northeast, of the C-720 Building. An RGA source term for TCE was developed from the groundwater data using conservative screening criteria, but it is more likely that the elevated TCE concentrations in RGA groundwater are due to a DNAPL source in the overlying UCRS. This sentence has been reworded to state that a DNAPL source is present near the northern edge of the building.
38	Volume 2; Appendix F; Figure 3.3	**Analytical Results for Soil Samples at Grid B**: The PCB-1260 result listed for sample 001101SA001 does not match the result listed in Table 4.5 of Volume 1. Indicate which result is accurate and make the necessary changes. Also, results for several radionuclides are off by several orders of magnitude if they are in fact in units of pCi/g as listed. Revise these numbers.	The correct PCB-1260 analytical result for sample 001101SA001 is 11,000 µg/kg. This is the value listed in Table 4.5. The corresponding value listed in Figure 3.3 of Appendix F is 11 mg/kg, and is the equivalent. Agreed. The radionuclide values, reported in Table 4.7 for these samples, are correct. The values listed for radionuclide results on Figure 3.3 have been revised so that they are correctly stated in pCi/g.

Comment No.	Section/Page/Para.	State Comment KDEP	Response
39	Volume 4; Section 1.2.1; Page 1-18; Paragraph 1	**Sources of Data**: Lines 8 through 10 state, "The analytical results of the environmental fate and transport modeling from Sect. 4 of Vol. 1 are used in the BHHRA as future contaminant concentrations in groundwater at points of exposure to which contamination may migrate." The environmental fate and transport modeling utilized is, at best, a tool for qualitative conclusions. Uncertainty is too great to depend on the resulting information for development of risk values. Generally, the concentration values used for current exposure calculations at the point of exposure should minimally equal what has actually been detected there (i.e., the 95% UCL of the mean). If adequate sampling has not been done to provide that information, then additional sampling should be performed. If predicting future concentrations, the conservative and preferred procedure by KDEP is to use the concentration that is currently detected at the source as being the same at the point of exposure. Even this procedure could fail to be conservative enough, if the concentrations detected are not representative of what is actually present, either currently or as the result of future releases (e.g., when pockets of DNAPLs have been missed).	Disagree. In order to predict future migration from on-site sources, transport modeling is required. This is consistent with guidance in the regulatory agency approved document entitled *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE/OR/07-1586&D1). Also, please note that if risk managers wish to consider the potential risk to an off-site user exposed to on-site contaminant concentrations, a value is available. For example, a surrogate for the use of on-site media by an off-site residential use area is available because an on-site residential scenario using current on-site contaminant concentrations is assessed. It is agreed that risk management should consider off-site migration of TCE in groundwater.

Comment No.	Section/Page/Para.	State Comment KDEP	Response
40	Volume 4; Section 1.2.1; Page 1-18; Paragraph 3	The first sentence of this paragraph states, "Note, because these SWMUs are not contiguous, both the BHHRA and BERA did not include evaluations of WAG 27 soil and groundwater data as a whole." The separation of the site into operable units (e.g., WAG 27), then into SWMUs, and finally into exposure pathways (e.g., groundwater contamination) would appear to be a legitimate method of addressing this large, complex facility. Certainly, evaluating risks from a particular pathway within a SWMU is a necessary subdivision, and this information is then combined with the other pathways within the SWMU. However, the risks from each SWMU within the WAG should then be combined into a WAG-wide risk assessment.	Disagree. It is not appropriate to combine risk estimates from noncontiguous areas. The result from such a procedure would neither be useful to risk managers nor be correct. Please consider the following: 1) Risk managers will develop remedies to address contamination within a specific area and not over widely separated areas. 2) Average contaminant concentrations (as defined by the lesser of the maximum detected and upper 95% UCL on the mean concentration) may be reduced improperly and lead to inadequate cleanup decisions because of the data summarization procedures. 3) The exposure duration that may be used for a particular location cannot be justified leading to results that are so uncertain as to be not useful for decision-making.

Comment No.	Section/Page/Para.	State Comment KDEP	Response
41	Volume 4; Section 1.2.2; Page 1-18; Last paragraph	**Sources of Data**: The detection limits were below the preliminary remediation goals (PRGs) for several chemicals, including the TCE degradation products 1,1 dichloroethylene and vinyl chloride in soils (detection limits range up to 1000 µg/kg). It appears appropriate to assume their presence at the detection level, and calculate risks based on that concentration or resample using better analytical procedures. These chemicals are likely to be present due to the presence of high TCE concentrations, but were not detected above the PQL in some areas, and hence the risk associated with those areas are likely underestimated. Qualitative assessments may serve the purpose of completeness but are of considerably less value in decision making.	Agreed. When summarizing data for suspected site-related contaminants (e.g., TCE and its breakdown products), the full "non-detect" values are used. Therefore, it is unlikely that risks are underestimated. However, as noted in the report, the uncertainty inherent in the risk assessment of chemicals with detection limits greater than the risk-based concentration (RBC) is important and deserves to be discussed.

Comment No.	Section/Page/Para.	State Comment KDEP	Response
42	Volume 4; Section1.2.2; Page 1-19; Paragraph 2	**Evaluation of toxicity of detected analytes**: The paragraph states, "Tagged-data were evaluated following rules in Exhibits 5-4 and 5-5 of RAGS. (Note: radionuclides with negative activities values were retained)." The laboratory data qualifier "A" is defined in RAGS to indicate "the TIC is a suspected aldol-condensation product," and data tagged as such is not to be included in a quantitative risk assessment. The validation code "A" appears to have a different meaning in the PGDP data, as it is only associated with testing for radionuclides, and sometimes this code is used for nondetects (U) and sometimes for detected concentrations. Please clarify the meaning of this validation code. Additionally, please clarify if the radionuclides with negative activities were factored into the calculations to determine the 95% UCL of the mean. This would lower the concentration term and make the risk results less conservative. A more reasonable approach would be to not use this data. After all, a radionuclide cannot remove radiation from the medium, as implied by a negative activity.	Agreed. The methods used for qualified data will be clarified in the D2 report. Disagree. Given the methods used to determine the concentration of radionuclides in samples, a negative value has as much validity as a positive value when determining the average concentration (as defined as the 95% UCL of the mean concentration). Therefore, negative values are neither removed from the data set nor changed to "0" prior to data summarization. A list of laboratory data qualifiers will be added to Section 2.8.2, Fixed-Base Laboratory Methods.

Comment No.	Section/Page/Para.	State Comment KDEP	Response
43	Volume 4; Section 1.2.2; Page 1-19; Paragraph 4	**Examination of toxicity of detected analytes**: This paragraph states, "Human health risk-based screening values used … were taken from the Methods Document." Please provide an example of the radionuclide PRG derivations used to obtain Risk-Based Concentrations. KDEP has been unable to reproduce the listed PRGs with information submitted to date. The PRGs that we derived from USEPA standard risk assessment procedures (RAGS-B, 1991) were lower, sometimes by several orders of magnitude, than the PRGs supplied by PGDP.	It is unlikely that the PRGs calculated using RAGS Part B methods are lower than those reported in the WAG 27 risk assessment for several reasons, the most important being that PRGs in the report include additional pathways and more "conservative" exposure parameters in their derivation. If any PRGs calculated by the Commonwealth are indeed "lower, sometimes by several orders of magnitude," please provide these examples so that they can be addressed directly. Please note, the methods used to calculate the PRGs are described in detail in *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE/OR/07-1586&D1).

Comment No.	Section/Page/Para.	State Comment KDEP	Response
44	Volume 4; Section 1.2.2; Page 1-19; Paragraph 5	**Comparison of analyte maximum concentrations and activities detected in site samples to analyte concentrations and activities detected in background samples**: The paragraph states, "Background concentrations for soil were taken from Background Levels of Selected Radionuclides and Metals in Soils and Geologic Media at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE 1997b) and were compared to the maximum detected analyte concentration over all site samples." The fact that metals and radionuclides detected at the PGDP site are naturally occurring does not indicate they are present at "natural" levels. Plant activities have potentially elevated contaminant levels all around the plant. Because of the problems that seem inherent in background sampling, KDEP generally does not accept background as screening levels for a risk assessment, although they may be utilized when developing remedial action goals.	The background screen was performed as required in the regulatory agency approved *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE/OR/07-1586&D1).

Comment No.	Section/Page/Para.	State Comment KDEP	Response
45	Volume 4; Section 1.2.2; Page 1-21; Paragraph 1	**Examination of analyte maximum concentrations for essential human nutrients detected in site samples to Recommended Dietary Allowances (RDAs) for children**: The last sentence in this paragraph states, "Analytes that were removed regardless of the results of this screen were calcium, chloride, iodine, magnesium, phosphorus, potassium, and sodium (EPA 1995a)." Although it is unlikely that any of these chemicals would be a driver for this risk assessment, the referenced document (Supplemental Guidance to RAGS: Region 4 Bulletins: Data Collection and Evaluation, November 1995) states that "the only chemicals which *may* [emphasis added] be eliminated based on essential nutrients are calcium, chloride, iodine, magnesium, phosphorus, potassium, and sodium. However, these chemicals may pose a risk if present at high concentrations." It has been noted in previous PGDP reviews, that the important comparison to be made is to assess the combination of normal dietary levels plus the additional input from exposure at the site. This comparison should be made to distinguish between harmful and non-harmful levels. It should further be noted that some of these constituents (e.g., manganese) may pose an ecological effect.	The method used in the essential nutrient screen is consistent with that required by the *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE/OR/07-1586&D1). Additionally, please note that this method accounts for the combination of intake from dietary and non-dietary (i.e., site contaminant) sources. Finally, it is not clear why the reviewer made the last statement in the comment. The report states that the essential nutrient screen was not used to reduce the data set that was used to derive the exposure concentrations, which were in turn utilized in the ecological assessment.

Comment No.	Section/Page/Para.	State Comment KDEP	Response
46	Volume 4; Section 1.2.3.1; Page 1-21; Paragraph 5	**Current Conditions - First SAS® program (data consolidation):**The second sentence in this paragraph states, "Groundwater data from samples collected from UCRS were dropped at this point because this groundwater is not available for use because of the poor yields from wells completed in the UCRS." Potential future residents could utilize the groundwater in the UCRS, thus that data should be retained and exposure scenarios involving that pathway should be investigated as part of the risk assessment, particularly considering the long half life of some of the constituents. In addition, although it is possible that no one is or will use the UCRS groundwater for drinking, inhalation of volatiles and dermal contact with groundwater must be considered as possible scenarios (e.g., in basements of nearby residents).	Residential use of UCRS groundwater does not need to be considered per guidance in the approved *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE/OR/07-1586&D1). Also, please note that the UCRS has been determined not to be a residential water source at PGDP in earlier reports. Finally, please note that the exposure routes involving exposure to vapors in basements and exposure to water in wet basements are not included in the list of routes determined to be important at PGDP in the approved *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE/OR/07-1586&D1). Therefore, they were not quantified.
47	Volume 4; Section 1.2.3.2; Page 1-25; Paragraph 2	**Evaluation of modeled concentrations for groundwater**: The first sentence in this paragraph states, "...models were used to simulate fate and transport of selected contaminants in soil to RGA and McNairy formation groundwater." In addition to comment number 40 above (1.2.1; Sources of Data), we are concerned that only "selected" contaminants were chosen. We recommend that monitoring of groundwater at the PGDP fence boundary be performed, particularly to ensure that all COPCs are included in the risk assessment.	The methods used to select contaminants for modeling are described in Appendix C of Volume 4 of the RI Report. Programmatic monitoring activities and their management are beyond the scope of the WAG 27 RI Report.

Comment No.	Section/Page/Para.	State Comment KDEP	Response
48	Volume 4; Section 1.2.3.2; Page 1-25; Paragraph 4	**Evaluation of modeled concentrations for groundwater**: The last sentence in this paragraph states, "No radionuclides were selected for modeling." Does this mean that they were assumed not to migrate into the groundwater from the soil? Laboratory data of radionuclide concentrations in the groundwater is not supportive, and we again recommend monitoring of groundwater at the PGDP fence boundary. Migration of contaminants off the property, including radionuclides, likely has occurred and will continue to occur for many years into the future.	The method used to select contaminants for modeling is described in Appendix C of Volume 4 of the report. The phrase "laboratory data of radionuclide concentrations… is not supportive" is not clear.
49	Volume 4; Section 1.2.4.1; Pages 1-29 through 1-30	**Groundwater User survey Phase I (CH2M HILL 1991a)**: It is stated that, "…a survey of users of groundwater and surface water in the vicinity of PGDP was conducted in February and March of 1990." It is also stated that, "Of the respondents, 58 percent used well water for some purpose. Eighty four percent used well water as their sole water supply." As long as PGDP continues to supply an alternative domestic water supply to residents and farms in the area, groundwater exposures should remain low (see comment number 46 above, regarding the First SAS® program). However, we (KDEP) do not consider it appropriate to condemn a groundwater source in perpetuity and prohibit its use other than as a temporary measure. Remedial efforts should be implemented to bring the groundwater back as a usable resource.	Agreed. Possible remedial efforts are being addressed as part of the FS for the groundwater OU.

Comment No.	Section/Page/Para.	State Comment KDEP	Response
50	Volume 4; Section 1.2.4.5; Page 1-31; Paragraph 1	**Exposure unit information for workers**: The paragraph states, "...an exposure unit representing a reasonable range a utility worker would cover in a day's time was selected. This value was 0.5 acres...." Please clarify the definition of a utility worker. The only workers referenced in the actual risk assessment are industrial workers and construction/excavation workers.	The utility worker does not need to be defined here because it has been defined in the approved *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE/OR/07-1586&D1). However, please note that the "industrial worker" noted in the comment can be inferred to be a utility worker because parameters for a utility worker are used in the assessment of the industrial worker.
51	Volume 4; Section 1.2.4.6; Page 1-31; Paragraph 2	**Exposure unit information for residents**: The paragraph states, "...an exposure unit representing a reasonable range for a rural resident in a day's time was selected. The selected value was the area of the average residential garden in western Kentucky (0.25 acres)." For the purposes of a baseline risk assessment, default values for relevant parameters should be used, particularly for predicting future potential risks. For example, it is assumed that a resident child ingests 200 mg/day of soil, and the fraction ingested from a contaminated source is assumed to be 1. Therefore, the size of the exposure unit is not a factor.	The use of an exposure unit is relevant per the approved *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE/OR/07-1586&D1).

Comment No.	Section/Page/Para.	State Comment KDEP	Response
52	Volume 4; Section 1.3.1.2; Page 1-34; Paragraph 4	**Physical Description of SWMU 91**: The last sentence of this paragraph states, "...100% of SWMU 91 is covered by gravel." The color photocopies of photographs of SWMU 91 appear to indicate nearly complete cover by vegetation. Was the figure mislabeled?	Agreed. The picture does show an area that is not completely gravel-covered. However, the picture is not of SWMU 91 alone; the picture also shows surrounding terrain. The text is correct.
53	Volume 4; Section 1.3.2.3; Page 1-41; Paragraph 3	**Delineation of exposure point/exposure route**: The last sentence in this paragraph states, "Note that not all exposure routes...are quantitatively evaluated in the BHHRA; after extensive review of all possible exposure routes, only the probable exposure routes are quantified in the BHHRA." The dismissal of several exposure routes from the quantitative risk assessments will underestimate potential risks to human health at PGDP. Many of the proposed exposure routes not quantified should be included in the risk assessment. The purpose of the risk assessment is to identify and estimate all risks to each population or subpopulation potentially exposed to contaminants at the site.	The exposure routes quantified in the assessment are those listed in the approved *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE/OR/07-1586&D1). Quantification of additional routes is not required.
54	Volume 4; Section 1.3.2.3; Page 1-46 and 1-48	**Delineation of exposure point/exposure route**: This section states, "Five exposure routes ending with external exposure to ionizing radiation were not quantified in the BHHRA...because radionuclide slope factors for external exposure to ionizing radiation emitted by radionuclides in water are currently not available from EPA...[and] recreational user exposure to ditch sediment would be greater; therefore, including	Disagree. Due to the shielding provided by water, it is unlikely that any appreciable dose (i.e., a dose that would necessitate remedial action) would result from exposure to radionuclide partitioning to water. Also, due to the same shielding effects, it would be incorrect to use HEAST-derived slope factors for external exposures involving water. Please see documentation concerning the

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54	Cont.	these routes for the resident would be redundant…." Slope factors for external exposure to ionizing radiation emitted by radionuclides are available from HEAST (USEPA, 1997a), and are not restricted to contaminants in soil. These values should be used to quantify exposure from contaminated surface and groundwater. Additionally, although risks to one subpopulation (e.g., rural resident) may be less than another (e.g., recreational visitor) for particular pathways, this does not constitute a reason for their exclusion from the risk assessment. This is also an issue for the risks from consumption of game animals, which should also be quantified for current off-site residents and future rural residents, in addition to recreational visitors (already included). Ideally, these should be based on actual measurements of animal tissue, and not on modeled results.	derivation of the HEAST radionuclide slope factors. As discussed in the approved *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE/OR/07-1586&D1) and in the WAG 27 report, the recreational user assumed to be exposed is the local resident. If risk managers need to have a value for "risk" for a resident who partakes in recreational activities, then this value can be derived by summing the appropriate scenario-specific values. (Note, this is discussed in the uncertainty section of the human health assessment.) The Commonwealth has stated that variability in tissue concentrations of contaminants makes measured values highly uncertain. For example, as noted by the Commonwealth in previous sets of comments, age and tissue effects on contaminant distribution in tissues are to be considered.

Comment No.	Section/Page/Para.	State Comment KDEP	Response
55	Volume 4; Section 1.3.2.3; Page 1-49; Paragraph 4	**Delineation of exposure point/exposure route**: This paragraph states, "Six routes of exposure involving contacts with media in ponds filled with groundwater were not quantitatively evaluated in the BHHRA." Although the exposure scenarios involving groundwater will be quantified for the whole plant when considering the groundwater integrator unit, they should be quantified for each SWMU and WAG 27 as well. Contaminated groundwater, if remediated at the SWMUs now rather than when the integrator unit is addressed, would likely reduce the impact of the contamination and could perhaps make remediation of the site-wide plume more easily achieved.	The approved *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE/OR/07-1586&D1) states that pond scenarios will not be assessed as part of source unit risk assessments.
56	Volume 4; Section 1.3.2.3; Page 1-50; Paragraphs 1 and 2	These paragraphs state, "Four routes of exposure involving consumption of livestock products by a rural resident were not quantitatively evaluated in the BHHRA…past assessments at PGDP have shown that dose from the livestock pathways can be significant…the assessor is directed to quantify these pathways only in assessment of the groundwater and surface water integrator OUs". As mentioned previously, although the exposure scenarios involving groundwater and surface water will be quantified when considering the integrator units, they should be quantified for each SWMU and WAG 27 as well.	The approved *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE/OR/07-1586&D1) also states that livestock scenarios will be not be quantified at source units.

Comment No.	Section/Page/Para.	State Comment KDEP	Response
57	Volume 4; Section 1.3.2.3; Page 1-50; Paragraph 3	**Delineation of exposure point/exposure route**: The third sentence in this paragraph states, "...fate and transport...indicates that surface migration of contaminants from the SWMUs of WAG 27 is unlikely." See comment number 48, above (1.2.3.2; Evaluation of modeled concentrations for groundwater). The exposure pathways involving surface water and sediments in creeks and ponds should be quantitatively evaluated for current off-site residents and future rural residents, as well as for the recreational users.	As discussed in Volume 1 (Section 5) and Appendix C of Volume 4, surface transport is not important at WAG 27. Ditches surrounding these units which may be sources to off-site locations will be included in the surface water OU.
58	Volume 4; Section 1.4.4; Page 1-141; Paragraph 2	**Chemicals for Which No EPA Toxicity Values are Available**: This paragraph states, "Oral [and absorbed dose] RfD values exist for all of the organic COPCs...expect 1,2-dichloroethane...." A route extrapolated value of 2.9E-03 can be found in the Region IX PRG tables (USEPA, 1998a) for an oral RfD, and an absorbed dose can then be calculated. Additionally, it should be noted that the oral RfD for trichloroethylene was withdrawn, although its use is acceptable to calculate systemic risk.	The RfD toxicity value in the Region IX list appears to be incorrectly referenced to IRIS. IRIS does not currently contain an oral RfD for 1,2-dichloroethane (i.e., as of April 9, 1999). Therefore, it would not be appropriate to include this value in the assessment of non-cancer effects. Agreed. Footnotes indicating the source and status of the toxicity values (i.e., withdrawn, etc.) will be added to Tables 1.90 through 1.93 (pages A-273 to A-280). The withdrawn TCE values were used in the assessments of risks.

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59	Volume 4; Section 1.4.4; Page 1-141; Paragraph 3	**Chemicals for Which No EPA Toxicity Values are Available**: The first sentence in this paragraph states, "All the inorganic COPCs, except...cadmium...lack inhalation RfD values." The inhalation RfD for cadmium was withdrawn, however, as stated above, its use is acceptable to calculate systematic risk.	Agreed. As directed by the approved *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE/OR/07-1586&D1), the potential increase in risks due to route extrapolation are discussed as an uncertainty.
60	Volume 4; Section 1.4.4; Page 1-141; Paragraph 3	**Chemicals for Which No EPA Toxicity Values are Available**: The paragraph's second sentence states, "...only 1,2-dichloroethane, carbon tetrachloride, methylene chloride, and toluene of the organic COPCs, have inhalation RfD values." The inhalation RfDs for 1,2-dichloroethane and carbon tetrachloride, were withdrawn, however, as stated above, their use is acceptable to calculated systemic risk. In addition, the following table lists route extrapolated values (r) for inhalation RfDs for several compounds, and one RfD (for tetrachloroethylene) from NCEA (n) that should be used for calculation of systemic risks (USEPA, 1998a).	Agreed. As directed by the approved *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE/OR/07-1586&D1), withdrawn values were used in the quantitative risk assessment. However, as also directed in the aforementioned document, the potential increases in risks due to route extrapolation are discussed as an uncertainty.
61	Volume 4; Section 1.4.4; Page 1-141; Paragraph 6	**Chemicals for Which No EPA Toxicity Values are Available**: This paragraph's second sentence states, "Organic COPCs with approved inhalation slope factors are...." The inhalation slope factor value of 7.0E+00 from NCEA for n-nitroso-di-n-propylamine can be used.	Agreed. As discussed previously, extrapolated values are discussed as an uncertainty in the risk assessment.

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62	Volume 4; Section 1.4.4; Page 1-142; Paragraph 1	**Chemicals for Which No EPA Toxicity Values are available**: The first sentence of this paragraph states, "Twenty-nine COPCs have absorbed dose slope factors…27 are organic compounds (these are identical to those analytes having oral slope factors). Although the information on oral (and absorbed dose) slope factors can be found in Appendix A, they were not listed in the text portion, as were the other reference doses and slope factors, which appears merely to be an oversight.	Agreed. The revised document will contain additional discussion about which chemicals have dermal toxicity values.

Comment No.	Section/Page/Para.	State Comment KDEP	Response
63	Volume 4; Section 1.6.1.4; Page 1-186; Paragraphs 2 and 3	**Use of concentrations from total versus filtered samples**: These two paragraphs state, "In this BHHRA, all analyte concentrations in water came from the analyses of unfiltered or total samples. ...the risk estimates could be markedly different if results from filtered samples were used. This conclusion is different from that reached in an earlier uncertainty analysis...the uncertainty in water sampling appears to be moderate in this assessment depending upon which comparisons are investigated." It must be stressed that it is unacceptable to use data from filtered groundwater samples in a baseline risk assessment for the purpose of estimating exposure concentrations (USEPA, 1989). Groundwater use should not be predicated upon being treated (filtered) before it can be used.	Disagree. Although it is true that unfiltered sampling results should be used in the main risk characterization of most risk assessments, it is not true that it is "unacceptable" to use data from filtered samples in an assessment. If in fact both filtered and unfiltered data exist, it is prudent to assess risks using results from both sets of data. Additionally, the results from the assessment of filtered samples are actually more illustrative of risks from nonvolatile materials at an off-site location, if modeling results are not available and on-site concentrations are used in the calculation of off-site risks, because the dissolved fraction is actually that which migrates with groundwater flow. (Note, if colloidal transport is suspected, then the actual pore size of the filter may be of concern.) In any case, this risk assessment provides a quantitative risk assessment for filtered samples in the uncertainty section so risk managers have information sufficient for decision-making. (Note, the quantitative assessment of filtered samples in the uncertainty section also agrees with procedures found in *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE/OR/07-1586&D1).)

Comment No.	Section/Page/Para.	State Comment KDEP	Response
64	Volume 4; Section 2.1.2.1; Page 2-3; Paragraph 7	**Ecological data evaluation considerations**: This paragraph states, "For the assessment of ecological risk from soils, only surface soil samples (<1 ft) and sediment were evaluated. Surface water is only present as intermittent flow in ditches associated with WAG 27 SWMUs." Although the contaminants within the SWMUs may not impact the ecological receptors at endpoints directly associated with the SWMU's boundaries or endpoints within them, the contaminants contributed by them likely impact them somewhere in conjunction with other sources at the PGDP. Since modeling results are questionable for impact to the surface water, measured concentrations should be obtained and used when possible. The contaminants would likely emerge at Bayou Creek, Little Bayou Creek, and probably the Ohio River, as well as surface water and sediments in ponds at the wildlife management units and farm ponds in the area. For screening assessments, assumptions such as exposure of aquatic biota to undiluted groundwater are appropriate (USDOE, 1995). Therefore, both current and future ecological impacts should be assessed for nearby surface waters.	The risk assessments associated with the site-wide surface water and groundwater OUs will address potential risks from contaminants in streams and groundwater beyond the boundaries of individual SWMUs as exposures in these areas may be related to multiple SWMUs. Risk results calculated using samples from Little Bayou and Bayou Creeks would be of little use in the identification of problems and selection of remedies at the WAG 27 source units. Generally, the only way a risk assessment at a complex site can relate source concentrations to concentrations in downgradient areas (e.g., the creeks) is through the use of the appropriate fate and transport modeling because of the presence of multiple sources (as mentioned in the comment). The fate and transport discussion in Volume 1 (Section 5) and Appendix C of Volume 4 states that none of the SWMUs in WAG 27 are sources of off-site contamination in surface water. Therefore, this migration pathway was not modeled.

Comment No.	Section/Page/Para.	State Comment KDEP	Response
65	Volume 4; Section 2.1.2.2; Page 2-5; Paragraph 2	**Selection of COPECs for WAG 27**: The third sentence in this paragraph states, "Essential nutrients (calcium, iron, magnesium, potassium, and sodium) and analytes with maximum concentrations within background limits were eliminated from further consideration in the analysis."	Agreed. The risk assessment is designed to focus on contaminants that may represent a concern as a result of site operations. Contaminants present at background concentrations and macro-elements are not carried through the assessment because they are unlikely to represent a site-related concern.
66	Volume 4; Section 2.1.6; Page 2-9; Paragraph 1	**Conceptual Site Model**: The second sentence in this paragraph states, "Given the industrial nature of WAG 27 and the lack of suitable habitat for ecological receptors, exposure of ecological receptors at WAG 27 under current conditions is unlikely." Unless contamination within the SWMUs has already eradicated ecological receptors on site, likely current receptors are microorganisms, earthworms and other soil invertebrates, and possibly small mammals such as mice and shrews, along with their predators (e.g., sparrow hawks). Also, as stated above, contaminants that have migrated off-site, particularly into surface waters and sediments, also are likely exposing current receptors.	The quote is meant to indicate that WAG 27 is an industrialized site that provides little quality habitat currently and that this is unlikely to change in the future. However, as requested in the comment, the potential effect of contamination upon a variety of ecological endpoints is examined so risk managers have information about the potential impact of contamination upon the various endpoints. Please see the Response to Comment #64 for a discussion of contaminant migration through the surface water pathway.

Comment No.	Section/Page/Para.	State Comment KDEP	Response
67	Volume 4; Section 2.2.2.1; Pages 2-10 through 2-11; Paragraph 5	**Nonradionuclide exposures**: This paragraph states, "Because surface water is not consistently available at WAG 27 SWMUs, ingestion of drinking water is not considered in the BERA. Reasons for not including exposure to surface water include the general principal that contaminant doses from drinking water are minor relative to doses from food and soil ingestion and that ditches in the vicinity of WAG 27 only contain water intermittently." See response to Specific Comment number 47 above. Additionally, although exposure from one pathway (e.g., drinking water) may be less than another (e.g., food and soil ingestion), this does not constitute a reason for its exclusion from the risk assessment. As stated in comments regarding the HHBRA, the purpose of the risk assessment is to identify and estimate all risks to each population or subpopulation potentially exposed to contaminants at the site.	Disagree. The WAG 27 ditches contain water for a short time after rain events. Therefore, they do not represent a consistent source of drinking water for wildlife in the area. Because of this, exposures are expected to be minimal. Not only are they likely minimal, but the drinking water exposure pathway itself is generally minor relative to other exposure pathways. The combination of low likelihood of exposure and minor pathway suggests that excluding this pathway has little impact on the conclusions of the risk assessment. However, to highlight the uncertainty of this decision and to provide information to risk managers, a discussion of drinking water ingestion will be added as an uncertainty to the revised risk evaluation section of the ecological risk assessment.

Comment No.	Section/Page/Para.	State Comment KDEP	Response
68	Volume 4; Section 2.3.1; Page 2-17; Paragraph 2	**Evaluation of Ecological Contaminants of Potential Concern - Chemical toxicity data for terrestrial biota**: This paragraph states, "Total exposure estimates for wildlife are compared to Lowest Observed Adverse Effects Levels (LOAELs)…." Contaminant concentrations which exceed the no observable effects level (NOEL) for ecological receptors are considered levels of concern. Therefore, the benchmark for ecological effects in Kentucky is the NOEL for aquatic and terrestrial species.	Disagree. The use of NOELs is appropriate for a screening assessment. However, the WAG 27 evaluation is a baseline assessment and seeks to focus attention on contaminants that exceed levels associated with adverse effects that may translate to population level effects. LOAELs were selected as the benchmark level most likely to indicate actual effects. However, in order to address the concern raised in the comment and ensure that risk managers receive additional information concerning potential effects to individuals, a discussion of the uncertainty in the selection of the basis of benchmarks will be added to the revised report.

Comment No.	Section/Page/Para.	State Comment KDEP	Response
69	Volume 4; Section 2.4; Page 2-19; Paragraph 1	**RISK CHARACTERIZATION**: This paragraph states, "HQs greater than 1 suggest that the chemical is potentially hazardous to the endpoint biota. HQs less than 1 suggest that the chemical is nonhazardous and need not be considered further. Hazard quotient calculations are performed by medium for each endpoint receptor population." The hazard quotient for each chemical for each receptor at each SWMU was evaluated individually, which does not take into consideration the additive effects of different chemicals within the entire WAG on each receptor. This will potentially underestimate the risks posed to these receptors. In addition, we were unable to reproduce the HQ calculations for terrestrial wildlife (deer, mouse, and shrew) with the information given.	Disagree. A discussion of the potential for increased or decreased effects related to synergistic or antagonistic relationships among individual chemical mixtures is included as an uncertainty in the risk evaluation. Disagree. All information needed to calculate risks is included in the report. Note that the shrew diet is assumed to be 100% soil invertebrates, deer diet is 100% vegetation, and mouse diet is 50 % plant and 50% invertebrate.
70	Volume 4; Section 2.4,2,4; Page 2-21; Paragraph 2	**Risks to terrestrial organisms from radiological exposures**: This paragraph states, "Estimated dose rates for plants, soil invertebrates, and wildlife receptors were all below the thresholds of 1 rad/day for plants and soil invertebrates and 100 mrad/day for wildlife.... No unacceptable risks from exposure to radionuclides are expected for ecological receptors...". Inclusion of risks from water ingestion (groundwater or surface water) and uptake would likely indicate risks above de minimis, and should be evaluated. The threshold levels for radiation promulgated here should be referenced as well.	The recommended dose rate limits for plants, soil invertebrates, and wildlife are referenced in the Effects Assessment. Inclusion of doses from ingestion of groundwater or surface water is not warranted at WAG 27. There is not a groundwater exposure pathway, and surface water is present only on an intermittent basis. Dose rates were well below the recommended limits for all receptors; including potential dose from water would not change the results of the assessment.

Remedial Investigation Report for the Waste Area Grouping 27 at the Paducah Gaseous Diffusion Plant, Paducah Kentucky
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Comment No.	Section/Page/Para.	State Comment Radiation Control Branch	Response
1	Section 2.3; Page 2-2; Third paragraph; Last sentence	**Surface and Subsurface Sampling Methods**: Provide the purpose for conducting alpha and beta/gamma screenings on the sampler. Screening the sampler would not provide any information regarding alpha and beta emissions because of shielding from the sampler.	Agreed. The purpose of the alpha/beta scan was for health and safety to ensure that the sampling tool which would be handled by the sampling crew had not become contaminated through contact with media having high radioactivity. This information has been added to the text.
2	Section 2.3; Page 2-2; Third paragraph	**Surface and Subsurface Sampling Methods**: Indicate whether the NaI screen was over the entire length of the core, conducted for select sample intervals, or conducted for each lift. Screening should be for the entire core and/or conducted for every lift.	Agreed. A homogenized sample from each lift was placed in a beaker and screened with a NaI detector.
3	Section 2.3; Page 2-2; Third paragraph	**Surface and Subsurface Sampling Methods**: Indicate that ten percent (10%) of the samples that did not exceed twice background were submitted for confirmatory analysis. Additionally, indicate the Th-234 action levels utilized to determine which samples required isotopic analysis.	Agreed. We believe this question refers to the fourth paragraph. The last sentence of the paragraph has been revised to indicate that 10% of the environmental samples were sent for confirmation analyses. Use of a high purity germanium detector was not required for the WAG 27 project. The action level for sending samples off-site for isotopic analysis was exceedence of a 3:1 gross alpha to beta ratio.
4	Section 2.3; Page 2-2; Third paragraph	**Surface and Subsurface Sampling Methods**: Provide the screening results for the NaI surveys and provide the background screening sample location and value(s). Indicate in the text where these results are presented relative to each area of investigation.	Field screening data are generally not included in the text portion of an RI report. These screening data can be found in the field logbooks along with similar information.

Comment No.	Section/Page/Para.	State Comment Radiation Control Branch	Response
5	Section 2.5; Pages 2-3 &2-4	**Borehole Groundwater Grab Samples**: Indicate the methodology utilized to identify dissolved contamination and suspended contamination that results from the sampling method that was utilized.	Generally, filtered groundwater samples and samples that were collected from installed and developed monitoring wells were considered to be the best indicator of the dissolved metals fraction. Unfiltered groundwater grab samples that were collected during the drilling of soil borings do generally contain a higher percentage of suspended solids that could impact the metals analyses. A discussion of the use of filtered vs. unfiltered samples is presented in Section 4 of the report and need not be duplicated in Section 2.
6	Section 2.8; Page 2.5	**Analytical Methods**: Provide the MDA's and justification for the utilization of gross alpha and gross beta CSL screen for soils. Provide procedures used with the nuclear spectroscopy analyzer.	The radioactivity detection limits for the CSL are contained in Table 2.6. These MDAs were established based on the type of instrument used and the scanning procedure. The method for calculating the MDAs and procedure for operating the nuclear spectroscopy analyzer are contained in the document titled WAG 27 Quality Assurance Project Plan-CSL. Determining the alpha and beta activity in a sample is an inexpensive, reliable method of assessing the relative concentration of radioactive isotopes that may be present. Based on the results of the screening, selected samples can then be analyzed for a suite of radioactive isotopes to determine quantitative concentrations. A copy of the WAG 27 QAPP-CSL will be forwarded to the Radiation Control Branch.

Comment No.	Section/Page/Para.	State Comment Radiation Control Branch	Response
7	Section 4.1.3; Page 4-3	**WAG 27 Groundwater**: Discuss the occurrence of Tc-99 and why it is only found off-site in the NW Plume. Provide recent data that identifies movement of Tc-99 in the Northeast Plume.	The investigation of the off-site occurrences of Tc-99 in the NW & NE plumes was not included within the scope of the WAG 27 RI.
8	Section 4.1.3.1; Page 4-3	**Filtered vs. Unfiltered Groundwater Samples**: Relate this discussion to radiological contaminants.	Agreed. A discussion of the relation of radionuclides to filtered samples has been added to the text in Section 4.1.3.1.
9	Section 4.2; Pages 4-5 through 4-11	**WAG 27 Soil and Groundwater**: Discuss the detection and fate of the U-235 in SWMU 001 in January 1998.	The information presented in Section 4 deals with the nature and extent of contamination discovered during the WAG 27 field investigation. At SWMU 001 the activities of U-235 detected in soil and water samples did not exceed background and PRG screening values. Therefore, U-235 is not specifically addressed in the SWMU 001 radiological discussion. Please also see Response to Comment No. 17, State Reviewer KDEP. A discussion of the fate and transport of site-related contaminants at all the WAG 27 SWMUs is presented in Volume 1, Section 5.
10	Section 4.2.1.5; Page 4-7	**Nature and Extent of Contamination**: Identify the depth of the test pit excavations. Discuss radiological screening conducted on the excavated material. Provide justification for no samples being collected from the test pits.	Agreed. Trench Samples -- Analytical Results, a subsection of Section 4.2.1.5 on page 4-7, has been revised to identify the depths of the test pit excavations, to provide information on field screening of the excavations, and to indicate how sampling locations were selected.

Comment No.	Section/Page/Para.	State Comment Radiation Control Branch	Response
11	Section 4.2.3.4; Page 4-17; Fourth paragraph	**Rationale for RI Field Sampling**: The mobility of uranium in soils depends on the acidic/basic conditions and prevalent redox equilibria existing at the soil. Modify the sentence to indicate that existing conditions at the site may be alkaline therefore uranium may be relatively immobile in soil.	Agreed. Uranium may be relatively immobile in soil and several factors such as the oxidation/redox potential, the acidic/basic nature of the soils, and the total organic content of the soil can affect mobility. During the WAG 27 RI, soil pH values were not collected; however, general soil data collected from the vicinity of PGDP indicate that soils in the area are slightly acidic. Therefore, the referenced text has not been modified.
12	Section 4.2.4.5; Page 4-28	**Nature and Extent of Contamination**: Provide sample results for the water found in the Compressor Shop Pit. Dissolved contamination in the pit may be mobile and should be evaluated.	A single sample consisting of a dark ooze with a high liquid content was collected from the bottom of the Compressor Shop Pit Sump during the WAG 27 RI. Results for this sample are discussed in the text on page 4-28, Compressor Shop Pit Sump - Analytical Results, are listed in C-720 Complex-specific tables in Section 4, and are noted on Fig. 4.27. Based on the results from this sample, the Compressor Shop Pit Sump has been designated at a separate SWMU (SWMU 209) and additional evaluation will be conducted in the future.
13	Section 5.1; Page 5-1	**Contaminant Fate and Transport**: Note that Tc-99 cannot be modeled because the source of Tc-99 in the UCRS has not been characterized.	Agreed. Tc-99 was not modeled in the RGA of SWMU 001 because no source for the Tc-99 was identified at that SWMU. The referenced text has been revised as requested.

Comment No.	Section/Page/Para.	State Comment Radiation Control Branch	Response
14	Section 5.2.1; Page 5-4	**Hydrologic Properties**: The mobility of uranium in soils depends on the acidic/basic conditions and prevalent redox equilibria existing at the soil. Modify the sentence to indicate that existing conditions at the site may be alkaline therefore uranium may be relatively immobile in soil.	It is unclear which section of text is referenced in this comment. However, as stated in Response to Comment No. 11 above, data from the vicinity of PGDP indicate that soils in the area are slightly acidic.
15	Section 5.3; Page 5-6	**Nomenclature for C_{fixed}**: Indicate clearly where and how C_{fixed} resides.	Agreed. The text in this section has been revised to more clearly indicate that the fixed concentration of metal (C_{fixed}) is contained within the chemical structure of the minerals found in the soil and is, therefore, unavailable for exchange or release to water.
16	Section 5.3.4; Page 5-13; Fourth paragraph	**Radionuclides**: This paragraph is incorrect. Provide correction and clarification.	Agreed. The referenced paragraph has been rewritten.
17	Section 5.3.4; Page 5-13; Fourth paragraph	**Radionuclides**: Provide references to support the conclusion that Th-230 and Ra-226 are radionuclides that are prudent to monitor for when evaluating contamination that results from enrichment process waste. Since DOE does not handle ores at PGDP, monitoring for Th-230 and Ra-226 is highly questionable.	Agreed. The referenced text has been deleted from Section 5.3.4.
18	Section 5.3.4; Page 5-13; Fifth paragraph	**Radionuclides**: It should be stated in the text that Tc-99 in the +7 oxidation state is highly soluble and mobile in groundwater. Other oxidation states of Tc-99 may not be mobile.	Agreed. The text has been revised as recommended.

Comment No.	Section/Page/Para.	State Comment Radiation Control Branch	Response
19	Section 5.3.4; Page 5-14; Fourth paragraph	**Radionuclides**: The text should note that Th-230 found in any media as a result of the decay of naturally occurring uranium will be accompanied by equivalent levels of uranium. If not accompanied by equivalent levels of uranium, the laboratory value is suspect or the Th-230 is the product of a process not related to uranium enrichment at the PGDP.	Agreed. The ratio of Th-230 to uranium can be used to reach conclusions concerning the possible origin of the uranium by-product. It does not, however, appear necessary to present possible scenarios in this section to explain hypothetical situations.
20	Section 5.4.1.1; Page 5-15; Second paragraph	**Soil to Groundwater Pathway-UCRS**: UCRS groundwater has been shown to be very shallow in all areas of the PGDP where measured with the exception of the immediate vicinity of the C-400 building. Provide reference to the data that indicates that the distance of travel from sources to groundwater is 50+ feet.	Sections 3 and 4 of the WAG 27 RI report contain text and several cross-sections clearly showing that the depth to groundwater is relatively deep. During the RI field activities, the depth to groundwater was found to be generally between 45 and 50 ft bgs. As stated in Section 3.8.3, Upper Continental Recharge System, "The UCRS.... is essentially dry."

Comment No.	Section/Page/Para.	EPA Comment	Response
	GENERAL COMMENTS		
1	General	Several places throughout the text the document refers to all risk exceeding 1E-6 as "de minimus". Why is this term used in place of stating that it is lower than the CERCLA risk range? It is recommended that when reporting CERCLA risk values the DOE state them relative to the risk range so as to allow the reader a point of reference from which the risk can be qualified and quantified.	The term *de minimis risk* is used in the RI report for cumulative ELCR less than 1E-6 per agreement between the Department of Energy, US EPA, and the Commonwealth of Kentucky as documented in response to several sets of comments and in *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE.OR.07-1506&D1). The suggestion in the comment that the risks be reported relative to the EPA CERCLA risk range was discussed between the three parties during the preparation of the aforementioned report and was rejected based upon Commonwealth concerns that such comparisons could bias decisions made by risk managers. Please note, comparisons against the CERCLA risk range are made in risk management and decision documents, such as feasibility studies.

Comment No.	Section/Page/Para.	EPA Comment	Response
2	General	Please ensure the proper radionuclides along with their decay products are used in PRGs and slope factor calculations. From the Table 4.3, it appears the "+D" was not used, thus some of the PRGs are 1+ orders of magnitude too high. Do these values need to be recalculated to convey accurate decay product values?	The PRG values listed in Table 4.3 were used as a screening tool for purposes of discussing the nature and extent of contamination at the WAG 27 SWMUs. This discussion is presented in Section 4, Nature and Extent of Contamination, in Volume 1. The PRG values that were used in the risk assessment for WAG 27 SWMUs did include the radionuclide daughter products. Results of the risk assessment are presented in Volume 4.
	SPECIFIC COMMENTS		
1	Executive Summary	The executive summary section of this document was missing from some of the review copies provided to EPA. Please ensure that the final approved version of this document contains all the sections identified within the table of contents.	Agreed. The D2 WAG 27 RI Report has been checked to ensure that all sections identified within the Table of Contents are present.
2	Page ES-3, next to last	The level considered "de minimus levels" needs to be defined briefly here or a reference provided to where discussed in the report.	Agreed. The term "*de minimis levels*" has been defined as values for cumulative excess cancer risk or hazard less than 1E-6 or 1, respectively.

Comment No.	Section/Page/Para.	EPA Comment	Response
3	Page 2-2, 4th	Please send us a copy of your new procedure, "Environ. Rad. Screening". The NaI detector will not detect beta or low beta energies like Tc-99, so how can we be assured that elevated Tc-99 was not missed? Please explain what is meant by the phrase "Tc-99 analysis?" What was the NaI detector calibrated for?	A copy of the Work Instruction RP-408, "Operation of the Ludlum Model 2221 Scaler/Ratemeter with the Model 44-10 2" NaI Detector", will be forwarded to Region IV EPA. While the NaI detector was used to screen for areas of elevated radioactivity, all soil samples collected were submitted to the laboratory to be analyzed for Tc-99, whether or not the NaI detector indicated that their radioactivity exceeded twice background. The NaI detector was calibrated by the manufacturer and source checked using a Cs-137 source.
4	Page 2-2, Section 2.3	Is there a location map showing where these samples were collected? None is referenced within the text and it is unclear where these samples were obtained. Without this information the reader cannot determine the adequacy of the sampling effort around these SWMUs.	Sample locations for all the WAG 27 SWMUs are noted on Fig. 3.6. Sample locations for individual SWMUs are also identified on maps in Section 4, Nature and Extent of Contamination, and references are included within the text of that section. The information presented in Section 2, Field Investigation, pertains to the methodology used during the WAG 27 RI field work and was not intended to reference specific locations.

Comment No.	Section/Page/Para.	EPA Comment	Response
5	Page 2-2, Section 2.3, Fifth paragraph; First sentence	Were these samples collected vertically or horizontally? While subsurface and surface soil samples are differentiated in other places within the text it is unclear where these were collected. Please clarify.	Agreed. The samples discussed in the referenced text are subsurface samples and the collection intervals denote the vertical separation of the sampling points within a specific sampling station. The text has been modified to indicate that these are subsurface samples.
6	Page 2-3, 2-4, and 2-5, Sections 2.4, 2.5, 2.6, and 2.7	Is there a location map showing where these individual sample/well/CPT/Piezometer locations are specified? Do they overlap with the soil sampling efforts (it should be stated as such)? An understanding of the magnitude and extent of the SWMU characterization is easily presented by showing a base map and indicating where the work occurred and where samples were collected.	All surface soil, subsurface soil, and groundwater sampling stations and piezometer locations for the WAG 27 SWMUs are noted on Fig. 3.6. and on SWMU-specific maps in Section 4. These maps have been revised in the D2 WAG 27 RI Report to also show the locations of all CPT borings. The locations of sludge samples collected during the WAG 27 field investigation are also noted on these maps.
7	Pages 2-19 and 2-20, Section 2.13	Some mention should be made as to how the PGDP plans to dispose of all the investigative derived waste generated during the investigation and characterization of these units. Nothing lengthy, just information which reflects the manner in which it will be disposed of as part of this investigation. Presently, all the reader knows is that it will be "managed" which is not adequate information.	Agreed. The referenced text has been modified as requested.

Comment No.	Section/Page/Para.	EPA Comment	Response
8	Page 4-14, Radionuclides	Only Pu is listed exceeding background PRG values. What about the Cs-137 value of 50 pCi/g in the sediment?	The referenced text states "Of the nine radionuclide isotopes detected in the four soil samples analyzed, only one was above background *and* PRG values." While the referenced Cs-137 value of 50 pCi/g does exceed the near-surface soil background screening value of 0.49 pCi/g, it does not exceed the PRG screening value for industrial soil of 1.0E+02 pCi/g used in this section.
9	Page 4-28, Section 4.2.4.6	Within the Summary of Findings section there is no mention of the sludge data (from Table 4.23). Please add this information.	Agreed. A brief statement concerning the results of the sludge sampling at the C-720 Complex has been added to the referenced summary.
10	Table 4.2	There should be no background level for Tc-99. Although this radionuclide has a long history with this site, it still is an artificial radioisotope with no background levels. Any levels identified in reference areas should be determined to be still affected by site releases. The value should be zero. True radiation background is defined consistently in national and international guidance as natural radioactivity, and from global fallout [i.e., Cs-137, Sr-90, Pu, etc.]. Please note this with the revised version of this document.	Disagree. As reported in the regulatory agency approved *Background Levels of Selected Radionuclides and Metals in Soils and Geologic Media at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE/OR/07-1586&D2), the background levels for Tc-99 in surface and subsurface soil are 2.5 and 2.8 pCi/g, respectively. A discussion of the source of Tc-99 as a fission product is contained in the background document cited above. Text has been added to the WAG 27 RI D2 Report to clarify the origin of the Tc-99 considered to be background.

Comment No.	Section/Page/Para.	EPA Comment	Response
11	Table 4.3	For the radionuclides, it appears the radioisotope "+D" was not used to calculate PRGs: i.e. Cs-137+D, Np-237+D, U-238+D… Please correct the radionuclide PRGs and recalculate risk assessment(s) accordingly.	The PRG values listed in Table 4.3 were used as a screening tool for purposes of discussing the nature and extent of contamination at the WAG 27 SWMUs. This discussion is presented in Section 4, Nature and Extent of Contamination, in Volume 1. The PRG values that were used in the risk assessment for WAG 27 SWMUs did include the radionuclide daughter products. Results of the risk assessment are presented in Volume 4.

Comment No.	Section/Page/Para.	EPA Comment	Response
12	Table 4.12	A level of 50 pCi/g was reported for Cs-137 in the SWMU 091 sediment. What is the source of this Cs-137? There should be no levels exceeding twice background, or 0.9 pCi/g. What was done to investigate the areal size of this contamination? Table 4.27 shows only 1 value above background, but it's 20 pCi/L in the RGA. Again, how is this possible? What is the source? The explanation on P. 5-14 only gives brief information, not reason enough for levels found above the CERCLA risk range. This is also an example of potentially underestimating the true risk. Only 2 samples were taken for Cs-137, 1 was 50 the other bkgd, thus the average was about 25. How representative of the contamination was the 50 level? This type of small analyses may be warranted due to cost and the industrial scenario, but the risks and decisions made rely on getting representative sampling. We suggest MARSSIM, as a tool to help statistically determine how many samples to take and how to deal with hot spots or elevated areas. "Reducing" the value to 1/2 of the maximum to calculate the risk is not the proper way to determine risk from this or any site. Compare this to Table 4.23, where 1 sample was taken and thus the max=min=avg. This overestimates the risk.	The Cs-137 levels reported from the sediment samples at SWMU 091 did not exceed background and PRG screening levels. Both samples were collected from a ditch on the south side of the SWMU below the confluence of a ditch that carries surface-water runoff from sites to the east of SWMU 091. Therefore, an upgradient source to the east may have contributed the Cs-137 to the ditch. Only 1 out of 63 groundwater samples contained detectable Cs-137. The source for this detection is unknown.

Comment No.	Section/Page/Para.	EPA Comment	Response
13	Page 7-11, First	The reference to the ecological acceptable dose limits needs to be specifically mentioned or referenced here. Assume the IAEA standards are being referred to.	Agreed. The ecologically acceptable dose rate limits are referenced in the Effects Assessment (Volume 4, Sect. 2.3). A reference to the IAEA standards has been added to Section 7.

DOE/OR/07-1777/V1&D2
PRIMARY DOCUMENT

Remedial Investigation Report for Waste Area Grouping 27 at the Paducah Gaseous Diffusion Plant Paducah, Kentucky

Volume 1 of 4. Sections 1 through 8

Date Issued—June 1999

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for the
U.S. Department of Energy
Office of Environmental Management

Environmental Management Activities at the
PADUCAH GASEOUS DIFFUSION PLANT
Paducah, Kentucky 42002
managed by
BECHTEL JACOBS COMPANY LLC
for the
U.S. DEPARTMENT OF ENERGY
Under contract DE-AC05-98OR22700

PREFACE

This Integrated Remedial Investigation Report for Waste Area Grouping (WAG) 27 at the Paducah Gaseous Diffusion Plant (DOE/OR/07-1777&D2) was prepared in accordance with the requirements under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA). This work was performed under Work Breakdown Structure 1.4.12.07.10.1.27.03 (Activity Data Sheet OR45301). This document provides information derived from implementing the WAG 27 Remedial Investigation.

In accordance with Section IV of the Federal Facilities Agreement for the Paducah Gaseous Diffusion Plant, this integrated technical document was developed to satisfy both CERCLA and RCRA corrective action requirements. It is noted that the phases of the investigation process are referenced by CERCLA terminology within this document to reduce the potential for confusion.

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ACRONYMS

ACO	Administrative Order by Consent
AFIRO	available for infiltration or surface runoff
Am-241	americium-241
amsl	above mean sea level
ANSI	American National Standards Institute
AOC	Area of Concern
ARARs	applicable or relevant and appropriate requirements
ASTM	American Society for Testing and Materials
AWQC	Ambient Water Quality Criteria
BCF	bioconcentration factor
BEHP	bis(2-ethylhexyl)phthalate
BERA	baseline ecological risk assessment
BG	background
bgs	below ground surface
BHHRA	baseline human health risk assessment
BJC LLC	Bechtel Jacobs Company LLC
BMP	Biological Monitoring Program
BRA	Baseline Risk Assessment
BTEX	benzene, toluene, ethylbenzene, and xylenes
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
CGI	combustible gas indicator
CLP	Contract Laboratory Program
cm/s	centimeter per second
COCs	contaminants of concern
COE	U.S. Army Corps of Engineers
COPCs	chemicals of potential concern
COPECs	chemicals of potential ecological concern
cpm	counts per minute
CPT	cone penetrometer test
CRP	Community Relations Plan
Cs-134	cesium-134
Cs-137	cesium-137
CSL	Close Support Laboratory
CSM	Conceptual Site Model
CWA	Clean Water Act
DCE	dichloroethene
DI	deionized
DNAPL	dense, nonaqueous-phase liquid
DNT	dinitrotoluene
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation

dpm	disintegrations per minute
DPT	direct push technology
DQOs	data quality objectives
DRO	diesel-range organic
DRMP	Data and Records Management
DWRC	dual wall reverse circulation
EDDs	electronic data deliverables
EDGe	Engineering, Design & Geosciences Group, Inc.
EIMS	Environmental Information Management System
ELCR	excess lifetime cancer risk
EMEF	Environmental Management and Enrichment Facilities
EPA	United States Environmental Protection Agency
ESPs	Environmental Surveillance Procedures
ER	Environmental Restoration
ERWM	Environmental Restoration and Waste Management
ETS	Environmental Technical Services
FCRF	Field Change Request Form
FFA	Federal Facilities Agreement
FOP	Field Operating Procedure
FR	*Federal Register*
FS	Feasibility Study
FSP	Field Sampling Plan
GRO	gasoline-range organic
GC	gas chromatograph
GSA	generator storage area
GWPP	Groundwater Protection Program
HASP	Health and Safety Plan
HEAST	Health Effects Assessment Summary Table
HI	hazard index
HQ	hazard quotient
HSWA	Hazardous and Solid Waste Amendments
I.D.	inside diameter
IDW	investigation-derived waste
IRIS	Integrated Risk Information System
KDEP	Kentucky Department for Environmental Protection
KPA	kinetic phosphorescence analyzer
KPDES	Kentucky Pollutant Discharge Elimination System
LCD	Lower Continental Deposits
LMES	Lockheed Martin Energy Systems, Inc. (also referred to as Energy Systems)
LMUS	Lockheed Martin Utility Services, Inc.
MCL	maximum contaminant level
MDL	method detection limit
MEPAS	Multimedia Environmental Pollutant Assessment System
mgd	million gallons per day
MSDSs	Material Safety Data Sheets

MS/MSD	matrix spike/matrix spike duplicate
NAPL	nonaqueous-phase liquid
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ND	non-detect
NEPA	National Environmental Policy Act
NFA	No Further Action
NGVD	National Geodetic Vertical Datum
Np-237	neptunium-237
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
NTU	nephelometric turbidity unit
O.D.	outside diameter
OREIS	Oak Ridge Environmental Information Systems
ORO-SMO	Oak Ridge Sample Management Office
OSHA	Occupational Safety and Health Administration
OSWR	Off-Site Waste Release
OU	operable unit
OVA	organic vapor analyzer
OVM	organic vapor meter
PAH	polycyclic aromatic hydrocarbon
PARCC	precision, accuracy, representativeness, completeness, and comparability
PCB	polychlorinated biphenyl
pCi/L	picoCurie per liter
PCSR	Preliminary Characterization Summary Report
PEL	permissible exposure limit
PEMS	Project Environmental Measurements System
PGDP	Paducah Gaseous Diffusion Plant
PID	photoionization detector
POC	pathway of concern
PPE	personal protective equipment
ppm	parts per million
PQL	Practical Quantitation Limit
PRG	Preliminary Remediation Goal
Pu-239	plutonium-239
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
RCRA	Resource Conservation and Recovery Act
RF	retardation factor
RfD	reference dose
RFD	Request for Disposal
RGA	Regional Gravel Aquifer
RI	remedial investigation
ROD	Record of Decision

rpm	revolutions per minute
RPP	Radiation Protection Program
RWP	radiation work permit
SAA	satellite accumulation area
SAR	SWMU Assessment Report
SARA	Superfund Amendments and Reauthorization Act of 1986
SDWA	Safe Drinking Water Act
SHSO	Site Health and Safety Officer
SI	site investigation
SMP	Site Management Plan
SPT	Standard Penetration Test
SQL	Standard Quantitation Limit
SVOA	semivolatile organic analyte
SWMU	solid waste management unit
TAL	Target Analyte List
1,1,1-TCA	trichloroethane
Tc-99	technetium-99
TCE	trichloroethene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
Th-230	thorium-230
TLD	thermoluminescent dosimeter
TRU	transuranic
TSCA	Toxic Substances Control Act
TVA	Tennessee Valley Authority
UCD	Upper Continental Deposits
U-234	uranium-234
U-235	uranium-235
U-238	uranium-238
UCRS	Upper Continental Recharge System
UF_6	uranium hexafluoride
USEC	United States Enrichment Corporation
USGS	U. S. Geological Survey
UST	underground storage tank
VOA	volatile organic analyte
WAG	Waste Area Grouping
WKWMA	West Kentucky Wildlife Management Area
WMP	Waste Management Plan

EXECUTIVE SUMMARY

In 1998, the U.S. Department of Energy (DOE) conducted a Remedial Investigation (RI) at three solid waste management units (SWMUs: 001, 091, and 196) and the C-720 Complex in Waste Area Grouping (WAG) 27 at the Paducah Gaseous Diffusion Plant (PGDP) in Paducah, Kentucky. The purpose of this activity was to assess the presence, nature, and extent of contaminants at each of the sites. The investigation focused on source characterization of the surrounding soils and the potential impacts of contaminants on groundwater. Investigative activities included sampling and analysis of sediment, surface and subsurface soils, and groundwater.

C-747-C FORMER OIL LANDFARM (SWMU 001)

The C-747-C former Oil Landfarm is a relatively flat, open, grass-covered area in the west-central part of PGDP. The landfarm was active from 1973 to 1979. Two roughly parallel disposal plots are located in the north central part of the SWMU. Use of the landfarm was discontinued in 1979.

Trichloroethene (TCE) was found in SWMU 001 soils at a maximum concentration of 439,000 micrograms per kilogram (ug/kg) at 15 ft below ground surface (bgs). This concentration is indicative of a dense, nonaqueous-phase liquid (DNAPL). Lower concentrations of several TCE degradation products are also present at the site. The areal extent of TCE contamination in the vadose zone soils on the north side of the site is approximately 175 x 115 ft. The TCE-impacted soil was found to extend from near ground surface to the top of the water table at 50 ft bgs. The volume of impacted soil is approximately 1,006,000 ft^3. Metals also were detected in the subsurface soils at concentrations that were 27 times background levels. The metals are widely dispersed throughout the SWMU, but the highest metals concentrations are generally restricted to the upper 20 ft of vadose soil. The maximum volume of soil contaminated by metals covers an area that is 290 x 200 x 28 ft for a volume of over 1,624,000 ft^3.

A plume of contaminated groundwater containing as much as 1578 micrograms per liter (ug/L) of TCE and technetium-99 (Tc-99) at a maximum activity of 3709 picoCuries per liter (pCi/L) has been identified in the Regional Gravel Aquifer (RGA) at SWMU 001. The contaminant plume appears to be migrating to the west-northwest (downgradient) and currently extends beyond the plant security fence. Historically, TCE concentrations at levels of 20,000 µg/L have been reported from the RGA near SWMU 001. The full extent of this contaminant plume has not been defined. The origin of the TCE observed in the RGA groundwater is primarily from leaching of Upper Continental Deposits (UCD) soils at SWMU 001; the source of the Tc-99 has not been defined. Downward migration of contaminants from the RGA is not indicated by the results of the field investigation.

UF_6 CYLINDER DROP TEST SITE (SWMU 091)

PGDP conducted cylinder drop tests in late 1964 and early 1965 and in February 1979 to demonstrate the structural integrity of steel cylinders used to store and transport UF_6. In the first test period, a brine-ice bath was used to chill one cylinder prior to its drop test. In the 1979 test, a

TCE and dry-ice bath was used to chill one of the steel cylinders. Leakage from an in-ground pit that was used to hold the TCE refrigerant and cylinder resulted in contamination of shallow soil and groundwater.

The UCD at SWMU 091 was investigated as part of a previous study. WAG 27 conducted limited sampling of the ditches and the RGA. From the ditch samples only metals and one radionuclide were detected above screening levels. Cadmium, at 6.53 mg/kg, was the only constituent found at a level that greatly exceeded background.

No groundwater samples were collected from the Upper Continental Recharge System (UCRS) at SWMU 091 during the WAG 27 RI. Groundwater samples from the RGA and the McNairy flow system contained the following at concentrations above screening levels: volatile organic analytes (VOAs), i.e., TCE and its degradation products; radioactive isotopes; and metals.

Contaminant migration within the RGA occurs predominantly as lateral flow and dispersion through the Lower Continental Deposits (LCD) as groundwater moves to the west-northwest. A contaminant plume of TCE and Tc-99 has been identified in the RGA groundwater beneath SWMU 091. The maximum concentration of TCE detected in the RGA groundwater was 112 ug/L. The maximum activity of Tc-99 detected was 568 pCi/L. Leaching of contaminants from the UCD does not appear to contribute significant amounts of TCE or Tc-99 to the RGA groundwater. Evidence also does not suggest that the metals present in RGA groundwater were derived from SWMU 091.

Groundwater samples from the McNairy Formation beneath SWMU 091 contain low levels of TCE (1.9 ug/L), thorium-230 (Th-230) (maximum 53.77 pCi/L), and uranium (0.001 mg/L).

C-746-A SEPTIC SYSTEMS (SWMU 196)

SWMU 196 is located in the north-central portion of the PGDP, on the north side of the C-746-A Building. The SWMU consists of two underground, out-of-service septic systems. Eighteen metals were detected above screening levels at SWMU 196. Many of the metals detected were only slightly above screening values. The area impacted by metals at the NE septic system is approximately 70 ft x 60 ft (includes septic tank and leachfield) and extends to approximately 10 ft bgs. The area impacted by the metals contamination along the NW drain lines is more extensive, and is approximately 100 ft x 10 ft along the line extending north-south to the west of the building and 180 ft x 10 ft along the line extending east-west to the west of the septic tank. The contamination extends to approximately 10 ft bgs along both of these lines. The metal most frequently detected above screening levels was antimony, which was found at a maximum concentration of 121 milligrams per kilogram (mg/kg). Other metals detected above screening levels include beryllium at a maximum concentration of 113 mg/kg, cadmium at a maximum of 116 mg/kg, and thallium at a maximum of 114 mg/kg. In the borings drilled at SWMU 196, all of which were less than 50 feet deep, the water table was not encountered.

C-720 COMPLEX

The C-720 Building is located in the west-central area of PGDP and consists of several repair and machine shops, as well as other support operations. The building was constructed in 1953.

Two separate areas of contamination were identified at the C-720 area. A large rectangular area impacted by TCE was defined north of the building measuring 1050 ft x 225 ft. An estimated 4,725,000 ft^3 of VOA-contaminated soil was reported from the zone between 17 and 42 ft bgs. The maximum TCE concentration was 14,000 µg/kg. The volume of metals-contaminated soil within this zone was 660,000 ft^3.

A second area impacted by TCE was delineated south of the building and measures 825 ft x 150 ft. The volume of VOA-impacted soils is 1,608,750 ft^3 and metals contamination encompassed more than 312,000 ft^3. UCD soil south of the building had a maximum TCE concentration of 68,000 µg/kg, an estimated maximum 1,2-DCE concentration of 450,000 µg/kg, and a maximum vinyl chloride concentration of 400 µg/kg. Several metals were detected above screening levels and bis(2ethylhexyl)phthalate was reported at a maximum concentration of 1,100 µg/kg.

A sludge sample collected from the Compressor Shop sump had the highest TCE concentration (420,000 ug/kg) and the highest Tc-99 activity (27,520 pCi/g) detected during the WAG 27 RI. Metals, 1,1-DCE, bis(2-ethylhexyl)phthalate, PCBs, and radionuclides were also detected in this sample. Based on the results of this sample, the Compressor Shop Pit sump has been designated as a SWMU (SWMU 209). Although no releases were identified during the WAG 27 RI, further assessment is planned.

TCE, at a maximum concentration of 149 ug/L, and small quantities of TCE degradation products were the only contaminants reported in the UCRS water samples at the C-720 Building.

High levels of TCE and Tc-99 were detected in RGA groundwater near the C-720 Building. However, of these two contaminants, only TCE was present above screening levels in the UCD soils. Migration of the RGA contaminant plume from the C-720 Complex is to the west-northwest. Because of the high transmissivity of the RGA, migration of fluids from the RGA into the McNairy does not appear to be a major groundwater flow path. This is evidenced by the fact that the contaminant levels found in McNairy groundwater samples were much lower than the levels reported from the overlying RGA groundwater.

BASELINE RISK ASSESSMENT

For all four sites, the cumulative human health excess lifetime cancer risk (ELCR) and systemic toxicity exceed the accepted standards of the Kentucky Department of Environmental Protection (KDEP) and the United States Environmental Protection Agency (EPA) for one or more scenarios when assessed using default exposure parameters.

The current industrial land use scenario has risk from dermal contact with soil or sediment that is above *de minimis* levels [values for cumulative ELCR of <1E-6 or a hazard index of <1 per the methods document (DOE 1996d)] at each SWMU, except at the C-720 Building, where contact with surface soil is not possible and no ditches are present. The primary contaminants driving ELCR within this pathway are beryllium and radionuclides (neptunium-237 and cesium-137) for all locations. Decisions about remedial action based on the dermal contact with soil exposure route should be carefully considered because of the uncertainty associated with risk from this exposure route.

Risk from use of groundwater (without the risk contribution of lead) drawn from both the RGA and the McNairy Formation exceeds *de minimis* levels for all risk scenarios at each site except SWMU 196, where no chemicals of potential concern (COPCs) were identified.

Contaminants of concern (COCs) migrating from soil and groundwater sources as determined by risk estimates for future residential groundwater users are phenanthrene, trans-1, 2-dichloroethene, TCE, vinyl chloride, xylenes, antimony, manganese, silver, thallium, and vanadium. Based on transport modeling, no radionuclide COCs are migrating from the site.

The most plausible future land use scenario, industrial use, has risk that is above *de minimis* levels at each site. The future industrial land use scenario is identical to the current industrial land use but also evaluates use of RGA and McNairy Formation groundwater. Addition of groundwater as a medium of exposure adds significantly to the risk for this scenario.

Metals concentrations in surface soil from SWMU 196 and sediments in drainage ditches associated with SMWUs 001, 091, and 196 were found to be at levels that may be greater than protective of nonhuman receptors. Adverse effects are not expected from exposure to radionuclides.

RECOMMENDATIONS

Conclusions based on the DQO process and the risk-based decision rules indicate that risk from exposure to contaminated media exists at SWMUs 001, 091, and 196 and at the C-720 Complex. However, these risks do not pose an imminent or immediate threat to human health or the environment at any of these four locations. Risk-based analysis of data generated during the investigation indicates that response actions may be appropriate for impacted media at each of these four sites.

1. INTRODUCTION

1.1 PURPOSE OF REPORT

The Paducah Gaseous Diffusion Plant (PGDP), located in western Kentucky, is an active uranium enrichment facility owned by the U. S. Department of Energy (DOE) (Fig. 1.1). On July 1, 1993, DOE leased the plant production operations facilities to the United States Enrichment Corporation, which in turn contracted with Lockheed Martin Utility Services, Inc. (LMUS) to provide operations and management services. Lockheed Martin Energy Systems, Inc. (LMES) managed the environmental restoration and waste management activities at PGDP for DOE. On April 1, 1998, Bechtel Jacobs Company (BJC) LLC replaced LMES in implementing the Environmental Management and Enrichment Facilities (EMEF) Program.

DOE and BJC LLC have undertaken to identify, investigate, and remediate, as necessary, all Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs) at PGDP. The regulatory driver for the Remedial Investigation (RI) to be performed at Waste Area Grouping (WAG) 27 has been administered by the U.S. Environmental Protection Agency (EPA) and the Commonwealth of Kentucky via the Resource Conservation and Recovery Act (RCRA) permits issued on July 16, 1991. The RCRA permit contains provisions of Hazardous and Solid Waste Amendments (HSWA) only, while the Commonwealth of Kentucky permit contains provisions to address hazardous waste management as well as the provisions of HSWA. The HSWA provisions require evaluation of hazardous constituent releases and implementation of interim and final corrective measures to address such releases. In June 1994, PGDP was identified as a Superfund site under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and placed on the National Priorities List (NPL). Both RCRA and CERCLA requirements have been integrated into the Federal Facilities Agreement (FFA) that has been negotiated by DOE, EPA, and the Commonwealth of Kentucky. The FFA is a result of PGDP's placement on the NPL.

To facilitate the EMEF process at the PGDP and focus investigations toward the most effective and efficient remedial actions, operable units (OUs) have been defined. These OUs consist of two types: source control units (i.e., units that may contribute contamination to other units) and integrator units (i.e., units that "collect" contamination from source control units–in the specific instance of the PGDP, the groundwater and surface-water units). Five OUs exist at PGDP: Groundwater, Surface Water, Surface Soil, Burial Grounds, and Comprehensive Site-wide (DOE 1998b).

This document reports the results of the RI conducted at WAG 27. The WAG 27 area is shown on Fig. 1.2. WAG 27 consists of four sites that were considered potential TCE DNAPL contributors on the west side of PGDP. The focus of the RI process was to collect data to define the nature and extent of contamination and to estimate the human health and environmental risks associated with contamination at the source control OUs. Collected data are also necessary to design the appropriate corrective measures where necessary. Data on the contaminant contribution from the source control OUs to the integrator OUs were also collected during implementation of the WAG 27 Work Plan. These data will be incorporated into subsequent studies focusing on remedial action for the Groundwater and Surface Soil OUs.

1.2 WAG 27 BACKGROUND INFORMATION

The WAG 27 RI addresses contamination at four sites: SWMUs 001, 091, and 196, and the C-720 Complex including the building and surrounding areas.

- SWMU 001, C-747-C former Oil Landfarm, located in the west-central portion of the plant;
- SWMU 091, UF_6 Cylinder Drop Test Area, located in the west-central portion of the plant;
- SWMU 196, C-746-A Septic Systems, located in the north-central portion of the plant; and
- C-720 Complex located in the southwest portion of the plant, including the Compressor Shop pit, the backfill areas surrounding the building floor drainage system where these drains exit the building, and SWMU 167, the White Room sump.

1.2.1 C-747-C Former Oil Landfarm (SWMU 001)

SWMU 001 is located in the west-central portion area of PGDP. The landfarm consisted of two plots of about 1125 sq. ft each that were plowed to a depth of 1 to 2 ft. The area was slightly depressed, causing superficial depressions to fill with water at times of heavy precipitation. At some point, a layer of gravel was placed below the soil in the landfarm to improve drainage. A 6 to 12 inch soil cover was placed over the plots following closure in 1979. The extent of the SWMU includes the area bounded by 4th Street to the east and by perimeter ditches on the north, west, and south. The total area is estimated to be 96,300 sq. ft.

The landfarm was used for at least 6 years, from 1973 to 1979, for the biodegradation of waste oils contaminated with TCE, trichloroethane (1,1,1-TCA), uranium, and polychlorinated biphenyls (PCBs). It is estimated that at least 5000 gallons of waste oil was applied to the landfarm; oil was added at 3- to 4-month intervals. The sources of the waste oils were not reported, but it is assumed the oils were from virtually all areas of the plant.

Portions of SWMU 001 were characterized in previous investigations. In the CERCLA Phase I and II Site Investigations (SIs) (CH2M HILL 1991 and 1992), the landfarm was investigated. This study included a geophysical survey to locate the former landfarm plots, four Regional Gravel Aquifer (RGA) soil borings, 10 shallow soil borings, and the installation of four monitoring wells. The geophysical survey identified several anomalies. Subsequent to the Phase I and II SIs, SWMU 001 surface soil was re-evaluated as part of the WAG 23 RI. The results of the previous investigations are discussed in Sect. 4.2.1.3.

Based on the review of available information, three data gaps were identified at SWMU 001. Closing these gaps would allow for (1) development of a more accurate representation of the levels of contamination in the ditches surrounding the unit, (2) determination of the origin of geophysical anomalies within the former oil landfarm, and (3) the extent of subsurface soil contamination at SWMU 001 and the potential impact associated with the leaching of these contaminants to the Upper Continental Recharge System (UCRS) and RGA groundwater.

1.2.2 UF_6 Cylinder Drop Test Area (SWMU 091)

SWMU 091 is located in the western portion of the fenced area of the PGDP. It is situated between the south side of the C-745-B cylinder yard and Virginia Avenue.

PGDP conducted cylinder drop tests in late 1964, early 1965, and February 1979 to demonstrate the structural integrity of steel cylinders used to store and transport UF_6. In the tests, a crane lifted the cylinders to a specified height and dropped them on a concrete and steel pad to simulate worst-case transportation accidents. Deformation of the cylinders was documented, and these tests supported application for an interplant transportation permit.

Drop tests were used to assess the effect of low temperatures on cylinder integrity. In the first test period, a brine-ice bath was used to chill one cylinder prior to its drop test. In the 1979 test, a TCE and dry-ice bath was used to chill one of the steel cylinders. Leakage from an in-ground pit, used to hold the TCE refrigerant and cylinder, resulted in contamination of shallow soil and groundwater.

Soil and groundwater sampling took place during various investigations, including the Phase I and II SIs and the LASAGNA ™ Technology demonstration. In general, many samples (i.e., more than 25) have been collected from soil associated with SWMU 091. However, fewer groundwater samples, except those analyzed for TCE and Tc-99, have been collected from this area. Results of the previous sampling for SWMU 091 are summarized in Sect. 4.2.

On the basis of available data, the nature and extent of contamination in SWMU 091, as well as its potential for release of contaminants to the environment, have been reasonably well characterized, especially with respect to TCE. Sediment in the ditches that convey surface runoff away from the TCE-impacted area had not been investigated. This data gap was to be filled during WAG 27 activities. To confirm that TCE contamination at the site had not been mobilized by remedial measures (e.g., LASAGNA™ demonstration) and to confirm that TCE had not migrated downward to further contaminate the RGA groundwater, two deep soil borings were installed downgradient of SWMU 091 during WAG 27 RI activities. Results of the deep soil borings are presented in Sect. 4.2.5.3.

1.2.3 C-746-A Septic Systems (SWMU 196)

SWMU 196 is located in the north-central portion of the PGDP, on the north side of the C-746-A Building. The SWMU consists of two underground, out-of-service septic systems. On the northeast corner, the septic system consists of a 960-gal septic tank (rectangular: 40 in. wide x 84 in. long x 66 in. deep) that feeds a 60-ft x 20-ft leachfield. The leachfield consists of 4-in. drain tiles in shallow soil.

C-746-A was used as a warehouse during plant construction. Subsequent operations consisted primarily of metal storage and smelting. From 1956 until 1985, an aluminum smelter was operated in the west end of the building and from 1975 until 1985, a nickel smelter was operated in the east end of the building. Current operations include storage of hazardous and PCB waste.

The northeast septic system was in operation from April 1958 to February 1980. The septic system originally processed sanitary waste from a toilet, a urinal, a bathroom floor drain, and a bathroom sink. Modifications were made in August 1975, when a change house and break area were added as part of the nickel smelter operation. The septic system then processed sanitary waste from a kitchen sink, a water cooler, two showers, a second urinal, and the change house floor drains, as well as the original toilet, urinal, bathroom floor drain, and bathroom sink. In 1980, the septic system was plugged and abandoned in place when C-746-A was tied into the C-615 sewage treatment plant system.

The northwest septic system was in operation from November 1956 to February 1980. The system processed sanitary waste from a toilet, two showers, a sink, and a water cooler installed shortly after construction of the aluminum smelter operation. No floor drain system exists in the area. In 1980, the septic system was plugged and abandoned in place when C-746-A was tied into the C-615 sewage treatment plant system. In 1982, regrading of a drainage ditch on the west end of C-746-A resulted in the destruction of approximately 25 ft of the vitreous clay pipe. Some sanitary waste that was in the 4-in. line upgradient (28 ft) at the time of abandonment in 1980 may have been released to the sediments of the drainage ditch.

SWMU 196 was first defined in 1993. Due to its recent addition, it was not one of the areas sampled during the CERCLA Phase I and II SIs and no subsequent investigation has provided sufficient information to characterize the septic systems. SWMU 196 was placed in WAG 27 to investigate the possibility that potential releases of TCE through the sanitary septic system could be a contributing source to the UCRS and to the TCE plume in the RGA emanating from the C-746-A area.

1.2.4 C-720 Complex (Compressor Shop Pit, SWMU 167, and Floor Drain Exit Points)

The C-720 Building is located in the west-central area of PGDP to the southwest of the C-400 Building. The C-720 Building consists of several repair and machine shops, as well as other support operations. The building was constructed in 1953, with a total area of 281,200 sq ft. Five SWMUs are associated with this building. SWMU 090 (an underground petroleum naphtha pipe) and SWMU 141 (an inactive TCE degreaser) have been designated as No Further Action (NFA) in the Site Management Plan, or SMP (DOE 1998b). SWMU 027 (acid neutralization tank) is being addressed under WAG 9, and SWMU 031 (compressor pit storage tank) is being addressed under WAG 5. WAG 27 deals with SWMU 167 (White Room sump) and the Compressor Shop pit. The Compressor Shop pit, which is located in the eastern portion of the C-720 Building, has been designated as SWMU 209 based on the results of the WAG 27 RI. WAG 27 also addresses the backfill areas around the major exit points from the building drainage system. The building drainage system discharges to the plant stormwater system.

The White Room sump was sampled during two separate events. During the first event (July 1992), the sludge was analyzed for total cyanide to establish if health threats in the C-720 Building existed and to provide guidance for future sampling events. Cyanide compounds were not detected. The sump sludge was sampled a second time in December 1992 and was analyzed for RCRA corrosivity parameters, RCRA ignitability parameters, RCRA reactivity parameters, TCLP metals, TCLP volatile organics, TCLP semivolatile organics, bulk metals, raw volatile organics including bulk TCE, bulk semivolatile organics, PCBs, and radionuclides.

A monitoring well pair (MW-203 and MW-204) was installed to the northeast of the C-720 Building during the CERCLA Phase II SI to assess contamination associated with SWMUs 027 (acid neutralization tank) and 141 (an inactive TCE degreaser).

The C-720 Complex was included in the WAG 27 RI because it was recognized as a possible source of TCE in the southwestern part of the plant during the Phase IV groundwater investigation. A detailed discussion of release potential is included in Sect. 4.2.4.3.

1.3 PROJECT SCOPE

The scope of the WAG 27 field effort included conducting a RI at the C-720 Complex and three SWMUs located within the fenced security area at PGDP. The primary focus was to collect sufficient information about surface and subsurface soil and the shallow groundwater of the UCRS to support an assessment of risks to human health and the environment and the selection of actions to reduce these risks, if required. In addition, contamination in the RGA was characterized during the RI to determine whether contamination in the RGA acts as a secondary source area. The uppermost 50 ft of the McNairy Formation was characterized. All data collected during the WAG 27 RI will be evaluated and incorporated as appropriate in future PGDP remedial action planning documents.

Within this scope, the goals of the WAG 27 RI were to:

- characterize the nature of contaminant source materials;
- define the nature, extent (vertical and lateral), and magnitude of source area contamination in soils, sediments, and groundwater.
- identify and define the extent of hot spots of groundwater contamination and migration trends;
- determine the presence, general location, if possible, and magnitude of any dense, non-aqueous phase liquid (DNAPL) zones;
- provide sufficient information associated with the C-720 Building and three SWMUs to support a baseline risk assessment for WAG 27, the groundwater OU, and the surface-water OU; and
- gather adequate data to analyze contaminant transport mechanisms and support a feasibility study (FS).

1.4 REPORT ORGANIZATION

Sect. 1 of this report has presented a brief overview of the four sites, as well as the rationale for RI field sampling. This section also discussed current and past activities conducted at PGDP.

Sect. 2 describes the investigative methods used to sample the various media, the analytical sampling parameters, and the historical waste management practices at each of the four sites covered under this investigation.

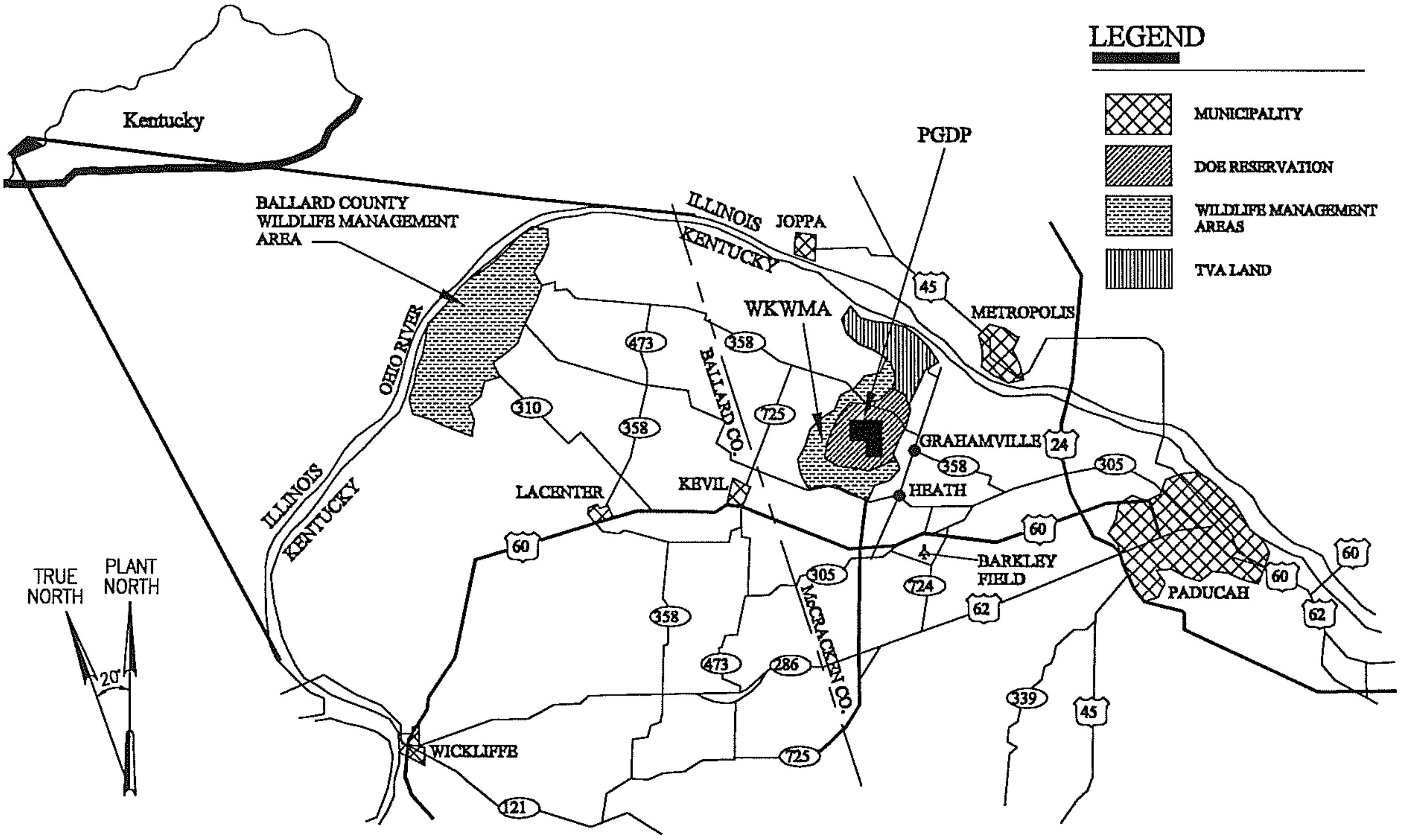
Sect. 3 details the physical characteristics of each SWMU, including the topography, surface-water hydrology, geology, and hydrogeology. In addition, a description of the meteorology, ecology, demography, and land use at PGDP is presented.

Sect. 4 presents a discussion of the nature and extent of the contamination at each site as concluded from analyses of the data collected during the investigation. The history of contamination as found in previous investigations is also presented.

Sect. 5 presents a discussion of the fate and transport of the contamination at each site. A conceptual site model has been developed in which exposure pathways of potential concern are discussed and contaminant persistence is evaluated. Models of contaminant transport are also presented.

Sect. 6 presents the results of a baseline risk assessment, including results of previous studies, identification of contaminants of concern (COCs), the exposure assessment, the toxicity assessment, the risk characterization, conclusions, and site-specific remedial action goals. Also included in Sect. 6 are the results of a baseline ecological risk assessment, including identification of contaminants, receptors, and exposure pathways of concern; any site that poses no risk; any site that may require immediate action; and any site that requires further investigation, as well as the data gaps that must be filled to complete such an investigation. The final sections (7 and 8) present the conclusions and references, respectively, of this report. Figures and tables, in that order, appear at the end of sections in which they are referenced.

Volumes 2 and 3 present appendix material referenced in this volume. Volume 4 presents the baseline risk assessment.



NOT TO SCALE

Fig. 1.1. PGDP location map.

FIGURE 1.2 REMOVED.

2. FIELD INVESTIGATION

This section presents a description of the field investigation activities and methods used during the WAG 27 RI. Major topics include sampling activities, procedures, and equipment, as well as analyses conducted on the samples.

All sampling at PGDP was conducted in accordance with the medium-specific procedures set forth in the Paducah Environmental Management and Enrichment Facilities (EMEF) Program Procedures Manual. These procedures are consistent with EPA Region IV Standard Operating Procedures (EPA 1996). Table 2.1 is a list of the PGDP procedures that provided guidance for the WAG 27 RI.

2.1 TRENCHING ACTIVITIES

CDM Federal Programs performed trenching activities at SWMUs 001 and 196 between January 20 and February 6, 1998. Field activities included excavation of test pits at SWMU 001 and septic tanks at SWMU 196. Excavations were completed using a Nissan N21SS Mini-Giant excavator and a Case 580L backhoe. All soil removed during the excavations was returned to the excavation following sampling to minimize waste generation. A site safety professional monitored all trenching activities using a photoionization detector (PID) for volatile organic compounds (VOAs) and a Geiger-Muller device for radioactivity. Five soil samples, including duplicates, were collected at SWMU 001. Seven sludge samples were collected from the septic tanks at SWMU 196. The SWMU 196 septic tanks were emptied and abandoned in place. Complete details of these activities are included in the report in Appendix F. Table 2.2 indicates the number of samples by sample type collected at each site.

2.2 SEDIMENT SAMPLING METHODS

Sediment samples were collected from the uppermost 1 ft of soil in accordance with PGDP Environmental Restoration and Waste Management (ERWM) Field Operating Procedure (FOP) PTSA-4201, Surface Soil Sampling. Sediment samples were collected using a 4-in.-outside-diameter (O. D.) stainless-steel bucket hand auger.

Before a sediment sample was collected, plastic sheeting was placed over the sampling location. A hole was then cut through the plastic and the upper 1 to 2 in. of soil or grass was removed to expose fresh material. No aliquots for volatile organic analyte (VOA) analyses were collected from sediment samples. The sediment was placed into a stainless-steel bowl and mixed thoroughly; a representative composite sample was then prepared in accordance with PTSA-4204, Composite Sample Preparation. After the sediment samples were containerized, a site safety professional field-scanned the container using a direct-measure radioactivity meter, wiped the container to determine radiation activity, and compared the readings against the free release criteria. A label was then affixed to the container and secured with tape, and the container was placed in a zippered plastic bag. The bags were then packed in ice within coolers and kept at a temperature of 4°C ± 2°C. A total of 13 sediment samples were collected during the WAG 27 RI. Table 2.2 indicates the number of samples by sample type collected at each site.

2.3 SURFACE AND SUBSURFACE SOIL SAMPLING METHODS

Surface and shallow subsurface soil samples were collected during the WAG 27 RI. Surface soil samples were collected in accordance with PGDP ERWM FOP CP4-ER-SAM4201, Collection of Sediment/Sludge Samples. This procedure was revised and replaced with PTSA-4201, Surface Soil Sampling, on December 22, 1997. Subsurface soil samples were collected in accordance with PGDP ERWM FOP CP4-ER-SAM4202, Subsurface Soil Sampling, and EPA Region IV protocol (EPA 1996). The PGDP procedure was revised and replaced with PTSA-4202, Subsurface Soil Sampling, on June 6, 1997. Direct push technology (DPT) was used to collect surface and subsurface soil samples during the WAG27 RI.

Before sampling was conducted at each site, plastic sheeting was placed on the sampling location and a hole cut through the plastic. Asphalt- and concrete-covered areas were cored to expose the underlying soil. Surface debris and the upper 1 to 2 in. of soil were removed to expose fresh material.

The majority of the shallow subsurface soil samples were collected using a DPT rig. DPT methods significantly minimized the volume of waste soil cuttings generated. Soil samples were collected using a 2-in.-O. D. 4-ft-long Geoprobe Macro-core continuous sampler fitted with clear acetate liner. The sampler was advanced in 2- and 4-ft intervals. Once a section of soil was collected in the sampler, the sampler was removed from the subsurface and detached. Before the sampler was opened, the entire sample (with additional focus on the ends) was screened by a site safety professional for volatile organic vapors using a flame ionization/photoionization detector. The outside of the sampler was also measured for alpha radioactivity emissions and beta/gamma radioactivity emissions as a safety precaution.

A new procedure, 'Environmental Radiological Screening,' was used to screen subsurface soils. A sodium iodide (NaI) detector was used as a field screening instrument to identify areas of elevated radioactivity. Environmental samples were collected for gamma spectroscopy and Tc-99 analysis when the gross alpha to beta ratio of the soil exceeded 3:1 as measured with the NaI detector. These samples were submitted for isotopic and radioactivity determination. Ten percent of the soil samples collected from intervals that did not exceed twice background were submitted for Tc-99 analysis only. QA/QC samples (duplicates) were submitted for isotopic analysis to confirm field screening results.

Subsurface samples were collected at 2-ft intervals at SWMU 196 and 5-ft intervals at SWMU 001 and the C-720 Building. VOA samples were collected first. VOA samples were collected for both the off-site fixed-base laboratory and an on-site Close Support Laboratory (CSL) using a veterinary syringe (with the end cut off) to transfer the soil from the fresh cut end of the liner to a 40-mL vial containing deionized (D. I.) water and hexane. The vial was sealed, labeled, and immediately placed on ice. Fifteen VOA samples were also collected for fixed-base laboratory analysis and consisted of a 6-in cut section of the acetate liner that was capped, taped, labeled, and immediately placed on ice. Subsurface soil samples collected for analyses other than VOAs were placed into stainless-steel bowls and mixed thoroughly. This representative composite sample was placed into appropriate sample container(s). These composite samples were prepared in accordance with PGDP Procedure PTSA-4204, Composite Sample Preparation. In most cases, the entire soil core was needed to fill the sample containers, significantly reducing the waste generated during the RI.

After the subsurface soil samples were containerized, a site safety professional field-scanned the container using a direct-measure radioactivity meter, wiped the container to determine radiation activity, and compared the readings against the free release criteria. A label was then affixed to the container and secured with tape, and the container was placed in a zippered plastic bag. The bags were then packed in ice within coolers and kept at a temperature of 4°C ± 2°C.

One set of 4 subsurface soil samples was collected using a 4-in. O.D. stainless-steel bucket hand auger at SWMU 196, location 196-003. Samples were collected at 2-ft intervals to a depth of 8 ft. Additionally, soil samples from location 720-030 were collected using 3-in O. D. split spoons through 4.25-in inside diameter (I. D.) hollow stem augers. Sample collection methods were identical to those used at the other subsurface sampling locations. Soil samples for chemical analysis were collected only from the upper 50-ft. Samples for grain size analysis were collected from the RGA at SWMUs 001 and 091 via the Dual Wall Reverse Circulation (DWRC) rig's cyclone separator. Cuttings discharged through the separator were collected in a bucket and transferred to the sample container. Because of this technique, these samples are only somewhat representative of the formation grain size due to the disturbance and destruction caused by the drill rig. However, the relative differences in grain size in the RGA can be approximated from these data.

A total of 13 surface soil samples (all from SWMU 196) and 424 subsurface soil samples ranging in depth from 2 to 50 feet were collected during the WAG 27 RI. Twenty-eight grain size samples were collected from the RGA at depths from 55 to 100 ft. Table 2.2 indicates the number of samples by sample type collected at each site. Completed lithologic logs are included in Appendix A.

2.4 CONE PENETROMETER TESTS

R. E. Wright Environmental used a 10-ton electronic subtraction cone to perform Cone Penetrometer Tests (CPTs). The CPT consisted of thrusting the cone into the soil at a constant rate of 2 cm/sec. Measurements of tip bearing stress or resistance (Qc), Sleeve Friction (Fs), inclination (I), and pore pressure (u) were recorded at 5-cm intervals during the test to provide a nearly continuous stratigraphic log and interpretive Standard Penetration Test (SPT) N values. The data were transmitted as analog voltage signal via a cable (inside a rod string) to a computer data acquisition system located on the CPT rig. All CPTs were performed in accordance with American Society for Testing and Materials (ASTM) standard (D5778). Two CPT points at the C-720 Building, four points at SWMU 001, and one point at SWMU 196 were completed during the RI. The complete report is included as Appendix E.

2.5 BOREHOLE GROUNDWATER GRAB SAMPLES

Collection of borehole groundwater grab samples was attempted when shallow groundwater was encountered, i. e., <50 ft below ground surface (bgs), at 5-ft intervals throughout the entire thickness of the RGA, and at two depth intervals in the upper McNairy Formation, terminating at the Levings Member of the McNairy Formation. The purpose of these samples was to obtain a vertical profile of groundwater contamination. Two DWRC rigs were used to collect groundwater grab samples from the UCRS, RGA, and McNairy Formation. A DPT rig was used to collect groundwater from the UCRS.

Groundwater grab samples were collected from the shallow groundwater (i.e., <50 ft deep) using primarily DPT drill methods. Sampling of the shallow groundwater was performed using a mini-bailer. Because the recharge rate of the shallow groundwater was very slow, purging was not feasible and sufficient water was not always available to collect a full suite of analytical parameters.

Borehole groundwater grab samples of the deep groundwater (i.e., >50-ft deep) were collected during drilling using the DWRC method. Boreholes drilled by the DWRC method were blown free of standing water before purging and sampling.

Purging and sampling were completed using a QED Well Wizard™ bladder pump. The use of these pumps allowed low-flow-rate purging and sampling, which significantly reduces the turbidity of the sample and results in more representative metals concentrations.

Selected water quality parameters including pH, temperature, dissolved oxygen (DO), and specific conductivity were monitored during purging and sampling using a QED water quality logger equipped with an in-line flow cell. Purging was discontinued when (1) pH stabilized to within 0.10 unit, (2) specific conductivity stabilized to within 10 micromhos per centimeter (µmhos/cm), and (3) temperature stabilized to within 10 percent.

All samples were collected directly into appropriate sample containers from the discharge line of the pump. VOA samples were collected first at a flow rate of approximately 100 mL/min. Samples for other parameters were collected at a flow rate of approximately 1L/min. For some sampling intervals, the recharge rate was very slow and purging was not feasible or could not be completed. Several samples were collected through the bladder pump before adequate purging or by using a disposable Teflon bailer. These samples are identified in Table 2.3. After the borehole groundwater grab samples were containerized, a site safety professional field-scanned the container using a direct-measure radioactivity meter, wiped the container, and compared the readings against the free release criteria. A label was then affixed to the container and secured with tape, and the container was placed in a zippered plastic bag. The bags were then packed in ice within coolers and kept at a temperature of 4°C ± 2°C.

Two-hundred-thirty-eight groundwater samples were collected during the WAG 27 RI. Completed lithologic logs are included in Appendix A.

2.6 PIEZOMETER INSTALLATION

Five piezometers were installed at depths ranging from 83 to 85 feet during the WAG 27 RI. The piezometers were constructed with 1.5-in. diameter polyvinyl chloride (PVC) well screens and casing. Construction materials were selected in accordance with the requirements and specifications of PGDP Procedure PTSA-4305-IAD, Filter Pack and Screen Selection for Wells and Piezometers. Piezometers were installed using a CME 85 hollow stem auger rig. The purpose of the piezometers was to measure the potentiometric surface of the RGA in the C-720 area. Water level measurements were recorded twice, the second time to confirm the first measurements, and are presented in Table 2.4. Construction diagrams are included with the boring logs in Appendix A.

The piezometer at location 720-012 was finished above ground surface with a 4-in. protective steel casing and 1-ft x 1-ft x 6-in. thick concrete pad. The remaining piezometers, located in high traffic areas or on concrete, were finished below ground surface with a flush-mount vault sealed with concrete. Piezometers were surveyed in accordance with the PGDP Procedure PTSA-3013-IAD, Site Surveying.

2.7 SLUDGE SAMPLING METHODS

Sludge samples were collected in accordance with PGDP Procedures, Collection of Sediment/Sludge Samples. Sludge samples were collected from the septic tanks at SWMU 196 and from the sump in the Compressor Shop pit at the C-720 Building. Details of the septic tank sampling are provided in Appendix F. The sump sampled at the C-720 Building is located below a staircase in the northwest corner of the Compressor Shop pit. The area is designated as a "Radiation Contamination Area," and the work was performed in accordance with the appropriate health and safety and radiation work permit (RWP). For the sample collection event, a site safety professional continuously monitored for radioactivity and organic vapor emissions. The samplers donned the appropriate Personal Protective Equipment (PPE) as designated by the RWP to enter the Compressor Shop pit, but did not enter the sump.

The samples were obtained by connecting two 10-ft lengths of schedule 80 PVC pipe and securing a glass sample jar to the pipe using duct tape. The jar was then extended to the bottom of the sump to collect the sludge. When the sludge was retrieved, it was placed in a stainless-steel bowl. Aliquots for VOA analysis were immediately transferred to the appropriate sample containers. Aliquots for analyses other than VOA were mixed thoroughly. This representative composite sample was placed into appropriate sample container(s). These composite samples were prepared in accordance with PGDP Procedure PTSA-4204, Composite Sample. A site safety professional then field-scanned the container using a direct-measure radioactivity meter, wiped the container to determine radiation activity, and compared the readings against the free release criteria. A label was then affixed to the container and secured with tape, and the container was placed in a zippered plastic bag. The bags were then packed in ice within coolers and kept at a temperature of 4°C ± 2°C.

2.8 ANALYTICAL METHODS

During the analytical program for the WAG 27 RI, the following laboratories were used:

- Close Support Laboratory (CSL) located on-site equipped with 2 gas chromatographs (GCs), one each for screening soil and groundwater samples;
- CSL located on-site equipped with a gas proportional radioactivity counter for gross alpha and gross beta screening of soil, water, and wipe screens;
- Fixed-Base Laboratory for soil and groundwater samples (Core Laboratory in Aurora, CO and LMUS C-710 laboratory and K25 lab for soil);
- Fixed-Base Laboratory for geotechnical samples (Southwest Research Institute, San Antonio, TX).

Previous sampling has allowed the development of a list of chemicals of potential concern (COPCs) associated with WAG 27. CSL screening techniques permitted adequate measurement of contaminant levels while reducing the overall cost of field and analytical services for the WAG 27 RI. In particular, field screening was relied upon to assess the presence of VOAs, radionuclides, and PCBs. An on-site GC using SW846 methods (EPA 1986) was used to perform field screening for VOAs. Immunoassay analytical kits were used for on-site field screening for PCBs. A nuclear spectroscopy analyzer was used to perform field screening for gross alpha, beta, and gamma activities. Samples of groundwater for metals analysis were collected only if the conductivity was greater than 400 µmhos/cm.

In addition, a minimum of 10% of the sample total (by medium) were split and submitted to an off-site fixed-base laboratory for analysis. These samples provided definitive data to confirm the results from the CSL screens. A separate sample aliquot was collected from each sample interval scheduled for off-site fixed-base laboratory analysis. This sample aliquot was analyzed at the CSL radiochemistry laboratory, where it underwent radiation screening. A wipe sample also was collected from the exterior of each sample container. The WAG 27 RI sample shipping team determined whether the samples could be shipped off-site for analysis based on wipe samples and radiological screening sample results compared to the U.S. Department of Transportation (DOT), International Air and Transportation Association (IATA), and DOE-specified limits. The DOT project specialist also prepared the shipment in accordance with DOT and IATA regulations for shipment of dangerous goods, if warranted.

2.8.1 Close Support Laboratory Methods

A CSL was mobilized to analyze soil and groundwater samples. The samples were analyzed for:

- VOA,
- PCB screening, and
- Gross alpha and gross beta activity.

Equipment. GC analysis was performed using two Hewlett-Packard HP5890 series II GCs. Owens-Illinois electrolytic conductivity detectors (Models 4420 and 5200) were used for the assessment of TCE and its degradation products. One GC was used to analyze VOAs in soil samples, and the other to analyze VOAs in water samples.

Immunoassay analytical kits manufactured by HACH Chemical Company or by Strategic Diagnostics Incorporated were used to assess levels of PCB contamination in soil samples.

Gross alpha and gross beta assessments were performed using a Tennelec Series 5 Low Background Gas Proportional Counter.

Methods. Table 2.5 indicates the types of analyses performed in the CSL.

CSL VOA Analysis for Soil Samples (Hexane Extraction). Veterinary syringes (with ends cut off) were used to transfer soil from the sampling sleeve (soil core) to a 40-mL vial containing DI water and hexane. The hexane extracts the VOAs from the soil/water solution. In the laboratory, a syringe was used to sample the hexane layer in the vial. The hexane, along with the VOAs dissolved in it, was injected into the GC for analysis.

CSL Radiological Analysis Procedures. When appropriate for the sample matrix, SW-846 methods were used. When SW-846 methods were not available or not appropriate, other nationally recognized methods such as EPA, DOE, and ASTM methods were used. The following procedure manuals were used as references for radiological analysis:

- *Prescribed Procedures for Measurement of Radioactivity in Drinking Water*, EPA-600/4-80-032 (EPA 1980);
- *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, SW-846 (EPA 1986);
- Eastern Environmental Radiation Facility, *Radiochemistry Procedures Manual*, EPA 520/5-84-006, (EPA 1984); and
- *Environmental Measurements Laboratory Procedures Manual*, HASL-300 (DOE 1982).

Sample Requirements. Table 2.6 indicates the analytical methods and sample requirements for CSL analysis.

2.8.2 Fixed-Base Laboratory Methods

Core Laboratory and Lockheed Martin Utility Services C-710 laboratory performed fixed-base laboratory analyses of soil and groundwater samples. These laboratories were contracted through the DOE Oak Ridge Sample Management Office (ORO-SMO) and are DOE-approved, Nuclear Regulatory Commission licensed laboratories. SW-846 methods were used for all samples, except those parameters for which other methods are necessary. The analysis followed SW-846 protocols and "Forms Only" data packages were provided along with electronic data deliverables. Table 2.7 summarizes the analytical methods and sample requirements of the fixed-base laboratories. Laboratory data qualifiers are defined below:

A. Inorganic Analysis

B - The reported value was obtained from a reading that was less than the Contract Required Detection Limit but greater than or equal to the Instrument Detection Limit.

U - The analyte was analyzed for but not detected.

E - The reported value is estimated because of the presence of interference. An explanatory note must be included under Comments on the Cover Page (if the problem applies to all samples) or on the specific FORM I-IN (if it is an isolated problem).

M - Duplicate injection precision not met.

N - Spiked sample recovery not within control limits.

S - The reported value was determined by the Method of Standard Additions (MSA).

W - Post-digestion spike for furnace atomic absorption analysis is out of control limits (85%-115%), while sample absorbance is less than 50% of spike absorbance.

* - Duplicate analysis not within control limits.
\+ - Correlation coefficient for the MSA is less than 0.995.

B. Organic Analysis

U - Indicated compound was analyzed for but not detected.

J - Indicates an estimated value. This flag is used under the following circumstances: (1) when estimating a concentration for tentatively identified compounds where a 1:1 response is assumed, (2) when the mass spectral and retention time data indicate the presence of a compound that meets the pesticide/Aroclor identification criteria and the result is less than the Contract Required Quantitation Limit but greater than zero.

P - This flag is used for a pesticide/Aroclor target analyte when there is greater than 25% difference for detected concentrations between the two GC columns.

C - This flag applies to pesticide results where the identification has been confirmed by GC/mass spectrometer (MS).

B - This flag is used when the analyte is found in the associated blank as well as in the sample.

E - This flag identifies compounds whose concentrations exceed the calibration range of the GC/MS instrument for that specific analysis.

D - This flag identifies all compounds identified in an analysis at a secondary dilution factor.

X - Other specific flags may be required to properly define the results.

2.8.3 Analytical Data Quality

Precision, Accuracy, Representativeness, Completeness, and Comparability. An assessment of the precision, accuracy, representativeness, completeness, and comparability of field measurements and analytical data was performed. The results of this assessment are discussed below.

- **Precision.** "Precision" is defined as the degree of agreement between repeated measurements of one property using the same method or technique. Duplicate samples are collected as a measure of precision of the sample collection and analytical process. For this field program, duplicate samples were collected for all media, at a frequency of 5%. Table 2.8 contains summary information on the WAG 27 data precision.

- **Accuracy.** "Accuracy" is defined as the degree of agreement of a measurement with an accepted reference or true value. Accuracy of laboratory analyses is estimated through the analysis of blank spikes, matrix spikes, or surrogate spikes. These laboratory quality control (QC) samples are analyzed as required by the appropriate analytical method.

- **Representativeness.** "Representativeness" is defined as the degree to which data accurately and precisely represent the nature and extent of contamination. The data collected during the RI were both accurate and precise. As indicated in Sect. 2.8.3, the samples required in the WAG 27 RI

Work Plan to define the nature and extent of contamination were collected. Based on the criteria noted above, the data from the WAG 27 RI were deemed representative.

- **Completeness**. "Completeness" is defined as a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained. In this RI, "completeness" refers to the percentage of valid measurements versus the total measurements planned. The Quality Assurance Project Plan (QAPP) specified a completeness objective of 90% for the analyses performed. The WAG 27 RI achieved completeness above 97%.

- **Comparability**. "Comparability" is defined as the degree of confidence with which one data set can be compared to another. Data collected for this investigation were generally collected according to the RI Work Plan and QAPP, and all field changes were approved by LMES.

Surveillances. BJC LLC and CH2M HILL conducted surveillances of the field activities and the CSL. Surveillance covered the following areas: CSL activities, sample management activities, log keeping and chain-of-custody documentation, equipment decontamination, waste management activities, sampling activities, implementation of quality-assured data policies, and well installation and development. CH2M HILL, as requested, corrected the findings that were identified. The ORO-SMO conducted laboratory surveillance of the fixed-base laboratories.

Data Quality Objectives. Data quality objectives (DQOs) are qualitative and quantitative criteria used to establish requirements for sample collection and analysis and are based on the intended uses of the data. The overall intent of DQOs is to generate data of appropriate quality to support the assessment of risks to human health and the environment and the selection of remedial actions. DQOs were documented in the approved WAG 27 RI Work Plan and were implemented as documented in the Field Sampling Plan and QAPP.

The DQO process was used to focus the sampling strategy on SWMU-specific media contamination and migration pathways. In addition, this process was used to identify the data requirements for the potential remedial action alternatives and FS.

Decisions to be made during the RI process include a determination of whether releases have occurred and whether remediation of the site will be required. Risk-based analysis of data generated during the WAG 27 investigation was used to make one of three decisions for each of the sites:

1. Where no contamination or contamination not presenting unacceptable risk to human health or the environment are found at the site, a determination for no further action was made.

2. Where contamination presenting imminent, immediate, unacceptable risks to human health and the environment is found, a determination for implementing interim remedial actions will be considered The interim measures may include institutional controls or temporary stabilization to prevent further contaminant migration and/or degradation.

3. Where contamination presenting unacceptable risks to human health and the environment is found but the risks are not imminent or immediate, an FS will be performed. An FS will also be performed for SWMUs or areas at which interim remedial actions were implemented.

The results of the DQO process and decision rules analysis are presented in Sect. 7.

CSL Performance. All data generated at the CSL were of sufficient quality to support the project decision-making process. Detection limits are method- and matrix-specific. CSL VOA reporting packages included chromatograms for all samples and standards, chain-of-custody information, raw instrument output, sample and data management logs, complete reports of QC samples, copies of laboratory logbooks, and all other supporting documentation and QC. Reporting of semivolatile organic analytes (SVOA) conformed to standard SW-846 documentation for each analytical batch by date.

Included in the documentation were initial and continuing instrument calibration, performance results, determination of method detection limits, identification and quantification of compounds and analytes detected, and laboratory QC samples. Selected data were conveyed to the Data Coordinator for direct download into the project database. The Project Chemist reviewed results before the data were input to the project database. The following criteria were reviewed to determine acceptability:

- Holding times—Most holding times were met. If holding times were not met, the fixed-base laboratories analyzed and qualified the samples.
- Initial calibration—Most initial calibrations met acceptance criteria. If the daily initial calibration criteria were not met, the instrument was recalibrated prior to use.
- Continuing calibration checks—Most calibration checks met acceptance criteria. If continuing calibration criteria were not met, the sample was reanalyzed or qualified.
- Method blanks—If target compounds were found in the blank and the associated sample, the sample records were flagged as "estimated." Few records were assigned flags for this reason.
- Laboratory duplicates—Most laboratory duplicates were within the acceptance criteria.

In general, all GC data were assessed as usable for their intended purpose (field screening). For VOA analyses, average soil spike recoveries ranged from 84.1% for vinyl chloride to 104% for 1,1-dichloroethene, and average water spike recoveries ranged from 102.4% for vinyl chloride to 107.3% for trans-1,2-dichloroethene. The majority of duplicate VOA results above the quantitation limit were for TCE, and the average relative percent difference (RPD) for TCE was 6.4% for soil and 10.8% for water. For gross alpha/gross beta determinations, spiked water samples averaged 107.1% recovery for alpha and 106.9% recovery for beta. For duplicate results above the minimum detectable activity, water RPD averaged 27.5% for alpha and 14.1% for beta. For PCB (immunoassay test kit) analysis, all duplicate results were non-detects. Table 2.8 presents the average precision and accuracy numbers for specific parameters analyzed at the CSL.

Fixed-Base Laboratory Performance. Fixed-base laboratory performance was based on the results of laboratory QC samples, matrix spike/matrix spike duplicate (MS/MSD) analysis, and adherence to laboratory procedures through data validation. The laboratories are audited annually by the ORO-SMO and are contracted to follow the Analytical Master Specification documents for various analytical chemistry protocols mandated by the ORO-SMO.

No significant data problems were reported for any of the laboratories used during this investigation. Specific laboratory problems with the data were addressed and resolved during the data assessment phase.

Comparison of TCE Results in Soils Analyzed Using Hexane Extraction vs Conventional Methods. The WAG 27 RI is one of the first major investigations at PGDP to use hexane extraction for analysis of chlorinated solvents in soils. The methodology had been refined on smaller projects, most notably in support of the LASANGA^{TM} Technology demonstration, and incorporated in the PGDP subsurface soil sampling procedure. The method is relatively new, and most fixed-base laboratories are not equipped to use it. In a recent study, samples were analyzed at a CSL using hexane extraction, and a section of sample sleeve was sent to the fixed-base laboratory for more conventional analysis. As results were received from the fixed-base laboratory and compared with the CSL results, it became obvious that the results of the two methods were not directly comparable. The CSL always returned higher values than the fixed-base laboratory. On average, the CSL reported TCE values nearly 500 times greater than those reported by the fixed-base laboratory. In general, as TCE concentrations increased, the difference in the two results decreased and there was generally good agreement between the two sets of results, although slight differences were attributed to the differences in analytical equipment.

The comparison demonstrated the effectiveness of using hexane extraction for chlorinated solvents in soil. This method, however, does have several disadvantages: (1) the method detection limit is 1 mg/kg or 1 ppm, and (2) the hexane method masks other VOAs.

Data Validation. Data validation is a process performed for a data set by a qualified individual independent from sampling, laboratory, project management, and other decision-making personnel for the project. In the data validation process, the laboratory adherence to analytical method requirements is evaluated. Definitive data collected for this RI were validated by CDM Federal Programs according to the following procedures:

- EMEF Intersite Procedure ERWM/ER-P2209, *Radiochemical Data Verification and Validation*, Revision 0
- EMEF Intersite Procedure ERWM/ER-P2210, *Volatile and Semivolatile Data Verification and Validation*, Revision 0
- EMEF Intersite Procedure ERWM/ER-P2211, *Pesticide and PCB Data Verification and Validation*, Revision 0
- EMEF Intersite Procedure ERWM/ER-P2212, *Inorganic Data Verification and Validation*, Revision 0

As part of the data review process, findings were qualified as necessary to reflect data validation results. The following qualifiers were assigned by the data validators:

U	The material was analyzed for, but was not detected. The associated numerical value is the quantitation limit.
J	Estimated value, either because QC criteria were not met or because the amount detected is below the documented quantitation limit.
UJ	Undetected, but the number reported as the quantitation limit is an estimated value.
DJ	Duplicate control limits were exceeded, the number reported, as the quantitation limit is an estimated value.

JR Estimated value and rejected, so data are of "information only" quality and should be supplemented with additional data for decision-making.

R Rejected, so data are of "information only" quality and should be supplemented with additional data for decision-making.

= Data were validated; however, no qualifier was added.

? Data were not validated.

Data generated by Core Laboratory and LMUS C-710 Laboratory were independently validated on a frequency of 10%. Actual data records indicated that 12% (6,299 data points) of the overall analytical data were validated.

Four data packages were validated for parameters including metals, cyanide, PCBs, and SVOAs. A review of the data validation summary reports indicates that the majority of data quality parameters, including MS/MSD recovery and RPD criteria, for the validated data packages were within established method-specific limits. Some quality problems with individual samples and/or analytes were identified in each of the validated packages; however, the only trends identified were for arsenic and zinc. Arsenic failed spike recovery criteria in three of the four validated data packages, and zinc failed serial dilution criteria in three out of the four validated data packages. Arsenic is difficult to quantitate accurately using the specified methods, and spike recoveries for this analyte are often erratic. The failed serial dilutions for zinc are indicative of matrix interference. Results that were not validated for these two analytes should be cautiously assessed during the project decision-making process.

Of the overall analytical data, 4831 data points (9%) were assigned one of the above qualifiers. Only 20 individual data points were rejected. The total number of data points collected and included in these percentages was 53,205.

2.8.4 Data Management

The WAG 27 Project Environmental Measurements System (PEMS) was used to manage field-generated data; import laboratory-generated data; add data qualifiers based on data verification, validation, and assessment; and transfer data to Paducah's Oak Ridge Environmental Information System (Paducah OREIS). PEMS included a tracking system to identify, track, and monitor each sample and associated data from point of collection through final data reporting. The system included field measurements, chain-of-custody information, and a tracking system for tracking hard-copy data packages and electronic data deliverables (EDDs). PEMS also included information for field planning and data evaluation.

All data packages and EDDs received from the laboratory were tracked, reviewed, and maintained in a secure environment. When first received, data packages were assigned a document control number and then logged into a tracking system. The following information was tracked: sample delivery group numbers, date received, document control number, number of samples, sample analyses, receipt of EDDs, and comments.

The data verification processes for laboratory data were implemented for both hard-copy data and EDDs. The data packages were reviewed to confirm that all samples had been analyzed for the requested parameters. Discrepancies were reported to the laboratory and the data validators. As part of a series of internal integrity checks within PEMS, a check was run to identify which of the requested samples and analyses were not received in an EDD. The hard copy was checked to confirm that missing fractions were in fact analyzed for and that the missing fractions from the EDD had been requested from the laboratory. Integrity checks in PEMS were also used to check the list of compounds generated by the laboratory to confirm that data were provided for all requested analytes. Discrepancies were reported to the laboratory and the data validators.

Data verification within PEMS included standardization of analytical methods, chemical names and units, as well as checks for holding time violations and detections above background values.

Validated results were imported electronically from the subcontracted third party data validators into PEMS. These results included data validation qualifiers.

PEMS system requirements included backups, security, change control, and interfacing with other data management systems. PEMS was housed on the Paducah EMEF network. System backups were performed nightly following standard Paducah EMEF network protocol. Updates made to the files were copied to a computer backup tape each night, and an entire backup was performed each week.

Security of PEMS and data used for the data management effort was considered essential to success of the project. The security protocol followed by the data management team was consistent with that of the Paducah EMEF network. Access to the network is password-protected. Access to PEMS was limited, on an as-needed basis, to the data management and project team. Read-write, graded access to PEMS was limited to the data management team, which consisted of the Project Data Coordinator, the Data Entry Coordinator, the Sample Manager, and the Data Manager. Read-only access to PEMS was granted to other members of the project team, including the Technical Manager.

Sample Location and Identification Number. Each sampling location and sample collected during the WAG 27 RI was assigned a discrete identification number, which consisted of a four-part alpha/numeric sequence. For example:

720-018-WA-095

Each segment of the sequence is used to designate information concerning the location from which a sample was collected, the medium from which it was collected, the nature of the sample, and the depth from which the sample was collected. The first three-digit code is a location definition corresponding to the SWMU from which the sample was collected (or "area" in the case of the C-720 Complex). For example, "720" would indicate the C-720 Complex, and "001" would indicate SWMU 001. This code is followed by another three-digit code used to define the boring or location within the SWMU (or area) from which the sample was collected. For example, "018" would indicate the 18th boring drilled in that area. The two-letter sequence is used to indicate the nature of the sample. "N" stands for a quality control sample. An "N" followed by an "E," "A," "T," "F" or "P" means equipment rinsate, ambient, trip, field, or preservative blank, respectively. Other codes in the third field are: "WA" for water sample and "WD" for a duplicate water sample collected from a single location; "SA" for a soil, sediment, or sludge sample, and "SD" for a duplicate soil sample collected from a single location. The predetermined three-digit field is used to designate the approximate depth from which the sample was to have been collected. For example, "095" would mean the sample was to have been collected at 95 ft. In conclusion, for the example above, the sample identification code "reads": *within the area of the C-720 Building, from boring location 18, a water sample was collected at approximately 95 ft bgs.*

2.8.5 Data Assessment

A large volume of data was generated during the WAG 27 RI. With four field teams using two different drilling methods to collect samples and five laboratories involved in sample analysis, the opportunities for problems, inconsistencies, and errors were significant. To confirm that the data set could be used in the decision-making process, the RI team performed various checks and reviews during and after the fieldwork to maintain data consistency and identify problem areas. These checks and reviews included electronic verification and manual assessments by the RI team, as well as third-party validation of fixed-base laboratory data. More than 53,000 records were reviewed during the data assessment.

2.8.5.1 Field Data

Field data consist of data generated by the on-site CSL and measurements taken in the field during a sampling event. For example, measurements taken in the field during a groundwater sampling event included water temperature, specific conductivity, DO, and pH. The CSL measured concentrations of TCE and its degradation products in soil and groundwater; measured gross alpha and beta radiation in soil and groundwater; and screened soil samples for PCBs using immunoassay analytical kits.

The field data underwent weekly reviews by the Data and Sample Management Teams as a means of identifying data entry errors, missing data, and inconsistencies. The Data Manager developed numerous queries in ACCESS to provide checks of the PEMS database and identify problems. The Data Manager, Sample Manager, Data Entry technician, and Lab Manager reviewed all queries. The field team manager (FTM) and the BJC LLC technical lead also performed weekly reviews, conducted primarily as a planning tool (for contingency sampling). Based on these reviews, questions and problems were noted and submitted to the Data Manager for resolution and correction. The types of problems found included missing or incorrect sample depths, missing or incorrect data qualifiers, and mis-keyed data. An additional review was also performed, comparing data against expected conditions to assess whether the results “made sense” within the context of the investigation.

2.8.5.2 Fixed-Base Data

The fixed-base data consist of data generated by the off-site laboratories contracted for the project. These laboratories provided analyses of VOAs, SVOA, PCBs, metals, radioisotopes, and soil properties. Ten percent of the fixed-base data was submitted to a third-party subcontractor (CDM Federal Programs) for independent validation of the data quality. The validation included (but was not limited to) review of sample holding times, minimum detection limits, analytical blanks, matrix spikes, laboratory duplicates, surrogates, and instrument calibrations. When appropriate, a qualifier was added to the data. The validation subcontractor submitted a report on each data package when the package was returned to the RI team. The results of the validation were then included in the data set.

2.8.5.3 Final Review

After the last data package was received from the fixed-base laboratory and loaded into the database, a final review and assessment of all the data was completed. This effort included electronic verification, database queries targeting known problem areas, and manual assessment. For manageability, the data set was divided by SWMU or area.

The electronic verification was used to compare the data set against various reference values, specifically holding time exceedances for all analyses and background exceedances for metals and radioisotopes in soils. Data records for all samples that exceeded holding times were flagged with a "T" in the verification field. Data records for all metals and radioisotopes in soils that exceeded established background levels for the site were flagged with an "I" in the verification field.

In conjunction with electronic verification, a set of data assessment queries was developed. These queries were designed to check the internal consistency of the database and to identify all analytes detected, the concentration and distribution of the analytes detected within the volume of soil and groundwater investigated, and the samples that might have been impacted by various problems that are inevitable during the course of a major investigation. The underlying data assessment question consistently asked was "Does this number make sense and what does it mean?"

The first group of data reviewed was from the QC samples. These included equipment rinsate samples, trip blanks, refrigerator blanks, field blanks, a comparison of field duplicates, and analysis of the potable water and DI water used in drilling and decontamination. During the assessment of these samples, four problem areas were identified:

- Possible incomplete decontamination of sampling and/or analytical equipment
- Possible cross-contamination from VOAs during sample storage
- Possible impacts attributable to the potable water used during drilling
- Possible impacts attributable to site conditions

Additional queries were run to identify which environmental samples might have been affected by these problems.

Some of the equipment rinsate samples had detections of analytes that indicated incomplete decontamination of the sampling equipment and/or possible cross-contamination in the laboratory at the time of analysis. Some of the contamination was attributable to low-level detects in the DI water blank; however, some rinsate samples had detects much greater than those found in the DI system blank. These samples indicate possible contamination from the potable water during decontamination. The environmental samples collected the day after the rinsate sample was collected were identified with a collection date query. The samples that were analyzed on the same day as the rinsate sample were identified with an analysis date query. Data records for these samples were then assigned the assessment flag "BH-NE," meaning that the chemical was detected in the associated equipment rinsate and that the result may be biased high due to incomplete decontamination or cross-contamination in the laboratory. Five-hundred-nine records in the database were assigned the "BH-NE" flag.

Field blanks were collected throughout the project at each of the sites. Several field blanks had detects of analytes at concentrations above those found in the DI water. These contaminants were attributed to impacts from site conditions. Samples associated with these blanks were assigned a "BH-FB" qualifier, indicating that these values were biased-high due to contaminants introduced at the site during sampling.

Holding time exceedances were a problem, particularly due to the DOT shipping issues that arose during the project and to the analytical method for nitrate/nitrite (holding time for this method was 2 days, which could not be met). All holding time exceedances were identified during the verification process. During the assessment process, the impact of those exceedances was evaluated. Analyses for VOAs and certain metals are particularly sensitive to holding times, whereas analyses for most SVOAs, metals, and radioisotopes are less sensitive. Both the analyses to be performed and the length of the holding time exceedance were evaluated to assess the potential impact. Records for those samples judged to be significantly impacted were assigned an assessment flag of "BL-T," meaning that the result may be biased low due to holding time exceedance. A total of 185 records in the database were assigned the "BL-T" flag.

Samples collected from the DI water system indicated low-level detects of some metals and SVOAs. Because this water was used as a final rinse in all of the decontamination procedures, samples with detects of these metals and SVOAs were assigned a "BH-DI" qualifier, indicating that these values were biased high due to possible contamination from the DI water. The "BH-DI" flag was assigned to 282 records.

In assessing other questionable results, laboratory-introduced contamination was identified. These contaminants consist of chemicals that are used in sample preparation or equipment cleaning and appear frequently in sample results. Records for these chemicals were assigned an assessment flag of "BH-LAB" or "BL-LAB," indicating that the values are due to laboratory contamination and the records are to be used for information only. A total of 37 records were assigned a "BH-LAB" qualifier, and 46 were assigned a "BL-LAB" flag.

During the data assessment process, all data received from the K-25 laboratory for volatile organic analysis were flagged with a "J," or estimated quantity qualifier, due to a lack of available laboratory QA/QC records.

The "R-C" assessment flag was used to reject data that did not pass the review process. Rejected data included, for example, chemicals that have not been used on-site or results that made no sense, e. g., if the dissolved concentration of a metal in groundwater exceeded the total concentration of the metal in the same sample. If the detected dissolved concentration was greater than 10%, the dissolved metal result was considered questionable. Three-hundred-sixty-six records in the database were assigned the "R-C" flag. Only these data were excluded from use in the evaluation of contaminant nature and extent or fate and transport.

An additional assessment flag, dealing with radioisotopes, was used in the WAG 27 RI. For radiological data, "U-Rad" was used to indicate that the reported result is considered a non-detect. This flag was applied at the time the laboratory data were entered and is based on the following premise: if the result is so low that the instrument measurement error bar is greater than or equal to the reported result, the result should be considered a non-detect. A total of 383 records in the database were assigned this flag.

2.8.6 Field Quality Control Procedures

Field QC Samples. EPA, DOE, the Commonwealth of Kentucky, and PGDP procedures require that field QC samples be collected to assess data quality. The QC samples collected and analyzed included:

- equipment rinsates;
- source blanks (water supply samples);
- trip blanks;
- field blanks; and
- duplicate samples.

Equipment Rinsates. Equipment rinsates were collected at a frequency of 1 in 20 samples. Appendix H provides the data from the equipment rinsate samples. A total of 35 equipment rinsates were collected during the project.

Water Supply Sample. Source blanks of the DI water used for equipment decontamination and blanks were collected at a frequency of one sample per water supply. One water supply sample was collected during the project.

Trip Blanks. Trip blanks were collected at a frequency of one sample per cooler containing samples for VOA analysis. A total of 74 trip blanks were analyzed during the project. Appendix H provides the results of the trip blank samples. Trip blank results from the K-25 lab were incorrectly reported in mg/kg. The trip blank values will be recalculated for the appropriate matrix and resubmitted as part of the D2 WAG 27 document.

Field Blanks. Field blanks were collected at a frequency of 1 in 20 samples. Appendix H provides the data from the field blanks. A total of 35 field blanks were collected during the project.

Duplicate Samples. Split samples were collected as field duplicates and sent to the fixed-base laboratory for analysis. Duplicates were collected at a frequency of 1 per 20 samples. Twenty soil and 20 water duplicate samples were collected during the project. Appendix H provides the results of the duplicate samples.

2.9 CIVIL SURVEY

An extensive civil surveying effort was required to assure the safety of personnel working on the WAG 27 RI. For example, the exact location of the sampling point was necessary to avoid penetrating the vast network of underground utilities in WAG 27 areas. Each sampling location was surveyed and an exhaustive excavation permit process was conducted. On several occasions, the sampling point was relocated and then surveyed again. No underground utilities were penetrated during the WAG 27 RI and field activities. Upon completion of the activities associated with the sampling points, soil borings, and piezometers, a final survey of the location and elevation was conducted.

The surveying was conducted in accordance with the Paducah EMEF engineering specifications. The civil survey was performed by a registered and licensed surveyor of the Commonwealth of Kentucky.

Site locations were surveyed on the Kentucky State Plane Coordinate System and the PGDP Plane Coordinate System. Benchmarks and reference points were supplied by the BJC LLC Civil Engineering Department. Grid coordinates were measured to an accuracy of plus or minus 0.01 ft and tied to the U.S. Geological Survey (USGS) National Geodetic Vertical Datum (NGVD) of 1929 or the North American Datum of 1983. Elevations were measured to a hundredth (0.01) of a foot. Surveying field activities were documented in field logbooks for archiving. The civil survey data are included in Appendix C.

2.10 SURFACE AND BOREHOLE GEOPHYSICAL SURVEYS

2.10.1 Surface Geophysical Surveys

WAG 27 includes a network of underground utilities, and avoiding penetration of these utilities during the intrusive sampling activities was a primary concern from the beginning of the effort. Therefore, an extensive excavation permit process, which included a geophysical survey, was conducted at each sampling point prior to intrusive sampling. The geophysical surveys were conducted in those areas that previously unidentified utilities could exist and adversely affect drilling operations. Geophysical surveys were also conducted to confirm the location of utilities. These surveys were used in conjunction with utility drawings, field measurements, and interviews with employees with extensive site knowledge to help locate these utilities before invasive drilling activities were preformed.

The geophysical investigation was designed to measure the conductive, magnetic, and dielectric properties of subsurface materials in the vicinity of the intrusive sampling and the nearby utility corridors. The geophysical investigation was conducted using a Geonics G-858G Cesium Vapor Magnetometer/Gradiometer, EM-31 electromagnetic conductivity meter, and GeoRadar 1000B Stepped-FM Ground Penetrating Radar System (GR-1000B).

Typically, one or more of the geophysical instruments detected the location of an underground utility expected to be present. Each site was unique and no single instrument was adequate to confirm the presence or absence of underground utilities. Underground utilities, which are shown on the as-built drawings and were detected by the instruments, were marked on the ground with spray paint. At some locations, however, the geophysical data were inconclusive and the utilities could not be located with a high level of confidence. Examples of these sites include reinforced steel bar in concrete and underground utility lines constructed with materials such as transite, concrete, or PVC. In these instances, the problems were noted in the logbook and the underground utilities were located using the as-built drawings.

Whenever necessary, sampling points were relocated based on a review of the pertinent information, such as the as-built drawings, the utility markings on the ground from the geophysical investigation, and site appurtenances (overhead power lines, buildings, roads, etc.). Some sampling points were relocated because sampling activities could not be conducted due to plant operation activities. In most cases whenever a sampling point was relocated, the permit process–including a geophysical survey–started again at the relocated point. At some locations, however, an excavation permit existed and a geophysical survey was not required.

More than 130 boring locations were sampled during the WAG 27 RI, and no penetrations of underground utility lines occurred. Geophysical investigation activities at each sampling point were documented in field logbooks.

2.10.2 Borehole Geophysical Surveys

Borehole geophysical logging of natural gamma count and neutron porosity was conducted inside the drill string at each RGA and McNairy location and in selected monitoring wells. The logging was conducted in accordance with PGDP Procedure PTSA-3010-IAD, Geophysical Logging. The logs were used to further define the subsurface stratigraphy at WAG 27. Copies of the geophysical logs are included in Appendix D.

2.11 HEALTH AND SAFETY MONITORING

To protect the health and safety of personnel during field activities, full-time site safety professionals were assigned to observe, monitor, direct, and document each activity. In addition, a Radiation Protection Program (RPP) was implemented to assure adherence to PGDP and DOE regulations. All of the site safety professionals were trained and accredited as radiation control technicians, as required by the RPP, prior to the start of site monitoring activities.

Two major categories of monitoring were performed, as discussed below. Monitoring included continuous observation of the work site for safety hazards, biological hazards, and the parameters listed in Table 2.9 using real-time instruments.

2.11.1 Work Area Monitoring

Several of the drilling and sampling locations for the WAG 27 RI were within the boundaries of known areas of surface radiation contamination. Before field activities began, an initial site radiation survey was performed covering a 60- x 60-ft area around the point of sampling or drilling. This area was scanned with the ESP-2 and Vic450P. The surveys were conducted in accordance with the CH2M HILL RPP screening procedures. Data were recorded on Form RP-301.1, "Special Purpose/Routine Radiological Survey Results." The purpose of the survey was to assure that the members of the sampling crew and the equipment were properly protected and to assure that surface contamination, if present, was properly managed.

All radiation abnormalities were reported immediately to the EMEF Health Physics Department and the project construction engineer.

Once the site had been thoroughly scanned for radiation and proper actions had been taken to protect workers from site hazards, equipment was moved in and work zones (with barriers) were established. These zones included an outer construction zone and an inner exclusion zone. The exclusion zone was a strictly controlled area. Every person or item that passed into this zone was considered contaminated and could not be removed until fully scanned for radiation. This was accomplished by discrete measurements with the Ludlum 2224 and smear counting using the Ludlum 2929. Site safety professionals were trained on proper operation of the equipment and guidelines used for releasing equipment and personnel from the zones in accordance with the CH2M HILL RPP.

Once the ground surface was broken at a work site, air was continuously monitored with direct read instruments until field activities were completed. Tools and equipment in direct contact with soil were presumed to be contaminated until they were measured and were therefore smeared before they were cleared. If levels were above the release limits, the material was bagged and properly tagged. The bagged material was then surveyed again to confirm that levels were below the release limits. The material was then moved to a designated area until it could be properly decontaminated. Instrument readings were recorded in the field geologist logbook. Typically, readings were recorded from soil cuttings created during the drilling operations, air space monitoring at the drilling location, smears and direct measurements, and readings that met or exceeded the project action levels specified in the Health and Safety Plan (HASP).

Work area monitoring was also performed to prevent overexposure to temperature extremes. On-site ambient temperature was measured and discussed on a daily basis. Cold and heat stress monitoring of personnel was conducted in the work area by a site safety professional. This monitoring included close scrutiny of personnel behavior, obvious signs of overexertion, and heart rates of exposed personnel. Heart rate checks were performed periodically during each exposure period.

Excessive noise was surveyed at each source of elevated noise. These included drill rigs, pressure washing equipment, generators, and other items equipped with combustion engines. Sound level monitoring data were recorded on a Sound Level Survey Form. Sound level surveys were performed with a Quest Model 2700 sound level meter at each source of elevated noise. Working conditions in the vicinity of this equipment were checked at regular intervals to confirm that the site was properly delineated with hearing conservation signs and to reassess the use of proper PPE. Hearing protection was required at any levels equal to or above 85 decibels.

2.11.2 Employee Biological Monitoring

All personnel who were required to enter a zone of potential contamination were required to participate in the BJC LLC Biological Monitoring Program (BMP). As part of this program, personnel wore thermo-luminescent dosimeter (TLD) badges to track possible radiation exposure; in addition; monthly urinalysis was conducted to document radiological ion uptake. The 29 CFR 1910.120 requirements were used for training and biological monitoring of WAG 27 field employees, including a physical examination consisting of blood analysis, audiometric testing, respiratory testing, and cardiopulmonary testing.

Upon arrival at the project site and before any participation in site work, employees were issued a TLD by BJC LLC Health Physics Department personnel and each person provided a urine sample to establish a baseline. The TLDs were exchanged and analyzed on a quarterly basis. The internal dose evaluation was performed each month and at the end of project participation. Also, all project employees were required to submit to a drug screen before participation in field activities.

2.12 DECONTAMINATION PRACTICES

All heavy equipment, drill rigs, and other large drilling-related equipment such as drill rods, casing, liners, and bits were steam-cleaned on the C-752-C Decontamination Pad. Decontamination of drilling-related equipment was conducted in accordance with PGDP EMEF Procedure PTSA-5001-IAD, Decontamination of Drilling-Related Equipment.

The drilling equipment was thoroughly steam cleaned and rinsed, then allowed to air dry. After decontamination, the drill rods and flights were wrapped in plastic and placed on the drill rig prior to transport back to the site. The wastewater generated during the decontamination process was allowed to collect in a sump before being pumped into a 3,000-gal holding tank located at the decontamination (decon) pad. The decon pad was operated in accordance with Paducah EMEF Procedure PTSA-5003, Operation of the C-752-C Decontamination Pad.

The sampling equipment, including all stainless-steel field sampling equipment such as spatulas, spoons, knives, and bowls, was decontaminated in accordance with Paducah EMEF Procedure PTSA-5002-IAD, Decontamination of Field Equipment. The decontamination process occurred in the following order:

- steam cleaned,
- rinsed with potable water,

- washed and scrubbed with phosphate-free detergent and water,
- rinsed with clean tap water,
- rinsed with DI water,
- double-rinsed with isopropanol,
- rinsed with nitric acid (10%),
- rinsed with DI water,
- air-dried; and
- wrapped in aluminum foil or plastic.

2.13 WASTE HANDLING PRACTICES

The following Paducah EMEF waste management procedures were used during the RI:

- CP4-ER-SAM4601, Drum and Special Container Staging and Sampling
- CP4-ER-SAM4602, Manual Drum Opening, which was replaced with PTWM-5501-IAD, Opening Containerized Waste
- CP4-ER-WM2001, Handling of Investigation-Derived Waste, which was replaced with PMWM-1002-IAD, On-Site Handling and Disposal of Waste Materials

A variety of potentially contaminated and non-contaminated wastes were generated during the RI activities. All wastes generated as a result of field-related investigative activities had the potential to contain contaminants related to past practices. These investigative techniques resulted in the generation of investigation-derived waste (IDW) that required proper containers, storage, and disposal.

2.13.1 Soil Cuttings and Drilling Mud

Shallow soil borings drilled via DPT generated subsurface soil cuttings, all of which were placed in appropriately labeled drums and managed according to applicable regulations and PGDP procedures.

RGA/McNairy borings drilled via dual wall reverse circulation generated a mixture of soil cuttings and drilling water. This mixture was collected in 1000-gal mobile tanks and transported to the C-752-C Building for separation. The mixture was separated into solids and liquids using one or more of the following methods: natural gravity settling of solids, separation by the addition of various polymers to aid flocculation, and physical separation via centrifuge. The solids (soils) were placed in appropriately labeled drums and sufficient quantities of absorbent media were added to prevent future separation of liquids from the solids. The drummed soil cuttings are scheduled to be characterized and disposed of in the PGDP landfill before the end of FY99. The liquids (water) were transferred to decontamination rinsate storage for proper disposal.

Many of the borings were drilled on concrete pads where the surface of the concrete was contaminated with radioactivity. For these borings, the concrete was cored and the plug of concrete was placed into appropriately labeled drums and managed according to applicable regulations and PGDP procedures.

A total of 730 drums of soil were generated during the WAG 27 RI.

2.13.2 Well Development, Drilling Water, Decontamination Rinsate, and Purge Water

Water generated from monitoring well development, purging, and sampling was placed into 1000-gal mobile tanks and evaluated against field screening data. If the water was found to be acceptable, it was transferred to the decontamination rinsate storage area for proper disposal.

Decontamination rinsate was generated from the cleaning of drilling and sampling equipment. Water from decontamination activities was collected in sumps located at the C-752-C Decontamination Pad. Some solids (soils) separated and were left in the sump for subsequent transfer to appropriately labeled drums. Water collected during other activities, such as well drilling, development, or purging, was mixed with the decontamination rinsate. The collected water was treated for total suspended solids, if necessary, using one or more of the following methods: natural gravity settling of solids, separation by the addition of various polymers to aid flocculation, and physical separation via centrifuge.

Wastewater, mixed with solvents, generated from the decontamination of laboratory equipment was collected in 55-gal drums, temporarily stored at the CSL, and then sampled for characterization.

In general, water generated from this project, except water generated at the laboratory, was transferred to a dedicated stationary tank (approximately 3000-gal capacity). When the tank was near capacity, a water sample was collected and analyzed for PCBs. PCBs were not detected in most of the samples and this non PCB-bearing water was transferred to a large water tank (approximately 20,000-gal capacity). Once this tank was near capacity, a set of water samples was collected and analyzed for the list of analytes required by the KPDES Outfall Permit. When the results were approved by the PGDP Waste Management Coordinator, the water was transported to the KPDES 001 Outfall for discharge. Water containing PCB detectable limits was transferred to PGDP Waste Management for disposal.

A total of 56,000 gallons of wastewater were generated and disposed of during the WAG 27 RI.

2.13.3 Personal Protective Equipment and Dirty Plastic

Modified Level D was the highest level of PPE worn, as required by the WAG 27 RI HASP. Before exiting an exclusion zone, personnel doffed and containerized all disposable PPE. This PPE was considered the same waste classification as the materials with which it had come into contact. Dirty plastic also was generated during the activities. During mobilization from the sampling sites and during the decontamination process, plastic was collected and placed in labeled containers. The dirty plastic was also considered the same waste classification as the materials with which it had come into contact.

In accordance with field screening information and laboratory results, PPE and dirty plastic determined to be contaminated was placed into appropriately labeled drums and managed according to applicable regulations and PGDP protocol. PPE and dirty plastic determined to be non-contaminated were placed into appropriately labeled bags and transferred into a roll-off container. Seven drums of contaminated PPE and 1 roll-off container of clean PPE were generated during the WAG 27 RI. Non-contaminated PPE was disposed of at the PGDP landfill.

2.13.4 CSL Wastes

Used sample containers (glass and plastic), PPE, soil, and wastewater were generated at the CSL. The PPE and soil from the CSL were combined with PPE and soil generated during the drilling activities. Used glass and used plastic containers were separated and managed as contaminated material. Wastewater generated at the CSL was collected and managed as RCRA waste. The wastewater was temporarily stored at a satellite accumulation area (SAA) set up at one of the CSLs.

Three drums of used glass containers, 5 drums of used plastic containers, and 2 drums of RCRA wastewater were generated at the CSL during the WAG 27 RI. This waste was moved to the appropriate hazardous waste long-term storage area.

2.13.5 Non-contaminated IDW

PGDP has implemented waste management activities for the segregation of all clean trash (i.e., trash that is not chemically or radiologically contaminated), such as office paper, aluminum cans, glass bottles not used to store potentially hazardous chemicals, aluminum foil, and food items. During this RI, all clean trash was segregated according to PGDP guidelines and then collected and placed into a dumpster located at the C-755 area for subsequent delivery to an off-site landfill as sanitary waste. Approval for off-site disposal of clean trash was granted by the Off-Site Waste Release (OSWR) Board prior to waste generation.

2.13.6 IDW Forms

Request for Disposal (RFD) forms and Waste Item Container log sheets were completed as the waste was generated at the work site. PGDP supplied RFD forms as needed. Completed forms were delivered to the PGDP EMEF Waste Disposal Coordinator for approval. The Waste Item Container log sheets, which are used to document each addition of waste to a particular container, were completed for each applicable waste container that was removed from the work site.

2.13.7 IDW Labeling

IDW containers were carefully labeled or marked to assure proper management of the wastes as outlined in PGDP EMEF Procedure CP4-ER-WM2001, Handling of Investigation-Derived Wastes.

2.13.8 IDW Storage

Generator Storage Areas (GSAs) and SAAs were established as necessary. The GSAs and SAAs were set up, inspected, and maintained in accordance with PGDP Procedure PMWM-1002.

Once the waste was accepted by the PGDP EMEF Waste Disposal Coordinator, the drums were transported to the C-752-A Building and the C-746-H3 Environmental Restoration Waste Storage Pads. These areas were available for the storage of non-hazardous waste, with no storage time limitation. The C-746-H3 storage pad was also available for the storage of hazardous waste for less than 90 days.

2.13.9 Types of Containers

Solid waste was containerized in 55-gal drums with a minimum rating of DOT 1A2/X 400/S or approved equals that were lined with a minimum 12-mil-thick plastic liner and absorbent pad. Liquid IDW was transported in 1000-gal mobile tanks and was transferred into 1000-gal portable tanks, 1500- or 3000-gal stationary tanks, or the large 20,000-gal tanks located at C-752-C.

2.13.10 IDW Characterization, Sampling, and Analysis

Unless wastes had been previously characterized using process knowledge, wastes generated from sites designated as potentially contaminated were sampled and analyzed to characterize and classify them for proper laboratory handling, record keeping, transfer, storage, and disposal. Waste analyses were performed using EPA-approved procedures as applicable. Analysis required for hazardous waste classification was performed in accordance with EPA SW-846 (1986). Wastewater analysis was performed in accordance with Clean Water Act (CWA) and/or Safe Drinking Water Act (SDWA) procedures.

2.14 DOCUMENTATION

Field documentation was maintained throughout the RI in various types of documents and formats, including field logbooks, field change requests, and lithologic logs.

Field team personnel used bound field logbooks with sequentially numbered pages to maintain field records and to document information pertinent to field activities. Information in the field logbooks obtained from site exploration, observation, and sampling activities was recorded by a designated field team member. Field documentation was in accordance with LMES guidance as detailed in the Paducah EMEF Procedure PMSA-1201-IAD, Site and Field Logbooks. Logbooks were maintained by the following to document each day's field activities:

- Field Task Manager
- Site Safety Coordinator
- Sample Coordinator
- Data Coordinator
- Waste Coordinator
- QA/QC Manager
- Field Geologists
- Laboratory Manager
- Close Support Radiological Laboratory
- Close Support Gas Chromatography Laboratory

Table 2.1. Paducah EMEF program procedures

Procedure No.	Procedure Title
PMSA–1201-IAD	Site and Field Logbooks
PTSA-1203	Lithologic Logging
PTSA-4201	Surface Soil Sampling
PTSA-4202	Subsurface Soil Sampling
PTSA-4301-IAD	Water Level Measurements (Wells)
PTSA-4302-IAD	Monitoring Well Purging
PTER-2010	Groundwater Monitoring Sampling
PTSA-4305-IAD	Filter Pack and Screen Selection for Wells and Piezometers
PTSA-4306-IAD	Monitoring Well Installation
PTSA-4308-IAD	Monitoring Well Development
PTSA-4501	Field Measurement of Water Temperature
PTSA-4502-IAD	Field Measurement: pH
PTSA-4503-IAD	Field Measurement: Dissolved Oxygen
PTSA-4506-IAD	Field Measurement: Specific Conductance
PTSA-4508	Field Gas Chromatography
PTWM-5500	Sampling Containerized Waste
PTWM-5501-IAD	Opening Containerized Waste
PMWM-1002-IAD	On-Site Handling and Disposal of Waste Materials
PMSA-2002	Sample Chain of Custody
PMSA-1102	Sample Tracking, Laboratory Coordination and Sample Handling Guidance
PTSA-5001-IAD	Decontamination of Drilling-Related Equipment
PTSA-5002-IAD	Decontamination of Field Equipment

Table 2. 2 Number of sample types by SWMU or area

	Soil					Groundwater		
	Trench/ Sludge	Sediment	Surface	Subsurface	RGA	UCRS	RGA	McNairy
SWMU 001	5	7		195	27	1	87	17
SWMU 091		4					17	4
SWMU 196	7	2	13	78				
C-720	1			122	1	5	83	24

Table 2.3 Samples with inadequate or no purging or collected by bailer

Sample ID	Analytical	Type
001173WA050	Full Range	Grab Sample
001181WA055	VOA/radscreen Alk/Ions Rad	Grab Sample
001181WA070	VOAscreen only	Grab Sample
001184WA140	Alk/Ions VOA/radscreen Rad	Bailer
001178WA140	VOA screen/radscreen	Grab Sample
001184WA120	Alk/Ions VOA/radscreen	Bailer
001182WA140	same as above	Bailer
720002WA015	VOA/radscreen	Bailer
720003WA015	VOA/radscreen	Bailer
720012WA070	Full range	Grab Sample
720013WA065	VOAscreen	Bailer
720022WA015	VOA/radscreen	Bailer
720024WA015	VOA/radscreen	Bailer
720029WA085	VOA/radscreen	Grab Sample

Notes:

- Grab samples were collected using a pump
- These samples were not submitted for metals analysis
- Sample ID explanation is contained in Sect. 2.8.4
- Full Range equals VOAs, Rad, Metals, and alkalinity/ions analyses

Table 2.4 Piezometer water level information

PIEZOMETER WATER LEVEL DATA FOR WAG 27 – 6/13/98							
PIEZOMETER /BORING	TIME	STATIC (FT)	TOC ELEV.	WATER ELEV.	MEASURE POINT	STICKUP (FT)	TOTAL DEPTH (FT)
PZ-1/720-012	1025	49.39	276.70	327.31	N-SIDE	3.0	82.25
PZ-2/720-013	1043	44.3	372.32	328.02	"	FLUSH	81.57
PZ-3/720-015	1038	45.86	373.71	327.85	"	"	80.76
PZ-4/720-017	1035	46.63	374.52	327.89	"	"	82.34
PZ-5/720-019	1020	45.22	373.96	328.74	"	"	83.14

Table 2.5 CSL analyses

Analysis	Parameters	Prep. Method (Matrix)	Analytical Method
VOA	TCE and TCE degradation products	SW-846 5030A (water)	Modified SW-846 8010
VOA	TCE and TCE degradation products	Direct Inject(hexane and soil gas)	Modified SW-846 8010
PCB	PCB	Immunoassay (soil)	SW-846 Method 4020

Table 2.6 Analytical methods and sample requirements for CSL screening samples

Parameter	Matrix	Holding time	Detection Limit	Container	Preservative
VOA	Water	14 days	4 µg/L	Two 40-mL amber glass vials with Teflon™-lined lids	Cool to 4°C
	Solid	14 days	1 mg/kg	One 40-mL glass vial with Teflon™-lined lids	Cool to 4°C, 5-mL D. I. water, 5-mL hexane
Gross alpha and gross beta	Water	6 months	10 pCi/L alpha 20 pCi/L beta	One 1-L plastic	Nitric pH<2
	Solid	6 months	12 pCi/g alpha 22 pCi/g beta	4-oz. widemouth glass jar with Teflon™-lined lid	None
Wipe samples (gross alpha and beta)	Wipe Media	6 months	< 1 cpm	One wipe per sample	None

Notes:
µg/L = micrograms per liter
mg/kg = milligrams per kilogram
pCi/L = picoCuries per liter
cpm = counts per minute

Table 2.7 Analytical methods, preservation, and container type for all samples analyzed by the fixed-base laboratories

Analysis	Analytical Method	Container Type	Preservative
Soil			
TCL metals	6010A 7060 7471 7740	8-oz widemouth glass	None
Cyanide	9010	8-oz widemouth glass	None
PCBs	8080	4-oz widemouth glass	4°C
Radiological	EPA 908.1 EPA 901.1 HASL-300 9310	16-oz widemouth glass	None
TCL SVOA	3550/8270	4-oz widemouth glass	4°C
TCL VOA	8240	Acetate sleeve or 2-oz widemouth glass	4°C
Groundwater			
Major ion analysis	EPA 310.2 EPA 300	1-L plastic	None
TCL metals/ uranium	KPA, uranium 6010 7060 7130 7420 7470 7740 7840	(2) 1-L Plastic One bottle filtered and one unfiltered	Nitric pH<2
PCBs	8080	2-L amber	4°C
Radiological	IN 7015 IN 70150 RL 7100	1 500-mL 2 125-mL plastic 1-L plastic	Nitric pH<2
TCL SVOA	3510/8270	2-L amber	4°C
TCL VOA	8260	3 40-mL vial	HCl pH< 2, 4°C

Note:
KPA = kinetic phosphorescence analyzer

2.8 Average spike recovery and duplicate relative percent difference (RPD) for the CSLs

Parameter	Water		Soil	
VOA	**Spike Recovery %**	**RPD %**	**Spike Recovery %**	**RPD %**
Vinyl chloride	102.4	ID	84.1	ID
1,1-dichloroethene	106.1	ID	104.0	ID
cis-1,2-dichloroethene	106.4	ID	101.1	ID
trans-1,2-dichloroethene	107.3	2.9	96.3	6.7
TCE	102.9	10.8	99.4	6.4
RAD				
Gross alpha	107.1	27.5*	NP	25.9
Gross beta	106.9	14.1	NP	18.1

ID=Insufficient Data: No duplicate results above the quantitation limit were reported for these parameters.
NP=Not Performed: Soil spikes for alpha and beta were not performed at the CSL due to health and safety concerns.
*Although this average is somewhat higher than the benchmark of 20% RPD for water matrices, in 93% of the cases the calculated counting errors overlapped, indicating equivalent results.

Table 2.9 Health and safety parameters monitored using real-time instruments

Parameter	Instrument
Airborne Organics	Organic Vapor Monitor—Photoionization Detector 11.8 eV
	Organic Vapor Analyzer—Flame Ionization Detector
	Colorimetric Tubes—Draeger Accuro 2000 Bellows Pump with Tubes for Benzene and Vinyl Chloride
Particulate	Aerosol Monitor—Miniram Personal Monitor PDM-3
Combustible Gas Indicators (CGI) and Oxygen Content	O_2/LEL Meter—MSA Model 360
Radioactivity	Eberline Model ESP-2 with SPA-8 Scintillation Probe
	Ludlum Model 3 with 44-9 GM Pancake and 43-5 Scintillation Detector
	Ludlum Model 2224 Scaler Instrument with 43-89 Scintillation Detector
	Ludlum Model 2221 Scaler Instrument with 2" NaI Detector
	Ludlum Model 2929 Counter Instrument with 43-10-1 Detector
	TLD
	Vic450P Dose Rate Meter
Noise	Sound Level Meter – Quest 2700 with Octave Band Analyzer

3. PHYSICAL CHARACTERISTICS OF WASTE AREA GROUPING 27

The on-site physical characteristics of PGDP have been detailed in previous investigations by Clausen et al. (1992b), CH2M HILL (1992), CDM Federal Programs (1992), and EDGe (1989). Miller and Douthitt (1993), TCT-St. Louis (1991), EDGe (1989), and Wehran (1981) have addressed the off-site physical characteristics. For this report, previous investigations of the geology and hydrogeology were used to describe the regional physical characteristics of western Kentucky and summarize the physical characteristic data compiled for the PGDP area during the WAG 27 RI.

3.1 REGIONAL TOPOGRAPHY AND SURFACE WATER

PGDP lies in the Jackson Purchase Region of western Kentucky between the Tennessee and Mississippi Rivers, bounded on the north by the Ohio River. The confluence of the Ohio and Mississippi Rivers is approximately 20 miles downstream (southwest) from the site. The confluence of the Ohio and Tennessee Rivers is approximately 15 miles upstream (east) from the site. The western Kentucky region has gently rolling terrain between 330 and 500 ft above mean sea level (amsl). Tributaries of the Ohio, Tennessee, and Mississippi Rivers dissect the region.

The average pool elevation of the Ohio River is 290 ft amsl, and the high water elevation is 342 ft amsl (TCT-St. Louis 1991). Approximately 100 small lakes and ponds exist on DOE property (TCT-St. Louis 1991). Seven settling basins and 17 gravel pits are also located within the boundary. A wetland area covering 165 acres exists immediately south of the confluence of Bayou Creek and Little Bayou Creek (TCT-St. Louis 1991).

All creeks that drain the site flow northward toward the Ohio River. Specific details of regional hydrology are presented in Sect 3.7.

Local elevations range from 290 ft amsl along the Ohio River to 450 ft amsl in the southwestern portion of PGDP near Bethel Church Road. Generally, the topography in the PGDP area slopes toward the Ohio River at an approximate gradient of 27 ft per mile (CH2M HILL 1992). Within the 960 acres of the plant boundaries, ground surface elevations vary from 360 to 390 ft amsl. Primary land uses at PGDP include industry and wildlife management; secondary uses include agriculture and fishing.

3.2 METEOROLOGY

Information presented herein regarding the climate at PGDP was derived from *Results of the Site Investigation, Phase II* (CH2M HILL 1992). The region in which PGDP is located has a humid-continental climate characterized by extremes of both temperature and precipitation. Table 3.1 presents a summary of the average monthly precipitation, temperature, potential evapotranspiration, estimated actual evapotranspiration, and infiltration and surface runoff for the region between 1969 and 1989, based on data generated at Barkley Field Airport, located southeast of PGDP. The 20-year average monthly precipitation is 4.19 in., varying from an average of 2.99 in. in January to an average of 5.16 in. in April. From March through July and during November and December, the weather is generally wetter than average. From August through October and during January and February, the weather is generally drier than average. The 20-year average monthly temperature is 57.1°F, varying from 29.9°F in January to 79.0°F in July.

Estimated actual and potential evapotranspiration rates are equal in all months except June, July, August, and September. For these 4 months, estimated actual evapotranspiration is a function of the available soil moisture and is less than potential evapotranspiration. Maximum potential and maximum estimated actual evapotranspiration rates occur in July. From June through October, precipitation either dissipates through evapotranspiration or replenishes the depleted soil moisture. During this time, water from precipitation is generally not available for infiltration, groundwater recharge either does not occur or is very limited, and little of the precipitation that falls within the stream drainage basins runs off and is available for stream flow.

From November through May, evapotranspiration is less, and water is available for infiltration and runoff. Most groundwater recharge and stream flooding occur during this part of the year, and contaminant migration in these two media would be increased during this time. The average annual amount of precipitation available for infiltration and runoff in the PGDP area is estimated to be 21.04 in. Both regional and PGDP groundwater investigations indicate that approximately 4.7 in. of rainfall per year infiltrates into the groundwater system.

Information on wind direction and speed was obtained from Barkley Field Airport. Figure 3.1 illustrates the wind rose for the average annual wind speed and direction. The average prevailing wind has a speed of 9.8 mph and blows from directions varying from south to southwest. Generally, stronger winds are recorded when the winds are from the southwest.

3.3 SOIL

The general soil map for Ballard and McCracken Counties indicates that three soil associations are present within the vicinity of PGDP (USDA 1976): the Rosebloom-Wheeling-Dubbs association, the Grenada-Calloway association, and the Calloway-Henry association. The predominant soil association in the vicinity of PGDP is the Calloway-Henry association, which consists of nearly level, somewhat poorly drained to poorly drained, medium-textured soils on upland positions. Several other soil groups also occur in the region in limited areas, including the Grenada, Falaya-Collins, Waverly, Vicksburg, and Loring.

The Henry and Calloway soil series are classified as fragiaqualfs and fragiudalfs, respectively. The fragipan subsurface horizon within these soils is a dense silty or loamy layer, which may be cemented by non-crystalline material. This diagnostic subsurface horizon greatly reduces the vertical movement of water in the soil and is typically responsible for causing seasonal high water tables in these soils. The lateral continuity and integrity of this layer may have been reduced due to construction activities (CH2M HILL 1991). The soil over the majority of PGDP is the Henry silt loam with a transition to Calloway, Falaya-Collins, and Vicksburg away from the site.

The soils in the vicinity of PGDP tend to have a low buffering capacity, with a pH ranging from 4.5 to 5.5. Low pH values are often associated with high cation exchange capacities, so these factors may alter the mobility of soil contaminants (particularly metals) (Birge et al. 1990). The cation exchange capacities measured during the recently completed WAG 6 RI range from 8.92 to 69.8 milliequivalents per liter (CH2M HILL 1998).

Although the soil over most of PGDP may be have been Henry silt loam with a transition to Calloway, Falaya-Collins, and Vicksburg away from the site, many of the characteristics of the original soil have been lost due to industrial activity which has occurred over the past 45 years. Activities that have disrupted the original soil classifications include filling, mixing, and grading.

3.4 POPULATION AND LAND USE

The West Kentucky Wildlife Management Area (WKWMA) and sparsely populated agricultural lands surround PGDP. The closest communities to the plant are Heath, Grahamville, and Kevil, all of which are located within 5 miles of DOE reservation boundaries. The closest municipalities are Paducah, Kentucky, located 15 miles east of the facility; Cape Girardeau, Missouri, which is approximately 40 miles west of the plant; and the cities of Metropolis and Joppa, Illinois, which are located across the Ohio River from PGDP.

Historically, the economy of western Kentucky has been based on agriculture, although there has been increased industrial development in recent years. PGDP employs approximately 2500 people and the TVA Shawnee Steam Plant employs 500 people (Oakes et al. 1987). Total population within a 50-mile radius of PGDP is approximately 500,000; approximately 50,000 people live within 10 miles of the plant. The population of McCracken County is approximately 62,879 (Verbal communication, Paducah Chamber of Commerce, Dec. 7, 1998).

In addition to the residential population surrounding the plant, WKWMA draws thousands of visitors each year for recreational purposes. Visitors use the area primarily for hunting and fishing; other activities include horseback riding, hiking, sanctioned field trials for hunting dogs, and bird watching. According to WKWMA management, an estimated 5000 anglers visit the area each year.

3.5 ECOLOGY

The following sections give a brief overview of the terrestrial and aquatic systems at PGDP. A more detailed description, including an identification and discussion of sensitive habitats and threatened/endangered species, is contained in the *Investigation of Sensitive Ecological Resources Inside the Paducah Gaseous Diffusion Plant* (CDM 1994) and *Environmental Investigations at the Paducah Gaseous Diffusion Plant and Surrounding Area, McCracken County, Kentucky* [U. S. Army Corps of Engineers (COE) 1994].

3.5.1 Terrestrial Systems

The terrestrial component of the PGDP ecosystem includes the plants and animals that use the upland habitats for food, reproduction, and protection. The communities range from an oak and hickory forest in areas that have been undisturbed to managed fencerows and agricultural lands in the more developed areas. The main crops present in the PGDP area include soybean, corn, tobacco, and various grain crops such as millet.

Old field grasslands constitute approximately 2000 acres of the WKWMA. Much of this herbaceous community is dominated by members of the *Compositae* family and various grasses. Woody species, such as red maple, are also occasionally present. Some of this area includes remnant prairie, as indicated by the presence of eastern gama and Indian grasses. The shrub community represents a more diverse habitat, including both herbaceous and woody species. Within WKWMA, approximately 800 acres consists of scrub-shrub habitat. Dominant trees include cherry, persimmon, sumac, young hickory, and three species of oak, as well as scattered growths of sweetgum and hackberry. Forest and shrub tracts alternate with fencerows and transitional edge habitats along roads and power transmission-line corridors. Elm, locust, oak, and maple, with an understory of sumac, honeysuckle, blackberry, poison ivy, and grape, dominate fencerow communities. Herbaceous growth in these areas includes clover, plantain, and numerous grasses.

Mice, rabbits, and a variety of other small mammals frequent open herbaceous areas. Birds identified in the area include red-winged blackbirds, quail, sparrows, and predators such as hawks and owls. In transitional areas, including fencerows, low shrub, and young forests, a variety of wildlife is present, including opossum, vole, mole, raccoon, and deer. Birds typically found in the transitional areas include red-winged blackbirds, shrikes, mourning doves, quail, turkeys, cardinals, and meadowlarks. Several groups of coyotes also reside in areas around PGDP. In addition to the larger mammals, mature forests contain squirrels, songbirds, and great horned owls. Muskrat and beaver are found in the aquatic habitats of the PGDP area. Many species of waterfowl also use these areas, including wood ducks, geese, herons, and various other migratory birds. Various reptiles, amphibians, and terrestrial invertebrates (e.g., insects and spiders) are present in all areas. Domestic livestock is abundant in surrounding farmlands.

3.5.2 Aquatic Systems

The aquatic communities in and around the PGDP area that could be impacted by plant discharges include two perennial streams, Bayou Creek and Little Bayou Creek; the North-South Diversion Ditch; a marsh located at the confluence of Bayou Creek and Little Bayou Creek; and other smaller drainage areas. The dominant taxa in the surface water include several species of sunfish, especially bluegill and green sunfish, as well as bass and catfish. Bluegills, green and longear sunfish, and stonerollers dominate shallow streams, characteristic of the two area creeks.

3.5.3 Wetlands and Floodplains

Wetlands were identified during the 1994 COE environmental investigation of 11,719 acres surrounding PGDP. In this investigation, 1083 separate wetland areas were identified and grouped into 16 vegetation cover types (COE 1994). Wetlands inside the plant security fence are confined to portions of drainage ditches traversing the site (CDM 1994). Functions and values of these areas as wetlands are low to moderate (Jacobs 1995); these areas provide some groundwater recharge, floodwater retention, and sediment/toxicant retention. While the opportunity for these functions and values is high, the effectiveness is low due to water exiting the area quickly via the drainage system. Other functions and values (e.g., wildlife benefits, recreation) are very low.

At PGDP, three bodies of water cause most area flooding: the Ohio River, Bayou Creek, and Little Bayou Creek. A floodplain analysis performed by the COE (1994) indicated that much of the built-up portions of the plant lie outside the 100- and 500-year floodplains of these streams. In addition, this analysis indicated that ditches within the plant area can contain the expected 100- and 500-year discharges.

3.6 REGIONAL GEOLOGY

3.6.1 Regional Geologic Setting.

PGDP is located in the Jackson Purchase Region of western Kentucky, which represents the northern tip of the Mississippi Embayment portion of the Coastal Plain Province (Fig. 3.2). The Jackson Purchase Region is an area of land that includes all of Kentucky west of the Tennessee River. The stratigraphic sequence in the region consists of Cretaceous, Tertiary, and Quaternary sediments unconformably overlying Paleozoic bedrock. A lithostratigraphic column of the Jackson Purchase Region is shown in Fig. 3.3.

Within the Jackson Purchase Region, strata deposited above the Precambrian basement rock attain a maximum thickness of 12,000 to 15,000 ft. Exposed strata in the region range in age from Devonian to Holocene. The Devonian stratum crops out along the western shore of Kentucky Lake. Mississippian carbonates form the nearest outcrop of bedrock and are exposed approximately 9 miles northwest of PGDP in southern Illinois (Clausen et al. 1992a). The Coastal Plain deposits unconformably overlie Mississippian carbonate bedrock and consist of the following: the Tuscaloosa Formation, the sand and clays of the Clayton/McNairy Formations, the Porters Creek Clay, and the Eocene sand and clay deposits (undivided Jackson, Claiborne, and Wilcox Formations). Continental deposits uncomformably overlie the Coastal Plain deposits, which are in turn covered by surface loess and/or alluvium. The following is a discussion of the strata.

Bedrock. The entire PGDP area is underlain by Mississippian carbonates. The bedrock consists of dark gray limestone with some interbedded chert and shale. Regionally the Mississippi strata dips to the south. Bedrock was not encountered during the WAG 27 RI.

Rubble Zone. The rubble zone consists of angular to subangular chert and silicified limestone fragments (Olive 1980). In the Late Eocene, before deposition of the Upper Cretaceous sediments, a long period of weathering occurred. During this time, erosion removed strata of the Upper Mississippian System (bedrock) and the Pennsylvanian System. Remnants of this weathering form the rubble zone. The rubble zone was not encountered during the WAG 27 RI.

McNairy Formation. In the Late Cretaceous, a sea encroached northward, leading to deposition of the McNairy Formation (Clausen et al. 1992b). In the southeastern part of the Jackson Purchase Region, the McNairy Formation consists of mostly sand. Farther north, including PGDP, the McNairy Formation consists of light gray to dark gray clay with lenses of fine to coarse sand that weathers to moderate yellow to reddish-brown. It is interbedded with varying amounts of gravel and dark gray silt. The middle portion of the McNairy is tentatively correlated to the Levings Member of Illinois. It is described as a lignitic silt in Illinois but as a series of silty, clayey, sands extending from 135 to 270 ft bgs in Kentucky. It serves as an aquitard in the middle of the McNairy Formation, separating the upper and lower units.

The Clayton Formation is Paleocene in age but is difficult to differentiate from the underlying McNairy Formation. The two formations are discussed as one geologic unit (the McNairy Formation) in this report because of the lithologic similarity and uncertainty associated with placement of the contact.

Porters Creek Clay, Porters Creek Terrace, and Eocene Sands. The Porters Creek Clay consists of dark gray to black clay with varying amounts of silt and fine-grained, micaceous, glauconitic sand. This is indicative of marine and brackish-water sediments deposited in a sea that occupied most of the Mississippi Embayment (Olive 1980). Eocene sediments consisting of interbedded and interlensing sand, silt, and clay overlie the Porters Creek Clay in the southern portion of the DOE property. Abrupt change from fine-grained deposition of the Porters Creek Clay to coarser-grained sedimentation during the Eocene probably resulted from regional uplift.

Post-Eocene erosion into the Paleocene Porters Creek Clay resulted in an important feature known as the Porters Creek Terrace. It lies immediately south, southeast, and southwest of PGDP and its slope extends northward toward the southern boundary of the PGDP fenced security area. Regionally, the Porters Creek Terrace is hydrogeologically important because it marks the southern extent of the Lower Continental Deposits (LCD) and therefore the southern extent of the RGA. It also serves as the aquitard below the RGA where the RGA laps onto the terrace slope. The Porters Creek Clay, Porters Creek Terrace, and Eocene Sands are not present in the WAG 27 area and thus were not encountered during the RI.

Continental Deposits. Pleistocene Continental Deposits unconformably overlie the Cretaceous through Eocene strata throughout the area. Ancestral rivers bordered the Jackson Purchase Region in approximately the same position as the present Tennessee, Ohio, and Mississippi Rivers (Olive 1980). Increased flow in the ancestral Tennessee River, combined with large sediment loads, resulted in the formation of an alluvial fan in the area of the confluence of the Ohio and Tennessee Rivers (Olive 1980). The Continental Deposits resemble a large low-gradient alluvial fan that covered much of the region and eventually buried the erosional topography.

Erosion and reworking of alluvial fan deposits have resulted in the present thickness and distribution of the Continental Deposits. The thicker sequences of Continental Deposits represent valley fill deposits and can be informally divided into a lower unit (gravel facies) and an upper unit (clay facies). The two distinct facies are as follows:

- Lower Continental Deposits (LCD). The LCD are found throughout the plant area and to the north, but pinch out to the south, southeast, and southwest along the slope of the Porters Creek Terrace. The LCD are gravel facies consisting of chert gravel in a matrix of poorly sorted sand and silt that rest on an erosional surface representing the beginning of the valley fill sequence. The LCD were deposited on an irregular east-west trending erosional surface exhibiting steps or terraces. Alluvial terraces are former floodplains corresponding to different glacial events. The gravel deposit averages approximately 30 ft thick, but some thicker deposits (as much as 50 ft) exist in deeper scour channels.

- Upper Continental Deposits (UCD). The UCD is primarily a fine-grained, clastic facies varying in thickness from 15 to 55 ft that consists of clayey silt with lenses of sand and occasional gravel. The UCD represent sediments deposited in a fluvial and lacustrine environment (Finch 1967; Frye et al. 1972). Widespread lacustrine sedimentation occurred along the present Ohio River and Tennessee River valleys when they became choked from draining glaciated areas. The sediment dammed valleys of tributaries, creating slackwater lakes that resulted in deposition of fine-grained sediments of the UCD. Depending on stages of glaciation, periods of lacustrine deposition were followed by periods of erosion. As aggradation of the fluvial system continued, stream gradients in the ancestral Tennessee River and tributaries lessened. Lower gradients favored a transition from a braided environment to a meandering environment. A very gravelly lower sequence becoming sandier upwards identifies the transition in the subsurface.

Surface Soil/Loess/Fill. The surface deposits found in the vicinity of PGDP are Pleistocene to Recent in age and consist of loess and alluvium. Both units are composed of clayey silt or silty clay and range in color from yellowish-brown to brownish-gray or tan, making field differentiation difficult.

The loess (wind-blown) deposits overlie the UCD throughout the PGDP area. Only the most recent (Illinoisan- and Wisconsinan-aged) deposits are represented in the sedimentary sequence.

As discussed in Sect. 3.3, the predominant soil association in the vicinity of PGDP is the Calloway-Henry association (USDA 1976). The fragipan subsurface horizon within this soil is a densified silty or loamy layer, which may be cemented by amorphous material. Excavation and construction activities at PGDP during the past 45 years have reduced the continuity of the fragipan layer and increased vertical drainage throughout the plant area (CH2M HILL 1992).

3.7 REGIONAL HYDROGEOLOGY

3.7.1 Regional Surface Water

Information presented herein regarding the surface-water setting at PGDP was derived from *Results of the Site Investigation, Phase II* (CH2M HILL 1992). PGDP is located in the western portion of the Ohio River basin. The plant is within the drainage areas of Bayou Creek and Little Bayou Creek and is situated on the divide between the two creeks (Fig. 3.4).

Bayou Creek is a perennial stream with drainage area of approximately 18.6 square miles that flows generally northward from approximately 2.5 miles south of the plant site to the Ohio River and extends along the western boundary of the plant. Little Bayou Creek, also a perennial stream, originates within the WKWMA, flows northward to the Ohio River, and extends along the eastern boundary of the plant. The approximate drainage area of Little Bayou Creek is 8.5 square miles (CH2M HILL 1992). The confluence of the two creeks is approximately 3 miles north of the plant site, just upstream of the location at which the creeks discharge into the Ohio River. The drainage areas for both creeks are generally rural; however, they receive surface drainage from numerous swales that drain residential and commercial properties, including the WKWMA, PGDP, and the TVA Shawnee Steam Plant. A major portion of the flow in both creeks north of PGDP is effluent water from the plant, discharged through KPDES-permitted outfalls. Deer Lick, Snake Creek, and Slough Creek drain the northwestern portion of the PGDP boundary.

Discharge flow, specific conductivity, and temperature measurements were recorded at 74 main channel sites and 7 tributary sites of Bayou Creek and Little Bayou Creek on August 15 and 16, 1989. Discharge for Bayou Creek during this time varied from 0.30 cubic feet per second (ft^3/s) at the farthest upstream site to 5.8 ft^3/s at the farthest downstream site. Tributary inflow along Bayou Creek was measured to be 5.7 ft^3/s. Discharge for Little Bayou Creek varied from 0.65ft^3/s at the farthest upstream site to 1.8 ft^3/s at the farthest downstream site. Total tributary inflow along Little Bayou Creek was 0.38 ft^3/s. Specific conductivity values recorded in Bayou Creek ranged from 208 to 489 microSiemens per centimeter ($\mu S/cm$) and water temperature ranged between 20.0°C and 32.6°C.

Specific conductivity values recorded in Little Bayou Creek ranged between 211 and 272 µS/cm, and water temperature ranged between 14.5°C and 24.9°C. Both Bayou Creek and Little Bayou Creek appear to lose stream volume to shallow groundwater south of PGDP but gain stream volume from shallow groundwater north of the plant (CH2M HILL 1992).

The U.S. Geological Survey (USGS) maintains gauging stations on Bayou Creek 4.1 and 7.3 miles from the Ohio River and a station on Little Bayou Creek 2.2 miles upstream from its confluence with Bayou Creek. The mean monthly discharge at Bayou Creek varies from 6.53 to 60.7 ft^3/s at the downstream station and 6.53 to 60.7 ft^3/s at the upstream station. The mean monthly discharge on Little Bayou Creek ranges from 0.89 to 33.5 ft^3/s.

Man-made drainages receive stormwater and effluent from PGDP. The plant monitors 17 outfalls, which have a combined average daily flow of approximately 4.9 million gallons per day (Mgd) (Clausen et al. 1992b). Drainage ditches bound parts of SWMUs 001 and 091. Water flow in these ditches is intermittent based on seasonal rainfall. The plant ditches are generally considered to be located in areas where the local groundwater table is below the bottoms of the ditch channels. Therefore, the ditches probably function as influent (losing) streams most of the time, resulting in some discharge to the subsurface.

Surface-water bodies in the vicinity of PGDP include the Ohio River, Metropolis Lake (located east of the Shawnee Steam Plant), and several small ponds, clay and gravel pits, and settling basins scattered throughout the area. There is a marshy area just south of the confluence of Bayou Creek and Little Bayou Creek. The smaller surface-water bodies are expected to have only localized effects on the regional groundwater flow pattern.

3.7.2 Regional Groundwater

The Jackson Purchase Region is characterized by several hundred feet of unconsolidated Cretaceous through Holocene sediments deposited on an erosionally truncated Paleozoic surface. The flow system in the vicinity of PGDP exists primarily within unconsolidated sediments. Information presented herein regarding the groundwater setting at PGDP was derived from the *Report of the Paducah Gaseous Diffusion Plant, Groundwater Investigation Phase III* (Clausen et al. 1992b). The regional hydrogeology discussion is intended to provide a general overview of the groundwater flow regime for PGDP.

The regional groundwater flow system occurs within the Mississippian Bedrock, Cretaceous McNairy Formation, Eocene Sands, Pliocene Terrace Gravel, Pleistocene LCD, and UCD. Terms used to describe the hydrogeologic flow system are the McNairy Flow System, Eocene Sands, Pliocene Terrace Gravel, the RGA, and the UCRS. Specific components have been identified for the regional groundwater flow system and are defined in the following paragraphs.

Paleozoic Bedrock Aquifer. Limestone, believed to be the Mississippian-aged Warsaw Limestone, subcrops beneath PGDP. Groundwater production from the bedrock aquifers comes from fissures and fractures and from the weathered rubble zone near the top of the bedrock. The bedrock aquifer was not encountered during the WAG 27 RI.

McNairy Flow System. Formerly termed the "deep groundwater system," this component consists of the interbedded and interlensing sand, silt, and clay of the Cretaceous McNairy Formation.

Regionally, the sand in the McNairy Formation is an excellent aquifer in the southeastern part of the Jackson Purchase Region. The McNairy Formation grades from mostly sand in those areas to containing significant amounts of silt and clay near PGDP (Clausen et al. 1992a). Regionally, the McNairy recharges along areas of outcrop in the eastern part of the region, near Kentucky Lake and Lake Barkley (Davis et al. 1973). Water movement is north and northwest toward discharge areas in Missouri and along the Ohio River.

The McNairy Formation subcrops beneath the plant at depths ranging from approximately 70 to 100 ft. Sand facies account for 40 to 50% of the total formation thickness of approximately 225 ft. In areas where the RGA overlies the McNairy Flow System and where the RGA is in direct hydraulic connection with coarser-grained sediments of the McNairy Formation, the McNairy flow is coincident with that of the RGA.

Davis et al. (1973) reported values of hydraulic conductivity for the McNairy Flow System ranging from 1.4×10^{-8} to 4.7×10^{-2} centimeters per second (cm/s). During the WAG 6 RI, values of hydraulic conductivity were measured from 8.2×10^{-8} to 1.1×10^{-3} cm/s (CH2M HILL 1998). The range of 5 orders of magnitude difference is due to depositional heterogeneity between the sand and clay of the McNairy Formation.

Pliocene Terrace Gravel and Eocene Sands. Pliocene-aged gravel deposits and Eocene-aged reworked sand and gravel overlie the Paleocene Porters Creek Clay in the southern portion of PGDP. However, in the south and west portions of the plant site, which includes the WAG 27 area, the units do not exist and thus were not encountered during the RI.

Regional Gravel Aquifer. The RGA consists of the gravel facies of the LCD. The RGA is the most prominent gravel facies beneath PGDP and is the primary local aquifer. The RGA consists of a Pleistocene gravel deposit overlying an erosional surface. The RGA is found throughout the plant area and to the north, but pinches out to the south, southeast, and southwest along the slope of the Porters Creek Terrace. Regionally, the RGA includes the Holocene-aged alluvium found adjacent to the Ohio River.

The RGA is the dominant aquifer within the local flow system. Figure 3.5 shows the hydraulic gradient within the flow system (Davis et al. 1973). Differences in permeability and aquifer thickness affect the hydraulic gradient, which is reflected in the spacing of the potentiometric contours on Fig. 3.5. Toward the southern part of PGDP, the RGA terminates against the Porters Creek Terrace. The restriction results in a high gradient and probably causes groundwater discharge to adjoining streams. In the north-central portion of the plant site, the lower gradients are a result of the thickened Pleistocene sequence containing higher fractions of coarse sand and gravel. Northward, near the Ohio River, the hydraulic gradient increases as a result of either a thinner section of RGA or low-permeability bottom sediments in the Ohio River.

Regional groundwater flow within the RGA trends north-northeast toward base level represented by the Ohio River. The hydraulic gradient varies spatially but is on the order of 1×10^{-4} to 1×10^{-3} ft/ft (Clausen et al. 1992b). Clausen et al. (1992b) report hydraulic conductivities for the RGA ranging from 10^{-4} to 1 cm/s. During the WAG 6 RI, values of hydraulic conductivity were measured from 1.8×10^{-7} to 9.4 cm/s (CH2M HILL 1998). The range of 8 orders of magnitude is due to depositional heterogeneities within the silt, sand, and gravel of the RGA.

Upper Continental Recharge System. The UCRS consists of the surface alluvium and UCD. The UCRS consists of clayey silt with lenses of sand and occasional gravel. PGDP hydrogeologists have differentiated the UCRS into 3 general horizons:

- Hydrologic Unit 1 (HU1) - an upper silt and clay interval,
- HU2 - an intervening sand and gravel interval, and
- HU3 - a lower silt and clay interval.

These horizons are highly subjective, but there are clear features that stand out throughout the plant area. "UCRS" generally refers to the sand and gravel lithofacies of the HU2. The HU2 appears relatively discontinuous in cross section but may be more connected in three dimensions. The HU2 permeable units are only seasonally saturated and may be considered perched groundwater rather than a regional aquifer. The UCRS groundwater flows downward into the RGA, hence the term "recharge system." Because it is defined as a recharge system, the UCRS not only includes the more permeable units in the HU2, but also the silty clay of the HU3 that confine the uppermost water-saturated units.

Regionally, the UCRS thickness ranges from 0 ft to 50 ft. In a study by Clausen et al. (1992a) UCRS hydraulic conductivity values ranged from 10^{-8} to 10^{-2} cm/s. During the WAG 6 RI, values of hydraulic conductivity ranged from 3.2 to 1.7 × 10^{-8} cm/s (CH2M HILL 1998). The range of 8 orders of magnitude is due to depositional heterogeneities within the sand, gravel, silt, and clay of the UCRS.

3.8 WAG 27 SURFACE FEATURES, GEOLOGY, AND HYDROGEOLOGY

The focus of the WAG 27 RI was the geologic strata ranging in age from Cretaceous to Holocene or recent. Borings advanced during WAG 27 ranged in depths from 1 to 157 ft bgs. Figure 3.6 depicts WAG 27 RI sample locations. Boring logs are located in Appendix A.

Seventy-seven soil borings (001-101 through 001-144; 001-151 through 001-169; and 001-171 through 001-184) were drilled at SWMU 001 during the WAG 27 RI fieldwork. Seven of these borings are located peripheral to the SWMU 001 site boundaries: (001-181) located to the east; (001-175; 001-178; and 001-182) located inside the security fence to the west of SWMU 001 boundaries; and (001-180; 001-183; and 001-184) located west of the security fence and east of Bayou Creek. Total boring depths ranged from 10 ft to 157 ft bgs. Surface sediment was collected from seven locations (001-145 through 001-150; 001-170).

At SWMU 091, two borings were drilled into the upper McNairy Formation to depths of 138 ft and 148 ft bgs. Four sediment samples were collected from site perimeter ditches. Fourteen shallow soil borings and one CPT were completed during the RI at SWMU 196. Most boring logs penetrated the subsurface to either 10 or 20 ft. However, one CPT log (196-012) that was conducted to 35.4 ft bgs was also used to determine the geology in the subsurface at SWMU 196.

Twenty-nine soil borings (720-001 through 720-024 and 720-026 through 720-030) were completed around the C-720 Complex during WAG 27 RI. With the exception of boring 720-028, all borings are located within 300 ft of the building. Boring 720-028 is located approximately 500 ft east of the C-720 Building. Boring depths ranged from 28.2 ft to 156 ft.

Six existing monitoring wells were geophysically logged using gamma and neutron tools. Each of the borings penetrating the RGA/McNairy were also logged (Appendix D).

The geology at WAG 27 has been characterized based on information from soil and characterization borings, monitoring wells, and information from previous studies.

3.8.1 WAG 27 Surface Features

The plant is drained by Bayou Creek, Little Bayou Creek, their tributaries, and man-made drainage ditches that flow into these two creeks. Most of the WAG 27 investigation area, including SWMUs 001 and 091 and the C-720 Complex, is drained by ditches that discharge to several KPDES outfalls and Bayou Creek west of the plant. Drainage ditches at SWMU 196 eventually drain into both Bayou Creek and the North-South Diversion Ditch.

SWMU 001 (C-747-C Oil Landfarm), a relatively flat, open, and grass covered area, is located in the west-central part of PGDP. The surface topography at SWMU 001 ranges from approximately 365 to 375 ft amsl. West trending drainage ditches are present on the north and south sides of SWMU 001, and a south trending drainage ditch is present on the west. Surface water at SWMU 001 drains to one of these perimeter ditches, with ultimate discharge to Bayou Creek, which is located approximately 300 ft west of the unit.

The ground surface at SWMU 091 is relatively flat and ranges from 371 ft amsl near the drop test pad to 367 ft amsl in the ditch to the south. Most of the ground surface is covered with a gravel road base up to 4 feet thick. The concrete and steel pad used during the drop tests covers an area of about 10-ft x 10-ft. Runoff from SWMU 091 predominantly flows into the ditch immediately south of the drop test area and discharges via KPDES Outfall 15 to Bayou Creek, which is located approximately 1500 ft to the west.

SWMU 196 is located in the north-central portion of the PGDP, on the north side of the C-746-A Building. The site is relatively flat, with ground elevations ranging from 368 to 371 ft amsl. The surface is covered with gravel over a majority of the area. A north-south drainage ditch collects surface runoff from the western part of the SWMU.

The C-720 Complex is located in the southwestern part of PGDP. The surface topography at this site ranges from approximately 371 to 376 ft. Drainage of the C-720 Complex is via the PGDP storm drain system. Most of the area surrounding the C-720 Building is paved with concrete or asphalt.

3.8.2 WAG 27 Geology

The units observed during WAG 27 sampling activities consisted of unconsolidated strata at depths above 157 ft bgs. Deeper units such as the Paleozoic bedrock or "rubble zone" were not encountered during WAG 27. The sites investigated during WAG 27 are located north of where the Porters Creek Clay and the Eocene Sands subcrop. Figure 3.7 depicts the regional stratigraphy for the PGDP area. The scope of the WAG 27 RI focused on the surface soil/loess/fill, the Continental Deposits, and the McNairy Formation. Generalized lithologic descriptions of each unit are described below. Figure 3.8 represents an area cross section developed from the information gathered during the WAG 27 RI. Cross sections for SWMUs 001, 091, and the C-720 Complex are depicted in Fig. 3.9, 3.10, and 3.11, respectively. Two perpendicular geologic cross sections of the northwest portion of SWMU 196 are shown in Fig. 3.12 and 3.13, while a cross section of the northeast area of SWMU 196 is depicted in Fig. 3.14.

The changes in subsurface lithologies were primarily determined based on borehole geophysical surveys (electric logs) supplemented by the geologist's boring logs.

McNairy Formation. The Upper Cretaceous McNairy Formation is the oldest unit investigated during the WAG 27 RI. The McNairy Formation subcrops beneath the WAG 27 area at depths ranging from 90 to 112 ft bgs. The elevation of the top of the McNairy Formation ranges between 259 ft amsl at SWMU 001 to 282.9 ft amsl at the C-720 Complex.

Twenty-one borings were advanced to characterize the upper 50-ft section of the McNairy Formation in the WAG 27 area: 11 borings at the C-720 Complex, 8 at SWMU 001, and 2 at SWMU 091. McNairy borings were advanced to identify the Levings Member of the McNairy Formation, which was typically encountered 40 to 50 ft below the Continental Deposits. The Levings Member consists of dry, stiff, light gray to gray micaceous silty clay in the WAG 27 area. The Levings Member was not observed in all McNairy borings. These borings were terminated approximately 50 ft into the upper McNairy or where analytical results were below screening levels. The Levings Member was encountered at depths of 145 ft bgs at the C-720 Building and 152 ft bgs at SWMU 001.

As previously noted, the elevation of the upper McNairy Formation gradually increases from SWMU 001 (boring 001-175) in a generally southeasterly direction toward the C-720 Complex. Elevations of the top of the McNairy were observed highest on the west side of the C-720 Complex. Local elevation differences at the top of the McNairy are probably due to differential erosion caused by streams that flowed over this unconformable surface during Pleistocene glacial episodes (Clausen 1992a).

The dominant lithology of the McNairy Formation in the WAG 27 area is a dark gray to bluish gray, micaceous, often pyritic or lignitic clay with interbedded variegated silt and fine- to medium-grained sand. At SWMU 001, occasional lenses of fine-grained silty sand or gravel were observed. In several borings in the WAG 27 area, the sand content in the McNairy increases with depth. At other locations, a silty sand facies of the McNairy was encountered immediately below the Continental Deposits.

Lower Continental Deposits. Twenty-six borings were advanced to characterize the Pleistocene LCD: 13 borings at the C-720 Complex, 11 at SWMU 001, and 2 at SWMU 091. The Pleistocene LCD is a prominent fluvial gravel facies beneath PGDP. These coarser-grained sediments unconformably overlie the finer-grained Cretaceous McNairy Formation. As shown in the cross sections (Fig. 3.8 to 3.11), the base of the LCD is a Pleistocene erosional surface. The top of this erosional surface is higher to the east of the C-720 Complex. The LCD is distinguished from the overlying UCD by grain size.

The dominant lithology of the LCD is poorly sorted, brownish yellow, yellowish brown, and strong brown chert gravel with occasional sand and silt at various intervals. Above the gravel facies, a fine -to medium- grained pale yellow to brownish yellow silty sand was present over most of the WAG 27 area. This sand unit is encountered immediately above the coarse-grained gravel of the LCD at many locations in the WAG 27 area and, where present, is considered to be part of the LCD. This sand, encountered at a depth of 45 bgs beneath SWMU 001, is approximately 10 to 15 ft thick and pinches out toward the southeast. The sand facies was observed at 50 to 60 ft beneath C-720 and varied in thickness from 5 to 15 ft. Immediately east and south of the C-720 Building, this sand unit thins and becomes siltier. At SWMU 091, this sand was observed to be approximately 10 ft thick.

Since the contact separating the UCD from the LCD is gradational at some locations, the greater thickness of the sand may be indicative of this gradational contact.

The elevation of the top of the gravel facies ranged from 316.5 ft amsl. at SWMU 001 to 293.5 ft amsl south of the C-720 Building. LCD thickness varied significantly among sites in the WAG 27 area. At SWMU 001, the LCD were observed to be between 65 to 70 ft thick. At SWMU 091, the LCD was 38 to 47 ft thick. The sand unit that directly overlies the LCD gravel is typically present in the C-720 Complex, with the greatest thickness occurring north of the C-720 Building. The LCD thickness ranges from approximately 45 ft north of the C-720 Building to 30 ft south of the building. Thinning of the LCD towards the south of the WAG 27 area is related to the proximity of the Porters Creek Terrace.

Upper Continental Deposits. The UCD consist primarily of finer-grained valley fill deposits that are differentiated from the underlying LCD by grain size. The UCD represent a fining-upward sequence of interbedded clay, silt, sand, and gravel. As shown in the cross sections (Fig. 3.8 to 3.14), the layers of clay, silt, sand, and gravel grade laterally into adjacent units throughout the UCD. UCD underlie the loess and range in thickness from 30 to 60 ft.

Eighty-four borings were drilled into or through the UCD during the WAG 27 field work. During the drilling of soil borings, the initial unit encountered was sediments of the HU1. These sediments consist of silty clay to clayey silt and were present to a depth of 15 to 17.5 ft bgs. The HU1 overlies the HU2 in the WAG 27 area. The HU2 consist of poorly sorted, dark yellowish brown to yellow brown silty sand and gravels that are interbedded silt and clay. These coarser-grained sediments are prevalent between 10 and 40 ft bgs and range in thickness from 1 to 10 ft. These units can be laterally continuous; however, this is not typical. At SWMU 001, discontinuous sand and gravel units are more common at depths of 15 to 40 ft bgs. The first sand and gravel unit is approximately 5 ft thick and occurs at 20 ft bgs. The second is encountered approximately 30 to 35 ft bgs. These two units, plus the intervening sandy clay, form the HU2 hydrogeologic unit at SWMU 001. The distinguishable lenses of sand and gravel typically occur in the 25- to 40-ft bgs range at the C-720 Complex, but are observed in several borings at 15 to 25 ft bgs.

Clay and silt percentages increase below the HU2, with minor occurrences of lenticular sand and gravels. The silts and clays from 25 to 50 ft bgs are considered part of the HU3 confining layer, but occurrences of sand and gravel at these depths in some borings indicate that the HU2/HU3 contact is gradational. Where the HU3 confining unit is clearly defined, it consists of yellowish brown and grayish brown silty clay with minor sand content. Generally, the HU2/HU3 contact is better defined at the C-720 Complex than at SWMU 001, where the sand and gravel content is less significant at levels below 30 ft bgs.

Surface Soil/Loess/Fill. Loess deposits overlie the UCD throughout the WAG 27 area. Loess was present in all borings from the surface to a depth of 15 to 20 ft, except in developed areas outside of SWMU 001 where fill was observed to a depth up to 5 ft. The loess consists of predominantly clayey silt and silty clay, with occasional traces of fine sand and gravel. It is difficult to distinguish the loess from the lacustrine deposits of the UCD.

Most of the fill observed in the WAG 27 area consists of sandy or clayey gravel and occurs to a maximum of 5 ft bgs, but typically only 0.5 to 1.0 ft bgs. Varying thickness (0.2 to 3 ft) of sandy gravel and gravely sand fill are distributed along the northern and western perimeter of Building C-746-A (SWMU 196). Boring locations 196-003 and 196-012 lack this fill.

3.8.3 WAG 27 Hydrogeology

Hydrogeologically, the scope of the WAG 27 RI focused on the McNairy Flow System, RGA, and UCRS. Other regional aquifers in the WAG 27 area were not encountered during the RI.

McNairy Flow System. The dominant lithology of the upper McNairy Formation in the WAG 27 area is clay. Laboratory geotechnical analysis from the WAG 6 RI indicates an average hydraulic conductivity of the McNairy Flow System of 2.9×10^{-4} cm/s (CH2M HILL 1998). Comparison of the hydraulic conductivity measurements taken from nearby SWMUs at the PGDP (Fig. 3.15) shows that the clay lithology of the McNairy is much less permeable than the coarser sediments of the RGA. McNairy Formation sands occur immediately below the RGA at several locations east of the C-720 Building, promoting potential downward flow of groundwater. Since contaminant concentrations are negligible in the McNairy at these locations and the sands below the RGA are of limited extent, substantial downward flow of groundwater does not occur. Groundwater flow in the McNairy is considered coincident with the RGA, where McNairy sands immediately underlie the RGA.

Regional Gravel Aquifer. The major pathway of groundwater flow at WAG 27 Complex is within the RGA, which dominates the flow regime. The RGA is the primary regional aquifer in the investigation area. In the WAG 6 RI, values of hydraulic conductivity were measured from 1.8×10^{-7} to more than 50 cm/s (CH2M HILL 1998). As illustrated in Fig. 3.15, the average hydraulic conductivity measured in the RGA is greater than those of the overlying and underlying sediments. The range of eight orders of magnitude is due to depositional heterogeneities within the sand and gravel of the RGA.

In the WAG 27 investigation area, sand constitutes up to 30% of RGA lithology and appears in discontinuous lenses at various intervals. The sands may impede groundwater flow and were observed to be more prevalent at SWMUs 001 and 091 than at the C-720 Complex.

The potentiometric surface of the RGA at SWMU 001 and 091 is shown on Fig. 3.16 based on water levels collected in January 1998 (Appendix B). Piezometer data in the C-720 Complex suggest that the groundwater flow in the RGA is primarily to the north-northwest, aided by an elevation decrease of the confining clay layer below the RGA in a northwest trend from C-720 to SWMU 001. The C-720 hydraulic gradient is measured to average 1.0×10^{-3} ft/ft, according to the potentiometric study during this RI at the C-720 Complex (see Fig. 3.17). The mapping at the C-720 Complex was based on four of five piezometer data points that were collected during the RI. Data from PZ-001 (720-012) were not used to construct the map, as the water level in this well was significantly lower than expected and contrary to the well-defined gradient in the RGA at the PGDP. This discrepancy may be due to placement of the screen in this well across a tight silty sand zone, as opposed to the more porous gravels that are typically screened in the RGA. The potentiometric surface below the SWMU 001 and SWMU 091 area is flatter, with hydraulic gradients of less than 2.0×10^{-4} ft/ft. Flow is primarily toward the northwest, but high conductivity intervals associated with ancestral fluvial deposits in the RGA at SWMUs 001 and 091 indicate a westerly flow component that may contribute to the hydraulic gradients.

The RGA is recharged by infiltration from the UCRS and underflow from the terrace gravels south of the WAG 27 area. Hydrograghs of RGA water levels show a decline in water levels during the summer and fall months, due to decreased precipitation and subsequent infiltration and runoff during these months. Water level data are presented in Appendix B.

Upper Continental Recharge System. "UCRS" generally refers to the sand and gravel of the HU2 and the silty and sandy clay of the HU3 aquitard. Groundwater flow in the UCRS in the WAG 27 area is predominantly vertical and provides the majority of RGA recharge. Strong vertical gradients occur between the UCRS and RGA based on hydraulic head difference of as much as 30 ft between MW-162 and MW-161, which are screened in the UCRS and RGA, respectively. Although some horizontal flow is apparent from transmissive zones in the UCRS, downward vertical flow is also demonstrated in head differences between the UCRS and RGA (MW-203 and -204). A strong southeasterly flow component has also been described using colloidal borescope measurements from MW–162 (DOE 1996a), but these data are of very localized nature and may not accurately represent the actual groundwater flow direction in the UCRS.

Horizontal flow in the UCRS may be more significant at the C-720 Complex, where the HU3 exhibits less coarse-grained sediments than at SWMU 001 and SWMU 091. One water sample was obtained from the UCRS at SWMU 001 and five water samples were obtained at the C-720 Complex. The water samples collected from the C-720 Complex were obtained from between 3 and 33 ft bgs. A water main leak immediately east of boring 720-012 could have been the source of shallow water encountered in the UCRS south of C-720. The UCRS at all other locations did not contain sufficient water during drilling to allow a sample to be collected and is essentially dry.

A 3- to 5-ft-thick interval of sandy gravel, the HU2, underlies the HU1 clays at SWMU 091. When this layer is saturated, hydraulic conductivity values range from 3.7×10^{-6} to 3.97×10^{-5} cm/sec and storage coefficients range from 7.43×10^{-3} to 5.9×10^{-2}. This sand and gravel unit overlies the silty clay to clay HU3. Together, the units between 0 and 48 ft bgs (091-002) to 59 feet bgs (091-001) constitute the UCRS at SWMU 091. The lower clay unit serves as an aquitard. Perched groundwater has been measured to 6 ft bgs. Although the UCRS consists of numerous horizontally oriented sand and gravel lenses in the clayey silt matrix; the groundwater flow direction is primarily downward. Water levels collected from the UCRS (MW-160) measured 9.25 ft below top of casing in January 1998.

Clausen et al. (1996) demonstrate a correlation between Ohio River water levels and those measured in the UCRS and RGA. Head differences between the RGA and UCRS (approximately 30 ft at SWMU 091 indicate a primarily downward gradient from the UCRS to the RGA. Colloidal borescope measurements taken in MW-160 during the WAG 6 Industrial Hydrogeologic Study (DOE 1996a) suggest a horizontal flow component ranging from southwest to southeast at the time of the measurements. Water level measurements from these wells support these findings. Depth to water in the two RGA wells (MW-158 and -159) were consistent at 49.88 and 50.11 ft below top of casing. The flow therefore appears to be predominantly downward with a small horizontal component. A detailed discussion of the hydrogeology at SWMU 091, in particular the sandy gravel generally between 18 and 26 ft bgs, is given by Clausen et al. (1996).

Little is known about the site-specific hydrogeology of SWMU 196. Six Geoprobe soil samplers were penetrated to a depth of 15-ft bgs around a nearby underground storage tank, SWMU 139. The next closest soil borings are 400 ft west and 700 ft northeast: the P4G12 and P4F8 borings from the Phase IV investigation, respectively. The closest monitoring wells are MW-257 and MW-261, which are RGA wells 500 ft west of the SWMU, and MW-173 and -174, which are RGA and UCRS wells 700 ft north of the SWMU. In general, the hydrogeology should be similar to those of SWMUs 001 and 091, with UCRS sands and gravels approximately 30 ft bgs and RGA sands and gravels approximately 55 ft bgs. The CPT point was completed to determine the presence of water in the UCRS. No water was encountered in this boring.

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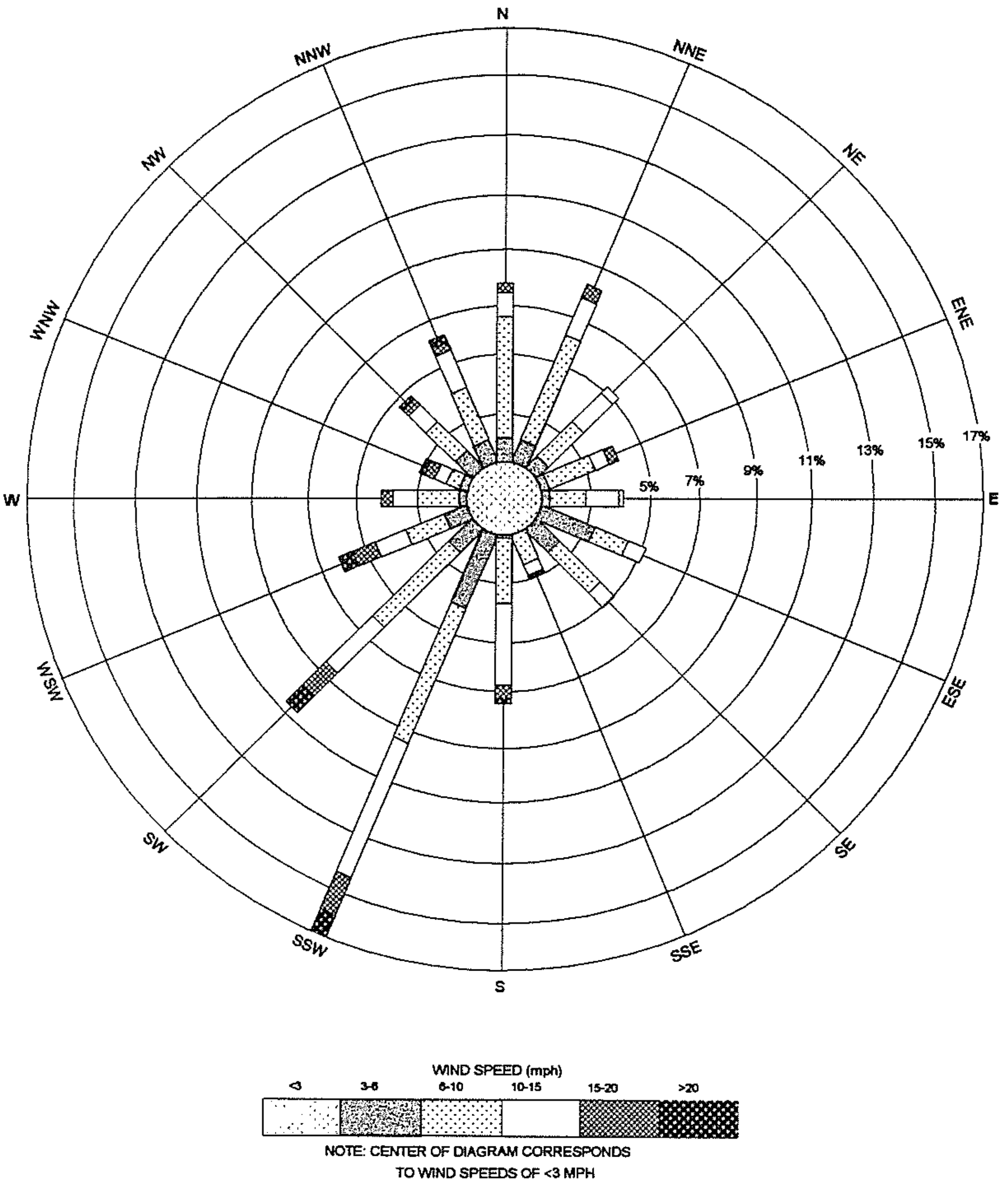


SOURCE: National Oceanic and Atmospheric Administration, Barkley Field, 1987.
"Wind Rose Diagram." Communication from PGDP.

Fig. 3.1 Wind rose diagram.

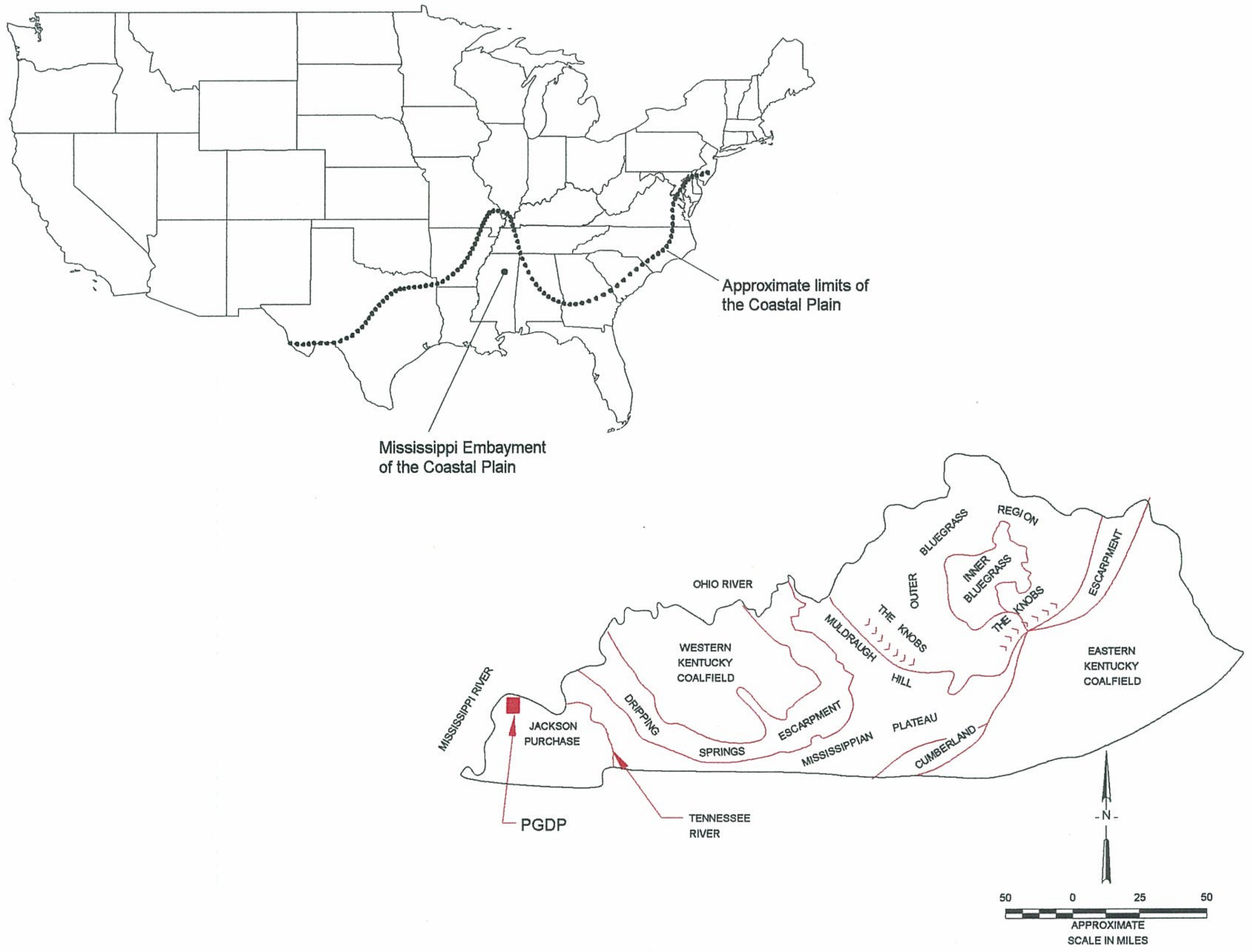


fig3-4.wor - 7/8/98

Fig. 3.2. Physiographic province map for PGDP.

SYSTEM	SERIES	FORMATION	THICKNESS IN FEET	DESCRIPTION	HYDROGEOLOGIC SYSTEMS
Quaternary	Pleistocene and Recent	Alluvium	0-40	Brown or gray sand and silty clay or clayey silt with streaks of sand	Upper Continental Recharge System (UCRS)
	Pleistocene	Loess		Brown or yellowish-brown to tan to gray unstratified silty clay	
	Pleistocene	Continental Deposits	3-121	Upper Continental Deposits (clay Facies) Orange to yellowish-brown to brown clayey silt, some very fine sand, trace of fine sand to gravel. Often micaceous.	
Tertiary	Pliocene(?)			Lower Continental Deposits (Gravel Facies) Reddish-brown silty and sandy gravel, silt and clay.	Regional Gravel Aquifer
	Eocene	Eocene Sands (Undiff)	0-100	Red brown, or white fine to coarse grained sand. Beds of white to dark gray clay are distributed at random.	McNairy Flow System
				White to gray sandy clay, clay conglomerate and boulders, scattered clay lenses and lenses of coarse red sand. Black to dark gray lignitic clay, silt, or fine grained sand.	
	Paleocene	Porters Creek Clay	0-200	Dark gray, slightly to very micaceous clay. Fine grained clayey sand, commonly glauconitic in the upper part. Glauconitic sand and clay at the base. A Gravel layer ("Terrace Gravel") present atop the clay terrace, 2-8 feet thick	
Cretaceous		Clayton and McNairy Formations	200-300	Grayish white to dark micaceous clay, often silty, interbedded with light gray to yellowish-brown very fine to medium grained sand. The upper part is mostly clay, the lower part is predominantly micaceous fine sand.	
		Tuscaloosa Formation	?	White, well rounded or broken chert gravel with clay.	
Mississippian		Mississippian Carbonates	500+	Dark gray limestone and interbedded chert, some shale.	

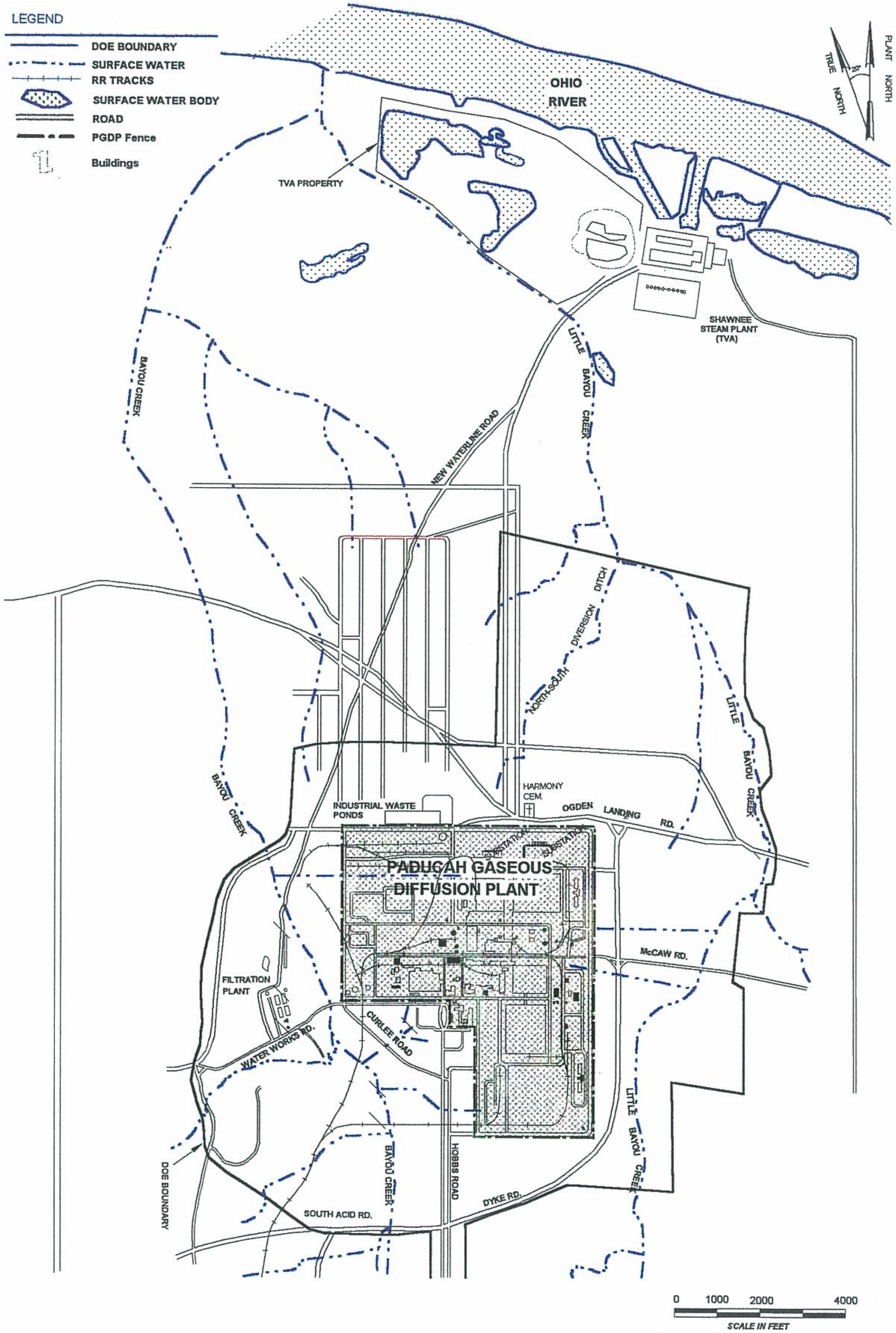
Adapted From:

Finch, W.L., 1967 Geological Map of part of the Joppa Quadrangle, McCracken County, Kentucky. U.S. Geological Survey GQ-652

Olive, W.W., 1966 Geological Map of part of the Heath Quadrangle, McCracken and Ballard Counties, Kentucky. U.S. Geological Survey GQ-561

fig3-3.wor - 7/8/98

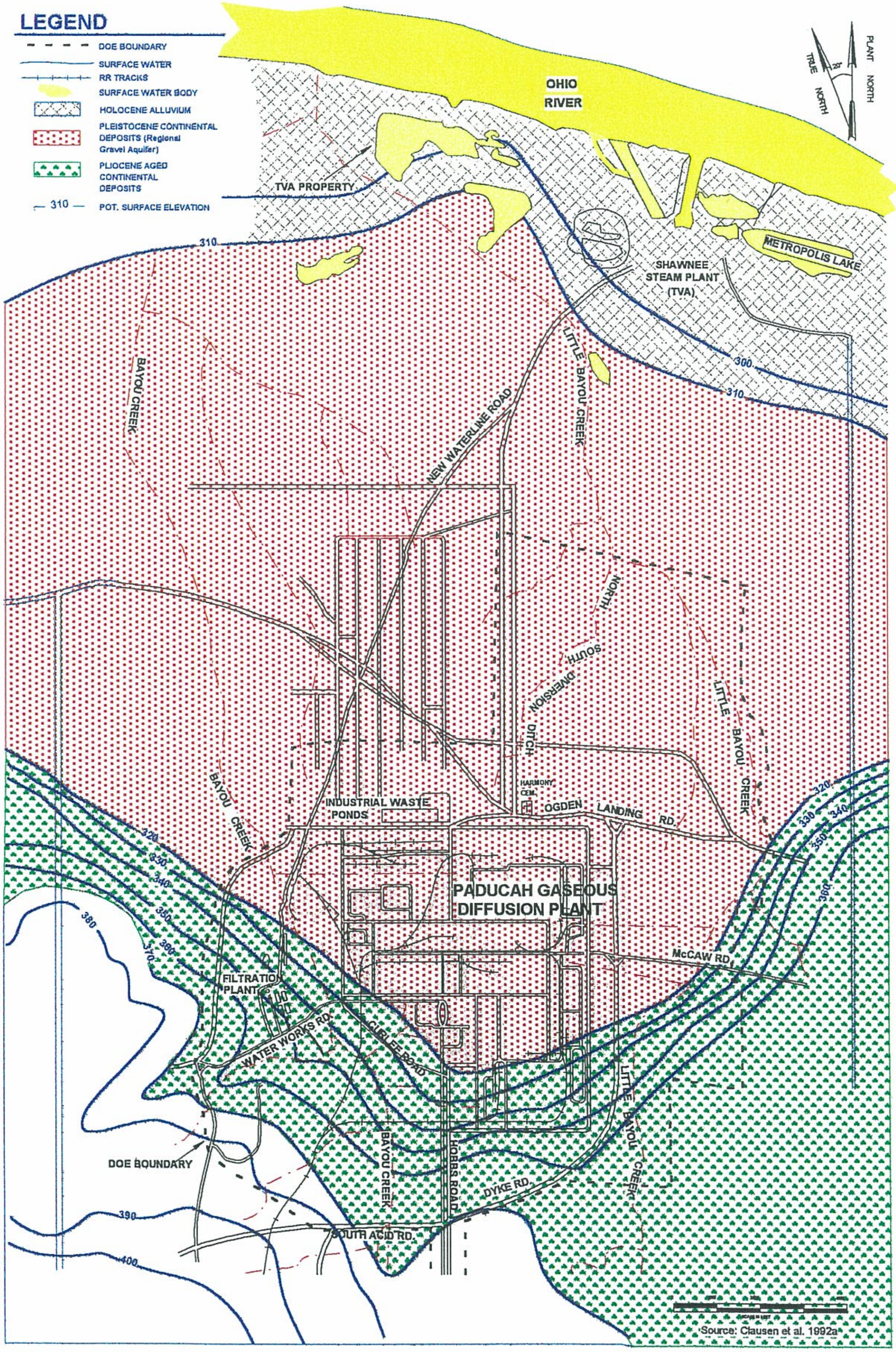
Fig. 3.3. Lithostratigraphic column of the Jackson Purchase Region.



Source: Clausen et al. 1992a

fig3- 7/8/98

Fig. 3.4. Surface water features in the vicinity of PGDP.



Source: Clausen et al. 1992a

fig3-8.wor - 7/9/98

Fig. 3.5. Water level elevations and geologic components of the regional groundwater flow system in the vicinity of PGDP.

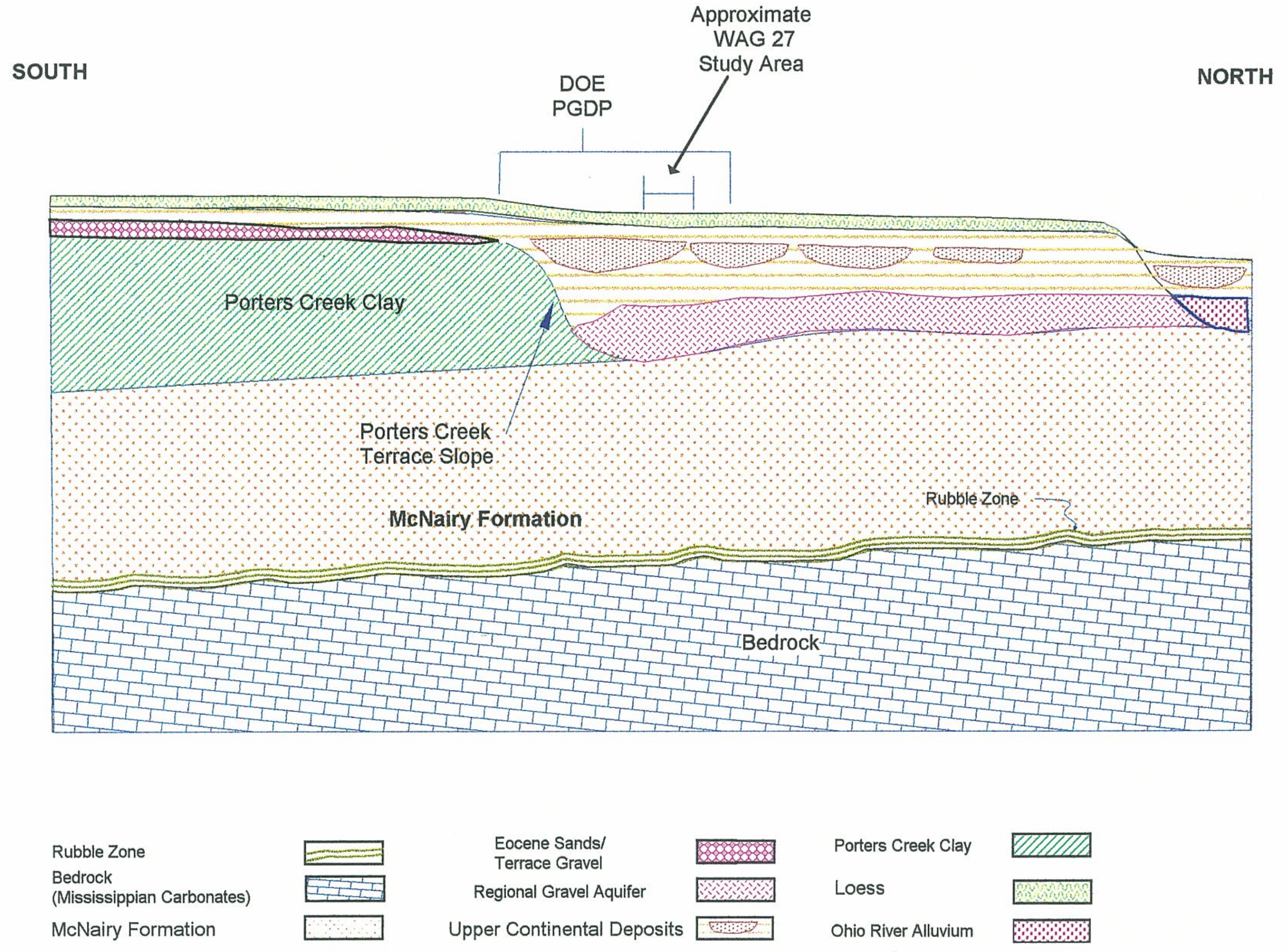


Fig. 3.7. Regional stratigraphy for PGDP area.

Figure 3.8
LARGE SCALE MAP NOT AVAILABLE IN PDF.

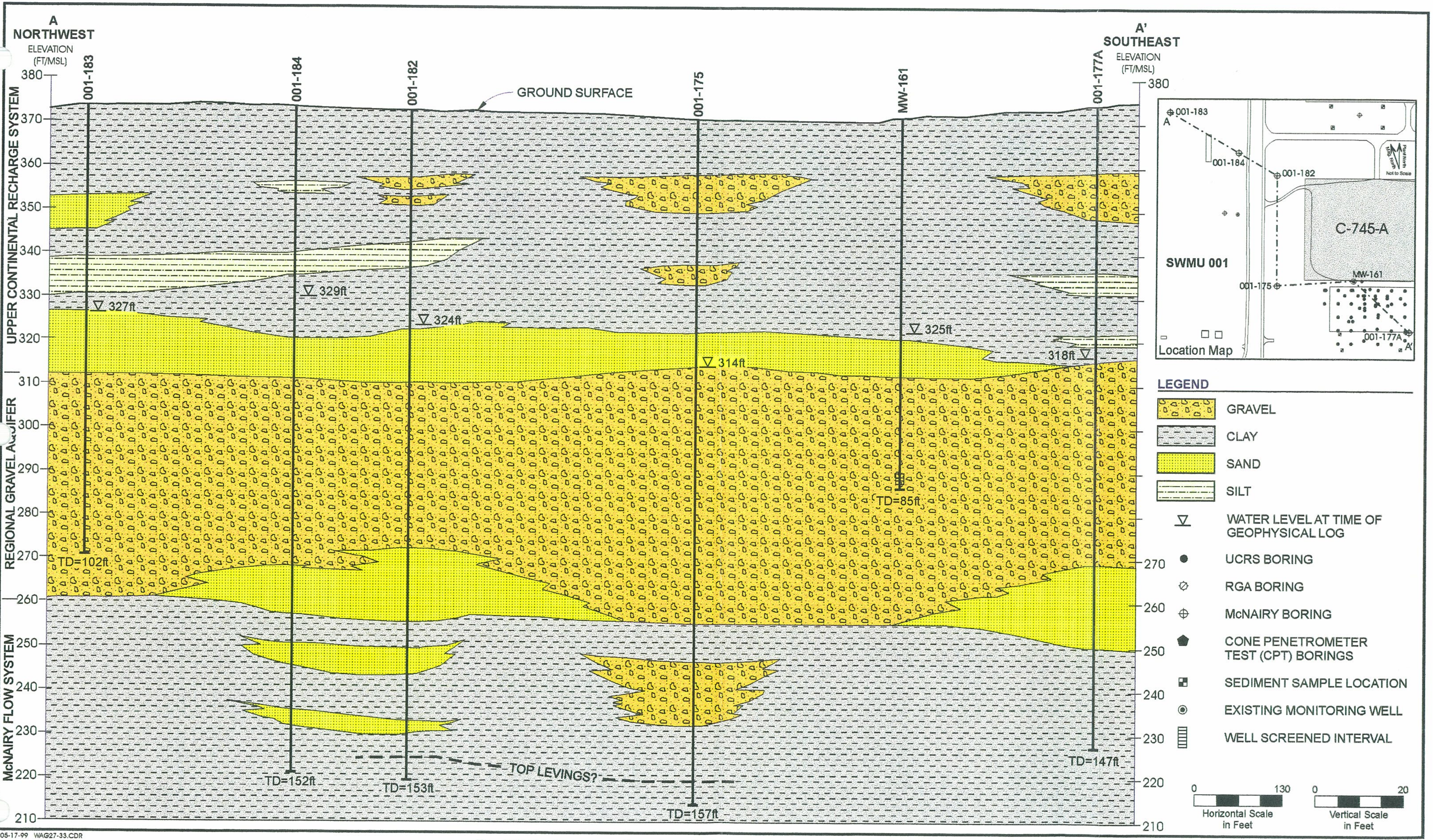
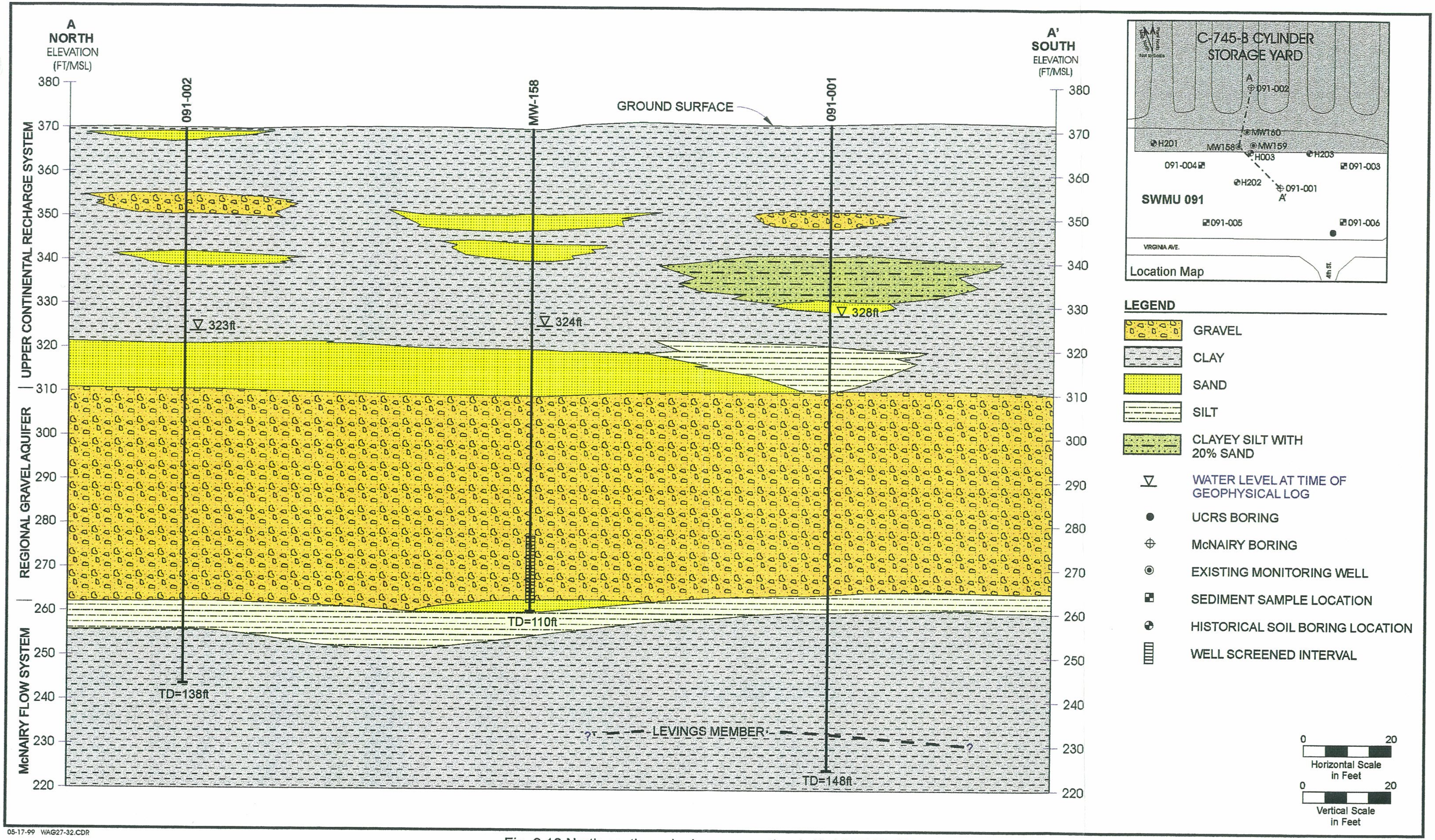
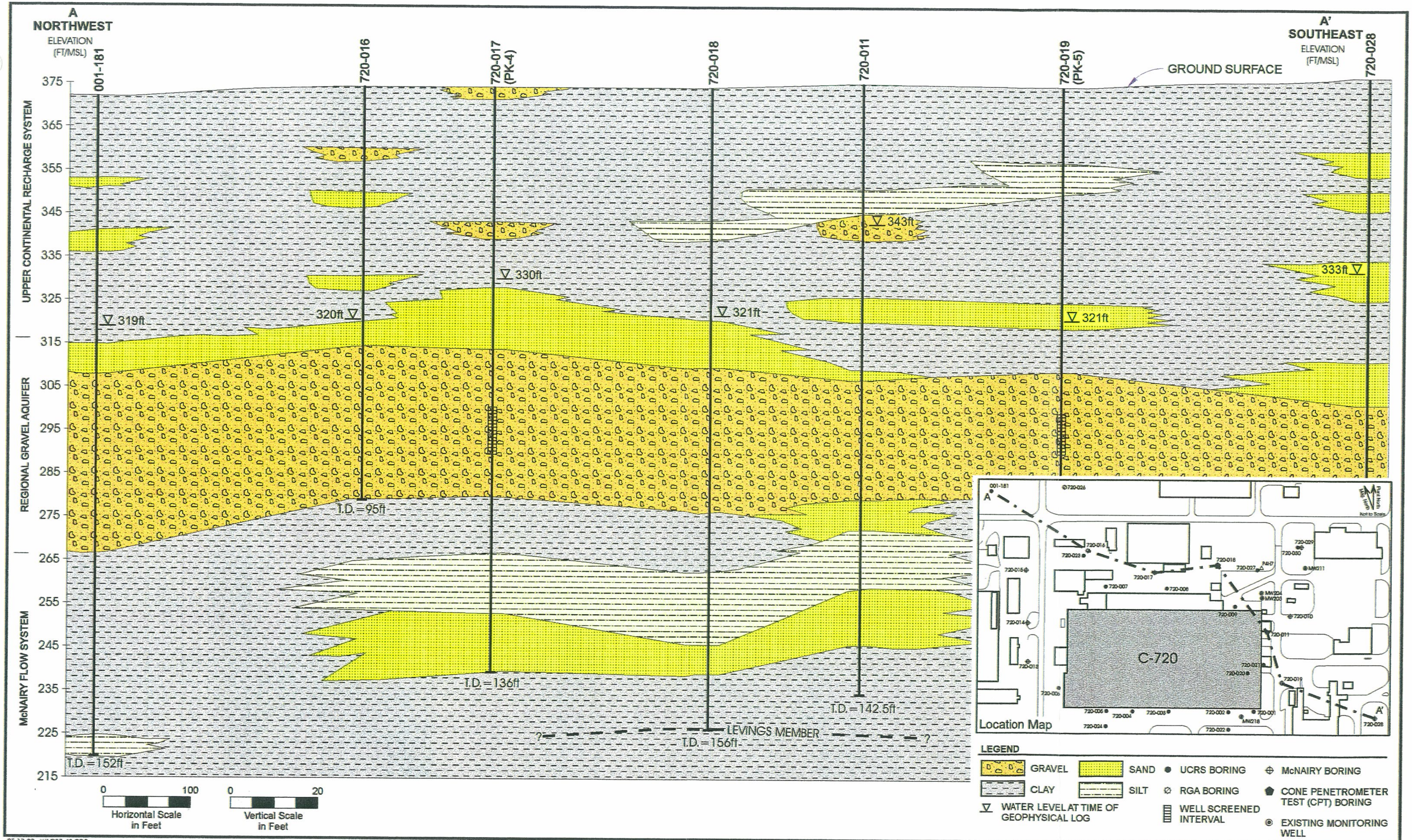


Fig. 3.9 Northwest-southeast geologic cross section A-A' at SWMU 001.



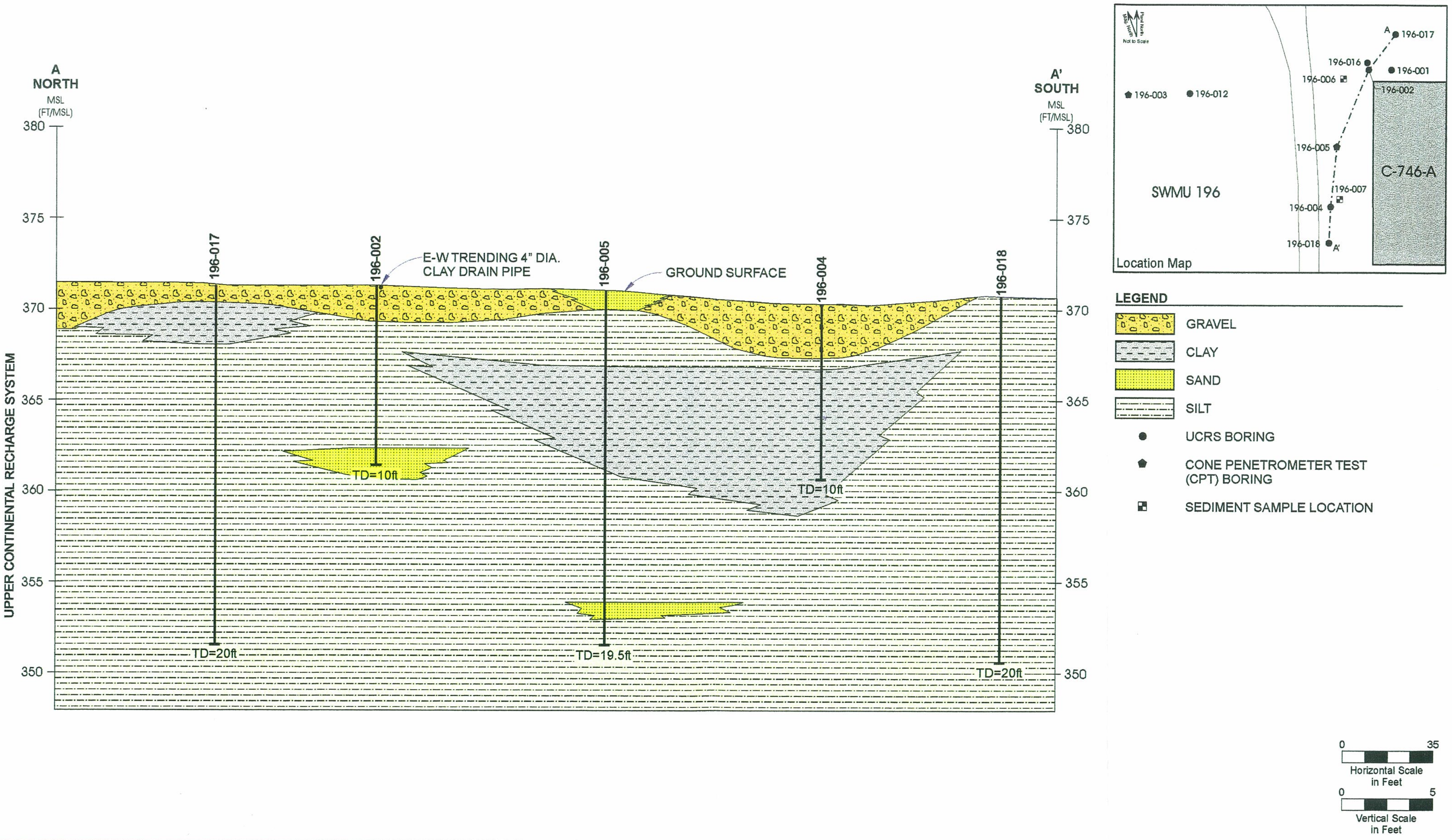
05-17-99 WAG27-32.CDR

Fig. 3.10 North-south geologic cross section A-A' at SWMU 091.



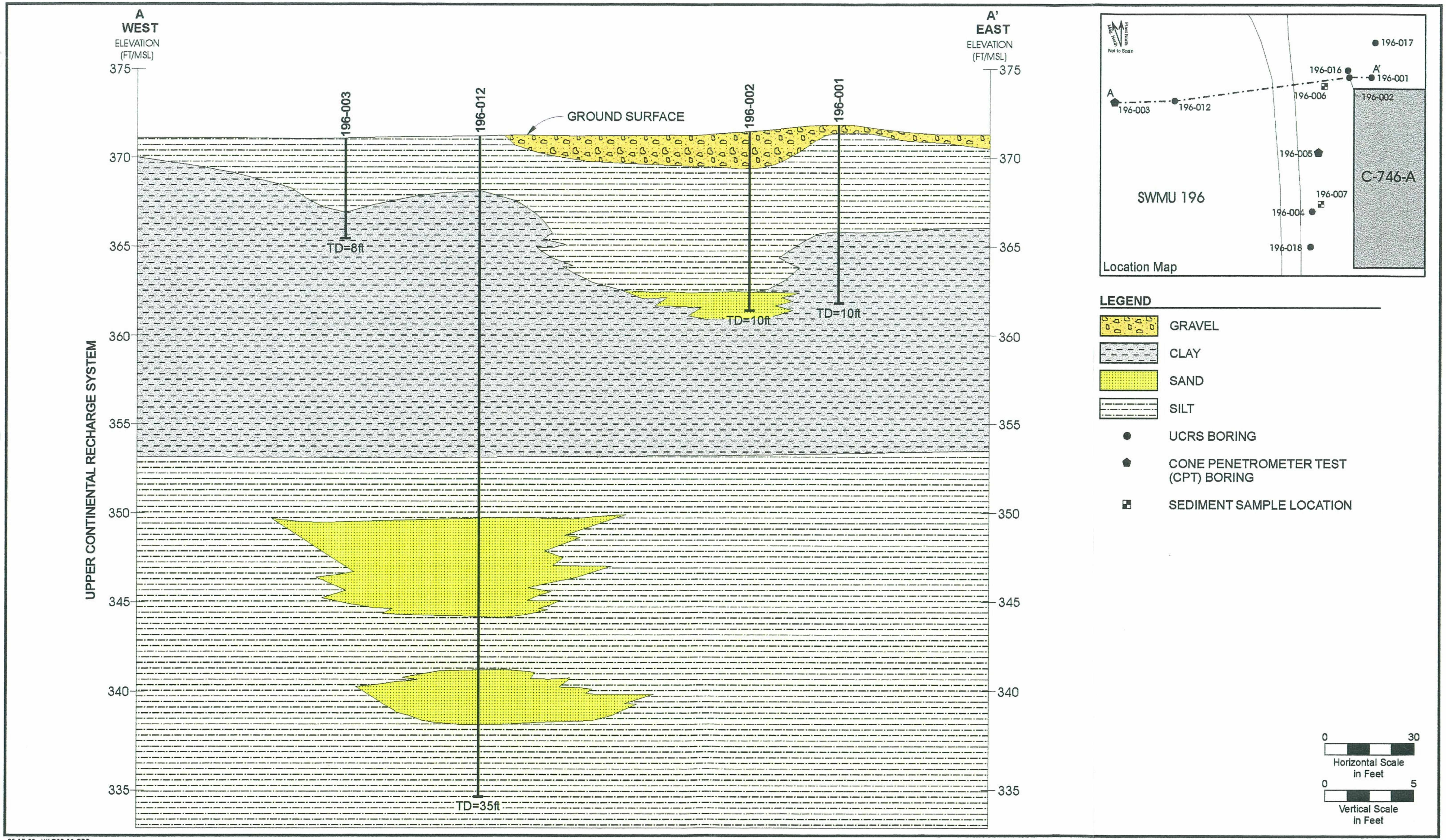
05-17-99 WAG27-40.CDR

Fig. 3.11 Northwest-southeast geologic cross section A-A' at C-720 Complex.



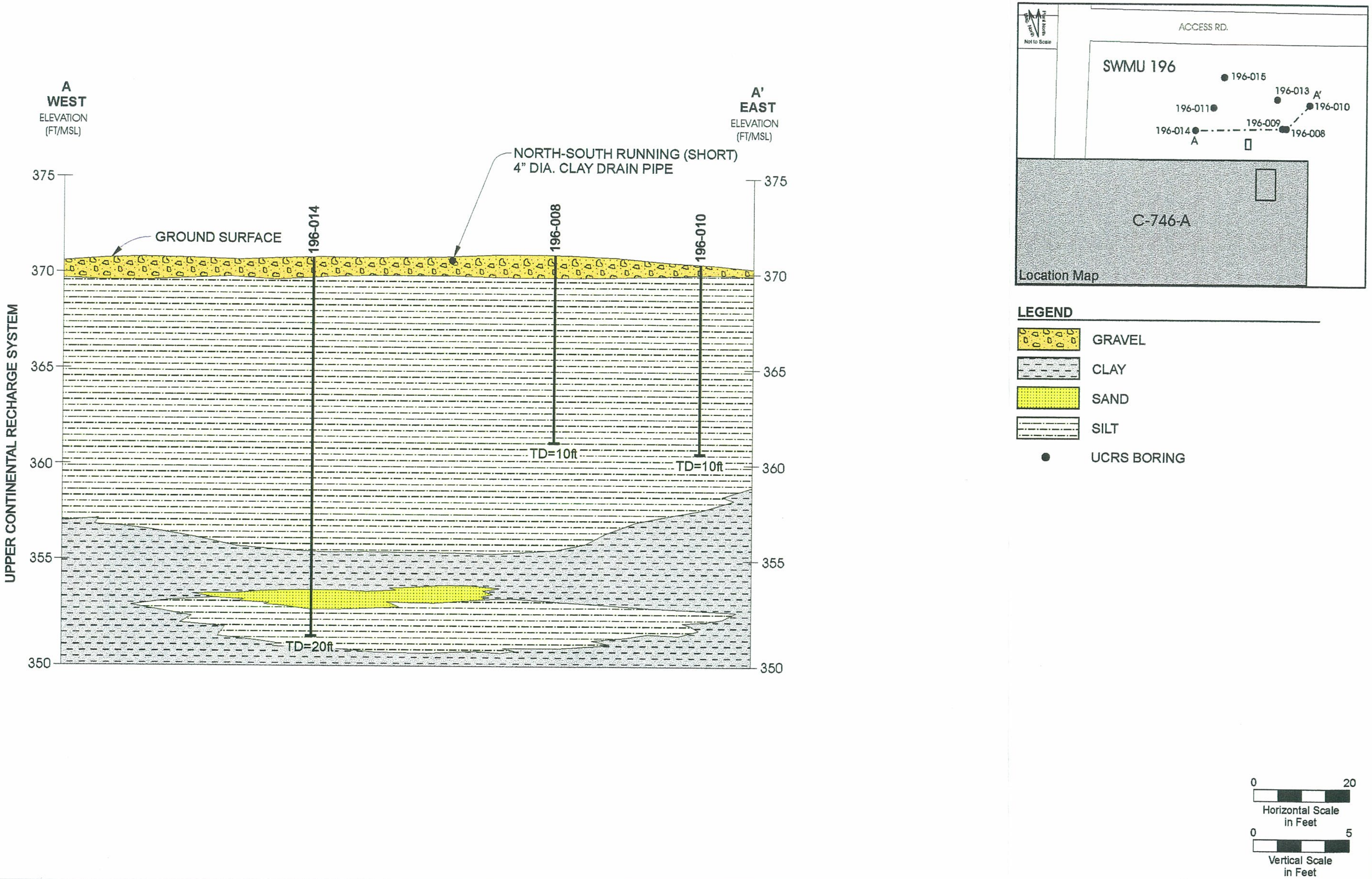
05-17-99 WAG27-31.CDR

Fig. 3.12 North-south geologic cross section A-A' in northwest area of SWMU 196.



05-17-99 WAG27-38.CDR

Fig. 3.13 East-west geologic cross section A-A' in northwest area of SWMU 196.



05-17-99 WAG27-39.CDR

Fig. 3-14 East-west geologic cross section A-A' in northeast area of SWMU 196.

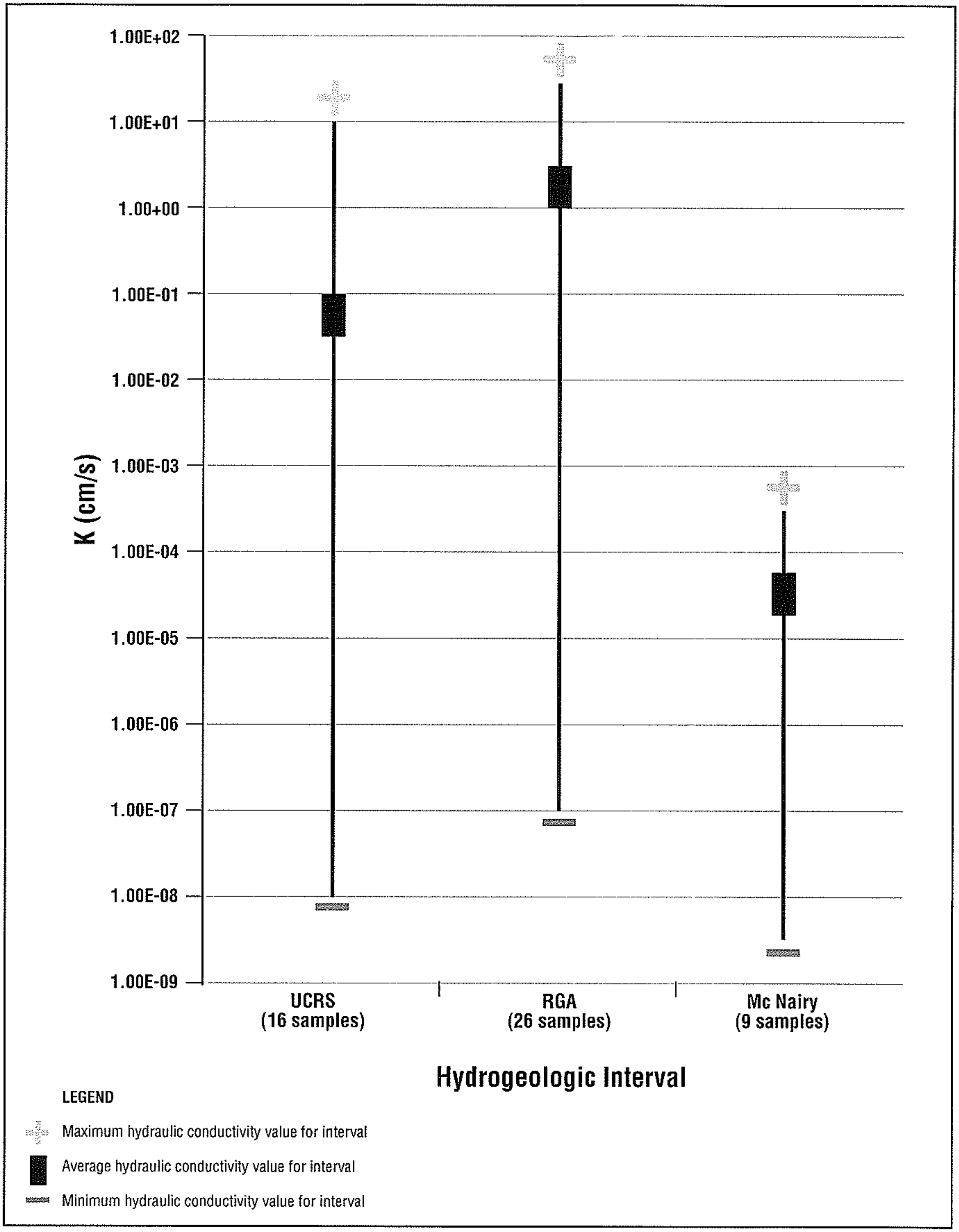
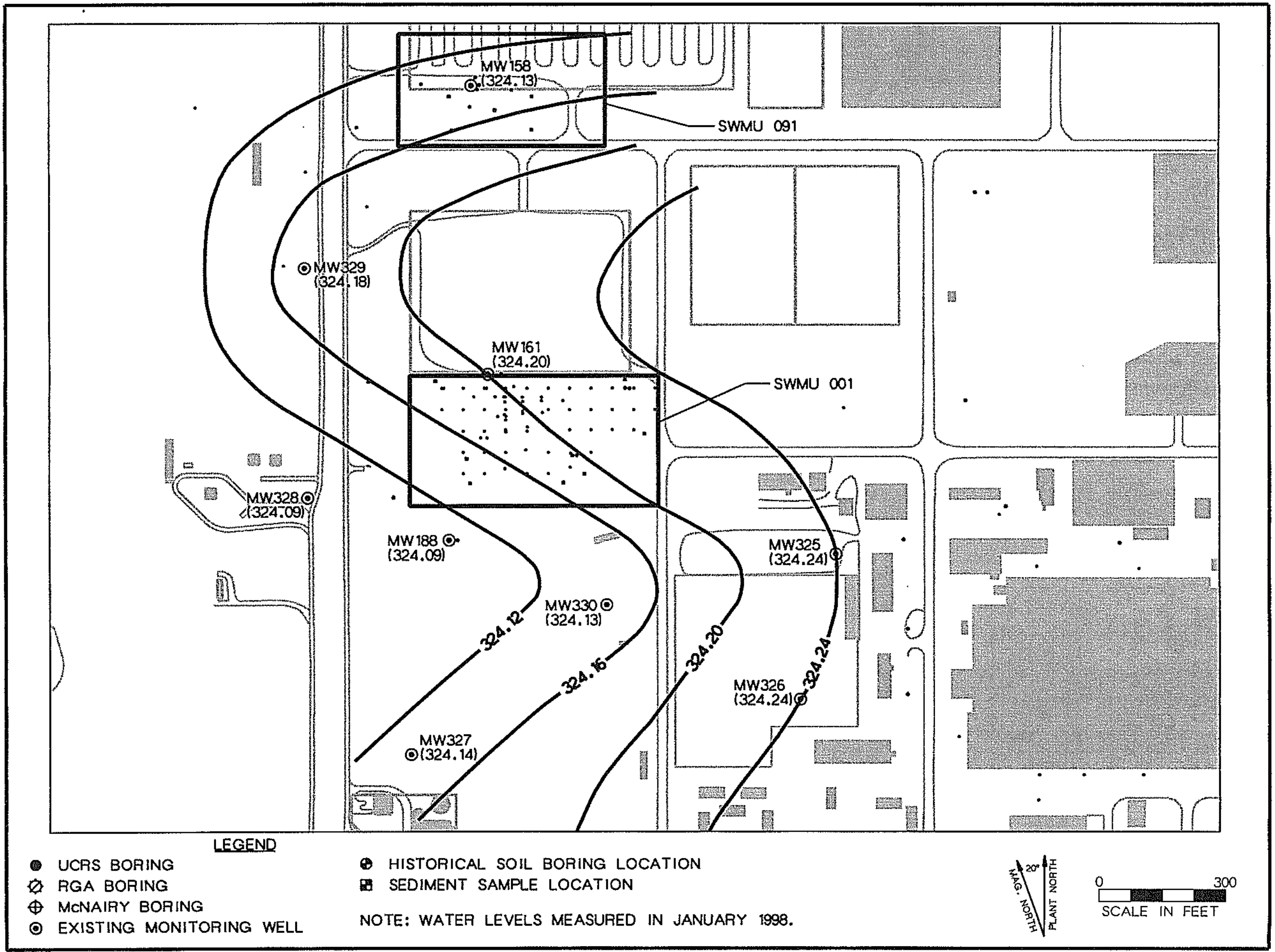
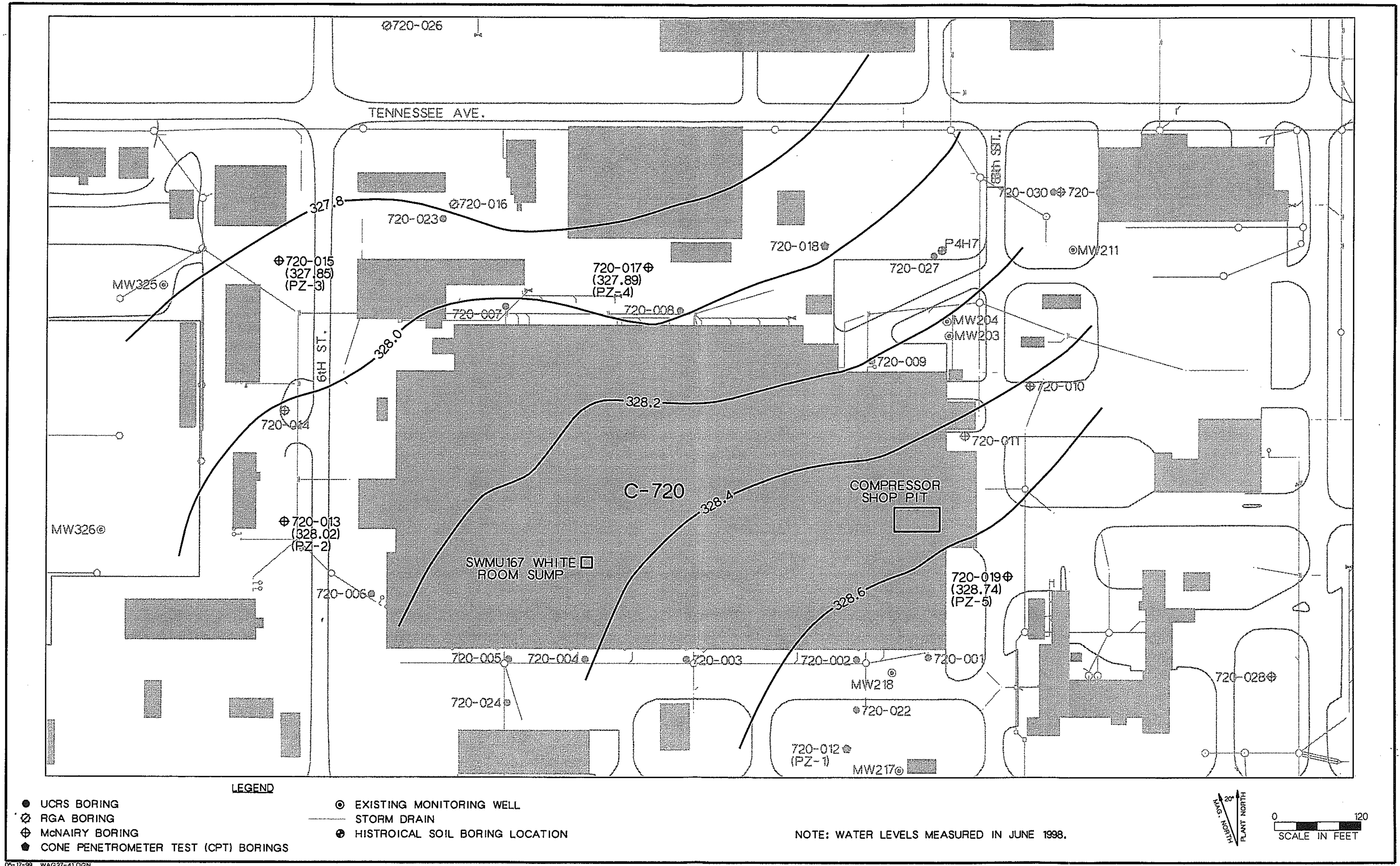


Fig. 3.15. Ranges of hydraulic conductivity (K) from WAG 6 RI laboratory results.



05-17-99 WAG27-42.DGN

Fig. 3.16 RGA potentiometric map for SWMU 001 and SWMU 091.



05-17-99 WAG27-41.DGN

Fig. 3.17 RGA potentiometric map of the C-720 Complex.

Table 3.1. Monthly average precipitation, temperature, potential evapotranspiration, estimated actual evapotranspiration, and infiltration and runoff: 1969-1989

Month	Precipitation (in.)	Temperature (°F)	Potential evapotranspiration (in.)	Estimated actual evapotranspiration (in.)	AFIRO[a] (in.)
January	2.99	29.9	0.00	0.00	2.99
February	3.84	36.5	0.11	0.11	3.74
March	4.68	47.6	1.00	1.00	3.67
April	5.16	58.1	2.29	2.29	2.87
May	4.91	66.5	4.06	4.06	0.86
June	4.14	75.2	5.60	5.38	0.00
July	4.57	79.0	6.67	5.65	0.00
August	3.43	77.2	5.92	4.10	0.00
September	3.67	70.3	3.90	3.62	0.00
October	3.37	58.8	2.17	2.17	0.00
November	4.90	47.5	0.79	0.79	2.50
December	4.65	38.2	0.19	0.19	4.41
Monthly Average	4.19	57.1	2.73	2.45	1.75
Total	50.31		32.70	29.36	21.04

[a] AFIRO = Available for infiltration or surface runoff.

Source: National Climatic Data Center, Asheville, North Carolina (from CH2M HILL 1992).

4. NATURE AND EXTENT OF CONTAMINATION

4.1 INTRODUCTION

Environmental data from the four sites investigated during the WAG 27 RI field activities have been compiled, screened, and evaluated to assess the nature and extent of each site-related contaminant and to supplement previously collected data. Summary tables containing analytical results for each of the four sites are included in this section. A complete report of analytical results for all samples collected during this investigation is provided in Appendix H. Appendix I contains selected analytical data collected during previous investigations of the sites that comprise WAG 27. Appendix G contains a complete list, by sample identification number, of all samples analyzed during the WAG 27 RI; it also provides information concerning which of the five analytical groups (VOAs, SVOAs, PCBs, metals, and/or radionuclides) were tested for in each sample.

The extent of contamination discussed in this report is based on the presence of site-related contaminants in surface or subsurface soils and groundwater. This section consists of three main parts following this introduction:

- A description of soil to 50 ft (typically the unsaturated zone, or approximately to the RGA) for each of the four sites;
- A description of contaminant impact on shallow UCRS groundwater; and
- A summary of findings for each site.

The PGDP site remedial objective is to select and implement actions protective of human health and the environment (DOE 1998b). The RI activities included investigations of the extent of potential groundwater contamination attributable to any of the four sites. Data collected from the WAG 27 RI also will be used as a basis for remedial action decisions concerning the groundwater OU.

4.1.1 Screening Process

The data screening process used in this RI was critical for determining when analytes represented site-related contaminants as opposed to laboratory contaminants or constituents that occur naturally in the soil or groundwater. Additionally, screening was used as a tool to focus the discussion of the nature and extent of contamination on those constituents that are most likely to have a potential for impact to human health or the environment. The screening process is described in the following paragraphs.

The results in the WAG 27 database were screened in a two-phase process. In the first phase, data collected during this RI were compared with historical data representative of naturally occurring conditions and concentrations in the surface soil, subsurface soil, and groundwater at the PGDP (i.e., background data). Background values for metals and radionuclides in groundwater were obtained from DOE (1994). These background data are used for reference only in the WAG 27 RI. Revised groundwater background data are currently being collected as part of the on-going groundwater OU study. Background values for metals and radionuclides in surface and subsurface soil were compiled from DOE (1997). Although Tc-99 is made artificially, the occurrence of Tc-99 has also been noted as a result of the spontaneous fission of uranium or via the irradiation of molybdenum. Low levels of Tc-99 identified in the PGDP site soil during the background study have been attributed to natural occurrences. Tables 4.1 and 4.2 contain the background data for the PGDP used to screen WAG 27 data. Because most organics such as VOAs, SVOAs, and PCBs are considered man-made, background for these compounds was set at zero. The analytical summary tables (Tables 4.4 to 4.31) contain all VOAs, SVOAs, PCBs, metals, and radionuclide results that were detected at WAG 27 *above background screening levels*. Where an environmental sample result and a duplicate result were available for the same sample, only the higher of the two results has been included in these summary tables.

To further the discussion of significant site-related contaminants, all results that exceeded the background values underwent a second screening against risk-based concentrations referred to in this report as the Preliminary Remediation Goals (PRGs). Because the PGDP is likely to remain an industrial site (DOE 1998b), soil results were screened using industrial use scenario PRGs. However, since groundwater can migrate to off-site receptors, groundwater data were screened using the more conservative residential use scenario PRGs. Some constituents, e.g., calcium, magnesium, and sodium, do not have PRG values. In such cases, the PRG for the constituents was set at zero. Table 4.3 contains the calculated PRGs used to screen the PGDP WAG 27 data set.

To emphasize those chemicals that were considered likely to have had an adverse impact on the site media, the discussion in this section is limited to analytes that exceed both screenings (background and PRG). Constituents that only slightly exceeded PGDP screening levels, were detected only in one sample, or were common mineral-forming elements are not discussed in detail.

4.1.2 WAG 27 Soils

To determine the nature and extent of contamination found within each of the four sites, samples of sediment and surface and subsurface soils were collected as needed. These samples were analyzed for suites of constituents in five groups: VOAs, SVOAs, PCBs, inorganics, and radionuclides.

Following a general introduction and description of the WAG 27 activities, the four WAG 27 sites are individually characterized. The discussion of each site begins with an introduction that provides a summary of the area's history, including site conditions. In addition to size, topography, and man-made features, the location of the physical boundaries of the site, previous sampling events, and relevant historical data are summarized. An accompanying base map depicts soil sample locations, facility structures, transportation pathways (e.g., roads), utility lines and pipes, and topographic features (e.g., ditch locations). The utility lines (stormwater, sanitary water, and sewer) and other pipes are extensive at some sites. Due to their potentially important role in contaminant transport, pertinent utility lines are depicted on the base maps.

Descriptions of the known processes and possible releases from each site that may have contributed to contaminant impact follow the paragraphs that characterize the site's physical properties. An understanding of the potential releases is key to the rationale behind the sampling that was performed during the WAG 27 RI investigation. Following the section "Rationale for RI Field Sampling," the text focuses on describing analytical results of samples collected at each of four sites. The text in this section includes the following information:

- Depth range from which samples were collected
- Number of locations within each site from which samples were collected
- Number and nature of individual constituents of each chemical group that were encountered
- Frequency of detection
- Description of analytical results

The "Summary of Findings" for each site provides a synopsis of the analytical results, including interpretations. The area or areas of concern at each site, the constituents involved, and the probable source or sources are described.

4.1.3 WAG 27 Groundwater

Two groundwater plumes of VOAs (notably TCE) and the radionuclide Tc-99 extend several miles off-site to the north of PGDP. In 1995, a groundwater study confirmed the C-400 Building area as the primary source of the Northwest Plume contaminants (Garner, Morti, and Smuin 1995). The C-400 area also has been shown to be a contributor of contaminants to the Northeast Plume. Potentiometric trends in the upper RGA and in well-flow measurements have confirmed a divergence of groundwater flow from under the C-400 area toward the north, as indicated by the geometry of the plumes (DOE 1997).

One of the objectives of the WAG 27 RI was to assess whether any additional VOA sources are currently contributing to the known northwest TCE plume or could contribute to the groundwater contamination in the near future. Another objective was to evaluate each site's potential contribution to the elevated Tc-99 concentrations previously detected in the PGDP groundwater.

To achieve these objectives, water samples were collected from the UCRS, RGA, and McNairy groundwater systems. In general, the water samples collected during the WAG 27 RI were analyzed for VOAs, metals, and radionuclides. Other selected parameters were measured to define the chemical and physical properties of the groundwater as needed to support fate and transport analysis and an FS.

4.1.3.1 Filtered vs. Unfiltered Groundwater Samples

Filtered and unfiltered grab water samples were analyzed for inorganic constituents (metals) and radionuclides during the WAG 27 RI. Comparison of the data sets indicated that the unfiltered samples often contain as much as 100 times higher metals content than filtered samples. The grab water samples were collected from an open borehole that had undergone only minimal development and contained *no* sand pack. As a result, the samples often contain a high percentage of suspended solids. The high metals content in the unfiltered water samples is a product of these suspended metals-bearing clays. Therefore, these unfiltered metals results are not representative of groundwater and are not included in the discussion concerning the nature and extent of the WAG 27 groundwater contaminants. Radionuclide results for filtered samples were consistently found to be below background or screening levels, while unfiltered samples generally contained low activities of some radionuclides. For discussions of the nature and extent of radionuclide distribution, unfiltered groundwater results were used. The complete data set (both filtered and unfiltered) is contained in Appendix H.

4.1.4 Historical Data Review

Limited historical data were available from two of the areas investigated during the WAG 27 RI. Three previous studies were found to have included portions of SWMUs 001 and 091: the Phase I and II SI (CH2M HILL 1991 and 1992, respectively), the WAG 23 RI (DOE 1994), and the LASANGA^{TM} Technology demonstration. All the historical data that were determined to be applicable to the WAG 27 study are listed in Appendices F and G of the *Integrated RI/FS Work Plan for WAG 27* (DOE 1998a).The analytical results for these samples are included in Appendix I.

For soils, historical data were available only for SWMUs 001 and 091. At SWMU 001, surface soils had been investigated during the WAG 23 RI and, therefore, were not included within the scope of the WAG 27 RI. During February 1996, additional surface soil sampling and subsurface sampling to 5 ft bgs were performed at SWMU 001 as part of a focused sampling event at WAG 23 SWMUs. These samples were included in the WAG 27 historical data set. During the Phase I and II SI, the subsurface soil at the SWMU 001 former Oil Landfarm was sampled on a grid pattern and a significant quantity of historical data was generated during this sampling event. Five soil borings were also sampled at SWMU 091 during the Phase I and II SI.

During the development of the Nature and Extent of Contamination section of the WAG 27 RI, the results of the historical sampling were incorporated. As part of the process, the results of the historical sampling were screened against the WAG 27 background values and PRGs. The screening results showed that a limited number of detections exceeded the screening values. Comparison of the screening results to the WAG 27 RI database indicated that the historical data supported the current findings concerning the nature and extent of contamination as reported in Sect. 4.2.1 and 4.2.2. Because the results for the historical data have been previously summarized, these data are not included in the summary analytical tables presented in Sect. 4 of this report. The historical soil data were, however, combined with the WAG 27 generated data set to conduct the Baseline Risk Assessment (BRA) as outlined in Vol. 4 of this report.

All of the historical groundwater results contained in the historical database were obtained prior to 1996 (some as early as 1991). The results of the historical groundwater analyses are contained in Appendix I. Because the RGA groundwater is a dynamic system in which the concentrations of contaminants can change significantly over short periods of time, the historical results for groundwater were used only to assess historic contaminant trends for Sect. 4 of this report. The historical groundwater data were, however, combined with the WAG 27 generated data set to conduct the BRA as outlined in Vol. 4 of this report.

4.2 WAG 27 SOIL AND GROUNDWATER

4.2.1 SWMU 001

4.2.1.1 Location and Physical Description

SWMU 001, site of the C-747-C former Oil Landfarm, is a relatively flat, open, and grass-covered area located in the western part of PGDP (Fig. 3.6). It encompasses an area of approximately 96,300 sq ft and is bounded by 4th Street to the east and by perimeter ditches to the north, west, and south. The C-747-C Oil Landfarm was active from 1973 to 1979. Two roughly parallel disposal plots were present within the boundaries of the landfarm. Each plot covered approximately 1125 sq ft and was plowed to a depth of 1 to 2 ft into native soil. At some time during the operation of the landfarm, a layer of sand and gravel was placed beneath the soil of the plots to improve drainage during times of heavy precipitation. Based on information derived from trench excavations conducted during the WAG 27 RI and the review of historical aerial photographs, the two disposal plots are believed to have been located in the northern portion of the SWMU.

Use of the C-747-C Oil Landfarm was discontinued in 1979. A minimal cover (<12 inches)was placed over the two disposal plots following closure. The area is now mowed regularly as part of PGDP maintenance operations.

4.2.1.2 Site History

The C-747-C Oil Landfarm was used from 1973 to 1979 for landfarming waste oils contaminated with TCE, 1,1,1-TCA, uranium, and PCBs. The waste oils were applied to the natural surface of two disposal plots and mechanically mixed with the native soil to promote biodegradation of the contaminants. It is estimated that approximately 5000 gallons of waste oil were applied to the landfarm during its period of operation, with oil being added to the plots at 3- to 4- month intervals. Although sources of the waste oils are not reported, it is assumed that they were derived from virtually all areas of the plant.

4.2.1.3 Location and Results of Previous Investigation

Results of previous sampling at SWMU 001 are summarized in Sect. 6.1.3 of the *Integrated RI/FS Work Plan for WAG 27 at PGDP* (DOE 1998a). Portions of SWMU 001 were characterized in two previous investigations. In the CERCLA Phase I and II SIs (CH2M HILL 1991 and 1992), the immediate SWMU area was investigated. This study included a geophysical survey to locate the former landfarm plots, 4 RGA soil borings, 10 shallow soil borings, and the installation of 4 monitoring wells. The geophysical survey identified two buried metal anomalies. Soil borings drilled during the investigation indicated PCBs, polycyclic aromatic hydrocarbons (PAHs), VOAs, and radionuclides in the soil. Perimeter ditches surrounding the SWMU were found to contain a contaminant suite similar to that identified in the soil borings. VOAs and radionuclides (specifically TCE and Tc-99, respectively) were encountered in downgradient monitoring wells MW-161 (RGA) and MW-162 (UCRS). SWMU 001 sampling locations from the Phase I and II SIs are shown in Fig. 4.1.

Subsequent to the SIs, groundwater samples taken at MW-161, located near the northwest corner of the SWMU, have documented the apparent passage of two concentrations of TCE in the RGA. The two concentration peaks were observed approximately 1 year apart and could have represented the passage of two separate contaminated water masses, or two isolated hot spots within the same water mass. Only a slight increase in TCE was noted in the nearby UCRS monitoring well MW-162 during these sampling events. The most recent (October 1994) detection of TCE in MW-162 was a low concentration of 70 ug/L. No other VOAs were reported in the sample collected from this monitoring well. Sodium, at concentrations only slightly above background, was the only metal reported above screening levels from the MW-162 water sample. This analysis was performed in February 1994. The most recently reported radionuclide analysis from MW-162, dated October 1994, showed only Tc-99 (55 pCi/L) above screening levels. A UCRS water sample collected from a nearby monitoring well (MW-189) was found to contain 10.7 mg/L of iron, a characteristic of anoxic conditions, in 1993, and 36 pCi/L Tc-99 during 1994 sampling events.

SWMUs where significant PCB contamination was identified during the Phase I and II SIs were assigned to WAG 23. At SWMU 001 surface soils were included in WAG 23, whereas subsurface soils and groundwater were assigned to WAG 27. In the WAG 23 RI, the Phase I and II data were re-examined and the resultant WAG 23 RI Addendum was issued in September 1994 (DOE 1994). In this addendum, surface soils at SWMU 001 were identified as a probable source of TCE, 1,1,1-TCA, PCBs, and uranium contamination. Other possible contaminants included heavy metals, dioxins/furans, PAHs, and Tc-99. TCE, 1,1,1-TCA, and Tc-99 were considered probable groundwater contaminants.

During February 1996, focused soil sampling designed to delineate the full extent of PCB contamination and the soil volumes to be remediated was performed at the WAG 23 sites. As a part of this fieldwork, surface soil sampling was conducted at SWMU 001. SWMU 001 had no PCB concentrations greater than 25 ppm. The maximum reported concentration was 3.34 ppm for Aroclor 1248 at Grid 29 within the 0- to 1-ft interval. One soil sample collected at Grid 17 from 5 ft bgs had a reported concentration of 2,400,000 ug/kg for cis-1,2-dichloroethene. The locations of these additional sample points are shown in Fig. 4.2. Full results of the WAG 23 focused sampling were published in the WAG 23 FS (DOE 1996b).

On September 11, 1997 DOE signed the Action Memorandum for WAG 23 and SWMU 001 of WAG 27 describing a non-time-critical removal action. In January 1998 the non-time-critical removal action was executed for the SWMUs of WAG 23 and SWMU 001 of WAG 27.

No action was taken for PCBs at SWMU 001 where the average PCB concentration is approximately 0.2 ppm. Soils with a total dioxin concentration greater than or equal to 1.3 ppb were excavated at SWMU 001 (23 yd^3). An analysis of the confirmatory sampling analytical results demonstrated that all of the samples had a total dioxin concentration less than the clean-up goal.

A No Further Action Proposed Remedial Action Plan for WAG 23 and SWMU 001 of WAG 27 was submitted November 6, 1998 to the regulatory agencies for review. The (D1) No Further Action Record of Decision (ROD) is expected in 1999.

4.2.1.4 Rationale for RI Field Sampling

Based on the review of available information, three data gaps were identified at SWMU 001.

Closing these gaps would allow for (1) development of a more accurate representation of the levels of contamination in the ditches surrounding the unit, (2) determination of the origin of geophysical anomalies within the former Oil Landfarm, and (3) determination of the extent of subsurface soil contamination at SWMU 001 and the potential impact associated with the leaching of these contaminants to the UCRS and RGA groundwater.

To gather information to close the data gaps, field sampling was conducted on the two buried geophysical anomalies in sediments in the ditches surrounding the SWMU, soils below the surface soil zone, and groundwater of the UCRS, the RGA, and the upper McNairy Formation. Activities included a magnetometer survey and eight test pits to investigate the buried anomalies, sediment sampling in the ditches, and collection of soil and water samples from 73 borings to identify subsurface contamination. Figure 4.3 shows the SWMU 001 sampling locations for the WAG 27 RI. The results of these sampling activities are discussed in the following sections.

4.2.1.5 Nature and Extent of Contamination

Trench Samples–Analytical Results. Two small magnetic anomalies were identified at SWMU 001 during the Phase I and II SIs (CH2M HILL 1991 and 1992). As part of the WAG 27 RI, a geophysical survey was conducted to better define the boundaries of these anomalies so that excavation test pits could be dug to determine if the anomalies contained material that might represent a source of contamination at SWMU 001. TN & Associates, Inc. and CDM Federal Programs performed this survey. A copy of their full report is provided in Appendix F.

Geophysical surveys were conducted in three areas at SWMU 001 to define the anomaly boundaries. First, a background survey was performed over a 50- by 20-ft area in the northwest corner of the SWMU. Surveys were then conducted in the vicinity of the western anomaly defined during the Phase I and II SIs (Grid A) and in the vicinity of the eastern anomaly (Grid B). Grid A covered an area 100 ft long by 50 ft wide. Grid B was 100 ft long by 60 ft wide. Using an EM-61 magnetometer, readings were obtained at 10-ft intervals throughout the grids. These grid readings were then augmented by continuous readings to further define the perimeter of the anomalies. Two anomalous areas were identified in Grid A and five in Grid B. A series of test pits (2 at Grid A and 6 at Grid B) were then excavated to depths of approximately 3.5 ft bgs to determine if any material that might represent a source of contamination was present at the site. Excavated test pits were scanned with a PID and a radiologic meter to check for the presence of organic vapors and radiological activity. Results of these scans were then used to select locations within the trenches to be sampled. Test pit locations are indicated in Fig 4.3. No large metallic objects such as drums were uncovered in any of the excavations at SWMU 001.

A large concrete drainpipe caused the anomaly in Grid A. The source and purpose of this pipe are unknown, but the pipe does not appear to have contributed to groundwater contamination.

The magnetic anomalies at Grid B closely defined two roughly parallel landfarm trenches that were confirmed by observations of subsurface material during excavation of the test pits. Magnetic anomalies in Grid B were probably caused by small metal items (e.g., drum lids, drum bungs, metal shavings in waste oil) and/or residual metals from oils disposed of in the landfarm.

A total of four surface soil samples and one duplicate were collected during trench excavation activities at Grid B. No samples were collected from excavations at Grid A because no PID or radiologic meter readings exceeded background in these test pits. Sample locations are shown in the inset on Fig 4.3. Each sample was tested for VOAs, SVOAs, PCBs, inorganic constituents, and radionuclides. Results that exceeded applicable background levels are listed in Tables 4.4 through 4.7. A frequency of detection table (Table 4.10) presents summary information concerning the analytical results exceeding background values.

Organics

VOAs. VOAs were detected at concentrations above screening levels in sample 001-101 and its duplicate. TCE was present in the two samples at concentrations of 510 ug/kg and 1200 ug/kg, respectively. Vinyl chloride was detected in sample 001-101 at a concentration of 67 ug/kg and in the duplicate at 270 ug/kg.

SVOAs. No SVOAs were detected above screening levels for any of the five samples analyzed.

PCBs. One sample and its duplicate contained PCBs above screening levels. Total PCBs were present in sample 001-101 at a concentration of 17,100 ug/kg. Individual PCB species were PCB-1242, PCB-1260, and PCB-1268 at concentrations of 500 ug/kg, 11,000 ug/kg, and 5600 ug/kg, respectively. PCB-1242 (500 ug/kg), PCB-1268 (4200 ug/kg), and polychlorinated biphenyls (4700 ug/kg) were also detected in the duplicate sample from this location.

Inorganics

Five soil samples from the trench excavations were submitted for metals analysis. None of the samples exhibited metal concentrations above screening levels.

Radionuclides

Five soil samples from the trench excavations were analyzed for radionuclides. No isotopes exhibited activities above screening levels. During excavation of the test pits at SWMU 001, a whitish granular material that appeared to be alumina pellets was uncovered. This material was sampled and analyzed. Analytical results indicated that the material contained 295 pCi/g total uranium assayed at 1.062 wt% U-235. A review of the size and activity of the deposits indicated that the source of the material was oil contaminated with alumina that had accumulated in the C-720 Instrument Shop. Detailed information on the origin of the alumina is included in the Geophysical Survey and Excavation Report. This report is included as Appendix F in Volume 2 of this document.

Sediments–Analytical Results. Perimeter ditches bound SWMU 001 to the north, west, and south. To evaluate the sediments contained in these ditches, seven sediment samples were analyzed for SVOAs, PCBs, inorganic constituents, and radionuclides. Six of the samples (001-145, 001-146, 001-147, 001-148, 001-149, and 001-150) were collected from a depth of 0 to 1 ft bgs. Sample 001-170 was collected from a depth of 1 to 1.75 ft bgs. Sediment sample locations are noted in Fig. 4.3. Results that exceeded applicable background levels are listed in Tables 4.4 through 4.7. A frequency of detection table (Table 4.10) presents summary information concerning the analytical results exceeding background values.

Organics

VOAs. None of the sediment samples were analyzed for VOAs.

SVOAs. Seven sediment samples were submitted for analysis of SVOAs. No SVOAs were detected in any of the samples.

PCBs. Each of the seven sediment samples was analyzed for PCBs. No PCBs were detected.

Inorganics

Soil from all seven sediment locations was sampled for metals analysis. Only one sample, 001-170, exhibited metals in excess of applicable background and PRG screening values. Four metals were detected in this sample: barium at 247 mg/kg; beryllium at 0.8 mg/kg; manganese at 1990 mg/kg; and thallium at 1.56 mg/kg.

Radionuclides

Three isotopes were detected above screening levels in sediment sample 001-149. Laboratory analyses of sample 001-149 detected Np-237 (12.15 pCi/g), Pu -239/240 (26.82 pCi/g), and Th-230 (187.9 pCi/g). The remaining sediment samples did not contain radionuclides with activities exceeding screening levels.

Subsurface Soils–Analytical Results. To investigate the subsurface soil within SWMU 001, 198 soil samples (excluding splits) were collected from 73 borings that ranged in total depth from 5 to 50 ft bgs. Figure 4.3 is a map of SWMU 001 showing the locations of the 73 borings sampled. Results that exceeded applicable background levels are listed in Tables 4.4 through 4.7. A frequency of detection table (Table 4.10) presents summary information concerning the analytical results exceeding background values.

Organics

VOAs. Only two VOAs, TCE and vinyl chloride, were detected in the subsurface soil of SWMU 001 at concentrations exceeding screening levels. All detections occurred in borings located in the immediate vicinity of the former landfarm plots. Vinyl chloride was detected in 5 samples, with the maximum detection of 4800 ug/kg occurring in boring 001-153. All detections of vinyl chloride occurred in the upper 7 ft of the subsurface. TCE concentrations in excess of PRGs were detected in 43 samples. A map showing the distribution of TCE detections at SWMU 001 is provided in Fig. 4.4.

The maximum reported TCE concentration at SWMU 001 was 439,000 ug/kg. This result was obtained from a sample collected at 15 ft bgs from boring 001-165 in the north-central portion of SWMU 001 and was the only TCE detection to exceed 225,000 ug/kg, the TCE concentration in soil considered indicative of DNAPL. In February 1996, as part of WAG 23 sampling, soil containing 2,400,000 ug/kg of the TCE breakdown product cis-1,2-dichloroethene was collected from 5 ft bgs at a location slightly east of boring 001-165.

As shown on the east-west cross section in Fig. 4.5, boring 001-165 exhibited elevated TCE throughout its vertical extent, with 25,000 ug/kg TCE present in soil at the end depth of 50 ft bgs.

East of 001-165, boring 001-168 also showed elevated TCE concentrations to total depth, with a maximum concentration of 5500 ug/kg occurring at 30 ft bgs and 4300 ug/kg of TCE present at 50 ft bgs. Lateral east-west definition of TCE content in soil in excess of PRGs is provided by borings 001-171 and 001-173, respectively.

The north-south cross section in Fig. 4.6 also shows elevated TCE concentrations in the vicinity of 001-165 to total depth, with the lateral extent of TCE in soil delimited to the south by boring 001-174. As demonstrated by boring 001-169, TCE concentrations above PRGs in subsurface soil appear to be contained within SWMU boundaries to above approximately 25 ft bgs. However, elevated TCE concentrations in soil appear to extend north of the SWMU boundaries below this depth.

SVOAs. No SVOAs were detected above screening levels.

PCBs. No PCBs were detected above screening levels.

Inorganics

One-hundred-thirty-eight soil samples were collected at SWMU 001 for analysis of 23 metals each during the WAG 27 RI. These samples were collected from 64 borings between the depths of 5 and 50 ft bgs and a total of 3174 metal analyses were run (138 analyses for each of 23 metals). Only 157 analyses (5%) detected metals at levels above background and/or PRGs.

Twelve of the 23 metals analyzed for were detected in the SWMU 001 subsurface at concentrations exceeding screening levels. Six of these–antimony, arsenic, beryllium, cadmium, manganese, and silver–were detected at concentrations that exceeded PGDP subsurface background values by a factor of two or more. Background data for PGDP are listed in Table 4.1. All elevated detections of arsenic, cadmium, manganese, and silver were from samples collected between 5 and 15 ft bgs, with the exception of one detection of cadmium (20 to 23 ft bgs in boring 001-171) and one manganese detection (48 to 50 ft bgs in 001-174). Distribution of arsenic, cadmium, manganese, and silver is shown on Fig. 4.7. Most antimony detections were also from 5 to 15 ft bgs, with only two borings (001-168 and 001-179) showing elevated concentrations at depths below 15 ft. Distribution of antimony is shown in Fig. 4.8. Beryllium was detected at concentrations above screening levels at depths ranging from 5 to 50 ft bgs.

The remaining six detected metals exceeded PGDP subsurface background values by a factor of less than two–aluminum, iron, lead, magnesium, sodium, and vanadium. Aluminum, sodium, and vanadium were detected at concentrations above screening levels at depths ranging from 5 to 50 ft bgs. Iron and lead were detected only in deeper samples (20 to 43 ft bgs and 35 to 38 ft bgs, respectively) and magnesium detections were restricted to 7 to 10 ft bgs. Magnesium distribution is shown in Fig. 4.8.

Subsurface soil containing metals above screening values is not restricted to any particular section of SWMU 001, either horizontally or vertically, although the zone from 5 to 15 ft bgs contains elevated concentrations of several metals. This concentration of metals in the shallow subsurface is probably related to past landfarming practices at SWMU 001. Detections of metals at values above screening levels are more random and isolated at depths below 15 ft bgs, with samples that did not contain elevated metal concentrations frequently collected from adjacent locations. These deeper concentrations cannot be directly related to any definite release from activities at SWMU 001.

Radionuclides

No isotopes were detected above screening levels.

UCRS Groundwater–Analytical Results. During the WAG 27 RI, sufficient water was not typically encountered in the shallow subsurface strata to allow a grab water sample to be collected during the drilling of the soil borings at SWMU 001. Only one UCRS grab water sample was collected for analysis from SWMU 001. Tables 4.8 and 4.9 contain a complete list of all the organic compounds, metals, and radionuclides detected at concentrations above background levels in this sample. The frequency of detection and maximum, minimum, and average concentrations for each reported constituent are contained in Table 4.10.

Organics

VOAs. VOAs were the only organic constituents for which the UCRS water sample was analyzed. The UCRS water sample from 50 ft bgs at location 001-173 on the northwest side of the former Oil Landfarm had the highest TCE content (312 ug/L) of any UCRS water sample collected during the WAG 27 RI. Smaller amounts of TCE degradation products were also reported from the sample.

Inorganics

The concentrations of 15 metals exceeded screening levels in the sample collected from boring 001-173. All of these exceedances were from an unfiltered grab water sample that was collected using a disposable teflon bailer. The sample was very muddy and contained a very high level of total suspended solids. The presence of a large amount of suspended clay material in the sample contributed to the reported elevated metals concentrations. Results for 001-173 are presented on page 201 of the SWMU 001 section of Appendix H, Volume 3.

Radionuclides

Only one radionuclide, Tc-99, exceeded both the PGDP groundwater background and PRG screening levels. The activity of Tc-99 was 41.1 pCi/L in a grab water sample collected at 50 ft bgs in boring 001-173. Uranium (total) also was reported at a concentration above screening levels (0.04 mg/L) from this sample.

4.2.1.6 Summary of Findings

Previous investigations conducted at SWMU 001 had identified PCBs, PAHs, volatile organics, and radionuclides in the subsurface soil and a similar suite of contaminants in sediment samples from the surrounding perimeter ditches. Volatile organics and radionuclides (TCE and Tc-99, respectively) were identified in groundwater. WAG 27 RI sampling at SWMU 001 was designed to further investigate these media and the possible contaminant source: the former plots of the C-747-C Oil Landfarm. One area of significant soil contamination by organic constituents (TCE) was defined. In addition, subsurface soil from 5 to 15 ft bgs appears to have been impacted by metals released from previous landfarming activities. Because radionuclides are not found above screening levels in either the subsurface or trench samples collected at SWMU 001, the radionuclides detected in one sediment sample from the ditches surrounding SWMU 001 are believed to have originated from the nearby cylinder yards.

RI results indicate that SWMU 001 subsurface soil and the UCRS groundwater have been impacted by the release of TCE from SWMU 001. TCE and several TCE degradation products were detected above screening levels in 43 samples and were found throughout the vadose zone at SWMU 001. The maximum detected TCE concentration in subsurface soil was 439,000 ug/kg, a concentration indicative of DNAPL. Vinyl chloride concentrations as high as 4800 ug/kg have also been documented in association with the TCE-contaminated soil. All detections of VOAs in soil samples were associated with samples collected from borings or trenches located in the immediate vicinity of the two former landfarm plots that operated from 1973 to 1979. The single UCRS grab water sample collected during the WAG 27 RI contained 312 ug/L of TCE, the highest TCE content of any UCRS water sample collected during the WAG 27 RI. This water sample was collected from a boring located immediately northwest (downgradient) of the identified area of subsurface soil that contained the maximum TCE concentration. From the location of these contaminated samples (soil and groundwater), it is apparent that leaching of TCE and associated contaminants contained in the former landfarm has resulted in contamination of the UCRS soil and groundwater.

SWMU 001 subsurface soil from 5 to 15 ft bgs exhibits elevated concentrations of the metals arsenic, antimony, cadmium, magnesium, manganese, and silver. Although metals are a normal constituent of all subsurface soils at PGDP, this localization of elevated metal concentrations indicates probable impact from past landfarming practices at the site. Detections of metals at values above screening levels are more random and isolated at depths below 15 ft bgs. These deeper detections cannot be directly related to any definite release from activities at SWMU 001 and there is no indication of metal contamination in groundwater due to a SWMU 001 source.

A revised site conceptual model for the C-747-C Oil Landfarm at SWMU 001 is presented in Fig. 4.9. This model, based on the results of the WAG 27 RI, depicts subsurface stratigraphy at SWMU 001 and the area of TCE soil contamination defined in the vadose zone beneath the former landfarm plots. Contamination encountered in RGA groundwater beneath SWMU 001 and to the northwest (downgradient) of the SWMU boundaries indicates that TCE is being leached from the overlying UCD sediments by the downward percolation of precipitation.

Although Tc-99 was not found in high concentrations in either the UCD soil or UCRS groundwater samples at SWMU 001, Tc-99 may have entered the RGA at SWMU 001 in the past due to leaching of vadose soil that contained higher concentrations of the mobile radionuclide. Metals detected in the subsurface soils of SWMU 001 during the WAG 27 RI were generally concentrated in the upper 15 ft of soil and probably are not impacting the underlying groundwater.

4.2.2 UF_6 Cylinder Drop Test Area (SWMU 091)

4.2.2.1 Location and Physical Description

SWMU 091 is located in the western portion of the fenced area of the PGDP. It is situated between the south side of the C-745-B cylinder yard and Virginia Avenue. Figure 3.6 shows the location of SWMU 091 in relation to the other SWMUs investigated in this RI.

4.2.2.2 Site History

PGDP conducted cylinder drop tests in late 1964 and early 1965 and in February 1979 to demonstrate the structural integrity of steel cylinders used to store and transport UF_6. In the tests, a crane lifted the cylinders to a specified height and dropped them on a concrete and steel pad to simulate worst-case transportation accidents.

Drop tests were used to assess the effect of low temperatures on cylinder integrity. In the first test period, a brine-ice bath was used to chill one cylinder prior to its drop test. The 1979 test used a TCE and dry-ice bath to chill one of the steel cylinders. Leakage from an in-ground pit, used to hold the TCE refrigerant and cylinder, resulted in contamination of shallow soil and groundwater.

The volume of leaked TCE is unknown. The dimensions of the cylinder and approximate dimensions of the pit suggest that a minimum of 572 gal of TCE and dry ice were required for the test. A maximum of 430 gal of TCE has been estimated to have been released during the test.

4.2.2.3 Location and Results of Previous Investigations

Results of previous sampling for SWMU 091 are summarized in the *Integrated RI/FS Work Plan for WAG 27 at PGDP* (DOE 1998a). Soil and groundwater sampling took place during various investigations including the Phase I and II SIs and the LASAGNA ^{TM} Technology demonstration. In general, many samples (more than 25) have been collected from soil associated with SWMU 091. However, fewer groundwater samples, except those analyzed for TCE and Tc-99, have been collected from this area. In groundwater samples, 24 inorganic, 8 radionuclides, and 11 VOAs were detected at least once. In soil samples, 23 inorganic, 6 radionuclides, 10 SVOAs, and 7 VOAs were detected at least once. Analytes detected in both groundwater and soil include several inorganic, radionuclides, and volatile organic analytes. Detections of SVOAs were restricted to soil.

CERCLA Investigation. The cylinder drop test area was one of the SWMUs investigated during the Phase I and II SIs performed by CH2M HILL. Investigation of the immediate SWMU 091 area included a geophysical survey, construction of four soil borings, and installation of three monitoring wells.

The locations of these borings and wells are shown in Fig. 4.10. Surface geophysical surveys, both terrain electromagnetic conductivity and magnetometry, delineated an anomaly thought to be due to metal in the tank pit fill material. Soil and well borings defined the site stratigraphy and identified elevated volatile organic concentrations in the shallow soils (CH2M HILL 1991 and 1992).

Analysis of groundwater from MW-160, a shallow well completed in a perched groundwater zone, indicated the presence of high dissolved-phase TCE concentrations, (e.g., 164,000 µg/L in March 1991). Only small quantities of TCE were present in the RGA at SWMU 091.

Remediation Technology Demonstration and Implementation. Four rounds of shallow soil sampling and two surface geophysical surveys were conducted at SWMU 091 beginning in January 1993 (Clausen et al. 1996). The first geophysical survey, conducted in January 1993, had little success. In August 1993, a geophysical survey was completed using ground penetrating radar that was able to image the top 20 ft of sediments and identify the shallow water surface and top of the targeted sand and gravel layer.

The first phase of soil sampling was performed in April and May of 1993. The remediation technology known as LASAGNA^{TM} was identified as one that might perform well in soils with low hydraulic conductivities. The second phase of sampling provided pre-test characterization data. The third round followed a limited-scale field test of the technology to determine post-test contaminant levels. The fourth phase, completed in May 1996, was conducted prior to implementation of a more extensive field test.

The bulk of the data collected in these investigations focused on the top 30 ft of sediments. Only six borings, part of the fourth phase, extended below 30 ft and none extended below 40 ft. The analytical data show TCE concentrations decreasing with depth; the highest concentrations occurred in the sandy gravel unit 20 to 25 ft bgs. This suggests that the TCE has not yet reached the RGA and that the TCE in MW-158 and MW-159 is due to an upgradient source. Clausen et al. (1996) suggest that chloride concentrations measured in these two wells support this interpretation. In the 1964 and 1965 tests, chilled brine was used instead of TCE and dry ice to chill a cylinder before testing. Chloride levels in MW-160 indicate some downward migration of brine. If the brine had migrated to the RGA, chloride concentrations should be significantly higher in MW-158 and MW-159 than those measured. Although this probably holds true for dissolved phase TCE, it may not be applicable to DNAPL migration.

The promising technology demonstration involving a limited pilot study in 1995 (reducing TCE by 98.4% in 120 days in an area 15 ft by 10 ft and 15 ft deep) was followed by a full-scale pilot test commencing in August 1996. The area for the Phase II test was 21 ft by 30 ft and 45 ft deep. The results showed that the technology had potential for use in the low-permeability soils at the site, and thus a ROD was signed in August of 1998 for Remedial Action at SWMU 091 using the LASAGNA^{TM} Technology. This action will address TCE in the shallow (< 45 ft bgs) soils to mitigate potential contamination of the RGA.

4.2.2.4 Rationale for RI Field Sampling

On the basis of available data, the nature and extent of contamination at SWMU 091, and the potential for release of contaminants to the environment have been reasonably well characterized, especially with respect to TCE. Releases to nearby surface water from surface soil runoff is unlikely, as the site is covered with gravel. Nonetheless, sediment in the ditches that convey surface runoff water away from the TCE-impacted area had not been investigated. This data gap was one to be filled by WAG 27 activities. To confirm that TCE contamination at the site had not been mobilized by remedial measures and to confirm that TCE had not migrated downward to further contaminate the RGA groundwater, two deep soil borings were to be installed downgradient of SWMU 091 during WAG 27 RI activities. Results of samples collected from the deep soil borings are presented in Sect. 4.2.5.3.

To support future decisions on appropriate actions for this site beyond the remedial action currently being addressed under the ROD, the sampling and analysis plan was developed to supplement existing data where they are inadequate. One such data gap was identified, i.e., insufficient information on the potential impact of subsurface soils by contaminated surface-water runoff from SWMU 091. As a result, a total of four shallow subsurface soil samples were collected (0.3 to 1 ft bgs) from two ditches that convey surface water from the impacted area to the west. Results that exceeded applicable background levels are listed in Tables 4.11 and 4.12. A frequency of detection table (Table 4.13) presents summary information concerning the analytical results exceeding background levels.

4.2.2.5 Nature and Extent of Contamination

Surface Soils–Analytical Results. Analytical results from surface soil samples are as follows.

Organics

VOAs and **SVOAs**. The four surface soil samples collected were not analyzed for VOAs or SVOAs.

PCBs. None of the four surface soil samples collected from locations 091-003, 091-004, 091-005, 091-006 exhibited detectable amounts of PCBs.

Inorganics

Although six metals were detected in the four samples analyzed, only three were reported at concentrations exceeding screening levels and PRGs: aluminum, cadmium, and sodium (Fig. 4.11). Aluminum, found at a concentration of 13,100 mg/kg in the two samples 091-003 and 091-004, was only slightly above the background value of 13,000 mg/kg. Likewise, sodium only slightly exceeded the PGDP background value of 320 mg/kg in the one sample in which it was detected (091-005 exhibited 348 mg/kg). The two samples 091-005 and 091-006 contained 2.93 and 6.53 mg/kg of cadmium, respectively. Cadmium has a PRG of 2.3 mg/kg for the PGDP; therefore, the exceedances are low.

Radionuclides

Of the nine radionuclide isotopes detected in the four soil samples analyzed, only one was above background and PRG values. Sample 091-003 exhibited an activity of 10.7 pCi/g for Pu-239/240, which is slightly above the industrial soil PRG of 10 pCi/g (Fig 4.12).

UCRS–Analytical Results. No new UCRS groundwater data were collected during the WAG 27 RI.

4.2.2.6 Summary of Findings

Figure 4.13 is a revised site conceptual model for SWMU 091 based on the findings of the WAG 27 RI. Contamination related to surface runoff from the known impacted area of SWMU 091 was not found. Four shallow subsurface (0.3 to 1 ft bgs) samples were collected from two east-west-trending ditches located south of the cylinder drop test site in order to assess the surface-water runoff impact from SWMU 091 and to assess migration of contaminants. The two samples collected from the ditch closest to the concrete and steel pad (and to the presumed location of the TCE pit) exhibited only slightly elevated aluminum concentrations. One of these (091-003) also contained low levels of Pu 239/240. The samples collected downgradient of this sample (091-006 and 091-005) contained neither of these constituents above screening levels, suggesting that neither is migrating along the ditch.

Cadmium and sodium were found in samples collected from the ditch located on the south side of the SWMU. Since neither of these metals was detected in samples closer to the impacted soils of SWMU 091, and because sites to the east of SWMU 091 discharge a portion of their surface-water runoff to the ditch from which these samples were collected, an upgradient source is assumed to have contributed these constituents to the ditch.

4.2.3 C-746-A Septic Systems (SWMU 196)

The characterization of SWMU 196 is presented in five subsections. The first presents a history of the SWMU including practices and release descriptions, the second describes the location and results of previous sampling, and the third summarizes the rationale behind the RI sampling efforts. The fourth subsection provides results of the samples analyzed during RI activities, and the fifth summarizes and discusses the findings.

During WAG 15 investigations, 28 soil samples from six locations around an underground storage tank (UST) located just northwest of Building C-746-A were collected and analyzed. Because the UST is located within the limits of the C-746-A Septic System leachfield, the results at the UST investigation were examined as part of the WAG 27 RI.

4.2.3.1 Location and Physical Description

SWMU 196 is located in the north-central portion of the PGDP, on the north side of the C-746-A Building (Fig 3.6). The SWMU consists of two underground, out-of-service septic systems. On the northeast corner, the system consists of a 960-gal septic tank (rectangular: 40 in. wide by 84 in. long and 66 in. deep) that feeds a 60-ft wide and 20-ft long leachfield. The leachfield consists of 4-in. drain tiles in shallow soil.

On the northwest corner, the system consists of a 500-gal septic tank (circular: 5-ft diameter by 3.4 ft deep) 47 ft east of a junction box that feeds two 4-in. vitreous clay pipes, 100 ft long extending south, and 130 ft long extending west, in shallow (1 to 2 ft bgs) soil (Fig. 4.14). According to a field topographic survey of the drainage ditch on the west end of C-746-A, the 500-gal septic tank is separated from the clay pipes at a point approximately 28 ft downgradient from the tank. Approximately 25 ft of clay pipe and the junction box were destroyed as a result of regrading the ditch.

An abandoned UST, formerly used for fuel oil storage, is located just northwest of Building C-746-A. A pipeline extends from the UST to the building.

4.2.3.2 Site History

C-746-A was used as a warehouse during plant construction. Subsequent operations consisted primarily of metal storage and smelting. From 1956 to 1985, an aluminum smelter was operated in the west end of the building, and from 1975 to 1985, a nickel smelter was operated in the east end of the building. Current operations include storage of hazardous and PCB waste. A 1993 DOE/USEC facility transition report states that there is a potential for heavy metal and radiological contamination in the septic systems.

The northeast septic system was in operation from April 1958 to February 1980. The system originally processed sanitary waste from a toilet, a urinal, a bathroom floor drain, and a bathroom sink. Modifications were made in August 1975, when a change house and break area were added as part of the nickel smelter operation. The septic system then processed sanitary waste from a kitchen sink, a water cooler, two showers, a second urinal, and the change house floor drains, as well as the original toilet, urinal, bathroom floor drain, and bathroom sink. In 1980, the septic system was plugged and abandoned in place when C-746-A was tied into the C-615 sewage treatment plant system.

The northwest septic system was in operation from November 1956 to February 1980. The system processed sanitary waste from a toilet, two showers, a sink, and a water cooler installed shortly after construction of the aluminum smelter operation. No floor drain system exists in this area. In 1980, the septic system was plugged and abandoned in place when C-746-A was tied into the C-615 sewage treatment plant system. In 1982, regrading of a drainage ditch on the west end of C-746-A resulted in the destruction of approximately 25 ft of the vitreous clay pipe. Some sanitary waste that was in the 4-in. line upgradient (28 ft) at the time of abandonment in 1980 may have been released to the sediments of the drainage ditch as a result of the regrading and destruction; however, since the septic system was plugged during abandonment, this was not a continuing release into the ditch.

The UST (SWMU 139) northwest of Building C-746-A was investigated in 1996 during WAG 15 activities. No COCs were found to pose risk to human health and the environment. Additional sampling was conducted in 1998 as part of a continuing investigation of this UST.

4.2.3.3 Location and Results of Previous Sampling

SWMU 196 was first defined in 1993. Due to its recent addition, it was not one of the areas sampled during the CERCLA Phase I and II SIs. During WAG 15 activities, 28 soil samples collected from six DPT soil borings to a 15-ft depth were analyzed in SWMU 139 for TCE, PCBs, benzene, toluene, ethylbenzene, and xylenes (BTEX), PAHs, RCRA metals, and radiological (total uranium, gross alpha/beta) contamination. Five sample locations were around the UST, and one was along the pipeline from the UST to Building C-746-A. The UST is located northwest of the northwest septic system; WAG 27 soil boring location 196-016, which was drilled near the UST, had to be abandoned because the DPT had refusal at approximately 3 ft bgs.

No BTEX compounds were detected in any of the soil samples. Sporadic low-level detects of several diesel-range organic (DRO) constituents were reported in several borings on the northeast side of the UST. One PAH, phenathrene, was detected in one soil sample. Metals and radioactivity were below quantitation limits or within PGDP background levels.

The information from this study was insufficient to provide a complete characterization of contamination associated with the septic systems. The detailed analytical data on the UST are presented in *Final Report for WAG 15, C-200-A UST and C-710-B UST Paducah Gaseous Diffusion Plant Paducah, Kentucky (DOE/OR/07-1540 & D1)* (DOE 1996c).

The UST (SWMU 139) is currently being re-investigated as a result of the detection of DRO constituents in soil from location 196-002 during WAG 27 activities.

4.2.3.4 Rationale for RI Field Sampling

SWMU 196 was originally included in WAG 27 to investigate the possibility of potential contaminant releases of TCE emanating from the C-746-A area. The release of TCE through the septic systems could be a contributing source of TCE to the UCRS and RGA. The discharge of TCE into the septic systems was considered highly unlikely but not impossible. A more likely release potential of TCE in the C-746-A area would have been through an unrecorded product spill or a waste discharge of TCE onto the ground in the warehouse area, although no specific releases have been documented at the SWMU.

Given the nature of the activities and facilities at SWMU 196, several other types of contamination could exist. Metals, particularly aluminum and nickel, could have entered the septic systems through the showers, sinks, and the northeast change house floor drain. Some of these metals were contaminated with uranium. Sanitary waste, potentially laden with radioactive heavy metals, would have been processed through the septic tanks and distributed into vitreous clay drain tile leachfield lines.

Because inorganics and uranium are relatively immobile in soils, the extent of contamination was not expected to exceed several feet beyond the subsurface lines. As a result, most of the samples were collected at locations adjacent to the lines and from varying depths up to 20 ft bgs. Samples from the septic tanks were collected to refine the list of potential COCs. In January and February 1998, residual liquid and sludge that were present in the two septic tanks were pumped out into drums and sampled. Three samples from the northwest tank (CDM sample numbers 196-001, -003, and –005) and three samples from the northeast tank (CDM sample numbers 196-002,-004, and-006) were analyzed for metals, PCBs, and radioactivity. A detailed description of these activities (sampling and abandonment of the septic tanks at SWMU 196) is presented in the *Geophysical Survey and Excavation Report* prepared by TNA/CDM in Appendix F.

All 93 soil samples collected, including 4 duplicates, were analyzed for metals and radionuclide activity, and a select group of 39 samples, including two duplicates, was submitted for VOA analysis. The original borings were sampled for VOA analysis. However, after these analyses returned as non-detects, VOAs were not included as potential COCs in subsequent sampling.

Northeast Septic System. The northeast septic system is entirely subsurface. Therefore, any potential COCs that would have been processed through this system would be in the subsurface soils beneath the vitreous clay drain tiles of the leachate system and the concrete septic tank. Samples from the tanks were collected to refine the list of potential COCs. Sampling of surface and subsurface soil was conducted at a total of 7 locations surrounding the 4-in. vitreous clay drain tiles and adjacent to the tanks. Four sample locations were within a few feet of these leachate lines, and 3 were approximately 20 ft away from the lines' ends. Subsurface soil samples were taken continuously at 2-ft intervals to a depth of 10 ft bgs at locations 196-008 through 196-011, and to 20 ft bgs at locations 196-013 through 196-015.

Northwest Septic System. The northwest septic system had a greater potential for contaminant release because approximately 25 ft of vitreous clay drain tiles were destroyed during excavation and regrading of a drainage ditch on the west end of C-746-A in 1982, 2 years after the septic system was plugged and abandoned in place. In addition to potential COCs that may exist in the subsurface soils beneath the vitreous clay drain tiles of the leachate system and the concrete septic tank, there is a release potential from the discharge of sanitary wastes in the abandoned septic system upgradient of the demolished portion of the line. However, because the septic system was plugged and abandoned, the release of material could occur only until equilibrium was restored with the septic tank. Another unlikely, yet potential area for contamination was identified as the drainage ditch surface sediments downgradient from the broken vitreous clay line.

Surface and subsurface soil samples were collected at a total of eight points adjacent to the 4-in. vitreous clay pipes (extending west and south) encompassing the leachfield. Subsurface soil samples were taken continuously at 2-ft intervals to a depth of 8, 10, or 20 ft bgs (196-001 through 004, 196-017, 196-018). Along the pipeline extending north-south, two sediment samples (196-006 and 196-007) were collected. One of these was between the septic tank and the destroyed clay line to assess the potential impact of any remaining liquid in the abandoned tank.

A cone penetrometer test (CPT) was conducted at location 196-012 adjacent to the leachate line extending to the west to determine the presence of UCRS groundwater. The position of the CPT point was changed from that proposed in the WAG 27 Work Plan due to limitations in rig access; thus the test was conducted approximately 100 ft west of Building C-746-A. The CPT point was pushed to refusal, which was 35 ft bgs. No water was encountered, and PID screening indicated no VOAs present in the soil. Therefore, no samples were submitted for VOA analysis.

4.2.3.5 Nature and Extent of Contamination

Surface Soil, Sediment, Subsurface Soil, and Sludge Samples-Analytical Results. SWMU 196 sample results that exceeded applicable background levels are listed in Tables 4.14 through 4.16. A frequency of detection table (Table 4.17) presents summary information concerning the analytical results exceeding background values.

Organics

VOAs. Eight surface and 31 subsurface soil samples from a total of 8 sample locations within SWMU 196 were analyzed for VOAs. No VOAs were detected in the soil between 0 and 10 ft bgs at either area surrounding the septic systems. PID readings from soil during the CPT test indicated no impact by VOAs.

SVOAs and PCBs. None of the soil samples collected from SWMU 196 during the WAG 27 RI were analyzed for SVOAs or PCBs. The results from the septic tank sludge exhibited PCB concentrations of only 100 to 300 μg/kg in the northwest tank. SVOAs were not analyzed for in the septic sludge sample.

Inorganics

Sludge from the northwest tank showed slightly elevated concentrations of four metals (barium, nickel, lead, and selenium), and the northeast tank contained three metals (barium, nickel, and lead), also at slightly elevated concentrations. Eighteen metals were detected above background and PRG values in the 93 soil samples analyzed from SWMU 196; however, many only slightly exceeded their respective screening values. The most frequent exception was antimony, which was found in three of eight locations (Fig. 4.15). The three samples associated with the northwest septic system lines that contained elevated antimony at varying depths were 196-001, 196-002, and 196-004, with maximum values of 61.5 mg/kg, 62.2 mg/kg, and 9.8 mg/kg. No antimony was detected in samples from five locations adjacent to the northwest septic system.

Samples collected from five locations near the northeast septic system contained elevated antimony concentrations. These locations were 196-008 through 196-011 and 196-013, with maximum antimony values ranging from 0.76 to 121 mg/kg. Generally, the highest antimony value from each location was observed in the surface sample and a sharp decrease in concentrations, often to "non-detect" (ND) was discernible with increasing depth. One exception is location 196-002,which had fairly stable concentrations throughout the profile, including 58.9 mg/kg at 10 ft bgs, the soil boring's final depth.

In addition to the high antimony concentrations (more than 300 times the PRG), a soil sample taken from 4 to 6 ft bgs at location 196-013 contained the highest concentration of seven other metals: beryllium, cadmium, lead, potassium, silver, sodium, and thallium (Fig. 4.16). The significant elevations included beryllium at 113 mg/kg, 164 times the PGDP background value; cadmium at 116 mg/kg, exceeding the PRG value by a factor of 50; and thallium at 114 mg/kg, or 335 times the background level.

Even though aluminum, calcium, magnesium, and sodium were frequently detected above their respective screening values, the concentrations were generally less than three times the background value. Nickel was found in only two samples (196-014 and 196-015), with concentrations of 587 and 365 mg/kg, respectively (the PRG is 240 mg/kg). Figure 4.17 shows the distribution of aluminum and nickel detected above background and PRG screening levels.

Radionuclides

The activities of radionuclides in the sludge samples were below PGDP background levels. Also, no radioactivity above the screening levels was detected in the 93 soil samples analyzed.

4.2.3.6 Summary of Findings

Figure 4.18 is a revised site conceptual model for SWMU 196 based on the findings of the WAG 27 RI. Although several metals were found in surface and subsurface samples across the SWMU, neither VOAs nor radiological constituents were detected in any samples. Samples analyzed during the investigation of residual sludge and liquids within the septic tanks exhibited low PCB concentrations (300 ug/kg to ND), so no additional samples were tested for this constituent group from the surrounding soils. Although Building C-746-A housed aluminum and nickel smelter operations for many years, neither constituent was found in high concentrations along the various septic leaching lines or their outlets. The septic systems apparently processed primarily sanitary waste, for which they were designed. Some septic system specific observations (NE and NW) are described below.

NE Septic System. Surface and subsurface soil sample location 196-013 near the east end of the 4-in. vitreous clay drain tiles of the northernmost leach lines exhibited several elevated metals concentrations, especially from 4 to 6 ft bgs. This location contained the highest concentrations of antimony, beryllium, cadmium, and thallium among all the SWMU 196 locations. Samples collected from other locations near the east end of the leach lines also showed elevated antimony (196-008 and 196-009), while the samples collected further away from these lines (196-014, 196-015, and 196-010) contained very low to no metals concentrations. This suggests that the lines are the source of the metals, but the extent of the impacted soil remains very limited, as the metals are not mobile in the unsaturated silty clay encountered from the surface to 20 ft bgs.

The fact that antimony concentrations decrease with depth suggests that the impact does not extend beyond the 10- to 20-ft depth. Although the eastern portion of the building was used for nickel smelting operations, only two samples exhibited nickel concentrations above screening values–and those exceedances were only slight. Four of the seven samples from this area contained minor concentrations of aluminum above the screening values.

NW Septic System. Overall, this area showed little evidence of impact from potential COCs; however, three of the nine sample locations exhibited elevated antimony concentrations. Two of these (196-001 and 196-002) are located along the septic system lines close to the northwest corner of the C-746-A Building, and the other is adjacent to the line extending north-south approximately 80 ft south of the septic tank (196-004). Generally, the concentration of antimony in soil samples decreased with increasing depth.

Despite the fact that aluminum smelter operations were conducted in the western portion of the C-746-A Building, only two sample locations (196-017 and 196-018) exhibited elevated values, and at both the exceedance was slight. The incident that caused 25 ft of vitreous clay drain tiles to be destroyed during excavation and regrading of a drainage ditch west of C-746-A does not appear to have had any influence on the subsurface, as suggested by the limited contamination found at location 196-004.

4.2.4 C-720 Complex

4.2.4.1 Location and Physical Description

The C-720 Building is located in the west-central area of PGDP (Fig 3.6) to the southwest of the C-400 Building. The C-720 Building consists of several repair and machine shops, as well as other support operations. The building was constructed in 1953 and encompasses 281,200 sq ft. Five SWMUs are associated with this building. SWMU 090 (an underground petroleum naphtha pipe) and SWMU 141 (an inactive TCE degreaser) have been designated as NFA in the PGDP SMP (DOE 1998b). SWMU 027 (acid neutralization tank) is currently being addressed under WAG 9, and SWMU 031 (compressor pit storage tank) is being addressed under WAG 5.

This investigation focused on the building drainage system exit points, SWMU 167 (White Room sump), and the Compressor Shop pit, which is located in the eastern portion of the C-720 Building. The building drainage system discharges to the plant stormwater system.

Compressor Shop Pit. The Compressor Shop pit is located in the east-central portion of the C-720 Building (Fig 4.19). The pit is 30 ft long by 60 ft wide by 15 ft deep, and the walls and floor are constructed of concrete that is 15 and 22 in. thick, respectively. The walls and floor of the pit, as well as the sump, have "ironite waterproofing." The floor is sloped toward a central drain at a grade of 1.5 in. per ft. A sump, 4 ft wide by 4 ft long by 8 ft 4 in. deep, was installed in the northwest corner of the pit. The sump walls and floor are constructed of unjointed, reinforced concrete that is 12 and 15 in. thick, respectively. Access to the sump is available through a 42-in.-diameter manhole.

A subsurface 4-in.-diameter open jointed drain, which is constructed of vitreous clay tile, surrounds the pit and is located at approximately the same elevation as the base of the pit footings (approximately 20 ft bgs). The open joints are spaced approximately ½-in. apart, and the upper portion of the joints is covered with tarpaper. The lower portion of the joints is open, allowing drainage into surrounding soils. According to a detail on the plan of underground plumbing for the C-720 Building, approximately 12 in. of gravel was packed around the drain prior to backfilling. The drain is gravity-sloped downward from east to west, with the lowest elevation being the connection point between the drain and the sump noted above.

Based on a review of the plumbing plan, the vitreous clay drain that surrounds the pit extends outside the eastern exterior wall of the C-720 Building. A duplex sump pump was used to empty the sump. Figure 4.20 depicts the approximate location of the subterranean drain, as well as details of its construction.

In April 1973, plans were approved to upgrade the floor drain in the Compressor Shop pit. A second sump, with interior dimensions of 2 ft wide by 2 ft long by 4 ft deep, was installed in the location of the floor drain. The walls and floor of the second sump were constructed with 6-in.-thick, unjointed reinforced concrete, and the second sump was lined with 1/4-in.-thick 304 L stainless-steel, which was welded together to hold liquids. A 1750-revolutions-per-minute (rpm) stainless-steel self-priming pump drains the second sump. The pump discharges to a floor drain located immediately north of the pit area, which ultimately discharges to the building drainage system.

In April 1974, plans were approved to install a degreaser, with dimensions of 6.5 ft wide by 6.5 ft long by 18 ft deep, in the southwest corner of the Compressor Shop pit. A 300-gal storage tank was installed at the base of the degreaser. TCE released from the degreaser discharged via aboveground piping to the C-720 Compressor Shop pit water storage tank (SWMU 031, WAG 5). The degreaser, referred to as SWMU 141, was active during the 1970s, and was "clean-closed" under RCRA in 1994 (Simmons Engineering 1994). SWMU 141 is designated as NFA in the PGDP SMP (DOE 1998b).

SWMU 167. The White Room sump is located in the south-central portion of the C-720 Building (Fig 4.19). The sump has dimensions of 8 ft long by 6 ft wide by 8 ft deep and is constructed of concrete. The sump was constructed as a baffle. Influent to the sump was directed through limestone to neutralize any acids prior to discharging to the building drainage system. This sump was active from the mid-1960s through the mid-1970s as part of the "clean room" operations, which manufactured electric circuit boards for Sandia National Laboratories. The sump is no longer in use and is covered with a metal plate.

Building Drainage System Exit Points. Eight major building drainage system exit points from the C-720 Building have been identified (Fig 4.19) and all eight discharge to the plant stormwater system. Approximately 150 floor drains are located within the C-720 Building; however, many are currently plugged and a few are backed up. Although most of the floor drains discharge into the stormwater drainage system, floor drains located in the bathrooms discharge to the sanitary water system, and a few floor drains located in the instrument shop in the northeast portion of the C-720 Building discharge to the acid neutralization pit. Storm sewers are constructed of either reinforced concrete piping or vitreous clay piping. The stormwater system at the PGDP discharges to on-site ditches, which direct runoff and site discharges to off-site streams. (Note: The Surface Water OU is addressed under WAGs 18 and 25.)

4.2.4.2 Site History

Compressor Shop Pit. Fluids drained from compressors in the shop were directed into the compressor trench, which is located to the west of the pit. One floor drain located in the compressor trench drains by gravity from west to east into the Compressor Shop pit. The design of the pit is such that if the sump pump located in the northwest portion of the pit fails and if liquid fills the sump to the height at which the subterranean drain discharges into the sump (3.5 ft above the bottom of the sump), the liquid will back up into the subterranean drain and (because of the construction of the drain system) will be released into the surrounding soil. There are no documented releases of this nature; therefore, no quantitative estimates are available. However, because of the building's age and the nature of the processes, the subterranean drain is considered to be a potential source of the existing TCE groundwater contamination in the vicinity of the C-720 Building. This area is still in use on a minimal basis for compressor reworking.

Based on practices performed in this area, the analytes of interest associated with these processes include SVOAs (in the fluid discharged from the compressors), TCE and its degradation products (degreasing agents), and metals and radionuclides (both released during the degreasing process).

SWMU 167. The White Room was used to build and clean circuit boards. Waste solutions associated with printed circuit board operations were discharged to the sump, flushed through limestone to neutralize acids, and ultimately discharged to the building drainage system. Wastes associated with processes performed in this area include TCE, cyanide, gold, silver, tin, lead, and chromium. According to the SWMU Assessment Report (SAR) 167, the integrity of the sump has not been established and therefore the sump should be considered a possible pathway for release. The sump is no longer in use, and the sludge in the sump was sampled to determine whether any potential health hazard existed if the sump were to remain unfilled. PCBs were detected in the sludge at concentrations ranging from 1.8 to 2.5 mg/kg.

Building Drainage System Exit Points. A thorough blueprint review and a process history review of general activities performed in the C-720 Building were conducted. The findings suggest that the backfill areas in the vicinity of the building drainage system exit points, as they connect to the storm sewer system, are potential release pathways of contaminants to the subsurface. Several maintenance and repair operations were performed in this building, and the major discharge location for wastewater from these processes was through the floor drains located throughout the building. Based on the construction of the drains, the connecting joints from the drainage system to the storm sewer system appear to be the most likely source of a release. TCE, radionuclides, mineral spirits, and various other electrical cleaning fluids have reportedly been discharged through the stormwater or sanitary water drains within the C-720 Building. Mercury that was used as part of the C-720 Building process was routed through an acid drain line to a building sump prior to discharge.

Stormwater lines that had extended to the north of the C-720 Building may have been relocated at the time of the construction of the C-720-C addition (approved for construction in 1971). Specifications of the construction and/or relocation activities with regard to the sewer lines are not available.

4.2.4.3 Location and Results of Previous Sampling

The White Room sump (SWMU 167) was sampled during two separate events. During the first event (July 1992), the sludge was analyzed for total cyanide to establish if any health threats in the C-720 Building existed and to provide guidance for future sampling events. Cyanide compounds were not detected. The sump sludge was sampled a second time (December 1992) and was analyzed for RCRA corrosivity parameters, RCRA ignitablility parameters, RCRA reactivity parameters, TCLP metals, TCLP volatile organics, TCLP semivolatile organics, bulk metals, raw volatile organics including bulk TCE, bulk semivolatile organics, PCBs, and radionuclides. According to internal correspondence from D. F. Hutcheson, Jr. to D. M. Ulrich, dated May 11, 1993, PCBs were detected at a concentration that ranged from 1.8 to 2.5 mg/L. The detected uranium activity was below the plant limit of 17 pCi/g (D. F. Hutcheson, Jr. 1993), and no other radionuclides were detected. All other above-listed analyses resulted in concentrations below regulatory limits; the sludge was therefore determined to be RCRA nonhazardous.

A monitoring well pair (MW-203 and MW-204) was installed to the northeast of the C-720 Building during the CERCLA Phase II SI (Fig 4.21). These wells were installed to assess contamination associated with SWMUs 027 (acid neutralization tank) and 141 (an inactive TCE degreaser). MW-204 was drilled to a depth of 55 ft bgs and was screened in the UCRS. Contaminants detected in a groundwater sample from MW-204 included TCE, TCE degradation products, and metals. Zinc, vanadium, and beryllium were detected at concentrations above reference values during total metals analysis; however, dissolved phase metals were not detected above reference values (CH2M HILL 1992).

Reference values are defined in the Phase II report (CH2M HILL 1992) as "those that are representative of naturally occurring conditions or conditions resulting from other, non-plant-related activities, such as fallout." TCE concentrations detected in the RGA well (MW-203) were lower than those detected in MW-204. Total and dissolved metal concentrations were comparable to those detected in MW-204. Technetium-99 activities were significantly higher in MW-204, the shallower well (843 to 950 pCi/L), than in the deeper RGA well (21 to 22 pCi/L). Plutonium-239 was detected in both wells at similar activities, 1.9 pCi/L in MW-203 and 1.5 pCi/L in MW-204.

Recent groundwater monitoring data for MW-203 and MW-204 were collected in August of 1996 and December of 1994, respectively. TCE was detected at concentrations of 33 µg/L (MW-203) and 320 µg/L (MW-204).

Soil boring P4H7 was located to the northeast of the C-720 Building (Fig 4.19) and was installed in association with the Northeast Plume study in 1994. A groundwater sample was collected at the top of the RGA and analyzed for TCE using both a field GC and a fixed-base laboratory; TCE concentrations were 6329 µg/L and 12,000 µg/L, respectively. An additional groundwater sample collected from the bottom of the RGA in boring P4H7 contained TCE at a concentration of 48 µg/L.

Monitoring wells MW-217 and MW-218, both of which are UCRS wells, are located to the south of the C-720 Building. These wells were installed in association with an UST investigation that was performed in 1992. MW-217 was drilled to a depth of 53 ft bgs and MW-218 was drilled to a depth of 40 ft bgs; both were screened in the UCRS. TCE was detected in groundwater samples collected during three sampling events from MW-218 at concentrations of 230 µg/L (1992), 180 µg/L (1992), and 59 µg/L (1993).

4.2.4.4 Rationale for RI Field Sampling

The C-720 Complex was included in WAG 27 because it was recognized as a possible source of TCE contamination in the southwestern part of the plant during the Phase IV groundwater investigation. The following were compiled and evaluated to establish release potentials from possible contaminant source areas within the C-720 Building: findings from a review of available data pertaining to process descriptions, blueprint reviews, interviews with former employees, and analytical data from monitoring wells and a previously installed boring located near the C-720 Building.

The release potential from contaminant sources in the Compressor Shop was determined to be high due to the design of the subterranean drain surrounding the pit. The drain was used as a discharge mechanism in the event that the sump pump located in the northwestern portion of the pit failed to operate. Based on the design of the drain lines, liquids that accumulated in the sump during pump failure would discharge to the surrounding soils via this line. Potential contaminants associated with the Compressor Shop included VOAs, primarily TCE and its degradation products, SVOAs, PCBs, metals, and radionuclides. Samples were collected from the sump and surrounding soils near the pit to characterize the nature and extent of contaminants in this area.

Release potential from the White Room sump was considered low. Any analytes of concern that would have been processed through the White Room sump would have been discharged to the building drainage system. Based on available data, the integrity of the sump itself has not been established; however, there is no evidence of a release from the sump. As discussed earlier, analytes of concern from the White Room sump are primarily metals, VOAs, and radionuclides. Soil borings were completed in the area south of the C-720 Building where a release of contaminants from this sump would have been detected.

The contaminant release potential was considered moderately high in the backfill areas surrounding the major building drainage system exit points from the C-720 Building. No releases are known to have occurred from the drainage system. The drains are constructed of reinforced concrete piping and vitreous clay piping. The integrity of vitreous clay piping in general has historically been poor and is therefore suspect. The connecting joints from the building drainage system to the storm sewer system are considered the most likely release points, and were therefore a focus of the investigation.

The drain system network connected to the exit points drains various shops within the C-720 Building, including the Compressor Shop, machine shop, paint shop, instrument shop, and valve shop. Because of activities within these shops, potential contaminants discharged to the drainage system include VOAs, SVOAs, metals, PCBs, and radionuclides. Soil borings were located at the drainage system exit points to investigate potential releases to the drainage system.

Another area was identified during the field investigation as having a moderately high release potential. Based on interviews with former employees, routine equipment cleaning and rinsing was performed in the area north of the east end of the C-720 Building. Solvents were used to clean parts, and the excess solvent was discharged on the ground. TCE, its degradation products, and metals are the primary analytes of concern in this area. Soil borings were completed in the area to determine the release potential in this area.

Deep borings, penetrating the McNairy Formation, were completed surrounding the C-720 Building to investigate contaminants in the RGA and McNairy from possible source areas at this site.

4.2.4.5 Nature and Extent of Contamination

Subsurface Soils–Analytical Results. To determine the nature and extent of contamination found within the C-720 Complex, samples of subsurface soils were collected. These samples were analyzed for suites of constituents in VOAs, SVOAs, PCBs, inorganics, and radionuclides. Most of the area surrounding C-720 is covered with asphalt or concrete, so the collection of surface soil samples was unnecessary. Additionally, no potential sources that might impact surface soils were identified in the initial contaminant source survey. Shallow (50-ft) borings were completed to investigate the drainage system exit points.

A total of 122 subsurface soil samples were collected from depths ranging from 5 to 50 ft at 16 locations (Fig 4.21). Two of these borings were located to investigate other potential sources identified during the field investigation. Boring 720-030 was drilled to investigate anomalously high flame ionization detector (FID) readings encountered at boring 720-029. The analyses for these samples differed slightly from those of the other borings and included VOA, SVOA, and radiological isotopes.

The results of all analyses that exceeded applicable background levels are presented in Tables 4.18 through 4.22. A frequency of detection table (Table 4.23) presents summary information concerning analytical results exceeding background values.

Organics

VOAs. Only eight VOA compounds were detected in the subsurface soil samples at the C-720 Complex. TCE and its degradation products were the most common compounds detected, but were present at very low frequencies. TCE was the most common VOA detected above screening levels.

The maximum TCE concentration, 68,000 µg/kg, was detected at boring 720-002 (Fig 4.22). Vinyl chloride at a concentration of 400 µg/kg and trans-1,2-dichloroethene at an estimated concentration of 450,000 µg/kg also had maximum detections in this boring. VOAs were detected throughout the entire depth of this boring (Fig 4.23), which was terminated at 25 ft bgs due to refusal. Vinyl chloride was also detected at a concentration of 400 µg/kg at a depth of 22 to 24 ft in boring 720-001.

In addition to boring 720-002, TCE was also detected in four other borings located along the building drainage system: 720-004, 720-005, 720-007, and 720-008. At boring 720-004, TCE was reported at 1300 µg/kg from 25 ft bgs. At boring 720-005, TCE was detected above screening levels from 10 to 30 ft bgs at concentrations ranging from 1600 to 17,000 µg/kg. Detections at 720-007 were 800 and 14,000 µg/kg at depths from 27 to 38 and 25 to 32 ft, respectively. Boring 720-008 had detections of TCE (above screening levels) of 400 and 1600 µg/kg at depths of 26 and 32 ft, respectively, and 1,1-DCE of 200 µg/kg at 32 ft bgs.

Appreciable concentrations of TCE also were found in samples from boring 720-027, which was drilled near a reported outside parts wash area in which TCE was used to clean used parts. Concentrations from 500 to 8100 µg/kg were detected at depths of 20 to 35 ft.

SVOAs. Few SVOAs were detected in the subsurface soils at the C-720 Complex. The most significant concentrations were observed in boring 720-024. One contaminant, bis(2-ethylhexyl)phthalate (BEHP), was detected in this boring above the PRG of 880 µg/kg at concentrations ranging from 890 to 1100 µg/kg (Fig. 4.24). Low concentrations of BEHP were detected at several other borings; however, each of these detects was well below the screening level. Notably, BEHP was detected in only one sample from boring 720-005 at a depth of 30 ft. This boring is located immediately north (upgradient) of 720-024 along the storm drain exit point from C-720. The absence of BEHP at significant concentrations in 720-005 suggests that the source of BEHP in 720-024 may not have been C-720.

BEHP is a common laboratory contaminant; however, it was detected in samples from the White Room sump and the Compressor Shop pit sump within the C-720 Building at high concentrations. Discussions with former employees indicate that the material was used in an aerosol form to test HEPA filters and as vacuum pump oil. Di-n-octylphthalate, an isomer of BEHP, was detected at five locations, but none above screening levels. One other SVOA contaminant, 4-chloro-3-methylphenol, was detected in sample 720006SA015 at a concentration of 40 µg/kg at 15 to 18 ft.

PCBs. A total of 117 samples were screened for PCBs in the C-720 Complex subsurface soils. No samples had detectable concentrations of PCBs. Twelve samples were also shipped to a fixed-base laboratory for confirmation of the field screens. No PCBs were detected in these samples.

Inorganics

All of the borings sampled for metals in subsurface soils had one or more values above screening levels (background and PRGs) (Fig. 4.25). The most common metals detected were beryllium, vanadium, sodium, and antimony at frequency of detects above screening levels of 20%, 13%, 12%, and 10%, respectively. Other metals detected above the screening levels included aluminum, arsenic, cadmium, iron, lead, magnesium, mercury, potassium, silver, and thallium. Each of these metals was detected at a frequency of less than 10%.

Boring 720-024 had anomalous concentrations of metals in subsurface soil samples from a depth of 35 to 48 ft. Water was encountered in the boring at 33 ft. Soil samples with the highest metals concentrations were generally collected from below the water table, where geochemical conditions may have contributed to the precipitation of the metals. Many of the analytes detected in 720-024 were not detected elsewhere. Concentrations of these metals greatly exceeded background–by as much as 400 times for some analytes. PGDP background values are listed in Table 4.1. Cadmium, magnesium, potassium, and silver were detected above screening levels only in boring 720-024.

Other than in boring 720-024, beryllium exceeded screening levels in 10 borings with a maximum concentration of 1.99 mg/kg at a depth of 23 ft in boring 720-027. Antimony exceeded screening levels in 5 borings, reaching a maximum in boring 720-027 of 1.59 mg/kg at a depth of 23 ft. Vanadium was detected in 6 borings above the PRG and background screening levels. The highest concentration (63.3 mg/kg) was also detected in boring 720-027 at 23 ft bgs. Sodium was detected above the PRG and background at 3 locations, and every sample collected from boring 720-022 had detects exceeding this level. Arsenic, lead, and mercury were detected only once in subsurface soils above PRGs and background. Boring 720-027 had an arsenic concentration of 10 mg/kg at a depth of 10 to 13 ft and a mercury concentration of 0.96 mg/kg at a depth of 15 to18 ft. Lead was detected at a concentration of 139 mg/kg in boring 720-002 at a depth of 12 to 16 ft. Aluminum was detected slightly above background in boring 720-021 at a concentration of 12,100 mg/kg at a depth of 23 ft.

Radionuclides

Thirty-eight samples were collected for radiological isotopic analysis. Forty-nine samples were collected for Tc-99 analysis. No isotopes were detected above screening levels in subsurface soils.

UCRS Groundwater–Analytical Results. Sufficient water was not typically encountered in the shallow subsurface strata to allow a water sample to be collected during the drilling of the soil borings. A total of only five grab water samples were collected for analyses from the C-720 Complex. Samples were collected from borings 720-002, 720-003, 720-011, 720-022, and 720-024. Table 4.22 presents a complete list of all the analytes and their respective concentrations or activities that were detected above background levels in the UCRS groundwater samples. The frequency of detection, mean concentration, and maximum concentration for each reported compound are presented in Table 4.23. All five of the UCRS water samples were collected in locations adjacent to the south and east sides of the C-720 Building. Coincidentally, a break in a water main located approximately 150 feet south of the building was being repaired during the RI. Therefore, the water recovered from the UCRS in this area may have been sourced from this broken water line.

Organics

VOAs were the only organic compounds for which the UCRS samples were analyzed. TCE was the only VOA to exceed screening levels in three of the five samples collected. The highest TCE content reported was 149 µg/L from a sample collected between 3 and 8 ft bgs on the south side of the C-720 Building at location 720-002 (Fig. 4.26). The sample was collected in close proximity to a building drainage exit point. Other VOAs detected in the UCRS groundwater included 1,1-dichloroethene and trans-1,1-dichloroethene, each of which was detected twice, and cis-1,2-dichloroethene and vinyl chloride, each of which was reported above screening levels in only one sample.

Inorganics

Due to the low volume of water recovered from the UCRS zone, none of the groundwater samples collected from the UCRS at the C-720 Complex were analyzed for the presence of metals.

Radionuclides

Four of the UCRS groundwater samples collected at the C-720 Complex were analyzed for radionuclides. No radionuclides were detected at concentrations above screening levels from any of the samples.

Compressor Shop Pit Sump–Analytical Results. One sample was collected from the sump within the northwest corner of the Compressor Shop pit. The sump was sampled to determine if an appreciable amount of sludge was present and if the sludge was hazardous or may be a source of contamination. Once the sump was opened, standing water was observed to a depth of approximately 2 to 3 ft below the floor of the pit (total of 4 ft). The water level was noted to be above the subterranean drain opening. Standing water was observed in the sump, so it is likely that the drain was clogged and no release from the sump was occurring at that time. The sample collected from the bottom of the sump was a dark ooze with a high liquid content. Several contaminants, including metals, PCBs, radionuclides, SVOA, and VOAs, were present in the sludge (Fig. 4.27). Metals included chromium, nickel, lead, and cadmium at concentrations of 724, 644, 138, and 4.32 mg/kg, respectively. Radiological isotopes included U-234, U-235, and U-238, Tc-99, and Np-237 at concentrations of 6167, 348, 10,480, 27,520.6, and 267 pCi/g, respectively.

The only SVOA detected was BEHP at a concentration of 170,000 µg/kg. PCBs included Aroclor 1254 and 1260 at concentrations of 2700 and 700 µg/kg, respectively. Two volatile organics, TCE and 1,1-DCE, were detected at concentrations of 420,000 and 2800 µg/kg, respectively. These concentrations were among the highest observed at the site.

As a result of this investigation, the Compressor Shop Pit sump is being designated as a separate SWMU (SWMU 209) and will undergo additional assessment in the future.

4.2.4.6 Summary of Findings

Contaminants related to potential releases at the C-720 Complex included VOAs, SVOAs, metals, and radiological contaminants. All 15 borings sampled for metals had detections of some analytes above screening levels. Eight of the 16 borings sampled for VOAs had detections above screening levels; only two borings had detections exceeding the screening levels for SVOAs.

A revised site conceptual model for the C-720 Complex is presented in Fig. 4.28. This model is based on the results of the WAG 27 RI and depicts the general stratigraphy at the C-720 Complex, areas of soil and shallow groundwater contamination detected in the partially saturated zone of the UCRS, and the probable pathway of contaminant transport into the RGA. Contaminants, primarily TCE, detected in the RGA beneath the site are likely being leached from the overlying UCD sediments where past releases to the shallow subsurface occurred. Leaks of contaminants from the Compressor Shop Pit Sump are not believed to be occurring at this time.

Several sites were identified where significant releases may have occurred at the C-720 Complex. First, an area south of the east end of the building displayed the highest VOA concentrations in the soil. The source of these contaminants may be the connection between the drain exit point and the storm drain at location 720-002. The depth of the storm drain was noted as 5.3 ft bgs on plant utility drawings. Volatiles, primarily TCE, were found throughout the upper 50 ft of soil at this location. This drain exit collected water from more than 20 drains located in the machine shop, Compressor Shop, vacuum pump shop, and valve shop. In these operations, solvents were routinely used for cleaning parts and machinery. Lead was the only other contaminant detected in this boring. Migration of TCE may have occurred along the stormwater line to the west, given the TCE detection in shallow groundwater at location 720-003 and the slope of the line in this direction. However, the extent of soil contamination appears to be well defined by the absence of VOAs in soil at boring 720-003 to the west and 720-022 to the south and with only one detect of vinyl chloride in boring 720-001 to the east.

Another release site may have occurred along the drainage exit point at location 720-005. TCE was detected in this boring throughout the entire depth drilled (30 ft bgs). The depth of the drain at this exit was noted as 7.8 ft on plant utility drawings. The networks of drains directed to this exit were primarily from general storage and the welding shop. The storm drains east and west of this location slope toward this point and discharge water through a 36-in. line extending south from this drain exit. No other significant contaminants were observed at this location.

An anomalous group of contaminants was observed in boring 720-024. Based on the release potential at the C-720 Building, the occurrence of SVOAs and metals in this boring is inexplicable. The BEHP concentrations in this area may be attributable to activities in the C-720 Building due to these contaminants' presence in samples from the Compressor Shop pit and White Room sumps. However, a specific pathway was not discovered. The boring is located adjacent to a large storm drain that collects stormwater from each of the drains along the south side of the C-720 Building. A release to one of these drains may have resulted in the transport of BEHP via the storm drain to this location, although the contaminant was not detected at significant concentrations in any other samples from the south side of the C-720 Building. The anomalously high concentrations of metals detected in deep subsurface soil samples at this location are probably precipitates from shallow groundwater. These metals were not detected in shallower soil samples, so their presence cannot be accounted for by a surface release. Additionally, many of these metals were not detected elsewhere at the site.

On the northeast side of the C-720 Building at location 720-027, TCE and several metals were detected throughout the boring. The boring was installed to investigate the possibility that a release in this area contributed to high TCE concentrations found in borings P4 H7 (Northeast Plume study) and 720-018. It was common practice in the past to rinse and clean parts with TCE in this area and to dispose of the solvent on the ground. The occurrence of TCE and metals in subsurface soil in this area suggests that this practice was followed, but an exact release point was not determined.

Two other locations (720-007 and 720-008) had significant TCE concentrations in the subsurface; however, these concentrations were found only at depth in this area, suggesting that the detections are attributable to lateral (and probably vertical) transport of the TCE through the UCRS from a nearby release. The low concentrations of TCE and TCE degradation products in the shallow groundwater south of the C-720 Building are probably attributable to contaminants migrating into that area via water from a broken water main. The water probably became contaminated with TCE that was leached from the contaminated soils along the building drain system on the south side of the C-720 Building.

4.2.5 RGA and McNairy Groundwater

One of the objectives of the WAG 27 RI was to define the nature and extent of contaminants in the RGA and McNairy flow systems and to determine the presence, location, and magnitude of any DNAPL zones as defined in the PGDP SMP (DOE 1998b). This phase of the investigation was focused on the RGA and upper 50 ft of the McNairy Formation above the Levings Member. The vertical extent of contamination within the McNairy was defined by concentrations of primarily TCE below 5 ug/L in the groundwater.

To achieve these objectives, grab water samples were collected from the RGA and the McNairy groundwater flow systems. In addition, historical analytical data from previously installed monitoring wells were reviewed and compared with recent data from the WAG 27 field effort to understand contaminant migration and distribution in the area. In general, the RGA and McNairy water samples were analyzed for VOAs, metals, and radionuclides. Other selected physical and chemical parameters were measured to support the development of remedial alternatives.

4.2.5.1 Location and Results of Previous Groundwater Investigations

C-747-C Oil Landfarm (SWMU 001). SWMU 001 was investigated during the CERCLA Phase I and II SIs. During these studies, four monitoring wells were installed at SWMU 001. Subsequent groundwater sampling of one of these wells (MW-161) documented the apparent passage of two elevated concentrations of TCE in the RGA groundwater. The two peak concentrations were observed approximately 1 year apart and were believed to represent either two separate masses or two areas within the same water mass that contained high concentrations of TCE. The maximum TCE content was reported at 23,000 μg/L in mid-1995. A more recent sample collected in mid-1996 showed only 750 µg/L TCE from the same well. A shallow UCRS well (MW-162), located in close proximity to the RGA well, registered only a slight increase in TCE level during the passing of the two TCE concentrations.

Cylinder Drop Test Area (SWMU 091). SWMU 091 also was one of the SWMUs investigated during the Phase I and II SIs. During these investigations three monitoring wells were installed: MW-158 (basal RGA), MW-159 (upper RGA), and MW-160 (UCRS). Analysis of groundwater from MW-160, which was completed in a perched groundwater zone in the UCRS, indicated the presence of DNAPL-suspect dissolved-phase TCE concentrations estimated at 164,000 µg/L in March 1991. Only small quantities of TCE (below 100 ug/L) were present in the RGA at SWMU 091.

Based on the results of data gathered during the LASAGNA™ Technology demonstration (Clausen et al. 1996), TCE at SWMU 091 had not yet reached the RGA, and the TCE observed in MW-158 and MW-159 was due to an upgradient source. Clausen et al. (1996) also suggest that low chloride concentrations measured in these two RGA wells support this interpretation. The chloride is believed to originate from tests conducted in 1964 and 1965 using a chilled brine to cool UF_6 cylinders before testing. According to Clausen et al., the higher chloride levels found in MW-160 indicate that some downward migration of brine had occurred, but that the chloride concentrations in the RGA were not so high as to suggest extensive migration into the RGA.

C-720 Complex. Four groundwater monitoring wells had been previously installed near the C-720 Building. MW-203 and MW-204 were installed near the northeast corner of the C-720 Building during the CERCLA Phase II SI. MW-203 was drilled to a total depth of 80 ft bgs and was screened in the RGA. MW-204 was drilled to a total depth of 55 ft bgs and was screened in the UCRS. These wells were installed to assess contamination associated with SWMU 027 (acid neutralization tank) and SWMU 141 (an inactive TCE degreaser). MW-217 and MW-218 were drilled near the southeast corner of the C-720 Building as part of a 1992 UST investigation. MW-217 and MW-218 were drilled to total depths of 53 ft and 40 ft, respectively, and both were screened in the UCRS.

TCE concentrations detected in the RGA well (MW-203) were found to be lower than those detected in MW-204 and total and dissolved metal concentrations were comparable to those detected in MW-204. The Phase II report did not specify a range of concentrations for these constituents. Technetium-99 activities were found to be significantly higher in MW-204 (843 ± 19 to 950 ± 20 pCi/L) than in the deeper RGA well (21 ± 3 to 22 ± 4 pCi/L). Plutonium-239 was detected in both wells at similar activities, 1.9 ± 0.5 pCi/L in MW-203 and 1.5 ± 0.5 pCi/L in MW-204.

The most recent groundwater monitoring data for MW-203 and MW-204 were collected in August of 1996 and December of 1994, respectively. TCE was detected at concentrations of 33 µg/L (MW-203) and 320 µg/L (MW-204).

Soil boring P4H7 was completed to the northeast of the C-720 Building as part of the Northeast Plume study in 1994. A groundwater sample was collected at the top of the RGA and analyzed for TCE using both a field GC and a fixed-base laboratory; TCE concentrations were 6,329 µg/L and 12,000 µg/L, respectively. An additional groundwater sample collected from the bottom of the RGA in boring P4H7 contained TCE at a concentration of 48 µg/L.

WAG 1 and 7 RI. Four RGA monitoring wells (MW-325, -328, -329, and -330) installed during the WAG 1 and 7 RI are located in close proximity to the WAG 27 study area. The most recent sampling events from the wells occurred in late 1996 and late 1997. Analyses of these samples showed that TCE and metals are present at some locations within the RGA groundwater. MW-325, which was drilled downgradient of the C-720 Building, had the highest TCE content among the four wells, 150 ug/L. MW-328 and MW-330 had relatively low TCE levels: 5 ug/L and 1 ug/L, respectively. TCE was not reported from MW-329. The most recent available metals data from the WAG 1 and 7 wells were collected during 1995. Each of the well samples contained one or more metals at a concentration above screening levels. Manganese was reported from all wells at a concentration below 5 mg/L. In addition to manganese, nickel was present in MW-328, barium in MW-330, and calcium and magnesium in MW-328, each above screening levels.

4.2.5.2 Rationale for WAG 27 RI Groundwater Sampling

RGA and McNairy groundwater sampling during the WAG 27 RI was designed to determine if leaks or leaching of contaminants from any of the WAG 27 SWMUs have contributed to previously discovered contamination within the RGA groundwater. The investigation was also designed to determine if the previously encountered contamination in the RGA represents a significant groundwater contaminant plume that exists south of the Northwest Plume and, if so, to help define the nature and extent of this plume. McNairy groundwater samples were collected to aid in determining the role of the McNairy flow system in contaminant transport.

4.2.5.3 Nature and Extent of Contamination

Regional Gravel Aquifer–Analytical Results. Two-hundred-twenty-five water samples were analyzed from 26 locations drilled into the RGA during the WAG 27 RI. WAG 27 RGA sampling locations are shown in Fig. 3.6. The RGA groundwater samples were analyzed for the presence of VOAs, metals, and radionuclides.

Results that exceeded applicable background levels are listed in Tables 4.24 through 4.26. A frequency of detection table (Table 4.27) presents summary information concerning the analytical results exceeding background values.

Organics

Nine VOAs were detected in the RGA groundwater samples collected during the WAG 27 RI. Carbon tetrachloride and 2-propanol (a chemical used in equipment decontamination) were each detected in only a single sample; carbon tetrachloride was found in a single sample and a corresponding duplicate sample. Chloroform and tetrachloroethene were each detected in only two samples. TCE, which was present in 209 of the 225 samples analyzed, was the most common VOA detected. TCE degradation products were also frequently detected in the RGA groundwater samples.

Figure 4.29 is a contour map of the maximum TCE concentration reported from the RGA at each sampling location during the WAG 27 RI. Figure 4.30 is a northwest to southeast cross section showing the vertical distribution of TCE in the groundwater in the area surrounding SWMU 001 and the C-720 Complex. The highest concentrations of TCE in groundwater were generally reported between 76 and 97 ft bgs from the lower part of the RGA.

Two distinct areas of TCE contamination are indicated by the distribution of the TCE on the map and cross section. One is associated with the C-720 Complex. In that area, a maximum TCE content of 1262 ug/L was found at 76 ft bgs at location 720-018 on the northeast side of the building. In the C-720 Complex, all of the highest detections of TCE were reported from samples collected immediately north of the building. The TCE content of the RGA groundwater upgradient (to the east-southeast) of the C-720 Building, as observed in samples collected from 720-010, 720-011, 720-012, 720-019, and 720-028, is significantly less than reported on the north side of the building, or from downgradient samples. These observations indicate that the TCE has been primarily introduced from a source that is located in or near the northeast corner of the C-720 Building. Based on the available data, the axis of the TCE-contaminated groundwater appears to pass slightly west of location 720-026, which had a TCE content of 903 ug/L at 92 ft bgs.

A second area of elevated TCE in the RGA groundwater has been defined at SWMU 001. The axis of the plume in that area has been mapped as extending from the north-central part of SWMU 001 to just west of SWMU 091 (Fig. 4.29). The highest detected TCE content within this plume is a relatively low 1578 ug/L from location 001-182, which was sampled at 82 ft bgs. Based on historical data collected from MW-161 (an RGA well drilled during the Phase I and II SIs), a significant increase in TCE content in the RGA occurred between 1993 and 1996: from a low of 600 ug/L in 1993 to a high of 23,000 ug/L in 1995, before decreasing to 750 ug/L in 1996. This well is located downgradient from the former Oil Landfarm and the changes in the TCE content observed in the RGA have been interpreted as possibly indicative of a "slug" of TCE that has migrated to the northwest from SWMU 001. The current location of the maximum concentration of this TCE slug is speculative, but the high TCE reported in 001-182 probably is located on the fringe. The lateral extent of the plume is well defined by samples collected in side-gradient positions from locations 001-175, 001-183, 001-184, and 001-185 on the west and two well samples collected at SWMU 091 on the east. Several samples, including one from 001-177A, which had a low TCE content of 10 ug/L, have been used to define the upgradient limit of the plume.

The cross section in Fig. 4.30 shows that the TCE observed in the RGA groundwater originates from the vicinity of the former Oil Landfarm (SWMU 001). SWMU 001 as the source of the TCE is further confirmed by soil data collected during the WAG 27 RI. A TCE concentration of more than 400,000 ug/kg was reported in a shallow soil sample collected from the former Oil Landfarm, immediately upgradient of MW-161. Elevated TCE levels in the soil were also detected in numerous samples collected down to a depth of 50 ft bgs, or just above the top of the RGA. Leaching of TCE from these soils is probably the source of the observed historical slug and the TCE that has since been observed in the RGA groundwater in this area. However, if the TCE and Tc-99 (see discussion below) are sourced from the same area, an upgradient release site is likely.

TCE degradation products and other chlorinated solvents were detected less frequently than TCE and in smaller quantities. In the 225 samples analyzed, trans-1,2-dichloroethene was detected in 108 samples at a maximum concentration of 25 ug/L; 1,1-dichlorethene was detected in 68 samples at a maximum of 54 ug/L; cis-1,2-dichloroethene was detected in 22 samples at a maximum of 31 ug/L; and vinyl chloride was detected in 18 samples at a maximum of 18 ug/L. As expected, the distributions of these TCE-related compounds are closely correlated with the areal extent of the TCE in the RGA groundwater.

Inorganics

Eight metals were detected at concentrations above PRG screening levels from the 83 water samples collected from the RGA at WAG 27. Cobalt exceeded the PRG screening level in only a single sample. Sodium, magnesium, calcium, and iron, four essential nutrients and common soil-forming minerals, and zinc were above PRG screening levels in less than 10% of the samples analyzed.

In every sample that contained elevated metals concentrations, manganese was detected at concentrations above screening levels. In many samples, manganese was the only metal to exceed screening levels. Six sample locations, all associated with SWMU 001, contained only manganese above screening levels. Interestingly, only samples from locations 001-176 and 001-180, collected upgradient and downgradient from SWMU 001, respectively, contained metals other than manganese. In both of these cases, the additional metals were calcium and magnesium, both of which were above screening levels in one sample from each location.

Manganese, at concentrations above screening levels, appears to be widespread in the RGA. High concentrations of manganese, however, are found both upgradient and downgradient from all four sites investigated under the WAG 27 RI. Upgradient concentrations of manganese as high as 1.57 mg/L were detected in 720-028, indicating that the metal is not being introduced to the groundwater from the WAG 27 sites.

With the possible exception of SWMU 091, the distribution of manganese in the RGA does not suggest a source location associated with any of the WAG 27 sites. At SWMU 091, an RGA sample (091-001), which was collected from near the center of the drop test area, had a maximum manganese content of 6.88 mg/L (the duplicate sample had only 4.33 mg/L). This was the highest manganese detection from any WAG 27 RGA water sample. In a downgradient (and slightly side-gradient) sample, only 0.37 mg/L manganese was reported from the same stratigraphic interval.

Manganese concentrations as high as 0.560 mg/L have been reported from Quaternary alluvial groundwater in the Paducah area (Pree et al. 1957), and natural groundwater may contain as much as 1.0 mg/L manganese (Hem 1992). The relatively high manganese content observed in the RGA groundwater at the PGDP may be related in part to stratigaphy or to an unidentified source upgradient of the WAG 27 study area. SWMU 091 may contribute manganese to the RGA, but due to the widespread variability of manganese within the RGA, a source at SWMU 091 has not been positively identified.

Radionuclides

Technetium-99 was the most commonly reported radionuclide above screening levels. The maximum concentrations of Tc-99 from each sample location are shown in Fig. 4.31. The highest reported activity was 3709.6 pCi/L from location 001-182, which was downgradient of SWMU 001. Contouring of the data suggests that the Tc-99 maximum in the RGA is located almost due north of SWMU 001. The upgradient extent of the Tc-99 plume in the RGA in this area is defined by low concentrations of Tc-99 in samples from 001-176, 001-177A, and 001-178. The downgradient extent of the Tc-99-plume is not defined by the available data.

A second area of elevated Tc-99 in the RGA is present in the vicinity of the C-720 Building, where the highest activities were detected on the north and northeast side of the building (Fig 4.31). Areas where the Tc-99 concentration is below screening levels have been determined, and they define the extent of the contaminant plume on the west, south, and east sides of the building. The extent of the Tc-99 in the RGA to the northeast is based on low concentrations of Tc-99, less than 100 pCi/L, reported from an RGA water sample collected on the southwest side of the C-400 Building in 1997 as part of the WAG 6 RI. In general, the distributions of Tc-99 at both SWMU 001 and the C-720 Building resemble the RGA TCE plumes that have been delineated for the same areas. This similarity in trends suggests that the two contaminants have related origins and transport histories. The possibility that an upgradient source of the high Tc-99 observed at 720-029 or near SWMU 001 cannot, however, be eliminated.

Cesium-137 was reported from one sample, and Pu-239/240 was detected above screening levels in three samples collected from two locations. The highest concentration of plutonium was 3.79 pCi/L from a sample collected at location 720-010. However, the duplicate of this sample was non-detect for plutonium. Eight detections of Th-230 were reported from the RGA groundwater samples. In four of these samples, Th-230 was non-detect in the associated duplicate sample. The maximum Th-230 activity was 37.58 pCi/L.

Uranium was detected in 28 unfiltered samples above the screening level. The most upgradient of all the samples (720-028) contained 0.02 mg/L uranium, which was higher than all but a few samples collected from the WAG 27 study area. The highest single concentration of uranium was 0.12 mg/L from a location (001-181) upgradient of SWMU 001.

In filtered water samples, uranium was the only radionuclide detected above background. Uranium was not present at concentrations that exceeded PRGs in any of the 55 unfiltered water samples tested.

McNairy Flow System–Analytical Results. McNairy water samples were collected from 22 borings drilled during the WAG 27 RI. Fifty samples were collected and analyzed. Forty-five of the samples were analyzed at the on-site laboratory for TCE and its degradation products. Five of these samples were sent to a fixed-base laboratory and analyzed for a full suite of VOAs as part of the WAG 27 RI. Metals were analyzed for in 16 samples. Tables 4.28 to 4.30 contain a complete list of the constituents that were detected above background levels in the McNairy water samples, and Table 4.31 presents a summary of the frequency of detections and range of detections for each of the reported analytes.

Organics

Except for a single occurrence of 2-propanol, TCE and its degradation products were the only VOAs detected above screening levels from any of the McNairy water samples. The highest concentration of TCE was 15 ug/L at location 001-181. At every sampling location within WAG 27, the TCE content in the McNairy was found to decrease to less than 1 ug/L within 25 ft below the top of the formation (see Fig. 4.30). Clearly, TCE is not migrating vertically into the McNairy strata from the overlying RGA in significant quantities.

Inorganics

Sixteen McNairy water samples were analyzed for dissolved metals, and six metals were detected above screening levels. Of these, barium, calcium, magnesium, and vanadium each exceeded screening levels in only one sample. All four detections were from the same sample, collected at 137 ft bgs at location 720-013 on the west side of the C-720 Building. Iron and manganese, the other two metals detected above screening levels in the McNairy, were also reported at high concentrations in this sample. Manganese, the most widespread of the metals detected in the RGA, was at its maximum in this sample. The absence of a similar suite of metals from the overlying sample of the McNairy groundwater makes the reported results from this sample suspect. Either the analysis is not valid or several metals in high concentrations are migrating laterally at depth–a conclusion that does not appear reasonable based on previous work at the PGDP–or the high metal content is due to localized physiochemical or stratigraphic conditions within the McNairy.

Iron was reported above screening levels from seven samples collected from five locations. Four of the locations are near the C-720 Building, and the fifth is in SWMU 001. An iron content above 5 mg/L in the McNairy was reported from upgradient location 720-029 at the C-720 Building. Except for the sample taken from 720-013, the other three McNairy water samples to exceed this level for iron content were from 720-017 at 120 and 140 ft bgs and 720-011 at 120 ft bgs. The sporatic occurrence of metals concentrations above screening levels is not attributed to the release of metals from the WAG 27 RI sites.

Radionuclides

Uranium, Th-230, and Tc-99 were the only radiological constituents detected above screening levels in the McNairy water samples. Thorium was present only in samples collected from SWMU 091 in boring 091-002. The activity of thorium was found to increase from 1.53 to 16.9 to 53.77 pCi/L in samples collected at 102, 127, and 137 ft bgs, respectively. Elevated activities of Tc-99 were reported from a single sample collected at the C-720 Complex in boring 720-010 at 96 ft bgs. Uranium was reported above the screening level from 13 of the 20 samples analyzed for radionuclides; its maximum concentration was 0.17 mg/L.

No radionuclides exceeded both background and PRG screening levels for filtered water samples.

4.2.5.4 Summary of Findings

TCE "background" in the RGA at the PGDP may be as high as 10 ug/L in the WAG 27 area. VOAs, predominantly TCE and its degradation products, found at concentrations as high as 1578 μg/L in the RGA appear to originate from two SWMUs investigated as part of the WAG 27 RI. At one of these sources, SWMU 001, a TCE plume in the RGA has been identified and extends from the site to the northwest. The full downgradient extent of the plume has not been defined by the available data. Analyses of the soils and groundwater data collected at SWMU 001 indicate that the TCE contamination in the RGA could have been derived from leaching of contaminated soils that were disposed of in the inactive oil landfarm. However, if the TCE and Tc-99 (see below) found in the RGA are derived from the same source, an upgradient release site cannot be ruled out.

Radionuclide (Tc-99) trends at SWMU 001 are similar to TCE concentrations, indicating that Tc-99 may also have been sourced from the landfarm and that the migration paths of the TCE- and Tc-99-contaminated groundwater are similar. Although only low concentrations of Tc-99 were found in SWMU 001 vadose zone soil or UCRS groundwater, this mobile radionuclide may have been more abundant at the site in the past. Another possibility is that the Tc-99 in the RGA near SWMU 001 has been sourced from one of the nearby cylinder storage yards.

The second source of TCE contamination within the RGA has been defined around the C-720 Complex. In that area, a maximum of 1262 µg/L TCE was detected in the RGA. The source of the TCE would appear to be related to past surface disposal of TCE near the northeast corner of the C-720 Building, with perhaps some contribution from leaks that have occurred along the building exit drain lines on the southeast side of the building.

Tc-99 activities in the RGA at the C-720 Complex indicate that this radionuclide also was derived from a source that was located on the northeast corner of the building, or from an upgradient location. An upgradient source of the Tc-99 is suggested by the high (525 pCi/L) Tc-99 activity reported from location 720-029. The downgradient extent of groundwater impacted by VOAs and radionuclides at the C-720 Complex is not fully defined by the available data. RGA groundwater contaminated with VOAs and radionuclides does not appear to be migrating vertically into the underlying McNairy Formation.

Several metals occur within the RGA at concentrations above screening levels. The distributions and concentrations of the metals in the RGA and McNairy groundwater appear to be unrelated to any identifiable source area within WAG 27.

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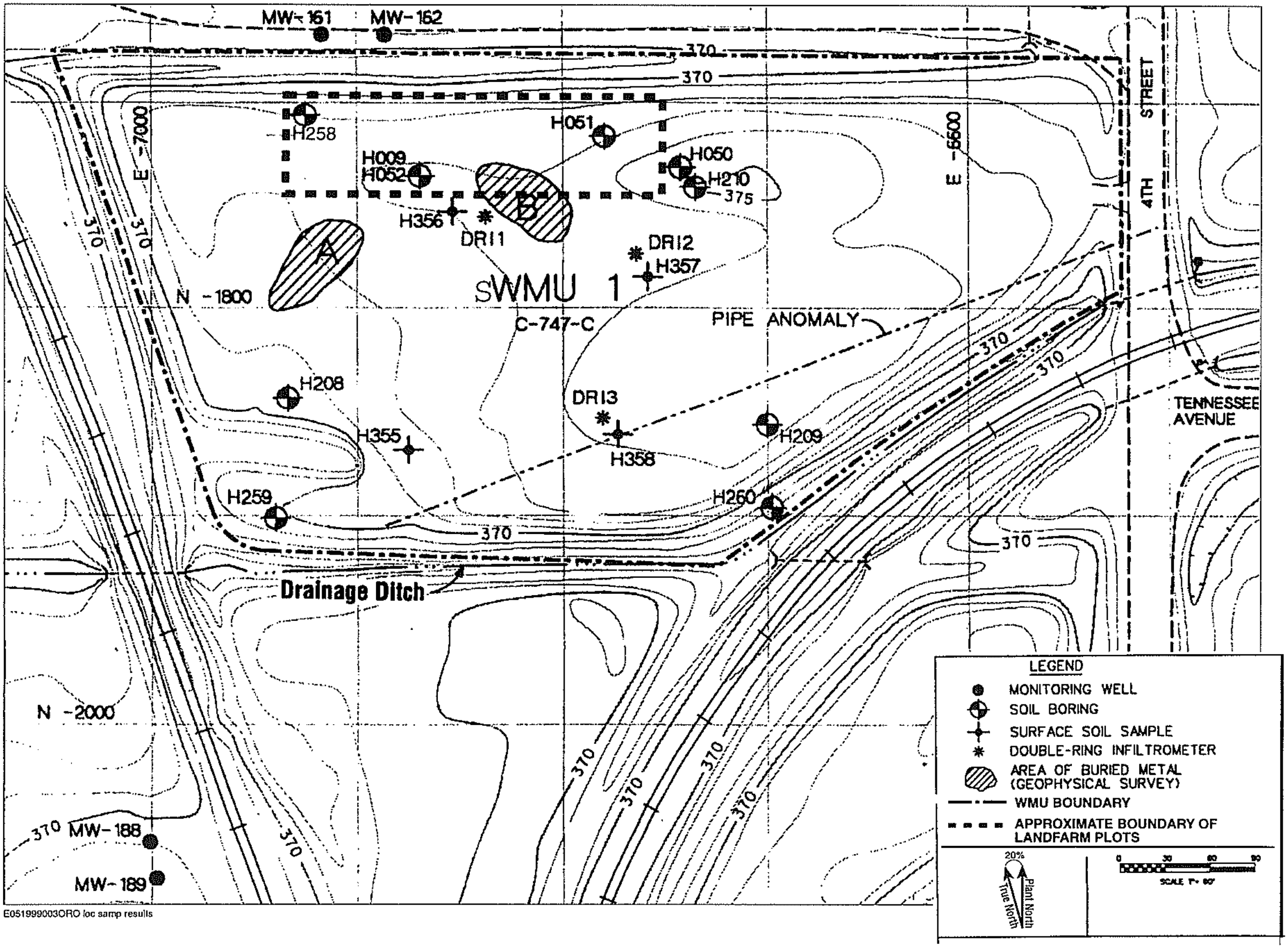


Fig. 4.1. Sampling locations from Phases I and II Site Investigations: SWMU 001.

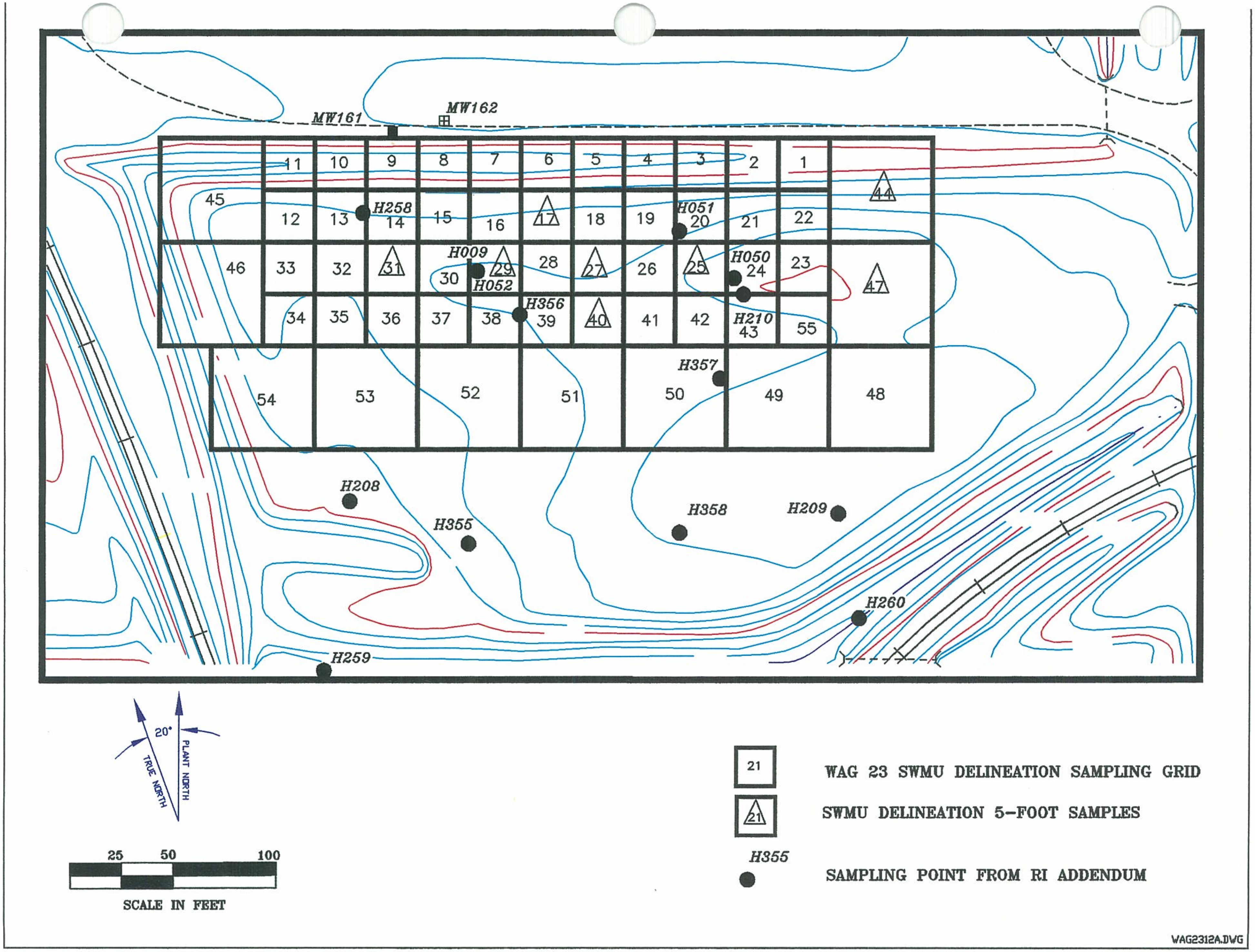
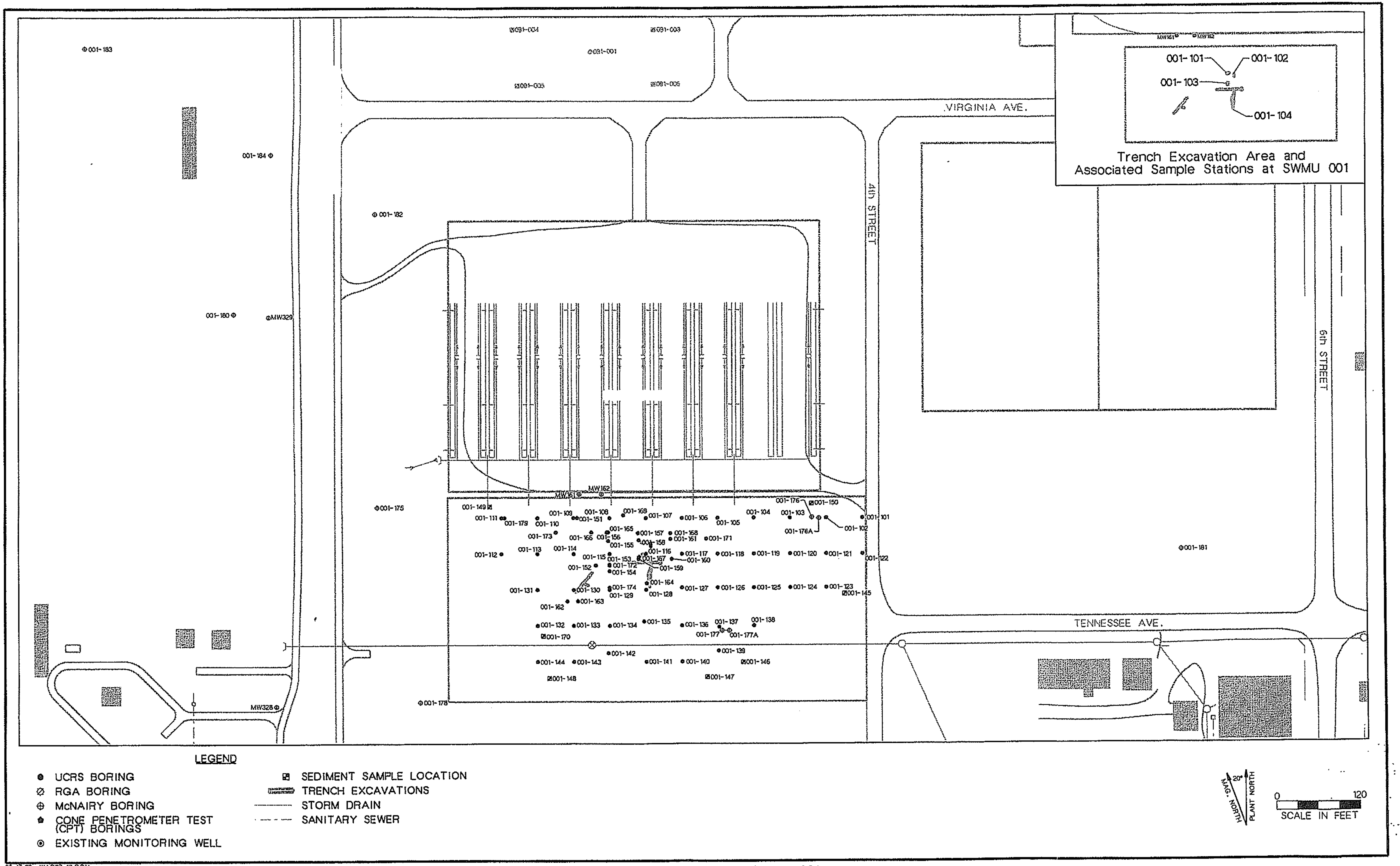


Fig.4.2 WAG 23 focused sampling grid at SWMU 001.



05-17-99 WAG27-18.DGN

Fig. 4.3 Sampling stations at SWMU 001.

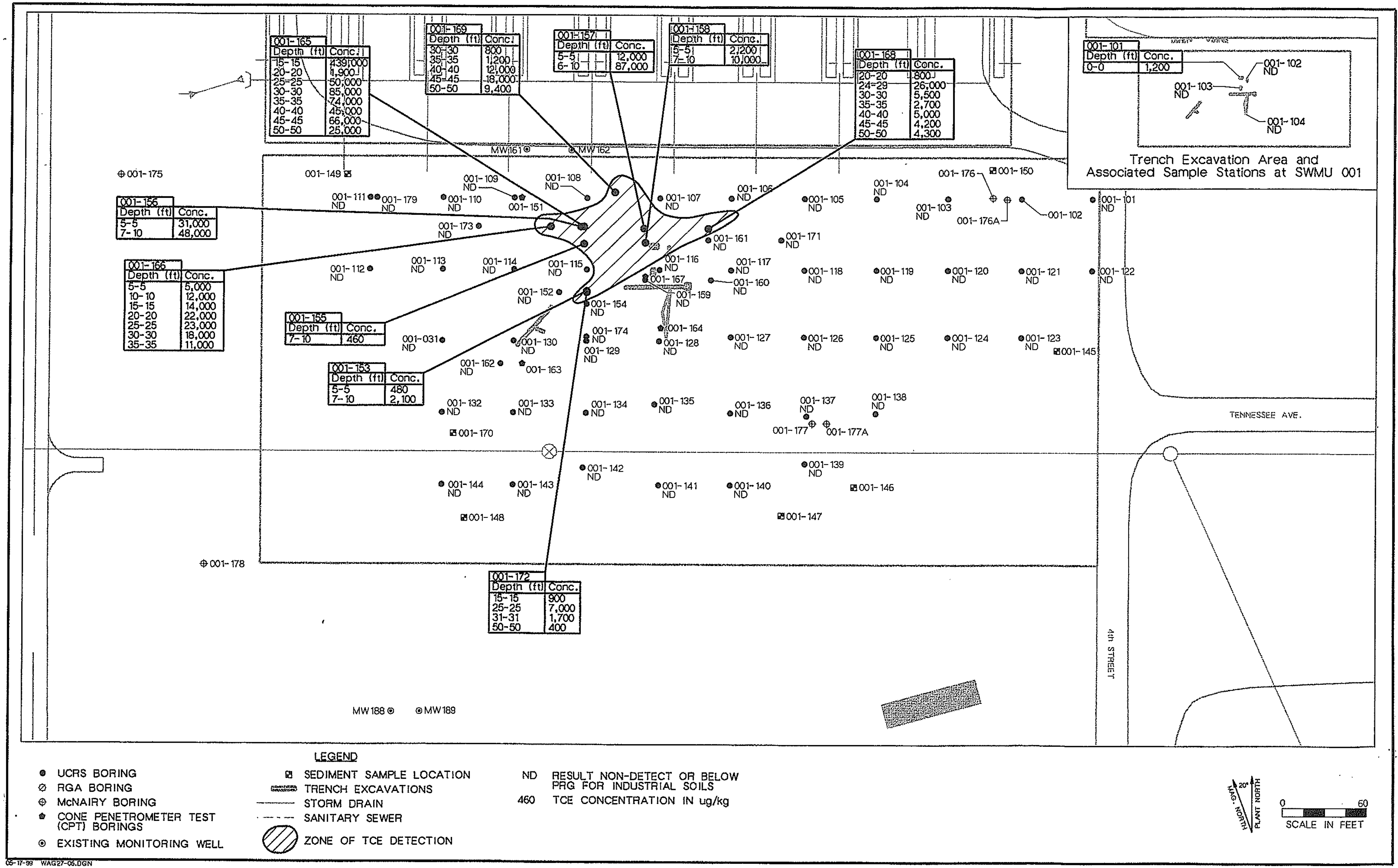


Fig. 4.4 Distribution of TCE in UCRS soil at SWMU 001.

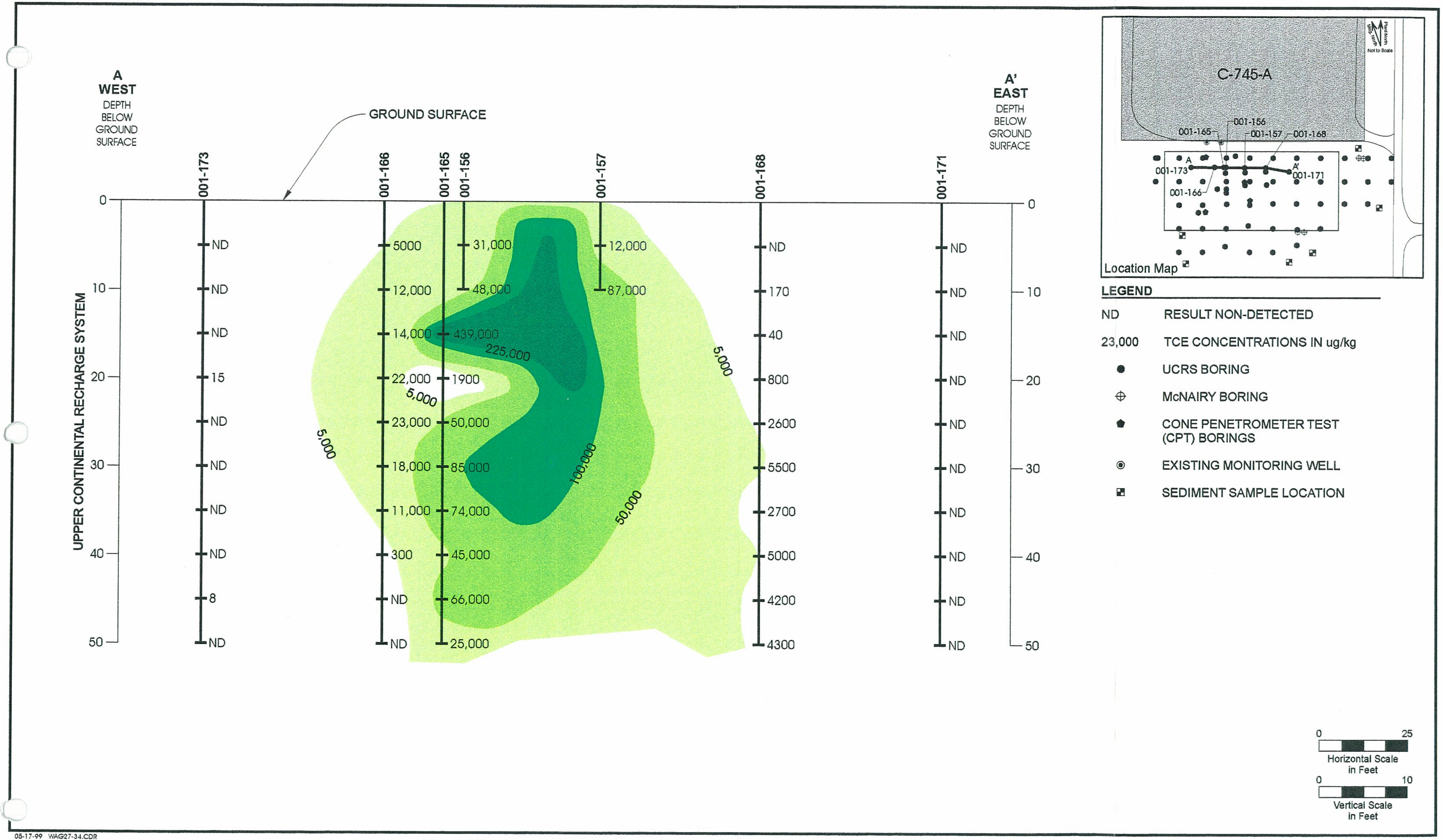
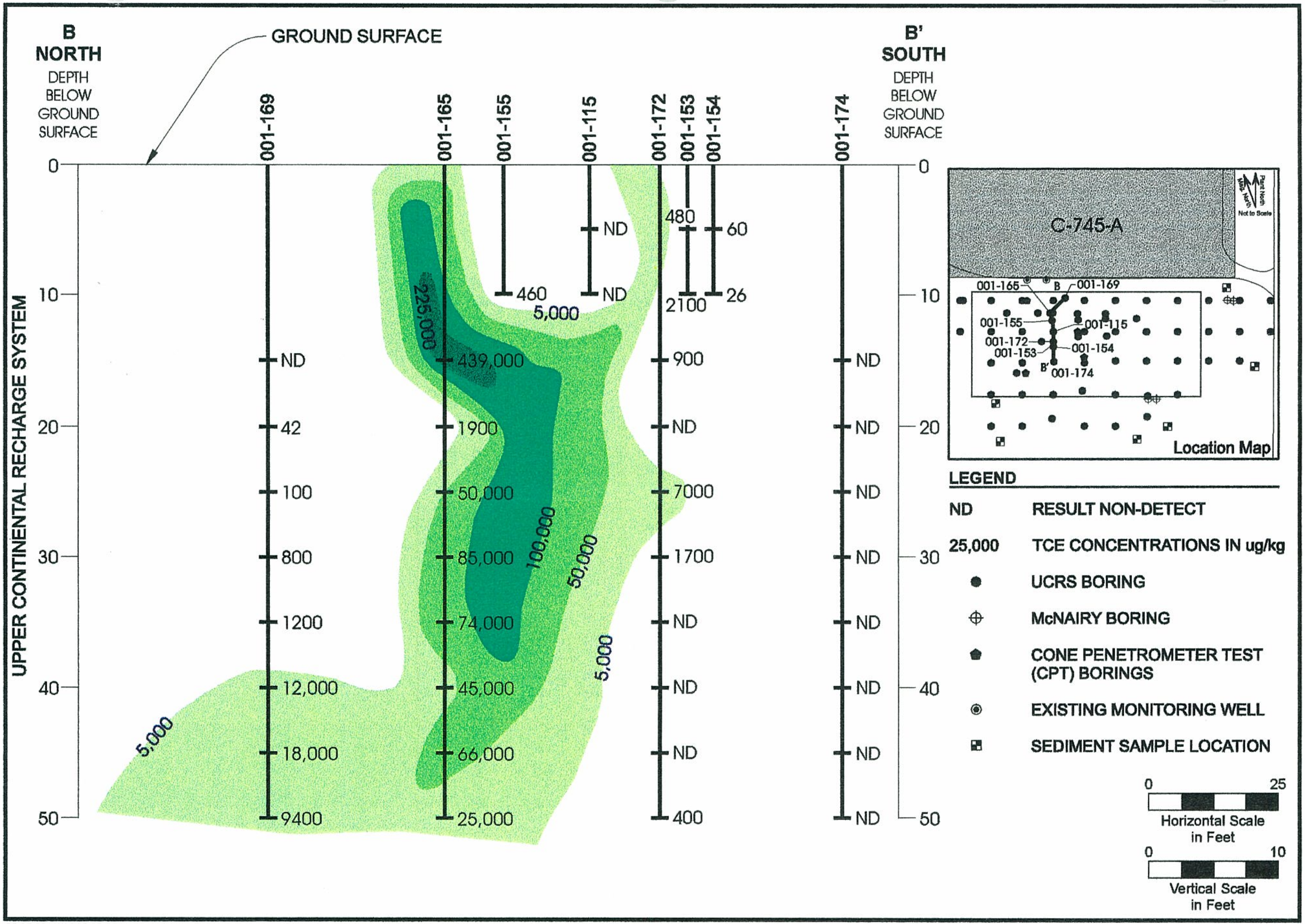
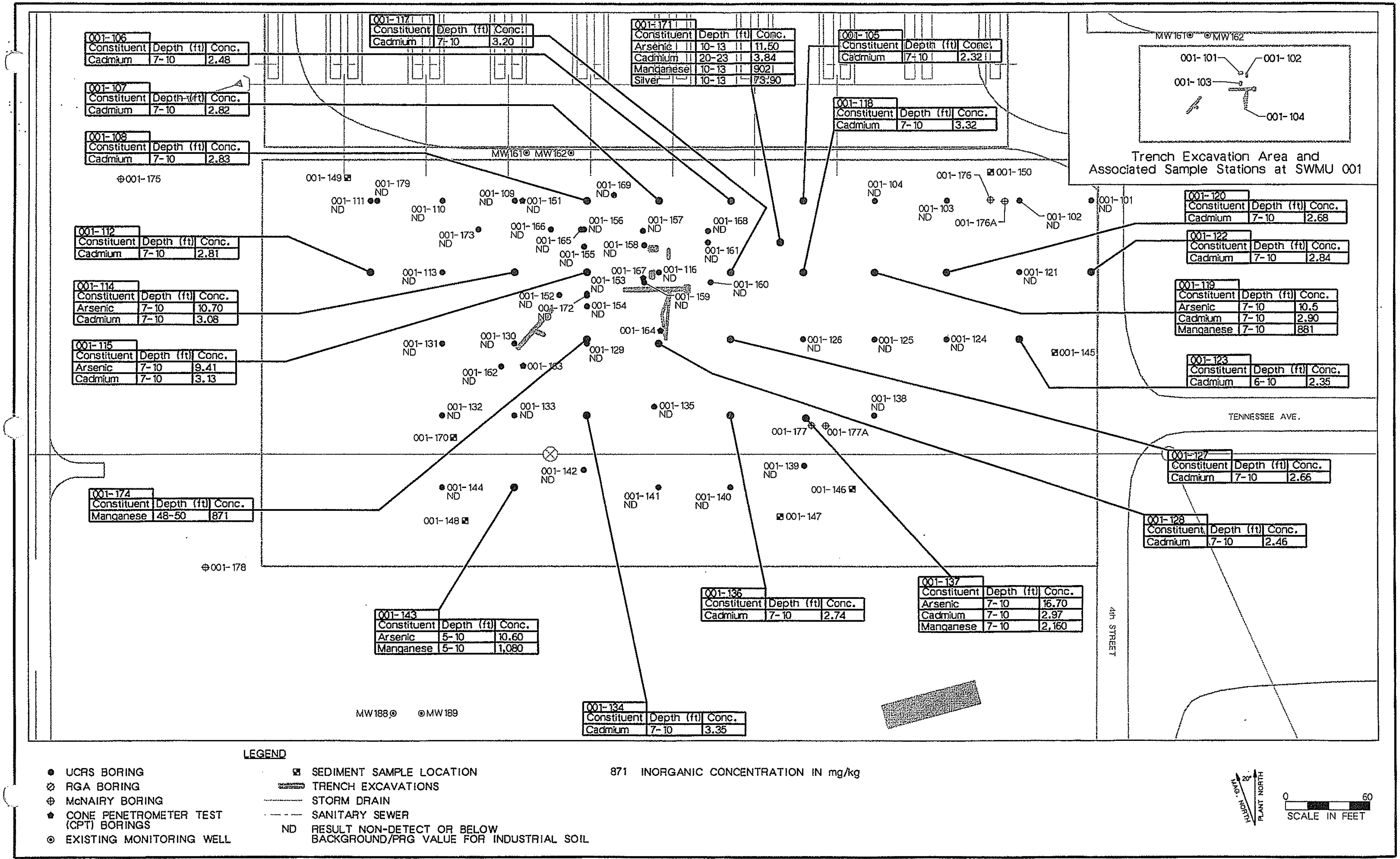


Fig. 4.5 East-west cross section A-A' showing TCE distribution in UCRS soils at SWMU 001.



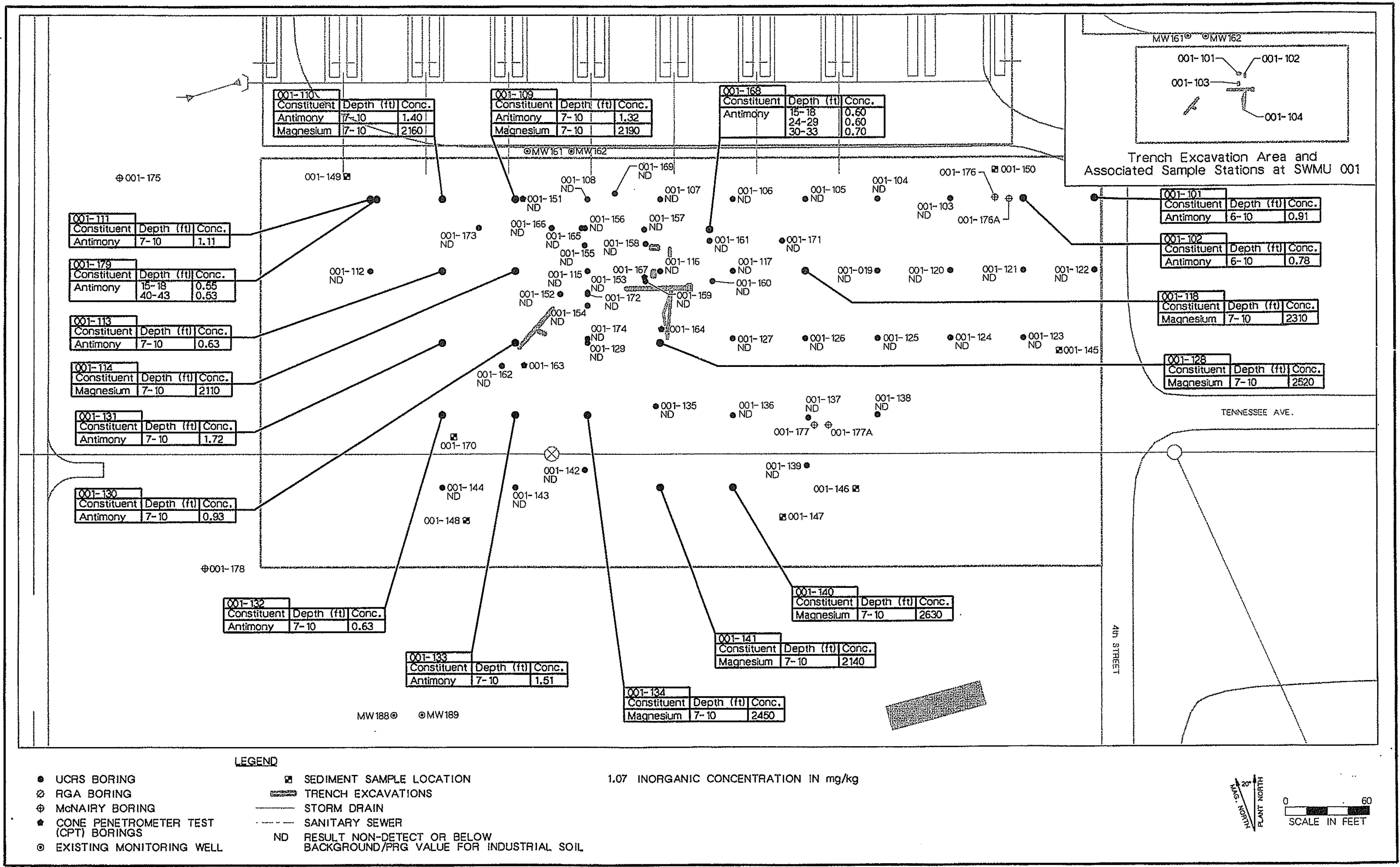
05-17-99 WAG27-35.CDR

Fig. 4.6 North-south cross section B-B' showing TCE distribution in UCRS soils at SWMU 001.



05-17-99 WAG27-29.DGN

Fig. 4.7 Distribution of arsenic, cadmium, manganese, and silver in UCRS soil at SWMU 001.



001-110

Constituent	Depth (ft)	Conc.
Antimony	7-10	1.40
Magnesium	7-10	2160

001-109

Constituent	Depth (ft)	Conc.
Antimony	7-10	1.32
Magnesium	7-10	2190

001-168

Constituent	Depth (ft)	Conc.
Antimony	15-18 24-29 30-33	0.60 0.60 0.70

001-111

Constituent	Depth (ft)	Conc.
Antimony	7-10	1.11

001-179

Constituent	Depth (ft)	Conc.
Antimony	15-18 40-43	0.55 0.53

001-113

Constituent	Depth (ft)	Conc.
Antimony	7-10	0.63

001-114

Constituent	Depth (ft)	Conc.
Magnesium	7-10	2110

001-131

Constituent	Depth (ft)	Conc.
Antimony	7-10	1.72

001-130

Constituent	Depth (ft)	Conc.
Antimony	7-10	0.93

001-132

Constituent	Depth (ft)	Conc.
Antimony	7-10	0.63

001-133

Constituent	Depth (ft)	Conc.
Antimony	7-10	1.51

001-134

Constituent	Depth (ft)	Conc.
Magnesium	7-10	2450

001-141

Constituent	Depth (ft)	Conc.
Magnesium	7-10	2140

001-140

Constituent	Depth (ft)	Conc.
Magnesium	7-10	2630

001-128

Constituent	Depth (ft)	Conc.
Magnesium	7-10	2520

001-118

Constituent	Depth (ft)	Conc.
Magnesium	7-10	2310

001-101

Constituent	Depth (ft)	Conc.
Antimony	6-10	0.91

001-102

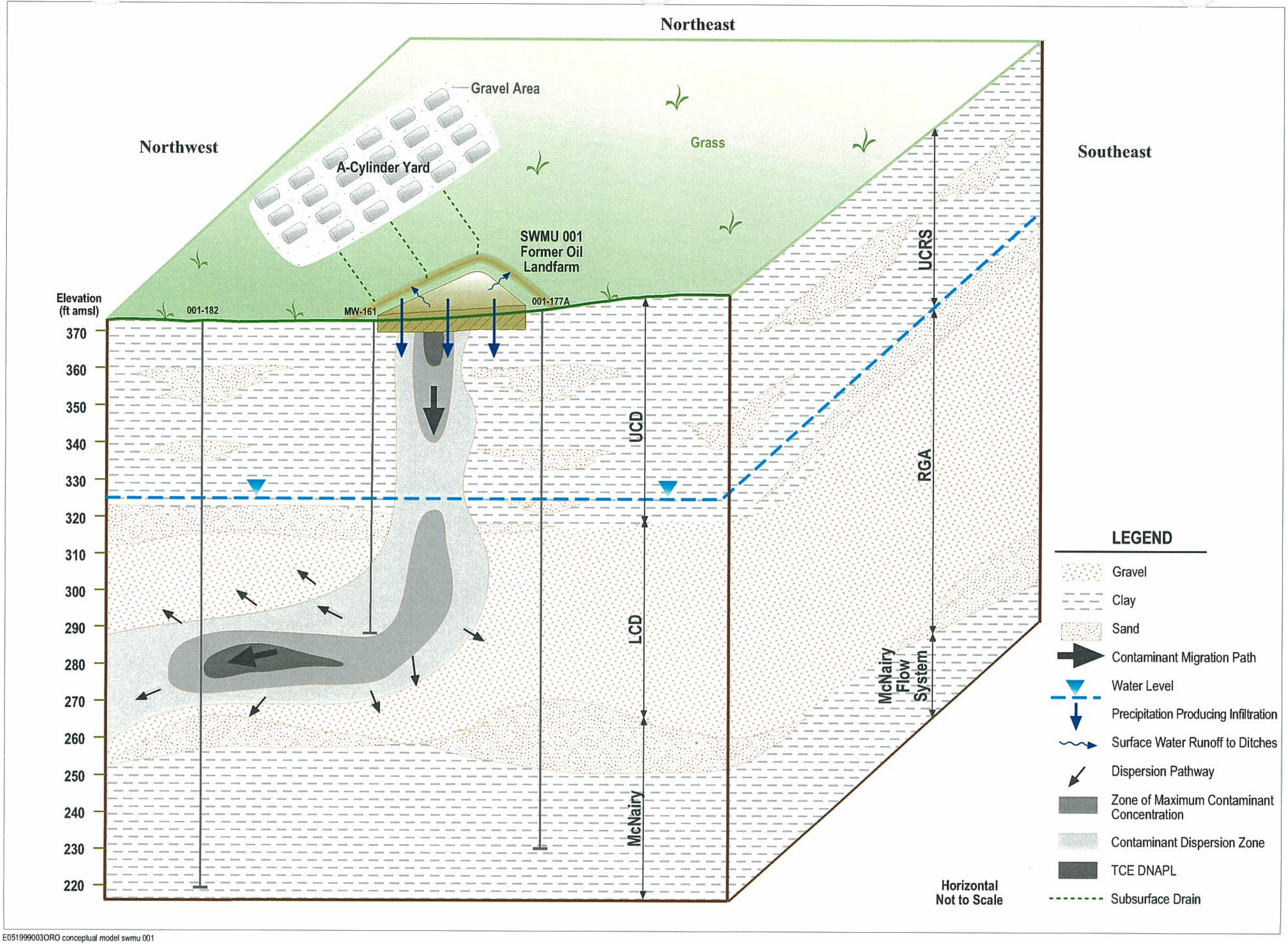
Constituent	Depth (ft)	Conc.
Antimony	6-10	0.78

LEGEND

- ● UCRS BORING
- ⊘ RGA BORING
- ⊕ McNAIRY BORING
- ● CONE PENETROMETER TEST (CPT) BORINGS
- ⊙ EXISTING MONITORING WELL
- ▨ SEDIMENT SAMPLE LOCATION
- ▨ TRENCH EXCAVATIONS
- ——— STORM DRAIN
- – · – · – SANITARY SEWER
- ND RESULT NON-DETECT OR BELOW BACKGROUND/PRG VALUE FOR INDUSTRIAL SOIL
- 1.07 INORGANIC CONCENTRATION IN mg/kg

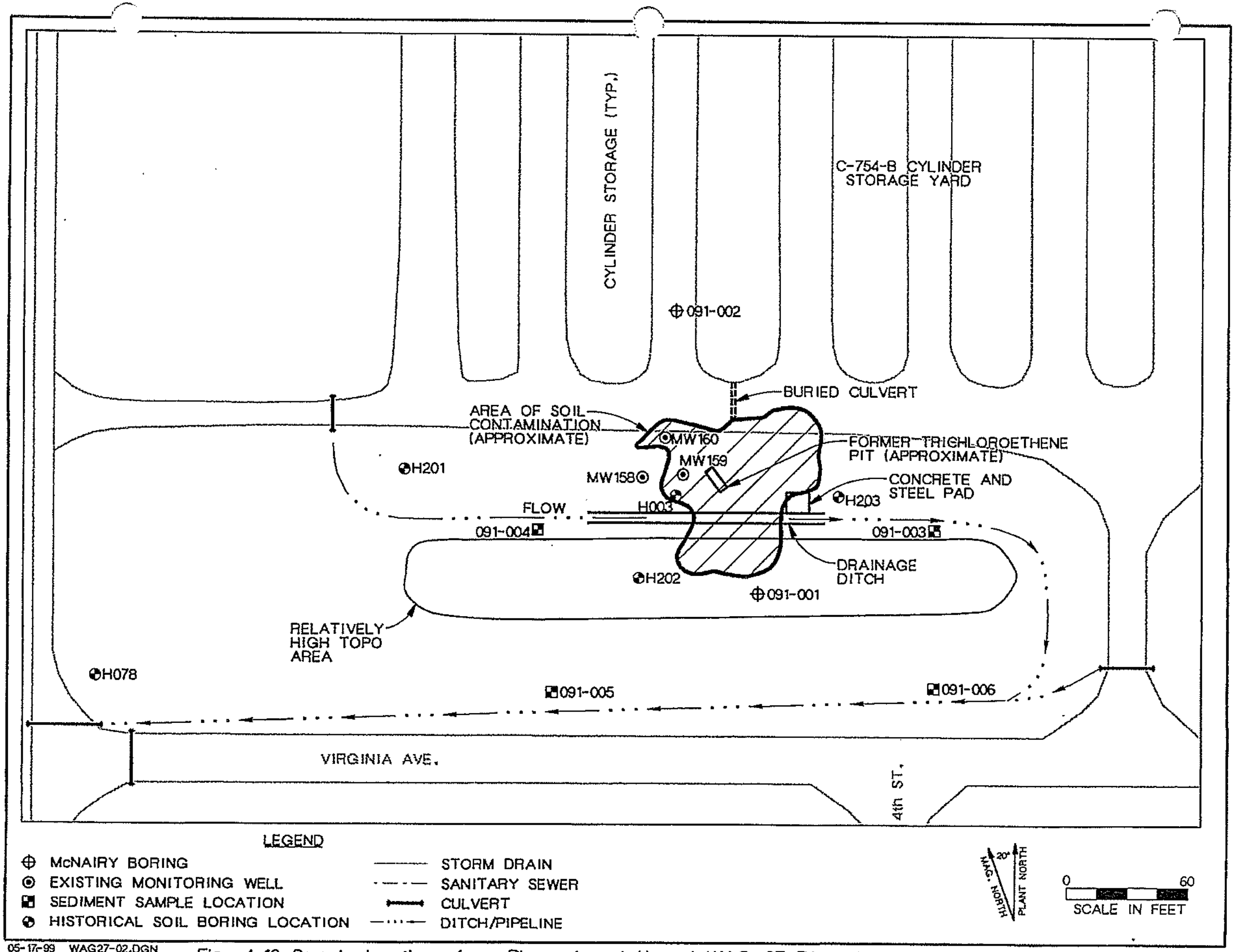
05-17-99 WAG27-28.DGN

Fig. 4.8 Distribution of antimony and magnesium in UCRS soil at SWMU 001.



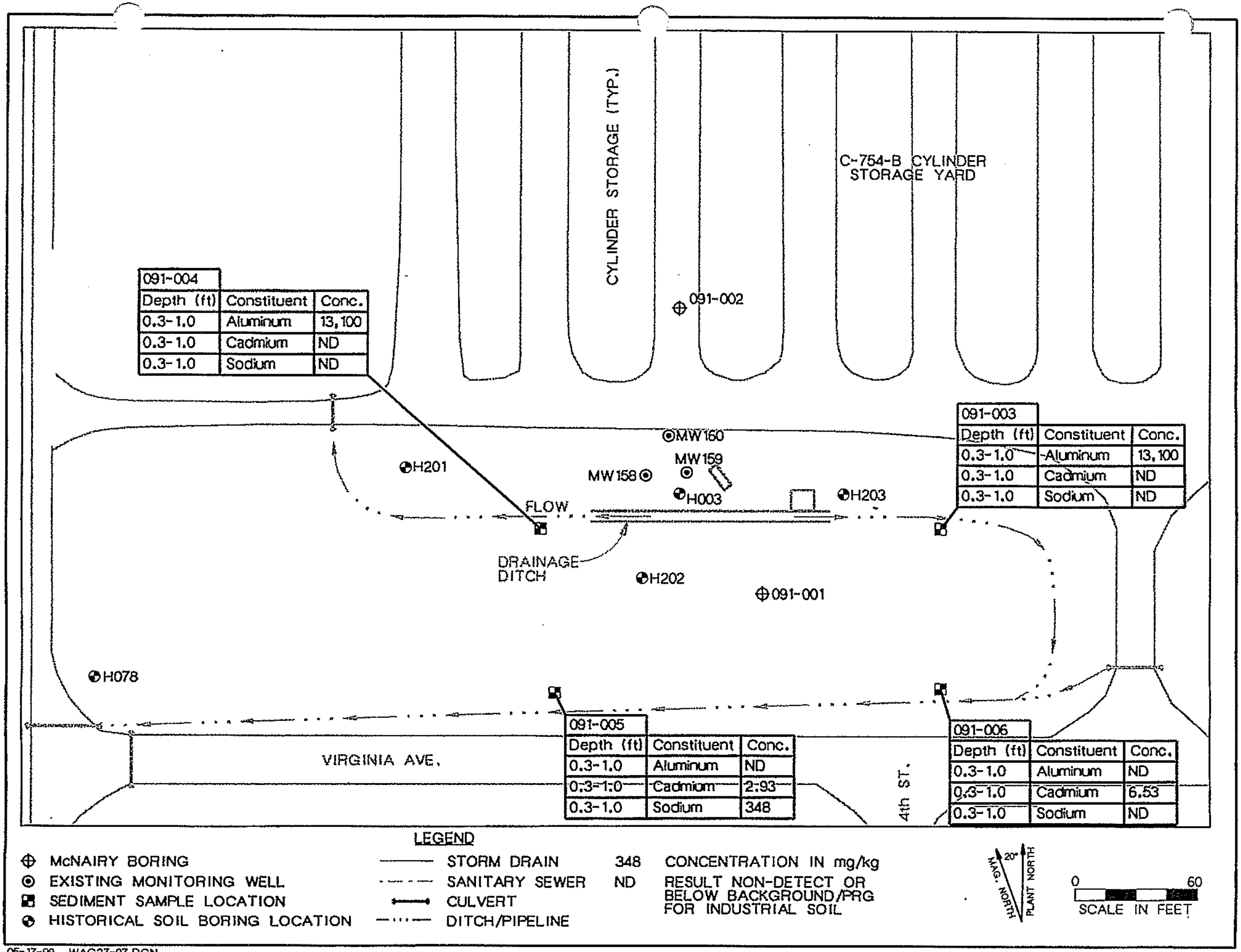
E051999003ORO conceptual model swmu 001

Fig. 4.9. SWMU 001 site conceptual model.



05-17-99 WAG27-02.DGN

Fig. 4.10 Sample locations from Phase I and II and WAG 27 RI activities at SWMU 091.



091-004

Depth (ft)	Constituent	Conc.
0.3-1.0	Aluminum	13,100
0.3-1.0	Cadmium	ND
0.3-1.0	Sodium	ND

091-003

Depth (ft)	Constituent	Conc.
0.3-1.0	Aluminum	13,100
0.3-1.0	Cadmium	ND
0.3-1.0	Sodium	ND

091-005

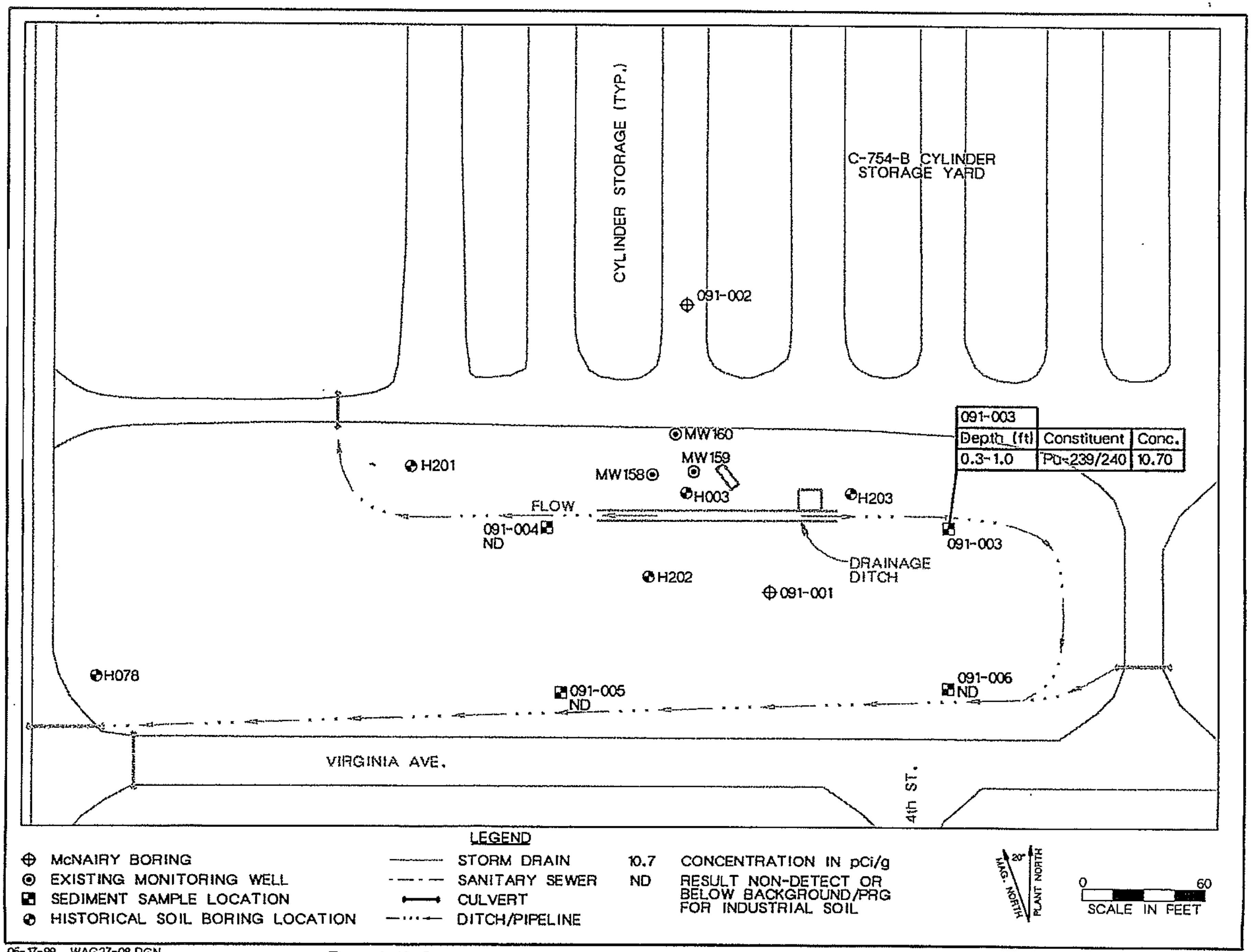
Depth (ft)	Constituent	Conc.
0.3-1.0	Aluminum	ND
0.3-1.0	Cadmium	2.93
0.3-1.0	Sodium	348

091-006

Depth (ft)	Constituent	Conc.
0.3-1.0	Aluminum	ND
0.3-1.0	Cadmium	6.53
0.3-1.0	Sodium	ND

05-17-99 WAG27-07.DGN

Fig. 4.11 Distribution of select metals at SWMU 091.



05-17-99 WAG27-08.DGN

Fig. 4.12 Distribution of radionuclides detected at SWMU 091.

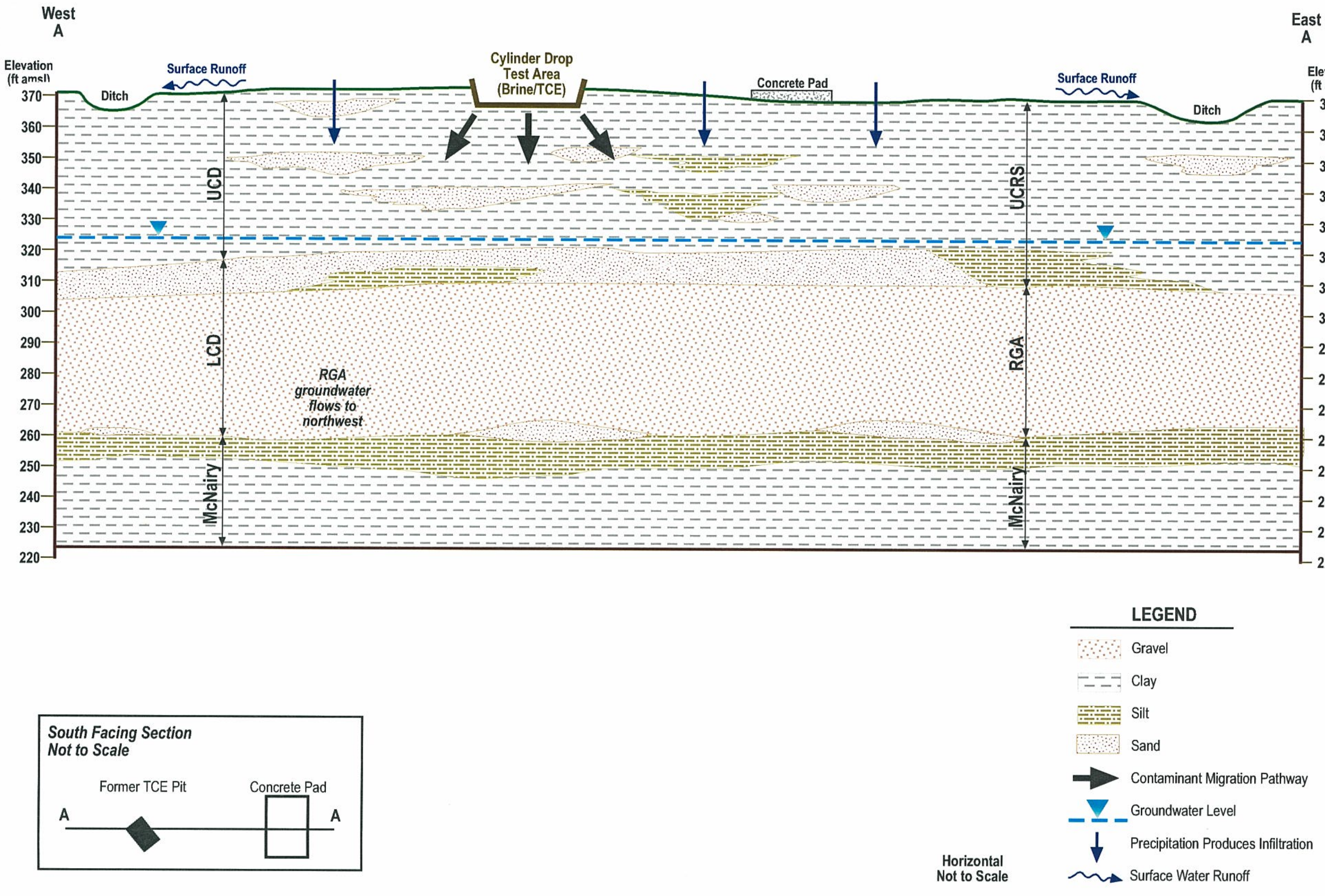
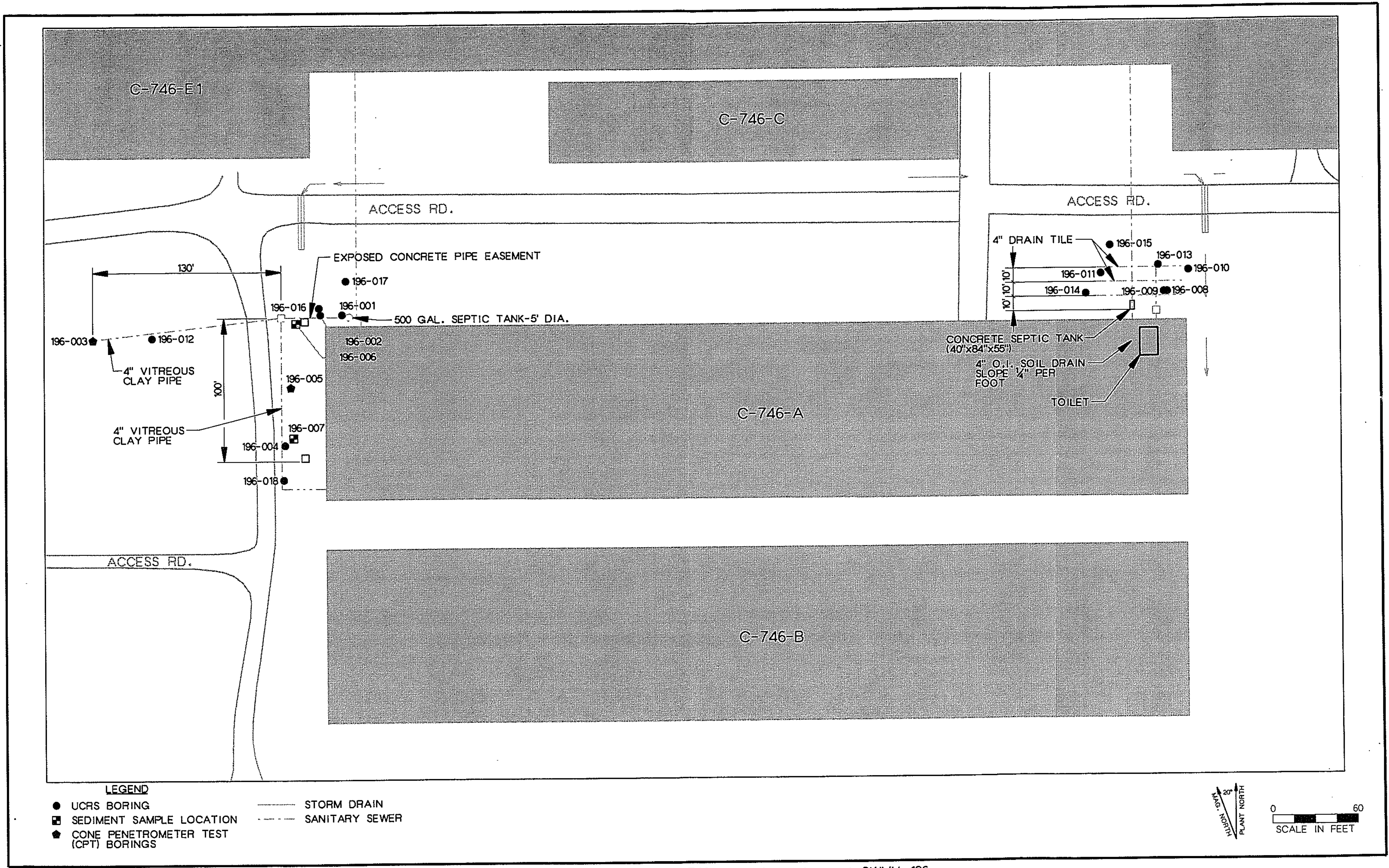
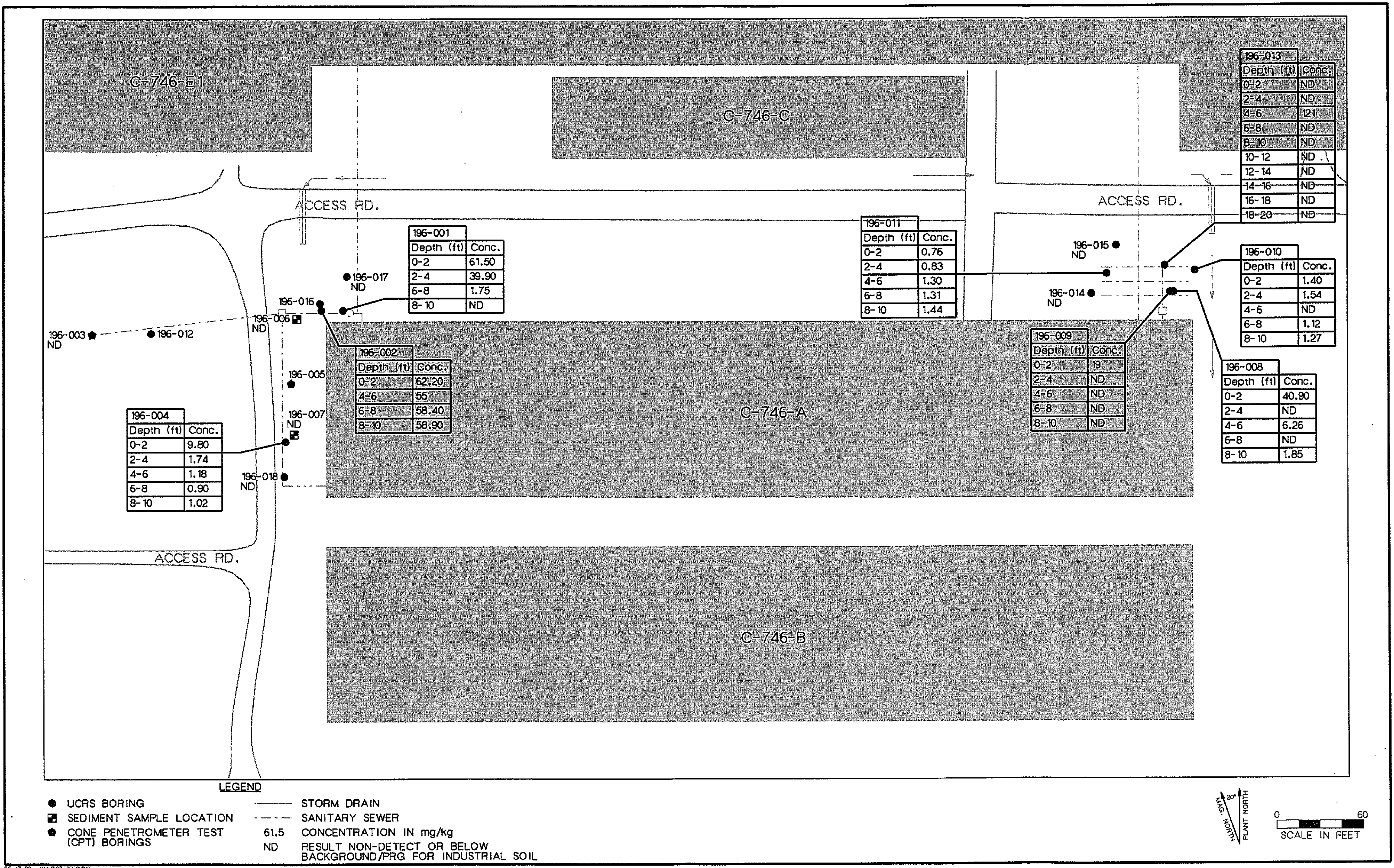


Fig. 4.13. SWMU 091 site conceptual model.



05-17-99 WAG27-22.DGN

Fig. 4.14 Sample locations for C-746-A septic systems at SWMU 196.



196-001

Depth (ft)	Conc.
0-2	61.50
2-4	39.90
6-8	1.75
8-10	ND

196-002

Depth (ft)	Conc.
0-2	62.20
4-6	55
6-8	58.40
8-10	58.90

196-004

Depth (ft)	Conc.
0-2	9.80
2-4	1.74
4-6	1.18
6-8	0.90
8-10	1.02

196-011

Depth (ft)	Conc.
0-2	0.76
2-4	0.83
4-6	1.30
6-8	1.31
8-10	1.44

196-009

Depth (ft)	Conc.
0-2	19
2-4	ND
4-6	ND
6-8	ND
8-10	ND

196-013

Depth (ft)	Conc.
0-2	ND
2-4	ND
4-6	121
6-8	ND
8-10	ND
10-12	ND
12-14	ND
14-16	ND
16-18	ND
18-20	ND

196-010

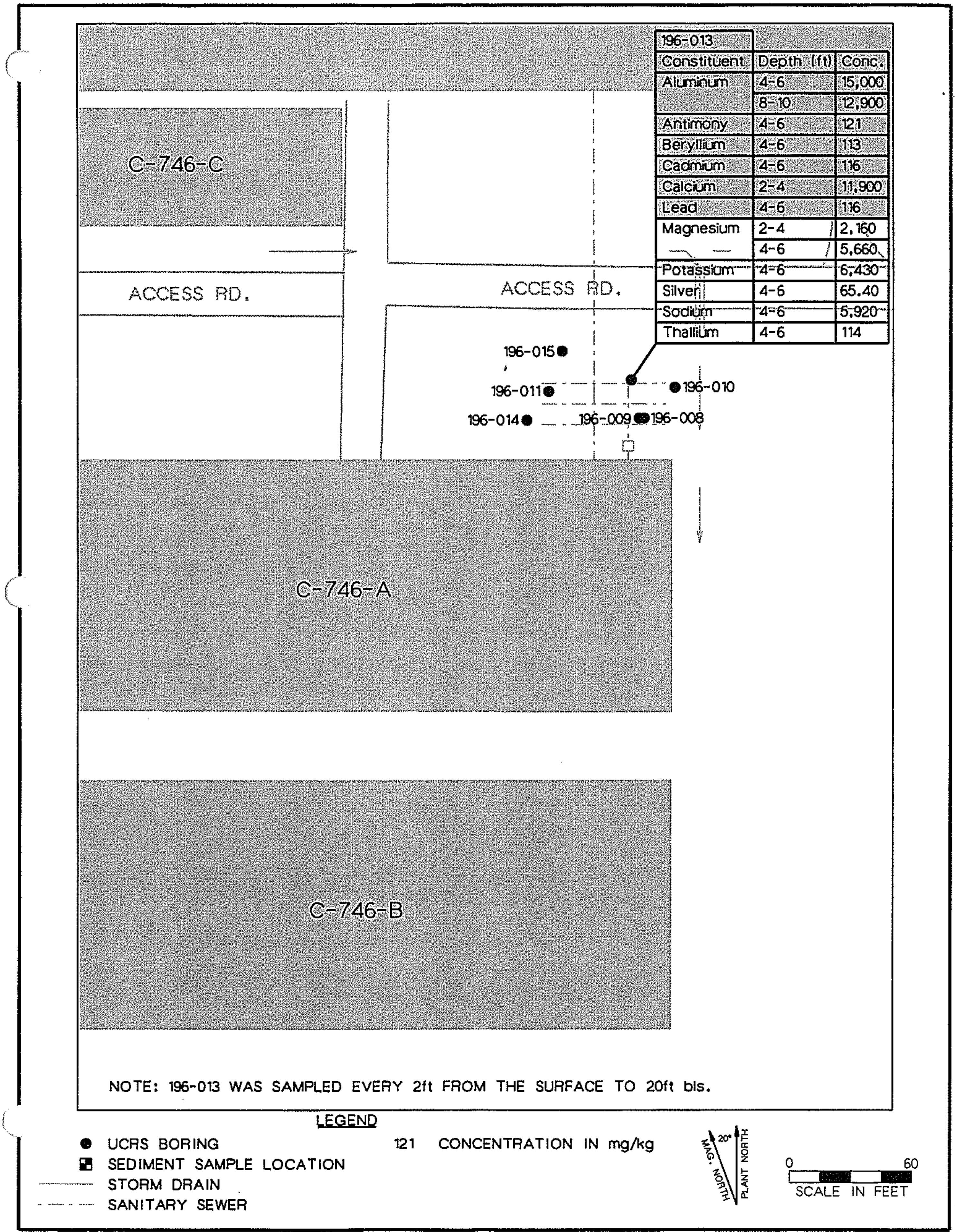
Depth (ft)	Conc.
0-2	1.40
2-4	1.54
4-6	ND
6-8	1.12
8-10	1.27

196-008

Depth (ft)	Conc.
0-2	40.90
2-4	ND
4-6	6.26
6-8	ND
8-10	1.85

05-17-99 WAG27-24.DGN

Fig. 4.15 Distribution of antimony at SWMU 196.



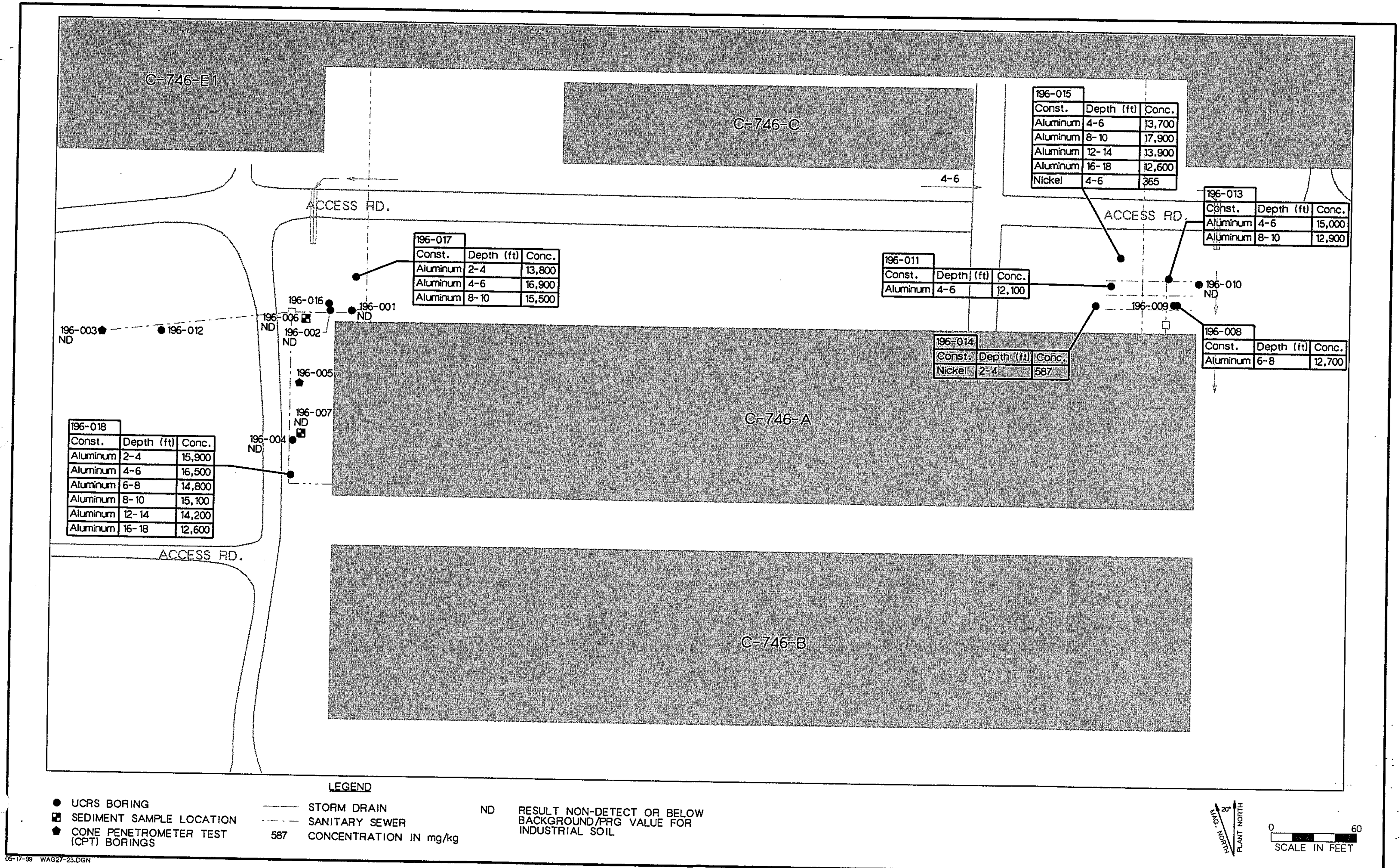
196-013

Constituent	Depth (ft)	Conc.
Aluminum	4-6	15,000
	8-10	12,900
Antimony	4-6	121
Beryllium	4-6	113
Cadmium	4-6	116
Calcium	2-4	11,900
Lead	4-6	116
Magnesium	2-4	2,160
	4-6	5,660
Potassium	4-6	6,430
Silver	4-6	65.40
Sodium	4-6	5,920
Thallium	4-6	114

NOTE: 196-013 WAS SAMPLED EVERY 2ft FROM THE SURFACE TO 20ft bls.

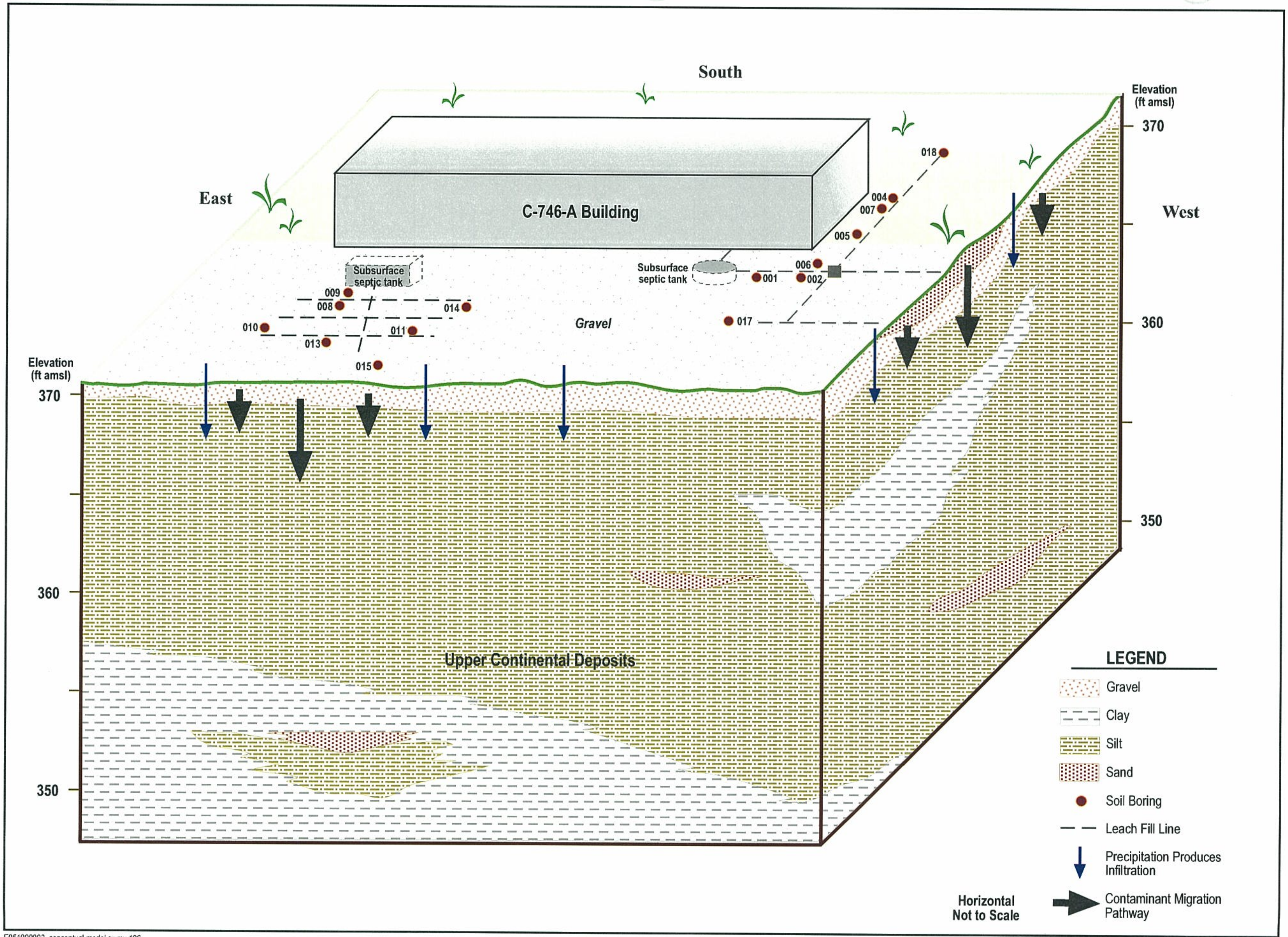
05-17-99 WAG27-25.DGN

Fig. 4.16 Distribution of all detected metals at 196-013.



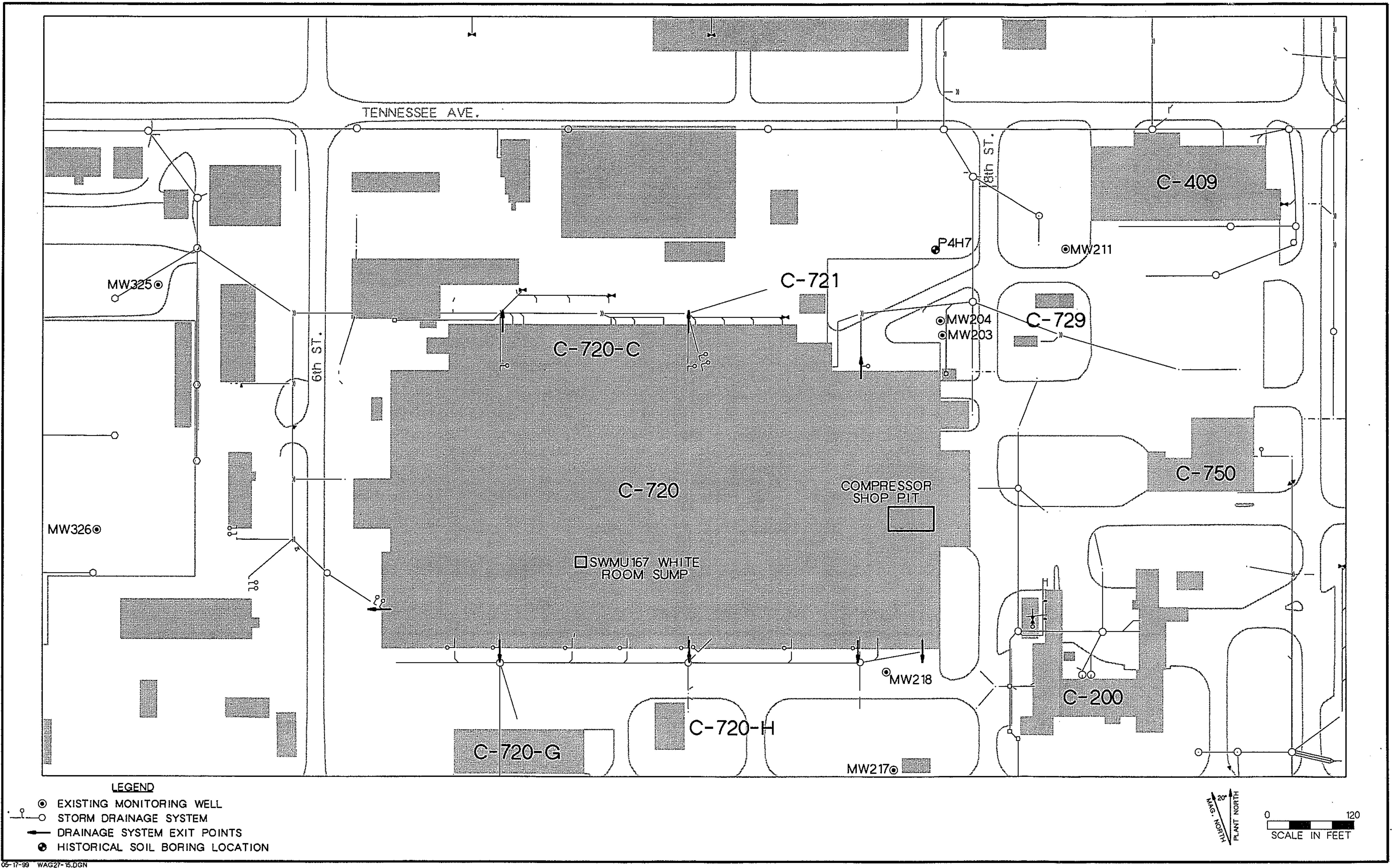
05-17-99 WAG27-23.DGN

Fig. 4.17 Distribution of aluminum and nickel detected at SWMU 196.



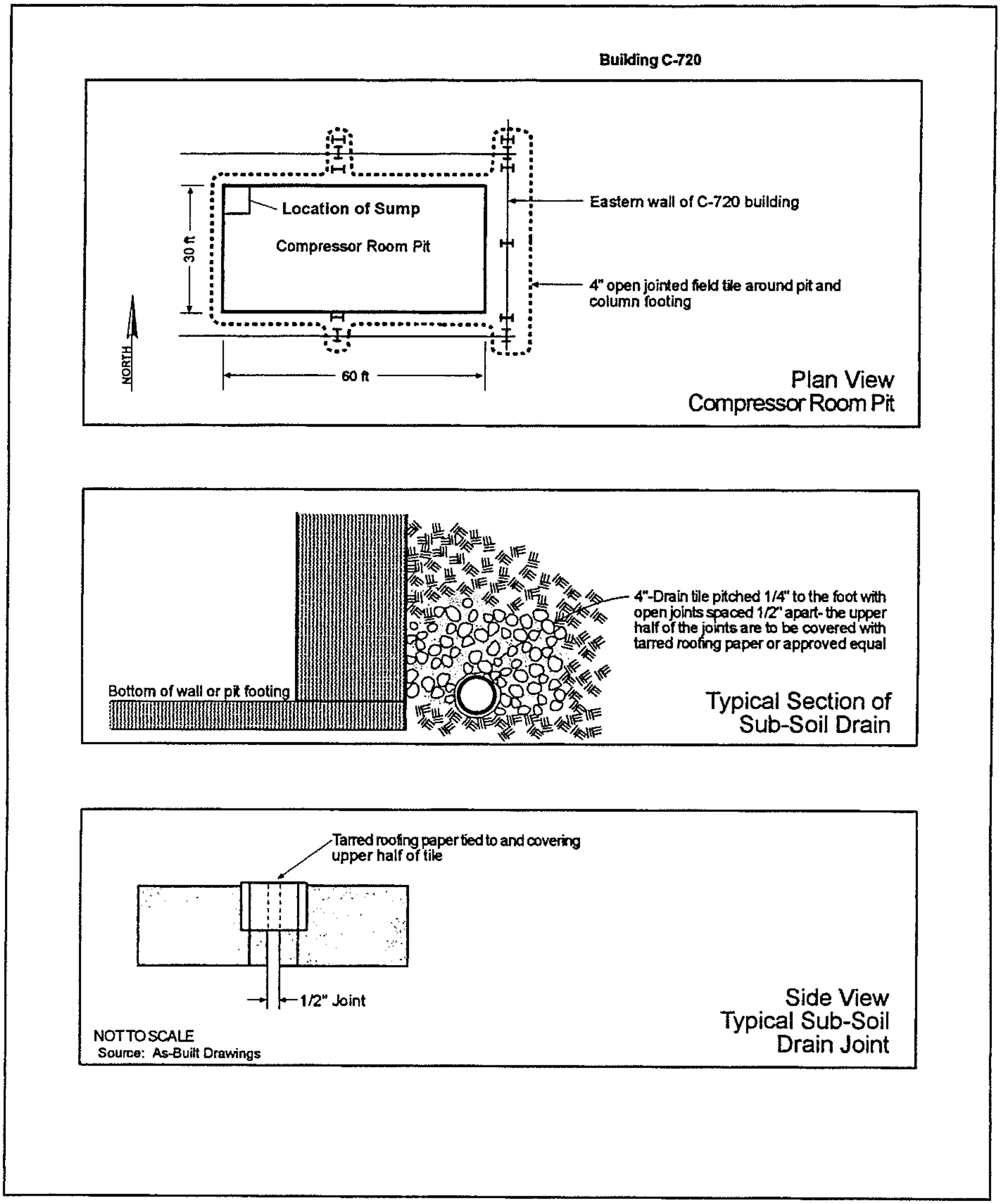
E051999003 conceptual model swmu 196

Fig. 4.18. SWMU 196 site conceptual model.



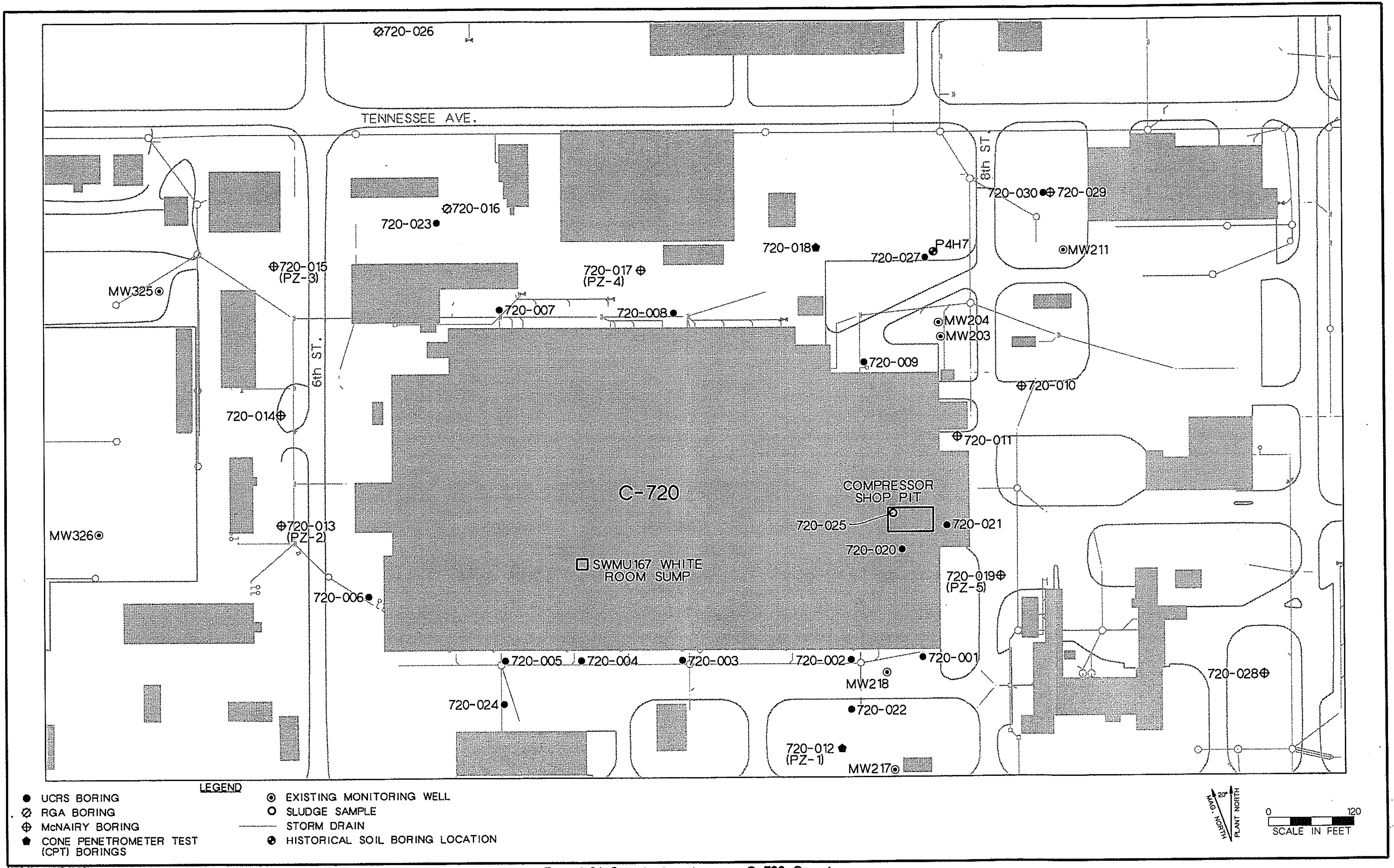
05-17-99 WAG27-15.DGN

Fig. 4.19 Location of Compressor Shop and major building exit drains at C-720 Building.



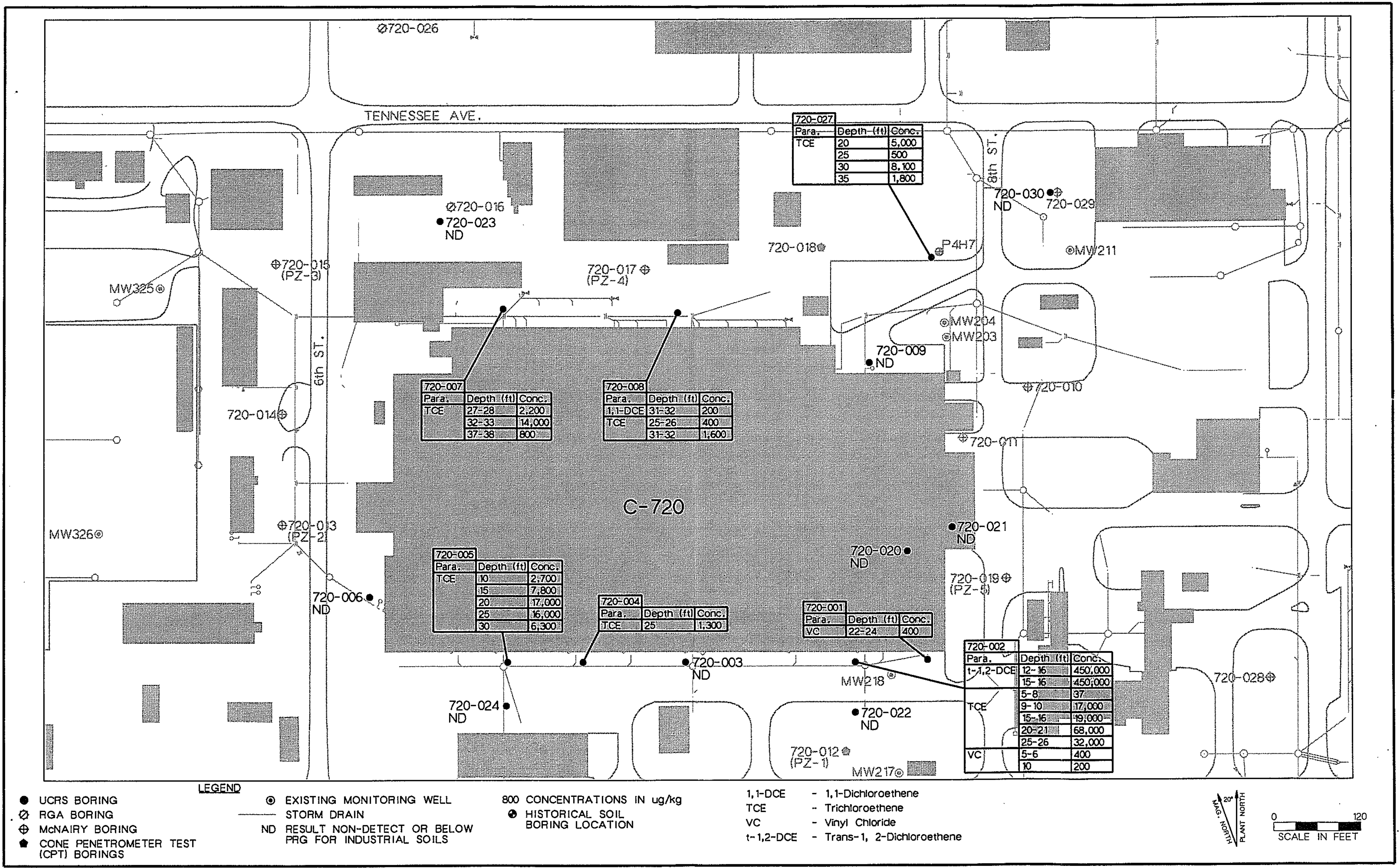
figh3.apr

Fig. 4.20 Compressor Shop pit plan and details.



05-17-99 WAG27-09.DGN

Fig. 4.21 Sample locations at C-720 Complex.



720-027

Para.	Depth (ft)	Conc.
TCE	20	5,000
	25	500
	30	8,100
	35	1,800

720-007

Para.	Depth (ft)	Conc.
TCE	27-28	2,200
	32-33	14,000
	37-38	800

720-008

Para.	Depth (ft)	Conc.
1,1-DCE	31-32	200
TCE	25-26	400
	31-32	1,600

720-005

Para.	Depth (ft)	Conc.
TCE	10	2,700
	15	7,800
	20	17,000
	25	16,000
	30	6,300

720-004

Para.	Depth (ft)	Conc.
TCE	25	1,300

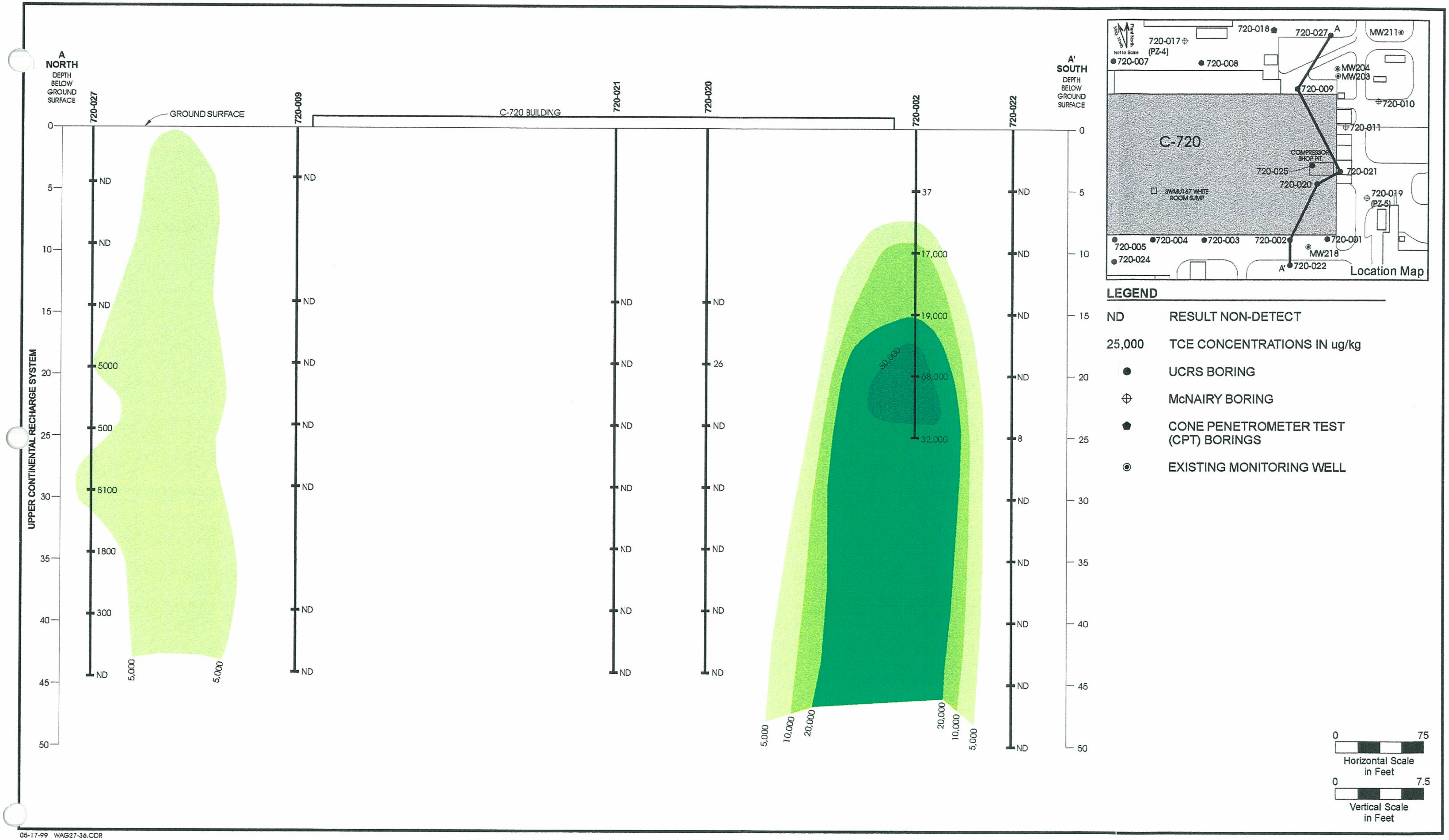
720-001

Para.	Depth (ft)	Conc.
VC	22-24	400

720-002

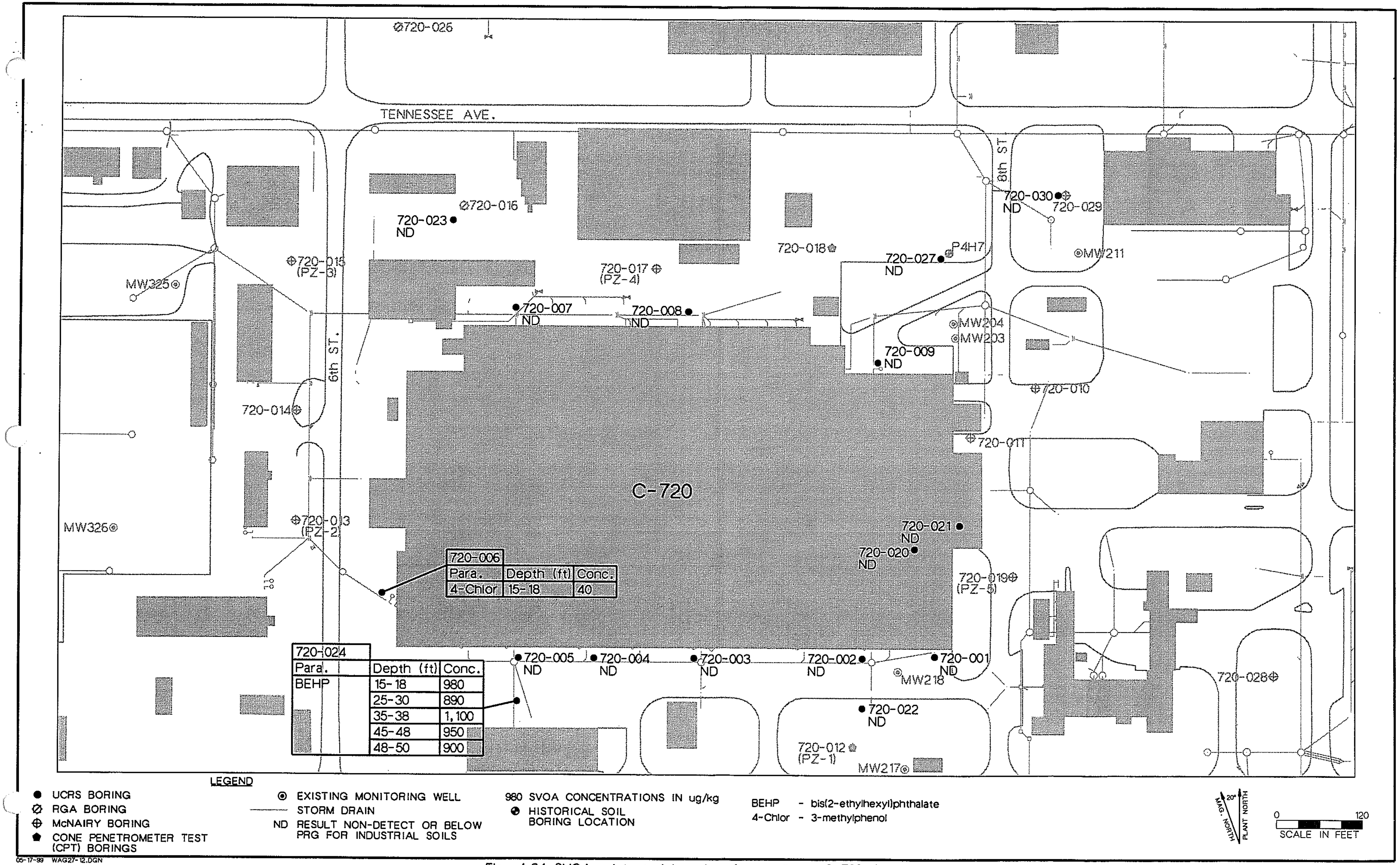
Para.	Depth (ft)	Conc.
t-1,2-DCE	12-16	450,000
	15-16	450,000
TCE	5-8	37
	9-10	17,000
	15-16	19,000
	20-21	68,000
	25-26	32,000
VC	5-6	400
	10	200

Fig. 4.22 VOAs detected in subsurface soils at C-720 Complex.



08-17-99 WAG27-36.CDR

Fig. 4.23 North-south cross section A-A' showing TCE distribution in UCRS soils.



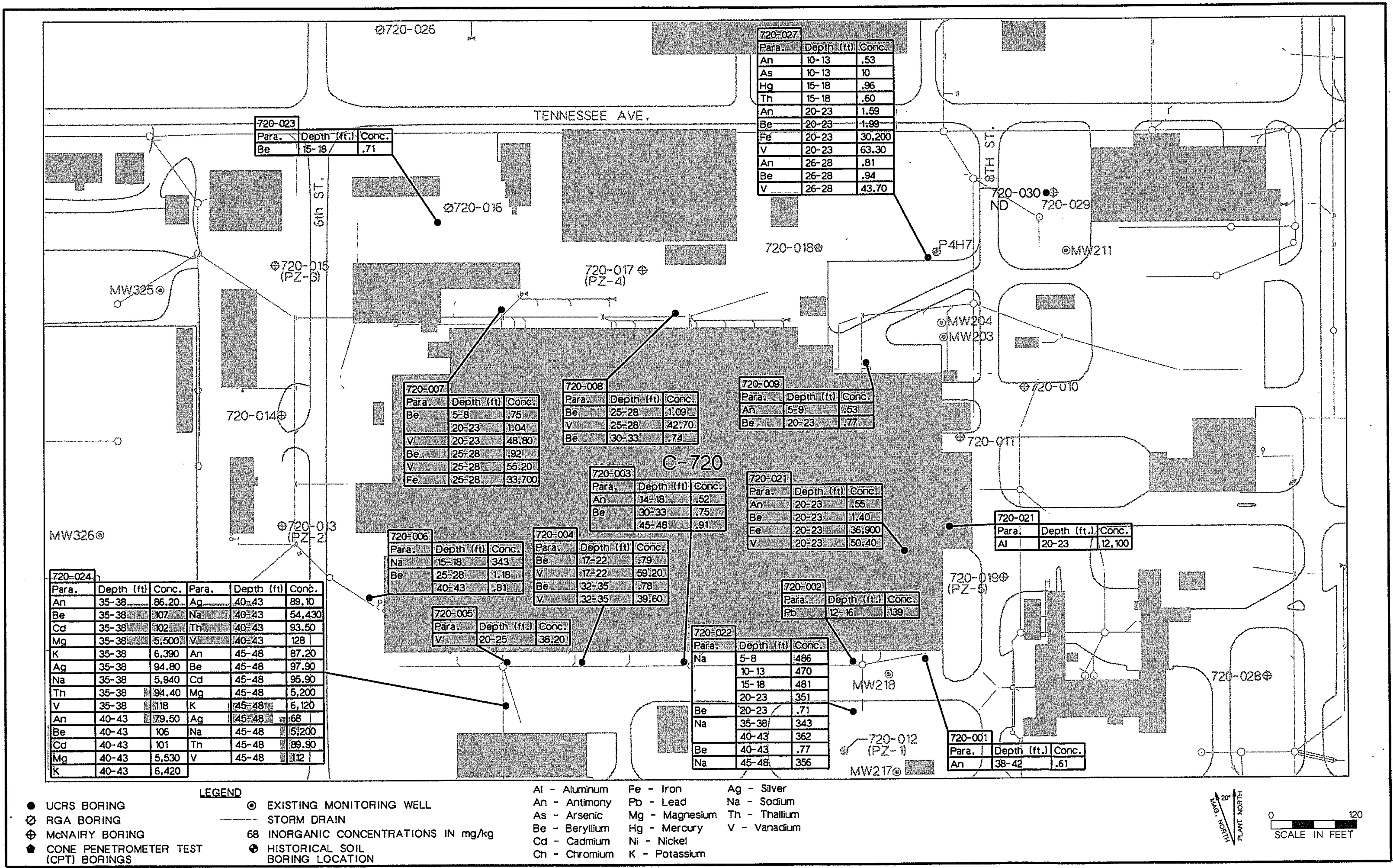
720-006

Para.	Depth (ft)	Conc.
4-Chlor	15-18	40

720-024

Para.	Depth (ft)	Conc.
BEHP	15-18	980
	25-30	890
	35-38	1,100
	45-48	950
	48-50	900

Fig. 4.24 SVOAs detected in subsurface soils at C-720 Complex.



720-023		
Para.	Depth (ft.)	Conc.
Be	15-18	.71

720-027		
Para.	Depth (ft)	Conc.
An	10-13	.53
As	10-13	10
Hg	15-18	.96
Th	15-18	.60
An	20-23	1.59
Be	20-23	1.99
Fe	20-23	30,200
V	20-23	63.30
An	26-28	.81
Be	26-28	.94
V	26-28	43.70

720-007		
Para.	Depth (ft)	Conc.
Be	5-8	.75
	20-23	1.04
V	20-23	48.80
Be	25-28	.92
V	25-28	55.20
Fe	25-28	33,700

720-008		
Para.	Depth (ft)	Conc.
Be	25-28	1.09
V	25-28	42.70
Be	30-33	.74

720-009		
Para.	Depth (ft)	Conc.
An	5-9	.53
Be	20-23	.77

720-003		
Para.	Depth (ft)	Conc.
An	14-18	.52
Be	30-33	.75
	45-48	.91

720-021		
Para.	Depth (ft)	Conc.
An	20-23	.55
Be	20-23	1.40
Fe	20-23	36,900
V	20-23	50.40

720-021		
Para.	Depth (ft.)	Conc.
Al	20-23	12,100

720-006		
Para.	Depth (ft)	Conc.
Na	15-18	343
Be	25-28	1.18
	40-43	.81

720-004		
Para.	Depth (ft)	Conc.
Be	17-22	.79
V	17-22	59.20
Be	32-35	.78
V	32-35	39.60

720-005		
Para.	Depth (ft.)	Conc.
V	20-25	38.20

720-002		
Para.	Depth (ft.)	Conc.
Pb	12-16	139

720-024					
Para.	Depth (ft)	Conc.	Para.	Depth (ft)	Conc.
An	35-38	86.20	Ag	40-43	89.10
Be	35-38	107	Na	40-43	54,430
Cd	35-38	102	Th	40-43	93.50
Mg	35-38	5,500	V	40-43	128
K	35-38	6,390	An	45-48	87.20
Ag	35-38	94.80	Be	45-48	97.90
Na	35-38	5,940	Cd	45-48	95.90
Th	35-38	94.40	Mg	45-48	5,200
V	35-38	118	K	45-48	6,120
An	40-43	79.50	Ag	45-48	68
Be	40-43	106	Na	45-48	5,200
Cd	40-43	101	Th	45-48	89.90
Mg	40-43	5,530	V	45-48	112
K	40-43	6,420			

720-022		
Para.	Depth (ft)	Conc.
Na	5-8	486
	10-13	470
	15-18	481
	20-23	351
Be	20-23	.71
Na	35-38	343
	40-43	362
Be	40-43	.77
Na	45-48	356

720-001		
Para.	Depth (ft.)	Conc.
An	38-42	.61

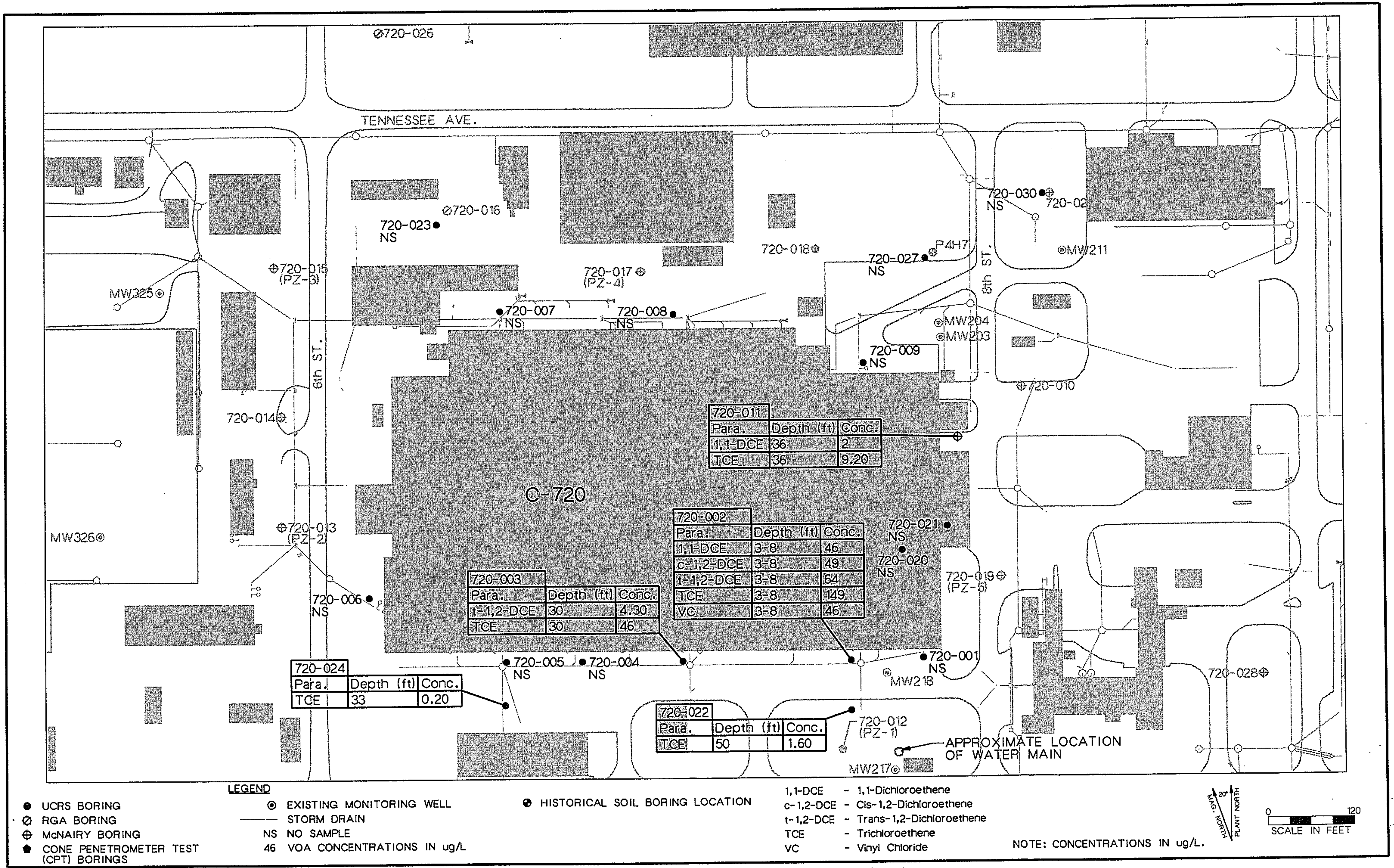
LEGEND

- ● UCRS BORING
- Ø RGA BORING
- ⊕ McNAIRY BORING
- ⬟ CONE PENETROMETER TEST (CPT) BORINGS
- ⊙ EXISTING MONITORING WELL
- —— STORM DRAIN
- 68 INORGANIC CONCENTRATIONS IN mg/kg
- ⊕ HISTORICAL SOIL BORING LOCATION

Al - Aluminum
An - Antimony
As - Arsenic
Be - Beryllium
Cd - Cadmium
Ch - Chromium
Fe - Iron
Pb - Lead
Mg - Magnesium
Hg - Mercury
Ni - Nickel
K - Potassium
Ag - Silver
Na - Sodium
Th - Thallium
V - Vanadium

05-17-99 WAG27-11.DGN

Fig. 4.25 Metals detected at C-720 Complex.



720-011

Para.	Depth (ft)	Conc.
1,1-DCE	36	2
TCE	36	9.20

720-002

Para.	Depth (ft)	Conc.
1,1-DCE	3-8	46
c-1,2-DCE	3-8	49
t-1,2-DCE	3-8	64
TCE	3-8	149
VC	3-8	46

720-003

Para.	Depth (ft)	Conc.
t-1,2-DCE	30	4.30
TCE	30	46

720-024

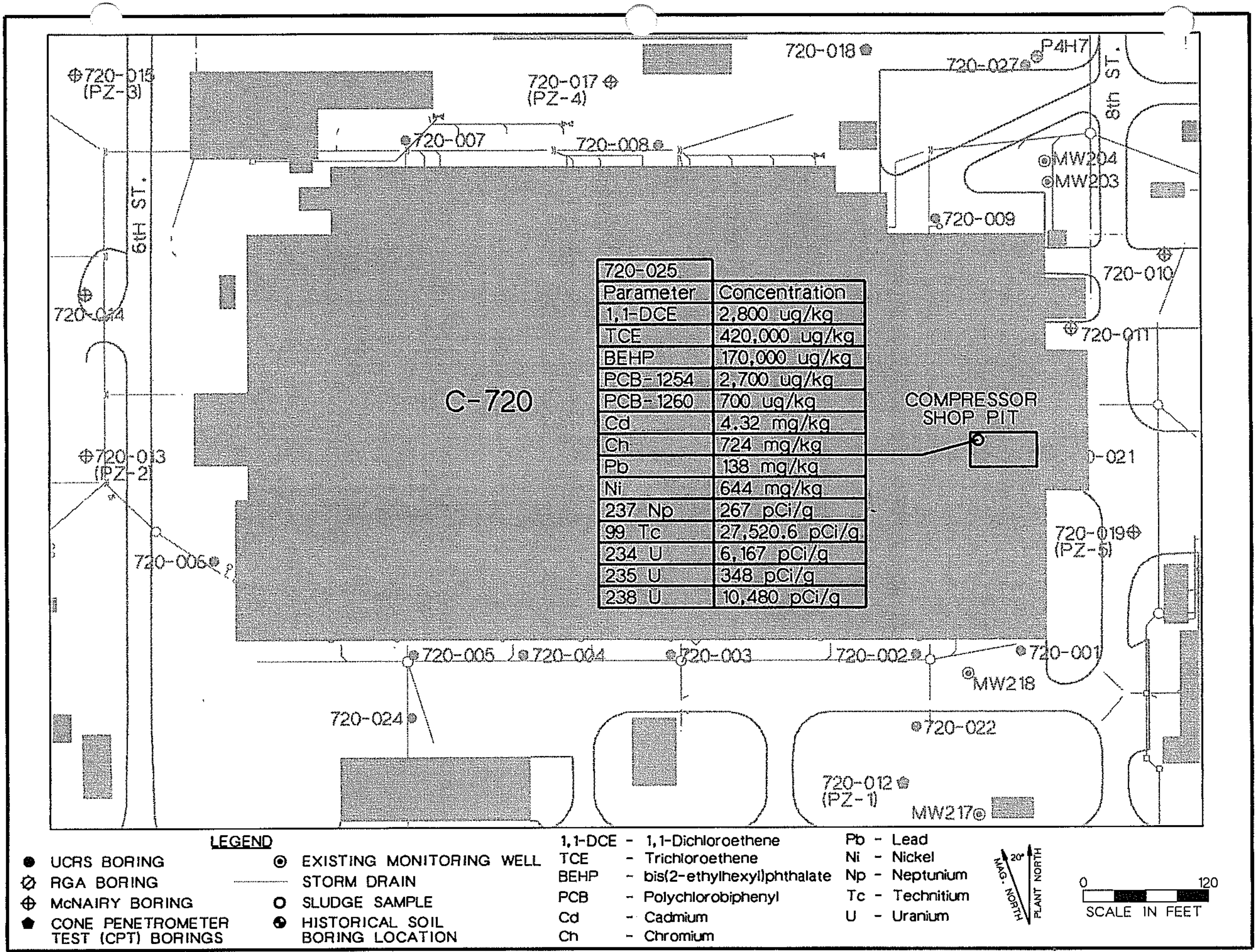
Para.	Depth (ft)	Conc.
TCE	33	0.20

720-022

Para.	Depth (ft)	Conc.
TCE	50	1.60

05-17-99 WAG27-26.DGN

Fig. 4.26 VOAs detected in UCRS groundwater at C-720 Complex.



720-025	
Parameter	Concentration
1,1-DCE	2,800 ug/kg
TCE	420,000 ug/kg
BEHP	170,000 ug/kg
PCB-1254	2,700 ug/kg
PCB-1260	700 ug/kg
Cd	4.32 mg/kg
Ch	724 mg/kg
Pb	138 mg/kg
Ni	644 mg/kg
237 Np	267 pCi/g
99 Tc	27,520.6 pCi/g
234 U	6,167 pCi/g
235 U	348 pCi/g
238 U	10,480 pCi/g

1,1-DCE - 1,1-Dichloroethene
TCE - Trichloroethene
BEHP - bis(2-ethylhexyl)phthalate
PCB - Polychlorobiphenyl
Cd - Cadmium
Ch - Chromium
Pb - Lead
Ni - Nickel
Np - Neptunium
Tc - Technitium
U - Uranium

Fig. 4.27 Parameters detected in Compressor Shop pit sump sample at C-720 Complex.

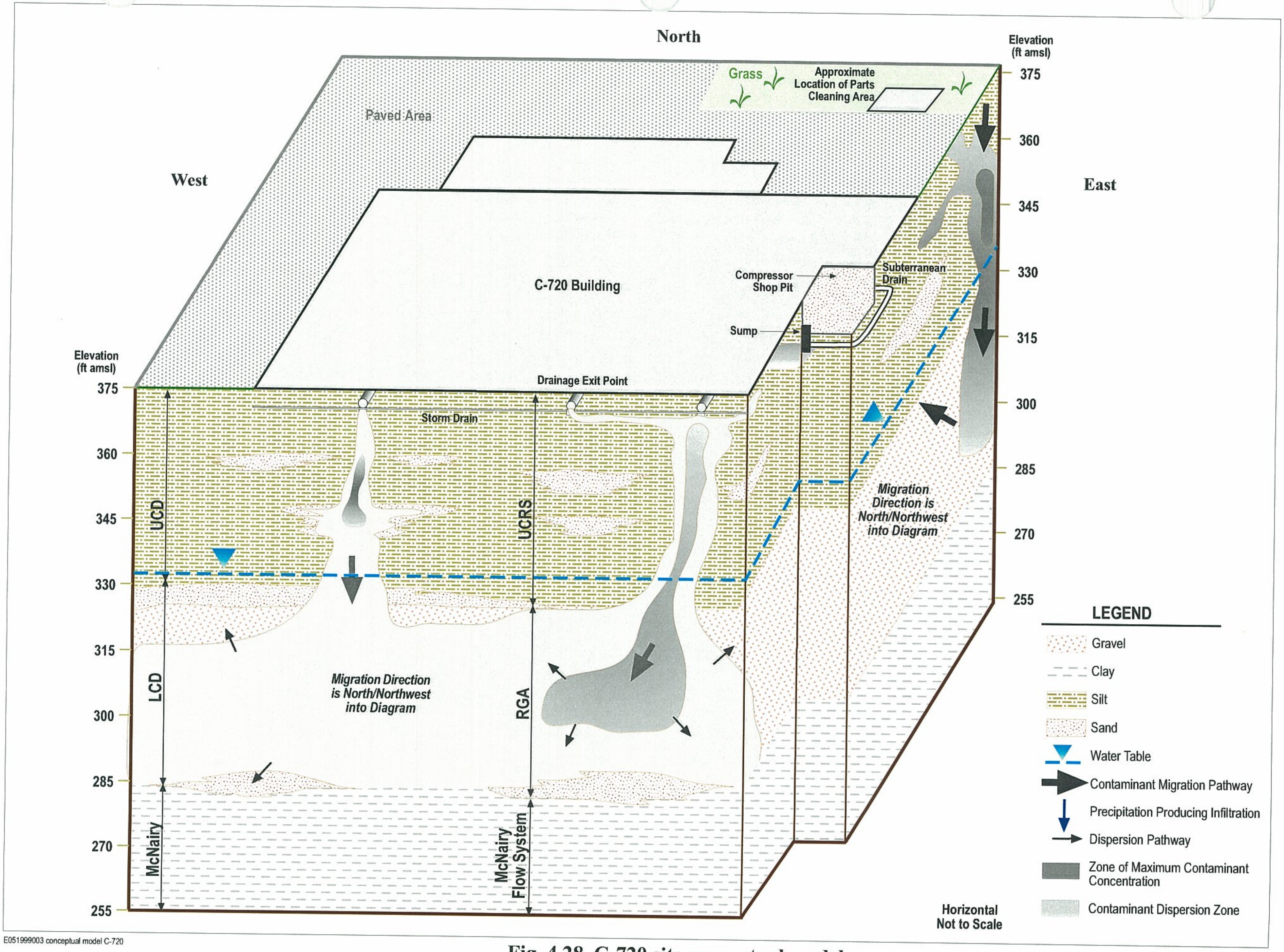
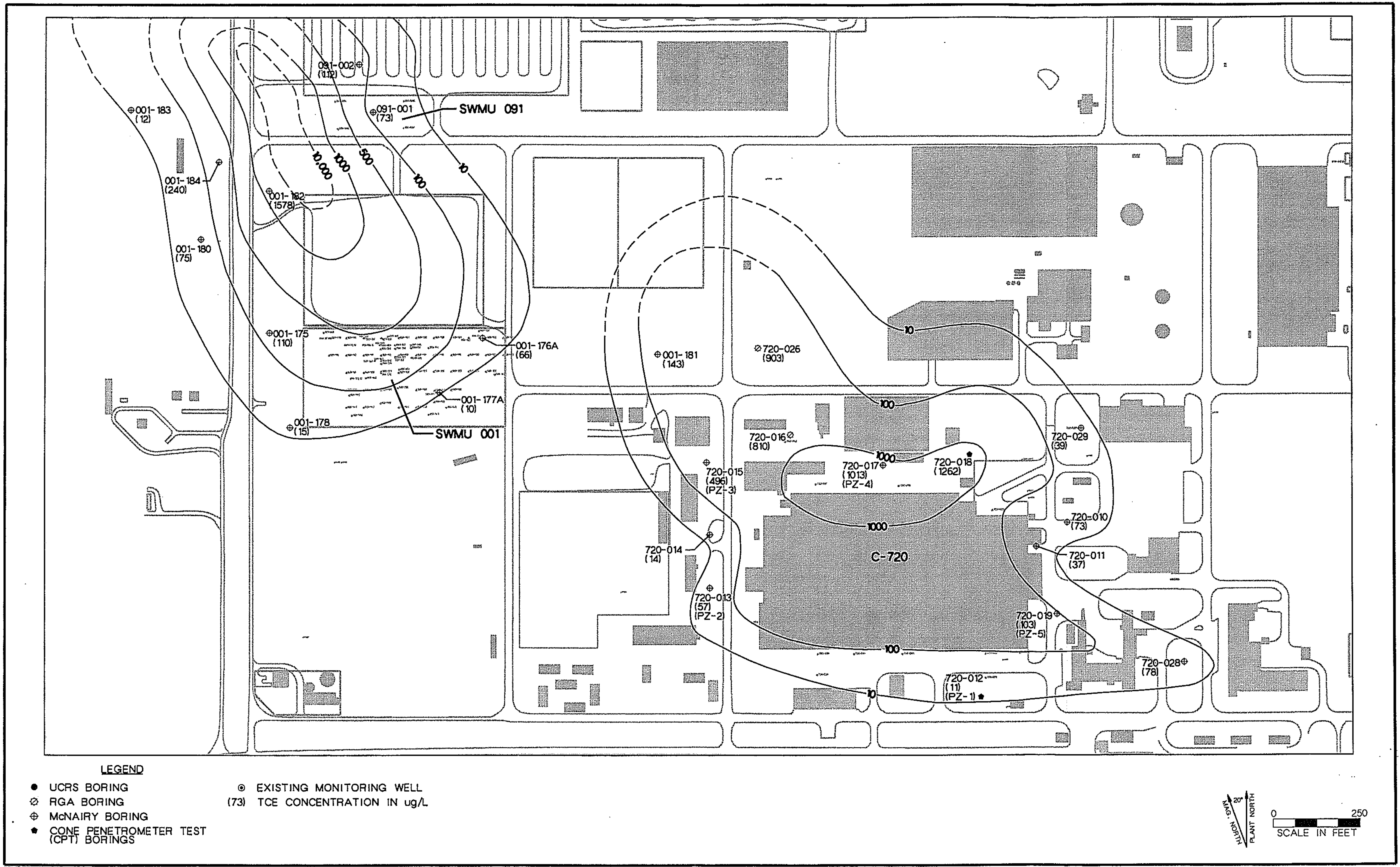
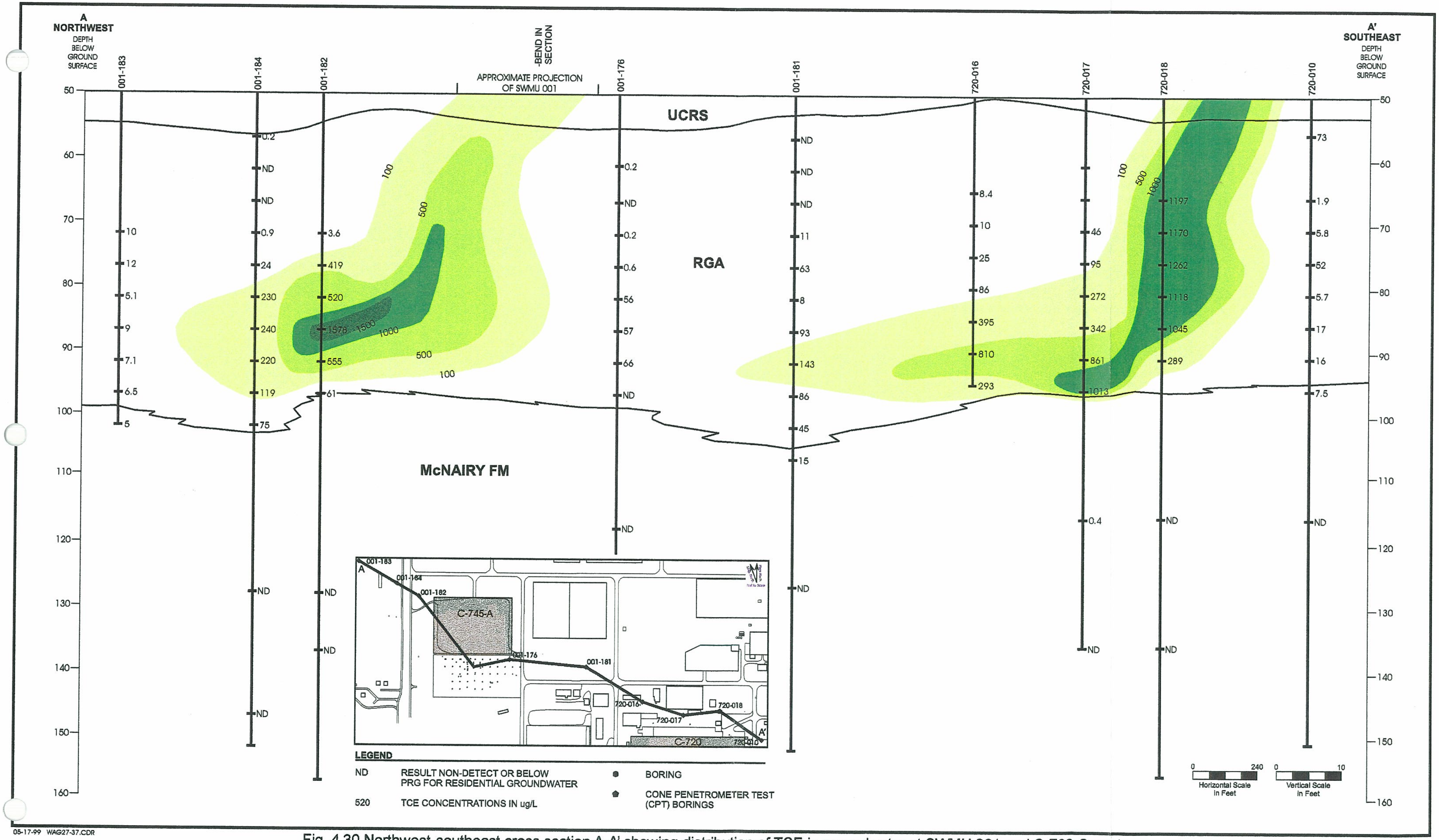


Fig. 4.28. C-720 site conceptual model.



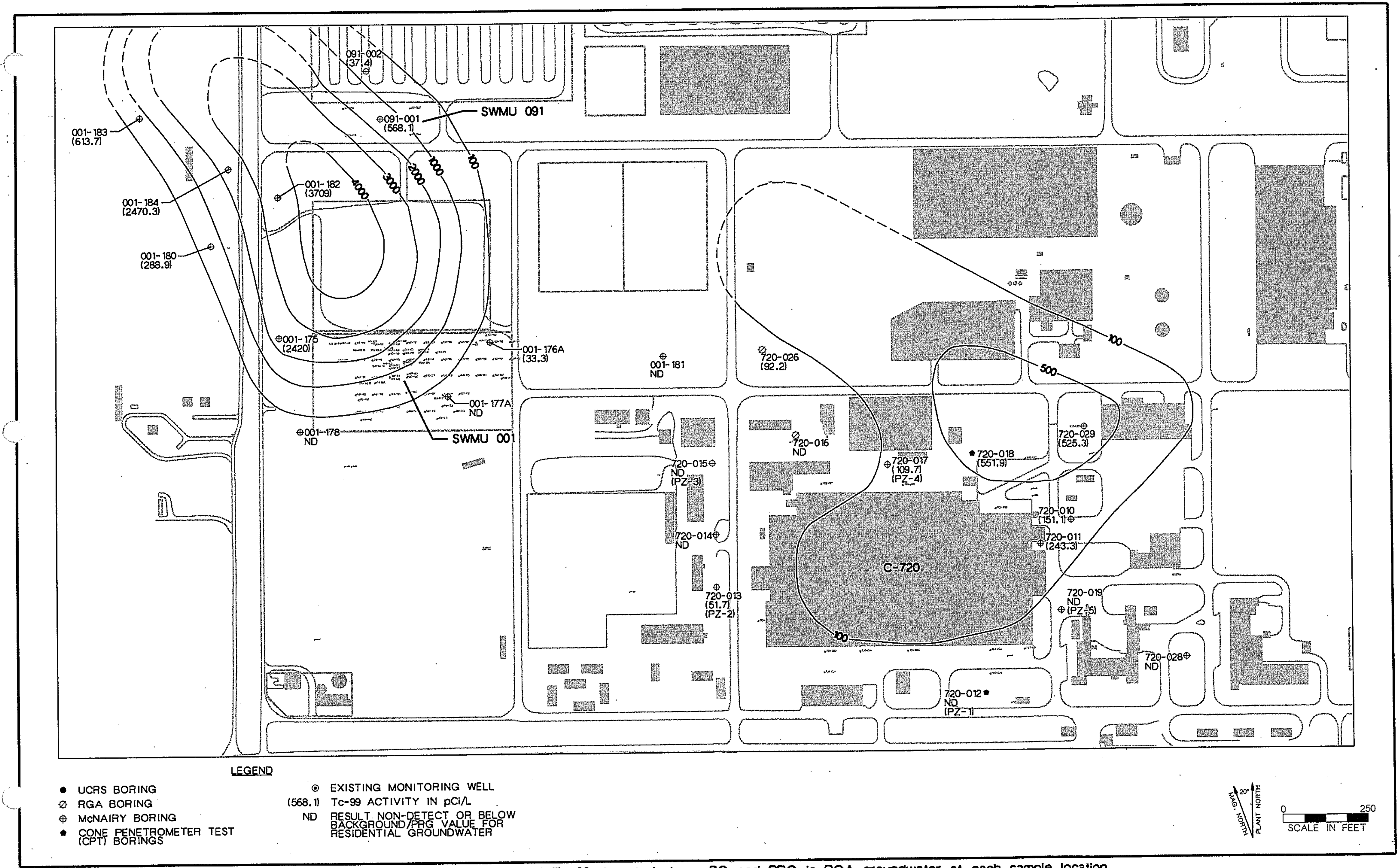
05-17-99 WAG27-03.DGN

Fig. 4.29 Maximum concentration of TCE detected in RGA groundwater above PRG at each sample location.



05-17-99 WAG27-37.CDR

Fig. 4.30 Northwest-southeast cross section A-A' showing distribution of TCE in groundwater at SWMU 001 and C-720 Complex.



05-17-99 WAG27-06.DGN

Fig. 4.31 Maximum concentration of Tc-99 detected above BG and PRG in RGA groundwater at each sample location.

Table 4.1. Metals background values

Analytical Compound	SOIL Background Data [a] (mg/kg) Near Surface	 Subsurface	WATER Background Data [b] (mg/L) Groundwater
Aluminum	13,000	12,000	22
Antimony	0.21	0.21	0.11
Arsenic	12	7.9	0.011
Barium	200	170	0.29
Beryllium	0.67	0.69	0.0093
Cadmium	0.21	0.21	0.021
Calcium	200,000	6,100	44
Chromium	16	43	0.13
Cobalt	14	13	0.096
Copper	19	25	0.022
Iron	28,000	28,000	5.1
Lead	36	23	0.1
Magnesium	7,700	2,100	17
Manganese	1,500	820	0.16
Mercury	0.2	0.13	0.00038
Nickel	21	22	0.062
Potassium	1,300	950	6.2
Selenium	0.8	0.7	0.0093
Silver	2.3	2.7	0.0041
Sodium	320	340	60
Thallium	0.21	0.34	0.11
Vanadium	38	37	0.14
Zinc	65	60	0.027

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[a] Background Levels of Selected Radionuclides and Metals in Soils and Geologic Media at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE, 1997)

[b] Baseline Risk Assessment and Technical Investigation Report for the Northwest Dissolved Phase Plume, Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE, 1994)

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Table 4.2. Radioactive isotopes background values

Analytical Compound	SOIL Background Data [a] (pCi/g) Near Surface	SOIL Background Data [a] (pCi/g) Subsurface	WATER Background Data [b] (pCi/L) Groundwater
Americium-241	N/A [c]	N/A	N/A
Cesium-137	0.49	0.28	0
Lead-210	N/A	N/A	N/A
Neptunium-237	0.1	0	0
Plutonium-238	0.073	0	0
Plutonium-239	0.025	0	0
Potassium-40	16	16	0
Radium-226	1.5	1.5	0
Technetium-99	2.5	2.8	0
Thorium-228	1.6	1.6	0
Thorium-230	1.5	1.4	1.4
Thorium-232	1.5	1.5	0
Uranium-234	2.5	2.4	1.2
Uranium-235	0.14	0.14	0.15
Uranium-238	1.2	1.2	1.1

(a) Background Levels of Selected Radionuclides and Metals in Soils and Geologic Media at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE, 1997)

(b) Baseline Risk Assessment and Technical Investigation Report for the Northwest Dissolved Phase Plume, Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE, 1994)

(c) Not Available

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Table 4.3. Preliminary Remediation Goals [(a)]

Analytical Compound	Industrial Soil	Soil Units	Residential Groundwater	Groundwater Units
Metals				
Aluminum	4.6E+03	mg/kg	1.5E+00	mg/L
Antimony	3.8E-01	mg/kg	5.6E-04	mg/L
Arsenic	3.3E-02	mg/kg	3.5E-06	mg/L
Asbestos	1.7E+02	mg/kg	---	---
Barium	2.3E+02	mg/kg	1.0E-01	mg/L
Beryllium	3.1E-04	mg/kg	1.0E-06	mg/L
Cadmium	2.3E+00	mg/kg	6.6E-04	mg/L
Calcium	0.00E+00	---	0.00E+00	---
Chromium	2.4E+02	mg/kg	1.2E+00	mg/L
Cobalt	1.9E+03	mg/kg	9.1E-02	mg/L
Copper	5.3E+02	mg/kg	6.0E-02	mg/L
Cyanide	1.6E+02	mg/kg	2.8E-02	mg/L
Fluoride	2.3E+03	mg/kg	9.1E-02	mg/L
Iron	2.1E+03	mg/kg	4.5E-01	mg/L
Lead	6.9E-04	mg/kg	1.5E-07	mg/L
Magnesium	0.00E+00	---	0.00E+00	---
Manganese	8.7E+01	mg/kg	6.7E-02	mg/L
Mercury	8.1E-01	mg/kg	4.4E-04	mg/L
Molybdenum	8.3E+01	mg/kg	7.5E-03	mg/L
Nickel	2.4E+02	mg/kg	3.0E-02	mg/L
Nitrate	3.4E+04	mg/kg	2.4E+00	mg/L
Nitrate as Nitrogen	3.4E+04	mg/kg	2.4E+00	mg/L
Nitrate/Nitrite	2.1E+03	mg/kg	1.5E-01	mg/L
Nitrite as Nitrogen	2.1E+03	mg/kg	1.5E-01	mg/L
Potassium	0.00E+00	---	0.00E+00	---
Selenium	9.5E+01	mg/kg	7.5E-03	mg/L
Silica	0.00E+00	---	0.00E+00	---
Silver	4.1E+01	mg/kg	7.5E-03	mg/L
Sodium	0.00E+00	---	0.00E+00	---
Thallium	0.00E+00	---	0.00E+00	---
Uranium	1.0E+02	mg/kg	4.5E-03	mg/L
Vanadium	3.3E+00	mg/kg	9.3E-03	mg/L
Zinc	2.7E+03	mg/kg	4.5E-01	mg/L
Organic Compounds				
1,1,1,2-Tetrachloroethane	6.50E+02	ug/kg	3.90E-02	ug/L
1,1,1-Trichloroethane	6.30E+05	ug/kg	5.40E+01	ug/L
1,1,2,2-Tetrachloroethane	7.00E+01	ug/kg	5.00E-03	ug/L
1,1,2-Trichloro-1,2,2-trifluoroethane	2.30E+07	ug/kg	1.90E+03	ug/L
1,1,2-Trichloroethane	2.20E+02	ug/kg	1.80E-02	ug/L
1,1-Dichloroethane	3.50E+05	ug/kg	2.70E+01	ug/L
1,1-Dichloroethene	2.00E+01	ug/kg	9.30E-04	ug/L
1,2,3-Trichloropropane	2.90E+00	ug/kg	3.90E-04	ug/L
1,2,4-Trichlorobenzene	2.00E+05	ug/kg	6.60E+00	ug/L
1,2-Dibromoethane	2.40E-01	ug/kg	5.90E-05	ug/L
1,2-Dichlorobenzene	4.40E+05	ug/kg	1.20E+01	ug/L
1,2-Dichloroethane	1.10E+02	ug/kg	1.10E-02	ug/L
1,2-Dichloroethene	6.60E+04	ug/kg	1.80E+00	ug/L
1,2-Dichloropropane	2.80E+02	ug/kg	7.60E-02	ug/L
1,2-Dimethylbenzene	1.80E+06	ug/kg	4.60E+01	ug/L
1,3-Dichlorobenzene	6.10E+05	ug/kg	5.30E-01	ug/L
1,4-Dichlorobenzene	9.60E+02	ug/kg	2.00E-01	ug/L
2,2'-oxybis(1-chloropropane)	0.00E+00	---	0.00E+00	---

Table 4.3. Preliminary Remediation Goals [(a)]

Analytical Compound	Industrial Soil	Soil Units	Residential Groundwater	Groundwater Units
Organic Compounds (cont.)				
2,4,5-Trichlorophenol	1.10E+06	ug/kg	2.00E+01	ug/L
2,4,6-Trichlorophenol	2.80E+03	ug/kg	4.00E-01	ug/L
2,4-Dichlorophenol	5.10E+04	ug/kg	4.10E+00	ug/L
2,4-Dimethylphenol	2.20E+05	ug/kg	3.90E+00	ug/L
2,4-Dinitrophenol	3.90E+04	ug/kg	3.00E+00	ug/L
2,4-Dinitrotoluene	7.60E+01	ug/kg	7.70E-03	ug/L
2,6-Dinitrotoluene	7.60E+01	ug/kg	7.70E-03	ug/L
2-Butanone	2.10E+06	ug/kg	6.20E+01	ug/L
2-Chloro-1,3-butadiene	3.00E+04	ug/kg	4.60E-01	ug/L
2-Chloroethyl vinyl ether	0.00E+00	---	0.00E+00	---
2-Chloronaphthalene	7.20E+05	ug/kg	1.50E+01	ug/L
2-Chlorophenol	4.60E+04	ug/kg	1.00E+00	ug/L
2-Hexanone	0.00E+00	---	0.00E+00	---
2-Methyl-4,6-dinitrophenol	0.00E+00	---	0.00E+00	---
2-Methylnaphthalene	0.00E+00	---	0.00E+00	---
2-Methylphenol	5.40E+05	ug/kg	7.20E+01	ug/L
2-Nitrobenzenamine	4.20E+02	ug/kg	1.20E-02	ug/L
2-Nitrophenol	0.00E+00	---	0.00E+00	---
2-Propanol	0.00E+00	---	0.00E+00	---
3,3-Dichlorobenzidine	7.00E+01	ug/kg	1.10E-02	ug/L
3-Nitrobenzenamine	0.00E+00	---	0.00E+00	---
4-Bromophenyl phenyl ether	0.00E+00	---	0.00E+00	---
4-Chloro-3-methylphenol	0.00E+00	---	0.00E+00	---
4-Chlorobenzenamine	4.40E+04	ug/kg	5.60E+00	ug/L
4-Chlorophenyl phenyl ether	0.00E+00	---	0.00E+00	---
4-Methyl-2-pentanone	1.60E+05	ug/kg	5.10E+00	ug/L
4-Methylphenol	6.90E+04	ug/kg	7.30E+00	ug/L
4-Nitrobenzenamine	0.00E+00	---	0.00E+00	---
4-Nitrophenol	1.30E+06	ug/kg	1.30E+01	ug/L
Acenaphthene	4.20E+05	ug/kg	1.10E+01	ug/L
Acenaphthylene	0.00E+00	---	0.00E+00	---
Acetone	5.50E+05	ug/kg	2.00E+01	ug/L
Acrolein	8.70E+01	ug/kg	1.30E-03	ug/L
Acrylonitrile	3.00E+01	ug/kg	3.40E-03	ug/L
Anthracene	4.90E+06	ug/kg	5.70E+01	ug/L
Benz(a)anthracene	2.30E+01	ug/kg	1.30E-03	ug/L
Benzene	2.80E+02	ug/kg	3.50E-02	ug/L
Benzenemethanol	0.00E+00	---	0.00E+00	---
Benzidine	2.10E-01	ug/kg	2.30E-05	ug/L
Benzo(a)pyrene	2.50E+00	ug/kg	9.50E-05	ug/L
Benzo(b)fluoranthene	1.90E+01	ug/kg	9.30E-04	ug/L
Benzo(ghi)perylene	0.00E+00	---	0.00E+00	---
Benzo(k)fluoranthene	2.60E+02	ug/kg	1.70E-02	ug/L
Benzoic Acid	7.40E+07	ug/kg	6.00E+03	ug/L
Bis(2-chloroethoxy)methane	0.00E+00	---	0.00E+00	---
Bis(2-chloroethyl) ether	2.30E+01	ug/kg	9.20E-04	ug/L
Bis(2-ethylhexyl)phthalate	8.80E+02	ug/kg	3.10E-01	ug/L
Bromodichloromethane	4.00E+02	ug/kg	8.40E-02	ug/L
Bromoform	1.80E+03	ug/kg	2.20E-01	ug/L
Bromomethane	3.00E+03	ug/kg	2.90E-01	ug/L
Butyl benzyl phthalate	2.70E+06	ug/kg	2.60E+02	ug/L
Carbon disulfide	2.30E+05	ug/kg	3.50E+01	ug/L
Carbon tetrachloride	7.50E+01	ug/kg	1.50E-02	ug/L

Table 4.3. Preliminary Remediation Goals [(a)]

Analytical Compound	Industrial Soil	Soil Units	Residential Groundwater	Groundwater Units
Organic Compounds (cont.)				
Chlorobenzene	2.90E+04	ug/kg	1.30E+00	ug/L
Chloroethane	1.50E+06	ug/kg	3.10E+02	ug/L
Chloroform	1.30E+02	ug/kg	1.50E-02	ug/L
Chloromethane	6.60E+02	ug/kg	1.30E-01	ug/L
Chrysene	1.60E+03	ug/kg	1.30E-01	ug/L
cis-1,2-Dichloroethene	3.10E+04	ug/kg	2.00E+00	ug/L
cis-1,3-Dichloropropene	3.60E+01	ug/kg	7.20E-03	ug/L
cis-1,4-Dichloro-2-butene	1.10E+01	ug/kg	1.30E-04	ug/L
Dibenz(a,h)anthracene	2.70E+00	ug/kg	4.60E-05	ug/L
Dibenzofuran	4.40E+04	ug/kg	1.60E+00	ug/L
Dibromochloromethane	1.80E+02	ug/kg	6.20E-02	ug/L
Dibromomethane	4.00E+04	ug/kg	2.00E+00	ug/L
Dichlorodifluoromethane	9.00E+04	ug/kg	1.30E+01	ug/L
Diethyl phthalate	1.50E+07	ug/kg	1.20E+03	ug/L
Dimethyl phthalate	1.80E+08	ug/kg	1.50E+04	ug/L
Dimethylbenzene	9.60E+06	ug/kg	4.00E+02	ug/L
Di-n-butyl phthalate	2.10E+06	ug/kg	1.30E+02	ug/L
Di-n-octylphthalate	3.90E+05	ug/kg	6.90E-01	ug/L
Ethanol	0.00E+00	---	0.00E+00	---
Ethyl cyanide	0.00E+00	---	0.00E+00	---
Ethyl methacrylate	6.60E+05	ug/kg	1.80E+01	ug/L
Ethylbenzene	6.50E+05	ug/kg	4.50E+01	ug/L
Fluoranthene	2.80E+05	ug/kg	2.30E+01	ug/L
Fluorene	4.40E+05	ug/kg	7.40E+00	ug/L
Hexachlorobenzene	1.90E+01	ug/kg	1.90E-03	ug/L
Hexachlorobutadiene	3.70E+02	ug/kg	4.80E-02	ug/L
Hexachlorocyclopentadiene	4.40E+03	ug/kg	9.80E+00	ug/L
Hexachloroethane	2.10E+03	ug/kg	3.30E-01	ug/L
Indeno(1,2,3-cd)pyrene	2.60E+01	ug/kg	6.30E-04	ug/L
Iodomethane	0.00E+00	---	0.00E+00	---
Isophorone	3.30E+04	ug/kg	5.50E+00	ug/L
m,p-Cresol	6.90E+04	ug/kg	7.30E+00	ug/L
m,p-Xylene	1.70E+06	ug/kg	4.60E+01	ug/L
Methacrylonitrile	6.10E+02	ug/kg	3.60E-02	ug/L
Methyl methacrylate	2.60E+06	ug/kg	4.60E+01	ug/L
Methylene chloride	2.20E+03	ug/kg	3.60E-01	ug/L
Naphthalene	3.20E+04	ug/kg	8.70E-02	ug/L
Nitrobenzene	4.00E+03	ug/kg	1.10E-01	ug/L
N-Nitroso-di-n-propylamine	2.30E+00	ug/kg	7.40E-04	ug/L
N-Nitrosodiphenylamine	3.30E+03	ug/kg	9.50E-01	ug/L
PCB-1016	4.20E+01	ug/kg	5.30E-03	ug/L
PCB-1221	4.20E+01	ug/kg	1.10E-02	ug/L
PCB-1232	4.20E+01	ug/kg	1.30E-02	ug/L
PCB-1242	4.20E+01	ug/kg	1.20E-02	ug/L
PCB-1248	4.20E+01	ug/kg	7.80E-03	ug/L
PCB-1254	4.20E+01	ug/kg	8.00E-03	ug/L
PCB-1260	4.20E+01	ug/kg	4.40E-03	ug/L
PCB-1262	0.00E+00	---	0.00E+00	---
PCB-1268	0.00E+00	---	0.00E+00	---
Pentachlorophenol	5.00E+02	ug/kg	2.10E-02	ug/L
Phenanthrene	0.00E+00	---	0.00E+00	---
Phenol	1.10E+07	ug/kg	9.00E+02	ug/L
Polybrominated biphenyl	6.30E+00	ug/kg	5.90E-04	ug/L

Table 4.3. Preliminary Remediation Goals [(a)]

Analytical Compound	Industrial Soil	Soil Units	Residential Groundwater	Groundwater Units
Organic Compounds (cont.)				
Polychlorinated biphenyl	4.20E+01	ug/kg	8.00E-03	ug/L
Pyrene	2.10E+05	ug/kg	1.80E+01	ug/L
Pyridine	8.40E+03	ug/kg	1.50E+00	ug/L
Styrene	1.20E+06	ug/kg	4.50E+01	ug/L
Tetrachloroethene	4.50E+02	ug/kg	5.70E-02	ug/L
Toluene	4.90E+05	ug/kg	2.40E+01	ug/L
Total Cresols	6.90E+04	ug/kg	7.30E+00	ug/L
trans-1,2-Dichloroethene	5.30E+04	ug/kg	4.00E+00	ug/L
trans-1,3-Dichloropropene	3.60E+01	ug/kg	7.20E-03	ug/L
trans-1,4-Dichloro-2-butene	1.10E+01	ug/kg	1.30E-04	ug/L
Trichloroethene	3.10E+02	ug/kg	1.40E-01	ug/L
Trichlorofluoromethane	2.80E+05	ug/kg	4.20E+01	ug/L
Vinyl Acetate	4.10E+05	ug/kg	1.30E+01	ug/L
Vinyl Chloride	7.30E+00	ug/kg	1.70E-03	ug/L
Radioactive isotopes				
Alpha activity	0.00E+00	---	0.00E+00	---
Americium-241	8.1E+00	pCi/g	1.2E-01	pCi/L
Beta activity	0.00E+00	---	0.00E+00	---
Cesium-137	1.0E+02	pCi/g	1.2E+00	pCi/L
Cobalt-60	2.2E-02	pCi/g	2.0E+00	pCi/L
Neptunium-237	7.9E+00	pCi/g	1.3E-01	pCi/L
Plutonium-239/240	1.0E+01	pCi/g	1.2E-01	pCi/L
Radon-222	0.00E+00	---	0.00E+00	---
Technetium-99	2.3E+03	pCi/g	2.8E+01	pCi/L
Thorium-230	8.3E+01	pCi/g	1.0E+00	pCi/L
Uranium-234	7.1E+01	pCi/g	8.7E-01	pCi/L
Uranium-235	8.2E-01	pCi/g	8.5E-01	pCi/L
Uranium-238	7.4E+01	pCi/g	9.0E-01	pCi/L

(a) Modified from Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, DOE/OR/07-1506&D1, August (DOE 1996d)

Table 4.4. VOA compounds detected in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
Trench	VOA	001101SA001	0	0	Trichloroethene	510.000 *	JE	?	
			0	0	Vinyl chloride	67.000 *	JX	?	
		001101SD001	0	0	Trichloroethene	1,200.000 *	JE	?	
			0	0	Vinyl chloride	270.000 *	JE	?	
		001102SA001	0	0	Trichloroethene	11.000		?	
		001103SA001	0	0	Trichloroethene	15.000	JX	?	
Subsurface Soil		001112SA010	7	10	Trichloroethene	6.000	J	?	BL-T J
		001116SA010	7	10	Trichloroethene	100.000	J	?	
		001117SA010	7	10	Vinyl chloride	500.000 *	J	?	
		001152SA005	5	5	cis-1,2-Dichloroethene	1,200.000	J	?	BL-T J
			5	5	trans-1,2-Dichloroethene	500.000		?	
			5	5	Trichloroethene	55.000	J	?	BL-T J
		001152SA010	7	10	cis-1,2-Dichloroethene	1,700.000	J	?	BL-T J
			7	10	trans-1,2-Dichloroethene	800.000		?	
			7	10	Trichloroethene	170.000	J	?	BL-T J
		001153SA005	5	5	cis-1,2-Dichloroethene	2,400.000	J	?	BL-T J

* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs. Exposed trenches were backfilled after sampling.

Table 4.4. VOA compounds detected in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
Subsurface Soil	VOA	001153SA005	5	5	trans-1,2-Dichloroethene	1,200.000		?	
			5	5	Trichloroethene	480.000 *		?	BL-T J
			5	5	Vinyl chloride	900.000 *		?	
		001153SA010	7	10	cis-1,2-Dichloroethene	6,000.000		?	BL-T J
			7	10	trans-1,2-Dichloroethene	4,300.000		?	
			7	10	Trichloroethene	2,100.000 *		?	BL-T J
			7	10	Vinyl chloride	4,800.000 *	J	?	BL-T J
		001154SA005	5	5	Trichloroethene	60.000	J	?	BL-T J
			5	5	Vinyl chloride	200.000 *	J	?	
		001154SA010	7	10	Trichloroethene	26.000	J	?	BL-T J
		001155SA010	7	10	cis-1,2-Dichloroethene	550.000	J	?	BL-T J
			7	10	trans-1,2-Dichloroethene	100.000	J	?	
			7	10	Trichloroethene	460.000 *		?	BL-T J
		001156SA005	5	5	trans-1,2-Dichloroethene	1,200.000	J	?	
			5	5	Trichloroethene	31,000.000 *		?	
		001156SA010	7	10	trans-1,2-Dichloroethene	6,500.000		?	

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs.
Exposed trenches were backfilled after sampling.

Table 4.4. VOA compounds detected in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Subsurface Soil	VOA	001156SA010	7	10	Trichloroethene	48,000.000*		?	
		001157SA005	5	5	trans-1,2-Dichloroethene	1,000.000		?	
			5	5	Trichloroethene	12,000.000*		?	
		001157SA010	6	10	trans-1,2-Dichloroethene	13,000.000		?	
			6	10	Trichloroethene	79,000.000*		?	
		001157SD010	6	10	trans-1,2-Dichloroethene	16,000.000		?	
			6	10	Trichloroethene	87,000.000*		?	
		001158SA005	5	5	trans-1,2-Dichloroethene	800.000		?	
			5	5	Trichloroethene	2,200.000*		?	
			5	5	Vinyl chloride	400.000*	J	?	
		001158SA010	7	10	trans-1,2-Dichloroethene	4,400.000		?	
			7	10	Trichloroethene	10,000.000*		?	
		001159SA010	7	10	trans-1,2-Dichloroethene	1,100.000		?	
			7	10	Trichloroethene	100.000	J	?	
		001160SA005	5	5	Trichloroethene	100.000	J	?	
		001160SA010	7	10	trans-1,2-Dichloroethene	100.000	J	?	

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs.
Exposed trenches were backfilled after sampling.

Table 4.4. VOA compounds detected in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Subsurface Soil	VOA	001160SA010	7	10	Trichloroethene	200.000	J	?	
		001161SA005	5	5	Trichloroethene	100.000	J	?	
		001161SA010	7	10	Trichloroethene	200.000	J	?	
		001165SA015	15	15	trans-1,2-Dichloroethene	1,200.000	J	?	
			15	15	Trichloroethene	439,000.000 *		?	
		001165SA020	19.75	20	1,1-Dichloroethane	4,300.000		?	BL-T J
			19.75	20	trans-1,2-Dichloroethene	360.000	J	?	BL-T J
			19.75	20	Trichloroethene	1,900.000 *		?	BL-T J
		001165SA025	25	25	trans-1,2-Dichloroethene	300.000	J	?	
			25	25	Trichloroethene	50,000.000 *		?	
		001165SA030	30	30	trans-1,2-Dichloroethene	300.000	J	?	
			30	30	Trichloroethene	85,000.000 *		?	
		001165SA035	35	35	trans-1,2-Dichloroethene	600.000	J	?	
			35	35	Trichloroethene	74,000.000 *		?	
		001165SA040	40	40	trans-1,2-Dichloroethene	300.000	J	?	
			40	40	Trichloroethene	45,000.000 *		?	

* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs.
Exposed trenches were backfilled after sampling.

Table 4.4. VOA compounds detected in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
Subsurface Soil	VOA	001165SA045	45	45	trans-1,2-Dichloroethene	300.000	J	?	
			45	45	Trichloroethene	66,000.000*		?	
		001165SA050	50	50	Trichloroethene	25,000.000*		?	
		001166SA005	5	5	Trichloroethene	5,000.000*		?	
		001166SA010	10	10	trans-1,2-Dichloroethene	100.000	J	?	
			10	10	Trichloroethene	12,000.000*		?	
		001166SA015	15	15	Trichloroethene	14,000.000*		?	
		001166SA020	20	20	trans-1,2-Dichloroethene	800.000	J	?	
			20	20	Trichloroethene	22,000.000*		?	
		001166SA025	25	25	trans-1,2-Dichloroethene	400.000	J	?	
			25	25	Trichloroethene	23,000.000*		?	
		001166SA030	30	30	1,1-Dichloroethane	2,800.000		?	BL-T J
			30	30	Trichloroethene	18,000.000*		?	
		001166SA035	35	35	Trichloroethene	11,000.000*		?	
		001166SA040	40	40	Trichloroethene	300.000	J	?	
		001168SA010	10	10	1,1-Dichloroethane	500.000		?	BL-T J

* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs.
Exposed trenches were backfilled after sampling.

Table 4.4. VOA compounds detected in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Subsurface Soil	VOA	001168SA010	10	10	Trichloroethene	170.000	J	?	BL-T J
		001168SA015	15	15	Trichloroethene	40.000	J	?	
		001168SA020	20	20	Trichloroethene	800.000*		?	
		001168SA025	24	29	trans-1,2-Dichloroethene	400.000	J	?	
			24	29	Trichloroethene	26,000.000*		?	
		001168SA030	30	30	Trichloroethene	5,500.000*		?	
		001168SA035	35	35	Trichloroethene	2,700.000*		?	
		001168SA040	40	40	Trichloroethene	5,000.000*		?	
		001168SA045	45	45	Trichloroethene	4,200.000*		?	
		001168SA050	50	50	Trichloroethene	4,300.000*		?	
		001168SD025	25	25	1,1-Dichloroethane	310.000	J	?	BL-T J
			25	25	trans-1,2-Dichloroethene	1,100.000	J	?	BL-T J
			25	25	Trichloroethene	26,000.000*		?	BL-T J
		001169SA020	20	20	1,1-Dichloroethane	120.000	J	?	BL-T J
			20	20	Trichloroethene	42.000	J	?	BL-T J
		001169SA025	25	25	Trichloroethene	100.000	J	?	

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs.
Exposed trenches were backfilled after sampling.

Table 4.4. VOA compounds detected in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
Subsurface Soil	VOA	001169SA030	30	30	trans-1,2-Dichloroethene	30.000	J	?	
			30	30	Trichloroethene	800.000*		?	
		001169SA035	35	35	Trichloroethene	700.000*	J	?	
		001169SA040	40	40	trans-1,2-Dichloroethene	800.000	J	?	
			40	40	Trichloroethene	12,000.000*		?	
		001169SA045	45	45	trans-1,2-Dichloroethene	1,400.000		?	
			45	45	Trichloroethene	18,000.000*		?	
		001169SA050	50	50	trans-1,2-Dichloroethene	800.000	J	?	
			50	50	Trichloroethene	9,400.000*		?	
		001169SD035	35	35	1,1-Dichloroethane	1,000.000		?	BL-T J
			35	35	trans-1,2-Dichloroethene	290.000	J	?	BL-T J
			35	35	Trichloroethene	1,200.000*		?	BL-T J
		001172SA015	15	15	trans-1,2-Dichloroethene	1,500.000		?	
			15	15	Trichloroethene	900.000*	J	?	
		001172SA020	20	20	trans-1,2-Dichloroethene	20.000	J	?	
		001172SA025	25	25	trans-1,2-Dichloroethene	1,500.000		?	

* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs.
Exposed trenches were backfilled after sampling.

Table 4.4. VOA compounds detected in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
Subsurface Soil	VOA	001172SA025	25	25	Trichloroethene	7,000.000*		?	
		001172SA030	31	31	1,1-Dichloroethane	1,000.000		?	J
			31	31	Trichloroethene	1,700.000*		?	J
		001172SA050	50	50	trans-1,2-Dichloroethene	600.000	J	?	
			50	50	Trichloroethene	400.000*	J	?	
		001173SA010	10	10.25	Acetone	3.000	J	?	
		001173SA020	20	20	1,1-Dichloroethane	90.000	J	?	J
			20	20	Acetone	7.000	J	?	
			20	20	Trichloroethene	13.000	J	?	J
		001173SA045	45	45.25	1,2-Dichloroethene	2.000	J	?	
			45	45.25	Acetone	8.000	J	?	
			45	45.25	cis-1,2-Dichloroethene	2.000	J	?	
			45	45.25	Trichloroethene	8.000	J	?	
		001173SD020	20.25	20.5	1,1-Dichloroethane	600.000		?	J
			20.25	20.5	Acetone	5.000	J	?	
			20.25	20.5	Trichloroethene	15.000	J	?	J

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs. Exposed trenches were backfilled after sampling.

Table 4.4. VOA compounds detected in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Subsurface Soil	VOA	001174SA030	30	30	1,1-Dichloroethane	230.000	J	?	BL-T J
			30	30	Trichloroethene	200.000	J	?	BL-T J
		001179SA020	20	20	Trichloroethene	9.000	J	?	BL-T J

Note: Trench samples not containing any detectable VOA compounds at SWMU 001 are:
001104SA001

Subsurface soil samples not containing any detectable VOA compounds at SWMU 001 are:
001101SA002 001101SA005 001101SA010 001102SA005 001102SA010 001103SA005 001103SA010 001104SA005 001104SA010
001105SA005 001105SA010 001106SA005 001106SA010 001107SA005 001107SA010 001108SA005 001108SA010 001109SA005
001109SA010 001110SA005 001110SA010 001111SA005 001111SA010 001112SA005 001113SA005 001113SA010 001114SA005
001114SA010 001115SA005 001115SA010 001116SA005 001117SA005 001118SA005 001118SA010 001119SA005 001119SA010
001120SA005 001120SA010 001121SA005 001121SA010 001122SA005 001122SA010 001123SA005 001123SA010 001123SD010
001124SA005 001124SA010 001125SA005 001125SA010 001126SA005 001126SA010 001127SA005 001127SA010 001128SA005
001128SA010 001129SA005 001129SA010 001130SA005 001130SA010 001131SA005 001131SA010 001132SA005 001132SA010
001133SA005 001133SA010 001134SA005 001134SA010 001135SA005 001135SA010 001136SA005 001136SA010 001137SA005
001137SA010 001138SA005 001138SA010 001139SA005 001139SA010 001140SA005 001140SA010 001141SA005 001141SA010
001142SA005 001142SA010 001143SA005 001143SA010 001143SD010 001144SA005 001144SA010 001162SA005 001162SA010
001166SA045 001166SA050 001168SA005 001169SA015 001171SA005 001171SA010 001171SA015 001171SA020 001171SA025
001171SA030 001171SA035 001171SA040 001171SA045 001171SA050 001171SD035 001172SA035 001172SA040 001172SA045
001173SA005 001173SA015 001173SA025 001173SA030 001173SA035 001173SA040 001173SA050 001174SA015 001174SA020
001174SA025 001174SA035 001174SA040 001174SA045 001174SA050 001179SA015 001179SA025 001179SA030 001179SA035
001179SA040 001179SA045 001179SA050

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs.
Exposed trenches were backfilled after sampling.

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Table 4.5. SVOA and PCB compounds detected in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Trench	SVOA	001101SA001	0	0	2,4-Dimethylphenol	15,000.000	X	?	
			0	0	Di-n-butyl phthalate	9,000.000	X	?	
			0	0	m,p-Cresol	8,600.000	X	?	
			0	0	Phenol	23,000.000	X	?	
			0	0	Total Cresols	8,600.000	JX	?	
		001101SD001	0	0	Phenol	2,900.000		?	
	PPCB	001101SA001	0	0	PCB-1242	500.000*	D	?	
			0	0	PCB-1260	11,000.000*	D	?	
			0	0	PCB-1268	5,600.000*	D	?	
			0	0	Polychlorinated biphenyl	17,100.000*	D	?	
		001101SD001	0	0	PCB-1242	500.000*	D	?	
			0	0	PCB-1268	4,200.000*	D	?	
			0	0	Polychlorinated biphenyl	4,700.000*	D	?	
Subsurface Soil	SVOA	001114SA010	7	10	Bis(2-ethylhexyl)phthalate	64.000	J	=	
		001118SA010	7	10	Bis(2-ethylhexyl)phthalate	100.000	J	=	
			7	10	Di-n-butyl phthalate	50.000	J	=	

* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs. Exposed trenches were backfilled after sampling.

Table 4.5. SVOA and PCB compounds detected in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Subsurface Soil	SVOA	001119SA010	7	10	Bis(2-ethylhexyl)phthalate	100.000	J	=	
			7	10	Butyl benzyl phthalate	200.000	J	=	
		001122SA010	7	10	Bis(2-ethylhexyl)phthalate	51.000	J	U	
		001131SA010	7	10	Bis(2-ethylhexyl)phthalate	80.000	J	=	
		001152SA010	7	10	Total Cresols	4,400.000	J	?	
		001165SA020	20	22.5	Bis(2-ethylhexyl)phthalate	39.000	J	?	
		001165SA045	44	47	Diethyl phthalate	60.000	J	?	
		001171SA015	15	18	Bis(2-ethylhexyl)phthalate	40.000	J	?	
		001171SA020	20	23	Bis(2-ethylhexyl)phthalate	50.000	J	?	
		001171SA035	35	40	Bis(2-ethylhexyl)phthalate	50.000	J	?	
		001171SA040	40	43	Bis(2-ethylhexyl)phthalate	40.000	J	?	
		001171SD035	35	40	Bis(2-ethylhexyl)phthalate	40.000	J	?	
		001172SA015	15	18	Bis(2-ethylhexyl)phthalate	80.000	J	?	
			15	18	Di-n-butyl phthalate	50.000	J	?	
		001172SA020	20	23	Bis(2-ethylhexyl)phthalate	46.000	J	?	
		001172SA025	25	28	Bis(2-ethylhexyl)phthalate	47.000	J	?	

* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs.
Exposed trenches were backfilled after sampling.

Table 4.5. SVOA and PCB compounds detected in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
Subsurface Soil	SVOA	001172SA050	48	50	2,4-Dimethylphenol	40.000	J	?	
			48	50	4-Methylphenol	480.000		?	
			48	50	Phenol	1,900.000		?	
		001179SA030	30	33	Bis(2-ethylhexyl)phthalate	61.000	J	?	
		001179SA035	35	38	Bis(2-ethylhexyl)phthalate	35.000	J	?	
		001179SA045	45	48	Bis(2-ethylhexyl)phthalate	35.000	J	?	

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs. Exposed trenches were backfilled after sampling.

Table 4.5. SVOA and PCB compounds detected in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					

Note: Trench samples not containing any detectable SVOA compounds at SWMU 001 are:
001102SA001 001103SA001 001104SA001

Trench samples not containing any detectable PPCB compounds at SWMU 001 are:
001102SA001 001103SA001 001104SA001

Sediment samples not containing any detectable SVOA compounds at SWMU 001 are:
001145SA001 001146SA001 001147SA001 001148SA001 001149SA001 001150SA001 001170SA001

Sediment samples not containing any detectable PPCB compounds at SWMU 001 are:
001145SA001 001146SA001 001147SA001 001148SA001 001149SA001 001150SA001 001170SA001

Subsurface soil samples not containing any detectable SVOA compounds at SWMU 001 are:
001101SA010 001102SA010 001103SA010 001104SA010 001105SA010 001106SA010 001107SA010 001108SA010 001109SA010
001110SA010 001111SA010 001112SA010 001113SA010 001115SA010 001116SA010 001117SA010 001120SA010 001121SA010
001123SA010 001123SD010 001124SA010 001125SA010 001126SA010 001127SA010 001128SA010 001129SA010 001130SA010
001132SA010 001133SA010 001134SA010 001135SA010 001136SA010 001137SA010 001138SA010 001139SA010 001140SA010
001141SA010 001142SA010 001143SA010 001143SD010 001144SA010 001153SA010 001154SA010 001155SA010 001156SA010
001157SA010 001157SD010 001158SA010 001159SA010 001160SA010 001161SA010 001162SA010 001165SA015 001165SA025
001165SA030 001165SA035 001165SA040 001165SA050 001166SA010 001166SA015 001166SA020 001166SA025 001166SA030
001166SA035 001166SA040 001166SA045 001166SA050 001168SA010 001168SA015 001168SA020 001168SA025 001168SA030
001168SA035 001168SA040 001168SA045 001168SA050 001168SD025 001169SA015 001169SA020 001169SA025 001169SA030
001169SA035 001169SA040 001169SA045 001169SA050 001169SD035 001171SA010 001171SA025 001171SA030 001171SA045
001171SA050 001172SA030 001172SA035 001172SA040 001172SA045 001173SA010 001173SA015 001173SA020 001173SA025
001173SA030 001173SA035 001173SA040 001173SA045 001173SA050 001173SD020 001174SA015 001174SA020 001174SA025
001174SA030 001174SA035 001174SA040 001174SA045 001174SA050 001179SA015 001179SA020 001179SA025 001179SA040
001179SA050

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs.
Exposed trenches were backfilled after sampling.

Table 4.5. SVOA and PCB compounds detected in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					

Subsurface soil samples not containing any detectable PPCB compounds at SWMU 001 are:

001101SA010 001102SA010 001103SA010 001104SA010 001105SA010 001106SA010 001107SA010 001108SA010 001109SA010
001110SA010 001111SA010 001112SA010 001113SA010 001114SA010 001115SA010 001116SA010 001117SA010 001118SA010
001119SA010 001120SA010 001121SA010 001122SA010 001123SA010 001123SD010 001124SA010 001125SA010 001126SA010
001127SA010 001128SA010 001129SA010 001130SA010 001131SA010 001132SA010 001133SA010 001134SA010 001135SA010
001136SA010 001137SA010 001138SA010 001139SA010 001140SA010 001141SA010 001142SA010 001143SA010 001143SD010
001144SA010 001152SA010 001153SA010 001154SA010 001155SA010 001156SA010 001157SA010 001157SD010 001158SA010
001159SA010 001160SA010 001161SA010 001162SA010 001165SA015 001165SA020 001165SA025 001165SA030 001165SA035
001165SA040 001165SA045 001165SA050 001166SA010 001166SA015 001166SA020 001166SA025 001166SA030 001166SA035
001166SA040 001166SA045 001166SA050 001168SA010 001168SA015 001168SA020 001168SA025 001168SA030 001168SA035
001168SA040 001168SA045 001168SA050 001168SD025 001169SA015 001169SA020 001169SA025 001169SA030 001169SA035
001169SA040 001169SA045 001169SA050 001169SD035 001171SA010 001171SA015 001171SA020 001171SA025 001171SA030
001171SA035 001171SA040 001171SA045 001171SA050 001171SD035 001172SA015 001172SA020 001172SA025 001172SA030
001172SA035 001172SA040 001172SA045 001172SA050 001173SA010 001173SA015 001173SA020 001173SA025 001173SA030
001173SA035 001173SA040 001173SA045 001173SA050 001173SD020 001174SA015 001174SA020 001174SA025 001174SA030
001174SA035 001174SA040 001174SA045 001174SA050

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs. Exposed trenches were backfilled after sampling.

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Table 4.6. Metals detected above BG in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
			Top	Bottom						
Trench	METAL	001101SA001	0	0	Mercury	0.310		?		0.200
		001101SD001	0	0	Mercury	0.260		?		0.200
			0	0	Nickel	116.000	W	?		21.000
		001104SA001	0	0	Chromium	17.100		?		16.000
Sediment		001147SA001	0	1	Nickel	23.400		?		21.000
		001148SA001	0	1	Chromium	16.800		?		16.000
		001149SA001	0	1	Zinc	67.000		?		65.000
		001170SA001	1	1.75	Barium	247.000 *		?		200.000
			1	1.75	Beryllium	0.800 *		?		0.670
			1	1.75	Cobalt	15.400		?		14.000
			1	1.75	Manganese	1,990.000 *		?		1,500.000
			1	1.75	Thallium	1.560 *		?		0.210
Subsurface Soil		001101SA010	6	10	Antimony	0.910 *	B	=		0.210
			6	10	Sodium	364.000 *		=		340.000
		001102SA010	6	10	Antimony	0.780 *	B	=		0.210
			6	10	Sodium	492.000 *		=		340.000

---

* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs. Exposed trenches were backfilled after sampling.

Table 4.6. Metals detected above BG in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
			Top	Bottom						
Subsurface Soil	METAL	001103SA010	6	10	Cadmium	1.650		=		0.210
			6	10	Sodium	480.000*	B	=		340.000
		001104SA010	7	10	Cadmium	2.190		=		0.210
			7	10	Sodium	556.000*		=		340.000
		001105SA010	7	10	Cadmium	2.320*		=		0.210
			7	10	Sodium	476.000*	B	=		340.000
		001106SA010	7	10	Cadmium	2.480*		=		0.210
			7	10	Sodium	434.000*	B	=		340.000
		001107SA010	7	10	Cadmium	2.820*		=		0.210
		001108SA010	7	10	Barium	181.000		J		170.000
			7	10	Cadmium	2.830*		=		0.210
			7	10	Nickel	26.200		=		22.000
			7	10	Sodium	405.000*	B	=		340.000
		001109SA010	7	10	Antimony	1.320*		=		0.210
			7	10	Magnesium	2,190.000*		=		2,100.000
			7	10	Sodium	418.000*		=		340.000

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs.
Exposed trenches were backfilled after sampling.

Table 4.6. Metals detected above BG in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
			Top	Bottom						
Subsurface Soil	METAL	001110SA010	7	10	Antimony	1.400*		=		0.210
			7	10	Magnesium	2,160.000*		=		2,100.000
			7	10	Nickel	26.800		=		22.000
			7	10	Sodium	431.000*		=		340.000
		001111SA010	7	10	Antimony	1.110*		=		0.210
			7	10	Sodium	393.000*		=		340.000
		001112SA010	7	10	Cadmium	2.810*		=		0.210
			7	10	Sodium	419.000*	B	=		340.000
		001113SA010	7	10	Antimony	0.630*	B	=		0.210
		001114SA010	7	10	Arsenic	10.700*		J		7.900
			7	10	Cadmium	3.080*		=		0.210
			7	10	Magnesium	2,110.000*		=		2,100.000
		001115SA010	7	10	Arsenic	9.410*		J		7.900
			7	10	Barium	174.000		J		170.000
			7	10	Cadmium	3.130*		=		0.210
		001116SA010	7	10	Barium	175.000		J		170.000

* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs.
Exposed trenches were backfilled after sampling.

Table 4.6. Metals detected above BG in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
			Top	Bottom						
Subsurface Soil	METAL	001116SA010	7	10	Cadmium	0.990		=		0.210
			7	10	Sodium	350.000*	B	=		340.000
		001117SA010	7	10	Cadmium	3.200*		=		0.210
			7	10	Sodium	410.000*	B	=		340.000
		001118SA010	7	10	Cadmium	3.320*		=		0.210
			7	10	Magnesium	2,310.000*		=		2,100.000
			7	10	Sodium	570.000*		=		340.000
		001119SA010	7	10	Arsenic	10.500*		J		7.900
			7	10	Barium	197.000		J		170.000
			7	10	Cadmium	2.900*		=		0.210
			7	10	Manganese	881.000*		=		820.000
			7	10	Nickel	29.700		=		22.000
			7	10	Sodium	534.000*		=		340.000
		001120SA010	7	10	Cadmium	2.680*		=		0.210
			7	10	Sodium	487.000*	B	=		340.000
		001121SA010	7	10	Cadmium	2.170		=		0.210

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs.
Exposed trenches were backfilled after sampling.

Table 4.6. Metals detected above BG in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
			Top	Bottom						
Subsurface Soil	METAL	001121SA010	7	10	Sodium	446.000*	B	=		340.000
		001122SA010	7	10	Cadmium	2.840*		=		0.210
			7	10	Sodium	493.000*	B	=		340.000
		001123SA010	6	10	Cadmium	2.350*		=		0.210
			6	10	Sodium	471.000*		=		340.000
		001123SD010	9.5	10	Cadmium	2.250		=		0.210
			9.5	10	Sodium	425.000*		=		340.000
		001124SA010	7	10	Cadmium	1.500		=		0.210
			7	10	Sodium	417.000*		=		340.000
		001125SA010	7	10	Cadmium	2.230		=		0.210
		001126SA010	7	10	Cadmium	1.520		=		0.210
		001127SA010	7	10	Cadmium	2.660*		=		0.210
		001128SA010	7	10	Cadmium	2.460*		=		0.210
			7	10	Magnesium	2,520.000*		J		2,100.000
		001129SA010	7	10	Cadmium	0.510		=		0.210
			7	10	Zinc	60.800		=		60.000

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs.
Exposed trenches were backfilled after sampling.

Table 4.6. Metals detected above BG in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
Subsurface Soil	METAL	001130SA010	7	10	Antimony	0.930*	B	=		0.210
			7	10	Beryllium	0.740*		=		0.690
		001131SA010	7	10	Antimony	1.720*		=		0.210
		001132SA010	7	10	Antimony	0.630*	B	=		0.210
		001133SA010	7	10	Antimony	1.510*		=		0.210
			7	10	Sodium	388.000*		=		340.000
		001134SA010	7	10	Beryllium	1.070*		=		0.690
			7	10	Cadmium	3.350*		=		0.210
			7	10	Magnesium	2,450.000*		J		2,100.000
		001135SA010	7	10	Cadmium	2.210		=		0.210
			7	10	Sodium	372.000*		=		340.000
		001136SA010	7	10	Cadmium	2.740*		=		0.210
			7	10	Mercury	0.150		=		0.130
		001137SA010	7	10	Arsenic	16.700*		J		7.900
			7	10	Barium	215.000		J		170.000
			7	10	Beryllium	0.930*		=		0.690

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs. Exposed trenches were backfilled after sampling.

Table 4.6. Metals detected above BG in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
			Top	Bottom						
Subsurface Soil	METAL	001137SA010	7	10	Cadmium	2.970*		=		0.210
			7	10	Cobalt	13.300		=		13.000
			7	10	Manganese	2,160.000*		J		820.000
			7	10	Nickel	24.000		=		22.000
			7	10	Sodium	350.000*		=		340.000
		001138SA010	7	10	Cadmium	1.990		=		0.210
		001139SA010	7	10	Cadmium	1.480		=		0.210
		001140SA010	7	10	Beryllium	0.770*		=		0.690
			7	10	Cadmium	0.220		=		0.210
			7	10	Magnesium	2,630.000*		=		2,100.000
			7	10	Sodium	421.000*		=		340.000
			7	10	Zinc	108.000		=		60.000
		001141SA010	7	10	Magnesium	2,140.000*		=		2,100.000
			7	10	Zinc	75.800		=		60.000
		001142SA010	6.75	10	Zinc	118.000		=		60.000
		001143SA010	5	10	Aluminum	13,000.000*		U		12,000.000

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs. Exposed trenches were backfilled after sampling.

Table 4.6. Metals detected above BG in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
			Top	Bottom						
Subsurface Soil	METAL	001143SA010	5	10	Arsenic	10.600*		J		7.900
			5	10	Manganese	1,080.000*		=		820.000
		001143SD010	5	10	Aluminum	14,300.000*		=		12,000.000
			5	10	Beryllium	0.760*		=		0.690
		001144SA010	7	10	Zinc	60.200		=		60.000
		001152SA010	7	10	Cadmium	0.280	B	?		0.210
			7	10	Zinc	70.100		?		60.000
		001153SA010	7	10	Zinc	64.700		?		60.000
		001155SA010	7	10	Zinc	73.300		?		60.000
		001156SA010	7	10	Zinc	63.600		?		60.000
		001157SA010	6	10	Zinc	165.000		?		60.000
		001157SD010	6	10	Zinc	84.700		?		60.000
		001160SA010	7	10	Sodium	409.000*		?		340.000
		001161SA010	7	10	Zinc	80.700		?		60.000
		001165SA020	20	22.5	Vanadium	39.200*		?		37.000
		001165SA040	40	43	Cadmium	0.300	B	?		0.210

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs. Exposed trenches were backfilled after sampling.

Table 4.6. Metals detected above BG in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
Subsurface Soil	METAL	001165SA045	44	47	Sodium	352.000 *		?		340.000
		001165SA050	47	50	Beryllium	0.770 *		?		0.690
			47	50	Sodium	363.000 *		?		340.000
			47	50	Zinc	120.000		?		60.000
		001166SA010	9	12	Sodium	354.000 *		?		340.000
		001166SA015	15	18	Cadmium	0.270	B	?		0.210
			15	18	Sodium	383.000 *		?		340.000
			15	18	Zinc	123.000		?		60.000
		001166SA020	18	21	Sodium	362.000 *		?		340.000
		001166SA025	24	27	Sodium	357.000 *		?		340.000
		001166SA030	30	33	Sodium	346.000 *		?		340.000
		001166SA040	39	42	Sodium	364.000 *		?		340.000
		001166SA045	44	47	Beryllium	1.050 *		?		0.690
		001166SA050	47	50	Beryllium	1.450 *		?		0.690
			47	50	Cobalt	23.700		?		13.000
			47	50	Sodium	350.000 *		?		340.000

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs.
Exposed trenches were backfilled after sampling.

Table 4.6. Metals detected above BG in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
Subsurface Soil	METAL	001166SA050	47	50	Zinc	82.800		?		60.000
		001168SA010	10	13	Zinc	78.900		?		60.000
		001168SA015	15	18	Antimony	0.600 *	B	?		0.210
			15	18	Chromium	55.100		?		43.000
			15	18	Zinc	61.600		?		60.000
		001168SA020	20	23	Zinc	96.700		?		60.000
		001168SA025	24	29	Zinc	86.000		?		60.000
		001168SA030	30	33	Antimony	0.700 *	B	?		0.210
			30	33	Zinc	306.000		?		60.000
		001168SA035	35	38	Zinc	137.000		?		60.000
		001168SA050	47	50	Zinc	123.000		?		60.000
		001168SD025	24	29	Antimony	0.600 *	B	?		0.210
			24	29	Beryllium	1.130 *		?		0.690
			24	29	Chromium	123.000		?		43.000
			24	29	Vanadium	59.000 *		?		37.000
		001169SA020	20	23	Beryllium	0.710 *		?		0.690

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs. Exposed trenches were backfilled after sampling.

Table 4.6. Metals detected above BG in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
Subsurface Soil	METAL	001169SA020	20	23	Vanadium	45.400 *		?		37.000
		001169SA025	25	28	Cobalt	19.800		?		13.000
		001171SA010	10	13	Arsenic	11.500 *		?		7.900
			10	13	Beryllium	0.750 *		?		0.690
			10	13	Manganese	902.000 *		?		820.000
			10	13	Nickel	27.000		?		22.000
			10	13	Silver	73.900 *		?		2.700
			10	13	Zinc	85.300		?		60.000
		001171SA015	15	18	Cadmium	1.020		?		0.210
		001171SA020	20	23	Cadmium	3.840 *		?		0.210
			20	23	Sodium	343.000 *		?		340.000
			20	23	Zinc	90.300		?		60.000
		001171SA025	25	28	Sodium	413.000 *		?		340.000
		001171SA030	30	33	Beryllium	0.740 *		?		0.690
			30	33	Cadmium	1.180		?		0.210
		001171SA035	35	40	Beryllium	0.720 *		?		0.690

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs. Exposed trenches were backfilled after sampling.

Table 4.6. Metals detected above BG in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
			Top	Bottom						
Subsurface Soil	METAL	001171SA035	35	40	Cadmium	0.730		?		0.210
			35	40	Cobalt	29.900		?		13.000
		001171SA045	45	48	Cadmium	0.450		?		0.210
		001171SA050	48	50	Sodium	426.000 *		?		340.000
		001171SD035	35	40	Beryllium	0.930 *		?		0.690
			35	40	Cadmium	0.580		?		0.210
			35	40	Chromium	43.500		?		43.000
			35	40	Vanadium	64.300 *		?		37.000
		001172SA015	15	18	Cadmium	1.670		?		0.210
		001172SA040	40	43	Beryllium	0.940 *		?		0.690
			40	43	Cadmium	0.220		?		0.210
		001172SA050	48	50	Cadmium	0.760		?		0.210
		001173SA010	10	13	Beryllium	0.710 *		?		0.690
			10	13	Sodium	489.000 *		?		340.000
		001173SA015	15	18	Sodium	415.000 *		?		340.000
		001173SA025	25	28	Aluminum	17,500.000 *		?		12,000.000

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs. Exposed trenches were backfilled after sampling.

Table 4.6. Metals detected above BG in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
			Top	Bottom						
Subsurface Soil	METAL	001173SA025	25	28	Beryllium	0.720 *		?		0.690
			25	28	Sodium	494.000 *		?		340.000
		001173SA030	30	33	Aluminum	12,700.000 *		?		12,000.000
			30	33	Sodium	431.000 *		?		340.000
		001173SA035	35	38	Aluminum	14,600.000 *		?		12,000.000
			35	38	Beryllium	1.240 *		?		0.690
			35	38	Iron	28,800.000 *		?		28,000.000
			35	38	Lead	29.700 *		?		23.000
			35	38	Sodium	478.000 *		?		340.000
			35	38	Vanadium	43.800 *		?		37.000
		001173SA040	40	43	Sodium	369.000 *		?		340.000
		001173SA045	45	48	Aluminum	12,800.000 *		?		12,000.000
			45	48	Beryllium	0.770 *		?		0.690
			45	48	Sodium	352.000 *		?		340.000
		001173SA050	48	50	Beryllium	0.700 *		?		0.690
			48	50	Sodium	401.000 *		?		340.000

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs. Exposed trenches were backfilled after sampling.

Table 4.6. Metals detected above BG in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
			Top	Bottom						
Subsurface Soil	METAL	001173SD020	20	25	Beryllium	0.730 *		?		0.690
			20	25	Sodium	452.000 *		?		340.000
			20	25	Vanadium	42.100 *		?		37.000
		001174SA015	15	18	Sodium	401.000 *		?		340.000
			15	18	Vanadium	40.200 *		?		37.000
		001174SA020	20	23	Beryllium	0.900 *		?		0.690
			20	23	Chromium	58.600		?		43.000
			20	23	Iron	30,900.000 *		?		28,000.000
			20	23	Vanadium	68.100 *		?		37.000
		001174SA025	25	28	Aluminum	14,100.000 *		?		12,000.000
			25	28	Sodium	499.000 *		?		340.000
		001174SA030	30	33	Aluminum	18,700.000 *		?		12,000.000
			30	33	Sodium	471.000 *		?		340.000
		001174SA035	35	38	Beryllium	0.780 *		?		0.690
			35	38	Iron	28,200.000 *		?		28,000.000
			35	38	Vanadium	44.100 *		?		37.000

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs.
Exposed trenches were backfilled after sampling.

Table 4.6. Metals detected above BG in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
Subsurface Soil	METAL	001174SA050	48	50	Barium	180.000		?		170.000
			48	50	Cobalt	14.800		?		13.000
			48	50	Manganese	871.000 *		?		820.000
		001179SA015	15	18	Antimony	0.550 *	B	?		0.210
			15	18	Cadmium	0.280		?		0.210
			15	18	Chromium	56.200		?		43.000
			15	18	Vanadium	53.300 *		?		37.000
		001179SA020	20	23	Vanadium	46.600 *		?		37.000
		001179SA025	25	28	Vanadium	40.100 *		?		37.000
		001179SA035	35	38	Cadmium	0.260		?		0.210
			35	38	Iron	35,500.000 *		?		28,000.000
			35	38	Vanadium	58.300 *		?		37.000
		001179SA040	40	43	Antimony	0.530 *	B	?		0.210
			40	43	Beryllium	1.660 *		?		0.690
			40	43	Cadmium	0.390		?		0.210
			40	43	Iron	29,700.000 *		?		28,000.000

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs.
Exposed trenches were backfilled after sampling.

Table 4.6. Metals detected above BG in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
			Top	Bottom						
Subsurface Soil	METAL	001179SA045	45	48	Beryllium	0.730*		?		0.690
		001179SA050	48	50	Beryllium	0.780*		?		0.690

Note: Trench samples not containing any detectable metals at concentrations above background at SWMU 001 are:
001102SA001 001103SA001

Sediment samples not containing any detectable metals at concentrations above background at SWMU 001 are:
001145SA001 001146SA001 001150SA001

Subsurface soil samples not containing any detectable metals at concentrations above background at SWMU 001 are:
001154SA010 001158SA010 001159SA010 001162SA010 001165SA015 001165SA025 001165SA030 001165SA035 001166SA035
001168SA040 001168SA045 001169SA015 001169SA030 001169SA035 001169SA040 001169SA045 001169SA050 001169SD035
001171SA040 001172SA020 001172SA025 001172SA030 001172SA035 001172SA045 001173SA020 001174SA040 001174SA045
001179SA030

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs.
Exposed trenches were backfilled after sampling.

Table 4.7. Radioactive isotopes detected above BG in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (pCi/g)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (pCi/g)
Trench	RADS	001101SA001	0	0	Americium-241	0.430		?		0.000
			0	0	Neptunium-237	0.570		?		0.100
			0	0	Technetium-99	10.000		?		2.500
			0	0	Uranium	60.000		?		0.000
		001101SD001	0	0	Neptunium-237	0.410		?		0.100
			0	0	Technetium-99	10.000		?		2.500
			0	0	Uranium	80.000		?		0.000
		001102SA001	0	0	Technetium-99	6.000		?		2.500
			0	0	Uranium	7.400		?		0.000
		001103SA001	0	0	Plutonium-239/240	0.130		?		0.000
			0	0	Uranium	60.000		?		0.000
		001104SA001	0	0	Uranium	6.800		?		0.000
Sediment		001146SA001	0	1	Plutonium-239/240	0.070		?		0.000
			0	1	Uranium	4.300		?		0.000
			0	1	Uranium-238	2.400		?		1.200
		001147SA001	0	1	Plutonium-239/240	0.070		?		0.000

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs. Exposed trenches were backfilled after sampling.

Table 4.7. Radioactive isotopes detected above BG in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (pCi/g)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (pCi/g)
			Top	Bottom						
Sediment	RADS	001147SA001	0	1	Technetium-99	3.700		?		2.500
			0	1	Uranium	3.900		?		0.000
			0	1	Uranium-238	2.300		?		1.200
		001148SA001	0	1	Plutonium-239/240	0.210		?		0.000
			0	1	Uranium	4.100		?		0.000
			0	1	Uranium-238	2.300		?		1.200
		001149SA001	0	1	Americium-241	7.830		?		0.000
			0	1	Cesium-137	0.550		?		0.490
			0	1	Neptunium-237	12.150 *		?		0.100
			0	1	Plutonium-239/240	26.820 *		?		0.000
			0	1	Technetium-99	24.300		?		2.500
			0	1	Thorium-230	187.900 *		?		1.500
			0	1	Uranium	8.100		?		0.000
			0	1	Uranium-234	3.500		?		2.500
			0	1	Uranium-235	0.180		?		0.140
			0	1	Uranium-238	4.400		?		1.200

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs. Exposed trenches were backfilled after sampling.

Table 4.7. Radioactive isotopes detected above BG in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (pCi/g)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (pCi/g)
			Top	Bottom						
Sediment	RADS	001150SA001	0	1	Americium-241	7.830		?		0.000
			0	1	Neptunium-237	0.110		?		0.100
			0	1	Plutonium-239/240	0.240		?		0.000
			0	1	Technetium-99	3.200		?		2.500
			0	1	Thorium-230	2.610		?		1.500
			0	1	Uranium	3.200		?		0.000
			0	1	Uranium-238	2.100		?		1.200
		001170SA001	1	1.75	Cesium-137	0.510		?		0.490
			1	1.75	Neptunium-237	0.170		?		0.100
			1	1.75	Uranium	12.300		?		0.000
			1	1.75	Uranium-234	6.840		?		2.500
			1	1.75	Uranium-235	0.310		?		0.140
			1	1.75	Uranium-238	5.200		?		1.200
Subsurface Soil		001103SA010	6	10	Uranium	1.500		?		0.000
			6	10	Uranium-238	1.300		?		1.200
		001105SA010	7	10	Uranium	2.200		?		0.000

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs. Exposed trenches were backfilled after sampling.

Table 4.7. Radioactive isotopes detected above BG in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (pCi/g)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (pCi/g)
Subsurface Soil	RADS	001106SA010	7	10	Uranium	1.800		?		0.000
			7	10	Uranium-238	1.300		?		1.200
		001107SA010	7	10	Uranium	2.400		?		0.000
		001109SA010	7	10	Uranium	1.900		?		0.000
		001110SA010	7	10	Uranium	1.600		?		0.000
		001111SA010	7	10	Technetium-99	4.500		?		2.800
		001112SA010	7	10	Uranium	1.600		?		0.000
		001113SA010	7	10	Uranium	1.900		?		0.000
		001114SA010	7	10	Uranium	1.800		?		0.000
		001115SA010	7	10	Uranium	1.800		?		0.000
		001116SA010	7	10	Uranium	2.100		?		0.000
		001117SA010	7	10	Uranium	3.200		?		0.000
		001118SA010	7	10	Uranium	1.700		?		0.000
		001119SA010	7	10	Uranium	2.400		?		0.000
		001122SA010	7	10	Uranium	2.100		?		0.000
		001123SA010	6	10	Uranium	2.000		?		0.000

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs.
Exposed trenches were backfilled after sampling.

Table 4.7. Radioactive isotopes detected above BG in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (pCi/g)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (pCi/g)
			Top	Bottom						
Subsurface Soil	RADS	001123SA010	6	10	Uranium-238	1.700		?		1.200
		001123SD010	9.5	10	Uranium	2.100		?		0.000
			9.5	10	Uranium-238	1.500		?		1.200
		001124SA010	7	10	Uranium	1.700		?		0.000
		001127SA010	7	10	Uranium	1.700		?		0.000
		001135SA010	7	10	Uranium	1.900		?		0.000
		001137SA010	7	10	Americium-241	0.080		J		0.000
			7	10	Uranium	2.200		?		0.000
			7	10	Uranium-238	1.300		?		1.200
		001138SA010	7	10	Uranium	1.700		?		0.000
			7	10	Uranium-238	1.300		?		1.200
		001141SA010	7	10	Uranium	1.700		?		0.000
		001142SA010	6.75	10	Uranium	1.700		?		0.000
		001143SA010	5	10	Uranium	1.800		?		0.000
			5	10	Uranium-238	1.300		?		1.200
		001143SD010	5	10	Plutonium-239/240	0.060		?		0.000

---

* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs. Exposed trenches were backfilled after sampling.

Table 4.7. Radioactive isotopes detected above BG in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (pCi/g)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (pCi/g)
Subsurface Soil	RADS	001143SD010	5	10	Technetium-99	8.600		?		2.800
		001144SA010	7	10	Americium-241	0.100		?		0.000
			7	10	Neptunium-237	0.200		?		0.000
			7	10	Plutonium-239/240	2.720		?		0.000
			7	10	Thorium-230	18.430		?		1.400
			7	10	Uranium	2.600		?		0.000
			7	10	Uranium-238	1.500		?		1.200
		001152SA010	7	10	Uranium	2.900		U		0.000
			7	10	Uranium-238	1.600		?		1.200
		001154SA010	7	10	Uranium	2.100		?		0.000
			7	10	Uranium-238	1.400		?		1.200
		001155SA010	7	10	Uranium	6.600		?		0.000
			7	10	Uranium-234	3.500		?		2.400
			7	10	Uranium-235	0.160		?		0.140
			7	10	Uranium-238	3.000		?		1.200
		001156SA010	7	10	Uranium	14.000		?		0.000

---

* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs. Exposed trenches were backfilled after sampling.

Table 4.7. Radioactive isotopes detected above BG in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (pCi/g)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (pCi/g)
			Top	Bottom						
Subsurface Soil	RADS	001156SA010	7	10	Uranium-234	7.200		?		2.400
			7	10	Uranium-235	0.340		?		0.140
			7	10	Uranium-238	6.300		?		1.200
		001157SA010	6	10	Uranium	3.600		?		0.000
			6	10	Uranium-238	2.300		?		1.200
		001157SD010	6	10	Uranium	5.400		?		0.000
			6	10	Uranium-238	3.500		?		1.200
		001158SA010	7	10	Uranium	1.600		?		0.000
			7	10	Uranium-234	3.200		?		2.400
			7	10	Uranium-238	1.300		?		1.200
		001159SA010	7	10	Uranium	1.500		?		0.000
		001160SA010	7	10	Uranium	2.500		?		0.000
			7	10	Uranium-238	1.300		?		1.200
		001161SA010	7	10	Uranium	2.100		?		0.000
			7	10	Uranium-238	2.000		?		1.200
		001162SA010	7	10	Uranium	3.100		?		0.000

---

* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs.
Exposed trenches were backfilled after sampling.

Table 4.7. Radioactive isotopes detected above BG in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (pCi/g)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (pCi/g)
			Top	Bottom						
Subsurface Soil	RADS	001162SA010	7	10	Uranium-238	1.800		?		1.200
		001165SA015	14	17	Uranium	22.000		?		0.000
			14	17	Uranium-234	12.600		?		2.400
			14	17	Uranium-235	0.570		?		0.140
			14	17	Uranium-238	9.000		?		1.200
		001165SA030	29	32	Uranium	19.400		?		0.000
			29	32	Uranium-234	11.000		?		2.400
			29	32	Uranium-235	0.500		?		0.140
			29	32	Uranium-238	7.900		?		1.200
		001168SA025	24	29	Uranium	3.200		?		0.000
			24	29	Uranium-238	2.200		?		1.200
		001168SD025	24	29	Plutonium-239/240	0.070		?		0.000

---

* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs. Exposed trenches were backfilled after sampling.

Table 4.7. Radioactive isotopes detected above BG in UCRS soil at SWMU 001

Sample Type**	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (pCi/g)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (pCi/g)
			Top	Bottom						

Note: Trench samples not containing any detectable radioactive isotopes at concentrations above background at SWMU 001 are:
None

Sediment samples not containing any detectable radioactive isotopes at concentrations above background at SWMU 001 are:
001145SA001

Subsurface soil samples not containing any detectable radioactive isotopes at concentrations above background at SWMU 001 are:
001101SA010 001102SA010 001104SA010 001108SA010 001120SA010 001121SA010 001125SA010 001126SA010 001128SA010
001129SA010 001130SA010 001131SA010 001132SA010 001133SA010 001134SA010 001136SA010 001139SA010 001140SA010
001152SA005 001153SA005 001153SA010 001154SA005 001156SA005 001157SA005 001158SA005 001160SA005 001161SA005
001162SA005 001165SA020 001165SA025 001165SA035 001165SA040 001165SA045 001165SA050 001166SA005 001166SA010
001166SA015 001166SA020 001166SA025 001166SA030 001166SA035 001166SA040 001166SA045 001166SA050 001168SA005
001168SA010 001168SA015 001168SA020 001168SA030 001168SA035 001168SA040 001168SA045 001168SA050 001169SA015
001169SA020 001169SA025 001169SA030 001169SA035 001169SA040 001169SA045 001169SA050 001169SD035 001171SA005
001171SA010 001171SA015 001171SA020 001171SA025 001171SA030 001171SA035 001171SA040 001171SA045 001171SA050
001171SD035 001172SA015 001172SA020 001172SA025 001172SA030 001172SA035 001172SA040 001172SA045 001172SA050
001173SA005 001173SA010 001173SA015 001173SA020 001173SA025 001173SA030 001173SA035 001173SA040 001173SA045
001173SA050 001173SD020 001174SA015 001174SA020 001174SA025 001174SA030 001174SA035 001174SA040 001174SA045
001174SA050 001175SA055 001175SA075 001175SA095 001176SA055 001176SA075 001176SA095 001177SA055 001177SA075
001177SA095 001178SA055 001178SA075 001178SA095 001179SA015 001179SA020 001179SA025 001179SA030 001179SA035
001179SA040 001179SA045 001179SA050 001180SA055 001180SA075 001180SA095 001181SA055 001181SA075 001181SA095
001182SA055 001182SA075 001182SA095 001183SA055 001183SA075 001183SA095 001184SA055 001184SA075 001184SA095

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* Result exceeds PRG screening values

** Trench samples were taken at base of excavated trench approximately 3.5 ft bgs.
Exposed trenches were backfilled after sampling.

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Table 4.8. VOA compounds detected in UCRS groundwater at SWMU 001

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Groundwater	VOA	001173WA050	50	50	1,1-Dichloroethene	7.000*	J	?	
			50	50	trans-1,2-Dichloroethene	46.000*	J	?	
			50	50	Trichloroethene	312.000*		?	

Note: UCRS groundwater samples not containing any detectable VOA compounds at SWMU 001 are:
None

* Result exceeds PRG screening values

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Table 4.9. Radioactive isotopes detected above BG in UCRS groundwater at SWMU 001

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results** (pCi/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG** (pCi/L)
			Top	Bottom						
Groundwater	RADS	001173WA050	50	50	Technetium-99	41.100 *		?		0.000
			50	50	Uranium	0.040 *		?		0.000

Note: UCRS groundwater samples not containing any detectable radioactive isotopes at concentrations above background at SWMU 001 are:
None

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* Result exceeds PRG screening values

** Results and background values for Uranium given in mg/L

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Table 4.10. Frequency of detection of organic compounds, metals, and radioactive isotopes exceeding BG in SWMU 001 trench, sediment, UCRS soil and UCRS groundwater samples

Sample Type	Analytical Group	Analytical Compound	Number of Analyses [a]	Number of Detections above BG [a]	Number of Detections above BG & PRG Screening Values [a]	Maximum Result above BG [a]	Minimum Result above BG [a]	Average Result above BG [a]	Units
Trench	VOA	Trichloroethene	5	4	2	1,200.000	11.000	434.000	ug/kg
		Vinyl chloride	5	2	2	270.000	67.000	168.500	ug/kg
	SVOA	Phenol	2	2	0	23,000.000	2,900.000	12,950.000	ug/kg
		2,4-Dimethylphenol	1	1	0	15,000.000	15,000.000	15,000.000	ug/kg
		Di-n-butyl phthalate	1	1	0	9,000.000	9,000.000	9,000.000	ug/kg
		m,p-Cresol	5	1	0	8,600.000	8,600.000	8,600.000	ug/kg
		Total Cresols	5	1	0	8,600.000	8,600.000	8,600.000	ug/kg
	PCB	PCB-1242	2	2	2	500.000	500.000	500.000	ug/kg
		PCB-1268	2	2	2	5,600.000	4,200.000	4,900.000	ug/kg
		Polychlorinated biphenyl	5	2	2	17,100.000	4,700.000	10,900.000	ug/kg
		PCB-1260	1	1	1	11,000.000	11,000.000	11,000.000	ug/kg
	Metals	Mercury	5	2	0	0.310	0.260	0.285	mg/kg
		Chromium	5	1	0	17.100	17.100	17.100	mg/kg
		Nickel	5	1	0	116.000	116.000	116.000	mg/kg
	Radioactive isotopes	Uranium	5	5	0	80.000	6.800	42.840	pCi/g
		Technetium-99	5	3	0	10.000	6.000	8.667	pCi/g
		Neptunium-237	5	2	0	0.570	0.410	0.490	pCi/g
		Americium-241	5	1	0	0.430	0.430	0.430	pCi/g
		Plutonium-239/240	5	1	0	0.130	0.130	0.130	pCi/g
Sediment	Metals	Barium	7	1	1	247.000	247.000	247.000	mg/kg
		Beryllium	7	1	1	0.800	0.800	0.800	mg/kg
		Chromium	7	1	0	16.800	16.800	16.800	mg/kg
		Cobalt	7	1	0	15.400	15.400	15.400	mg/kg
		Manganese	7	1	1	1,990.000	1,990.000	1,990.000	mg/kg
		Nickel	7	1	0	23.400	23.400	23.400	mg/kg

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[a] Number of analyses/detections include both environmental samples and duplicate results

Table 4.10. Frequency of detection of organic compounds, metals, and radioactive isotopes exceeding BG in SWMU 001 trench, sediment, UCRS soil and UCRS groundwater samples

Sample Type	Analytical Group	Analytical Compound	Number of Analyses [a]	Number of Detections above BG [a]	Number of Detections above BG & PRG Screening Values [a]	Maximum Result above BG [a]	Minimum Result above BG [a]	Average Result above BG [a]	Units
Sediment (cont.)	Metals (cont.)	Thallium	7	1	1	1.560	1.560	1.560	mg/kg
		Zinc	7	1	0	67.000	67.000	67.000	mg/kg
	Radioactive isotopes	Uranium	6	6	0	12.300	3.200	5.983	pCi/g
		Uranium-238	6	6	0	5.200	2.100	3.117	pCi/g
		Plutonium-239/240	6	5	1	26.820	0.070	5.482	pCi/g
		Neptunium-237	6	3	1	12.150	0.110	4.143	pCi/g
		Technetium-99	6	3	0	24.300	3.200	10.400	pCi/g
		Americium-241	6	2	0	7.830	7.830	7.830	pCi/g
		Cesium-137	6	2	0	0.550	0.510	0.530	pCi/g
		Thorium-230	6	2	1	187.900	2.610	95.255	pCi/g
		Uranium-234	6	2	0	6.840	3.500	5.170	pCi/g
		Uranium-235	6	2	0	0.310	0.180	0.245	pCi/g
Subsurface soil	VOA	Trichloroethene	222	72	49	439,000.000	6.000	18,520.194	ug/kg
		trans-1,2-Dichloroethene	222	36	0	16,000.000	20.000	1,786.111	ug/kg
		1,1-Dichloroethane	27	10	0	4,300.000	90.000	1,095.000	ug/kg
		cis-1,2-Dichloroethene	222	6	0	6,000.000	2.000	1,975.333	ug/kg
		Vinyl chloride	222	6	6	4,800.000	200.000	1,250.000	ug/kg
		Acetone	4	4	0	8.000	3.000	5.750	ug/kg
		1,2-Dichloroethene	199	1	0	2.000	2.000	2.000	ug/kg
	SVOA	Bis(2-ethylhexyl)phthalate	138	17	0	100.000	35.000	56.353	ug/kg
		Di-n-butyl phthalate	138	2	0	50.000	50.000	50.000	ug/kg
		2,4-Dimethylphenol	138	1	0	40.000	40.000	40.000	ug/kg
		4-Methylphenol	115	1	0	480.000	480.000	480.000	ug/kg
		Butyl benzyl phthalate	138	1	0	200.000	200.000	200.000	ug/kg
		Diethyl phthalate	138	1	0	60.000	60.000	60.000	ug/kg

[a] Number of analyses/detections include both environmental samples and duplicate results

Table 4.10. Frequency of detection of organic compounds, metals, and radioactive isotopes exceeding BG in SWMU 001 trench, sediment, UCRS soil and UCRS groundwater samples

Sample Type	Analytical Group	Analytical Compound	Number of Analyses [a]	Number of Detections above BG [a]	Number of Detections above BG & PRG Screening Values [a]	Maximum Result above BG [a]	Minimum Result above BG [a]	Average Result above BG [a]	Units
Subsurface soil (cont.)	SVOA (cont.)	Phenol	138	1	0	1,900.000	1,900.000	1,900.000	ug/kg
		Total Cresols	23	1	0	4,400.000	4,400.000	4,400.000	ug/kg
	Metals	Sodium	138	50	50	570.000	343.000	421.520	mg/kg
		Cadmium	138	46	19	3.840	0.220	1.828	mg/kg
		Beryllium	138	26	26	1.660	0.700	0.892	mg/kg
		Zinc	138	24	0	306.000	60.200	100.646	mg/kg
		Antimony	138	15	15	1.720	0.530	0.928	mg/kg
		Vanadium	138	13	13	68.100	39.200	49.577	mg/kg
		Aluminum	138	8	8	18,700.000	12,700.000	14,712.500	mg/kg
		Magnesium	138	8	8	2,630.000	2,110.000	2,313.750	mg/kg
		Arsenic	138	6	6	16.700	9.410	11.568	mg/kg
		Barium	138	6	0	215.000	174.000	187.000	mg/kg
		Chromium	138	5	0	123.000	43.500	67.280	mg/kg
		Cobalt	138	5	0	29.900	13.300	20.300	mg/kg
		Iron	138	5	5	35,500.000	28,200.000	30,620.000	mg/kg
		Manganese	138	5	5	2,160.000	871.000	1,178.800	mg/kg
		Nickel	138	5	0	29.700	24.000	26.740	mg/kg
		Lead	138	1	1	29.700	29.700	29.700	mg/kg
		Mercury	138	1	0	0.150	0.150	0.150	mg/kg
		Silver	138	1	1	73.900	73.900	73.900	mg/kg
	Radioactive isotopes	Uranium	66	40	0	22.000	1.500	3.528	pCi/g
		Uranium-238	66	21	0	9.000	1.300	2.610	pCi/g
		Uranium-234	66	5	0	12.600	3.200	7.500	pCi/g
		Uranium-235	66	4	0	0.570	0.160	0.393	pCi/g
		Plutonium-239/240	66	3	0	2.720	0.060	0.950	pCi/g
		Americium-241	66	2	0	0.100	0.080	0.090	pCi/g

---

[a] Number of analyses/detections include both environmental samples and duplicate results

Table 4.10. Frequency of detection of organic compounds, metals, and radioactive isotopes exceeding BG in SWMU 001 trench, sediment, UCRS soil and UCRS groundwater samples

Sample Type	Analytical Group	Analytical Compound	Number of Analyses [a]	Number of Detections above BG [a]	Number of Detections above BG & PRG Screening Values [a]	Maximum Result above BG [a]	Minimum Result above BG [a]	Average Result above BG [a]	Units
Subsurface soil (cont.)	Radioactive isotopes (cont.)	Technetium-99	68	2	0	8.600	4.500	6.550	pCi/g
		Neptunium-237	66	1	0	0.200	0.200	0.200	pCi/g
		Thorium-230	66	1	0	18.430	18.430	18.430	pCi/g
Groundwater	VOA	1,1-Dichloroethene	1	1	1	7.000	7.000	7.000	ug/L
		trans-1,2-Dichloroethene	1	1	1	46.000	46.000	46.000	ug/L
		Trichloroethene	1	1	1	312.000	312.000	312.000	ug/L
	Radioactive isotopes	Technetium-99	1	1	1	41.100	41.100	41.100	pCi/L
		Uranium	1	1	1	0.040	0.040	0.040	mg/L

---

[a] Number of analyses/detections include both environmental samples and duplicate results

Table 4.11. Metals detected above BG in UCRS soil at SWMU 091

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
			Top	Bottom						
Sediment	METAL	091003SA001	0.3	1	Aluminum	13,100.000*		?		13,000.000
		091004SA001	0.3	1	Aluminum	13,100.000*		?		13,000.000
		091005SA001	0.3	1	Cadmium	2.930*		?		0.210
			0.3	1	Sodium	348.000*		?		320.000
			0.3	1	Zinc	163.000		?		65.000
		091006SA001	0.3	1	Cadmium	6.530*		?		0.210
			0.3	1	Chromium	16.800		?		16.000
			0.3	1	Mercury	0.470		?		0.200

Note: Sediment samples not containing any detectable metals at concentrations above background at SWMU 091 are:
None

* Result exceeds PRG screening values

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Table 4.12. Radioactive isotopes detected above BG in UCRS soil at SWMU 091

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (pCi/g)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (pCi/g)
			Top	Bottom						
Sediment	RADS	091005SA001	0.3	1	Cesium-137	1.730		?		0.490
			0.3	1	Plutonium-239/240	0.150		?		0.000
			0.3	1	Thorium-230	4.330		?		1.500
			0.3	1	Uranium	8.100		?		0.000
			0.3	1	Uranium-234	2.600		?		2.500
			0.3	1	Uranium-235	0.150		?		0.140
			0.3	1	Uranium-238	5.400		?		1.200
		091006SA001	0.3	1	Americium-241	0.380		?		0.000
			0.3	1	Cesium-137	50.000		?		0.490
			0.3	1	Plutonium-239/240	10.700 *		?		0.000
			0.3	1	Technetium-99	17.300		?		2.500
			0.3	1	Thorium-230	7.800		?		1.500
			0.3	1	Uranium	13.000		?		0.000
			0.3	1	Uranium-234	6.500		?		2.500
			0.3	1	Uranium-235	0.310		?		0.140
			0.3	1	Uranium-238	6.500		?		1.200

* Result exceeds PRG screening values

Table 4.12. Radioactive isotopes detected above BG in UCRS soil at SWMU 091

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (pCi/g)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (pCi/g)
			Top	Bottom						

Note: Sediment samples not containing any detectable radioactive isotopes at concentrations above background at SWMU 091 are:
091003SA001 091004SA001

Subsurface soil samples not containing any detectable radioactive isotopes at concentrations above background at SWMU 091 are:
091002SA095

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* Result exceeds PRG screening values

Table 4.13. Frequency of detection of metals and radioactive isotopes exceeding BG in SWMU 091 sediment samples

Sample Type	Analytical Group	Analytical Compound	Number of Analyses [a]	Number of Detections above BG [a]	Number of Detections above BG & PRG Screening Values [a]	Maximum Result above BG [a]	Minimum Result above BG [a]	Average Result above BG [a]	Units
Sediment	Metals	Aluminum	4	2	2	13,100.000	13,100.000	13,100.000	mg/kg
		Cadmium	4	2	2	6.530	2.930	4.730	mg/kg
		Chromium	4	1	0	16.800	16.800	16.800	mg/kg
		Mercury	4	1	0	0.470	0.470	0.470	mg/kg
		Sodium	4	1	1	348.000	348.000	348.000	mg/kg
		Zinc	4	1	0	163.000	163.000	163.000	mg/kg
	Radioactive isotopes	Cesium-137	2	2	0	50.000	1.730	25.865	pCi/g
		Plutonium-239/240	2	2	1	10.700	0.150	5.425	pCi/g
		Thorium-230	2	2	0	7.800	4.330	6.065	pCi/g
		Uranium	2	2	0	13.000	8.100	10.550	pCi/g
		Uranium-234	2	2	0	6.500	2.600	4.550	pCi/g
		Uranium-235	2	2	0	0.310	0.150	0.230	pCi/g
		Uranium-238	2	2	0	6.500	5.400	5.950	pCi/g
		Americium-241	2	1	0	0.380	0.380	0.380	pCi/g
		Technetium-99	2	1	0	17.300	17.300	17.300	pCi/g

---

[a] Number of analyses/detections include both environmental samples and duplicate results

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Table 4.14. PCB compounds detected in sludge at SWMU 196

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Sludge	PPCB	196001SA001	0	0	Polychlorinated biphenyl	100.000 *		?	
		196001SD001	0	0	PCB-1260	200.000 *		?	
			0	0	Polychlorinated biphenyl	200.000 *		?	
		196003SA001	0	0	Polychlorinated biphenyl	300.000 *		?	

Note: Sludge samples not containing any detectable PPCB compounds at SWMU 196 are:
196002SA001 196004SA001 196005SA001 196006SA001

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* Result exceeds PRG screening values

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Table 4.15. Metals detected above BG in sludge and UCRS soil at SWMU 196

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
			Top	Bottom						
Sludge	METAL	196001SA001	0	0	Cadmium	12.500 *		?		0.210
			0	0	Lead	55.100 *	N	?		36.000
			0	0	Mercury	0.540		?		0.200
			0	0	Nickel	78.100	W	?		21.000
			0	0	Selenium	4.820	N*W	?		0.800
		196001SD001	0	0	Cadmium	6.770 *		?		0.210
			0	0	Lead	29.300 *	N	?		36.000
			0	0	Mercury	0.240		?		0.200
			0	0	Nickel	36.700	W	?		21.000
			0	0	Selenium	2.130	N*W	?		0.800
		196002SA001	0	0	Mercury	2.140 *		?		0.200
			0	0	Nickel	326.000 *	W	?		21.000
		196003SA001	0	0	Mercury	0.790		?		0.200
			0	0	Silver	21.000		?		2.300
		196004SA001	0	0	Mercury	0.520		?		0.200
			0	0	Nickel	88.400	W	?		21.000
		196005SA001	0	0	Cadmium	9.180 *		?		0.210

* Result exceeds PRG screening values

Table 4.15. Metals detected above BG in sludge and UCRS soil at SWMU 196

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
			Top	Bottom						
Sludge	METAL	196005SA001	0	0	Lead	31.500 *	N	?		36.000
			0	0	Mercury	0.340		?		0.200
			0	0	Nickel	68.200	W	?		21.000
			0	0	Selenium	2.350	NW*	?		0.800
		196006SA001	0	0	Mercury	0.970 *		?		0.200
			0	0	Nickel	140.000	W	?		21.000
Surface Soil		196001SA002	0	2	Antimony	61.500 *		=		0.210
			0	2	Cadmium	1.030		=		0.210
			0	2	Zinc	67.100		J		65.000
		196002SA002	0	2	Antimony	62.200 *		=		0.210
			0	2	Cadmium	0.970		=		0.210
			0	2	Calcium	216,000.000 *		J		200,000.000
			0	2	Zinc	91.100		J		65.000
		196003SA002	1	2	Cadmium	1.480		?		0.210
			1	2	Sodium	331.000 *		?		320.000
		196004SA002	0	2	Antimony	9.800 *		=		0.210
			0	2	Cadmium	0.890		=		0.210

* Result exceeds PRG screening values

Table 4.15. Metals detected above BG in sludge and UCRS soil at SWMU 196

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
Surface Soil	METAL	196004SA002	0	2	Chromium	32.800		=		16.000
			0	2	Copper	25.200		=		19.000
			0	2	Zinc	97.900		J		65.000
		196008SA002	0	2	Antimony	40.900 *		=		0.210
			0	2	Cadmium	0.360		=		0.210
			0	2	Magnesium	9,010.000 *		=		7,700.000
		196009SA002	0	2	Antimony	19.000 *		=		0.210
			0	2	Cadmium	0.300		=		0.210
			0	2	Zinc	69.700		=		65.000
		196010SA002	0	2	Antimony	1.400 *		=		0.210
		196011SA002	0	2	Antimony	0.760 *	B	=		0.210
		196015SA002	0	2	Cadmium	0.220		?		0.210
			0	2	Magnesium	10,000.000 *		?		7,700.000
			0	2	Nickel	172.000		?		21.000
			0	2	Sodium	388.000 *		?		320.000
		196017SA002	0	2	Aluminum	13,800.000 *		?		13,000.000
			0	2	Cadmium	0.780		?		0.210

* Result exceeds PRG screening values

Table 4.15. Metals detected above BG in sludge and UCRS soil at SWMU 196

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
			Top	Bottom						
Surface Soil	METAL	196017SA002	0	2	Chromium	17.000		?		16.000
			0	2	Nickel	80.100		?		21.000
			0	2	Potassium	1,650.000 *		?		1,300.000
			0	2	Sodium	418.000 *		?		320.000
			0	2	Zinc	119.000		?		65.000
Sediment		196006SA001	0	1	Antimony	0.370		=		0.210
			0	1	Cadmium	1.830		=		0.210
			0	1	Sodium	322.000 *	B	=		320.000
			0	1	Zinc	148.000		J		65.000
		196007SA001	0	1	Antimony	0.290		=		0.210
			0	1	Cadmium	2.530 *		=		0.210
			0	1	Copper	20.900		=		19.000
			0	1	Nickel	73.600		=		21.000
			0	1	Sodium	423.000 *	B	=		320.000
			0	1	Zinc	222.000		J		65.000
Subsurface Soil		196001SA004	2	4	Antimony	39.900 *		=		0.210
			2	4	Cadmium	1.000		=		0.210

* Result exceeds PRG screening values

Table 4.15. Metals detected above BG in sludge and UCRS soil at SWMU 196

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
Subsurface Soil	METAL	196001SA004	2	4	Calcium	66,000.000 *		J		6,100.000
			2	4	Magnesium	2,360.000 *		=		2,100.000
		196001SA008	6	8	Antimony	1.750 *		=		0.210
		196001SA010	8	10	Cadmium	0.720		=		0.210
		196001SD010	8	10	Cadmium	0.300		=		0.210
		196002SA006	4	6	Antimony	55.000 *		=		0.210
			4	6	Cadmium	0.550		=		0.210
			4	6	Calcium	86,300.000 *		J		6,100.000
			4	6	Magnesium	2,920.000 *		=		2,100.000
		196002SA008	6	8	Antimony	58.400 *		=		0.210
			6	8	Cadmium	0.520		=		0.210
			6	8	Calcium	96,900.000 *		J		6,100.000
			6	8	Magnesium	3,670.000 *		=		2,100.000
		196002SA010	8	10	Antimony	58.900 *		=		0.210
			8	10	Cadmium	0.420		=		0.210
			8	10	Calcium	97,300.000 *		J		6,100.000
			8	10	Magnesium	3,370.000 *		=		2,100.000

* Result exceeds PRG screening values

Table 4.15. Metals detected above BG in sludge and UCRS soil at SWMU 196

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
Subsurface Soil	METAL	196003SA004	3	4	Arsenic	7.990 *		?		7.900
			3	4	Beryllium	0.960 *		?		0.690
			3	4	Cadmium	1.670		?		0.210
			3	4	Chromium	66.000		?		43.000
			3	4	Iron	30,200.000 *		?		28,000.000
			3	4	Vanadium	62.500 *		?		37.000
		196004SA004	2	4	Antimony	1.740 *		=		0.210
			2	4	Nickel	54.400		=		22.000
		196004SA006	4	6	Antimony	1.180 *		=		0.210
			4	6	Magnesium	2,160.000 *		=		2,100.000
			4	6	Zinc	86.800		J		60.000
		196004SA008	6	8	Antimony	0.900 *	B	=		0.210
		196004SA010	8	10	Antimony	1.020 *		=		0.210
		196008SA004	2	4	Manganese	1,370.000 *		=		820.000
		196008SA006	4	6	Antimony	6.260 *		=		0.210
			4	6	Calcium	11,800.000 *		=		6,100.000
		196008SA008	6	8	Zinc	94.700		=		60.000

* Result exceeds PRG screening values

Table 4.15. Metals detected above BG in sludge and UCRS soil at SWMU 196

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
			Top	Bottom						
Subsurface Soil	METAL	196008SA010	8	10	Antimony	1.850 *		=		0.210
			8	10	Nickel	27.500		=		22.000
		196008SD008	6	8	Aluminum	12,700.000 *		=		12,000.000
			6	8	Barium	292.000 *		=		170.000
			6	8	Zinc	88.600		=		60.000
		196009SA004	2	4	Beryllium	0.710 *		=		0.690
		196009SA006	4	6	Zinc	94.800		=		60.000
		196010SA004	2	4	Antimony	1.540 *		=		0.210
			2	4	Beryllium	0.750 *		=		0.690
			2	4	Vanadium	37.300 *		=		37.000
		196010SA008	6	8	Antimony	1.120 *		=		0.210
		196010SA010	8	10	Antimony	1.270 *		=		0.210
			8	10	Zinc	61.700		J		60.000
		196011SA004	2	4	Antimony	0.830 *	B	=		0.210
		196011SA006	4	6	Aluminum	12,100.000 *		J		12,000.000
			4	6	Antimony	1.300 *		=		0.210
			4	6	Cobalt	19.800		=		13.000

* Result exceeds PRG screening values

Table 4.15. Metals detected above BG in sludge and UCRS soil at SWMU 196

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
			Top	Bottom						
Subsurface Soil	METAL	196011SA006	4	6	Magnesium	2,480.000 *		=		2,100.000
			4	6	Manganese	1,980.000 *		J		820.000
		196011SA008	6	8	Antimony	1.310 *		=		0.210
			6	8	Cobalt	13.800		=		13.000
		196011SA010	8	10	Antimony	1.440 *		=		0.210
			8	10	Beryllium	0.800 *		=		0.690
			8	10	Vanadium	43.800 *		=		37.000
		196013SA004	2	4	Cadmium	0.460		?		0.210
			2	4	Calcium	11,900.000 *		?		6,100.000
			2	4	Magnesium	2,160.000 *		?		2,100.000
		196013SA006	4	6	Aluminum	15,000.000 *		?		12,000.000
			4	6	Antimony	121.000 *		?		0.210
			4	6	Beryllium	113.000 *		?		0.690
			4	6	Cadmium	116.000 *		?		0.210
			4	6	Chromium	112.000		?		43.000
			4	6	Cobalt	112.000		?		13.000
			4	6	Copper	112.000		?		25.000

* Result exceeds PRG screening values

Table 4.15. Metals detected above BG in sludge and UCRS soil at SWMU 196

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
			Top	Bottom						
Subsurface Soil	METAL	196013SA006	4	6	Lead	116.000 *		?		23.000
			4	6	Magnesium	5,660.000 *		?		2,100.000
			4	6	Nickel	112.000		?		22.000
			4	6	Potassium	6,430.000 *		?		950.000
			4	6	Silver	65.400 *		?		2.700
			4	6	Sodium	5,920.000 *		?		340.000
			4	6	Thallium	114.000 *		?		0.340
			4	6	Zinc	119.000		?		60.000
		196013SA010	8	10	Aluminum	12,900.000 *		?		12,000.000
		196013SA018	16	18	Nickel	24.700		?		22.000
		196014SA004	2	4	Cadmium	0.300		?		0.210
			2	4	Calcium	30,600.000 *		?		6,100.000
			2	4	Magnesium	3,220.000 *		?		2,100.000
			2	4	Nickel	587.000 *		?		22.000
			2	4	Zinc	62.800		?		60.000
		196014SA006	4	6	Calcium	223,000.000 *		?		6,100.000
			4	6	Magnesium	3,400.000 *		?		2,100.000

* Result exceeds PRG screening values

Table 4.15. Metals detected above BG in sludge and UCRS soil at SWMU 196

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
Subsurface Soil	METAL	196014SA006	4	6	Nickel	47.900		?		22.000
			4	6	Selenium	2.130		?		0.700
			4	6	Sodium	408.000 *		?		340.000
			4	6	Zinc	1,650.000		?		60.000
		196014SA008	6	8	Barium	178.000		?		170.000
			6	8	Beryllium	0.800 *		?		0.690
			6	8	Magnesium	2,110.000 *		?		2,100.000
		196014SA010	8	10	Cadmium	3.050 *		?		0.210
			8	10	Calcium	42,000.000 *		?		6,100.000
			8	10	Selenium	3.930		?		0.700
			8	10	Zinc	445.000		?		60.000
		196014SA016	14	16	Sodium	373.000 *		?		340.000
		196014SA018	16	18	Calcium	7,980.000 *		?		6,100.000
		196015SA006	4	6	Aluminum	13,700.000 *		?		12,000.000
			4	6	Barium	389.000 *		?		170.000
			4	6	Calcium	74,200.000 *		?		6,100.000
			4	6	Magnesium	2,390.000 *		?		2,100.000

* Result exceeds PRG screening values

Table 4.15. Metals detected above BG in sludge and UCRS soil at SWMU 196

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
			Top	Bottom						
Subsurface Soil	METAL	196015SA006	4	6	Nickel	365.000 *		?		22.000
			4	6	Potassium	2,190.000 *		?		950.000
			4	6	Sodium	519.000 *		?		340.000
		196015SA008	6	8	Beryllium	0.940 *		?		0.690
			6	8	Iron	29,600.000 *		?		28,000.000
		196015SA010	8	10	Aluminum	17,900.000 *		?		12,000.000
			8	10	Barium	189.000		?		170.000
			8	10	Nickel	29.500		?		22.000
			8	10	Potassium	1,080.000 *		?		950.000
			8	10	Zinc	150.000		?		60.000
		196015SA014	12	14	Aluminum	13,900.000 *		?		12,000.000
		196015SA018	16	18	Aluminum	12,600.000 *		?		12,000.000
			16	18	Sodium	344.000 *		?		340.000
			16	18	Zinc	96.300		?		60.000
		196015SD004	2	4	Calcium	6,290.000 *		?		6,100.000
		196017SA004	2	4	Arsenic	8.740 *		?		7.900
			2	4	Calcium	8,750.000 *		?		6,100.000

* Result exceeds PRG screening values

Table 4.15. Metals detected above BG in sludge and UCRS soil at SWMU 196

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
			Top	Bottom						
Subsurface Soil	METAL	196017SA006	4	6	Aluminum	16,900.000 *		?		12,000.000
			4	6	Calcium	20,000.000 *		?		6,100.000
			4	6	Magnesium	3,450.000 *		?		2,100.000
			4	6	Potassium	1,400.000 *		?		950.000
			4	6	Zinc	91.800		?		60.000
		196017SA010	8	10	Aluminum	15,500.000 *		?		12,000.000
			8	10	Barium	172.000		?		170.000
			8	10	Magnesium	2,520.000 *		?		2,100.000
			8	10	Zinc	92.000		?		60.000
		196017SA014	12	14	Calcium	7,260.000 *		?		6,100.000
		196017SA018	16	18	Magnesium	2,220.000 *		?		2,100.000
		196017SA020	18	20	Mercury	0.140		?		0.130
		196018SA004	2	4	Aluminum	15,900.000 *		?		12,000.000
			2	4	Magnesium	2,590.000 *		?		2,100.000
		196018SA006	4	6	Aluminum	16,500.000 *		?		12,000.000
			4	6	Calcium	10,700.000 *		?		6,100.000
			4	6	Magnesium	3,430.000 *		?		2,100.000

* Result exceeds PRG screening values

Table 4.15. Metals detected above BG in sludge and UCRS soil at SWMU 196

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
Subsurface Soil	METAL	196018SA006	4	6	Potassium	1,090.000 *		?		950.000
			4	6	Thallium	0.570 *	B	?		0.340
		196018SA008	6	8	Aluminum	14,800.000 *		?		12,000.000
			6	8	Barium	190.000		?		170.000
			6	8	Magnesium	2,730.000 *		?		2,100.000
		196018SA010	8	10	Aluminum	15,100.000 *		?		12,000.000
			8	10	Magnesium	2,160.000 *		?		2,100.000
		196018SA014	12	14	Aluminum	14,200.000 *		?		12,000.000
			12	14	Barium	194.000		?		170.000
			12	14	Magnesium	2,180.000 *		?		2,100.000
			12	14	Zinc	77.400		?		60.000
		196018SA018	16	18	Aluminum	12,600.000 *		?		12,000.000
			16	18	Cobalt	14.300		?		13.000
			16	18	Magnesium	2,200.000 *		?		2,100.000
			16	18	Manganese	855.000 *		?		820.000
		196018SD008	6	8	Aluminum	14,800.000 *		?		12,000.000
			6	8	Barium	187.000		?		170.000

* Result exceeds PRG screening values

Table 4.15. Metals detected above BG in sludge and UCRS soil at SWMU 196

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
			Top	Bottom						
Subsurface Soil	METAL	196018SD008	6	8	Magnesium	2,670.000 *		?		2,100.000
			6	8	Thallium	0.560 *	B	?		0.340
			6	8	Zinc	63.700		?		60.000

Note: Sludge samples not containing any detectable metals at concentrations above background at SWMU 196 are:
None

Surface soil samples not containing any detectable metals at concentrations above background at SWMU 196 are:
196013SA002 196014SA002 196018SA002

Sediment samples not containing any detectable metals at concentrations above background at SWMU 196 are:
None

Subsurface soil samples not containing any detectable metals at concentrations above background at SWMU 196 are:
196003SA006 196003SA008 196009SA008 196009SA010 196010SA006 196013SA008 196013SA012 196013SA014 196013SA016
196013SA020 196014SA012 196014SA014 196014SA020 196015SA004 196015SA012 196015SA016 196015SA020 196017SA008
196017SA012 196017SA016 196018SA012 196018SA016 196018SA020

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* Result exceeds PRG screening values

Table 4.16. Radioactive isotopes detected above BG in sludge and UCRS soil at SWMU 196

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (pCi/g)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (pCi/g)
			Top	Bottom						
Sludge	RADS	196001SA001	0	0	Neptunium-237	0.290		?		0.100
			0	0	Technetium-99	30.000		?		2.500
			0	0	Uranium	10.000		?		0.000
		196001SD001	0	0	Neptunium-237	0.290		?		0.100
			0	0	Technetium-99	40.000		?		2.500
			0	0	Uranium	10.000		?		0.000
		196002SA001	0	0	Neptunium-237	0.120		?		0.100
			0	0	Technetium-99	20.000		?		2.500
			0	0	Uranium	7.400		?		0.000
		196003SA001	0	0	Neptunium-237	0.070		?		0.100
			0	0	Technetium-99	10.000		?		2.500
			0	0	Uranium	3.500		?		0.000
		196004SA001	0	0	Plutonium-239/240	0.160		?		0.000
			0	0	Technetium-99	9.600		?		2.500
			0	0	Uranium	10.000		?		0.000
		196005SA001	0	0	Neptunium-237	0.140		?		0.100
			0	0	Technetium-99	40.000		?		2.500

* Result exceeds PRG screening values

Table 4.16. Radioactive isotopes detected above BG in sludge and UCRS soil at SWMU 196

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (pCi/g)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (pCi/g)
			Top	Bottom						
Sludge	RADS	196005SA001	0	0	Uranium	10.000		?		0.000
		196006SA001	0	0	Plutonium-239/240	3.160		?		0.000
			0	0	Uranium	10.000		?		0.000
			0	0	Uranium-235	0.640		?		0.140
Surface Soil		196008SA002	0	2	Uranium	2.500		?		0.000
			0	2	Uranium-238	1.300		?		1.200
Sediment		196006SA001	0	1	Neptunium-237	0.680		?		0.100
			0	1	Technetium-99	33.400		?		2.500
			0	1	Uranium-238	3.100		?		1.200
		196007SA001	0	1	Technetium-99	12.300		?		2.500
			0	1	Uranium	3.900		?		0.000
			0	1	Uranium-238	2.300		?		1.200
Subsurface Soil		196001SA010	8	10	Americium-241	0.180		?		0.000
			8	10	Uranium	2.800		?		0.000
			8	10	Uranium-238	2.000		?		1.200
		196001SD010	8	10	Uranium	2.600		?		0.000
			8	10	Uranium-238	1.900		?		1.200

* Result exceeds PRG screening values

Table 4.16. Radioactive isotopes detected above BG in sludge and UCRS soil at SWMU 196

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (pCi/g)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (pCi/g)
Subsurface Soil	RADS	196002SA006	4	6	Uranium	5.000		?		0.000
			4	6	Uranium-238	3.000		?		1.200
		196004SA004	2	4	Neptunium-237	0.060		?		0.000
			2	4	Uranium	3.900		?		0.000
			2	4	Uranium-238	1.900		?		1.200
		196004SA010	8	10	Uranium	1.600		?		0.000
		196008SA004	2	4	Plutonium-239/240	0.110		?		0.000
			2	4	Uranium	3.100		?		0.000
			2	4	Uranium-238	1.900		?		1.200
		196008SA006	4	6	Technetium-99	5.000		?		2.800
			4	6	Uranium	2.200		?		0.000
		196008SA008	6	8	Uranium	2.500		?		0.000
		196008SA010	8	10	Uranium	1.600		?		0.000
			8	10	Uranium-238	1.400		?		1.200
		196008SD008	6	8	Uranium	2.500		?		0.000
			6	8	Uranium-238	1.700		?		1.200
		196009SA008	6	8	Plutonium-239/240	0.070		?		0.000

* Result exceeds PRG screening values

Table 4.16. Radioactive isotopes detected above BG in sludge and UCRS soil at SWMU 196

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (pCi/g)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (pCi/g)
			Top	Bottom						
Subsurface Soil	RADS	196009SA010	8	10	Plutonium-239/240	0.190		?		0.000
			8	10	Uranium	1.700		?		0.000
		196010SA004	2	4	Uranium	2.000		?		0.000
		196010SA006	4	6	Uranium	2.500		?		0.000
			4	6	Uranium-238	1.550		?		1.200
		196010SA008	6	8	Uranium	1.700		?		0.000
		196011SA004	2	4	Uranium	1.800		?		0.000
			2	4	Uranium-238	1.500		?		1.200
		196011SA006	4	6	Uranium	2.000		?		0.000
			4	6	Uranium-238	1.400		?		1.200
		196011SA008	6	8	Uranium	2.600		?		0.000
			6	8	Uranium-238	2.100		?		1.200
		196011SA010	8	10	Uranium	2.200		?		0.000

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* Result exceeds PRG screening values

Table 4.16. Radioactive isotopes detected above BG in sludge and UCRS soil at SWMU 196

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (pCi/g)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (pCi/g)
			Top	Bottom						

Note: Sludge samples not containing any detectable radioactive isotopes at concentrations above background at SWMU 196 are:
None

Surface soil samples not containing any detectable radioactive isotopes at concentrations above background at SWMU 196 are:
196001SA002 196002SA002 196003SA002 196004SA002 196009SA002 196010SA002 196011SA002 196013SA002 196014SA002
196015SA002 196017SA002 196018SA002

Sediment samples not containing any detectable radioactive isotopes at concentrations above background at SWMU 196 are:
196006SA001 196007SA001

Subsurface soil samples not containing any detectable radioactive isotopes at concentrations above background at SWMU 196 are:
196001SA004 196001SA008 196002SA008 196002SA010 196003SA004 196003SA006 196003SA008 196004SA006 196004SA008
196009SA004 196009SA006 196010SA010 196013SA004 196013SA006 196013SA008 196013SA010 196013SA012 196013SA014
196013SA016 196013SA018 196013SA020 196014SA004 196014SA006 196014SA008 196014SA010 196014SA012 196014SA014
196014SA016 196014SA018 196014SA020 196015SA004 196015SA006 196015SA008 196015SA010 196015SA012 196015SA014
196015SA016 196015SA018 196015SA020 196015SD004 196017SA004 196017SA006 196017SA008 196017SA010 196017SA012
196017SA014 196017SA016 196017SA018 196017SA020 196018SA004 196018SA006 196018SA008 196018SA010 196018SA012
196018SA014 196018SA016 196018SA018 196018SA020 196018SD008

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* Result exceeds PRG screening values

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Table 4.17. Frequency of detection of organic compounds, metals, and radioactive isotopes exceeding BG in SWMU 196 sludge, surface soil, sediment and UCRS soil samples

Sample Type	Analytical Group	Analytical Compound	Number of Analyses [a]	Number of Detections above BG [a]	Number of Detections above BG & PRG Screening Values [a]	Maximum Result above BG [a]	Minimum Result above BG [a]	Average Result above BG [a]	Units
Sludge	PCB	Polychlorinated biphenyl	7	3	3	300.000	100.000	200.000	ug/kg
		PCB-1260	1	1	1	200.000	200.000	200.000	ug/kg
	Metals	Mercury	7	7	2	2.140	0.240	0.791	mg/kg
		Nickel	7	6	1	326.000	36.700	122.900	mg/kg
		Cadmium	7	3	3	12.500	6.770	9.483	mg/kg
		Lead	7	3	3	55.100	29.300	38.633	mg/kg
		Selenium	7	3	0	4.820	2.130	3.100	mg/kg
		Silver	7	1	0	21.000	21.000	21.000	mg/kg
	Radioactive isotopes	Technetium-99	7	7	0	40.000	9.600	24.229	pCi/g
		Uranium	7	7	0	10.000	3.500	8.700	pCi/g
		Neptunium-237	7	6	0	0.290	0.070	0.170	pCi/g
		Plutonium-239/240	7	2	0	3.160	0.160	1.660	pCi/g
		Uranium-235	1	1	0	0.640	0.640	0.640	pCi/g
Surface soil	Metals	Cadmium	13	8	0	1.480	0.220	0.754	mg/kg
		Antimony	13	7	7	62.200	0.760	27.937	mg/kg
		Zinc	13	5	0	119.000	67.100	88.960	mg/kg
		Sodium	13	3	3	418.000	331.000	379.000	mg/kg
		Chromium	13	2	0	32.800	17.000	24.900	mg/kg
		Magnesium	13	2	2	10,000.000	9,010.000	9,505.000	mg/kg
		Nickel	13	2	0	172.000	80.100	126.050	mg/kg
		Aluminum	13	1	1	13,800.000	13,800.000	13,800.000	mg/kg
		Calcium	13	1	1	216,000.000	216,000.000	216,000.000	mg/kg
		Copper	13	1	0	25.200	25.200	25.200	mg/kg
		Potassium	13	1	1	1,650.000	1,650.000	1,650.000	mg/kg
	Radioactive	Uranium	5	1	0	2.500	2.500	2.500	pCi/g

[a] Number of analyses/detections include both environmental samples and duplicate results

Table 4.17. Frequency of detection of organic compounds, metals, and radioactive isotopes exceeding BG in SWMU 196 sludge, surface soil, sediment and UCRS soil samples

Sample Type	Analytical Group	Analytical Compound	Number of Analyses [a]	Number of Detections above BG [a]	Number of Detections above BG & PRG Screening Values [a]	Maximum Result above BG [a]	Minimum Result above BG [a]	Average Result above BG [a]	Units
	isotopes								
Surface soil (cont.)	Radioactive isotopes (cont.)	Uranium-238	5	1	0	1.300	1.300	1.300	pCi/g
Sediment	Metals	Antimony	2	2	0	0.370	0.290	0.330	mg/kg
		Cadmium	2	2	1	2.530	1.830	2.180	mg/kg
		Nickel	2	2	0	73.600	31.700	52.650	mg/kg
		Sodium	2	2	2	423.000	322.000	372.500	mg/kg
		Zinc	2	2	0	222.000	148.000	185.000	mg/kg
		Copper	2	1	0	20.900	20.900	20.900	mg/kg
	Radioactive isotopes	Technetium-99	2	2	0	33.400	12.300	22.850	pCi/g
		Uranium	2	2	0	5.000	3.900	4.450	pCi/g
		Uranium-238	2	2	0	3.100	2.300	2.700	pCi/g
		Neptunium-237	2	1	0	0.680	0.680	0.680	pCi/g
		Plutonium-239/240	2	1	0	0.370	0.370	0.370	pCi/g
Soil soil	Metals	Magnesium	78	22	22	5,660.000	2,110.000	2,820.455	mg/kg
		Antimony	78	19	19	121.000	0.830	18.774	mg/kg
		Aluminum	78	17	17	17,900.000	12,100.000	14,535.294	mg/kg
		Calcium	78	16	16	223,000.000	6,290.000	50,061.250	mg/kg
		Zinc	78	15	0	1,650.000	61.700	218.307	mg/kg
		Cadmium	78	11	2	116.000	0.300	11.363	mg/kg
		Barium	78	8	2	389.000	172.000	223.875	mg/kg
		Nickel	78	8	2	587.000	24.700	156.000	mg/kg
		Beryllium	78	7	7	113.000	0.710	16.851	mg/kg
		Potassium	78	5	5	6,430.000	1,080.000	2,438.000	mg/kg
		Sodium	78	5	5	5,920.000	344.000	1,512.800	mg/kg

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[a] Number of analyses/detections include both environmental samples and duplicate results

Table 4.17. Frequency of detection of organic compounds, metals, and radioactive isotopes exceeding BG in SWMU 196 sludge, surface soil, sediment and UCRS soil samples

Sample Type	Analytical Group	Analytical Compound	Number of Analyses [a]	Number of Detections above BG [a]	Number of Detections above BG & PRG Screening Values [a]	Maximum Result above BG [a]	Minimum Result above BG [a]	Average Result above BG [a]	Units
		Cobalt	78	4	0	112.000	13.800	39.975	mg/kg
Subsurface soil (cont.)	Metals (cont.)	Manganese	78	3	3	1,980.000	855.000	1,401.667	mg/kg
		Thallium	78	3	3	114.000	0.560	38.377	mg/kg
		Vanadium	78	3	3	62.500	37.300	47.867	mg/kg
		Arsenic	78	2	2	8.740	7.990	8.365	mg/kg
		Chromium	78	2	0	112.000	66.000	89.000	mg/kg
		Iron	78	2	2	30,200.000	29,600.000	29,900.000	mg/kg
		Selenium	78	2	0	3.930	2.130	3.030	mg/kg
		Copper	78	1	0	112.000	112.000	112.000	mg/kg
		Lead	78	1	1	116.000	116.000	116.000	mg/kg
		Mercury	78	1	0	0.140	0.140	0.140	mg/kg
		Silver	78	1	1	65.400	65.400	65.400	mg/kg
	Radioactive isotopes	Uranium	25	18	0	5.000	1.600	2.461	pCi/g
		Uranium-238	25	11	0	3.000	1.400	1.850	pCi/g
		Plutonium-239/240	25	3	0	0.190	0.070	0.123	pCi/g
		Americium-241	25	1	0	0.180	0.180	0.180	pCi/g
		Neptunium-237	25	1	0	0.060	0.060	0.060	pCi/g
		Technetium-99	25	1	0	5.000	5.000	5.000	pCi/g

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[a] Number of analyses/detections include both environmental samples and duplicate results

Table 4.17. Frequency of detection of organic compounds, metals, and radioactive isotopes exceeding BG in SWMU 196 sludge, surface soil, sediment and UCRS soil samples

Sample Type	Analytical Group	Analytical Compound	Number of Analyses [(a)]	Number of Detections above BG [(a)]	Number of Detections above BG & PRG Screening Values [(a)]	Maximum Result above BG [(a)]	Minimum Result above BG [(a)]	Average Result above BG [(a)]	Units

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(a) Number of analyses/detections include both environmental samples and duplicate results

Table 4.18. VOA compounds detected in sludge and UCRS soil at C-720 Complex

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Sludge	VOA	720025SA001	1	1	1,1-Dichloroethene	2,800.000 *		?	
			1	1	Trichloroethene	420,000.000 *	EX	?	
Subsurface Soil		720001SA020	22	23.5	Vinyl chloride	400.000 *	J	?	
		720002SA005	5	5.5	cis-1,2-Dichloroethene	3,200.000	J	?	BL-T J
			5	5.5	Trichloroethene	37.000	J	?	BL-T J
			5	5.5	Vinyl chloride	400.000 *	J	?	
		720002SA010	10	10	Trichloroethene	17,000.000 *		?	
			10	10	Vinyl chloride	200.000 *	J	?	
		720002SA015	15	15.5	cis-1,2-Dichloroethene	750.000	J	?	BL-T J
			15	15.5	trans-1,2-Dichloroethene	450,000.000 *	P	?	BL-T J
			15	15.5	Trichloroethene	19,000.000 *		?	
		720002SA020	20	20.5	Trichloroethene	68,000.000 *		?	
		720002SA025	25	25.5	Trichloroethene	32,000.000 *		?	
		720003SA020	19	19.5	Trichloroethene	39.000	J	?	BL-T J
		720004SA020	20	20	Trichloroethene	200.000	J	?	
		720004SA025	25	25	1,1-Dichloroethane	70.000	J	?	BL-T J
			25	25	Trichloroethene	1,300.000 *		?	BL-T J

* Result exceeds PRG screening values

Table 4.18. VOA compounds detected in sludge and UCRS soil at C-720 Complex

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
Subsurface Soil	VOA	720004SD020	20	20	Trichloroethene	300.000	J	?	
		720005SA010	9.75	10	Acetone	4.000	BJ	?	
			10	10	Trichloroethene	2,700.000 *		?	
		720005SA015	15	15	Trichloroethene	7,800.000 *		?	
		720005SA020	19.75	20	Acetone	7.000	BJ	?	
			20	20	Trichloroethene	17,000.000 *		?	
		720005SA025	25	25	Trichloroethene	1,600.000 *		?	
		720005SA030	30	30	Trichloroethene	6,300.000 *		?	
		720005SD025	25	25	Trichloroethene	1,600.000 *		?	
		720006SA005	5	5.25	Acetone	4.000	J	?	
		720006SA010	10	10.25	Acetone	10.000		?	
		720006SA020	20	20.25	Acetone	4.000	J	?	
		720006SA045	45	45.25	2-Butanone	5.000	J	?	
			45	45.25	Acetone	30.000		?	
		720007SA005	5	8	Acetone	6.000	BJ	?	
		720007SA020	20	23	Acetone	6.000	BJ	?	
		720007SA025	27.5	28	Trichloroethene	2,200.000 *		?	

* Result exceeds PRG screening values

Table 4.18. VOA compounds detected in sludge and UCRS soil at C-720 Complex

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Subsurface Soil	VOA	720007SA030	32.5	33	Trichloroethene	14,000.000 *		?	
		720007SA035	37.5	38	Trichloroethene	800.000 *		?	
		720008SA020	20	20.5	Trichloroethene	10.000	J	?	
		720008SA025	25	25.5	Trichloroethene	400.000 *	J	?	
		720008SA030	31.5	32	1,1-Dichloroethene	200.000 *	J	?	
			31.5	32	Trichloroethene	1,600.000 *		?	
		720008SD020	20	20.5	Trichloroethene	50.000	J	?	
		720020SA020	20	20	Trichloroethene	26.000	J	?	J
		720022SA025	25	25	Trichloroethene	8.000	J	?	BL-T J
		720027SA020	20	20	1,1-Dichloroethane	950.000		?	J
			20	20	Trichloroethene	5,000.000 *		?	J
		720027SA025	25	25	Trichloroethene	500.000 *	J	?	
		720027SA030	30	30	Trichloroethene	8,100.000 *		?	
		720027SA035	35	35	Trichloroethene	1,800.000 *		?	J
		720027SA040	40	40	Trichloroethene	300.000	J	?	
		720027SD035	35	35	Trichloroethene	1,800.000 *		?	

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* Result exceeds PRG screening values

Table 4.18. VOA compounds detected in sludge and UCRS soil at C-720 Complex

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					

Note: Sludge samples not containing any detectable VOA compounds at C-720 Complex are:
None

Subsurface soil samples not containing any detectable VOA compounds at C-720 Complex are:
720001SA015 720001SA025 720001SA035 720001SA040 720001SA045 720003SA005 720003SA015 720003SA025 720003SA030
720003SA035 720003SA040 720003SA045 720004SA010 720004SA015 720004SA030 720004SA035 720004SA040 720004SA045
720004SA050 720006SA015 720006SA025 720006SA030 720006SA035 720006SA040 720006SA050 720006SD030 720007SA010
720007SA015 720007SA040 720007SA045 720008SA010 720008SA015 720009SA005 720009SA015 720009SA020 720009SA025
720009SA030 720009SA040 720009SA045 720016SA055 720020SA015 720020SA025 720020SA030 720020SA035 720020SA040
720020SA045 720020SD040 720021SA015 720021SA020 720021SA025 720021SA030 720021SA035 720021SA040 720021SA045
720022SA005 720022SA010 720022SA015 720022SA020 720022SA030 720022SA035 720022SA040 720022SA045 720022SA050
720023SA015 720023SA020 720023SA025 720023SA030 720024SA015 720024SA020 720024SA025 720024SA030 720024SA035
720024SA040 720024SA045 720024SA050 720024SD025 720027SA005 720027SA010 720027SA015 720027SA045 720030SA005
720030SA010 720030SA015 720030SA020 720030SA025 720030SA030

* Result exceeds PRG screening values

Table 4.19. SVOA and PCB compounds detected in sludge and UCRS soil at C-720 Complex

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Sludge	SVOA	720025SA001	1	1	Bis(2-ethylhexyl)phthalate	170,000.000 *		?	
	PPCB		1	1	PCB-1254	2,700.000 *	D	?	
			1	1	PCB-1260	700.000 *	D	?	
			1	1	Polychlorinated biphenyl	3,400.000 *	D	?	
Subsurface Soil	SVOA	720005SA030	28	31	Bis(2-ethylhexyl)phthalate	79.000	J	?	
		720006SA010	10	13	Bis(2-ethylhexyl)phthalate	60.000	J	?	
		720006SA015	15	18	4-Chloro-3-methylphenol	40.000 *	J	?	
		720006SA030	30	35	Bis(2-ethylhexyl)phthalate	50.000	J	?	
		720006SA035	35	38	Bis(2-ethylhexyl)phthalate	40.000	J	?	
		720007SA005	5	8	Bis(2-ethylhexyl)phthalate	80.000	J	?	
		720007SA020	20	23	Bis(2-ethylhexyl)phthalate	120.000	J	?	
		720020SA035	35	38	Bis(2-ethylhexyl)phthalate	34.000	J	?	
		720020SA040	40	45	Bis(2-ethylhexyl)phthalate	34.000	J	?	
		720023SA015	15	18	Bis(2-ethylhexyl)phthalate	38.000	J	?	
		720023SA025	25	28	Bis(2-ethylhexyl)phthalate	47.000	J	?	
		720023SA030	30	33	Bis(2-ethylhexyl)phthalate	39.000	J	?	
		720024SA015	15	18	Bis(2-ethylhexyl)phthalate	980.000 *		?	

* Result exceeds PRG screening values

Table 4.19. SVOA and PCB compounds detected in sludge and UCRS soil at C-720 Complex

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Subsurface Soil	SVOA	720024SA015	15	18	Di-n-octylphthalate	51.000	J	?	
		720024SA020	20	23	Bis(2-ethylhexyl)phthalate	620.000		?	
		720024SA025	25	30	Bis(2-ethylhexyl)phthalate	820.000		?	
			25	30	Di-n-octylphthalate	78.000	J	?	
		720024SA030	30	33	Bis(2-ethylhexyl)phthalate	790.000		?	
			30	33	Di-n-octylphthalate	34.000	J	?	
		720024SA035	35	38	Bis(2-ethylhexyl)phthalate	1,100.000 *		?	
			35	38	Di-n-octylphthalate	35.000	J	?	
		720024SA040	40	43	Bis(2-ethylhexyl)phthalate	310.000	J	?	
		720024SA045	45	48	Bis(2-ethylhexyl)phthalate	950.000 *		?	
		720024SA050	48	50	Bis(2-ethylhexyl)phthalate	900.000 *		?	
		720024SD025	25	30	Bis(2-ethylhexyl)phthalate	890.000 *		?	
			25	30	Di-n-octylphthalate	40.000	J	?	
		720027SA025	26	28	Bis(2-ethylhexyl)phthalate	35.000	J	?	

* Result exceeds PRG screening values

Table 4.19. SVOA and PCB compounds detected in sludge and UCRS soil at C-720 Complex

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					

Note: Sludge samples not containing any detectable SVOA compounds at C-720 Complex are:
None

Sludge samples not containing any detectable PPCB compounds at C-720 Complex are:
None

Subsurface soil samples not containing any detectable SVOA compounds at C-720 Complex are:
720001SA015 720001SA020 720001SA025 720001SA035 720001SA040 720001SA045 720002SA005 720002SA015 720002SA020
720002SA025 720003SA005 720003SA015 720003SA020 720003SA025 720003SA030 720003SA035 720003SA040 720003SA045
720004SA010 720004SA015 720004SA020 720004SA025 720004SA030 720004SA035 720004SA040 720004SA045 720004SA050
720004SD020 720005SA010 720005SA015 720005SA020 720005SA025 720005SD025 720006SA005 720006SA020 720006SA025
720006SA040 720006SA045 720006SA050 720006SD030 720007SA010 720007SA015 720007SA025 720007SA030 720007SA035
720007SA040 720007SA045 720008SA010 720008SA015 720008SA020 720008SA025 720008SA030 720008SD020 720009SA005
720009SA015 720009SA020 720009SA025 720009SA030 720009SA040 720009SA045 720020SA015 720020SA020 720020SA025
720020SA030 720020SA045 720020SD040 720021SA015 720021SA020 720021SA025 720021SA030 720021SA035 720021SA040
720021SA045 720022SA005 720022SA010 720022SA015 720022SA020 720022SA025 720022SA030 720022SA035 720022SA040
720022SA045 720022SA050 720023SA020 720027SA005 720027SA010 720027SA015 720027SA020 720030SA005 720030SA010
720030SA015 720030SA020 720030SA025 720030SA030

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* Result exceeds PRG screening values

Table 4.19. SVOA and PCB compounds detected in sludge and UCRS soil at C-720 Complex

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/kg)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					

Subsurface soil samples not containing any detectable PPCB compounds at C-720 Complex are:

720001SA015 720001SA020 720001SA025 720001SA035 720001SA040 720001SA045 720002SA005 720002SA015 720002SA020
720002SA025 720003SA005 720003SA015 720003SA020 720003SA025 720003SA030 720003SA035 720003SA040 720003SA045
720004SA010 720004SA015 720004SA020 720004SA025 720004SA030 720004SA035 720004SA040 720004SA045 720004SA050
720004SD020 720005SA010 720005SA015 720005SA020 720005SA025 720005SA030 720005SD025 720006SA005 720006SA010
720006SA015 720006SA020 720006SA025 720006SA030 720006SA035 720006SA040 720006SA045 720006SA050 720006SD030
720007SA005 720007SA010 720007SA015 720007SA020 720007SA025 720007SA030 720007SA035 720007SA040 720007SA045
720008SA010 720008SA015 720008SA020 720008SA025 720008SA030 720008SD020 720009SA005 720009SA015 720009SA020
720009SA025 720009SA030 720009SA040 720009SA045 720020SA015 720020SA020 720020SA025 720020SA030 720020SA035
720020SA040 720020SA045 720020SD040 720021SA015 720021SA020 720021SA025 720021SA030 720021SA035 720021SA040
720021SA045 720022SA005 720022SA010 720022SA015 720022SA020 720022SA025 720022SA030 720022SA035 720022SA040
720022SA045 720022SA050 720023SA015 720023SA020 720023SA025 720023SA030 720024SA015 720024SA020 720024SA025
720024SA030 720024SA035 720024SA040 720024SA045 720024SA050 720024SD025

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* Result exceeds PRG screening values

Table 4.20. Metals detected above BG in sludge and UCRS soil at C-720 Complex

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
			Top	Bottom						
Sludge	METAL	720025SA001	1	1	Cadmium	4.320 *		?		0.210
			1	1	Chromium	724.000 *	N	?		16.000
			1	1	Lead	138.000 *	N	?		36.000
			1	1	Mercury	0.640	N	?		0.200
			1	1	Nickel	644.000 *	N	?		21.000
Subsurface Soil		720001SA015	14	15.5	Cadmium	0.240	B	?		0.210
		720001SA040	38	42	Antimony	0.610 *	B	?		0.210
		720002SA015	12	16	Lead	139.000 *		?		23.000
		720003SA015	14	18	Antimony	0.520 *	B	?		0.210
		720003SA030	30	33	Beryllium	0.750 *		?		0.690
		720003SA045	45	48	Beryllium	0.910 *		?		0.690
		720004SA020	17	22	Beryllium	0.790 *		?		0.690
			17	22	Chromium	45.300		?		43.000
			17	22	Vanadium	59.200 *		?		37.000
		720004SA035	32	35	Beryllium	0.780 *		?		0.690
			32	35	Vanadium	39.600 *		?		37.000
		720004SD020	17	22	Vanadium	42.100 *		?		37.000

* Result exceeds PRG screening values

Table 4.20. Metals detected above BG in sludge and UCRS soil at C-720 Complex

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
Subsurface Soil	METAL	720005SD025	20	25	Vanadium	38.200 *		?		37.000
		720006SA015	15	18	Cobalt	18.600		?		13.000
			15	18	Sodium	343.000 *		?		340.000
		720006SA020	20	23	Selenium	0.730		?		0.700
		720006SA025	25	28	Beryllium	1.180 *		?		0.690
			25	28	Cadmium	0.480		?		0.210
		720006SA040	40	43	Beryllium	0.810 *		?		0.690
		720007SA005	5	8	Barium	225.000		?		170.000
			5	8	Beryllium	0.750 *		?		0.690
		720007SA020	20	23	Beryllium	1.040 *		?		0.690
			20	23	Vanadium	48.800 *		?		37.000
		720007SA025	25	28	Beryllium	0.920 *		?		0.690
			25	28	Iron	33,700.000 *		?		28,000.000
			25	28	Vanadium	55.200 *		?		37.000
		720008SA025	25	28	Beryllium	1.090 *		?		0.690
			25	28	Vanadium	42.700 *		?		37.000
		720008SA030	30	33	Beryllium	0.740 *		?		0.690

* Result exceeds PRG screening values

Table 4.20. Metals detected above BG in sludge and UCRS soil at C-720 Complex

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
			Top	Bottom						
Subsurface Soil	METAL	720008SA030	30	33	Zinc	87.600		?		60.000
		720009SA005	5	9	Antimony	0.530 *	B	?		0.210
		720009SA020	20	23	Beryllium	0.770 *		?		0.690
		720009SA045	45	48	Zinc	61.500		?		60.000
		720020SA020	20	23	Antimony	0.550 *	B	?		0.210
			20	23	Beryllium	1.400 *		?		0.690
			20	23	Chromium	45.800		?		43.000
			20	23	Iron	36,900.000 *		?		28,000.000
			20	23	Vanadium	50.400 *		?		37.000
		720020SD040	40	45	Zinc	78.400		?		60.000
		720021SA015	15	15	Chromium	71.800		?		43.000
		720021SA020	20	23	Aluminum	12,100.000 *		?		12,000.000
		720022SA005	5	8	Sodium	486.000 *		?		340.000
		720022SA010	10	13	Cobalt	14.000		?		13.000
			10	13	Sodium	470.000 *		?		340.000
		720022SA015	15	18	Sodium	481.000 *		?		340.000
		720022SA020	20	23	Beryllium	0.710 *		?		0.690

* Result exceeds PRG screening values

Table 4.20. Metals detected above BG in sludge and UCRS soil at C-720 Complex

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
Subsurface Soil	METAL	720022SA020	20	23	Sodium	351.000 *		?		340.000
		720022SA035	35	38	Sodium	343.000 *		?		340.000
		720022SA040	40	43	Beryllium	0.770 *		?		0.690
			40	43	Sodium	362.000 *		?		340.000
		720022SA045	45	48	Sodium	356.000 *		?		340.000
		720022SA050	48	50	Sodium	351.000 *		?		340.000
		720023SA015	15	18	Beryllium	0.710 *		?		0.690
		720024SA035	35	38	Antimony	86.200 *		?		0.210
			35	38	Beryllium	107.000 *		?		0.690
			35	38	Cadmium	102.000 *		?		0.210
			35	38	Chromium	109.000		?		43.000
			35	38	Cobalt	103.000		?		13.000
			35	38	Copper	106.000		?		25.000
			35	38	Magnesium	5,550.000 *		?		2,100.000
			35	38	Nickel	105.000		?		22.000
			35	38	Potassium	6,390.000 *		?		950.000
			35	38	Silver	94.800 *		?		2.700

* Result exceeds PRG screening values

Table 4.20. Metals detected above BG in sludge and UCRS soil at C-720 Complex

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
Subsurface Soil	METAL	720024SA035	35	38	Sodium	5,490.000 *		?		340.000
			35	38	Thallium	94.400 *		?		0.340
			35	38	Vanadium	118.000 *		?		37.000
		720024SA040	40	43	Antimony	79.500 *		?		0.210
			40	43	Beryllium	106.000 *		?		0.690
			40	43	Cadmium	101.000 *		?		0.210
			40	43	Chromium	117.000		?		43.000
			40	43	Cobalt	103.000		?		13.000
			40	43	Copper	105.000		?		25.000
			40	43	Magnesium	5,530.000 *		?		2,100.000
			40	43	Nickel	108.000		?		22.000
			40	43	Potassium	6,420.000 *		?		950.000
			40	43	Silver	89.100 *		?		2.700
			40	43	Sodium	5,440.000 *		?		340.000
			40	43	Thallium	93.500 *		?		0.340
			40	43	Vanadium	128.000 *		?		37.000
		720024SA045	45	48	Antimony	87.200 *		?		0.210

* Result exceeds PRG screening values

Table 4.20. Metals detected above BG in sludge and UCRS soil at C-720 Complex

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
			Top	Bottom						
Subsurface Soil	METAL	720024SA045	45	48	Beryllium	97.900 *		?		0.690
			45	48	Cadmium	95.900 *		?		0.210
			45	48	Chromium	103.000		?		43.000
			45	48	Cobalt	95.100		?		13.000
			45	48	Copper	96.400		?		25.000
			45	48	Magnesium	5,200.000 *		?		2,100.000
			45	48	Nickel	97.800		?		22.000
			45	48	Potassium	6,120.000 *		?		950.000
			45	48	Silver	68.000 *		?		2.700
			45	48	Sodium	5,200.000 *		?		340.000
			45	48	Thallium	89.900 *		?		0.340
			45	48	Vanadium	112.000 *		?		37.000
		720024SA050	48	50	Antimony	87.000 *		?		0.210
			48	50	Beryllium	97.900 *		?		0.690
			48	50	Cadmium	95.600 *		?		0.210
			48	50	Chromium	103.000		?		43.000
			48	50	Cobalt	95.300		?		13.000

* Result exceeds PRG screening values

Table 4.20. Metals detected above BG in sludge and UCRS soil at C-720 Complex

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
			Top	Bottom						
Subsurface Soil	METAL	720024SA050	48	50	Copper	96.300		?		25.000
			48	50	Magnesium	5,200.000 *		?		2,100.000
			48	50	Nickel	97.000		?		22.000
			48	50	Potassium	6,120.000 *		?		950.000
			48	50	Silver	68.000 *		?		2.700
			48	50	Sodium	5,220.000 *		?		340.000
			48	50	Thallium	89.200 *		?		0.340
			48	50	Vanadium	113.000 *		?		37.000
		720027SA010	10	13	Antimony	0.530 *	B	?		0.210
			10	13	Arsenic	10.000 *		?		7.900
		720027SA015	15	18	Mercury	0.960 *		?		0.130
			15	18	Thallium	0.600 *	B	?		0.340
			15	18	Zinc	91.900		?		60.000
		720027SA020	20	23	Antimony	1.590 *		?		0.210
			20	23	Beryllium	1.990 *		?		0.690
			20	23	Chromium	52.200		?		43.000
			20	23	Iron	30,200.000 *		?		28,000.000

* Result exceeds PRG screening values

Table 4.20. Metals detected above BG in sludge and UCRS soil at C-720 Complex

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (mg/kg)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/kg)
Subsurface Soil	METAL	720027SA020	20	23	Silver	2.740		?		2.700
			20	23	Vanadium	63.300 *		?		37.000
			20	23	Zinc	124.000		?		60.000
		720027SA025	26	28	Antimony	0.810 *	B	?		0.210
			26	28	Beryllium	0.940 *		?		0.690
			26	28	Chromium	47.300		?		43.000
			26	28	Vanadium	43.700 *		?		37.000

Note: Sludge samples not containing any detectable metals at concentrations above background at C-720 Complex are:
None

Subsurface soil samples not containing any detectable metals at concentrations above background at C-720 Complex are:
720001SA020 720001SA025 720001SA035 720001SA045 720002SA005 720002SA020 720002SA025 720003SA005 720003SA020
720003SA025 720003SA035 720003SA040 720004SA010 720004SA015 720004SA025 720004SA030 720004SA040 720004SA045
720004SA050 720005SA010 720005SA015 720005SA020 720005SA025 720005SA030 720006SA005 720006SA010 720006SA030
720006SA035 720006SA045 720006SA050 720006SD030 720007SA010 720007SA015 720007SA030 720007SA035 720007SA040
720007SA045 720008SA010 720008SA015 720008SA020 720008SD020 720009SA015 720009SA025 720009SA030 720009SA040
720020SA015 720020SA025 720020SA030 720020SA035 720020SA040 720020SA045 720021SA025 720021SA030 720021SA035
720021SA040 720021SA045 720022SA025 720022SA030 720023SA020 720023SA025 720023SA030 720024SA015 720024SA020
720024SA025 720024SA030 720024SD025 720027SA005

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* Result exceeds PRG screening values

Table 4.21. Radioactive isotopes detected above BG in sludge and UCRS soil at C-720 Complex

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (pCi/g)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (pCi/g)
			Top	Bottom						
Sludge	RADS	720025SA001	1	1	Neptunium-237	267.000 *		?		0.100
			1	1	Technetium-99	27,520.600 *		?		2.500
			1	1	Thorium-230	5.170		?		1.500
			1	1	Uranium	16,997.000 *		?		0.000
			1	1	Uranium-234	6,167.000 *		?		2.500
			1	1	Uranium-235	348.000 *		?		0.140
			1	1	Uranium-238	10,480.000 *		?		1.200
Subsurface Soil		720001SA035	34	38	Uranium	1.600		?		0.000
		720001SA040	38	42	Uranium	2.400		?		0.000
		720001SA045	42	46	Uranium	1.900		?		0.000
		720003SA035	35	38	Uranium	1.600		?		0.000
		720003SA040	40	43	Uranium	1.700		?		0.000
		720004SD020	17	22	Plutonium-239/240	0.140		?		0.000
		720009SA005	5	9	Uranium	1.600		?		0.000
		720024SA025	25	30	Uranium	2.200		?		0.000
		720027SA035	35	39	Uranium	2.700		?		0.000
			35	39	Uranium-238	1.500		?		1.200

* Result exceeds PRG screening values

Table 4.21. Radioactive isotopes detected above BG in sludge and UCRS soil at C-720 Complex

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (pCi/g)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (pCi/g)
			Top	Bottom						
Subsurface Soil	RADS	720027SD035	35	39	Uranium	3.000		?		0.000
			35	39	Uranium-238	1.400		?		1.200
		720030SA005	4	5	Uranium	2.100		?		0.000
		720030SA015	13	15	Uranium	1.800		?		0.000
		720030SA020	19	20	Uranium	1.700		?		0.000
		720030SA025	23	25	Technetium-99	23.400		?		2.800
		720030SA030	28	30	Uranium	1.700		?		0.000

Note: Sludge samples not containing any detectable radioactive isotopes at concentrations above background at C-720 Complex are:
None

Subsurface soil samples not containing any detectable radioactive isotopes at concentrations above background at C-720 Complex are:
720001SA015 720001SA020 720001SA025 720002SA005 720002SA015 720002SA020 720002SA025 720003SA005 720003SA015
720003SA025 720003SA030 720003SA045 720004SA010 720004SA015 720004SA020 720004SA025 720004SA030 720004SA035
720004SA040 720004SA045 720004SA050 720005SA010 720005SA015 720005SA020 720005SA025 720005SA030 720005SD025
720006SA005 720006SA010 720006SA015 720006SA020 720006SA025 720006SA030 720006SA035 720006SA040 720006SA045
720006SA050 720006SD030 720007SA005 720007SA010 720007SA015 720007SA020 720007SA025 720007SA030 720007SA035
720007SA040 720007SA045 720008SA010 720008SA015 720008SA020 720008SA025 720008SA030 720008SD020 720009SA015
720009SA020 720009SA025 720009SA030 720009SA040 720009SA045 720016SA055 720020SA015 720020SA020 720020SA025
720020SA030 720020SA035 720020SA040 720020SA045 720020SD040 720021SA015 720021SA020 720021SA025 720021SA030
720021SA035 720021SA040 720021SA045 720022SA005 720022SA010 720022SA015 720022SA020 720022SA025 720022SA030
720022SA035 720022SA040 720022SA045 720022SA050 720023SA015 720023SA020 720023SA025 720023SA030 720024SA015
720024SA020 720024SA030 720024SA035 720024SA040 720024SA045 720024SA050 720024SD025 720027SA005 720027SA010
720027SA015 720027SA020 720027SA025 720027SA030 720027SA040 720027SA045 720030SA010 720003SA020

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* Result exceeds PRG screening values

Table 4.22. VOA compounds detected in UCRS groundwater at C-720 Complex

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Groundwater	VOA	720002WA015	3	8	1,1-Dichloroethene	46.000*	J	?	
			3	8	cis-1,2-Dichloroethene	49.000*	J	?	
			3	8	trans-1,2-Dichloroethene	64.000*	J	?	
			3	8	Trichloroethene	149.000*		?	
			3	8	Vinyl chloride	46.000*	J	?	
		720003WA015	30	30	trans-1,2-Dichloroethene	4.300*	J	?	
			30	30	Trichloroethene	46.000*	J	?	
		720011WA035	36	36	1,1-Dichloroethene	2.000*	J	?	
			36	36	trans-1,2-Dichloroethene	1.200	J	?	
			36	36	Trichloroethene	9.200*		?	
		720022WA015	50	50	Trichloroethene	1.600*	J	?	
		720024WA015	33	33	Trichloroethene	0.200*	J	?	

Note: UCRS groundwater samples not containing any detectable VOA compounds at C-720 Complex are:
None

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* Result exceeds PRG screening values

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Table 4.23. Frequency of detection of organic compounds, metals, and radioactive isotopes exceeding BG in C-720 Complex sludge, UCRS soil and UCRS groundwater samples

Sample Type	Analytical Group	Analytical Compound	Number of Analyses [a]	Number of Detections above BG [a]	Number of Detections above BG & PRG Screening Values [a]	Maximum Result above BG [a]	Minimum Result above BG [a]	Average Result above BG [a]	Units
Sludge	VOA	1,1-Dichloroethene	1	1	1	2,800.000	2,800.000	2,800.000	ug/kg
		Trichloroethene	1	1	1	420,000.000	420,000.000	420,000.000	ug/kg
	SVOA	Bis(2-ethylhexyl)phthalate	1	1	1	170,000.000	170,000.000	170,000.000	ug/kg
	PPCB	PCB-1254	1	1	1	2,700.000	2,700.000	2,700.000	ug/kg
		PCB-1260	1	1	1	700.000	700.000	700.000	ug/kg
		Polychlorinated biphenyl	1	1	1	3,400.000	3,400.000	3,400.000	ug/kg
	Metals	Cadmium	1	1	1	4.320	4.320	4.320	mg/kg
		Chromium	1	1	1	724.000	724.000	724.000	mg/kg
		Lead	1	1	1	138.000	138.000	138.000	mg/kg
		Mercury	1	1	0	0.640	0.640	0.640	mg/kg
		Nickel	1	1	1	644.000	644.000	644.000	mg/kg
	Radioactive isotopes	Neptunium-237	1	1	1	267.000	267.000	267.000	pCi/g
		Technetium-99	1	1	1	27,520.600	27,520.600	27,520.600	pCi/g
		Thorium-230	1	1	0	5.170	5.170	5.170	pCi/g
		Uranium	1	1	1	16,997.000	16,997.000	16,997.000	pCi/g
		Uranium-234	1	1	1	6,167.000	6,167.000	6,167.000	pCi/g
		Uranium-235	1	1	1	348.000	348.000	348.000	pCi/g
		Uranium-238	1	1	1	10,480.000	10,480.000	10,480.000	pCi/g
Subsurface soil	VOA	Trichloroethene	148	37	25	68,000.000	1.000	6,338.000	ug/kg
		Acetone	8	8	0	30.000	4.000	8.875	ug/kg
		Vinyl chloride	148	3	3	400.000	200.000	333.333	ug/kg
		1,1-Dichloroethane	19	2	0	950.000	70.000	510.000	ug/kg
		cis-1,2-Dichloroethene	142	2	0	3,200.000	750.000	1,975.000	ug/kg
		trans-1,2-Dichloroethene	142	2	1	450,000.000	400.000	225,200.000	ug/kg
		1,1-Dichloroethene	137	1	1	200.000	200.000	200.000	ug/kg

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[a] Number of analyses/detections include both environmental samples and duplicate results

Table 4.23. Frequency of detection of organic compounds, metals, and radioactive isotopes exceeding BG in C-720 Complex sludge, UCRS soil and UCRS groundwater samples

Sample Type	Analytical Group	Analytical Compound	Number of Analyses [a]	Number of Detections above BG [a]	Number of Detections above BG & PRG Screening Values [a]	Maximum Result above BG [a]	Minimum Result above BG [a]	Average Result above BG [a]	Units
Subsurface soil (cont.)	VOA (cont.)	2-Butanone	14	1	0	5.000	5.000	5.000	ug/kg
	SVOA	Bis(2-ethylhexyl)phthalate	110	21	5	1,100.000	34.000	381.714	ug/kg
		Di-n-octylphthalate	110	5	0	78.000	34.000	47.600	ug/kg
		4-Chloro-3-methylphenol	110	1	1	40.000	40.000	40.000	ug/kg
	Metals	Beryllium	110	22	22	107.000	0.710	19.357	mg/kg
		Vanadium	110	14	14	128.000	38.200	68.157	mg/kg
		Sodium	110	13	13	5,490.000	343.000	1,914.846	mg/kg
		Antimony	110	11	11	87.200	0.520	31.367	mg/kg
		Chromium	110	9	0	117.000	45.300	77.156	mg/kg
		Cadmium	110	6	4	102.000	0.240	65.870	mg/kg
		Cobalt	110	6	0	103.000	14.000	71.500	mg/kg
		Silver	110	5	4	94.800	2.740	64.528	mg/kg
		Thallium	110	5	5	94.400	0.600	73.520	mg/kg
		Zinc	110	5	0	124.000	61.500	88.680	mg/kg
		Copper	110	4	0	106.000	96.300	100.925	mg/kg
		Magnesium	110	4	4	5,550.000	5,200.000	5,370.000	mg/kg
		Nickel	110	4	0	108.000	97.000	101.950	mg/kg
		Potassium	110	4	4	6,420.000	6,120.000	6,262.500	mg/kg
		Iron	110	3	3	36,900.000	30,200.000	33,600.000	mg/kg
		Aluminum	110	1	1	12,100.000	12,100.000	12,100.000	mg/kg
		Arsenic	110	1	1	10.000	10.000	10.000	mg/kg
		Barium	110	1	0	225.000	225.000	225.000	mg/kg
		Lead	110	1	1	139.000	139.000	139.000	mg/kg
		Mercury	110	1	1	0.960	0.960	0.960	mg/kg
		Selenium	110	1	0	0.730	0.730	0.730	mg/kg
	Radioactive isotopes	Uranium	38	13	0	3.000	1.600	2.000	pCi/g

[a] Number of analyses/detections include both environmental samples and duplicate results

Table 4.23. Frequency of detection of organic compounds, metals, and radioactive isotopes exceeding BG in C-720 Complex sludge, UCRS soil and UCRS groundwater samples

Sample Type	Analytical Group	Analytical Compound	Number of Analyses [a]	Number of Detections above BG [a]	Number of Detections above BG & PRG Screening Values [a]	Maximum Result above BG [a]	Minimum Result above BG [a]	Average Result above BG [a]	Units
Subsurface soil (cont.)	Radioactive isotopes (cont.)	Uranium-238	38	2	0	1.500	1.400	1.450	pCi/g
		Plutonium-239/240	38	1	0	0.140	0.140	0.140	pCi/g
		Technetium-99	49	1	0	23.400	23.400	23.400	pCi/g
Groundwater	VOA	Trichloroethene	5	5	5	149.000	0.200	41.200	ug/L
		trans-1,2-Dichloroethene	5	3	2	64.000	1.200	23.167	ug/L
		1,1-Dichloroethene	5	2	2	46.000	2.000	24.000	ug/L
		cis-1,2-Dichloroethene	5	1	1	49.000	49.000	49.000	ug/L
		Vinyl chloride	5	1	1	46.000	46.000	46.000	ug/L

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[a] Number of analyses/detections include both environmental samples and duplicate results

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Table 4.24. VOA compounds detected in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Groundwater	VOA	001175WA060	62	62	Trichloroethene	0.600 *	J	?	
		001175WA065	67	67	cis-1,2-Dichloroethene	1.600	J	?	
			67	67	trans-1,2-Dichloroethene	0.500	J	?	
			67	67	Trichloroethene	45.000 *		?	
		001175WA070	72	72	1,1-Dichloroethene	0.400 *	J	?	
			72	72	trans-1,2-Dichloroethene	2.100	J	?	
			72	72	Trichloroethene	77.000 *		?	
		001175WA075	77	77	trans-1,2-Dichloroethene	0.400	J	?	
			77	77	Trichloroethene	29.000 *		?	
		001175WA080	82	82	trans-1,2-Dichloroethene	2.500	J	?	
			82	82	Trichloroethene	110.000 *		?	
		001175WA085	87	87	trans-1,2-Dichloroethene	0.200	J	?	
			87	87	Trichloroethene	28.000 *		?	
		001175WA090	92	92	trans-1,2-Dichloroethene	0.600	J	?	
			92	92	Trichloroethene	7.700 *		?	
		001175WA095	97	97	trans-1,2-Dichloroethene	0.300	J	?	
			97	97	Trichloroethene	4.000 *		?	

* Result exceeds PRG screening values

Table 4.24. VOA compounds detected in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
Groundwater	VOA	001175WA100	102	102	trans-1,2-Dichloroethene	0.600	J	?	
			102	102	Trichloroethene	6.500*		?	
		001175WA105	107	107	Trichloroethene	1.400*	J	?	
		001175WA110	112	112	Trichloroethene	0.200*	J	?	
		001175WD075	77	77	trans-1,2-Dichloroethene	0.400	J	?	
			77	77	Trichloroethene	26.000*		?	
		001176WA060	62	62	1,1-Dichloroethene	0.700*	J	?	
			62	62	Trichloroethene	0.200*	J	?	
		001176WA065	67	67	Trichloroethene	0.100	J	?	
		001176WA070	72	72	Trichloroethene	0.200*	J	?	
		001176WA075	77	77	Trichloroethene	0.600*	J	?	
		001176WA080	82	82	Trichloroethene	56.000*		?	
		001176WA085	87	87	1,1-Dichloroethene	0.500*	J	?	
			87	87	Trichloroethene	57.000*		?	
		001176WA090	92	92	Trichloroethene	66.000*		?	
		001176WA095	97	97	Chloroform	3.200*	J	?	
			97	97	Trichloroethene	1.400*	J	?	

* Result exceeds PRG screening values

Table 4.24. VOA compounds detected in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Groundwater	VOA	001176WD080	82	82	Trichloroethene	53.000 *		?	
		001177WA065	67	67	Trichloroethene	2.100 *	J	?	
		001177WA070	72	72	Trichloroethene	0.090	J	?	BH-NE
		001177WA075	77	77	Trichloroethene	0.600 *	J	?	BH-NE
		001177WA080	82	82	1,1-Dichloroethene	0.080 *	J	?	
			82	82	Trichloroethene	2.800 *	J	?	
		001177WA085	87	87	1,1-Dichloroethene	0.080 *	J	?	
			87	87	Trichloroethene	6.100 *		?	
		001177WA090	92	92	trans-1,2-Dichloroethene	0.900	J	?	
			92	92	Trichloroethene	6.900 *		?	
		001177WA095	97	97	1,1-Dichloroethene	0.100 *	J	?	
			97	97	trans-1,2-Dichloroethene	0.800	J	?	
			97	97	Trichloroethene	10.000 *		?	
		001177WA100	102	102	trans-1,2-Dichloroethene	0.600	J	?	
			102	102	Trichloroethene	8.800 *		?	
		001177WD080	82	82	Trichloroethene	3.500 *	J	?	
		001177WD085	87	87	1,1-Dichloroethene	0.100 *	J	?	

* Result exceeds PRG screening values

Table 4.24. VOA compounds detected in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Groundwater	VOA	001177WD085	87	87	trans-1,2-Dichloroethene	0.100	J	?	BH-NE
			87	87	Trichloroethene	6.000*		?	
		001178WA060	62	62	Trichloroethene	0.500*	J	?	
		001178WA065	67	67	Trichloroethene	0.500*	J	?	
		001178WA070	72	72	Trichloroethene	4.400*		?	
		001178WA075	77	77	trans-1,2-Dichloroethene	0.200	J	?	
			77	77	Trichloroethene	5.200*		?	
		001178WA080	82	82	trans-1,2-Dichloroethene	0.400	J	?	
			82	82	Trichloroethene	9.200*		?	
		001178WA085	87	87	trans-1,2-Dichloroethene	0.500	J	?	
			87	87	Trichloroethene	9.200*		?	
		001178WA090	92	92	trans-1,2-Dichloroethene	0.400	J	?	
			92	92	Trichloroethene	12.000*		?	
		001178WA095	97	97	trans-1,2-Dichloroethene	0.400	J	?	
			97	97	Trichloroethene	13.000*		?	
		001178WA100	102	102	trans-1,2-Dichloroethene	0.080	J	?	
			102	102	Trichloroethene	1.200*	J	?	

* Result exceeds PRG screening values

Table 4.24. VOA compounds detected in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
Groundwater	VOA	001178WD090	92	92	trans-1,2-Dichloroethene	0.400	J	?	
			92	92	Trichloroethene	15.000 *		?	
		001180WA060	62	62	Trichloroethene	0.050	J	?	BH-NE
		001180WA065	67	67	cis-1,2-Dichloroethene	0.060	J	?	
			67	67	trans-1,2-Dichloroethene	0.050	J	?	
			67	67	Trichloroethene	0.080	J	?	BH-NE
		001180WA070	72	72	cis-1,2-Dichloroethene	0.040	J	?	
			72	72	Trichloroethene	0.200 *	J	?	BH-NE
		001180WA075	77	77	trans-1,2-Dichloroethene	0.100	J	?	
			77	77	Trichloroethene	8.600 *		?	
		001180WA080	82	82	1,1-Dichloroethene	0.500 *	J	?	
			82	82	cis-1,2-Dichloroethene	0.300	J	?	
			82	82	trans-1,2-Dichloroethene	1.000	J	?	
			82	82	Trichloroethene	29.000 *		?	
		001180WA085	87	87	1,1-Dichloroethene	0.500 *	J	?	
			87	87	trans-1,2-Dichloroethene	1.000	J	?	
			87	87	Trichloroethene	75.000 *		?	

* Result exceeds PRG screening values

Table 4.24. VOA compounds detected in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Groundwater	VOA	001180WA090	92	92	trans-1,2-Dichloroethene	0.100	J	?	
			92	92	Trichloroethene	8.300*		?	
		001180WA095	97	97	trans-1,2-Dichloroethene	0.080	J	?	
			97	97	Trichloroethene	1.600*	J	?	
		001180WA100	102	102	trans-1,2-Dichloroethene	0.050	J	?	
			102	102	Trichloroethene	0.800*	J	?	
		001180WD070	72	72	Trichloroethene	0.200*	J	?	BH-NE
		001181WA070	72	72	1,1-Dichloroethene	0.080*	J	?	
			72	72	trans-1,2-Dichloroethene	0.300	J	?	
			72	72	Trichloroethene	11.000*		?	
		001181WA075	77	77	trans-1,2-Dichloroethene	2.100	J	?	
			77	77	Trichloroethene	63.000*		?	
		001181WA080	82	82	cis-1,2-Dichloroethene	2.000	J	?	
			82	82	trans-1,2-Dichloroethene	1.600	J	?	
			82	82	Trichloroethene	80.000*		?	
		001181WA085	87	87	trans-1,2-Dichloroethene	1.300	J	?	
			87	87	Trichloroethene	93.000*		?	

* Result exceeds PRG screening values

Table 4.24. VOA compounds detected in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Groundwater	VOA	001181WA090	92	92	Trichloroethene	143.000*		?	
		001181WA095	97	97	1,1-Dichloroethene	0.700*	J	?	
			97	97	Trichloroethene	86.000*		?	
		001181WA100	102	102	Trichloroethene	45.000*		?	
		001181WD080	82	82	cis-1,2-Dichloroethene	1.900	J	?	
			82	82	trans-1,2-Dichloroethene	1.600	J	?	
			82	82	Trichloroethene	81.000*		?	
		001182WA070	72	72	Trichloroethene	3.600*	J	?	
		001182WA075	77	77	Trichloroethene	419.000*		?	
		001182WA080	82	82	trans-1,2-Dichloroethene	5.200*	J	?	
			82	82	Trichloroethene	520.000*		?	
		001182WA085	87	87	trans-1,2-Dichloroethene	23.000*	J	?	
			87	87	Trichloroethene	1,578.000*		?	
		001182WA090	92	92	1,1-Dichloroethene	5.300*		?	
			92	92	cis-1,2-Dichloroethene	4.500*	J	?	
			92	92	Trichloroethene	555.000*		?	
		001182WA095	97	97	1,1-Dichloroethene	0.500*	J	?	

* Result exceeds PRG screening values

Table 4.24. VOA compounds detected in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Groundwater	VOA	001182WA095	97	97	trans-1,2-Dichloroethene	0.900	J	?	
			97	97	Trichloroethene	61.000 *		?	
		001182WD070	72	72	Trichloroethene	3.600 *	J	?	
		001183WA070	72	72	trans-1,2-Dichloroethene	0.100	J	?	
			72	72	Trichloroethene	10.000 *		?	
		001183WA075	77	77	Trichloroethene	12.000 *		?	
		001183WA080	82	82	Trichloroethene	5.100 *		?	
		001183WA085	87	87	Trichloroethene	9.000 *		?	
		001183WA090	92	92	Trichloroethene	7.100 *		?	
		001183WA095	97	97	trans-1,2-Dichloroethene	0.100	J	?	
			97	97	Trichloroethene	6.500 *		?	
		001183WD075	77	77	Trichloroethene	12.000 *		?	
		001184WA055	57	57	Trichloroethene	0.200 *	J	?	
		001184WA070	72	72	Trichloroethene	0.900 *	J	?	
		001184WA075	77	77	Trichloroethene	24.000 *		?	
		001184WA080	82	82	cis-1,2-Dichloroethene	2.300 *	J	?	
			82	82	Trichloroethene	220.000 *		?	

* Result exceeds PRG screening values

Table 4.24. VOA compounds detected in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
Groundwater	VOA	001184WA085	87	87	1,1-Dichloroethene	2.200*	J	?	
			87	87	cis-1,2-Dichloroethene	2.600*	J	?	
			87	87	Trichloroethene	240.000*		?	
		001184WA090	92	92	Trichloroethene	220.000*		?	
		001184WA095	97	97	Trichloroethene	119.000*		?	
		001184WA100	102	102	Trichloroethene	75.000*		?	
		001184WD080	82	82	cis-1,2-Dichloroethene	2.200*	J	?	
			82	82	Trichloroethene	230.000*		?	
		091001WA065	65	66	Trichloroethene	6.500*		?	
		091001WA070	70	71	1,1-Dichloroethene	0.100*	J	?	
			70	71	trans-1,2-Dichloroethene	0.400	J	?	
			70	71	Trichloroethene	12.000*		?	
		091001WA075	75	76	trans-1,2-Dichloroethene	0.400	J	?	
			75	76	Trichloroethene	10.000*		?	
		091001WA080	80	81	1,1-Dichloroethene	2.300*	J	?	
			80	81	trans-1,2-Dichloroethene	1.500	J	?	
			80	81	Trichloroethene	73.000*		?	

* Result exceeds PRG screening values

Table 4.24. VOA compounds detected in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
Groundwater	VOA	091001WA085	85	86	1,1-Dichloroethene	22.000*		?	
			85	86	trans-1,2-Dichloroethene	1.100	J	?	
			85	86	Trichloroethene	51.000*		?	
			85	86	Vinyl chloride	1.700*	J	?	
		091001WA090	90	91	1,1-Dichloroethene	30.000*		?	
			90	91	cis-1,2-Dichloroethene	12.500*	J	?	
			90	91	trans-1,2-Dichloroethene	0.300	J	?	
			90	91	Trichloroethene	23.000*		?	
			90	91	Vinyl chloride	0.500*	J	?	
		091001WA095	95	96	1,1-Dichloroethene	44.000*		?	
			95	96	trans-1,2-Dichloroethene	1.500	J	?	
			95	96	Trichloroethene	30.000*		?	
			95	96	Vinyl chloride	0.800*	J	?	
		091001WA100	100	101	1,1-Dichloroethene	9.400*		?	
			100	101	trans-1,2-Dichloroethene	2.300	J	?	
			100	101	Trichloroethene	12.000*		?	
			100	101	Vinyl chloride	0.100*	J	?	

* Result exceeds PRG screening values

Table 4.24. VOA compounds detected in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Groundwater	VOA	091001WA105	106	107	1,1-Dichloroethene	6.100*	J	?	
			106	107	trans-1,2-Dichloroethene	5.700*	J	?	
			106	107	Trichloroethene	38.000*		?	
		091001WD085	85	86	1,1-Dichloroethene	18.000*	J	?	
			85	86	trans-1,2-Dichloroethene	1.000	J	?	
			85	86	Trichloroethene	43.000*		?	
			85	86	Vinyl chloride	1.400*	J	?	
		091002WA065	63.5	64.5	Trichloroethene	2.700*	J	?	
		091002WA070	68.5	69.5	1,1-Dichloroethene	0.040*	J	?	
			68.5	69.5	trans-1,2-Dichloroethene	0.080	J	?	
			68.5	69.5	Trichloroethene	3.700*	J	?	
		091002WA075	73.5	74.5	1,1-Dichloroethene	0.300*	J	?	
			73.5	74.5	trans-1,2-Dichloroethene	0.500	J	?	
			73.5	74.5	Trichloroethene	17.000*		?	
		091002WA085	83.5	84.5	1,1-Dichloroethene	0.800*	J	?	
			83.5	84.5	trans-1,2-Dichloroethene	6.700*	J	?	
			83.5	84.5	Trichloroethene	112.000*		?	

* Result exceeds PRG screening values

Table 4.24. VOA compounds detected in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
Groundwater	VOA	091002WA090	88.5	89.5	trans-1,2-Dichloroethene	0.060	J	?	
			88.5	89.5	Trichloroethene	1.700*	J	?	
		091002WA095	93.5	94.5	trans-1,2-Dichloroethene	0.100	J	?	
			93.5	94.5	Trichloroethene	6.000*		?	
		091002WD085	83.5	84.5	1,1-Dichloroethene	1.100*	J	?	
			83.5	84.5	trans-1,2-Dichloroethene	5.800*	J	?	
			83.5	84.5	Trichloroethene	95.000*		?	
		720010WA055	56	56	1,1-Dichloroethene	1.700*	J	?	
			56	56	trans-1,2-Dichloroethene	6.300*	J	?	
			56	56	Trichloroethene	73.000*		?	
		720010WA065	66	66	trans-1,2-Dichloroethene	0.060	J	?	
			66	66	Trichloroethene	1.600*	J	?	
			66	66	Vinyl chloride	0.100*	J	?	
		720010WA070	71	71	1,1-Dichloroethene	0.080*	J	?	
			71	71	trans-1,2-Dichloroethene	0.500	J	?	
			71	71	Trichloroethene	5.800*		?	
			71	71	Vinyl chloride	0.100*	J	?	

* Result exceeds PRG screening values

Table 4.24. VOA compounds detected in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Groundwater	VOA	720010WA075	76	76	1,1-Dichloroethene	0.100*	J	?	
			76	76	trans-1,2-Dichloroethene	1.500	J	?	
			76	76	Trichloroethene	52.000*		?	
			76	76	Vinyl chloride	0.100*	J	?	
		720010WA080	81	81	1,1-Dichloroethene	0.200*	J	?	
			81	81	trans-1,2-Dichloroethene	3.700	J	?	
			81	81	Trichloroethene	5.700*		?	
			81	81	Vinyl chloride	0.100*	J	?	
		720010WA085	86	86	trans-1,2-Dichloroethene	0.400	J	?	
			86	86	Trichloroethene	17.000*		?	
		720010WA090	91	91	Trichloroethene	16.000*		?	
		720010WD065	66	66	trans-1,2-Dichloroethene	0.070	J	?	
			66	66	Trichloroethene	1.900*	J	?	
			66	66	Vinyl chloride	0.100*	J	?	
		720011WA060	57.5	57.5	1,1-Dichloroethene	0.200*	J	?	
			57.5	57.5	cis-1,2-Dichloroethene	29.000*		?	
			57.5	57.5	trans-1,2-Dichloroethene	25.000*		?	

* Result exceeds PRG screening values

Table 4.24. VOA compounds detected in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
Groundwater	VOA	720011WA060	57.5	57.5	Trichloroethene	25.000 *		?	
		720011WA070	67.5	67.5	trans-1,2-Dichloroethene	9.000 *		?	
			67.5	67.5	Trichloroethene	9.200 *		?	
		720011WA075	72.5	72.5	trans-1,2-Dichloroethene	2.200	J	?	
			72.5	72.5	Trichloroethene	3.800 *	J	?	
		720011WA080	77.5	77.5	trans-1,2-Dichloroethene	14.000 *		?	
			77.5	77.5	Trichloroethene	36.000 *		?	
		720011WA085	82.5	82.5	1,1-Dichloroethene	0.700 *	J	?	
			82.5	82.5	trans-1,2-Dichloroethene	9.000 *		?	
			82.5	82.5	Trichloroethene	22.000 *		?	
		720011WA090	87.5	87.5	trans-1,2-Dichloroethene	0.800	J	?	
			87.5	87.5	Trichloroethene	32.000 *		?	
		720011WA095	92.5	92.5	Trichloroethene	26.000 *		?	
		720011WA100	97.5	97.5	Trichloroethene	37.000 *		?	
			97.5	97.5	Vinyl chloride	2.100 *	J	?	
		720012WA070	72	73	Trichloroethene	0.700 *	J	?	
		720012WA075	77	78	Trichloroethene	0.200 *	J	?	

* Result exceeds PRG screening values

Table 4.24. VOA compounds detected in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Groundwater	VOA	720012WA080	82	83	Trichloroethene	2.100 *	J	?	
		720012WA085	87	88	trans-1,2-Dichloroethene	0.700	J	?	
			87	88	Trichloroethene	11.000 *		?	
		720013WA070	72	72	trans-1,2-Dichloroethene	2.000	J	?	
			72	72	Trichloroethene	7.700 *		?	
		720013WA075	77	77	trans-1,2-Dichloroethene	2.600	J	?	
			77	77	Trichloroethene	9.600 *		?	
			77	77	Vinyl chloride	0.100 *	J	?	
		720013WA080	82	82	cis-1,2-Dichloroethene	12.000 *		?	
			82	82	trans-1,2-Dichloroethene	9.300 *	J	?	
			82	82	Trichloroethene	51.000 *		?	
		720013WA085	87	87	trans-1,2-Dichloroethene	6.400 *	J	?	
			87	87	Trichloroethene	32.000 *		?	
		720013WA090	92	92	trans-1,2-Dichloroethene	10.000 *	J	?	
			92	92	Trichloroethene	57.000 *		?	
		720014WA070	68	68	trans-1,2-Dichloroethene	0.080	J	?	
			68	68	Trichloroethene	0.700 *	J	?	

* Result exceeds PRG screening values

Table 4.24. VOA compounds detected in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
Groundwater	VOA	720014WA070	68	68	Vinyl chloride	0.070 *	J	?	
		720014WA075	73	73	Trichloroethene	6.500 *		?	
			73	73	Vinyl chloride	0.060 *	J	?	
		720014WA080	78	78	trans-1,2-Dichloroethene	3.200	J	?	
			78	78	Trichloroethene	14.000 *		?	
			78	78	Vinyl chloride	0.090 *	J	?	
		720014WA085	83	83	trans-1,2-Dichloroethene	2.500	J	?	
			83	83	Trichloroethene	6.500 *		?	
			83	83	Vinyl chloride	0.100 *	J	?	
		720014WA090	88	88	cis-1,2-Dichloroethene	4.500 *	J	?	
			88	88	trans-1,2-Dichloroethene	3.600	J	?	
			88	88	Trichloroethene	11.000 *		?	
		720014WD070	68	68	trans-1,2-Dichloroethene	0.100	J	?	
			68	68	Trichloroethene	0.800 *	J	?	
			68	68	Vinyl chloride	0.070 *	J	?	
		720015WA065	66	67	Trichloroethene	3.300 *	J	?	
		720015WA070	72	73	1,1-Dichloroethene	0.100 *	J	?	

* Result exceeds PRG screening values

Table 4.24. VOA compounds detected in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Groundwater	VOA	720015WA070	72	73	trans-1,2-Dichloroethene	0.300	J	?	
			72	73	Trichloroethene	21.000 *		?	
		720015WA075	77	78	1,1-Dichloroethene	1.300 *	J	?	
			77	78	trans-1,2-Dichloroethene	2.100	J	?	
			77	78	Trichloroethene	97.000 *		?	
		720015WA080	82	83	1,1-Dichloroethene	3.500 *	J	?	
			82	83	trans-1,2-Dichloroethene	5.700 *	J	?	
			82	83	Trichloroethene	249.000 *		?	
		720015WA085	87	88	1,1-Dichloroethene	4.200 *	J	?	
			87	88	cis-1,2-Dichloroethene	20.000 *	J	?	
			87	88	Trichloroethene	254.000 *		?	
		720015WA090	92	93	1,1-Dichloroethene	9.000 *	J	?	
			92	93	trans-1,2-Dichloroethene	7.500 *	J	?	
			92	93	Trichloroethene	496.000 *		?	
		720016WA065	65	65	Trichloroethene	8.400 *		?	
		720016WA070	70	70	1,1-Dichloroethene	0.070 *	J	?	
			70	70	trans-1,2-Dichloroethene	0.600	J	?	

* Result exceeds PRG screening values

Table 4.24. VOA compounds detected in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
Groundwater	VOA	720016WA070	70	70	Trichloroethene	10.000*		?	
		720016WA075	75	75	1,1-Dichloroethene	0.300*	J	?	
			75	75	trans-1,2-Dichloroethene	4.200*	J	?	
			75	75	Trichloroethene	25.000*		?	
		720016WA080	80	80	1,1-Dichloroethene	2.000*	J	?	
			80	80	trans-1,2-Dichloroethene	6.600*	J	?	
			80	80	Trichloroethene	86.000*		?	
		720016WA085	85	85	1,1-Dichloroethene	10.000*	J	?	
			85	85	trans-1,2-Dichloroethene	12.000*	J	?	
			85	85	Trichloroethene	395.000*		?	
		720016WA090	90	90	1,1-Dichloroethene	19.000*	J	?	
			90	90	trans-1,2-Dichloroethene	11.000*	J	?	
			90	90	Trichloroethene	810.000*		?	
		720016WA095	95	95	1,1-Dichloroethene	4.400*	J	?	
			95	95	trans-1,2-Dichloroethene	3.800	J	?	
			95	95	Trichloroethene	293.000*		?	
		720016WD080	80	80	1,1-Dichloroethene	1.600*	J	?	

* Result exceeds PRG screening values

Table 4.24. VOA compounds detected in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
Groundwater	VOA	720016WD080	80	80	trans-1,2-Dichloroethene	6.300*	J	?	
			80	80	Trichloroethene	82.000*		?	
		720017WA060	61	61	trans-1,2-Dichloroethene	0.200	J	?	
			61	61	Trichloroethene	0.100	J	?	
		720017WA065	66	66	trans-1,2-Dichloroethene	0.100	J	?	
		720017WA070	71	71	1,1-Dichloroethene	3.800*	J	?	
			71	71	cis-1,2-Dichloroethene	23.000*		?	
			71	71	trans-1,2-Dichloroethene	23.000*		?	
			71	71	Trichloroethene	46.000*		?	
		720017WA075	76	76	1,1-Dichloroethene	2.800*	J	?	
			76	76	trans-1,2-Dichloroethene	22.000*	J	?	
			76	76	Trichloroethene	95.000*		?	
		720017WA080	81	81	1,1-Dichloroethene	4.400*	J	?	
			81	81	trans-1,2-Dichloroethene	9.900*	J	?	
			81	81	Trichloroethene	272.000*		?	
		720017WA085	86	86	1,1-Dichloroethene	4.200*	J	?	
			86	86	trans-1,2-Dichloroethene	4.700*	J	?	

* Result exceeds PRG screening values

Table 4.24. VOA compounds detected in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Groundwater	VOA	720017WA085	86	86	Trichloroethene	342.000*		?	
		720017WA090	91	91	1,1-Dichloroethene	6.100*	J	?	
			91	91	Trichloroethene	861.000*		?	
		720017WA095	96	96	1,1-Dichloroethene	10.000*	J	?	
			96	96	Trichloroethene	1,013.000*		?	
		720018WA065	66	66	1,1-Dichloroethene	31.000*	J	?	
			66	66	Trichloroethene	1,197.000*		?	
		720018WA070	71	71	Trichloroethene	1,170.000*		?	
		720018WA075	76	76	1,1-Dichloroethene	19.000*	J	?	
			76	76	Trichloroethene	1,262.000*		?	
		720018WA080	81	81	1,1-Dichloroethene	28.000*	J	?	
			81	81	Trichloroethene	1,118.000*		?	
		720018WA085	86	86	1,1-Dichloroethene	52.800*	J	?	
			86	86	Trichloroethene	1,013.000*		?	
		720018WA090	91	91	1,1-Dichloroethene	48.000*	J	?	
			91	91	cis-1,2-Dichloroethene	31.000*	J	?	
			91	91	Trichloroethene	289.000*		?	

* Result exceeds PRG screening values

Table 4.24. VOA compounds detected in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Groundwater	VOA	720018WD085	86	86	1,1-Dichloroethene	54.000*	J	?	
			86	86	Trichloroethene	1,045.000*		?	
		720019WA075	77	78	trans-1,2-Dichloroethene	2.400	J	?	
			77	78	Trichloroethene	75.000*		?	
		720019WA080	82	83	trans-1,2-Dichloroethene	3.400	J	?	
			82	83	Trichloroethene	102.000*		?	
		720019WA085	87	88	trans-1,2-Dichloroethene	3.500	J	?	
			87	88	Trichloroethene	103.000*		?	
		720019WA090	92	93	cis-1,2-Dichloroethene	4.700*	J	?	
			92	93	trans-1,2-Dichloroethene	2.900	J	?	
			92	93	Trichloroethene	92.000*		?	
		720026WA070	71	71	Trichloroethene	100.000*		?	
		720026WA080	82	82	1,1-Dichloroethene	12.000*		?	
			82	82	2-Propanol	540.000*		?	
			82	82	Carbon tetrachloride	4.200*	J	?	
			82	82	Chloroform	2.100*	J	?	
			82	82	cis-1,2-Dichloroethene	7.900*		?	

* Result exceeds PRG screening values

Table 4.24. VOA compounds detected in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Groundwater	VOA	720026WA080	82	82	trans-1,2-Dichloroethene	2.600	J	?	
			82	82	Trichloroethene	500.000*		?	
		720026WA085	87	87	1,1-Dichloroethene	9.200*	J	?	
			87	87	Trichloroethene	767.000*		?	
			87	87	Vinyl chloride	17.000*	J	?	
		720026WA090	92	92	1,1-Dichloroethene	15.000*	J	?	
			92	92	Trichloroethene	903.000*		?	
		720026WD085	87	87	1,1-Dichloroethene	31.000*		?	
			87	87	Carbon tetrachloride	12.000*		?	
			87	87	Chloroform	2.900*	J	?	
			87	87	cis-1,2-Dichloroethene	11.000*		?	
			87	87	Tetrachloroethene	4.000*	J	?	
			87	87	Trichloroethene	860.000*		?	
		720028WA080	81	81	trans-1,2-Dichloroethene	0.400	J	?	
			81	81	Trichloroethene	24.000*		?	
		720028WA085	86	86	trans-1,2-Dichloroethene	2.700	J	?	
			86	86	Trichloroethene	34.000*		?	

* Result exceeds PRG screening values

Table 4.24. VOA compounds detected in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Groundwater	VOA	720028WA090	91	91	cis-1,2-Dichloroethene	5.000 *	J	?	
			91	91	trans-1,2-Dichloroethene	2.600	J	?	
			91	91	Trichloroethene	78.000 *		?	
		720028WA095	96	96	trans-1,2-Dichloroethene	3.000	J	?	
			96	96	Trichloroethene	71.000 *		?	
		720028WD090	91	91	cis-1,2-Dichloroethene	5.000 *		?	
			91	91	trans-1,2-Dichloroethene	3.000	J	?	
			91	91	Trichloroethene	78.000 *		?	
		720029WA060	61	61	Trichloroethene	0.050	J	?	BH-NE
		720029WA065	66	66	Trichloroethene	0.060	J	?	
		720029WA080	81	81	1,1-Dichloroethene	5.800 *	J	?	
			81	81	Tetrachloroethene	2.000 *	J	?	
			81	81	trans-1,2-Dichloroethene	0.100	J	?	
			81	81	Trichloroethene	39.000 *		?	
		720029WA085	86	86	1,1-Dichloroethene	1.500 *	J	?	
			86	86	trans-1,2-Dichloroethene	0.200	J	?	
			86	86	Trichloroethene	24.000 *		?	

* Result exceeds PRG screening values

Table 4.24. VOA compounds detected in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
			Top	Bottom					
Groundwater	VOA	720029WA090	91	91	1,1-Dichloroethene	1.900 *	J	?	
			91	91	trans-1,2-Dichloroethene	0.300	J	?	
			91	91	Trichloroethene	33.000 *		?	
		720029WA095	96	96	1,1-Dichloroethene	2.200 *	J	?	
			96	96	trans-1,2-Dichloroethene	0.400	J	?	
			96	96	Trichloroethene	34.000 *		?	
		720029WD065	66	66	Trichloroethene	0.060	J	?	
		720029WD095	96	96	1,1-Dichloroethene	1.700 *	J	?	
			96	96	trans-1,2-Dichloroethene	0.300	J	?	
			96	96	Trichloroethene	27.000 *		?	

Note: RGA groundwater samples not containing any detectable VOA compounds are:
001181WA055 001181WA060 001181WA065 001184WA060 001184WA065 720013WA065 720028WA070

*** Result exceeds PRG screening values**

Table 4.25. Metals detected above BG in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (mg/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/L)
Groundwater	METAL-D	001175WA065	67	67	Manganese	1.37000*		?		0.16000
		001176WA060	62	62	Calcium	49.20000*		?		44.00000
			62	62	Magnesium	19.10000*		?		17.00000
			62	62	Manganese	0.30000*		?		0.16000
		001176WA065	67	67	Manganese	0.40000*		?		0.16000
		001176WA070	72	72	Sodium	70.60000*		?		60.00000
		001176WA075	77	77	Manganese	1.51000*		?		0.16000
		001176WA080	82	82	Manganese	0.38000*		?		0.16000
		001176WD080	82	82	Manganese	0.32000*		?		0.16000
		001177WA065	67	67	Manganese	0.26000*		?		0.16000
		001177WA090	92	92	Manganese	2.07000*		?		0.16000
		001177WA095	97	97	Manganese	0.23000*		?		0.16000
		001177WA100	102	102	Manganese	0.50000*		?		0.16000
		001177WD080	82	82	Manganese	1.18000*		?		0.16000
		001180WA060	62	62	Calcium	89.30000*		?		44.00000
			62	62	Magnesium	37.80000*		?		17.00000
			62	62	Manganese	0.95000*		?		0.16000

* Result exceeds PRG screening values

Table 4.25. Metals detected above BG in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/L)
			Top	Bottom						
Groundwater	METAL-D	001180WA065	67	67	Manganese	1.84000*		?		0.16000
		001181WA080	82	82	Manganese	0.55000*		?		0.16000
		001181WA085	87	87	Manganese	0.54000*		?		0.16000
		001181WD080	82	82	Manganese	0.57000*		?		0.16000
		001182WA070	72	72	Manganese	0.66000*		?		0.16000
		001182WD070	72	72	Manganese	0.65000*		?		0.16000
		001183WA070	72	72	Manganese	1.12000*		?		0.16000
		001183WA075	77	77	Manganese	1.87000*		?		0.16000
		001183WA080	82	82	Manganese	0.78000*		?		0.16000
		001183WA085	87	87	Manganese	0.22000*		?		0.16000
		001183WA090	92	92	Manganese	0.30000*		?		0.16000
		001183WA095	97	97	Manganese	0.53000*		?		0.16000
		001183WD075	77	77	Manganese	1.25000*		?		0.16000
		001184WA055	57	57	Manganese	1.19000*		?		0.16000
		001184WA060	62	62	Manganese	0.84000*		?		0.16000
		001184WA065	67	67	Manganese	0.93000*		?		0.16000
		001184WA070	72	72	Manganese	0.92000*		?		0.16000

* Result exceeds PRG screening values

Table 4.25. Metals detected above BG in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/L)
			Top	Bottom						
Groundwater	METAL-D	001184WA075	77	77	Manganese	1.13000*		?		0.16000
		001184WA080	82	82	Manganese	1.17000*		?		0.16000
		001184WA085	87	87	Manganese	0.37000*		?		0.16000
		001184WD080	82	82	Manganese	1.08000*		?		0.16000
		091001WA085	85	86	Manganese	4.33000*		?		0.16000
		091001WD085	85	86	Barium	0.71000*		?		0.29000
			85	86	Iron	11.80000*		?		5.10000
			85	86	Manganese	6.88000*		?		0.16000
		091002WA085	83.5	84.5	Manganese	0.37000*		?		0.16000
		091002WD085	83.5	84.5	Manganese	0.38000*		?		0.16000
		720011WA060	57.5	57.5	Manganese	0.55000*		?	BH-LAB	0.16000
			57.5	57.5	Sodium	161.00000*		?		60.00000
		720011WA080	77.5	77.5	Manganese	0.29000*		?	BH-LAB	0.16000
		720011WA085	82.5	82.5	Manganese	0.67000*		?	BH-LAB	0.16000
			82.5	82.5	Zinc	0.08000		?	BH-LAB	0.02700
		720011WA090	87.5	87.5	Iron	11.60000*		?		5.10000
			87.5	87.5	Zinc	0.03000		?		0.02700

* Result exceeds PRG screening values

Table 4.25. Metals detected above BG in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/L)
			Top	Bottom						
Groundwater	METAL-D	720011WA100	97.5	97.5	Iron	15.70000 *		?		5.10000
			97.5	97.5	Manganese	1.21000 *		?		0.16000
			97.5	97.5	Zinc	0.05000		?		0.02700
		720013WA070	72	72	Manganese	1.28000 *		?		0.16000
		720013WA075	77	77	Barium	0.74000 *		?		0.29000
			77	77	Cobalt	0.14000 *		?		0.09600
			77	77	Manganese	4.05000 *		?		0.16000
		720013WA080	82	82	Iron	6.86000 *		?		5.10000
			82	82	Manganese	1.12000 *		?		0.16000
		720013WA085	87	87	Barium	0.33000 *		?		0.29000
			87	87	Manganese	3.32000 *		?		0.16000
		720013WA090	92	92	Iron	5.83000 *		?		5.10000
			92	92	Manganese	2.04000 *		?		0.16000
		720017WA075	76	76	Barium	0.38000 *		?		0.29000
			76	76	Iron	8.95000 *		?		5.10000
			76	76	Manganese	1.31000 *		?		0.16000
			76	76	Zinc	0.89000 *		?		0.02700

* Result exceeds PRG screening values

Table 4.25. Metals detected above BG in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/L)
			Top	Bottom						
Groundwater	METAL-D	720017WA080	81	81	Manganese	0.29000 *		?		0.16000
		720017WA085	86	86	Manganese	0.25000 *		?		0.16000
		720017WA090	91	91	Iron	5.13000 *		?		5.10000
			91	91	Manganese	0.40000 *		?		0.16000
			91	91	Zinc	0.91000 *		?		0.02700
		720017WA095	96	96	Manganese	2.29000 *		?		0.16000
		720019WA075	77	78	Iron	10.50000 *		?		5.10000
			77	78	Manganese	1.38000 *		?		0.16000
			77	78	Zinc	0.05000		?		0.02700
		720019WA080	82	83	Manganese	0.25000 *		?		0.16000
		720019WA085	87	88	Manganese	0.34000 *		?		0.16000
		720019WA090	92	93	Manganese	1.02000 *		?		0.16000
			92	93	Zinc	0.04000		?		0.02700
		720026WA080	82	82	Barium	0.30000 *		?		0.29000
			82	82	Manganese	0.82000 *		?		0.16000
		720026WA085	87	87	Barium	0.40000 *		?		0.29000
			87	87	Manganese	1.54000 *		?		0.16000

* Result exceeds PRG screening values

Table 4.25. Metals detected above BG in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/L)
			Top	Bottom						
Groundwater	METAL-D	720026WD085	87	87	Barium	0.40000*		?		0.29000
			87	87	Manganese	1.56000*		?		0.16000
		720028WA080	81	81	Barium	0.30000*		?		0.29000
			81	81	Manganese	0.18000*		?		0.16000
		720028WA085	86	86	Barium	0.45000*		?		0.29000
			86	86	Manganese	1.57000*		?		0.16000
		720028WA090	91	91	Barium	0.36000*		?		0.29000
			91	91	Manganese	1.09000*		?		0.16000
		720028WA095	96	96	Barium	0.31000*		?		0.29000
			96	96	Manganese	0.90000*		?		0.16000
		720028WD090	91	91	Barium	0.36000*		?		0.29000
			91	91	Manganese	1.12000*		?		0.16000
		720029WA060	61	61	Barium	0.47000*		?		0.29000
			61	61	Calcium	47.80000*		?		44.00000
			61	61	Magnesium	22.80000*		?		17.00000
		720029WA065	66	66	Barium	0.58000*		?		0.29000
			66	66	Calcium	51.20000*		?		44.00000

* Result exceeds PRG screening values

Table 4.25. Metals detected above BG in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/L)
			Top	Bottom						
Groundwater	METAL-D	720029WA065	66	66	Manganese	0.17000 *		?		0.16000
		720029WA090	91	91	Manganese	0.48000 *		?		0.16000
		720029WA095	96	96	Manganese	0.53000 *		?		0.16000
		720029WD065	66	66	Barium	0.54000 *		?		0.29000
			66	66	Calcium	48.10000 *		?		44.00000
			66	66	Magnesium	21.80000 *		?		17.00000
		720029WD095	96	96	Manganese	0.53000 *		?		0.16000

Note: RGA groundwater samples not containing any detectable metals at concentrations above background are:
001177WA085 001177WD085 001181WA075 001184WA090 720011WA075 720011WA095 720017WA070 720018WA085 720018WD085
720026WA090 720028WA070 720029WA080

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* Result exceeds PRG screening values

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Table 4.26. Radioactive isotopes detected above BG in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results** (pCi/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG** (pCi/L)
			Top	Bottom						
Groundwater	RADS	001175WA060	62	62	Technetium-99	2,420.000 *		?		0.000
			62	62	Uranium	0.008 *		?		0.000
		001175WA075	77	77	Uranium	0.001		?		0.000
		001175WA085	87	87	Uranium	0.001		?		0.000
		001175WA095	97	97	Uranium	0.004		?		0.000
		001175WA110	112	112	Uranium	0.001		?		0.000
		001175WD075	77	77	Uranium	0.001		?		0.000
		001176WA065	67	67	Technetium-99	33.300 *		?		0.000
			67	67	Uranium	0.002		?		0.000
		001176WA080	82	82	Uranium	0.001		?		0.000
		001176WA085	87	87	Uranium	0.002		?		0.000
		001176WD080	82	82	Uranium	0.006 *		?		0.000
		001177WA065	67	67	Technetium-99	18.000		?		0.000
			67	67	Uranium	0.030 *	X	?		0.000
		001177WA080	82	82	Uranium	0.001		?		0.000
		001177WA085	87	87	Uranium	0.001		?		0.000
		001177WA090	92	92	Uranium	0.002		?		0.000

* Result exceeds PRG screening values

** Results and background values for Uranium given in mg/L

Table 4.26. Radioactive isotopes detected above BG in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results** (pCi/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG** (pCi/L)
			Top	Bottom						
Groundwater	RADS	001177WA100	102	102	Technetium-99	20.000		?		0.000
			102	102	Uranium	0.002		?		0.000
		001177WD080	82	82	Uranium	0.001		?		0.000
		001177WD085	87	87	Uranium	0.001		?		0.000
		001178WA065	67	67	Uranium	0.006*		?		0.000
		001178WA085	87	87	Uranium	0.002		?		0.000
		001178WA090	92	92	Uranium	0.005*		?		0.000
		001178WD090	92	92	Uranium	0.006*		?		0.000
		001180WA070	72	72	Uranium	0.001		?		0.000
		001180WA080	82	82	Technetium-99	288.900*		?		0.000
			82	82	Uranium	0.002		?		0.000
		001180WA085	87	87	Cesium-137	20.000*		?		0.000
			87	87	Technetium-99	106.500*		?		0.000
			87	87	Uranium	0.001		?		0.000
		001180WA100	102	102	Uranium	0.001		?		0.000
		001180WD070	72	72	Uranium	0.001		?		0.000
		001181WA055	57	57	Uranium	0.120*		?		0.000

* Result exceeds PRG screening values

** Results and background values for Uranium given in mg/L

Table 4.26. Radioactive isotopes detected above BG in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results** (pCi/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG** (pCi/L)
Groundwater	RADS	001181WA060	62	62	Uranium	0.006*		?		0.000
		001181WA065	67	67	Uranium	0.001		?		0.000
		001181WA080	82	82	Uranium	0.002		?		0.000
		001181WD080	82	82	Uranium	0.001		?		0.000
		001182WA070	72	72	Uranium	0.001		?		0.000
		001182WA075	77	77	Technetium-99	597.200*		?		0.000
			77	77	Uranium	0.001		?		0.000
		001182WA080	82	82	Technetium-99	3,709.600*		?		0.000
			82	82	Uranium	0.001		?		0.000
		001182WA085	87	87	Technetium-99	1,029.600*		?		0.000
			87	87	Uranium	0.002		?		0.000
		001182WA090	92	92	Technetium-99	225.500*		?		0.000
			92	92	Uranium	0.001		?		0.000
		001182WD070	72	72	Technetium-99	30.000*		?		0.000
			72	72	Uranium	0.001		?		0.000
		001183WA070	72	72	Technetium-99	494.500*		?		0.000
			72	72	Uranium	0.002		?		0.000

* Result exceeds PRG screening values

** Results and background values for Uranium given in mg/L

Table 4.26. Radioactive isotopes detected above BG in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results** (pCi/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG** (pCi/L)
Groundwater	RADS	001183WA075	77	77	Technetium-99	575.100*		?		0.000
			77	77	Uranium	0.001		?		0.000
		001183WA080	82	82	Technetium-99	334.700*		?		0.000
			82	82	Uranium	0.004		?		0.000
		001183WD075	77	77	Technetium-99	613.700*		?		0.000
			77	77	Uranium	0.001		?		0.000
		001184WA055	57	57	Uranium	0.100*		?		0.000
		001184WA060	62	62	Uranium	0.030*	X	?		0.000
		001184WA085	87	87	Technetium-99	2,470.300*		?		0.000
			87	87	Uranium	0.001	X	?		0.000
		001184WA090	92	92	Technetium-99	1,851.700*		?		0.000
			92	92	Uranium	0.001	X	?		0.000
		001184WA100	102	102	Uranium	0.001	X	?		0.000
		001184WD080	82	82	Technetium-99	1,692.300*		?		0.000
			82	82	Uranium	0.001	X	?		0.000
		091001WA070	70	71	Technetium-99	354.700*		?		0.000
			70	71	Thorium-230	4.730*		?		1.400

* Result exceeds PRG screening values

** Results and background values for Uranium given in mg/L

Table 4.26. Radioactive isotopes detected above BG in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results** (pCi/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG** (pCi/L)
Groundwater	RADS	091001WA070	70	71	Uranium	0.020*		?		0.000
		091001WA075	75	76	Technetium-99	568.100*		?		0.000
			75	76	Uranium	0.003		?		0.000
		091001WA085	85	86	Technetium-99	38.000*		?		0.000
			85	86	Uranium	0.005*		?		0.000
		091001WD085	85	86	Technetium-99	41.200*		?		0.000
			85	86	Uranium	0.005*		?		0.000
		091002WA070	68.5	69.5	Uranium	0.010*		?		0.000
		091002WA075	73.5	74.5	Technetium-99	37.400*		?		0.000
			73.5	74.5	Uranium	0.002		?		0.000
		091002WA085	83.5	84.5	Technetium-99	18.500		?		0.000
			83.5	84.5	Uranium	0.001		?		0.000
		091002WA090	88.8	89.5	Thorium-230	3.990*		?		1.400
			88.8	89.5	Uranium	0.010*		?		0.000
		091002WA095	93.5	94.5	Thorium-230	3.820*		?		1.400
			93.5	94.5	Uranium	0.004		?		0.000
		091002WD085	83.5	84.5	Uranium	0.002		?		0.000

* Result exceeds PRG screening values

** Results and background values for Uranium given in mg/L

Table 4.26. Radioactive isotopes detected above BG in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results** (pCi/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG** (pCi/L)
Groundwater	RADS	720010WA055	56	56	Uranium	0.010*		?		0.000
		720010WA065	66	66	Technetium-99	19.400		?		0.000
			66	66	Uranium	0.002		?		0.000
		720010WA085	86	86	Technetium-99	151.100*		?		0.000
			86	86	Uranium	0.001		?		0.000
		720010WA090	91	91	Technetium-99	101.400*		?		0.000
			91	91	Uranium	0.001		?		0.000
		720010WD065	66	66	Plutonium-239/240	3.790*		?		0.000
			66	66	Technetium-99	23.100		?		0.000
			66	66	Thorium-230	8.600*		?		1.400
			66	66	Uranium	0.002		?		0.000
		720011WA060	57.5	57.5	Technetium-99	35.200*		?		0.000
			57.5	57.5	Uranium	0.007*		?		0.000
		720011WA075	72.5	72.5	Uranium	0.001		?		0.000
		720011WA085	82.5	82.5	Technetium-99	134.300*		?		0.000
			82.5	82.5	Uranium	0.002		?		0.000
		720011WA090	87.5	87.5	Technetium-99	243.300*		?		0.000

* Result exceeds PRG screening values

** Results and background values for Uranium given in mg/L

Table 4.26. Radioactive isotopes detected above BG in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results** (pCi/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG** (pCi/L)
Groundwater	RADS	720011WA090	87.5	87.5	Uranium	0.001		?		0.000
		720013WA080	82	82	Technetium-99	51.700*		?		0.000
			82	82	Uranium	0.001		?		0.000
		720013WA085	87	87	Technetium-99	38.600*		?		0.000
			87	87	Uranium	0.001		?		0.000
		720014WA070	68	68	Plutonium-239/240	1.550*		?		0.000
			68	68	Uranium	0.005*		?		0.000
		720014WA085	83	83	Technetium-99	27.600		?		0.000
			83	83	Uranium	0.002		?		0.000
		720014WD070	68	68	Thorium-230	2.690*		?		1.400
			68	68	Uranium	0.003		?		0.000
		720015WA075	77	78	Uranium	0.001		?		0.000
		720016WA075	75	75	Uranium	0.010*		?		0.000
		720016WA080	80	80	Thorium-230	4.410*		?		1.400
			80	80	Uranium	0.009*		?		0.000
		720016WD080	80	80	Thorium-230	4.340*		?		1.400
			80	80	Uranium	0.009*		?		0.000

* Result exceeds PRG screening values

** Results and background values for Uranium given in mg/L

Table 4.26. Radioactive isotopes detected above BG in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results** (pCi/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG** (pCi/L)
Groundwater	RADS	720017WA070	71	71	Uranium	0.009 *		?		0.000
		720017WA080	81	81	Technetium-99	81.300 *		?		0.000
			81	81	Uranium	0.001		?		0.000
		720017WA085	86	86	Technetium-99	109.700 *		?		0.000
			86	86	Uranium	0.001		?		0.000
		720017WA090	91	91	Technetium-99	105.500 *		?		0.000
			91	91	Uranium	0.001		?		0.000
		720017WA095	96	96	Technetium-99	78.900 *		?		0.000
			96	96	Uranium	0.001		?		0.000
		720018WA065	66	66	Technetium-99	551.900 *		?		0.000
			66	66	Uranium	0.007 *		?		0.000
		720018WA070	71	71	Technetium-99	285.800 *		?		0.000
			71	71	Uranium	0.009 *		?		0.000
		720018WA080	81	81	Technetium-99	98.800 *		?		0.000
			81	81	Uranium	0.001		?		0.000
		720018WA085	86	86	Technetium-99	71.900 *		?		0.000
			86	86	Uranium	0.001		?		0.000

* Result exceeds PRG screening values

** Results and background values for Uranium given in mg/L

Table 4.26. Radioactive isotopes detected above BG in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results** (pCi/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG** (pCi/L)
			Top	Bottom						
Groundwater	RADS	720018WD085	86	86	Technetium-99	85.300*		?		0.000
			86	86	Uranium	0.001		?		0.000
		720019WA075	77	78	Uranium	0.001		?		0.000
		720019WA085	87	88	Uranium	0.001		?		0.000
		720019WA090	92	93	Uranium	0.001		?		0.000
		720026WA070	71	71	Uranium	0.001		?		0.000
		720026WA085	87	87	Technetium-99	76.600*		?		0.000
			87	87	Uranium	0.001		?		0.000
		720026WA090	92	92	Technetium-99	92.200*		?		0.000
			92	92	Uranium	0.001		?		0.000
		720026WD085	87	87	Technetium-99	72.000*		?		0.000
			87	87	Uranium	0.001		?		0.000
		720028WA070	71	71	Plutonium-239/240	2.190*		?		0.000
			71	71	Uranium	0.020*		?		0.000
		720028WA090	91	91	Uranium	0.001		?		0.000
		720028WD090	91	91	Uranium	0.001		?		0.000
		720029WA065	66	66	Uranium	0.005*		?		0.000

* Result exceeds PRG screening values

** Results and background values for Uranium given in mg/L

Table 4.26. Radioactive isotopes detected above BG in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results** (pCi/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG** (pCi/L)
			Top	Bottom						
Groundwater	RADS	720029WA080	81	81	Technetium-99	525.300*		?		0.000
			81	81	Uranium	0.001		?		0.000
		720029WA090	91	91	Technetium-99	157.400*		?		0.000
			91	91	Uranium	0.001		?		0.000
		720029WA095	96	96	Technetium-99	69.000*		?		0.000
			96	96	Uranium	0.005*		?		0.000
		720029WD065	66	66	Thorium-230	37.580*		?		1.400
			66	66	Uranium	0.006*		?		0.000
		720029WD095	96	96	Technetium-99	85.000*		?		0.000
			96	96	Uranium	0.002		?		0.000
	RADS-D	001175WA060	62	62	Uranium	0.001		?		0.000
		001175WA095	97	97	Uranium	0.001		?		0.000
		001175WA110	112	112	Uranium	0.001		?		0.000
		001176WA065	67	67	Uranium	0.001		?		0.000
		001176WA080	82	82	Uranium	0.001		?		0.000
		001176WA085	87	87	Uranium	0.001		?		0.000
		001176WD080	82	82	Uranium	0.001		?		0.000

* Result exceeds PRG screening values

** Results and background values for Uranium given in mg/L

Table 4.26. Radioactive isotopes detected above BG in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results** (pCi/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG** (pCi/L)
			Top	Bottom						
Groundwater	RADS-D	001177WA065	67	67	Uranium	0.001		?		0.000
		001177WA090	92	92	Uranium	0.001		?		0.000
		001177WA100	102	102	Uranium	0.001		?		0.000
		001178WA065	67	67	Uranium	0.001		?		0.000
		001178WA085	87	87	Uranium	0.001		?		0.000
		001178WA090	92	92	Uranium	0.001		?		0.000
		001178WD090	92	92	Uranium	0.001		?		0.000
		001180WA080	82	82	Uranium	0.001		?		0.000
		001181WA055	57	57	Uranium	0.001		?		0.000
		001181WA060	62	62	Uranium	0.001		?		0.000
		001181WA080	82	82	Uranium	0.001		?		0.000
		001182WA085	87	87	Uranium	0.001		?		0.000
		001183WA070	72	72	Uranium	0.001		?		0.000
		001183WA075	77	77	Uranium	0.001		?		0.000
		001183WA080	82	82	Uranium	0.001		?		0.000
		001183WD075	77	77	Uranium	0.001		?		0.000
		001184WA055	57	57	Uranium	0.001		?		0.000

* Result exceeds PRG screening values

** Results and background values for Uranium given in mg/L

Table 4.26. Radioactive isotopes detected above BG in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results** (pCi/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG** (pCi/L)
Groundwater	RADS-D	001184WA060	62	62	Uranium	0.001		?		0.000
		001184WA100	102	102	Uranium	0.001		?		0.000
		091002WA070	68.5	69.5	Uranium	0.001		?		0.000
		091002WA075	73.5	74.5	Uranium	0.003		?		0.000
		091002WA085	83.5	84.5	Uranium	0.001		?		0.000
		091002WA090	88.8	89.5	Uranium	0.001		?		0.000
		091002WA095	93.5	94.5	Uranium	0.001		?		0.000
		091002WD085	83.5	84.5	Uranium	0.001		?		0.000
		720010WA055	56	56	Uranium	0.001		?		0.000
		720010WA065	66	66	Uranium	0.001		?		0.000
		720010WA090	91	91	Uranium	0.001		?		0.000
		720010WD065	66	66	Uranium	0.001		?		0.000
		720011WA060	57.5	57.5	Uranium	0.001		?		0.000
		720011WA085	82.5	82.5	Uranium	0.001		?		0.000
		720013WA085	87	87	Uranium	0.001		?		0.000
		720014WA070	68	68	Uranium	0.001		?		0.000
		720014WA085	83	83	Uranium	0.001		?		0.000

* Result exceeds PRG screening values

** Results and background values for Uranium given in mg/L

Table 4.26. Radioactive isotopes detected above BG in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results** (pCi/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG** (pCi/L)
			Top	Bottom						
Groundwater	RADS-D	720014WD070	68	68	Uranium	0.001		?		0.000
		720015WA075	77	78	Uranium	0.001		?		0.000
		720017WA070	71	71	Uranium	0.001		?		0.000
		720017WA095	96	96	Uranium	0.001		?		0.000
		720018WA065	66	66	Uranium	0.001		?		0.000
		720018WA070	71	71	Uranium	0.001		?		0.000
		720018WA080	81	81	Uranium	0.001		?		0.000
		720026WA085	87	87	Uranium	0.001		?		0.000
		720028WA070	71	71	Uranium	0.001		?		0.000
		720028WA090	91	91	Uranium	0.001		?		0.000
		720029WA065	66	66	Uranium	0.001		?		0.000
		720029WA095	96	96	Uranium	0.001		?		0.000
		720029WD065	66	66	Uranium	0.001		?		0.000
		720029WD095	96	96	Uranium	0.001		?		0.000

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* Result exceeds PRG screening values

** Results and background values for Uranium given in mg/L

Table 4.26. Radioactive isotopes detected above BG in RGA groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results** (pCi/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG** (pCi/L)
			Top	Bottom						

Note: RGA groundwater samples not containing any detectable radioactive isotopes at concentrations above background are:

001175WA065 001175WA070 001175WA080 001175WA090 001175WA100 001175WA105 001176WA060 001176WA070 001176WA075
001176WA090 001176WA095 001177WA070 001177WA075 001177WA095 001178WA060 001178WA070 001178WA075 001178WA080
001178WA095 001178WA100 001180WA060 001180WA065 001180WA075 001180WA090 001180WA095 001181WA075 001181WA085
001181WA090 001181WA095 001181WA100 001182WA095 001183WA085 001183WA090 001183WA095 001184WA065 001184WA070
001184WA075 001184WA080 001184WA095 091001WA065 091001WA080 091001WA090 091001WA095 091001WA100 091001WA105
091002WA065 720010WA070 720010WA075 720010WA080 720011WA070 720011WA080 720011WA095 720011WA100 720012WA070
720012WA075 720012WA080 720012WA085 720013WA070 720013WA075 720013WA090 720014WA075 720014WA080 720014WA090
720015WA065 720015WA070 720015WA080 720015WA085 720015WA090 720016WA065 720016WA070 720016WA085 720016WA090
720016WA095 720017WA060 720017WA065 720017WA075 720018WA075 720018WA090 720019WA080 720026WA080 720028WA080
720028WA085 720028WA095 720029WA060 720029WA085

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* Result exceeds PRG screening values

** Results and background values for Uranium given in mg/L

Table 4.27. Frequency of detection of organic compounds, metals, and radioactive isotopes exceeding BG in RGA groundwater

Sample Type	Analytical Group	Analytical Compound	Number of Analyses [a]	Number of Detections above BG [a]	Number of Detections above BG & PRG Screening Values [a]	Maximum Result above BG [a]	Minimum Result above BG [a]	Average Result above BG [a]	Units
Groundwater	VOA	Trichloroethene	225	209	201	1,578.000	0.050	126.384	ug/L
		trans-1,2-Dichloroethene	225	108	24	25.000	0.050	3.141	ug/L
		1,1-Dichloroethene	225	68	68	54.000	0.040	8.248	ug/L
		cis-1,2-Dichloroethene	225	22	16	31.000	0.040	8.323	ug/L
		Vinyl chloride	225	18	18	17.000	0.060	1.366	ug/L
		Chloroform	37	3	3	3.200	2.100	2.733	ug/L
		Carbon tetrachloride	37	2	2	12.000	4.200	8.100	ug/L
		Tetrachloroethene	37	2	2	4.000	2.000	3.000	ug/L
		2-Propanol	37	1	1	540.000	540.000	540.000	ug/L
	Metals - dissolved	Manganese	83	67	67	6.880	0.170	1.082	mg/L
		Barium	83	15	15	0.740	0.300	0.442	mg/L
		Iron	83	8	8	15.700	5.130	9.546	mg/L
		Zinc	83	7	2	0.910	0.030	0.293	mg/L
		Calcium	83	5	5	89.300	47.800	57.120	mg/L
		Magnesium	83	4	4	37.800	19.100	25.375	mg/L
		Sodium	83	2	2	161.000	70.600	115.800	mg/L
		Cobalt	83	1	1	0.140	0.140	0.140	mg/L
	Radioactive isotopes	Uranium	101	101	28	0.120	0.001	0.006	mg/L
		Technetium-99	102	50	44	3,709.600	18.000	418.822	pCi/L
		Thorium-230	54	8	8	37.580	2.690	8.770	pCi/L
		Plutonium-239/240	54	3	3	3.790	1.550	2.510	pCi/L
		Cesium-137	54	1	1	20.000	20.000	20.000	pCi/L
	Radioactive isotopes - dissolved	Uranium	55	55	0	0.003	0.001	0.001	mg/L

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[a] Number of analyses/detections include both environmental samples and duplicate results

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Table 4.28. VOA compounds detected in McNairy groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
Groundwater	VOA	001176WA120	118	118	Trichloroethene	0.070	J	?	
		001177WA140	147	147	trans-1,2-Dichloroethene	0.100	J	?	
		001178WA120	117	117	2-Propanol	420.000*		?	
		001178WA140	152	152	Trichloroethene	0.100	J	?	BH-NE
		001181WA105	107	107	Trichloroethene	15.000*		?	
		001182WA120	128	128	Trichloroethene	0.100		?	
		001183WA100	102	102	Trichloroethene	5.000*		?	
		091002WA100	102	103	Trichloroethene	1.900*	J	?	
		091002WA120	122.4	123.4	cis-1,2-Dichloroethene	0.070	J	?	
			122.4	123.4	Trichloroethene	0.070	J	?	
		091002WA140	137	138	cis-1,2-Dichloroethene	0.060	J	?	
		720010WA095	96	96	Trichloroethene	7.500*		?	
			96	96	Vinyl chloride	0.100*	J	?	
		720010WA120	116	116	Vinyl chloride	0.200*	J	?	
		720012WA090	92	93	trans-1,2-Dichloroethene	1.000	J	?	
			92	93	Trichloroethene	12.000*		?	
		720014WA095	93	93	trans-1,2-Dichloroethene	1.800	J	?	

* Result exceeds PRG screening values

Table 4.28. VOA compounds detected in McNairy groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (ug/L)	Lab Qualifier	Validation Qualifier	Data Assessment
Groundwater	VOA	720014WA095	93	93	Trichloroethene	3.000*	J	?	
		720015WA120	120	122	cis-1,2-Dichloroethene	0.070	J	?	
			120	122	Trichloroethene	0.200*	J	?	
		720017WA120	116	116	Trichloroethene	0.400*	J	?	
		720019WA120	117	118	Trichloroethene	0.400*	J	?	
			117	118	Vinyl chloride	0.500*	J	?	
		720019WA140	137	138	Trichloroethene	0.100	J	?	
			137	138	Vinyl chloride	0.300*	J	?	
		720028WA100	101	101	Trichloroethene	0.200*	J	?	
		720029WA100	101	101	1,1-Dichloroethene	0.200*	J	?	
			101	101	trans-1,2-Dichloroethene	0.100	J	?	
			101	101	Trichloroethene	11.000*		?	

Note: McNairy groundwater samples not containing any detectable VOA compounds are:
001175WA120 001175WA140 001176WA140 001177WA105 001177WA120 001180WA105 001181WA120 001182WA140 001184WA120
001184WA140 091001WA120 720011WA120 720011WA140 720012WA120 720013WA120 720013WA140 720014WA120 720014WA140
720017WA140 720018WA120 720018WA140 720028WA120 720029WA120 720029WA140

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* Result exceeds PRG screening values

Table 4.29. Metals detected above BG in McNairy groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results (mg/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/L)
			Top	Bottom						
Groundwater	METAL-D	001177WA105	107	107	Manganese	1.14000*		?		0.16000
		001177WA120	127	127	Manganese	0.52000*		?		0.16000
		001177WA140	147	147	Manganese	0.49000*		?		0.16000
		001181WA120	127	127	Iron	10.10000*		?		5.10000
			127	127	Manganese	0.72000*		?		0.16000
		001183WA100	102	102	Manganese	0.74000*		?		0.16000
		720011WA120	117.5	117.5	Iron	10.00000*		?		5.10000
			117.5	117.5	Manganese	0.40000*		?		0.16000
		720011WA140	134.5	134.5	Iron	5.89000*		?		5.10000
			134.5	134.5	Manganese	0.46000*		?		0.16000
		720013WA120	117	117	Manganese	0.73000*		?		0.16000
		720013WA140	137	137	Barium	0.48000*		?		0.29000
			137	137	Calcium	54.10000*		?		44.00000
			137	137	Iron	8.44000*		?		5.10000
			137	137	Magnesium	19.00000*		?		17.00000
			137	137	Manganese	9.60000*		?		0.16000
			137	137	Vanadium	0.21000*		?		0.14000

* Result exceeds PRG screening values

Table 4.29. Metals detected above BG in McNairy groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results (mg/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG (mg/L)
Groundwater	METAL-D	720017WA120	116	116	Iron	13.60000 *		?		5.10000
			116	116	Manganese	0.71000 *		?		0.16000
		720017WA140	136	136	Iron	19.20000 *		?		5.10000
			136	136	Manganese	0.58000 *		?		0.16000
		720028WA120	116	116	Manganese	0.20000 *		?		0.16000
		720029WA100	101	101	Manganese	0.45000 *		?		0.16000
		720029WA120	121	121	Manganese	0.29000 *		?		0.16000
		720029WA140	136	136	Iron	5.23000 *		?		5.10000
			136	136	Manganese	0.45000 *		?		0.16000

Note: McNairy groundwater samples not containing any detectable metals at concentrations above background are:
720028WA100

*** Result exceeds PRG screening values**

Table 4.30. Radioactive isotopes detected above BG in McNairy groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results** (pCi/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG** (pCi/L)
			Top	Bottom						
Groundwater	RADS	001175WA140	141	141	Uranium	0.170 *		?		0.000
		001176WA140	138	138	Uranium	0.040 *		?		0.000
		001177WA140	147	147	Uranium	0.010 *		?		0.000
		001178WA120	117	117	Uranium	0.004		?		0.000
		001180WA105	107	107	Technetium-99	25.400		?		0.000
			107	107	Uranium	0.001		?		0.000
		001182WA140	137	137	Uranium	0.120 *		?		0.000
		001183WA100	102	102	Technetium-99	27.800		?		0.000
			102	102	Uranium	0.002		?		0.000
		001184WA120	127	127	Uranium	0.020 *		?		0.000
		091002WA100	102	103	Thorium-230	1.530 *		?		1.400
			102	103	Uranium	0.003		?		0.000
		091002WA120	122.4	123.4	Thorium-230	16.900 *		?		1.400
			122.4	123.4	Uranium	0.020 *		?		0.000
		091002WA140	137	138	Thorium-230	53.770 *		?		1.400
			137	138	Uranium	0.100 *		?		0.000
		720010WA095	96	96	Technetium-99	29.300 *		?		0.000

* Result exceeds PRG screening values

** Results and background values for Uranium given in mg/L

Table 4.30. Radioactive isotopes detected above BG in McNairy groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs) Top	Sample Interval (ft bgs) Bottom	Analytical Compound	Results** (pCi/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG** (pCi/L)
Groundwater	RADS	720010WA095	96	96	Uranium	0.002		?		0.000
		720011WA140	134.5	134.5	Uranium	0.003		?		0.000
		720012WA120	117	118	Uranium	0.020*		?		0.000
		720013WA120	117	117	Uranium	0.005*		?		0.000
		720013WA140	137	137	Uranium	0.030*		?		0.000
		720014WA095	93	93	Technetium-99	27.500		?		0.000
			93	93	Uranium	0.005*		?		0.000
		720018WA120	116	116	Uranium	0.002		?		0.000
		720019WA120	117	118	Uranium	0.001		?		0.000
		720028WA120	116	116	Uranium	0.020*		?		0.000
		720029WA140	136	136	Uranium	0.010*		?		0.000
	RADS-D	001175WA140	141	141	Uranium	0.001		?		0.000
		001176WA140	138	138	Uranium	0.001		?		0.000
		001177WA140	147	147	Uranium	0.001		?		0.000
		001178WA120	117	117	Uranium	0.001		?		0.000
		001182WA140	137	137	Uranium	0.001		?		0.000
		001183WA100	102	102	Uranium	0.001		?		0.000

* Result exceeds PRG screening values

** Results and background values for Uranium given in mg/L

Table 4.30. Radioactive isotopes detected above BG in McNairy groundwater

Sample Type	Analytical Group	Sample ID	Sample Interval (ft bgs)		Analytical Compound	Results** (pCi/L)	Lab Qualifier	Validation Qualifier	Data Assessment	BG** (pCi/L)
			Top	Bottom						
Groundwater	RADS-D	001184WA120	127	127	Uranium	0.001		?		0.000
		091002WA100	102	103	Uranium	0.001		?		0.000
		091002WA120	122.4	123.4	Uranium	0.001		?		0.000
		091002WA140	137	138	Uranium	0.001		?		0.000
		720010WA095	96	96	Uranium	0.001		?		0.000
		720011WA140	134.5	134.5	Uranium	0.001		?		0.000
		720012WA120	117	118	Uranium	0.001		?		0.000
		720013WA120	117	117	Uranium	0.001		?		0.000
		720013WA140	137	137	Uranium	0.001		?		0.000
		720014WA095	93	93	Uranium	0.001		?		0.000
		720018WA120	116	116	Uranium	0.001		?		0.000
		720019WA120	117	118	Uranium	0.001		?		0.000
		720028WA120	116	116	Uranium	0.001		?		0.000
		720029WA140	136	136	Uranium	0.001		?		0.000

Note: McNairy groundwater samples not containing any detectable radioactive isotopes at concentrations above background are:
001175WA120 001176WA120 001177WA105 001177WA120 001178WA140 001181WA105 001181WA120 001182WA120 001184WA140
091001WA120 720010WA120 720011WA120 720012WA090 720014WA120 720014WA140 720015WA120 720017WA120 720017WA140
720018WA140 720019WA140 720028WA100 720029WA100 720029WA120

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* Result exceeds PRG screening values

** Results and background values for Uranium given in mg/L

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Table 4.31. Frequency of detection of organic compounds, metals, and radioactive isotopes exceeding BG in McNairy groundwater

Sample Type	Analytical Group	Analytical Compound	Number of Analyses [a]	Number of Detections above BG [a]	Number of Detections above BG & PRG Screening Values [a]	Maximum Result above BG [a]	Minimum Result above BG [a]	Average Result above BG [a]	Units
Groundwater	VOA	Trichloroethene	50	16	11	15.000	0.070	3.565	ug/L
		trans-1,2-Dichloroethene	50	4	0	1.800	0.100	0.750	ug/L
		Vinyl chloride	50	4	4	0.500	0.100	0.275	ug/L
		cis-1,2-Dichloroethene	50	3	0	0.070	0.060	0.067	ug/L
		1,1-Dichloroethene	50	1	1	0.200	0.200	0.200	ug/L
		2-Propanol	6	1	1	420.000	420.000	420.000	ug/L
	Metals - dissolved	Manganese	16	15	15	9.600	0.200	1.165	mg/L
		Iron	16	7	7	19.200	5.230	10.351	mg/L
		Barium	16	1	1	0.480	0.480	0.480	mg/L
		Calcium	16	1	1	54.100	54.100	54.100	mg/L
		Magnesium	16	1	1	19.000	19.000	19.000	mg/L
		Vanadium	16	1	1	0.210	0.210	0.210	mg/L
	Radioactive isotopes	Uranium	21	21	13	0.170	0.001	0.028	mg/L
		Technetium-99	21	4	1	29.300	25.400	27.500	pCi/L
		Thorium-230	9	3	3	53.770	1.530	24.067	pCi/L
	Radioactive isotopes - dissolved	Uranium	20	20	0	0.001	0.001	0.001	mg/L

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[a] Number of analyses/detections include both environmental samples and duplicate results

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5. CONTAMINANT FATE AND TRANSPORT

5.1 INTRODUCTION

This section provides an overview of the release mechanisms, potential migration pathways, mechanisms for transport, and behavior of radiological and chemical substances reported in the four sites evaluated in this report, i. e., SWMUs 001, 091, and 196, and the C-720 Complex (which includes SWMU 167). The fate and transport of site-related contaminants are important in assessing the potential for exposure to these contaminants, as well as the potential changes in concentration or migration if no actions are taken. Risk management decisions are based in part on the following issues:

- Potential for direct contact with chemicals in surface soil and sediment
- Potential for residual constituents in soils to impact groundwater
- Potential for continued migration of groundwater contaminants to impact downgradient receptors

The potential risks associated with residuals in the environmental media relate to changes in concentration over time (persistence) and migration to downslope or downgradient areas.

Physical, chemical, and biological processes affect the nature and distribution of chemicals in the environment. Because WAG 27 is composed of four sites, migration is addressed for the entire WAG 27 area. Although in many instances the specific chemicals, sources, and concentrations differ across the four sites, physio-chemical and hydrogeologic conditions that affect the migration and fate of contaminants are similar.

This section presents the following:

- Overview of the conceptual site model, sources, and transport pathways for each site
- Chemical-specific discussions of common constituents at WAG 27, including the properties that influence migration
- Discussion of the soil leachability analysis

Computer-based contaminant fate and transport modeling analyses (leachability analysis) were performed to predict the maximum concentration of source-related COPCs at the site boundary based on the most current chemical data. These analyses indicate likely future contaminant concentrations at receptor locations via multiple media. The ultimate objectives of the analyses were to evaluate potential future impacts to human health and the environment and to provide a basis for evaluating the effectiveness of proposed remedial alternatives in the FS. Tc-99 was not modeled in the RGA at SWMU 001 because no source for the Tc-99 was identified at the SWMU in the overlying UCRS soils.

The principles of contaminant fate and transport analysis and the results of modeling activities are summarized in this section. Section 5.2 presents a conceptual model for potential contaminant migration pathways at WAG 27 that considers site topography, geology, hydrology, and site-related chemicals. Section 5.3 presents a discussion of the persistence of the contaminants in the environment and the physical and chemical properties of the site-related chemicals that were used in the fate and transport modeling. Contaminant release mechanisms and transport media are also described in this section. Chemical migration rates for the WAG 27 COCs are presented in Sect. 5.4. Section 5.5 presents a soil leachability analysis, including its application and underlying assumptions. A discussion of uncertainties associated with the modeling results is also presented in Sect. 5.5.

5.2 CONCEPTUAL SITE MODEL

The conceptual site model (CSM) developed for WAG 27 is a representation of known site conditions that serves as the framework for quantitative modeling. Site conditions described by the CSM include waste source information, the surrounding geologic and hydrologic conditions, site-related chemicals, and current spatial distribution of the site-related chemicals. This information is combined to identify the likely chemical migration pathways. See Sect. 4 for the conceptual model for each of the WAG 27 sites.

Potential source areas include a pit that contained a brine during one test period and a TCE-dry ice slurry during a second test period, a landfarm used to biodegrade waste oils, former septic systems, and a sump and floor drains used to dispose of chemicals. Releases from these sources would directly impact soils below or adjacent to the source and/or sediments and surface water in nearby drainages. Continuing transport processes may also result in secondary releases that may impact larger areas or affect additional environmental media. Transport processes likely to be active at the site include vertical infiltration in soil, lateral and vertical migration in groundwater, soil erosion and surface runoff, volatilization, and mobilization of dust particles.

The air pathway is not a viable exposure route; air monitoring during the field investigation indicates no impacts to on-site workers. Flow in the ditches that cross the WAG 27 SWMUs is intermittent based on seasonal rainfall. Surface water is not a viable exposure pathway for the site because all runoff from the site flows into surface ditches, the storm sewer system, and eventually into Outfalls 8, 9, and 15. The plant ditches are generally considered to be located in areas where the local groundwater table is below the bottoms of the ditches. Therefore, the ditches probably function as influent (losing) streams most of the time, resulting in some discharge to the subsurface. However, some sediment samples were collected to confirm that runoff is not a potential pathway for migration at these sites. Current data indicate no impacts to these surface waters. All these routes of surface-water contaminant migration ultimately discharge to Bayou Creek. A more detailed description of the air and surface-water pathways is presented in Appendix C of Vol. 3 (MEPAS Modeling).

Data were collected during the RI to characterize potential exposure pathways, including groundwater and surface and subsurface soil. Where data on source characteristics were lacking, sampling was also performed to evaluate the nature of the source. Based on this evaluation, a fate and transport model was developed and used to simulate vertical transport of contaminants from source areas to the UCRS and RGA (see Sect. 5.5). The simulations were used to establish maximum concentrations in the RGA at the property boundary and the risk associated with the simulated concentrations to potential receptors.

5.2.1 Contaminant Sources, Release Mechanisms, and Migration Pathways

In accordance with historical process knowledge and the findings of sampling and analysis performed at WAG 27, several contaminant sources have been identified. Detections of chemicals in soil and groundwater confirm the potential for media-specific chemical transport. The migration pathways discussed below by site appear to be the most viable exposure routes and include the potential for:

- Leaching of contaminants through soil to groundwater
- Migration of groundwater to downgradient receptors

The sources, release mechanisms, and pathways for migration are as follows:

- **SWMU 001.** The source of release is the landfarm that was used from 1973 to 1979 for the biodegradation of waste oils contaminated with TCE, 1,1,1-TCA, uranium, and PCBs. It is estimated that at least 5000 gal of waste oil was applied to the landfarm over the 6-year period; oil was added at 3- to 4-month intervals. The sources of the waste oils were not reported, but it is assumed the oils were from virtually all areas of the plant. Contaminants in the surface soil have, in the past, percolated into subsurface soil, ultimately contaminating groundwater.

- **SWMU 091.** PGDP conducted cylinder drop tests at SWMU 091. The tests were performed in late 1964 and early 1965 and in February 1979. The 1979 test used a TCE and dry-ice bath to chill one of the steel cylinders prior to testing. The cylinder was placed in a pit containing approximately 572 gal of TCE prior to the drop test.

  The source of contamination was the TCE pit, which no longer exists. The contents of the pit leaked into the subsurface soil, then percolated into the deeper zone, possibly reaching the saturated zone.

- **SWMU 196.** This SWMU consists of two abandoned septic systems that were operated from April 1956 to February 1980. Modifications to the facility included the addition of various sanitary waste operations and conversion of operations within the building to nickel and aluminum smelting. All floor drains have been removed. Current operations at the SWMU include storage of hazardous and PCB waste. According to a 1993 DOE/USEC facility transition report, there is a potential for heavy metal and radiological contamination in the septic systems.

  The sources of contamination for SWMU 196 are subsurface leaks from the tanks or drain fields and surface soil contamination from excavation of the lines feeding the leachfield. Contaminants in the surface soil percolate into subsurface soil and eventually into groundwater. Alternatively, contaminants in the surface soil are transported via runoff to surface water (i.e., ditches and creeks).

- **C-720 Complex.** The C-720 Building was built in 1953 and housed the Compressor Shop. Fluids drained from compressors in the shop were directed into the compressor trench, which is located to the west of the Compressor Shop pit. One floor drain located in the compressor trench drains by gravity from west to east into the Compressor Shop pit. The design of the Compressor Shop pit is such that if the sump pump located in the northwest portion of the pit fails and if liquid fills the sump to the height at which the subterranean drain discharges into the sump (3.5 ft above the bottom of the sump), the liquid will back up into the subterranean drain and (because of the construction of the drain system) will be released into the surrounding soil. There are no documented releases of this nature; therefore, no quantitative estimates are available. Based on practices performed in this area, the analytes of interest associated with these processes include SVOAs (from the fluid discharged from the compressors), TCE and its degradation products (degreasing agents), and metals and radionuclides (both released during the degreasing process).

The White Room (SWMU 167), which is located in the C-720 Building, was part of the process used to build and clean circuit boards. Waste solutions associated with printed circuit board operations were discharged to the sump, flushed through limestone to neutralize acids, and ultimately discharged to the building drainage system. Wastes associated with processes performed in this area include TCE, cyanide, gold, silver, tin, lead, and chromium. According to the SWMU Assessment Report (SAR) 167, the integrity of the sump has not been established and therefore the sump is considered a possible pathway for release. The sump is no longer in use, and the sludge in the sump was sampled during two separate events in 1992 to determine the potential health hazard that would exist if the sump were to remain unfilled. PCBs were detected in the sludge at concentrations ranging from 1.8 to 2.5 mg/L.

The C-720 building drainage system is a source of contamination. The major releases from this system are subsurface leaks from the subterranean drain located near the Compressor Shop pit, leaks from the White Room sump, and leaks and/or discharges from the major exit points of the stormwater system as it exits the building.

Contaminants in the subsurface soil percolate into deeper strata, ultimately contaminating groundwater.

5.2.2 Hydrologic Properties

A description of the site hydrogeology and hydrology is provided in Sect. 3. Stormwater runoff from WAG 27 is captured by the stormwater drainage system, consisting of sewers and ditches. Flow from the site is in a westerly direction, and the discharge points (Outfalls 8, 9, and 15) are located along Bayou Creek.

Three hydrogeologic units underlie PGDP and control the flow of groundwater and thus contaminant migration. These are, in descending order:

- UCRS: approximately 50 ft of discontinuous and variable interfingerings of sand, silt, clay, and gravel beneath an overlying loess deposits
- RGA: approximately 70 ft of gravel, sand, and silt deposits that overlie the McNairy Formation
- McNairy Formation: approximately 225 ft of a sandy silty confining clay

For modeling purposes, it was assumed that the UCRS is not perennially saturated. Instead, it was assumed that groundwater infiltrates and migrates downward to recharge the RGA. This is a conservative assumption because, if saturated conditions in UCRS were assumed, contaminant transport through it would have been further attenuated.

Computer simulations of vertical transport from the UCRS to the RGA and horizontal transport within the RGA to receptor locations were also performed. The results of these simulations are presented in Sect.5.4 and in Appendix C of Vol. 4.

5.2.2.1 Water Balance

A water balance is a means of quantitatively accounting for all of the components of the hydrologic cycle at a site. The components of a simple steady-state water balance model include: precipitation (P), evapotranspiration (ET), surface runoff (Sr), and groundwater recharge or deep percolation (Gr). The simple steady-state model is defined as follows:

$$P = ET + Sr + Gr$$

$$P - ET = Sr + Gr$$

The amount of rainfall that enters the surface runoff and groundwater recharge compartments (Sr + Gr) is the amount available to promote chemical migration away from a waste source. The annual average water balance estimates, derived primarily from the Geotrans (1992) model for PGDP, are:

- Evapotranspiration = 54% of total rainfall
- Surface runoff = 38% of total rainfall
- Groundwater recharge (percolation) = 8% of total rainfall; a small amount of which (7% of the recharged water) flows laterally through the top portion of surface soil and is discharged to the surface-water drainage system prior to reaching the saturated zone. For this analysis, the saturated zone is the UCRS.

A past study (Geotrans 1992) has suggested that as much as 93% of the recharge to the UCRS may flow downward to recharge the RGA.

5.2.3 Site-related Chemicals

Site-related chemicals for WAG 27 are identified in Sect.4. These chemicals were detected frequently and at elevated concentrations in various environmental media. It is important to note that all waste-source chemicals that were detected at least once (above screening criteria) are addressed in the quantitative fate and transport modeling. The primary site-related chemicals are:

- VOAs, including TCE and its degradation products (cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride), and carbon tetrachloride
- Tc-99, Cs-137, Np-237, Pu-239, Th-230, and uranium and its decay products U-234, U-235, and U-238
- Fourteen metals: arsenic, barium, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, thallium, and vanadium
- PCBs
- SVOAs, including bis2(ethylhexyl)phthlate, 4-chloro-3-methylphenol, and di-n-octylphthlate

5.3 CHEMICAL PROPERTIES

The physical and chemical properties of the primary chemicals reported at WAG 27 that affect contaminant migration are presented in Tables 5.1 through 5.3. Organic and inorganic chemicals with high solubilities are more mobile in water than those that sorb more strongly to soils. Henry's Law constants are a measure of the partitioning of a chemical between the air phase and water phase. Because of the abundance of water in the environment, this property is best used to estimate the tendency to volatilize.

The following are properties that must be measured when identifying a compound's mobility within a specific medium:

- K_{oc}, the soil organic carbon partition coefficient, is a measure of the tendency for organic compounds to be adsorbed to the organic matter of soil and sediments. K_{oc} is expressed as the ratio of the amount of chemical adsorbed per unit weight of organic carbon to the chemical concentration in solution at equilibrium.
- K_{ow}, the octanol-water partition coefficient, is an indicator of hydrophobicity (the tendency of a chemical to avoid the aqueous phase) and is correlated with potential adsorption to soils. It is also used to estimate the potential for bioconcentration of chemicals into tissues.
- K_d, the soil/water partition coefficient, is a measure of the tendency of a chemical to adsorb to soil or sediment particles. For organic compounds, this coefficient is calculated as the product of the K_{oc} value and the fraction of organic carbon in the soils. In general, chemicals with higher K_d values sorb more strongly to soil/sediment particles and are less mobile than those with lower K_d values.

Chemical distributions in both soil and water are more difficult to predict for metals than for organic compounds. A direct relationship between the measured total metal concentration in soil and the extractable aqueous concentration cannot be assumed. The metal may be fixed in the interior of the soil and unavailable for exchange or release to water, or exchangeable metal may be present at the surface of the particles.

Published K_d values generally represent the potential relationship between water and exchangeable metal at the surface of the soil, which is as follows:

$$C_{total} = C_{fixed} + C_{adsorbed}$$
$$K_d = C_{adsorbed}/C_{water}$$

where

C_{total} = total concentration of metal (fixed plus adsorbed)
C_{fixed} = fixed concentration of metal (contained within the chemical structure of the minerals)
$C_{adsorbed}$ = adsorbed concentration of metal
C_{water} = concentration of metal in water

This relationship is useful in determining retardation (the tendency for the metal to sorb to the surface of the soil), but it does not relate the total metal concentration in the solid to a dissolved concentration.

5.3.1 PAHs/PCBs

PAHs are common components of fuel oils and tar mixtures. Fuel use, vehicular traffic, and asphalt surfaces can contribute to detected levels of PAHs. PAHs are relatively persistent and represent a broad class of compounds ranging from low molecular weight components (such as naphthalene) to high molecular weight compounds [such as dibenzo(a,h)anthracene]. Solubility, volatility, biodegradability, and toxicity vary widely across this class of compounds.

Volatility, as indicated by the Henry's Law constant, decreases as the molecular weight of PAHs increases. Particulate emissions to ambient air can result from adsorption onto soot particles that can be carried on wind currents and then returned to the surface (dry deposition). High molecular weight PAHs are more likely to be transported via particulate emissions, whereas low molecular weight PAHs have a higher tendency to volatilize.

The behavior of PAHs in tar and oil waste mixtures is determined to a large extent by the mobility and behavior of the waste itself. For example, as tar waste weathers, volatilization, degradation, and leaching of the more mobile constituents occur. The overall loss rate decreases exponentially over time, and the material left behind becomes richer in more viscous and persistent components. Therefore, low molecular weight PAHs can migrate from spills and continuous releases of tars and oils; however, as weathering occurs, the rate of release decreases. Higher molecular weight PAHs would persist in the vicinity of the original release.

Lower molecular weight PAHs have higher water solubilities and are more likely to be released into groundwater than higher weight molecular weight PAH compounds. The higher molecular weight PAHs have relatively high K_{oc} values, indicating an increased tendency for adsorption to soil or other organic matter. A primary fate and transport mechanism is the migration of adsorbed PAHs with mobile soil and sediment. The erosion of soil and movement of suspended sediments may result in PAH migration to surface water. However, the low solubility of adsorbed PAHs indicates that they would not partition significantly to water. Most PAHs in aquatic environments are associated with particulate materials. Only about 33% are present in dissolved form (SAIC 1998).

Photolysis, oxidation, and biodegradation are common attenuation mechanisms for PAH compounds. Although all PAHs transform in the presence of light via photolysis, their transformation rates are highly variable. Photolysis may reduce the concentrations of these chemicals in surface waters or surface soils, but is not relevant for subsurface soils. Biodegradation rates of PAHs in soils are also extremely variable across the chemical class. Generally, the dicyclic and tricyclic PAHs biodegrade more readily than the higher molecular weight PAHs. Factors that affect the rate of biodegradation in soils include the types of microorganisms present, the availability of nutrients, the presence of oxygen, and the chemical concentration. The extent to which chemicals may biodegrade also can be affected by their presence in mixtures. Some PAHs are more degradable than others. If both stable and mobile PAHs are present in a mixture, the less degradable materials may be co-metabolized at rates similar to or greater than the rates of the more degradable compounds.

In general, PAHs are not mobile in soil or groundwater. Model simulations of solute transport of PAHs in soil (Clausen 1996) and their physical properties (Table 5.1) indicate limited migration potential (Table 5.2). The distributions of PAHs and PCBs are not widespread; these compounds are limited to the shallow subsurface soils, and none were detected in the groundwater. The majority of the PAHs were detected at SWMU 001; however, none at

SWMU 001 were detected above PRGs or background concentrations. The only PAHs detected above PRGs or background concentrations were those reported in soil at the C-720 Complex.

5.3.2 Chlorinated VOAs

Chlorinated VOAs were detected at SWMU 001, SWMU 091, and C-720. These are related to the use of solvents such as TCE, PCE, or 1,1,1-TCA, which are typically used for degreasing activities, and in the case of SWMU 091 the brine and TCE-dry ice slurry used to submerge the steel cylinders. In addition to these solvents, common degradation products were detected, including 1,2-DCE (related to the degradation of PCE or TCE), 1,1-DCE, and 1,1-DCA (related to the degradation of 1,1,1-TCA).

The nature of the release is considered in interpreting constituent patterns. When releases are associated with aqueous discharges that contain trace amounts of solvents, migration is associated with the behavior of the aqueous phase. In some instances, the organic solvent itself could be spilled or released, in which case the migration of the organic phase must be considered. The presence of a solvent phase is generally suspected only when high concentrations of chlorinated VOAs are reported. These constituents were reported at various sites at levels that typically ranged from trace amounts to values as high as 1,578 µg/L. At SWMU 001 and the C-720 Complex, maximum concentrations of TCE exceeded 1,578 and 1,262 µg/L, respectively. EPA (1991b) suggests that a groundwater concentration equal to 1% effective solubility (TCE = 11,000 µg/L) is a good indicator of DNAPL. Therefore, the implications of a solvent phase would not be relevant. However, historical data indicate that TCE was detected in MW-160 at 94,000 ug/L at SWMU 091 (September 14, 1993) and in MW-161 in excess of 23,000 ug/L at SWMU 001 (May 8, 1995). Furthermore, the 15-ft bgs soil sample in boring 001-165 had a TCE concentration of 439,000 ug/L. This level exceeds the TCE DNAPL indicator concentration of 225,000 ug/L, determined from tests performed at SWMU 091 (LMES 1997). Overall, the levels of TCE in groundwater at SWMU 001 and the C-720 Complex have declined over the past 3 years, as indicated by the most recent data. Dispersion, diffusion, and degradation have contributed to the observed trend.

These chemicals have high vapor pressures and Henry's Law constants, indicating a potential for volatilization. Therefore, they are not expected to persist in surface soils. The rate of loss from volatilization depends on the compound, temperature, soil gas permeability, and chemical-specific vapor pressure.

Release and transport mechanisms include vertical migration through unsaturated soils toward the water table. The range of K_{oc} values indicates that chlorinated VOAs are mobile through soils and tend not to partition significantly from water to soil. As these compounds migrate through soil, some are retained in the pore spaces. Some VOAs may spread across layers of lower permeability. Lateral migration may occur if a low-permeability zone (or higher permeability zone) is reached, in which case the non-aqueous phase liquids (NAPLs) will migrate, depending in part on the contours of the layer surface. Generally, the flow is predominantly vertical through more permeable zones, such as those formed by sandy materials.

Biodegradation and chemical degradation are important considerations in evaluating chlorinated solvents because of the potential formation of chemicals of potential concern (COPCs) and/or losses of COPCs. The redox conditions in the RGA appear to be somewhat variable; however, the groundwater chemistry indicates that only limited anaerobic degradation is occurring.

Aerobic and anaerobic biodegradation are important transformation processes for chlorinated aliphatic compounds in natural water systems and soil. Considerable research has been done on the degradation mechanisms and pathways for this class of compounds. Although several degradation pathways could occur for these constituents, the patterns described below have been identified for degradation under anaerobic conditions. The anaerobic degradation pathway is as follows:

PCE-------> TCE-------> DCE------> vinyl chloride or chloroethane

The anaerobic biodegradation of TCE, which initially forms cis-1,2-DCE, occurs under reducing conditions where sulfide- and/or methane-producing conditions exist. Such conditions occur primarily in the presence of other natural or anthropogenic carbon sources such as the oil that was applied to the landfarm at SWMU 001. The total organic carbon (TOC) level in soil ranged from a low of 248 mg/kg at location 001-171 (SWMU 001) to 4550 mg/kg at location 001-175 (SWMU 001), and averaged 801 mg/kg. A higher TOC level, possibly due to the availability of oil (source of free carbon) indicates a greater potential for VOAs to sorb to soil, which may be why more TCE is not present in the groundwater within and downgradient of the source (centered around location 001-165). DCE is an indicator for this degradation pathway, because it is not used as a pure product but is found solely as a degradation product. 1,2-DCE may further degrade anaerobically to vinyl chloride, but the rate is slower and the process may require stronger reducing conditions than those required for reduction of PCE or TCE.

This condition persists for the WAG 27 sites, since 1,2-DCE was present; however, a much lower concentration relative to TCE and vinyl chloride was rarely detected as a degradation product. In most cases, the ratios of TCE to DCE were high, indicating that TCE was not readily transforming into 1,2-DCE. Ratios of TCE to 1,2-DCE for SWMU 001, SWMU 091, and C-720 ranged from 1 to 270, and typically exceeded 40. In addition, at the locations where TCE levels were highest, no degradation products were detected. At SWMU 001, the ratio of TCE to 1,2-DCE at the source (centered around the 001-165 area) was 43. Ratios of these compounds downgradient of the source at 001-175 and 001-180 were 48 and 44, respectively, indicating little transformation of TCE to DCE. A few locations (720-001, 720-002, 720-008, and 720-025 at SWMU 001) did exhibit the presence of 1,2-DCE and vinyl chloride at daughter to parent ratios less than one or trends of decreasing concentration away from the source, indicating biodegradation

TCE generally would be expected to persist under aerobic or denitrifying conditions. Denitrifying conditions are indicated when nitrates are present in groundwater, but no oxygen is present.

Aerobic biodegradation of TCE may occur under certain conditions. For example, specialized microorganisms have been identified that aerobically degrade some of these solvents in the presence of ammonia, methane, and toluene. Lower molecular weight chlorinated hydrocarbons, such as DCE, undergo anaerobic degradation less readily than the higher molecular weight chlorinated hydrocarbons such as TCE, but undergo aerobic degradation more readily.

1,1,1-TCA can degrade anaerobically to 1,1-DCA, which subsequently degrades to the relatively non-persistent chloroethane. Significant levels of 1,1-DCA were detected at SWMU 001 and SWMU 091. However, no detections of 1,1,1-TCA were reported in any of the soil and groundwater samples collected from WAG 27. 1,1,1-TCA can degrade chemically to 1,1-DCE.

The fact that 1,1-DCE is present and no 1,1,1-TCA was detected in any of the WAG 27 samples indicates that degradation has completely transformed the 1,1,1-TCA into 1,1-DCE and that the 1,1,-DCE is probably an aged byproduct.

The abiotic rate depends only on temperature and allows some estimations of the residence time in groundwater. The half-life for the chemical transformation is approximately 8 months at 25°C, which is within 8 degrees of the temperature measured in groundwater. During this degradation process, approximately 75% of the TCA is transformed to acetic acid and only 25% to 1,1-DCE. Based on these ratios, a significant amount of TCA was probably released.

In summary, TCE, DCE, and vinyl chloride were reported in groundwater at concentrations exceeding background or PRG concentrations, demonstrating a complete migration pathway from soil to groundwater at SWMU 001 and the C-720 Complex.

5.3.3 Metals

Inorganic chemicals released to unsaturated soil become dissolved in soil moisture or adsorbed onto soil particles. Dissolved inorganic analytes detected at WAG 27 include the metals listed in Table 5.2. These dissolved metals are subject to movement by vadose zone water. Aqueous transport mechanics may result in metal migration through the vadose zone to groundwater. Metals, unlike organic compounds, cannot be degraded. However, metals migration can be attenuated by retarding reactions such as adsorption, surface complexation, coprecipitation, and ion-exchange reactions with the soils with which they come into contact. Such reactions are affected by pH; oxidation-reduction conditions; and the type and amount of organic matter, clay, and hydrous oxides present. These reactions are typically reversible, resulting in dynamic metal solubility in immature or poorly developed soils. Some metals, such as arsenic and chromium, can be transformed to other oxidation states in soil. Such transformations can reduce the metals' toxicities and/or affect their mobilities by affecting the way in which they react with soil particles or other solid surfaces by ion exchange, adsorption, precipitation, or complexation.

The oxidation state and chemical speciation of inorganic chemicals control solubility and thus, to a great extent, mobility in the environment. The mobility of metals and radionuclides can be significantly enhanced by the formation of organometalic and/or anionic complexes. Chemical speciation may be an important process in determining the chemical form present in the soil. However, speciation is very complex and difficult to distinguish in routine laboratory analysis; therefore, its impact may not be measurable or predictable. In soil, metals are typically found in the following states:

- Dissolved in interstial fluids
- Occupying exchange sites on inorganic soil constituents
- Adsorbed on inorganic soil constituents
- Associated with insoluble soil organic matter
- Precipitated as pure or mixed solids
- Present in the structure of secondary minerals
- Present in the structure of primary minerals

In situations where metals have been introduced into the environment through human activities, metals are typically associated with the first five conditions. The dissolved aqueous fraction and its equilibrium solid fraction are of primary importance when considering the migration potential of metals associated with soils. The unfilterable inorganics represent the dissolved fraction, which is the more mobile fraction. Of the compounds that are most likely to form in soils, chlorides, nitrates, and nitrites are the most soluble. Sulfates, carbonates, and hydroxides have low to moderate solubility. In general, soluble compounds are transported in aqueous forms that are subject to retardation, whereas insoluble compounds remain as precipitates and limit the overall dissolution of metals.

Adsorption depends on the surface charge, the dissolved ion and its charge, and the pH of the soils. Positively charged metal ions (such as trivalent chromium, cadmium, lead, iron, manganese, and zinc) tend to be adsorbed, and the transport of these species is slower than the groundwater or pore water velocity. The retardation factor (R_f) describes numerically the extent to which the velocity of the contaminant migration is decreased and is largely derived from the partition coefficient (K_d).

Table 5.2 presents the range of K_d values for metals for the loam-type soils prevalent at WAG 27. The K_d values of metals vary widely in the same soil type and may vary by orders of magnitude among samples from the same site. However, for purposes of conducting transport analyses in the vertical direction through the UCRS (i.e., migration from the site sources to the RGA), only the average K_d values for loam soil were used. For lateral transport in the RGA, average K_d values for sandy soil were used.

Contaminant persistence is a function of physical, chemical, and biological processes that affect the chemical as it moves through air, soil, and water. Some inorganic contaminants may undergo chemical species transformation after being released to the environment. An important example of one such transformation is the change of the charge state from Cr^{+6} to Cr^{+3}. Organometallic compounds can undergo a variety of chemical reactions that may transform one compound into another, change the state of the compound, or cause a compound to combine with other chemicals; however, the metallic portion of the organometallic compounds only changes oxidation states. With the exception of changing oxidation states or possibly exchanging metallic species, inorganic contaminants are much more stable than organic contaminants.

The mobility of metals is directly related to their solubility in water or other fluids and to pH and redox conditions. The pH of the RGA water samples ranged from a low of 5.75 (location 001-176 at SWMU 001) to 8.28 (location 091-002 at SWMU 091) and averaged 6.24. In the absence of fluids to mobilize and transport metals, virtually no transport is possible. Even if fluids are present, metals become more mobile only under favorable pH and redox conditions. Movement of metals is also controlled by the solubility (pH- and Eh-dependent), adsorption, and redox state of the metal. With the exceptions of hexavalent chromium, barium, and selenium, the solubility of other metals of concern is inversely proportional to pH. However, iron, manganese, and aluminum oxides, plus carbonates, hydroxides, and organic materials, may cause metals to precipitate or be adsorbed onto soil particles.

5.3.3.1 Abundant Metals

A recurring issue in the WAG 27 RI is the ubiquitous presence of abundant metals identified in all media. The most common of these are aluminum and iron. It is important to distinguish evidence for release and transport from the natural variability at the site or secondary factors that may alter the solubility. A review of the patterns of these constituents at all sites confirms that they are not primary constituents in the industrial processes performed at SWMU 001, SWMU 091, SWMU 196, and the C-720 Complex based on the following:

- Past industrial processes indicate that nickel and aluminum were used in the SWMU 196 smelting process; and gold, cyanide, silver, tin, lead, and chromium were known waste byproducts at the C-720 Complex.
- Eleven metals occur in the RGA and McNairy aquifer systems above screening levels and their distribution is random. The random distribution makes it impossible to establish background areas relative to process/source areas.
- Aluminum and iron, which have been detected above background or PRG concentrations, are the second and third, respectively, most abundant metals in the earth's crust. These were present in the soil and sediment samples analyzed.
- The PGDP background values for metals in soil and groundwater identified in this study are lower than generally reported literature values for metals.
- The metals reported in groundwater at elevated concentrations form no distinguishable "plume" (pattern of high to lower concentrations). Dissolved concentrations were generally low. In RGA water sample 720-017, aluminum was 70 times higher in the unfiltered (total) sample than in the filtered (dissolved) sample. In the same sample, iron was 18 times higher in the unfiltered sample than in the filtered sample.
- Elevated dissolved iron is also frequently related to anaerobic conditions in the groundwater, increasing the solubility of iron in its reduced form (Fe^{+2}).

During this RI, the fate and transport of metals were frequently estimated based on the dissolved concentrations, which are typically low across WAG 27. Colloids may migrate in aquifer systems if the particle size is much smaller than the pore size. Mobile colloids are commonly smaller than 0.45 micron. The samples were filtered with a 0.45-micron filter to limit removal of the non-mobile colloids. Filtered versus unfiltered metals data for the monitoring wells were evaluated and compared to unfiltered metals data for the borehole water samples. The results indicate that average concentrations in borehole water samples for virtually all metals were higher than values reported in the well samples.

This condition is a result of the high volume of particulate matter introduced into the samples during collection. Although turbidity was not measured on the borehole water samples, the chemists have indicated that the borehole water samples in many cases were visually turbid. It can be concluded that the concentrations of metals in the borehole water samples are not representative of the groundwater in the RGA; the evaluation indicated anomalously high metals concentrations in these samples. At WAG 27, because of the sporadic distribution of metals, it is not possible to attribute the metals observed in groundwater to the localized soil hot spots (i.e. 720-024, 198-013, and others located at SWMU 001). Thus it is impossible to delineate the extent of any one particular metal COPC.

As proven during the WAG 6 RI, determinations of the extent of metals in groundwater and the associated risk levels are valid only if samples from permanent monitoring wells are collected using a protocol that results in acceptable turbidity level. Only then can background and source areas be confidently delineated.

5.3.3.2 Trace Metals

The potential release and migration of metals in the subsurface environment is a complex process. The migration of metals depends on factors such as the overall groundwater composition, pH, presence of dissolved organic matter that may complex with the metals, the valence state of the metal, and the cation exchange capacity. Metals may be removed from the water phase through mechanisms such as precipitation and irreversible sorption.

In addition to the abundant metals (aluminum and iron), other metals were sometimes reported above background levels in the various environmental media.

In groundwater, interpretation of the unfiltered metals is complicated by turbid samples. In these cases, low-mobility constituents (such as lead) that do not represent a dissolved plume are typically detected at significant levels.

5.3.4 Radionuclides

Radionuclides represent a special case of inorganic species. Although radionuclides behave chemically as metals, the radioactive nuclides undergo spontaneous transformations that involve the emission of particles and radiant energy. Most important for WAG 27 are the emission of alpha and beta particles and the emission of gamma energy. The resulting daughters (i.e., product nuclides) may be radioactive themselves (in which case they too will undergo spontaneous decay) or may be stable nuclides. The decay process can occur by various spontaneous mechanisms.

Two of the more important decay modes are alpha decay and beta decay; the latter is differentiated into negatron and positron decay. As with inorganic and organic chemical species that do not undergo nuclear transformations, the persistence of radionuclide contaminants at WAG 27 is related largely to their geochemical mobility in the environment. Table 5.3 presents the half-lives ($t_{1/2}$), radioactive decay constants, and K_d values for the site-related radionuclides. The K_d values for uranium in Table 5.3 are the most conservative site-specific value reported.

Natural uranium consists of three primary isotopes: U-234, U-235, and U-238. The decay products of uranium isotopes are also radioactive and form decay chains. The half-lives, decay constants, and K_d of each WAG 27 COPC radionuclide, are presented in Table 5.3.

Uranium hexaflouride is the sole raw material used in the enrichment process at PGDP. Some of the uranium feed material that was handled at PGDP has been reclaimed or recycled from reprocessed, spent reactor fuel. The chemical processes by which recycled uranium is purified leave trace amounts of transuranic elements (neptunium and plutonium) and fission products (mainly Tc-99). Tc-99 (in the +7 oxidation state) is highly soluble in groundwater and is very mobile (its K_d is similar to that of TCE). The groundwater plumes of TCE and Tc-99 are similar in size and geometry. Tc-99 has migrated extensively from two suspected sources: the SWMU 001 landfarm and the C-720 Complex. The levels of Tc-99 in soil are low because of its mobility and high solubility in water, a trend that is evident at WAG 6 and other sites where Tc-99 is a COC.

On an activity basis, the principal radionuclides expected to pass through chemical processing and contaminate the recycled uranium are the transuranic radionuclides produced in highest abundance and with moderate half-lives: Np-237, Pu-238, Pu-239, Pu-240, and Am-241. However, characterization studies (CH2M HILL 1998; SAIC 1998) have generally shown that these radioisotopes are usually present in activities that are <1% of the uranium activity unless treatment processes have collected and concentrated them in sludges or trap material. Of the transuranic radionuclides, neptunium fluoride is believed to have been the most mobile in the gaseous phase and to have migrated further in the process system before being deposited. The others are believed to have been present in the feed in lower concentrations and to have been more persistent in the heel of the feed cylinders.

In addition, certain fission and activation products may form volatile compounds in the fluorination process: Zr-95, Nb-95, Tc-99, Ru-106, Cs-134, and Cs-137. However, Zr-95, Nb-95, Ru-106, and Cs-134 have short half-lives (65 days, 55 days, 368 days, and 2.1 years, respectively) compared to the 15-plus years since recycled uranium was last introduced; as a result, they are unlikely to be present in significant quantities today. Because Cs-137 has a half-life of 30 years, it is the most likely fission product (except for Tc-99) still to be present at the site.

Radionuclides such as Th-230, which was detected in all media at all WAG 27 sites, are probably a result of the long-term decay of natural uranium in soil and/or groundwater.

5.3.4.1 Buildup of Uranium Daughter Products

Uranium, U-234, U-235, and U-238 were detected in soil and groundwater at the WAG 27. Due to the very long half-lives of U-238 and U-235, relatively little daughter activity is produced until periods approaching the half-life have expired. Once the half-life has expired, most of the uranium activity is due to U-238. Table 5.3 lists daughter activities for several radionuclides for periods of up to 10,000 years. The radionuclides U-238, Th-234, and Pa-234 are in radioactive equilibrium and show essentially no decrease in activity, even after 10,000 years (SAIC 1998).

5.4 CHEMICAL MIGRATION RATES

Most chemicals in soil or groundwater migrate at a velocity slower than that of the water, which is the transport medium. The retardation factor, R_f, is the relative chemical migration velocity, which is calculated as follows:

$$R_f = 1 + (K_d \rho) / \eta$$

where

R_f = chemical-specific retardation factor (dimensionless)

ρ = bulk mass density of dry aquifer system skeleton (g/cc)
{1.67 g/cc (based on soil samples collected during this RI)}

η = total porosity (dimensionless)
{0.37 value from literature}

K_d = chemical-specific distribution coefficient (cc/g)

The distribution coefficient K_d for organic constituents is estimated as follows:

$$K_d = K_{oc} * foc$$

where

K_{oc} = chemical-specific organic carbon partition coefficient
foc = fraction of organic carbon {0.00801 (based on soil samples collected during this RI; see Appendix H}

In general, metals are persistent in the environment. Metals are not typically volatile, so any emissions to ambient air would be in the form of particulate emissions. The chemical migration rates for site-related COCs are presented in Table 5.4.

5.4.1 Migration Pathways

5.4.1.1 Soil to Groundwater Pathway—UCRS

Contaminants present in surface and subsurface soils may leach to the underlying aquifer. Several factors influence the dissolution of COPCs in soils and the rate of contaminant movement through soils. These include the physical/chemical properties of the contaminants (e.g., solubility, density, viscosity, mineralogy, K_d) and the physical/chemical properties of the environment (e.g., rainfall, percolation rate, soil permeability, porosity, particle size, and amount of organic carbon). Contaminants migrate to groundwater through infiltration, leaching, and the movement of subsurface water within the capillary fringe.

Generally, the groundwater is relatively deep at WAG 27, and many of the potential source areas have been present for a long time. Therefore, leaching potential is indicated by the observed groundwater concentrations. The amount of water available for infiltration is based on an average rainfall recharge rate of 7 in. per year. The interstitial groundwater velocity (in./year) is estimated by dividing the recharge rate by the volumetric moisture content of the unsaturated zone. Assuming a water-filled porosity of 0.37, the velocity of the infiltrating water is about 19 in. per year. The depth to the water table in many areas is approximately 50 ft, suggesting a 32-year travel time from the surface to the water table. In areas beneath pavement or other low-permeability zones, less infiltration would occur. Adjacent to paved areas, higher rates of recharge may occur as runoff increases the infiltration in localized areas.

It is obvious that vertical migration has occurred at a much higher rate than indicated by advection/leaching, primarily because of diffusion. Diffusion along permeable zones of sand can significantly increase the rate of contaminant migration as the chemical moves to counteract concentration gradients, which are estimated to be quite significant at WAG 27. It appears that the dominant driving force for chemical migration in the UCRS is diffusion.

Chemicals can attenuate in the vadose zone. Chemicals that strongly sorb to soils, including most PAH compounds, tend to remain in or near the point of release. The R_fs for these constituents indicate that they would be expected to migrate much more slowly than water in some instances. In addition to their strong tendency to adsorb, these compounds biodegrade during the slow transport, limiting the impacted area. Other constituents such as VOAs tend to volatilize in the unsaturated zone, decreasing their persistence in that medium.

5.4.1.2 Groundwater Migration—RGA

The COCs reported in RGA groundwater include arsenic, beryllium, iron, chromium, lead, manganese, thallium, silver, TCE, cis-1,2-DCE, trans-1,2-DCE, vinyl chloride, 1,1-DCA, 1,1,1-

TCA, 1,1,2-TCA, and several radionuclides. VOAs and Tc-99 are the most widespread of the COCs. The highest concentrations of VOAs were reported at SWMU 001. TCE was present in SWMU 001 and C-720 in the RGA and McNairy aquifers at concentrations ranging from 0.05 μg/L to 1,578 μg/L. 1,2-DCE was reported in SWMU 001 and C-720 sites, but at much lower concentrations. As noted earlier, 1,2-DCE is formed from anaerobic biodegradation of TCE or the DCE intermediates. It subsequently degrades to ethene and/or ethane. The data in this report indicate that anaerobic biodegradation (e.g., TCE to DCE) is not a major process in the hydrogeological/geochemical environment at WAG 27. The major source of TCE at the C-720 Complex is believed to be the outside parts wash area located on the northeast side of the building and leaks in the floor drain exit point near 720-002 and along a storm drain near 720-024. The most significant source is VOAs at the SWMU 001 landfarm, where VOAs have migrated downward to the RGA and are a continuing source to the RGA.

Once in the groundwater, the COCs generally move through the RGA via advection. Using the hydraulic properties of the RGA as a conservative estimate of advective transport, the seepage velocity (advection velocity) at the site was estimated at 1.2 ft/day. Therefore, based on advection alone, it was estimated that contaminants from the site could migrate 438 ft each year.

COCs spread both horizontally and vertically due to the process of dispersion, while adsorption retards the movement of chemicals in groundwater. Dispersion generally causes chemicals to migrate from 10 to 20% farther than migration caused by advection alone. Adsorption, which retards the movement of chemicals, counteracts the advection and dispersion processes. Adsorption is generally described by a chemical's distribution coefficient (K_d). The migration potential for 1 year was calculated for COCs in accordance with the groundwater flow velocities at that location. These calculations were based on the following equation:

$$V_c = V / R_f$$

where

V_c = chemical horizontal migration velocity in feet per year (ft/yr)
V = site-specific groundwater flow velocity (ft/yr)
R_f = chemical-specific retardation factor (dimensionless)

Calculated horizontal migration velocities are based on advection, retardation, and dispersion, but not on the effects of biodegradation. Of the COCs identified in Table 5.5, the most mobile constituents include the chlorinated VOAs. Other constituents, including PAHs and metals (such as lead and vanadium), are not readily transported in groundwater. Consistent with these properties, PAHs were not detected in the groundwater. The widespread occurrence of unfiltered metals such as iron is the result of highly turbid groundwater samples and is not a result of migration or site-related activities.

TCE is the COC that represents the maximum extent of contamination confirmed in the RGA. Considering that operations began approximately 46 years ago at the C-720 Complex and 25 years ago at SWMU 001 (the two major sources at WAG 27), the current horizontal migration potentials of TCE due to advection, retardation, and dispersion are estimated to be 7947 and 4319 feet, respectively. This distance is consistent with fate and transport modeling of TCE contamination in the RGA as reported in Sect. 5.5.

5.5 FATE AND TRANSPORT MODELING

Contaminant fate and transport modeling has been conducted for SWMU 001, SWMU 091, SWMU 196, and the C-720 Complex. The modeling was conducted using the Multimedia Environmental Pollutant Assessment System (MEPAS) software developed at Pacific Northwest National Laboratory. The MEPAS model calculates the fate and transport of contaminants from specified source terms and determines the associated risk to identified receptors. It can model contaminant releases to the atmosphere, surface water, and groundwater. For purposes of this analysis, only the groundwater contaminant transport portion of the model was run to calculate predicted contaminant concentrations in groundwater at receptor points within the RGA. Concentrations were modeled to two receptor points: the PGDP security fence and the DOE property boundary. The output tables (Appendix C of Vol. 4) list the maximum concentrations for each source constituent and the corresponding times at which they reach each receptor point.

The following section provides a general overview of the results of the modeling for each area in WAG 27. More details concerning contaminant screening, development of the contaminant source terms, and the parameter values entered into the model are provided in Appendix C. The results of the MEPAS modeling are compared to risk-based values in Sect. 6 to assist in the evaluation of risks to future residential groundwater users.

5.5.1 SWMU 001

Based on soil boring logs, three model layers (two partially saturated and one saturated) were delineated at SWMU 001. These layers correspond to the upper porous, portion of the UCRS (1 to 40 ft bgs), the HU 3 aquitard (40 to 55 ft bgs), and the RGA (55 to 105 ft bgs). Figure C-6 in Appendix C of Vol. 4 presents a cross section delineating the layers modeled at the unit. The travel distances from the source to each downgradient exposure point were 500 ft to the PGDP security fence and 3300 feet to the DOE property boundary.

Subsurface soil data used to develop the source terms were provided by the WAG 27 RI, the CERCLA SI, and a recent (January 1998) investigation (including test pit excavations) of geophysical anomalies at the unit. RGA soil sampling data were available from three soil borings installed at the unit for the CERCLA SI (CH2M HILL 1992). Source terms were developed for four metal contaminants (antimony, cadmium, manganese, and beryllium) and four organic [TCE, vinyl chloride, bis(2-ethylhexyl)phthalate, and xylene] subsurface soil contaminants at SWMU 001. No patterns of contaminant distribution were observed that would allow grouping of these subsurface contaminants into common source areas. Discrete subsurface source areas were defined for each contaminant present in each subsurface layer.

Antimony was present in all three layers at the site above screening levels, so three separate source terms were developed. The largest antimony source was centered around boring H 208 at the southern end of the oil landfarm and extended from 5 ft to 33 ft bgs. The dimensions of this source (290 ft x 200 ft) were defined to include H 208 and the eight WAG 27 RI borings in which antimony was detected above screening levels. A smaller source (100 ft x 75 ft) in the southeast corner of the landfarm (around boring H 209) was delineated from 40 to 43 ft bgs in the HU 3 layer. A detection in boring H 210 in the 57- to 60-ft interval was used to define the 50-ft x 50-ft RGA source term for antimony. No other contaminants were detected above the screening levels in RGA soil samples from the unit.

A cadmium source was developed that encompassed most of the SWMU 001 area in the 7- to 10-ft interval (Model Layer 1). A small 85-ft x 80-ft source area was defined for manganese, which was detected in one 7- to 10-ft sample from soil boring 001-137 at the southern edge of the unit. Beryllium was detected in Model Layers 2 and 3, requiring the development of two source terms: a 50-ft x 50-ft area around boring H 210 extending from 15 to 20 ft bgs, and a 175-ft x 75-ft rectangular area encompassing the 40- to 50-ft interval (Model Layer 3) in borings 001-179 and 001-166.

Of the four organics detected above industrial soil PRGs at the unit, TCE and vinyl chloride source areas have the most significant concentrations and encompass the largest areas. The TCE and vinyl chloride source areas are located in the north-central portion of the landfarm and are defined by several WAG 27 RI soil borings as well as by January 1998 CDM excavation samples from Test Pit 5. TCE was found at high concentrations (average of 15,287 µg/kg) in 88 soil samples taken in and around the Test Pit 5 area in the 1- to 50-ft interval (Model Layers 1 and 2). Vinyl chloride was found within the same area and was confined to the 1- to 10-ft interval. The dimensions of the Model Layers 1 and 2 source areas for xylene were based on its detection in one shallow soil sample (2 to 6 ft) from boring H 052 and in one deep (50- to 55-ft) sample from boring H 208 in the western part of the unit. The source area for bis(2-ethylhexyl)phthalate extends from 1 to 32 ft in boring H 009, located in the north-central part of the SWMU.

Most contaminants were detected above screening levels in fewer than five samples, so maximum concentrations were used to estimate contaminant inventories. The exception for SWMU 001 was TCE, for which the source term was developed using the average concentration of 88 samples. Table 5.5 lists the results of MEPAS modeling for SWMU 001.

5.5.2 SWMU 091

Four model layers (three partially saturated and one saturated) were delineated at SWMU 091. These layers include the loess deposits making up HU 1 (1 to 20 ft), the permeable but discontinuous sand and gravel lenses of the UCRS (20 to 35 ft), a silty clay aquitard HU 3 (35 to 48 ft), and the RGA (48 to 106 ft). A cross section showing the depths of these layers at the unit is presented in Figure C-7 in Appendix C of Vol. 4. The travel distance from the source to each downgradient exposure point is 350 feet to the PGDP security fence and 2500 feet to the DOE property boundary.

Subsurface soil data were provided by the WAG 27 RI, the CERCLA SI, and soil-sampling activities conducted in support of the LASAGNA™ demonstration at SWMU 091. RGA soil sampling data were provided by three soil borings (H 003, H 201, and H 203) installed at the unit for the CERCLA SI (CH2M HILL 1992). These data were used to develop the source terms and inventories for the site contaminants.

Five constituents (antimony, lead, phenanthrene, uranium, and di-n-butylphthalate), were identified as present above screening levels in subsurface soils at SWMU 091. However, uranium was not retained for modeling because it was detected only once above the screening levels (in the LASAGNA™ Phase I boring LAG11). These were unvalidated data. The MEPAS source terms were developed for the remaining four UCRS soil contaminants. In addition, one of the UCRS soil contaminants, di-n-butylphthalate, also was detected above screening levels in

RGA soils at the site. A separate RGA source term for this constituent was developed and input into the model.

A UCRS soil contaminant, antimony, was assumed to be present at its maximum detected concentration (5 mg/kg) from 5 to 30 ft bgs in a 300-ft x 125-ft area encompassing borings H 202 and H 203. Lead (maximum 133 mg/kg) and di-n-butylphthalate (maximum 84J μg/kg) were both detected above screening levels in boring H 203, in the 25-to 30-ft (Model Layer 2) and 25- to 75-ft (Model Layers 2-4) intervals, respectively. Because no sampling was conducted beneath 75 ft, the di-n-butylphthalate source was assumed to extend throughout the entire thickness of the RGA, to 106 bgs. Phenanthrene was detected at a maximum concentration of 220J μg/kg in boring H 003 in the 18- to 24-ft interval (Model Layer 2). The maximum concentrations of each contaminant were used to estimate contaminant inventories. The results of the MEPAS modeling at SWMU 091 are presented in Table 5.6

5.5.3 SWMU 196

Four model layers (three partially saturated and one saturated) were delineated at SWMU 196. These layers include the loess deposits making up HU 1 (1 to 18 ft), the permeable, discontinuous sand and gravel lenses of the UCRS (18 to 35 ft), a silty clay aquitard HU 3 (35 to 49 ft), and the RGA (49 to 99 ft). The travel distances from the source to each downgradient exposure point are 800 ft to the PGDP security fence and 2800 feet to the DOE property boundary.

Surface and subsurface soil data were provided by the WAG 27 RI. No RGA soil or groundwater sampling data were available for the area, so an RGA source term could not be developed. The RI soil data were used to develop the source terms and inventories for the site contaminants.

One contaminant, antimony, was found above screening levels in surface (0 to 2 ft) soil samples from the site. Because it was detected in all surface soil samples, the source area was delineated to include all unpaved portions of the site. The maximum concentration in surface soil (62.2 mg/kg) was used to calculate the contaminant inventory for the area. Antimony also was detected above screening levels in these same seven borings in subsurface (2- to 10-ft) samples, so a source area of the same dimensions (175 ft x 160 ft) was developed for the loess layer (unsaturated Layer 1) using the maximum detected concentration in subsurface soils (58.9 mg/kg) to calculate the inventory.

Ten additional metals were identified as present above screening levels in subsurface soils: barium, beryllium, cadmium, cobalt, copper, lead, manganese, nickel, silver, and thallium. Each was detected in only 1 or 2 borings in shallow (2- to 8-ft bgs) samples. Their source areas are relatively thin (2 to 4 ft) rectangular areas in Model Layer 1 centered around the borings in which the detections occurred. It was assumed conservatively that these contaminants were distributed homogeneously at their maximum detected concentrations across their source areas. The results of the MEPAS modeling conducted for SWMU 196 are presented in Table 5.7.

5.5.4 C-720 Complex

Four model layers (three partially saturated and one saturated) were delineated at SWMU 091. These layers include the loess deposits making up HU 1 (1 to 17 ft), the permeable but discontinuous sand and gravel lenses of the UCRS (17 to 42 ft), a silty clay aquitard HU 3 (42 to 60 ft), and the RGA (60 to 100 ft). The travel distances from the source to each downgradient exposure point are 1800 ft to the PGDP security fence and 4600 feet to the DOE property boundary located to the west.

Subsurface soil data were provided by the WAG 27 RI. Groundwater sampling data from the WAG 27 borings and from wells installed in the surrounding area were used to develop the RGA source terms. The source terms and inventories for the site contaminants are presented in Appendix C of Vol. 4.

Thirteen subsurface contaminants were found above screening levels and retained for MEPAS modeling in the C-720 Complex. The most significant subsurface source areas defined in the C-720 Complex are associated with elevated levels of organics, in particular TCE, trans-1,2-DCE, and vinyl chloride. The high levels of TCE define two large source areas: one large rectangular (1,050-ft x 225-ft) area located along the northern side of the C-720 Building and one slightly smaller area (825 ft x 150 ft) located along the southern side. TCE was detected in the 20- to 40-ft interval in these source areas, so separate sources were modeled originating from Model Layers 2 and 3 and the results were then summed for like time values. Vinyl chloride was found in shallow soils (< 23 ft bgs) in two borings (720-001 and 720-002) near the southeast corner of the building, so small source areas were defined in Model Layers 1 and 2. Trans-1,2-DCE also was detected in one of these borings (720-002) at very high concentrations. A 200-ft x 150-ft source area, centered around the boring and encompassing the 12- to 16-ft interval, was used for modeling trans-1,2-DCE.

Metals detected in the C-720 Complex appear to be concentrated in one boring (720-024) located at the southwest corner of the building. Eight metals (antimony, beryllium, cadmium, cobalt, copper, silver, thallium, and vanadium) were detected above screening levels in this boring in the 35- to 50- ft interval. A rectangular source area 200 ft x 120 ft in Model Layers 2 and 3 was defined for these metals. The organic compound bis(2-ethylhexyl)phthalate also was detected in this boring above its PRG throughout the 15- to 50- ft interval. Lead was detected in only one boring (720-002) located near the southeast corner of the building. It was confined to the shallow (12- to 16-ft) Model Layer 1 soils. Antimony and beryllium also were detected at the northeast corner of the building (boring 720-027) in the 20- to 28-ft interval.

Because no deep soil sampling data are available for the C-720 Complex, the RGA source term for the MEPAS modeling has been developed using groundwater data. The chemicals detected above screening levels in the RGA (60 to 100 ft bgs) are TCE; trans-1,2-DCE; and cis-1,2-DCE. The maximum detected concentrations of trans-1,2-DCE (25 μg/L) and cis-1,2-DCE (29 μg/L) do not greatly exceed their residential groundwater PRGs (4 μg/L and 2 μg/L, respectively). In addition, neither was detected in more than 6 groundwater samples from the area. For these reasons (and also because MEPAS does not include cis-1,2-DCE in its chemical list), only TCE was modeled. More information concerning development of the TCE source term for the C-720 Complex can be found in Appendix C of Vol. 4. Results of the RGA modeling for the C-720 Complex are included in Table 5.8. These results indicate that a DNAPL source is present near the northern edge of the C-720 Building.

Table 5.1 Physical and chemical properties of volatile and semi-volatile compounds.

Constituents	SWMU 1			SWMU 91			SWMU 196			C-720 Building				Mol. wt. (g/mol)	Solubility S_w (mg/L)	S_w @ temp. (°C)	K_{ow} (ml/ml)	Vapor pressure (torr @ °C)	Henry's constant (K_h) (atm.m³/mol)	K_h @ temp. (°C)	Air Diff. coeff. (cm^2/s)		K_{oc} (ml/g)		Biodegradation rate, 1 (1/d)	Biodeg. half-life (day)	Log (K_{ow})	CAS No.	Biodeg. half-life (hr)
	SS	SB	GW	SS	SB	GW	SL	SS	SB	SL	SS	SB	GW																
Volatile Organics																													
1,1 Dichloroethene		x	X			X				X	X	X	X	96.9	2.10E+02	25	3.02E+01	591@ 25	1.49E-02	25	0.114	s	6.50E+01	m	3.85E-03	180	1.48	75-35-4	4.32E+03
1,2 Dichloroethene		x												96.9	8.00E+02	#	1.23E+02	200 #	6.60E-03	ssc	0.114		7.75E+01		2.41E-04	2875	2.09	540-59-0	6.90E+04
cis-1,2-Dichloroethene		x	X			X						x	X	96.9	3.50E+03		7.24E+01		4.08E-03		0.074		3.55E+01				1.86		
trans-1,2-Dichloroethene		x	X			X						X	X	96.9	6.30E+03		1.17E+02	324@20-25 e	9.38E-03		0.071		3.80E+01				2.07	156-60-5	
2-Butanone												x		72.1	2.75E+05		1.82E+00	100 @ 25	6.61E-07	25#	0.092	s	1.15E+00		2.48E-02	28	0.26	78-93-3	6.72E+02
2-Propanal			X										X																
Acetone		x										x		58.1	1.00E+06		5.75E-01	270 @ 30	5.14E-07	25#	0.110	s	3.63E-01		2.48E-02	28	-0.24	67-64-1	6.72E+02
Carbon Tetrachloride													X	153.8	8.00E+02	20	5.37E+02	113 @ 25	2.93E-02	25	0.082	s	1.52E+02	m	1.93E-03	360	2.73	56-23-5	8.64E+03
Chloroform			X										X	119.4	9.30E+03	25	9.33E+01	160 @ 20	3.39E-03	25	0.091	s	5.30E+01	m	3.85E-04	1800	1.97	67-66-3	4.32E+04
Tetrachloroethene													X	165.8	1.50E+02	25	3.39E+02	19 @ 25	2.87E-02	25	0.077	s	2.65E+02	m	4.19E-04	1653	2.53	127-18-4	3.97E+04
Trichloroethene		X	X			X				X	X	X	X	131.4	1.10E+03	25	3.39E+02	77 @ 25	1.17E-02	25	0.088	s	9.40E+01	m	4.19E-04	1653	2.53	79-01-6	3.97E+04
Vinyl Chloride		X				X						X	X	62.5	1.10E+00	25	3.98E+00	760@20-25 e	2.78E-02	25	0.106	s	2.51E+00		2.41E-04	6.90E+04	0.60	75-01-4	6.90E+04
Semi-volatile Organics																													
2,4-Dimethylphenol		x												122.2	7.87E+03	na	2.63E+02	0.026 (units-mmHg)	5.31E-07		0.069		1.70E+01				2.42	105679	
4-Methylphenol		x												108.2	2.40E+04	na	7.76E+01	0.04 (mmHg)	2.37E-07		0.075		7.76E+01				1.89	106-44-5	
4-Chloro-3-Methylphenol											X	X		na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Bis-(2-Ethylhexyl)phthalate		x								X	X	X		390.6	1.30E+00	25	2.00E+05	1.2 @ 200	3.00E-07	20	0.032	s	1.11E+05	m	1.78E-03	389	5.30	117-81-7	9.34E+03
Butylbenzylphthalate		x												312.4	2.90E+00		#REF!	8.6E-6 @ 20	3.18E-08	25#	0.040		1.37E+04	m	3.85E-03	180	4.78	85-68-7	4.32E+03
Diethylphthalate		x												222.2	2.10E-02		9.12E+02	0.05 @ 70	1.17E-08	25#	0.053		8.20E+01	m	3.09E-03	224	2.96	84-66-2	5.38E+03
Di-n-butylphthalate		x												278.4	4.00E+02	25	1.58E+05	0.1 @ 115	2.80E-07	25	0.042		1.57E+03	m	3.01E-02	23	5.20	84-74-2	5.52E+02
Di-n-octylphthalate											X	X		390.6	3.00E+00	25	1.58E+09	0.2 @ 150	3.45E-14		0.035		9.98E+08		1.90E-03	365	9.20	117-84-0	8.76E+03
m,p Cresol		x												128.2	3.00E+01	25	2.34E+03	0.082 @ 25	4.83E-04	25	0.059		1.19E+03	m	2.69E-03	258	3.37	91-20-3	6.19E+03
Phenol		x												94.1	8.00E+04	25	2.88E+01	0.341@20-25 e	1.30E-06	25	0.087	s	1.82E+01		2.48E-02	6.72E+02	1.46	108-95-2	6.72E+02
Total Cresols		x																											
Pesticides/PCBS																													
Aroclor-1242		X												261	2.40E-01	na	2.40E+04	0.00043 (mmHg)	2.20E-04	25	0.046		6.30E+03				5.90	53469-21-9	
Aroclor-1254										X				328	0.041			0.000043(mmHg)	0.0002		0.053		2.14E+06				6.94	11091-69-1	
Aroclor-1260		X					X			X				372	0.0144			0.000011 (mmHg)	0.00025		0.049		6.70E+06				6.91	11096-82-5	
Aroclor-1268		X												na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
Polychlorinated biphenyls		X					X			X																			

Solubilities, Henry's Constant, and Log (K_{ow}) have been taken from RREL Treatability Data Base (EPA 1994) unless otherwise indicated.

Biodegradation half-lives are taken from Hand Book of Environmental Degradation Rates (Howard et al. 1991) unless otherwise indicated.

Air diffusion coefficients are obtained from EPA 1987 unless otherwise indicated.

[*] Represents calculated values, [**] indicates the source of Lyman et al. 1990, [#] indicates STF Data Base (EPA 1991) as the source, and [s] indicates Shen et. al 1993 as the source.

[e] Represents Electronic Handbook of Risk Assessment Values, 1997

[w]-EPA WATER7 database November 1990, m = measured Koc values, L = Source from EPA 1995. SS = surface soil, SB = subsurface soil, and GW = groundwater.

x Detected above the method detection limit.

X Detected above the method detection limit and PRG or background concentration.

SS = Surface Soil

SB = Subsurface Soil

GS = Groundwater

SL = Sludge

Table 5.2 Distribution coefficients (K_d) for inorganic COPCs at WAG 27 sites

Site Related	*SWMU 1*			*SWMU 91*			*SWMU 196*			*C-720 Building*				K_d[a] for Loam	K_d[a] for Sand
Analytes	*SS*	*SB*	*GW*	*SS*	*SB*	*GW*	*SL*	*SS*	*SB*	*SL*	*SS*	*SB*	*GW*	(mL/kg)	(mL/kg)
Aluminum		X	x	X		x		X	X			X	x	1500.0	1500.0
Antimony		X	x					X	X			X	x	185.0	45.0
Arsenic		X	x			x		x	X			X	x	200[b]	25.0
Barium		X	x			X	x	x	X				X	50[b]	0.5
Beryllium		X	x			x		x	X			X	x	800.0	650.0
Cadmium		X	x	X		x	X	X	X			X	x	190.0	80.0
Calcium		x	X			x		X	X			x	X	5.0	25.0
Chromium		x	x	x		x	x	x	x			X	x	418.0	35.0
Cobalt		x	x			x		x	x			x	x	1,300 (100 to 9700)	60.0
Copper		x	x			x		x	x			x	X	3.5E+01[b]	22.0
Iron		X	X			x		x	X			X	X	351.0	220.0
Lead		X	x			x	X	x	X			X	x	16000 (100 to 59000)	270.0
Magnesium		X	X			x		X	X			X	X	13.0	1.6
Manganese		X	X			X		x	X			x	X	750 (40 to 77000)	50.0
Mercury		x	x	x			X	x	x			X	x	10[c] to 10,000[c]	82.0
Nickel		x	x			x	X	x	X			X	x	438.0	400.0
Potassium		x	x			x		X	X			X	x	40.0	15.0
Selenium		x	x				x	x	x			x	x	385.0	150.0
Silver		X	x				x	x	X			X	x	120 (28 to 333)	90.0
Sodium		X	X	X		x		X	X			X	X		
Thallium		X						x	X			X		1500[b]	74.0
Vanadium		X	x			x		x	X			X	X	1.0E+03[b]	1000.0
Zinc		x	x	x		X		x	x			x	X	200.0	200.0

[a] K_d values taken from Sheppard and Thibault 1990 unless otherwise noted; the range is provided in parenthesis if available.

[b] K_d values obtained from Baes et al. 1984.

[c] Source: Looney et al. 1987

X Indicates constituent detected above PRG or Background concentrations.

x Detected above the method detection limit.

SS = Surface Soil

SB = Subsurface Soil

GW = Groundwater

SL = Sludge

Table 5.3. Radioactive half-lives, decay constants, and distribution coefficients (K_d) for radionuclide COPCs at WAG 27 sites

Site related	*SWMU 1*			*SWMU 91*			*SWMU 196*			*C-720 Building*				Half life	Decay constant	K_d in loam[a]	K_d in sand[a]
radionuclides	*SS*	*SB*	*GW*	*SS*	*SB*	*GW*	*SL*	*SS*	*SB*	*SL*	*SS*	*SB*	*GW*	(Year)	(day^{-1})	(L/kg)	(L/kg)
^{241}Am		*x*		*x*					*x*			*x*		4.33E+02	4.38E-06	9600 (400 to 48,309)	1900
^{137}Cs		*x*	*X*	*x*			*x*	*x*					*X*	3.00E+01	6.33E-05	4600 (560 to 61,287)	280
^{237}Np		*X*					*x*	*x*	*x*	*X*				2.14E+06	8.87E-10	25 (1.3 to 79)	5
$^{239/240}$Pu		*X*		*X*		*X*	*x*	*x*	*x*			*x*	*X*	6.58E+03	2.89E-07	1200 (100 to 5,933)	550
^{99}Tc		*x*	*X*	*x*		*X*	*x*	*x*	*x*	*X*		*x*	*X*	2.10E+05	9.04E-09	0.1 (0.01 to 0.4)	0.1
^{230}Th		*X*		*x*		*X*	*x*	*x*	*x*	*x*		*x*	*X*	8.00E+04	2.37E-08	24,000	5,800
Uranium		*x*	*X*	*x*		*X*	*x*	*x*	*x*	*X*		*x*	*X*				
$^{233/234}$U		*x*		*x*				*x*	*x*	*X*		*x*	*x*	1.62E+05	1.17E-08	421[b]	35
^{235}U		*x*		*x*			*x*	*x*	*x*	*X*		*x*		7.10E+08	2.67E-12	421[b]	35
^{238}U		*x*		*x*				*x*	*x*	*X*		*x*		4.51E+09	4.21E-13	421[b]	35

[a] K_d values were obtained from either Sheppard and Thibault (1990) or Baes and Sharp (1984).

[b] K_d values were obtained from site-specific uranium sorption analysis (SAIC 1996).

X Indicates constituent detected above PRG or Background concentrations.

x Detected above the method detection limit.

SS = Surface Soil

SB = Subsurface Soil

GW = Groundwater

SL = Sludge

Table 5.4 Horizontal groundwater migration potential

Chemical Name of Groundwater COPC	Distribution Coefficient K_d (cc/g)	Retardation Factor (R_f)	Chemical Migration Rate (ft/year)	Chemical Migration Rate (20% Increase Due to Dispersion) (ft/yr)	Horizontal Migration Potential (C-720) (Distance [ft] over 46 years)	Horizontal Migration Potential (C-720) (Distance [ft] over 25 years)
Volatile Organic Compounds						
1,1-Dichloroethane	0.0	2.9	181.5	217.8	10019.2	5445.2
1,1 Dichloroethene	0.1	2.9	149.1	178.9	8230.1	4472.9
cis-1,2-Dichloroethene	0.03	2.8	154.7	185.7	8540.2	4641.4
trans-1,2-Dichloroethene	0.03	2.8	154.2	185.1	8513.0	4626.6
Acetone	0.00	2.7	162.0	194.4	8941.4	4859.4
Carbon Tetrachloride	0.1	3.3	134.7	161.6	7434.2	4040.3
Chloroform	0.04	2.9	151.3	181.6	8353.5	4539.9
Tetrachloroethene	0.2	3.7	119.6	143.6	6604.5	3589.4
Trichloroethene	0.1	3.0	144.0	172.8	7946.5	4318.8
Vinyl Chloride	0.002	2.7	161.5	193.8	8915.8	4845.5
Metals						
Aluminum	1500.0	6773.0	0.1	0.1	3.6	1.9
Antimony	45.0	205.8	2.1	2.6	117.5	63.8
Arsenic	25.0	115.5	3.8	4.5	209.3	113.7
Barium	0.5	5.0	88.3	106.0	4875.0	2649.5
Beryllium	650.0	2936.5	0.1	0.2	8.2	4.5
Cadmium	80.0	363.8	1.2	1.4	66.5	36.1
Calcium	25.0	115.5	3.8	4.5	209.3	113.7
Chromium	35.0	160.7	2.7	3.3	150.5	81.8
Cobalt	60.0	273.5	1.6	1.9	88.4	48.0

Table 5.4 Horizontal groundwater migration potential

Chemical Name of Groundwater COPC	Distribution Coefficient K_d (cc/g)	Retardation Factor (R_f)	Chemical Migration Rate (ft/year)	Chemical Migration Rate (20% Increase Due to Dispersion) (ft/yr)	Horizontal Migration Potential (C-720) (Distance [ft] over 46 years)	Horizontal Migration Potential (C-720) (Distance [ft] over 25 years)
Copper	22.0	102.0	4.3	5.2	237.0	128.8
Cyanide	10.0	47.8	9.2	11.0	505.4	274.7
Iron	220.0	995.7	0.4	0.5	24.3	13.2
Lead	270.0	1221.4	0.4	0.4	19.8	10.8
Magnesium	1.6	9.9	44.1	53.0	2436.2	1324.0
Manganese	50.0	228.4	1.9	2.3	105.9	57.5
Mercury	82.0	372.8	1.2	1.4	64.9	35.2
Nickel	400.0	1808.1	0.2	0.3	13.4	7.3
Potassium	15.0	70.4	6.2	7.5	343.4	186.6
Selenium	150.0	679.7	0.6	0.8	35.6	19.3
Silver	90.0	408.9	1.1	1.3	59.1	32.1
Thallium	74.0	336.7	1.3	1.6	71.8	39.0
Vanadium	1000.0	4516.2	0.1	0.1	5.4	2.9
Zinc	200.0	905.4	0.5	0.6	26.7	14.5
Radionuclides						
137Cs	280.0	1266.5	0.3	0.4	19.1	10.4
239/240Pu	550.0	2485.1	0.2	0.2	9.7	5.3
99Tc	0.1	3.2	138.9	166.6	7665.6	4166.1
230Th	5800.0	26181.1	0.02	0.02	0.9	0.5
233/234U	35.0	160.7	2.7	3.3	150.5	81.8
235U	35.0	160.7	2.7	3.3	150.5	81.8
238U	35.0	160.7	2.7	3.3	150.5	81.8

Table 5.5. MEPAS results for SWMU 001

Source	Constituent	PGDP Security Fence		DOE Property Boundary	
		Maximum Concentration (mg/L)	Time (yr)	Maximum Concentration (mg/L)	Time (yr)
UCRS	Antimony	6.43E-2	794	1.31E-2	862
	Beryllium[1]	0	10,000	0	10,000
	Bis(2-ethylhexyl) phthalate[1]	0	10,000	0	10,000
	Cadmium[2]	6.456E-33	9,946 to 15,696	1.543E-34	9,974 to 15,696
	Manganese	1.73E-1	2,334	2.63E-2	2,643
	Trichloroethene	20.44	120	3.4	122
	Vinyl chloride	8.19E-2	57	1.29E-2	63
	Xylenes	1.193E-4	159	1.86E-5	171
RGA	Antimony	1.67E-2	7	8.22E-4	54

[1] Receptor concentrations are zero over the given time range.

[2] Concentrations vary by less than 1/100th of 1% of the maximum concentration over the given time range (steady state).

Table 5.6. MEPAS results for SWMU 091

Source	Constituent	PGDP Security Fence		DOE Property Boundary	
		Maximum Concentration (mg/L)	Time (yr)	Maximum Concentration (mg/L)	Time (yr)
UCRS	Antimony	4.2E-2	498	5.7E-3	615
	Di-n-butylphthalate[1,2]	2.23E-29	10,001	0	10,000
	Lead[1,2]	1.76E-31	9,821 to 11,821	0	10,000
	Phenanthrene	3.85E-5	4,877	5.6E-6	5,377
RGA	Di-n-butylphthalate[1]	5.380E-6	4,609 to 10,055	7.878E-7	10,001

[1] Concentrations vary by less than 1/100th of 1% of the maximum concentration over the given time range (steady state).

[2] Receptor concentrations are zero over the given time range.

Table 5.7. MEPAS results for SWMU 196

Source	Constituent	PGDP Security Fence		DOE Property Boundary	
		Maximum Concentration (mg/L)	Time (yr)	Maximum Concentration (mg/L)	Time (yr)
Surface Soil	Antimony	4.81E-4	6,539	1.519E-4	6,546
Subsurface Soil	Antimony	1.826E-03	6,543	5.768E-4	6,544
	Barium[1]	0	10,000	0	10,000
	Beryllium[1]	0	10,000	0	10,000
	Cadmium[2,1]	1.401E-39	9,881 to 12,381	0	10,000
	Cobalt	1.416E-9	9,804	3.529E-10	9,805
	Copper[2]	3.105E-17	9,925 to 10,675	5.50E-18	9,933 to 10,675
	Lead[2]	6.963E-29	9,961 to 14,211	1.026E-35	9,821 to 14,211
	Manganese	5.91E-4	9,952	1.591E-4	9,953
	Nickel[2]	1.004E-23	9,868 to 10,368	2.664E-24	9,876 to 10,368
	Silver	1.814E-5	9,771	5.289E-6	9,772
	Thallium	1.541E-03	394	4.401E-4	395

[1] Receptor concentrations are zero over the given time range.

[2] Concentrations vary by less than 1/100th of 1% of the maximum concentration over the given time range (steady state).

Table 5.8. MEPAS results for C-720 Complex

Source	Constituent	PGDP Security Fence		DOE Property Boundary	
		Maximum Concentration (mg/L)	Time (yr)	Maximum Concentration (mg/L)	Time (yr)
Subsurface Soil	Antimony	2.55E-1	229	8.73E-2	361
	Bis(2-ethylhexyl) phthalate[2]	3.67E-12	9,930 to 11,180	5.14E-21	9,996 to 11,180
	Beryllium[2, 1]	0	10,000	0	10,000
	Cadmium[2]	4.075E-6	9,973 to 10,723	1.13E-19	9,959 to 10,723
	Cobalt	1.3E-2	4,252	5.6E-3	4,301
	Copper	7.88E-3	7,931	3.24E-3	9,974
	Lead[1]	0	10,000	0	10,000
	Silver	6.3E-2	847	3.0E-2	976
	Thallium	1.935	31	8.026E-1	38
	Trans-1,2-Dichloroethene	7.22	25	2.83	30
	Trichloroethene	12.7E-1	72	5.35E-1	82
	Vanadium	2.39E-2	3,797	7.7E-3	6,039
	Vinyl chloride	3.63E-3	54	1.50E-3	60
RGA	Trichloroethene	7.66E-2	9.2	2.56E-1	20.7

[1] Receptor concentrations are zero over the given time range.

[2] Concentrations vary by less than 1/100th of 1% of the maximum concentration over the given time range (steady state).

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6. RESULTS OF BASELINE RISK ASSESSMENT

This section presents the results of the baseline risk assessment (BRA) conducted for WAG 27, which consisted of two parts as discussed in Vol. 4: the baseline human health risk assessment (BHHRA) and the baseline ecological risk assessment (BERA). (Note, baseline risks are those which may be present now or in the future in absence of corrective or remedial actions.) In these assessments, information collected during the recently completed RI of WAG 27 and the results of previous risk assessments for the four sites in WAG 27 were used to characterize the baseline risks posed to human health and the environment from contact with contaminants in soil, ditch sediment, and groundwater at the four sites. In addition, this BRA uses results of fate and transport modeling to estimate the baseline risks posed to human health and the environment through contact with media impacted by contaminants migrating from the various sources in WAG 27. Methods used for fate and transport modeling are presented in Sect. 5 and in the BRA in Appendix C of Vol. 4.

To facilitate data aggregation and to focus results on specific areas, this BRA derives risk estimates for the four WAG 27 sites individually.

Consistent with regulatory guidance and agreements contained in the approved human health risk assessment methods document (DOE 1996d), the BHHRA was used to evaluate scenarios that encompass current use and several hypothetical future uses of the WAG 27 sites and the areas to which contaminants from those sites may migrate. The scenarios assessed in Vol. 4 are as follows.

- Current on-site industrial–direct contact with sediment and surface soil (soil found 0 to 1 ft bgs).
- Future on-site industrial–direct contact with sediment, surface soil, and use of groundwater drawn from aquifers below the WAG 27 sites.
- Future on-site excavation–direct contact with surface soil combined with subsurface soil (soil found 0 to 15 ft bgs).
- Future on-site recreational user–direct contact with sediment and consumption of game exposed to contaminated surface soil.
- Future off-site recreational user–direct contact with surface water impacted by contaminants migrating from sources and consumption of game exposed to this surface water.
- Future on-site rural resident–direct contact with surface soil at and use of groundwater drawn from aquifers below the WAG 27 sites, including consumption of vegetables that were posited to be raised in this area.
- Future off-site rural resident–use in the home of groundwater drawn from the RGA at the DOE property boundary.

Also consistent with regulatory guidance and the strategy for the ecological risk assessment of source units (DOE 1993, EPA 1998), the BERA was used to evaluate risks under both current and potential future conditions to several nonhuman receptors that may come into contact with contaminated media at or migrating from sources in the WAG 27 sites. In the BERA, as with the

BHHRA, information collected during the recently completed RI (including the fate and transport information in Sect. 5) and from the BRA in Appendix C of Vol. 4 was used. (Note, because the fate and transport information indicates that surface migration of contaminants from WAG 27 to creeks surrounding PGDP is not significant, a quantitative assessment of risks from surface migration to these creeks is not included in this summary or in Vol. 4.)

6.1 CONCLUSIONS

For all four WAG 27 sites, the cumulative human health excess lifetime cancer risk (ELCR) and systemic toxicity exceed the accepted standards of KDEP and EPA for one or more scenarios when assessed using default exposure parameters. The land uses and media assessed for risk to human health for each site are presented Table 6.1. Table 6.1 also indicates the scenarios and media previously addressed. No groundwater was assessed at SWMU 196 and no surface water was evaluated at any site for current concentrations. The scenarios for which risk exceeds *de minimis* levels [i.e., a cumulative ELCR of 1×10^{-6} or a cumulative hazard index (HI) of 1] are summarized in Table 6.2. This information is taken from the risk summary tables located at the end of this section (Tables 6.3 through 6.7), which present the cumulative risk values for each scenario, the COCs, and the pathways of concern (POCs).

Because the WAG 27 sites are located in the industrialized portion of the PGDP, the BERA project team concluded during problem formulation that it would not be appropriate to derive risk estimates for impacts to nonhuman receptors under current conditions. However, an analysis to determine potential impacts to nonhuman receptors exposed to contaminants in surface soil or ditch sediment in the future, if the industrial infrastructure were removed, and to estimate the potential impact of surface migration of contaminated media was performed. Because contaminants at the C-720 Complex and SWMU 091 are restricted to subsurface soils below gravel- or cement-covered areas, effectively eliminating potential exposures, the BERA project team concluded that it would not be appropriate to derive risk estimates for nonhuman receptors to contaminants in surface soil at these two sites. Surface soils at SWMU 001 have already been evaluated and addressed as part of the WAG 23 ROD, so they are not re-evaluated for SWMU 001 here. Several contaminants in surface soil from SWMU 196 and sediments in drainage ditches associated with SWMUs 001, 091, and 196 were found to be at concentrations greater than levels protective of nonhuman receptors. Table 6.7 summarizes these chemicals of potential ecological concern (COPECs).

6.2 OBSERVATIONS

Specific observations of the BHHRA and the BERA are as presented here. Note, the observations from the BHHRA focus on the industrial land use, the current and most plausible future land use for the WAG 27 sites, and the observations of the BERA focus on the potential risks to nonhuman receptors. Vol. 4 includes more extensive discussions of each of the observations presented below.

6.2.1 Observations of the Baseline Human Health Risk Assessment

- Use of the provisional lead reference doses (RfDs) provided by KDEP results in total HIs that exceed 1000 for the use of groundwater at the WAG 27 sites and for those locations where the maximum detected concentration of lead in soil exceeded its background concentration. However, when these provisional values are not included in the risk characterization, total HIs are markedly reduced. (Note, because the risks calculated using the provisional lead RfDs are so uncertain, all observations presented in this summary after this discussion and in Tables 6.2 through 6.6 do not include the quantitative contribution from lead. Therefore, the reader must take care when examining the individual uncertainties to determine if the reported results contain or do not contain lead as a COPC.) Due to the uncertainty in the results using the provisional lead RfDs, a better understanding of the risks presented by lead may be gained by comparing the representative exposure concentrations of lead in soil and groundwater to screening levels from KDEP and EPA. In these comparisons (see Sect. 1.5.6 in Vol. 4), the concentrations of lead in RGA and McNairy Formation groundwater at all sites are seen to exceed the KDEP screening level. The EPA screening level is also exceeded for RGA and McNairy Formation groundwater at all sites except the C-720 Complex. The representative exposure concentrations of lead in sediment and subsurface soil never exceed either screening level. However, the representative concentration of lead in surface soil at SWMU 196 exceeds only the KDEP screening level. None of the representative concentrations of lead in surface soil exceed the EPA screening level.

- The dermal contact with soil exposure route poses considerable risk, predominantly from contact with metals in soil (primarily beryllium). In fact, for all land use scenarios evaluated, the systemic toxicity and the ELCR posed through the soil and sediment dermal exposure route exceed that posed by the ingestion route. As illustrated in Sect. 1.6 of Vol. 4, this is a direct result of using dermal absorption factors (ABS values) that exceed gastrointestinal absorption values and may be too conservative. This observation indicates that the risk estimates from the dermal exposure route may be unrealistic and exceed the real risk posed by this route of exposure. Although chemical-specific ABS values were used when available, default ABS values were used for most chemicals because chemical-specific values are lacking. Chemical-specific ABS values were available for PCBs, cadmium, and carbon disulfide and were used in the BHHRA. Remedial action decisions based on the dermal contact with soil exposure route should be carefully considered because of the uncertainty associated with risk from this exposure route.

- The current land use scenario, industrial use, has risk that is above *de minimis* levels at each site except the C-720 Complex, where contact with surface soil is not possible and no ditches are present. At SWMU 001, the pathway driving both systemic toxicity and ELCR is dermal contact with sediment. At SWMU 091, the pathway driving systemic toxicity is dermal contact with sediment, and ELCR is driven by external exposure to sediment. At SWMU 196, the pathway driving systemic toxicity is dermal contact with sediment, and the ELCR is driven by both external exposure to soil and dermal contact with sediment. For the C-720 Complex, no COCs were identified for soil or sediment for the current industrial worker.

  The total HI at each site is less than 3. No one contaminant dominates contribution to systemic toxicity. The primary contaminant driving ELCR within this pathway is beryllium, and also contributing are radionuclides (Np-237 and Cs-137) for all sites.

- The most plausible future land use scenario, industrial use, has risk that is above *de minimis* levels at each WAG 27 site. As discussed in the BHHRA, the future industrial land use scenario is identical to the current industrial land use scenario except that the former also includes use of RGA and McNairy Formation groundwater. The addition of groundwater as a medium of exposure adds significantly to the risk for this scenario. If groundwater contribution is removed from the risk totals, the driving pathways are identical to those of the current industrial land use scenario.

- Risks from use of groundwater (without the risk contribution of lead) drawn from both the RGA and the McNairy Formation exceed *de minimis* levels for all scenarios at each site except SWMU 196, where no COPCs were identified. For the RGA, across all land uses at SWMU 001, the contaminants contributing greater than 10% ELCR were arsenic, radon-222, beryllium, and Tc-99. The contaminants contributing greater than 10% systemic toxicity were various metals. For the McNairy, across all land uses at SWMU 001, the contaminants contributing greater than 10% ELCR were beryllium, Am-241, and U-238. The contaminants contributing greater than 10% systemic toxicity were various metals. For the RGA, across all land uses at SWMU 091, the contaminants contributing greater than 10% ELCR were radon-222, americium-241, and beryllium. The contaminants contributing greater than 10% systemic toxicity were various metals and trichloroethene. For the McNairy, across all land uses at SWMU 091, the contaminants contributing greater than 10% ELCR were Am-241, Np-237, and U-238. The contaminant contributing greater than 10% systemic toxicity was uranium. For the RGA, across all land uses at the C-720 Complex, the contaminants contributing greater than 10% ELCR were beryllium, Am-241, Np-237, U-238, 1,1-dichloroethene, and Tc-99. The contaminants contributing greater than 10% systemic toxicity were various metals, trichloroethene, and carbon tetrachloride. For the McNairy, across all land uses at the C-720 Complex, the contaminants contributing greater than 10% ELCR were beryllium, Am-241, Np-237, and U-238. The contaminants contributing greater than 10% systemic toxicity were various metals.

- In this assessment, the inhalation of VOCs and particulates emitted via the soil exposure route is a POC for the excavation worker at SWMU 001 and the C-720 Complex. The contaminant driving risk within this pathway and scenario combination is vinyl chloride. Unlike many previous assessments that have been performed at PGDP, this exposure route is seldom a POC. WAG 6 is the most recent exception.

- COCs migrating from sources in the WAG 27 soil and groundwater as determined by risk estimates for future residential groundwater users are phenanthrene, *trans*-1, 2-dichloroethene, trichloroethene, vinyl chloride, xylenes, antimony, manganese, silver, thallium, and vanadium. There were no radionuclide COCs.

6.2.2 Observations of the Baseline Ecological Risk Assessment

- Nine inorganic COPECs exceeded benchmarks for at least one receptor group (Table 6.7). The inorganics were aluminum, cadmium, chromium, lead, mercury, nickel, selenium, silver, and zinc. Of these, aluminum, chromium, and lead were near background levels. Aluminum is unlikely to be of concern at WAG 27, as the maximum aluminum concentration in any of the four sites was only 1.01 times background. Similarly, chromium and lead were near background levels (maximum of 1.05 times and 1.5 times background, respectively). Cadmium was of concern only for plants in the SWMU 091 ditch and SWMU 196 soil. However, hazard quotients were low (less than 3.1), and the areas are currently covered with vegetation. Mercury was of concern only for soil invertebrates exposed to ditch sediment in SWMUs 091 and 196 and surface soil in SWMU 196. Nickel was of potential concern for plants and invertebrates in SWMU 196 surface soil and for plants in SWMU 196 ditches. Selenium and silver were of potential concern for plants in SWMU 196 surface soil. Zinc was of potential concern, with low hazard quotients for plants, soil invertebrates, and shrews in SWMU 196 ditches; plants and soil invertebrates in SWMU 091 ditches; and plants in SWMU 001 ditches. However, the maximum zinc concentration was only 3.4 times background. (No COPECs were identified for the C-720 Complex because contaminants are restricted to subsurface soils in that area.)

- No organic analytes exceeded available benchmarks for any ecological receptors.
- Estimated doses from exposure to radionuclides in soil or ditch sediment were below recommended dose rate limits for all receptors in all areas. Therefore, adverse effects are not expected from exposure to radionuclides.
- Uncertainty concerning the future condition, the bioavailability of various metals (e.g., aluminum and chromium were only slightly elevated above background), and use of only one line of evidence (comparison of exposures to Lowest Observed Adverse Effects Levels or LOAELs) may have led to an overestimate of potential future ecological risks.

A summary of COEPCs and receptors potentially at risk should future exposures occur is presented in Table 6.7. Additional discussion of these results is presented in Sect. 2 of Vol. 4.

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Table 6.1. Land uses and media assessed for each SWMU and area of WAG 27

Land Use Scenario	Location			
	SWMU 1	SWMU 91	SWMU 196	C-720 Complex
Current On-site Industrial Worker				
Surface soil	P	P	X	N
Sediment	X	X	X	N
Surface Water	N	N	N	N
Future On-site Industrial Worker				
Surface soil	P	P	X	N
Surface Water	X	X	X	N
Sediment	N	N	N	N
RGA Groundwater	X	X	N	X
McNairy Groundwater	X	X	N	X
Future On-site Excavation Worker				
Surface and Subsurface soil	X	X	X	X
Future On-site Recreational User				
Soil (game)	P	P	P	N
Sediment	X	X	X	N
Surface water	N	N	N	N
Future Off-site Recreational User				
Surface water	X	X	X	N
Future On-site Rural Resident				
Surface soil	P	P	X	N
RGA Groundwater	X	X	N	X
McNairy Groundwater	X	X	N	X
Future Off-site Rural Resident				
RGA Groundwater	X	X	X	X
McNairy Groundwater	X	X	X	X

Notes: Scenarios that were assessed in this BHHRA are marked with an X. Scenarios that were assessed as part of previous risk assessments are marked with a P (SWMU 1 surface soils were addressed as part of WAG 23 RI, and SWMU 91 surface soils were addressed as part of LASAGNA™). Risk results from previously assessed scenarios are combined with the risk results from this BHHRA. Scenarios that are not applicable, or for which the medium is not present, are marked with an N

Table 6.2. Scenarios for which human health risk exceeds *de minimis* levels

Scenario	Location			
	SWMU 001	SWMU 091	SWMU 196	C-720 Complex
Results for excess lifetime cancer risk:				
Current On-site Industrial Worker				
Exposure to Soil	NA	NA	X	NA
Exposure to Sediment	X	X	X	NA
Future On-site Industrial Worker				
Exposure to Soil	NA	NA	X	NA
Exposure to Sediment	X	X	X	NA
Exposure to Groundwater[b]	X	X	—	X
Future On-site Excavation Worker				
Exposure to Soil	X	X	X	X
Future On-site Recreational User				
Exposure to Game	NA	NA	—	NA
Exposure to Sediment	X	X	X	NA
Future Off-site Recreational User				
Exposure to Surface Water	—	—	—	—
Future On-site Rural Resident				
Exposure to Soil	NA	NA	X	NA
Exposure to Groundwater[b]	X	X	—	X
Future Off-site Rural Resident				
Exposure to Groundwater[c]	X	X	X	X
Results for systemic toxicity[a]:				
Current On-site Industrial Worker				
Exposure to Soil	NA	NA	—	NA
Exposure to Sediment	X	X	X	NA
Future On-site Industrial Worker				
Exposure to Soil	NA	NA	—	NA
Exposure to Sediment	X	X	X	NA
Exposure to Groundwater[b]	X	X	—	X
Future On-site Excavation Worker				
Exposure to Soil	X	X	X	—
Future On-site Recreational User				
Exposure to Game	NA	NA	—	NA
Exposure to Sediment	X	X	X	NA

Table 6.2. Scenarios for which human health risk exceeds *de minimis* levels

Scenario	Location			
	SWMU 001	**SWMU 091**	**SWMU 196**	**C-720 Complex**
Future Off-site Recreational User				
Exposure to Surface Water[c]	—	—	—	—
Future On-site Rural Resident				
Exposure to Soil	NA	NA	X	NA
Exposure to Groundwater[b]	X	X	—	X
Future Off-site Rural Resident				
Exposure to Groundwater[c]	X	X	X	X

Notes: Scenarios where risk exceeded the benchmark levels are marked with an X. Scenarios where risk did not exceed a benchmark level are marked with a —. NA indicates that the scenario/land use combination is not appropriate.

[a] For the future recreational user and the future on-site resident, the child results are used.

[b] The BHHRA assessed risks associated with use of water drawn from the RGA separately from use of water drawn from the McNairy Formation. The value reported here is for use of water from the RGA.

[c] Based on results of contaminant transport modeling. X indicates that the location contains one or more sources of off-site contamination in exceedance of benchmarks, and — indicates that the location is not a source of off-site contamination.

Table 6.3. Summary of risk characterization results for SWMU 001 without lead as a COPC

Receptor	Total ELCR[a]	COCs	% Total ELCR	POCs	% Total ELCR	Total HI[a]	COCs	% Total HI	POCs	% Total HI
Current industrial worker at current concentrations (soil only)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Future industrial worker at current concentrations (soil only)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Current industrial worker at current concentrations (sediment only)	1.3×10^{-4}	Arsenic Beryllium Cesium-137 Neptunium-237 Uranium Uranium-235	7 74 3 12 2 <1	Ingestion of sediment Dermal contact External exposure	1 81 18	1.7	Chromium Iron Manganese Vanadium	16 23 25 23	Dermal contact	99
Future industrial worker at current concentrations (sediment only)	1.3×10^{-4}	Arsenic Beryllium Cesium-137 Neptunium-237 Uranium Uranium-235	7 74 3 12 2 <1	Ingestion of sediment Dermal contact External exposure	1 81 18	1.7	Chromium Iron Manganese	16 23 25	Dermal contact	99
Future industrial worker at current concentrations (RGA groundwater only)	1.9×10^{-3}	Arsenic Beryllium 1,1-Dichloroethene Bis(2-ethyl hexyl)phthalate Trichloroethene Americium-241 Cesium-137 Neptunium-237 Radon-222 Technetium-99 Uranium-235 Uranium-238	53 10 1 <1 <1 3 <1 2 25 <1 <1 4	Ingestion of groundwater Dermal contact Inhalation while showering	71 3 26	14.2	Aluminum Antimony Arsenic Barium Chromium Iron Manganese Vanadium Trichloroethene	4 1 45 1 1 18 21 3 1	Ingestion of groundwater Dermal contact	95 5

Table 6.3. Summary of risk characterization results for SWMU 001 without lead as a COPC

Future industrial worker at current concentrations (McNairy groundwater only)	3.9×10^{-4}	Arsenic Beryllium Americium-241 Cesium-137 Uranium-235 Uranium-238	6 15 36 <1 <1 41	Ingestion of groundwater Dermal contact	96 4	2.99	Arsenic Iron Manganese Uranium Vanadium	5 58 9 12 7	Ingestion of groundwater Dermal contact	95 5
Future child rural resident at current concentrations (RGA groundwater only)	NA	NA	NA	NA	NA	152	Aluminum Antimony Arsenic Barium Beryllium Cadmium Chromium Cobalt Copper Fluoride Iron Manganese Nickel Nitrite as Nitrogen Uranium Vanadium Zinc 1,1-Dichloroethene 1,2-Dichloroethene Acetone Bis(2-ethylhexyl)phthalate Chloroform Methylene chloride Trichloroethene cis-1,2-Dichloroethene	4 1 47 1 <1 <1 1 <1 <1 <1 19 16 <1 <1 <1 3 <1 <1 <1 <1 <1 <1 <1 3 <1	Ingestion of groundwater Dermal contact Ingestion of vegetables Inhalation while showering Inhalation from household use	60 1 36 <1 3
Future child rural resident at current concentrations (McNairy groundwater only)	NA	NA	NA	NA	NA	32.3	Aluminum Arsenic Barium Beryllium Chromium Iron Manganese Nickel Uranium Vanadium Trichloroethene	2 5 1 <1 2 60 7 <1 13 6 2	Ingestion of groundwater Dermal contact Ingestion of vegetables Inhalation from household use	59 1 38 1

Table 6.3. Summary of risk characterization results for SWMU 001 without lead as a COPC

Future adult rural resident at current concentrations (RGA groundwater only)	1.6×10^{-2}	Arsenic Beryllium 1,1-Dichloroethene Bis(2-ethyl hexyl)phthalate Chloroform Methylene chloride Trichloroethene Americium-241 Cesium-137 Neptunium-237 Plutonium-239/240 Radon-222 Technetium-99 Uranium-235 Uranium-238	53 8 5 <1 <1 <1 <1 2 <1 1 <1 7 18 <1 3	Ingestion of groundwater Dermal contact Inhalation while showering Inhalation from household use Ingestion of vegetables	44 1 7 4 44	57	Aluminum Antimony Arsenic Barium Beryllium Cadmium Chromium Fluoride Iron Manganese Nickel Nitrite as Nitrogen Uranium Vanadium 1,1-Dichloroethene 1,2-Dichloroethene Acetone Bis(2-ethylhexyl)phthalate Trichloroethene	4 1 47 1 <1 <1 1 <1 19 17 <1 <1 <1 3 <1 <1 <1 <1 2	Ingestion of groundwater Dermal contact Ingestion of vegetables Inhalation from household use	66 2 31 2
Future adult rural resident at current concentrations (McNairy groundwater only)	2.8×10^{-3}	Arsenic Beryllium Trichloroethene Americium-241 Cesium-137 Technetium-99 Uranium-235 Uranium-238	8 14 <1 32 <1 8 <1 37	Ingestion of groundwater Dermal contact Inhalation from household use Ingestion of vegetables	59 1 <1 39	12.2	Aluminum Arsenic Barium Chromium Iron Manganese Uranium Vanadium Trichloroethene	2 5 1 2 60 7 13 6 1	Ingestion of groundwater Dermal contact Ingestion of vegetables	65 2 3
Future child recreational user at current concentrations (soil only)	NA	NA	NA	NA	NA	NE	NE	NE	NE	NE
Future child recreational user at current concentrations (sediment only)	NA	NA	NA	NA	NA	3.36	Aluminum Arsenic Chromium Iron Manganese Vanadium	6 4 19 28 10 28	Dermal contact	98

Table 6.3. Summary of risk characterization results for SWMU 001 without lead as a COPC

Future teen recreational user at current concentrations (soil only)	NA	NA	NA	NA	NA	NE	NE	NE	NE	NE
Future teen recreational user at current concentrations (sediment only)	NA	NA	NA	NA	NA	2.22	Aluminum Chromium Iron Manganese Vanadium	6 19 28 10 28	Dermal contact	<99
Future adult recreational user at current concentrations (soil only)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Future adult recreational user at current concentrations (sediment only)	1.7×10^{-4}	Arsenic Beryllium Neptunium-237	9 89 1	Ingestion of sediment Dermal contact External exposure	2 97 1	0.481	NE	NE	NE	NE
Future excavation worker at current concentrations	2.4×10^{-4}	Arsenic Beryllium PAHs Bis(2-chloroethyl)ether Dieldrin Heptachlorodibenzofuran Hexachlorobenzene N-Nitroso-di-n-propylamine PCBs Trichloroethene Vinyl chloride Cobalt-60 Uranium	10 46 13 <1 <1 2 <1 6 7 <1 6 <1 3	Ingestion of soil Dermal contact Inhalation of VOCs and particulates External exposure	20 74 3 3	1.92	Arsenic Chromium Manganese Vanadium 2-Nitroanaline PCBs Trichloroethene cis-1,2-dichloroethene	7 16 14 14 12 7 5 7	Ingestion of soil Dermal contact Inhalation of VOCs and particulates	17 74 9

Note: NA = ELCR not applicable to child and teen cohorts. Values for adult include exposure as child and teen.
NE = Land use scenario not of concern or land use not evaluated because contact with medium is not possible.

[a] Total ELCR and total HI columns reflect values from Tables 1.94 to 1.103 in Vol. 4 without lead included.

Table 6.4. Summary of risk characterization results for SWMU 091 without lead as a COPC

Receptor	Total ELCR^a	COCs	% Total ELCR	POCs	% Total ELCR	Total HI ^{a}	COCs	% Total HI	POCs	% Total HI
Current industrial worker at current concentrations (soil only)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Future industrial worker at current concentrations (soil only)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Current industrial worker at current concentrations (sediment only)	5.8 × 10^{-4}	Arsenic Beryllium Cesium-137 Uranium Uranium-238	2 17 80 <1 <1	Ingestion of sediment Dermal contact External exposure	2 19 81	1.96	Aluminum Cadmium Chromium Iron Manganese Vanadium	8 6 15 22 19 22	Dermal contact	99
Future industrial worker at current concentrations (sediment only)	5.8 × 10^{-4}	Arsenic Beryllium Cesium-137 Uranium Uranium-238	2 17 80 <1 <1	Ingestion of sediment Dermal contact External exposure	2 19 81	1.96	Aluminum Cadmium Chromium Iron Manganese Vanadium	8 6 15 22 19 22	Dermal contact	99
Future industrial worker at current concentrations (RGA groundwater only)	1.0 × 10^{-3}	Arsenic Beryllium 1,1-Dichloroethene Trichloroethene Vinyl chloride Americium-241 Cesium-137 Neptunium-237 Radon-222 Technetium-99 Uranium-235 Uranium-238	1 6 3 <1 <1 43 <1 7 11 <1 <1 3	Ingestion of groundwater Dermal contact Inhalation while showering	86 2 13	4.24	Chromium Iron Manganese Trichloroethene	10 53 22 4	Ingestion of groundwater Dermal contact	92 6

Table 6.4. Summary of risk characterization results for SWMU 091 without lead as a COPC

Receptor	Total ELCR[a]	COCs	% Total ELCR	POCs	% Total ELCR	Total HI [a]	COCs	% Total HI	POCs	% Total HI
Future industrial worker at current concentrations (McNairy groundwater only)	6.9×10^{-4}	Americium-241 Cesium-137 Neptunium-237 Thorium-230 Uranium-235 Uranium-238	30 1 13 2 7 47	Ingestion of groundwater	100	0.334	NE	NE	NE	NE
Future child rural resident at current concentrations (RGA groundwater only)	NA	NA	NA	NA	NA	48.1	Aluminum Arsenic Barium Beryllium Cadmium Chromium Iron Manganese Nickel Nitrate/Nitrite Uranium Vanadium 1,1-Dichloroethene 1,2-Dichloroethene Trichloroethene cis-1,2-Dichloroethene trans-1,2-Dichloroethene	1 2 <1 <1 <1 9 52 15 2 <1 <1 <1 1 <1 11 1 <1	Ingestion of groundwater Dermal contact Ingestion of vegetables Inhalation while showering Inhalation from household use	55 1 33 <1 9
Future child rural resident at current concentrations (McNairy groundwater only)	NA	NA	NA	NA	NA	3.88	Uranium Trichloroethene	95 5	Ingestion of groundwater Ingestion of vegetables Inhalation from household use	57 39 3

Table 6.4. Summary of risk characterization results for SWMU 091 without lead as a COPC

Receptor	Total ELCR*	COCs	% Total ELCR	POCs	% Total ELCR	Total HI *	COCs	% Total HI	POCs	% Total HI
Future adult rural resident at current concentrations (RGA groundwater only)	8.2×10^{-3}	Arsenic Beryllium 1,1-Dichloroethene Bis(2-ethylhexyl)phthalate Trichloroethene Vinyl chloride Americium-241 Cesium-137 Neptunium-237 Plutonium-239/240 Radon-222 Technetium-99 Thorium-230 Uranium-235 Uranium-238	2 5 11 <1 <1 2 33 <1 6 <1 3 16 <1 3 18	Ingestion of groundwater Dermal contact Inhalation while showering Inhalation from household use Ingestion of vegetables	45 <1 4 9 42	17.4	Aluminum Arsenic Barium Cadmium Chromium Iron Manganese Nickel Uranium Vanadium 1,1-Dichloroethene Trichloroethene cis-1,2-Dichloroethene	1 2 <1 <1 10 54 17 2 <1 <1 <1 8 <1	Ingestion of groundwater Dermal contact Ingestion of vegetables Inhalation from household use	62 2 29 5
Future adult rural resident at current concentrations (McNairy groundwater only)	4.4×10^{-3}	Trichloroethene Americium-241 Cesium-137 Neptunium-237 Thorium-230 Uranium-235 Uranium-238	<1 29 1 14 2 7 47	Ingestion of groundwater Ingestion of vegetables	65 35	1.43	Uranium	97	Ingestion of groundwater Ingestion of vegetables	64 34
Future child recreational user at current concentrations (soil only)	NA	NA	NA	NA	NA	NE	NE	NE	NE	NE
Future child recreational user at current concentrations (sediment only)	NA	NA	NA	NA	NA	4.06	Aluminum Arsenic Cadmium Chromium Iron Manganese Vanadium	9 5 7 17 25 7 25	Dermal contact	98
Future teen recreational user at current concentrations (soil only)	NA	NA	NA	NA	NA	NE	NE	NE	NE	NE

Table 6.4. Summary of risk characterization results for SWMU 091 without lead as a COPC

Receptor	Total ELCR[a]	COCs	% Total ELCR	POCs	% Total ELCR	Total HI[a]	COCs	% Total HI	POCs	% Total HI
Future teen recreational user at current concentrations (sediment only)	NA	NA	NA	NA	NA	2.68	Aluminum Arsenic Cadmium Chromium Iron Manganese Vanadium	9 5 7 17 25 7 25	Dermal contact	<99
Future adult recreational user at current concentrations (soil only)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Future adult recreational user at current concentrations (sediment only)	2.3×10^{-4}	Arsenic Beryllium Cesium-137	9 70 20	Ingestion of sediment Dermal contact External exposure	<1 79 21	0.583	NE	NE	NE	NE
Future excavation worker at current concentrations	1.5×10^{-4}	Arsenic Beryllium	7 93	Ingestion of soil Dermal contact	6 94	2.03	Antimony Chromium Vanadium	46 10 32	Ingestion of soil Dermal contact	6 94

Note: NA = ELCR not applicable to child and teen cohorts. Values for adult include exposure as child and teen.
NE = Land use scenario not of concern or land use not evaluated because contact with medium is not possible.

[a] Total ELCR and total HI columns reflect values from Tables 1.94 to 1.103 in Vol. 4 without lead included.

Table 6.5. Summary of risk characterization results for SWMU 196 without lead as a COPC

Receptor	Total ELCR[a]	COCs	% Total ELCR	POCs	% Total ELCR	Total HI [a]	COCs	% Total HI	POCs	% Total HI
Current industrial worker at current concentrations (soil only)	4.8×10^{-6}	Uranium	55	External exposure	80	0.521	NE	NE	NE	NE
Future industrial worker at current concentrations (soil only)	4.8×10^{-6}	Uranium	55	External exposure	80	0.521	NE	NE	NE	NE
Current industrial worker at current concentrations (sediment only)	8.7×10^{-5}	Arsenic Beryllium Cesium-137 Cobalt-60 Neptunium-237 Uranium	9 81 2 2 2 3	Dermal contact External exposure	89 10	2.1	Aluminum Chromium Iron Manganese Vanadium	11 12 33 9 16	Dermal contact	99
Future industrial worker at current concentrations (sediment only)	8.7×10^{-5}	Arsenic Beryllium Cesium-137 Cobalt-60 Neptunium-237 Uranium	9 81 2 2 2 3	Dermal contact External exposure	89 10	2.1	Aluminum Chromium Iron Manganese Vanadium	11 12 33 9 16	Dermal contact	99
Future industrial worker at current concentrations (RGA groundwater only)	NC	NE	NE	NE	NE	NC	NE	NE	NE	NE
Future industrial worker at current concentrations (McNairy groundwater only)	NC	NE	NE	NE	NE	NC	NE	NE	NE	NE
Future child rural resident at current concentrations (RGA groundwater only)	NA	NA	NA	NA	NA	NC	NE	NE	NE	NE

Table 6.5. Summary of risk characterization results for SWMU 196 without lead as a COPC

Receptor	Total ELCR[a]	COCs	% Total ELCR	POCs	% Total ELCR	Total HI [a]	COCs	% Total HI	POCs	% Total HI
Future child rural resident at current concentrations (McNairy groundwater only)	NA	NA	NA	NA	NA	NC	NE	NE	NE	NE
Future adult rural resident at current concentrations (RGA groundwater only)	NC	NA	NA	NA	NA	NC	NE	NE	NE	NE
Future adult rural resident at current concentrations (McNairy groundwater only)	NC	NA	NA	NA	NA	NC	NE	NE	NE	NE
Future child rural resident at current concentrations (soil only)	NA	NA	NA	NA	NA	23.9	Cadmium Chromium Mercury Nickel Silver	35 8 23 27 6	Ingestion of soil Dermal contact Ingestion of vegetables	<1 12 87
Future adult rural resident at current concentrations (soil only)	3.7×10^{-4}	PCBs Cobalt-60 Neptunium-237 Uranium	39 2 6 53	Ingestion of sediment Dermal contact Ingestion of vegetables External exposure	<1 <1 90 9	7.26	Cadmium Chromium Mercury Nickel Silver	35 7 24 28 6	Dermal contact Ingestion of vegetables	8 91
Future child recreational user at current concentrations (soil only)	NA	NA	NA	NA	NA	<0.1	NE	NE	NE	NE
Future child recreational user at current concentrations (sediment only)	NA	NA	NA	NA	NA	4.68	Aluminum Antimony Arsenic Cadmium Chromium Iron Manganese Mercury Vanadium	12 5 2 4 13 35 3 3 17	Dermal contact	98

Table 6.5. Summary of risk characterization results for SWMU 196 without lead as a COPC

Receptor	Total ELCR[a]	COCs	% Total ELCR	POCs	% Total ELCR	Total HI[a]	COCs	% Total HI	POCs	% Total HI
Future teen recreational user at current concentrations (soil only)	NA	NA	NA	NA	NA	<0.1	NE	NE	NE	NE
Future teen recreational user at current concentrations (sediment only)	NA	NA	NA	NA	NA	3.08	Aluminum Antimony Cadmium Chromium Iron Mercury Vanadium	12 5 4 13 35 3 17	Dermal contact	<99
Future adult recreational user at current concentrations (soil only)	1.7×10^{-7}	NE	NE	NE	NE	<0.1	NE	NE	NE	NE
Future adult recreational user at current concentrations (sediment only)	1.3×10^{-4}	Arsenic Beryllium	10 90	Dermal contact	99	0.672	NE	NE	NE	NE
Future excavation worker at current concentrations	5.8×10^{-4}	Arsenic Beryllium Uranium	2 98 <1	Ingestion of soil Dermal contact External exposure	3 96 <1	3.0	Antimony Beryllium Chromium Iron Manganese Vanadium	42 6 16 11 7 9	Ingestion of soil Dermal contact	8 92

Note: NA = ELCR not applicable to child and teen cohorts. Values for adult include exposure as child and teen.
NE = Land use scenario not of concern or land use not evaluated because contact with medium is not possible.
NC = no COPCs were retained after data screens.

[a] Total ELCR and total HI columns reflect values from Tables 1.94 to 1.103 in Vol. 4 without lead included.

Table 6.6. Summary of risk characterization results for C-720 Complex without lead as a COPC

Receptor	Total ELCR[a]	COCs	% Total ELCR	POCs	% Total ELCR	Total HI [a]	COCs	% Total HI	POCs	% Total HI
Current industrial worker at current concentrations (soil only)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Future industrial worker at current concentrations (soil only)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Current industrial worker at current concentrations (sediment only)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Future industrial worker at current concentrations (sediment only)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Future industrial worker at current concentrations (RGA groundwater only)	6.0×10^{-4}	Arsenic Beryllium 1,1-Dichloroethene Carbon tetrachloride Tetrachloroethene Trichloroethene Vinyl chloride Americium-241 Cesium-137 Neptunium-237 Plutonium-239/240 Technetium-99 Thorium-230 Uranium-235 Uranium-238	1 10 4 <1 <1 2 <1 23 <1 12 <1 <1 <1 6 38	Ingestion of groundwater Dermal contact Inhalation while showering	94 3 3	3.03	Antimony Iron Manganese Carbon tetrachloride Trichloroethene	6 45 11 6 17	Ingestion of groundwater Dermal contact Inhalation while showering	85 8 7

Table 6.6. Summary of risk characterization results for C-720 Complex without lead as a COPC

Receptor	Total ELCR[a]	COCs	% Total ELCR	POCs	% Total ELCR	Total HI [a]	COCs	% Total HI	POCs	% Total HI
Future industrial worker at current concentrations (McNairy groundwater only)	6.6×10^{-4}	Arsenic Beryllium 1,1-Dichloroethene Vinyl chloride Americium-241 Cesium-137 Neptunium-237 Uranium-235 Uranium-238	<1 30 2 <1 19 <1 11 4 32	Ingestion of groundwater Dermal contact Inhalation while showering	91 8 <1	9.75	Aluminum chromium Iron Manganese Vanadium	9 3 72 6 7	Ingestion of groundwater Dermal contact	95 5
Future child rural resident at current concentrations (RGA groundwater only)	NA -	NA	NA	NA	NA	47.5	Aluminum Antimony Arsenic Barium Beryllium Cadmium Chromium Iron Manganese Nickel Nitrite as nitrogen Uranium Vanadium 1,1-Dichloroethene Carbon tetrachloride Chloroform Trichloroethene cis-1,2-Dichloroethene trans-1,2-Dichloroethene	1 4 < 1 <1 <1 2 32 6 <1 <1 <1 1 <1 14 <1 33 <1 <1	Ingestion of groundwater Dermal contact Ingestion of vegetables Inhalation while showering Inhalation during household use	36 1 26 3 3

Table 6.6. Summary of risk characterization results for C-720 Complex without lead as a COPC

Receptor	Total ELCR^a	COCs	% Total ELCR	POCs	% Total ELCR	Total HI ^{a}	COCs	% Total HI	POCs	% Total HI
Future child rural resident at current concentrations (McNairy groundwater only)	NA	NA	NA	NA	NA	105	Aluminum Arsenic Barium Beryllium Cadmium Chromium Iron Manganese Nickel Uranium Vanadium Zinc 1,1-Dichloroethene Trichloroethene	9 <1 <1 <1 <1 3 74 4 <1 <1 6 <1 <1 <1	Ingestion of groundwater Dermal contact Ingestion of vegetables Inhalation during household use	59 1 39 <1
Future adult rural resident at current concentrations (RGA groundwater only)	6.0×10^{-1}	Arsenic Beryllium 1,1-Dichloroethene Carbon tetrachloride Chloroform Tetrachloroethene Trichloroethene Vinyl chloride Americium-241 Cesium-137 Neptunium-237 Plutonium-239/240 Technetium-99 Thorium-230 Uranium-235 Uranium-238	<1 7 11 1 <1 <1 3 2 14 <1 8 <1 24 <1 4 24	Ingestion of groundwater Dermal contact Inhalation while showering Inhalation from household use Ingestion of vegetables	41 <1 <1 10 48	15.0	Aluminum Antimony Arsenic Barium Chromium Iron Manganese Nickel Nitrite as nitrogen Vanadium Carbon tetrachloride Trichloroethene	2 5 1 1 2 38 7 <1 <1 1 11 26	Ingestion of groundwater Dermal contact Ingestion of vegetables Inhalation while showering Inhalation during household use	48 2 26 2 22

Table 6.6. Summary of risk characterization results for C-720 Complex without lead as a COPC

Receptor	Total ELCR[a]	COCs	% Total ELCR	POCs	% Total ELCR	Total HI[a]	COCs	% Total HI	POCs	% Total HI
Future adult rural resident at current concentrations (McNairy groundwater only)	4.9×10^{-3}	Arsenic Beryllium 1,1-Dichloroethene Trichloroethene Vinyl chloride Americium-241 Cesium-137 Neptunium-237 Technetium-99 Uranium-235 Uranium-238	1 28 6 <1 2 16 <1 10 7 4 27	Ingestion of groundwater Dermal contact Inhalation while showering Inhalation from household use Ingestion of vegetables	55 3 <1 5 37	39.7	Aluminum Arsenic Barium Beryllium Chromium Iron Manganese Nickel Uranium Vanadium Trichloroethene	9 <1 <1 <1 3 74 4 <1 <1 6 <1	Ingestion of groundwater Dermal contact Ingestion of vegetables	65 2 33
Future child rural resident at current concentrations (soil only)	NA	NA	NA	NA	NA	NE	NE	NE	NE	NE
Future adult rural resident at current concentrations (soil only)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Future child recreational user at current concentrations (soil only)	NA	NA	NA	NA	NA	NE	NE	NE	NE	NE
Future child recreational user at current concentrations (sediment only)	NA	NA	NA	NA	NA	NE	NE	NE	NE	NE
Future teen recreational user at current concentrations (soil only)	NA	NA	NA	NA	NA	NE	NE	NE	NE	NE
Future teen recreational user at current concentrations (sediment only)	NA	NA	NA	NA	NA	NE	NE	NE	NE	NE

Table 6.6. Summary of risk characterization results for C-720 Complex without lead as a COPC

Receptor	Total ELCR[a]	COCs	% Total ELCR	POCs	% Total ELCR	Total HI [a]	COCs	% Total HI	POCs	% Total HI
Future adult recreational user at current concentrations (soil only)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Future adult recreational user at current concentrations (sediment only)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Future excavation worker at current concentrations	7.9×10^{-5}	Arsenic Beryllium Vinyl chloride	11 82 6	Ingestion of soil Dermal contact Inhalation of VOCs and particulates	9 88 2	0.388	NE	NE	NE	NE

Note: NA = ELCR not applicable to child and teen cohorts. Values for adult include exposure as child and teen.
NE = Land use scenario not of concern or land use not evaluated because contact with medium is not possible.
NC = no COPCs were retained after data screens.

[a] Total ELCR and total HI columns reflect values from Tables 1.94 to 1.103 in Vol. 4 without lead included.

Table 6.7 Summary of hazard quotients for chemicals[a] posing potential future risks[b] to nonhuman receptors

		Chemicals of Potential Ecological Concern								
Location	Receptor	Al	Cd	Cr	Pb	Hg	Ni	Se	Ag	Zn
SWMU 001 Ditch soil	Plant	—		16.8	—	—	—	—		1.3
	Worm	—		42.0	—	—	—	—		—
	Shrew	—		—	—	—	—	—		—
	Mouse	—		—	—	—	—	—		—
	Deer	—		—	—	—	—	—		—
SWMU 091 Ditch soil	Plant	262.0	1.6	16.8	—	—	—	—		3.3
	Worm	nb	—	42.0	—	4.7	—	—		1.6
	Shrew	25.4	—	—	—	—	—	—		—
	Mouse	1.2	—	—	—	—	—	—		—
	Deer	1.5	—	—	—	—	—	—		—
SWMU 196 Ditch soil	Plant	—	—	—	—	—	4.7	—		4.4
	Worm	—	—	—	—	9.7	—	—		2.2
	Shrew	—	—	—	—	—	—	—		4.0
	Mouse	—	—	—	—	—	—	—		—
	Deer	—	—	—	—	—	—	—		—
SWMU 196 Surface soil	Plant	—	3.1	—	1.1	—	10.9	4.8	10.5	—
	Worm	—	—	—	—	21.4	1.6	—	nb	—
	Shrew	—	—	—	—	—	—	—	nb	—
	Mouse	—	—	—	—	—	—	—	nb	—
	Deer	—	—	—	—	—	—		nb	—

Notes: Al = aluminum; Cd = cadmium; Cr = chromium; Pb = lead; Hg = mercury; Ni = nickel; Se = selenium; Ag = silver; Zn = zinc.

"—" indicates that the hazard quotient for the chemical/receptor combination did not exceed 1 or the chemical was below background at that site.

"nb" indicates no toxicological benchmark was available for the chemical/receptor combination.

[a] The table includes values for those chemicals with a maximum concentration above background (or no background available) and at least one hazard quotient > 1.0. Analytes for which ecological benchmarks were not available are shown in Tables 2.1 and 2.2 of Vol. 4.

[b] Values in this table are hazard quotients estimated by dividing the dose to the receptor by the benchmark dose.

7. CONCLUSIONS

7.1 INTRODUCTION

This section presents conclusions about the hydrogeologic setting (Sect. 3), contaminant sources, contaminant migration pathways, affected environmental media, human health risk assessment, and ecological risk assessment at the four WAG 27 sites. These conclusions are drawn from known site conditions (Sect. 3), the nature and extent of contamination (Sect. 4), the fate and transport of contaminants (Sect. 5), and the risk to human health and the ecological communities associated with the identified contaminants (Sect. 6).

7.1.1 Major Findings of Contaminant Distribution

The major contaminant distribution findings of the WAG 27 RI are:

- Environmental media have been impacted by releases of contaminants at each of the four sites investigated during the WAG 27 RI;
- Metals contamination was detected at all sites, but soils contaminated with metals are generally confined to the upper 20 ft of the UCD;
- TCE and TCE degradation products are site-derived contaminants and are the primary contaminants in the soil at all sites except at the C-746-A Septic Systems (SWMU 196);
- High concentrations of TCE at SWMU 001 and the C-720 Building indicate that isolated areas of free phase TCE may be present in the UCD soil;
- TCE leaching from primary and secondary sources at SWMU 001 and the C-720 Building has impacted the RGA groundwater. TCE released at SWMU 091 does not appear to have had a measurable impact on the RGA groundwater;
- Tc-99 is present in the RGA groundwater at SWMUs 001 and 091 and the C-720 Building but is not a significant contaminant in the overlying soils at any of the sites. The absence of elevated Tc-99 levels in the UCD suggests that this mobile radionuclide has been flushed from the system or that the source of the Tc-99 is unrelated to the WAG 27 sites;
- TCE and Tc-99 contaminant plumes in the RGA have been identified at the C-720 Complex and at SWMUs 001/091. The RGA plume at SWMUs 001/091 extends off-site for an undetermined distance; and
- Contaminant transport from the RGA into the underlying McNairy Formation is not a significant migration pathway.

7.1.2 Hydrogeologic Setting

During the WAG 27 RI process, data were gathered on the stratigraphy and hydrogeologic conditions at each of the four sites. Due to the proximity of the investigated sites, the subsurface geology and hydrogeology were found to be very similar for each area studied. Several of the

DQO questions that were developed during the WAG 27 Work Plan development stage concern the physical and chemical properties, stratigraphy, and hydrogeology of the geologic units at each of the sites. To eliminate redundancy, these related DQO questions are addressed below in a single section. However, special emphasis has been given to variations in conditions specific to each individual SWMU or to the C-720 Building.

What is the stratigraphy (and physical and chemical properties) of the soil and how do these parameters affect the migration and distribution of contaminants from the source?

Three lithologic units are encountered in the subsurface at WAG 27. These are, in ascending order: the McNairy Formation, the LCD, and the UCD. Sediments included within the McNairy Formation are predominantly gray lignitic clays and silts that subcrop at approximately 100 ft bgs. The McNairy sediments are overlain by 50 ft of porous and permeable coarse-grained sands and chert gravels of the LCD. The LCD is in turn overlain by a fining-upward sequence of gravels, sands, silts, and clays of the UCD. Sands and gravels within the UCD are typically fine-grained, poorly sorted, and occur as laterally discontinuous lenses within a matrix of finer-grained material.

At the PGDP, the UCD averages approximately 50 ft in thickness and the water table is typically encountered at approximately 45 to 50 ft bgs. As a result, most of the UCD sediments are within the vadose zone, whereas the LCD and McNairy Formation are below the water table.

The physical and chemical properties of subsurface soil and the depth to the water table at WAG 27 play an important role in the migration and distribution of contaminants in the subsurface. Because the primary releases at each of the sites occurred in the upper few ft of soil, the significant secondary contaminant sources are located within the clay rich UCD sediments. Relative to the LCD, the permeability of the UCD sediments is relatively low. However, the UCD is not an aquitard and leaching of contaminants from the UCD during the infiltration and downward migration of precipitation toward the LCD (and water table) is the primary contaminant dispersion pathway at each of the sites investigated.

As contaminated fluids migrate through the UCD, the physiochemical properties of the shallow soil can have a pronounced affect on the preferential migration pathway and can retard the migration of selected contaminants. At each of the three SWMUs and the C-720 Building, where metals have been identified as COCs, the most and highest concentrations of metals are typically restricted to the upper 20 ft of the UCD. The metals are apparently trapped by the clay rich soil in the upper UCD because the metal ions have a high affinity to sorb to clays. At SWMU 001, the UCD soil also was found to have a high TOC content (average 801 mg/kg) which affects the migration of VOAs to the deeper subsurface. The source for this carbon is possibly from the decomposition of waste oil that was landfarmed at SWMU 001. The presence of a high carbon content increases the probability that VOAs will be sorbed to the soil, which may explain why higher concentrations of TCE are not present in the RGA groundwater downgradient from the source.

Because most of the UCD is within the vadose zone, lateral transport of contaminants is not a significant contaminant distribution process. An exception to this observation occurs at the C-720 Building. On the south side of the building, shallow groundwater (probably sourced from a broken water line) has resulted in the lateral transport of contaminants within the UCD. However, even where shallow groundwater is present in the UCD, the lack of continuous sands limits the availability of conduits for long distance lateral migration. The combination of a deep water table, the lack of shallow continuous sands in the vadose zone, and the presence of a DNAPL (TCE) as the principle contaminant at most sites has resulted in the development of a UCD soil contaminant zone that is cylinder-shaped and extends from the near surface source to the top of the local water table.

Once the downward migrating contaminated fluids intersect the water table (the RGA), the migration pathway is redirected from vertical to lateral as the contaminants are incorporated into, and carried along with, the groundwater flow toward the west-northwest. Because the McNairy Formation has a lower permeability than the overlying RGA sediments, and because groundwater flow typically will follow the path of least resistance, mixing of the contaminated RGA groundwater with the deeper McNairy flow system is not extensive. As a result, the McNairy groundwater is relatively uncontaminated.

7.2 WAG 27 SWMU-SPECIFIC DQO QUESTIONS

The primary DQO questions that were developed during scoping of the work plan have been grouped into like categories and are addressed individually for each of the three SWMUs investigated and for the C-720 Building.

C-747-C Oil Landfarm (SWMU 001)

What are the potential contaminants? What are the plant processes that have contributed? When did the release(s) occur?

The C-747-C Oil Landfarm was used from 1973 to 1979 for landfarming of waste oils contaminated with TCE, uranium, PCBs and 1,1,1-trichloroethene. These waste oils were believed to have been derived from a variety of plant processes. During the WAG 27 RI, VOAs (including TCE and vinyl chloride) and several metals, including arsenic, antimony, cadmium, magnesium, manganese and silver, were identified at concentrations above screening levels in the shallow subsurface soil and sediments at SWMU 001. Although not detected in soils at high concentrations, Tc-99 also may have been contained in the waste oils that were landfarmed at SWMU 001.

What are the concentrations and activities at the source? What is the area and volume of the source zone?

TCE was found in SWMU 001 soils at a maximum concentration of 439,000 ug/kg, a concentration that is indicative of DNAPL. Lower concentrations of several TCE degradation products are also present at the site. The extent of TCE contamination in the vadose soils is confined to a zone that is approximately 175 x 115 ft in size located near the north side of the old landfarm. Soils impacted with TCE and associated VOAs were found to extend from the near ground surface to the top of the water table at 50 ft bgs. The volume of soil impacted by TCE and related VOAs is approximately 1,006,000 cubic ft. Metals were detected in the subsurface soils at concentrations that exceed background levels by up to 27 times. The metals are widely dispersed throughout the landfarm, but the highest concentrations of metals are generally restricted to the upper 20 ft of vadose zone soil. The maximum volume of soil contaminated by metals covers an area that is 290 x 200 x 28 ft for a volume of over 1,624,000 cubic ft. of soil.

What are the past, current, and future release and migration pathways? What are the contaminant migration trends? What is the effect of utilities on the migration pathways?

Releases of contaminants to the environment occurred at SWMU 001 during the landfarming of waste oils. The landfarm is not currently active and secondary releases from the contaminated soil within the landfarm represent the current and future potential release mechanism. Past migration pathways at SWMU 001 during the active phase of the landfarm may have included downward leaching of contaminants to groundwater, possible surface-water runoff, airborne dispersion of particulates, and volatilization. The passage of time and the stabilization of the landfarm surface by vegetation have effectively reduced volatilization, airborne dispersion, and surface runoff pathways. Monitoring of intermittent surface-water runoff at controlled discharge points indicates that runoff is not currently a factor for contaminant migration from SWMU 001 to downgradient receptors.

Infiltration of groundwater through the vadose zone is the primary migration pathway for the dispersion of contaminants from SWMU 001. Underground utilities do not represent a current or potential future migration pathway. Migration of the groundwater through the vadose zone is predominantly in a vertical direction. Evidence of significant lateral transport of contaminants within the UCD was not observed.

Does contamination reach the groundwater? What is the role of the UCRS in contaminant transport? Where is the dissolved phase plume migrating to?

Leaching of contaminants from the UCD soil has resulted in the migration of contaminants into the UCRS groundwater. Site-related contaminants identified in the UCRS at SWMU 001 include low concentrations of TCE (312 ug/L) and TCE degradation products. Although 18 borings were drilled into the lower UCRS, groundwater was present only in a single sample and is therefore not laterally extensive. When present, groundwater in the UCRS probably serves to transport dissolved phase contaminants vertically into the underlying RGA.

Within the RGA, the preferential migration direction is by lateral movement (flow and dispersal) through LCD sediments. A plume of contaminated groundwater containing as much as 1578 ug/L of TCE and Tc-99 at a maximum activity of 3709.6 pCi/L has been identified at SWMU 001. The contaminant plume appears to be migrating to the west-northwest (downgradient) and currently extends beyond the plant security fence. The source of the TCE observed in the RGA groundwater is from leaching of UCD soils at SWMU 001; the source of the Tc-99 has not been defined.

Downward migration of contaminants into the underlying McNairy Formation, as evidenced by the lack of TCE at concentrations above a few ug/L, does not appear to be an ongoing process.

UF_6 Cylinder Drop Test Site (SWMU 091)

What are the potential contaminants? What are the plant processes that have contributed? When did the release(s) occur?

During late 1964 and early 1965 and again in February 1979, cylinder drop tests were conducted at SWMU 091. A brine-ice bath was used to chill the cylinder during the first test, and a TCE and dry-ice bath was used during the 1979 test. Leakage from the unlined in-ground pit that was used to hold the TCE refrigerant and cylinder during this second test is presumed to be the source of the shallow soil and groundwater contamination identified at SWMU 091 during past investigations. Results of the RI indicate that metals and radionuclides are present at elevated concentrations in the shallow soils.

What are the concentrations and activities at the source? What is the area and volume of the source zone?

Three metals (Al, Cd, and Na) and one radionuclide (Pu-239/240) were detected above screening levels in the ditch sediment samples at SWMU 091. Only one constituent, Cd, was found at a significant concentration. Pu-239/240 was detected once at an activity only slightly above screening levels. No area or volume was calculated for the sediment source zone. TCE contamination in the subsurface soil at SWMU 091 has been addressed in a May 1998 ROD.

What are the past, current, and future release and migration pathways? What are the contaminant migration trends? What is the effect of utilities on the migration pathways?

Releases of contaminants to the environment at SWMU 091 occurred when TCE leaked from an in-ground pit during cylinder drop testing in 1979. This pit is no longer in use and secondary releases from the contaminated soil represent the current and future potential release mechanisms. Past migration pathways at SWMU 091 may have included downward leaching of contaminants to groundwater, possible surface-water runoff, and volatilization. Underground utilities are not present at SWMU 091 and, therefore, do not represent a pathway for migration.

Precipitation, mostly as rainfall infiltrating through the vadose zone to the groundwater, is the primary migration pathway for the dispersion of contaminants from SWMU 091. Remediation of the contamination (specifically TCE) in shallow (<45 ft bgs) subsurface soils currently is being implemented under an August 1998 ROD.

Based on the results of the WAG 27 RI, the release of contaminants to nearby surface water from runoff is not a significant migration pathway.

Does contamination reach the groundwater? What is the role of the UCRS in contaminant transport? Where is the dissolved phase plume migrating to?

No groundwater samples were collected from the UCRS at SWMU 091. Groundwater samples from the RGA and the McNairy flow system contained VOAs (TCE and its degradation products), radioactive isotopes, and metals at concentrations above screening levels.

Contaminant migration within the RGA occurs predominantly as lateral flow and dispersion through the LCD as groundwater moves to the west-northwest. A contaminant plume of TCE and Tc-99 has been identified in the RGA groundwater beneath SWMU 091, but the primary sources of the contaminants appear to lie in an upgradient direction. While vertical migration of fluid through the UCD is a major migration pathway at SWMU 091, leaching of contaminants to the RGA groundwater is not believed to be significant due to the small volume of TCE released at the site. Beneath SWMU 091, the maximum concentration of TCE detected in an RGA groundwater sample was 112 ug/L. The maximum activity of Tc-99 detected was 568.1 pCi/L.

No clear evidence suggests that the metals detected in RGA groundwater samples at SWMU 091 were derived from a source at SWMU 091.

Groundwater samples from the McNairy Formation beneath SWMU 091 contain low levels of TCE (1.9 ug/L), Th-230 (maximum 53.77 pCi/L), and uranium (0.001 pCi/L). These very low concentrations/activities indicate that the downward migration of contaminants into the low-permeability McNairy clays from the overlying RGA, is not a major contaminant migration pathway.

C-746-A Septic Systems (SWMU 196)

What are the potential contaminants? What are the plant processes that have contributed? When did the releases occur?

The C-746-A Building was used as a warehouse during plant construction. Subsequent operations were for metal storage and smelting. An aluminum smelter was operated in the west end of the building between 1956 and 1985. Beginning in 1975 and continuing until 1985, a nickel smelter was operated in the east end of the building. Current operations include storage of hazardous and PCB waste. Although no specific releases are recorded, hazardous materials may have been processed through the septic systems. Based on the activities taking place in the C-746-A Building, VOAs, metals and radionuclides could have been released. Results of this RI indicate that only metals are present at concentrations above screening levels in the UCD soil at SWMU 196.

What are the concentrations and activities? What is the area and volume of the source?

Eighteen metals were detected above screening levels at SWMU 196, many of which were only slightly above screening values. The area impacted by metals at the NE septic system is approximately 70 ft x 60 ft (includes septic tank and leachfield) and extends to approximately 10 ft bgs. The area impacted by the metals contamination along the NW drain lines is more extensive, and is approximately 100 ft x 10 ft along the line extending north-south to the west of the building and 180 ft x 10 ft along the line extending east-west to the west of the septic tank. The contamination extends to approximately 10 ft bgs along both of these lines. The most frequently detected metal was antimony, which was found in 28 samples from eight locations at a maximum concentration of 121 mg/kg. Other metals detected include beryllium (113 mg/kg), cadmium (116 mg/kg), and thallium (114 mg/kg).

What are the past, current and future release and migration pathways? What are the contaminant migration trends? What is the effect of utilities on the migration pathways?

Past potential release points include septic tanks and leachfield lines. The septic systems were plugged and abandoned in 1980 and are not a current or future release point. The septic tanks were emptied and filled with inert masonary sand in January and February 1998 and are not a current or future release point.

Past migration pathways at SWMU 196 include downward leaching to groundwater. Precipitation, mostly as rainfall that infiltrates into the subsurface and migrates vertically, is the primary migration pathway for the dispersion of contaminants from SWMU 196. Results of the WAG 27 RI show that vertical migration of metals extends to approximately 10 ft bgs at SWMU 196.

Does contamination reach the groundwater? What is the role of the UCRS in contaminant transport? Where is the dissolved phase plume migrating to?

The water table was not encountered in the shallow borings drilled at SWMU 196.

C-720 Complex

What are the potential contaminants? What are the plant processes that have contributed? When did the releases occur?

The C-720 Building was constructed in the mid-1950s and housed various facilities, including a compressor shop, machine shop, paint shop, valve shop and White Room for cleaning electronics. Oils, solvents, and degreasers were used frequently in the shop processes for machining and cleaning equipment. Solvents, such as TCE, were also used at a staging area north of the building for cleaning various parts and smaller pieces of equipment.

Although no specific occurrence of a release or spill was documented, the drains and sumps may have been mechanisms for contaminants to be released to the subsurface soil and groundwater. Liquids collected in the network of 150 floor drains throughout the building were discharged via eight exit points that connected to the plant stormwater system. Due to the construction and condition of the stormwater manholes where the building drainage system connected, these areas represented potential release mechanisms of contaminants discharged into the building drainage system.

Based on the history of activities and processes within the C-720 Building, VOAs, SVOAs, PCBs, metals, and radionuclides could have been released to the surrounding environment. Data from this RI indicate, however, that only VOAs, primarily TCE and it degradation products, SVOAs, and metals have contaminated shallow subsurface soil.

What are the concentrations and activities at the source? What is the area and volume of the source zone?

Two separate areas of contamination were identified at the C-720 Complex. A large rectangular area was defined north of the building measuring 1050 ft x 225 ft. An estimated 4,725,000 ft^3 of VOA-contaminated soil was reported from the zone between 17 and 42 ft. The volume of metals–contaminated soil in this zone was 660,000 ft^3. In the north area, a maximum TCE concentration of 14,000 μg/kg was found. 1,1-DCE was detected at a concentration of 200 μg/kg. Maximum detected metals concentrations were much lower than those found in the south source.

Another area delineated south of the building measures 825 ft x 150 ft. The constituents accounting for the greatest volumes of soil contamination south of the building were TCE (1,608,750 ft^3)and metals (312,000 ft^3).These areas are considered secondary sources due to the contaminant occurrence in the subsurface. The UCD soil south of the building had a maximum TCE concentration of 68,000 μg/kg, an estimated maximum concentration of *trans*-1,2-DCE of 450,000 μg/kg, and a maximum vinyl chloride concentration of 400 μg/kg. Metals were detected at maximum concentrations in boring 720-024 between 35 and 50 ft. Bis(2ethylhexyl)phthalate was also detected at a maximum concentration of 1,100 μg/kg in this boring.

The Compressor Shop pit sump is a potential source if material is being released. The sludge sample collected from the sump had the highest TCE concentration (420,000 ug/kg) and the highest Tc-99 activity (27,520.6 pCi/g) detected at the site. 1,1-DCE, bis(2-ethylhexyl)phthalate, metals, PCBs, and radionuclides were also detected in this sample.

What are the past, current, and future release and migration pathways? What are the contaminant migration trends? What is the effect of underground utilities on the migration pathway?

Three historic release points were identified in the RI: the drainage system exit points, the cleaning area north of the building, and the Compressor Shop pit sump. Significant soil contamination was observed at five of the drainage exit points and at the cleaning area north of the building. These areas represent secondary sources that will likely continue to release contaminants to groundwater. Based on the subsurface soil contaminant distribution, the primary migration pathway is vertical through the UCD to the RGA groundwater. Lateral transport in the UCD occurs on the south side of the C-720 Building along the east-west storm drain in the 7- to 10-ft depth range. Although there is potential leaching from the Compressor Shop pit sump, this was not confirmed from soil samples taken in the area.

Does contamination reach the groundwater? What is the role of the UCRS in contaminant transport? Where is the dissolved phase plume migrating to?

TCE, at a maximum concentration of 149 ug/L, and small quantities of TCE degradation products were the only contaminants reported in the UCRS water samples at the C-720 Building. All five of the UCRS water samples were collected in locations adjacent to the south and east side of the building. Coincidentally, a break in a water main located some tens of feet south of the building was being repaired during the RI. Therefore, the water recovered from the UCRS in this area may have been sourced from this broken water line.

TCE and Tc-99 were detected at significant levels in RGA groundwater at the C-720 Building; however, of these only TCE was detected above screening levels in the UCD soils. Once contaminants reach the RGA, migration is to the west-northwest. Because of the transmissivity of the RGA, migration of fluids from the RGA into the McNairy is not a major groundwater flow path. This is evidenced by the fact that little or no contamination was found in groundwater samples collected from the McNairy flow system.

7.3 BASELINE RISK ASSESSMENT

For all four WAG 27 sites, the cumulative human health ELCR and systemic toxicity exceed the accepted standards of the KDEP and the EPA for one or more scenarios when assessed using default exposure parameters. The scenarios for which risk exceeds *de minimis* levels (i.e., a cumulative ELCR of 1×10^{-6} or a cumulative HI of 1) are summarized in Table 6.2.

Because WAG 27 is located in the industrialized portion of the PGDP, the BERA project team concluded during problem formulation that it would not be appropriate to derive risk estimates for impacts to nonhuman receptors under current conditions. However, in an analysis to determine potential impacts to nonhuman receptors exposed to contaminants in surface soil or ditch sediment in the future, if the industrial infrastructure were removed, and to estimate the potential impact of surface migration of contaminated media was performed. Several contaminants in surface soil from SWMU 196 and exposed sediments in drainage ditches associated with SWMUs 001, 091, and 196 were found to be at concentrations greater than levels believed protective of nonhuman receptors. Table 6.7 summarizes these COPECs. Because contaminants at the C-720 Building and SWMU 091 are restricted to subsurface soils below gravel- or cement-covered areas, effectively eliminating potential exposures, the BERA project team concluded that it would not be appropriate to derive risk estimates for nonhuman receptors to contaminants in surface soil at these two sites. Surface soils at SWMU 001 have already been evaluated and addressed as part of the WAG 23 ROD, so they are not re-evaluated for SWMU 001 here.

7.3.1 Observations of the Baseline Human Health Risk Assessment

Observations from the BHHRA focus on the industrial land use (the current and most plausible future land uses for the WAG 27 sites), and the observations of the BERA focus on the potential risks to nonhuman receptors.

- Use of the provisional lead RfDs provided by KDEP results in total HIs that exceed 1000 for the use of groundwater at the WAG 27 sites and for those locations where the maximum detected concentration of lead in soil exceeded its background concentration. However, when these provisional values are not included in the risk characterization, total HIs are markedly reduced. Due to the uncertainty in the results using the provisional lead RfDs, a better understanding of the risks presented by lead may be gained by comparing the representative exposure concentrations of lead in soil and groundwater to screening levels from KDEP and EPA. In these comparisons, the concentrations of lead in RGA and McNairy Formation groundwater, at all sites, are seen to exceed the KDEP screening level. The EPA screening level is also exceeded for RGA and McNairy Formation groundwater at all sites except the C-720 Complex. The representative exposure concentrations of lead in sediment and subsurface soil never exceed either screening level. However, the representative concentration of lead in surface soil at SWMU 196 exceeds only the KDEP screening level. None of the representative concentrations in surface soil exceed the EPA screening level.

- The dermal contact with soil exposure route poses considerable risk, predominantly from contact with metals in soil (primarily beryllium). In fact, for all land use scenarios evaluated, the systemic toxicity and the ELCR posed through the soil and sediment dermal exposure route exceed that posed by the ingestion route. Remedial action decisions based on the dermal contact with soil exposure route should be carefully considered because of the uncertainty associated with risk from this exposure route.

- The current land use scenario, industrial use, has risk that is above *de minimis* levels at each site except the C-720 Complex, where contact with surface soil is not possible and no ditches are present. At SWMU 001, the pathway driving both systemic toxicity and ELCR is dermal contact with sediment. At SWMU 091, the pathway driving systemic toxicity is dermal contact with sediment, and ELCR is driven by external exposure to sediment. At SWMU 196, the pathway driving systemic toxicity is dermal contact with sediment, and the ELCR is driven by both external exposure to soil and dermal contact with sediment. For the C-720 Complex, no COCs were identified for soil or sediment for the current industrial worker.

No one contaminant dominates contribution to systemic toxicity. The total HI at each site is less than 3. The primary contaminant driving ELCR within this pathway is beryllium, and also contributing are radionuclides (Np-237 and Cs-137) for all sites.

- The most plausible future land use scenario, industrial use, has risk that is above *de minimis* levels at each WAG 27 site. The future industrial land use scenario is identical to the current industrial land use scenario except that the former also includes use of RGA and McNairy Formation groundwater. The addition of groundwater as a medium of exposure adds significantly to the risk for this scenario. If groundwater contribution is removed from the risk totals, the driving pathways are identical to those of the current industrial land use scenario.

- Risks from use of groundwater (without the risk contribution of lead) drawn from both the RGA and the McNairy Formation exceed *de minimis* levels for all scenarios at each site except SWMU 196, where no COPCs were identified. For the RGA, across all land uses at SWMU 001, the contaminants contributing greater than 10% ELCR were arsenic, radon-222, beryllium, and technetium-99. The contaminants contributing greater than 10% systemic toxicity were various metals. For the McNairy, across all land uses at SWMU 001, the contaminants contributing greater than 10% ELCR were beryllium, americium-241, and uranium-238. The contaminants contributing greater than 10% systemic toxicity were various metals. For the RGA, across all land uses at SWMU 091, the contaminants contributing greater than 10% ELCR were radon-222, americium-241, and beryllium. The contaminants contributing greater than 10% systemic toxicity were various metals and TCE. For the McNairy, across all land uses at SWMU 091, the contaminants contributing greater than 10% ELCR were americium-241, neptunium-237, and uranium-238. The contaminant contributing greater than 10% systemic toxicity was uranium. For the RGA, across all land uses at the C-720 Building, the contaminants contributing greater than 10% ELCR were beryllium, americium-241, neptunium-237, uranium-238, 1,1-dichloroethene, and technetium-99. The contaminants contributing greater than 10% systemic toxicity were various metals, TCE, and carbon tetrachloride. For the McNairy, across all land uses at the C-720 Complex, the contaminants contributing greater than 10% ELCR were beryllium, americium-241, neptunium-237, and uranium-238. The contaminants contributing greater than 10% systemic toxicity were various metals.

- Inhalation of VOAs and particulates emitted via the soil exposure is a POC for the excavation worker at SWMU 001 and the C-720 Complex. The contaminant driving risk within this pathway and scenario combination is vinyl chloride.

- COCs migrating from sources in the WAG 27 soil and groundwater as determined by risk estimates for future residential groundwater users are phenanthrene, *trans*-1,2-dichloroethene, TCE, vinyl chloride, xylenes, antimony, manganese, silver, thallium, and vanadium. There were no radionuclide COCs.

7.3.2 Observations of the Baseline Ecological Risk Assessment

- Nine inorganic COPECs, all, exceeded benchmarks for at least one receptor group (Table 6.7). The inorganics were aluminum, cadmium, chromium, lead, mercury, nickel, selenium, silver, and zinc. Of these, aluminum, chromium, and lead were near background levels. Aluminum is unlikely to be of concern at WAG 27, as the maximum aluminum concentration in any of the four sites was only 1.01 times background. Similarly, chromium and lead were near background levels (maximum of 1.05 times and 1.5 times background, respectively). Cadmium was of concern only for plants in the SWMU 091 ditch and SWMU 196 soil. However, hazard quotients were low (less than 3.1), and the areas are currently covered with vegetation. Mercury was of concern only for soil invertebrates exposed to ditch sediment in SWMUs 091 and 196 and surface soil in SWMU 196. Nickel was of potential concern for plants and invertebrates in SWMU 196 surface soil and for plants in SWMU 196 ditches. Selenium and silver were of potential concern for plants in SWMU 196 surface soil. Zinc was of potential concern, with low hazard quotients for plants, soil invertebrates, and shrews in SWMU 196 ditches; plants and soil invertebrates in SWMU 091 ditches; and plants in SWMU 001 ditches. However, the maximum zinc concentration was only 3.4 times background.

- Estimated doses from exposure to radionuclides in soil or ditch sediment were below recommended dose rate limits (IAEA, 1992) for all receptors in all areas. Therefore, no unacceptable risks are expected from exposure to radionuclides.

- Uncertainty concerning the future condition, the bioavailability of various metals (e.g., aluminum and chromium were only slightly elevated above background), and use of only one line of evidence may have led to an overestimate of potential future ecological risks.

A summary of COEPCs and receptors potentially at risk should future exposures occur is presented in Table 6.7.

7.4 WAG 27 SWMU-SPECIFIC DECISION RULES AND CONCLUSIONS

The decision rules for the WAG 27 RI are addressed individually for SWMUs 001, 091, and 196 and the C-720 Complex in Tables 7-1 through 7-4. Conclusions based on the DQO process and the risk-based decision rules indicate that risk from exposure to contaminated media exists at each of these sites. However, these risks do not pose an imminent or immediate threat to human health or the environment at any of the four locations. Risk-based analysis of data generated during the investigation indicates that response actions may be appropriate for impacted media at each of the four sites.

Based on the remediation strategy stated in the PGDP SMP (DOE 1998b), the appropriate response actions will be incorporated into the major Remedial Actions (RAs) proposed for three of the five PGDP OUs. Specifically, impacted media at the four sites will be addressed as follows:

- Impacted sediments at each of the three SWMUs will be addressed as part of the Surface Water OU. Sediments are not present at the C-720 Complex.

- Impacted soils at SWMUs 001 and 196 will be considered as part of the Surface Soil OU. Contaminated soils at SWMU 091 are included within the scope of the LASAGNA Technology. Surface soils (1 to 10 ft bgs) are not applicable at the C-720 Complex.

- Impacted groundwater at SWMUs 001 and 091 and at the C-720 Complex will be evaluated as part of the PGDP Groundwater OU. Contaminated groundwater was not identified at SWMU 196.

Table 7.1. WAG 27 SWMU 001-specific decision rules and conclusions

DECISION RULE	CONCLUSION	COMMENTS
D1a: If the concentration of analytes found in the source zone may result in a cumulative excess lifetime cancer risk greater than 1×10^{-6} or a cumulative hazard index greater than 1 through contact with contaminated media, or if the concentration of analytes in the source zone may result in detrimental impacts to nonhuman receptors through contact with contaminated media as indicated by exceeding ecological screening criteria, and if the concentrations of analytes in the source zone are greater than those that are expected to occur naturally in the environment, then evaluate actions that will mitigate risk; otherwise pursue a "no further action" decision (see D1b and D1c).	Risks from direct contact with sediment exceed *de minimis* levels for industrial workers. Risks to the excavation worker exposed to contaminated soils exceed *de minimis* levels. Risks from potential use of the RGA as a drinking water source at the SWMU exceed *de minimis* levels for the industrial worker. Risks to nonhuman receptors are *de minimis* under current conditions due to the industrial nature of the SWMU; additionally, the contaminant concentrations are such that risks may not exceed *de minimis* levels in the future.	Risks for the industrial worker from exposure to sediment were greater than *de minimis* when the analysis was performed using default exposure parameters. When the assessment was performed using site-specific exposure parameters and reduced dermal absorption values for inorganic chemicals, the systemic toxicity risk was less than the *de minimis* level, and the cancer risk approached the *de minimis* level. Risks were greater than *de minimis* for the excavation worker when default exposure parameters were used. However, when the assessment was performed using site-specific exposure parameters, the systemic toxicity risk was less than the *de minimis* level and the cancer risk was 1×10^{-5}. Groundwater drawn from the RGA below the plant is not currently used at PGDP. Exposure to surface soil was not evaluated as part of the WAG 27 project. These risks are being mitigated as part of the WAG 23 project. Migration of contaminants from soil to groundwater and surface water is discussed under Decision Rules D3a and D3b, respectively.
D1b: If concentrations of analytes found in the source zone exceed applicable or relevant and appropriate requirements (ARARs), then evaluate actions that will bring contamination within the source zone into compliance with ARARs; otherwise, pursue a "no further action" decision (see D1a and D1c).	Contaminant concentrations in RGA groundwater exceed MCLs for some contaminants.	No chemical-specific ARARs are available for screening contaminant concentrations in sediment or soil. Migration of contaminants from soil to groundwater and surface water is discussed under Decision Rules D3a and D3b, respectively.

Table 7.1. WAG 27 SWMU 001-specific decision rules and conclusions

DECISION RULE	CONCLUSION	COMMENTS
D1c: If contaminants found at the site are known to transform or degrade into chemicals that could lead to increased risks to human health or the environment or into chemicals for which there are ARARs, and if the concentrations of these contaminants may result in risks greater than those defined in D1a or concentrations greater than ARARs, then evaluate actions that will mitigate potential future risk or promote compliance with ARARs; otherwise, pursue a "no further action" decision (see D1a and D1b).	The COCs driving direct contact risks in soil, sediment, and groundwater at SWMU 001 may degrade into more toxic substances that lead to increased risk at concentrations that exceed chemical-specific ARARs.	
D2a: If secondary sources are found, and if the concentrations of analytes within the secondary sources are found to potentially result in a cumulative excess lifetime cancer risk greater than 1 x 10^{-6} or a cumulative hazard index greater than 1 through contact with contaminated media at the unit, and if the concentrations of analytes are greater than those that are expected to occur naturally in the environment, then evaluate actions that will mitigate risk; otherwise, do not consider secondary sources when making remedial decisions for the unit.	Secondary sources were identified. These secondary sources may continue to release contaminants to groundwater.	TCE DNAPL is present in subsurface soil at SWMU 001.
D3a: If contaminants are found in the source zone, or if secondary sources are found, and are found to be migrating or may migrate from the source zone or from secondary sources at concentrations that may potentially result in a cumulative excess lifetime cancer risk greater than 1 x 10^{-6} or a cumulative hazard index greater than 1 through use of contaminated media at downgradient points of exposure, and the concentrations of analytes are greater than those that are expected to occur naturally in the environment, then evaluate actions that will mitigate risk; otherwise, do not consider risk posed by migratory pathways when evaluating remedial alternatives for the unit (see D3b).	Multimedia transport modeling indicates that contaminants may be released from soils and secondary sources at SWMU 001 and result in risks to off-site residential groundwater users that exceed *de minimis* levels. The RI determined that contaminants are not migrating from SWMU 001 through the surface-water pathway at concentrations that would lead to risks that exceed *de minimis* levels.	Transport modeling identified antimony, TCE, and vinyl chloride as migrating off-site through groundwater at concentrations that lead to risks that exceed *de minimis* levels.

Table 7.1. WAG 27 SWMU 001-specific decision rules and conclusions

DECISION RULE	CONCLUSION	COMMENTS
D3b: If contaminants are found in the source zone, or if secondary sources are found, and if these contaminants are found to be migrating or may migrate from the source zone or from the secondary sources at concentrations that exceed ARARs, then evaluate actions that will bring migratory concentrations into compliance with ARARs; otherwise, do not consider ARARs when examining migratory pathways during the evaluation of remedial actions (see D3a).	Multimedia transport modeling indicates that contaminants may be released from soil and secondary sources at SWMU 001 and result in concentrations in off-site groundwater that exceed MCLs.	ARARs for TCE and breakdown products in groundwater are exceeded in off-site locations.
D4a: If Decision Rules D1a, D1b, D1c, D2a, D3a, or D3b indicate that remedial actions are needed, then evaluate response actions to mitigate risk in the source zone. (Refer to Sect. 5.11 and 5.12 of the WAG 27 Work Plan for discussions of the possible response actions.)	Results for Decision Rules D1a, D1b, D1c, D2a, D3a, and D3b indicate that response actions are needed. Evaluations of response actions to mitigate risk in the source zone may be appropriate.	
D5a: If contaminants in the source zone are found to migrate to the RGA, then determine the contributions from the source zone to support future remedial actions for existing groundwater contamination in the groundwater integrator unit; otherwise, do not determine contributions.	Multimedia transport modeling to off-site locations was completed because contaminants were suspected to migrate to the RGA. This information will be considered when determining remedial actions for the Groundwater Operable Unit at PGDP.	Multimedia transport modeling was completed using MEPAS. A more sophisticated modeling tool may be appropriate when determining remedial actions for the Groundwater Operable Unit.
D5b: If contaminants in the source zone are found to migrate to the Surface Water Integrator Unit (i.e., Big and Little Bayou Creek and ditches discharging directly to regulated outfalls), then determine the contributions from the source zone to support future remedial actions for past releases to the Surface Water Integrator Unit; otherwise, do not determine contributions.	Transport modeling to the Surface Water Integrator Unit was not completed because results indicated that contaminants were not migrating.	

Table 7.1. WAG 27 SWMU 001-specific decision rules and conclusions

General Conclusions for SWMU 001:	1) Contamination is present in ditches at SWMU 001 at levels that may lead to risks to industrial workers that exceed *de minimis* levels. However, the contaminants in the ditches are not migrating to the Surface Water Integrator Unit. Per Decision Rule D4a, response actions to mitigate the direct contact risks may be appropriate. 2) Contamination is present in subsurface soil at SWMU 001 at levels that may lead to risks to an unprotected excavation worker that exceed *de minimis* levels. Per Decision Rule D4a, response actions to mitigate the direct contact risks may be appropriate. 3) Contamination is present in groundwater at SWMU 001 that may lead to risks to industrial workers that exceed *de minimis* levels. Additionally, results indicate that contamination is present in soil and in secondary sources at concentrations that will lead to continuing contamination of groundwater. Per Decision Rule D4a, response actions to mitigate direct contact risks through groundwater use and to address continued contaminant migration to groundwater may be appropriate. 4) Contaminants in subsurface soil and secondary sources in the RGA have migrated through groundwater to off-site locations at concentrations that lead to risks that exceed *de minimus* levels. Per Decision Rule D4a, response actions to address migration from subsurface soil and secondary sources may be appropriate.

Table 7.2. WAG 27 SWMU 091-specific decision rules and conclusions

DECISION RULE	CONCLUSION	COMMENTS
D1a: If the concentration of analytes found in the source zone may result in a cumulative excess lifetime cancer risk greater than 1 x 10^{-6} or a cumulative hazard index greater than 1 through contact with contaminated media, or if the concentration of analytes in the source zone may result in detrimental impacts to nonhuman receptors through contact with contaminated media as indicated by exceeding ecological screening criteria, and if the concentrations of analytes in the source zone are greater than those that are expected to occur naturally in the environment, then evaluate actions that will mitigate risk; otherwise pursue a "no further action" decision (see D1b and D1c).	Risks from direct contact with sediment exceed *de minimis* levels for industrial workers. Risks to the excavation worker exposed to contaminated soils exceed *de minimis* levels. Risks from potential use of the RGA as a drinking water source at the SWMU exceed *de minimis* levels for the industrial worker. Risks to non-human receptors are *de minimis* under current conditions due to the industrial nature of the SWMU; however, contaminant concentrations are such that risks may exceed *de minimis* levels in the future.	Risks for the industrial worker from exposure to sediment were greater than *de minimis* when the analysis was performed using default exposure parameters. When the assessment was performed using site-specific exposure parameters and reduced dermal absorption values for inorganic chemicals, the systemic toxicity risk was less than the *de minimis* level, and the cancer risk was less than 1 x 10^{-4}. Risks to the excavation worker from exposure to subsurface soil were greater than *de minimis* when the analysis was performed using default exposure parameters. However, when the assessment was performed using site-specific parameters, the risks were *de minimis*. Groundwater drawn from the RGA below the plant is not currently used at PGDP. Migration of contaminants from soil to groundwater and surface water is discussed under Decision Rules D3a and D3b, respectively.
D1b: If concentrations of analytes found in the source zone exceed applicable or relevant and appropriate requirements (ARARs), then evaluate actions that will bring contamination within the source zone into compliance with ARARs; otherwise, pursue a "no further action" decision (see D1a and D1c).	Contaminant concentrations in RGA groundwater exceed MCLs for some contaminants.	No chemical-specific ARARs are available for screening contaminant concentrations in sediment. Migration of contaminants from soil to groundwater and surface water is discussed under Decision Rules D3a and D3b, respectively.

Table 7.2. WAG 27 SWMU 091-specific decision rules and conclusions

DECISION RULE	CONCLUSION	COMMENTS
D1c: If contaminants found at the site are known to transform or degrade into chemicals that could lead to increased risks to human health or the environment or into chemicals for which there are ARARs, and if the concentrations of these contaminants may result in risks greater than those defined in D1a or concentrations greater than ARARs, then evaluate actions that will mitigate potential future risk or promote compliance with ARARs; otherwise, pursue a "no further action" decision (see D1a and D1b).	The COCs driving direct contact risks in soil and sediment at SWMU 091 are not expected to transform or degrade into chemicals that lead to increased risk to human health and the environment. However, some contaminants present in groundwater may transform or degrade to more toxic substances that lead to increased risk at concentrations that exceed ARARs.	Contaminants identified in soil at the site are predominantly metals and radionuclides, which are not expected to degrade into more harmful products. Risks posed by solvents (e.g., TCE) in soil are not considered because they are being addressed as part of the LASAGNA™ project.
D2a: If secondary sources are found, and if the concentrations of analytes within the secondary sources are found to potentially result in a cumulative excess lifetime cancer risk greater than 1 x 10^{-6} or a cumulative hazard index greater than 1 through contact with contaminated media at the unit, and if the concentrations of analytes are greater than those that are expected to occur naturally in the environment, then evaluate actions that will mitigate risk; otherwise, do not consider secondary sources when making remedial decisions for the unit.	Secondary sources were not found at SWMU 091.	
D3a: If contaminants are found in the source zone, or if secondary sources are found, and are found to be migrating or may migrate from the source zone or from secondary sources at concentrations that may potentially result in a cumulative excess lifetime cancer risk greater than 1 x 10^{-6} or a cumulative hazard index greater than 1 through use of contaminated media at downgradient points of exposure, and the concentrations of analytes are greater than those that are expected to occur naturally in the environment, then evaluate actions that will mitigate risk; otherwise, do not consider risk posed by migratory pathways when evaluating remedial alternatives for the unit (see D3b).	Multimedia transport modeling indicates that contaminants may be released from soils at SWMU 091 and result in risks to off-site residential groundwater users that exceed *de minimis* levels. The RI determined that contaminants are not migrating from SWMU 091 through the surface-water pathway at concentrations that would lead to risks that exceed *de minimis* levels.	Transport modeling identified antimony as migrating off-site through groundwater at concentrations that lead to risks that exceed the *de minimis* levels. Risks posed by solvents (e.g., TCE) migrating from soil are not considered because they are being addressed as part of the LASAGNA™ project.

Table 7.2. WAG 27 SWMU 091-specific decision rules and conclusions

DECISION RULE	CONCLUSION	COMMENTS
D3b: If contaminants are found in the source zone, or if secondary sources are found, and if these contaminants are found to be migrating or may migrate from the source zone or from the secondary sources at concentrations that exceed ARARs, then evaluate actions that will bring migratory concentrations into compliance with ARARs; otherwise, do not consider ARARs when examining migratory pathways during the evaluation of remedial actions (see D3a).	Multimedia transport modeling indicates that contaminants may be released from soil at SWMU 091 and result in concentrations in off-site groundwater that exceed MCLs.	Transport modeling identified antimony as migrating off-site at concentrations that exceed MCLs. Concentrations of VOAs (e.g., TCE) migrating from soil are not considered because they are being addressed as part of the LASAGNA™ project.
D4a: If Decision Rules D1a, D1b, D1c, D2a, D3a, or D3b indicate that remedial actions are needed, then evaluate response actions to mitigate risk in the source zone. (Refer to Sect. 5.11 and 5.12 of the WAG 27 Work Plan for discussions of the possible response actions.)	Results for Decision Rules D1a, D1b, D1c, D3a, and D3b indicate that response actions are needed. Evaluations of response actions to mitigate risk in the source zone may be appropriate.	
D5a: If contaminants in the source zone are found to migrate to the RGA, then determine the contributions from the source zone to support future remedial actions for existing groundwater contamination in the groundwater integrator unit; otherwise, do not determine contributions.	Multimedia transport modeling to off-site locations was completed because contaminants were suspected to migrate to the RGA. This information will be considered when determining remedial actions for the groundwater operable unit at PGDP.	Multimedia transport modeling was completed using MEPAS. A more sophisticated modeling tool may be appropriate when determining remedial actions for the groundwater operable unit. Contamination with VOAs is being addressed as part of the LASAGNA™ project.
D5b: If contaminants in the source zone are found to migrate to the Surface Water Integrator Unit (i.e., Big and Little Bayou Creek and ditches discharging directly to regulated outfalls), then determine the contributions from the source zone to support future remedial actions for past releases to the Surface Water Integrator Unit; otherwise, do not determine contributions.	Transport modeling to the Surface Water Integrator Unit was not completed because results indicated that contaminants were not migrating.	

Table 7.2. WAG 27 SWMU 091-specific decision rules and conclusions

General Conclusions:	1) Contamination is present in ditches at SWMU 091 at levels that may lead to risks to industrial workers that exceed *de minimis* levels. However, the contaminants in the ditches are not migrating to the surface water integrator unit. Per Decision Rule D4a, response actions to mitigate the direct contact risks may be appropriate. 2) Contamination is present in subsurface soil at SWMU 091 at levels that may lead to risks to an unprotected excavation worker that exceed *de minimis* levels (under site-specific exposure parameters, risks were *de minimis*). Per Decision Rule D4a, response actions to mitigate the direct contact risks may be appropriate. 3) Contamination is present in groundwater at SWMU 091 that may lead to risks to industrial workers that exceed *de minimis* levels. Additionally, results indicate that contamination is present in soil at concentrations that will lead to continuing contamination of groundwater. Per Decision Rule D4a, response actions to mitigate direct contact risks through groundwater use and to address continued contaminant migration to groundwater may be appropriate. 4) Contaminants in subsurface soil have migrated to off-site locations through groundwater at concentrations that lead to risks that exceed *de minimus* levels. Per Decision Rule D4a, response actions to address migration from subsurface soil and secondary sources may be appropriate.

Table 7.3. WAG 27 SWMU 196-specific decision rules and conclusions

DECISION RULE	CONCLUSION	COMMENTS
D1a: If the concentration of analytes found in the source zone may result in a cumulative excess lifetime cancer risk greater than 1 x 10^{-6} or a cumulative hazard index greater than 1 through contact with contaminated media, or if the concentration of analytes in the source zone may result in detrimental impacts to nonhuman receptors through contact with contaminated media as indicated by exceeding ecological screening criteria, and if the concentrations of analytes in the source zone are greater than those that are expected to occur naturally in the environment, then evaluate actions that will mitigate risk; otherwise pursue a "no further action" decision (see D1b and D1c).	Risks from direct contact with surface soil approach *de minimis* levels for industrial workers. Risks from direct contact with sediment exceed *de minimis* levels for industrial workers. Risks to the excavation worker exposed to contaminated soils exceed *de minimis* levels. Risks to non-human receptors are *de minimis* under current conditions due to the industrial nature of the SWMU; however, contaminant concentrations are such that risks may exceed *de minimis* levels in the future.	Risks to the industrial worker from exposure to sediment and soil were greater than *de minimis* when the analyses were performed using default exposure parameters. When the analyses were performed using site-specific exposure parameters and reduced dermal absorption values for inorganic chemicals, the systemic toxicity risks were less than the *de minimis* level, and the cancer risks were less than 1×10^{-5}. Risks to the excavation worker from exposure to subsurface soil were greater than *de minimis* when the analysis was performed using default exposure parameters. However, when the assessment was performed using site-specific parameters, the risks were *de minimis* for systemic toxicity and approached *de minimis* for cancer risk. Risks due to groundwater use were not assessed at SWMU 196. Data were not available. Migration of contaminants from soil to groundwater and surface water is discussed under Decision Rules D3a and D3b, respectively.
D1b: If concentrations of analytes found in the source zone exceed applicable or relevant and appropriate requirements (ARARs), then evaluate actions that will bring contamination within the source zone into compliance with ARARs; otherwise, pursue a "no further action" decision (see D1a and D1c).	No chemical-specific ARARs were exceeded.	No chemical-specific ARARs are available for screening contaminant concentrations in soil and sediment. Migration of contaminants from soil to groundwater and surface water is discussed under Decision Rules D3a and D3b, respectively.

Table 7.3. WAG 27 SWMU 196-specific decision rules and conclusions

DECISION RULE	CONCLUSION	COMMENTS
D1c: If contaminants found at the site are known to transform or degrade into chemicals that could lead to increased risks to human health or the environment or into chemicals for which there are ARARs, and if the concentrations of these contaminants may result in risks greater than those defined in D1a or concentrations greater than ARARs, then evaluate actions that will mitigate potential future risk or promote compliance with ARARs; otherwise, pursue a "no further action" decision (see D1a and D1b).	Contaminants identified at the site are predominantly metals, which are not expected to degrade into more harmful products or into products with concentrations that exceed chemical-specific ARARs.	
D2a: If secondary sources are found, and if the concentrations of analytes within the secondary sources are found to potentially result in a cumulative excess lifetime cancer risk greater than 1 x 10^{-6} or a cumulative hazard index greater than 1 through contact with contaminated media at the unit, and if the concentrations of analytes are greater than those that are expected to occur naturally in the environment, then evaluate actions that will mitigate risk; otherwise, do not consider secondary sources when making remedial decisions for the unit.	Secondary sources were not found at SWMU 196.	
D3a: If contaminants are found in the source zone, or if secondary sources are found, and are found to be migrating or may migrate from the source zone or from secondary sources at concentrations that may potentially result in a cumulative excess lifetime cancer risk greater than 1 x 10^{-6} or a cumulative hazard index greater than 1 through use of contaminated media at downgradient points of exposure, and the concentrations of analytes are greater than those that are expected to occur naturally in the environment, then evaluate actions that will mitigate risk; otherwise, do not consider risk posed by migratory pathways when evaluating remedial alternatives for the unit (see D3b).	Multimedia transport modeling indicates that contaminants are not being released from soils at SWMU 196 at rates that will result in risks to off-site residential groundwater users that exceed *de minimis* levels. Transport modeling indicates that contaminants are not being released from soils at SWMU 196 at rates that will result in risks that exceed *de minimis* levels for any receptor.	

Table 7.3. WAG 27 SWMU 196-specific decision rules and conclusions

DECISION RULE	CONCLUSION	COMMENTS
D3b: If contaminants are found in the source zone, or if secondary sources are found, and if these contaminants are found to be migrating or may migrate from the source zone or from the secondary sources at concentrations that exceed ARARs, then evaluate actions that will bring migratory concentrations into compliance with ARARs; otherwise, do not consider ARARs when examining migratory pathways during the evaluation of remedial actions (see D3a).	Multimedia transport modeling indicates that contaminants are not being released from soils at SWMU 196 at rates that will result in groundwater or surface water concentrations greater than chemical-specific ARARs.	
D4a: If Decision Rules D1a, D1b, D1c, D2a, D3a, or D3b indicate that remedial actions are needed, then evaluate response actions to mitigate risk in the source zone. (Refer to Sect. 5.11 and 5.12 of the WAG 27 Work Plan for discussions of the possible response actions.)	Results for Decision Rule D1a indicate that response actions are needed. Evaluations of response actions to mitigate risk in the source zone may be appropriate.	
D5a: If contaminants in the source zone are found to migrate to the RGA, then determine the contributions from the source zone to support future remedial actions for existing groundwater contamination in the groundwater integrator unit; otherwise, do not determine contributions.	Multimedia transport modeling to off-site locations was completed because contaminants were suspected to migrate to the RGA. This information will be considered when determining remedial actions for the groundwater operable unit at PGDP.	Multimedia transport modeling was completed using MEPAS. A more sophisticated modeling tool may be appropriate when determining remedial actions for the groundwater operable unit.
D5b: If contaminants in the source zone are found to migrate to the Surface Water Integrator Unit (i.e., Big and Little Bayou Creek and ditches discharging directly to regulated outfalls), then determine the contributions from the source zone to support future remedial actions for past releases to the Surface Water Integrator Unit; otherwise, do not determine contributions.	Multimedia transport modeling to off-site locations was completed because contaminants were suspected to migrate to the surface water integrator unit. This information will be considered when determining remedial actions for the surface water operable unit at PGDP.	Multimedia transport modeling was completed using MUSLE. A more sophisticated modeling tool may be appropriate when determining remedial actions for the surface water operable unit.

Table 7.3. WAG 27 SWMU 196-specific decision rules and conclusions

General Conclusions:	1) Contamination is present in ditches and surface soil at SWMU 196 at levels that may lead to risks to industrial workers that exceed *de minimis* levels. However, the contaminants in the ditches are not migrating to the surface water integrator unit. Per Decision Rule D4a, response actions to mitigate the direct contact risks may be appropriate. 2) Contamination is present in subsurface soil at SWMU 196 at levels that may lead to risks to an unprotected excavation worker that exceed *de minimis* levels (under site-specific exposure parameters, risks were *de minimis*). Per Decision Rule D4a, response actions to mitigate the direct contact risks may be appropriate. 3) Contamination is not migrating through either groundwater or surface water from SWMU 196 at concentrations that exceed *de minimis* risk levels or chemical-specific ARARs. Per Decisions Rule D4a, response actions to address contaminant migration are not necessary at SWMU 196.

Table 7.4. WAG 27 C-720 Complex-specific decision rules and conclusions

DECISION RULE	CONCLUSION	COMMENTS
D1a: If the concentration of analytes found in the source zone may result in a cumulative excess lifetime cancer risk greater than 1 x 10^{-6} or a cumulative hazard index greater than 1 through contact with contaminated media, or if the concentration of analytes in the source zone may result in detrimental impacts to nonhuman receptors through contact with contaminated media as indicated by exceeding ecological screening criteria, and if the concentrations of analytes in the source zone are greater than those that are expected to occur naturally in the environment, then evaluate actions that will mitigate risk; otherwise pursue a "no further action" decision (see D1b and D1c).	Risks to the excavation worker exposed to contaminated soils exceed *de minimis* levels (cancer risk only). Risks from potential use of the RGA as a drinking water source at the SWMU exceed *de minimis* levels for the industrial worker.	No surface soils or sediments are present at the C-720 Complex. Cancer risks were greater than *de minimis* for the excavation worker when default exposure parameters were used. When the assessment was performed using site-specific exposure parameters, the systemic toxicity risk remained *de minimis* and the cancer risk was 4 x 10^{-5}. Groundwater drawn from the RGA below the plant is not currently used at PGDP. Migration of contaminants from soil to groundwater and surface water is discussed under Decision Rules D3a and D3b, respectively.
D1b: If concentrations of analytes found in the source zone exceed applicable or relevant and appropriate requirements (ARARs), then evaluate actions that will bring contamination within the source zone into compliance with ARARs; otherwise, pursue a "no further action" decision (see D1a and D1c).	Contaminant concentrations in RGA groundwater exceed MCLs for some contaminants.	No surface soils or sediments are present at the C-720 Complex. No chemical-specific ARARs are available for screening contaminant concentrations in soil. Migration of contaminants from soil to groundwater and surface water is discussed under Decision Rules D3a and D3b, respectively.
D1c: If contaminants found at the site are known to transform or degrade into chemicals that could lead to increased risks to human health or the environment or into chemicals for which there are ARARs, and if the concentrations of these contaminants may result in risks greater than those defined in D1a or concentrations greater than ARARs, then evaluate actions that will mitigate potential future risk or promote compliance with ARARs; otherwise, pursue a "no further action" decision (see D1a and D1b).	Some contaminants present in groundwater may transform or degrade to more toxic substances that lead to increased risk at concentrations that exceed ARARs.	No risk from direct contact was identified.

Table 7.4. WAG 27 C-720 Complex-specific decision rules and conclusions

DECISION RULE	CONCLUSION	COMMENTS
D2a: If secondary sources are found, and if the concentrations of analytes within the secondary sources are found to potentially result in a cumulative excess lifetime cancer risk greater than 1 x 10^{-6} or a cumulative hazard index greater than 1 through contact with contaminated media at the unit, and if the concentrations of analytes are greater than those that are expected to occur naturally in the environment, then evaluate actions that will mitigate risk; otherwise, do not consider secondary sources when making remedial decisions for the unit.	Secondary sources were not identified at the C-720 Complex.	
D3a: If contaminants are found in the source zone, or if secondary sources are found, and are found to be migrating or may migrate from the source zone or from secondary sources at concentrations that may potentially result in a cumulative excess lifetime cancer risk greater than 1 x 10^{-6} or a cumulative hazard index greater than 1 through use of contaminated media at downgradient points of exposure, and the concentrations of analytes are greater than those that are expected to occur naturally in the environment, then evaluate actions that will mitigate risk; otherwise, do not consider risk posed by migratory pathways when evaluating remedial alternatives for the unit (see D3b).	Multimedia transport modeling indicates that contaminants may be released from soil at the C-720 Complex and result in risks to off-site residential groundwater users that exceed *de minimis* levels.	Transport modeling identified antimony, trans-1,2-DCE, TCE, and vinyl chloride as migrating off-site through groundwater at concentrations that lead to risks that exceed *de minimis* levels. The lack of surface soil precludes contaminant transport to the surface water integrator unit.
D3b: If contaminants are found in the source zone, or if secondary sources are found, and if these contaminants are found to be migrating or may migrate from the source zone or from the secondary sources at concentrations that exceed ARARs, then evaluate actions that will bring migratory concentrations into compliance with ARARs; otherwise, do not consider ARARs when examining migratory pathways during the evaluation of remedial actions (see D3a).	Multimedia transport modeling indicates that contaminants may be released from soil at the C-720 Complex and result in concentrations in off-site groundwater that exceed MCLs.	ARARs for TCE and breakdown products in groundwater are exceeded and these compounds may migrate off-site. The lack of surface soil precludes contaminant transport to the surface water integrator unit.

Table 7.4. WAG 27 C-720 Complex-specific decision rules and conclusions

DECISION RULE	CONCLUSION	COMMENTS
D4a: If Decision Rules D1a, D1b, D1c, D2a, D3a, or D3b indicate that remedial actions are needed, then evaluate response actions to mitigate risk in the source zone. (Refer to Sect. 5.11 and 5.12 of the WAG 27 Work Plan for discussions of the possible response actions.)	Results for Decision Rules D1a, D1b, D1c, D3a, and D3b indicate that response actions are needed. Evaluations of response actions to mitigate risk in the source zone may be appropriate.	
D5a: If contaminants in the source zone are found to migrate to the RGA, then determine the contributions from the source zone to support future remedial actions for existing groundwater contamination in the groundwater integrator unit; otherwise, do not determine contributions.	Multimedia transport modeling to off-site locations was completed because contaminants were suspected to migrate to the RGA. This information will be considered when determining remedial actions for the groundwater operable unit at PGDP.	Multimedia transport modeling was completed using MEPAS. A more sophisticated modeling tool may be appropriate when determining remedial actions for the groundwater operable unit.
D5b: If contaminants in the source zone are found to migrate to the Surface Water Integrator Unit (i.e., Big and Little Bayou Creek and ditches discharging directly to regulated outfalls), then determine the contributions from the source zone to support future remedial actions for past releases to the Surface Water Integrator Unit; otherwise, do not determine contributions.	Transport modeling to the Surface Water Integrator Unit was not completed because surface soil is not present.	

Table 7.4. WAG 27 C-720 Complex-specific decision rules and conclusions

General Conclusions:	1) Contamination is present in subsurface soil at the C-720 Complex at levels that may lead to risks to an unprotected excavation worker that exceed *de minimis* levels. Per Decision Rule D4a, response actions to mitigate the direct contact risks may be appropriate. 2) Contamination is present in groundwater at the C-720 Complex that may lead to risks to industrial workers that exceed *de minimis* levels. Additionally, results indicate that contamination is present in soil at concentrations that will lead to continuing contamination of groundwater. Per Decision Rule D4a, response actions to mitigate direct contact risks through groundwater use and to address continued contaminant migration to groundwater may be appropriate. 3) Contaminants in subsurface soil have migrated to off-site locations through groundwater at concentrations that lead to risks that exceed *de minimus* levels. Per Decision Rule D4a, response actions to address migration from subsurface soil and secondary sources may be appropriate.

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