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GROUNDWATER PROTECTION PROGRAM CALENDAR YEAR 1999 EVALUATION OF GROUNDWATER QUALITY DATA FOR THE CHESTNUT RIDGE HYDROGEOLOGIC REGIME AT THE U.S. DEPARTMENT OF ENERGY Y-12 PLANT, OAK RIDGE, TENNESSEE

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List of Acronyms and Abbreviations

AJA	AJA Technical Services, Inc.
BCV	Bear Creek Valley
bgs	below ground surface
Chestnut Ridge Regime	Chestnut Ridge Hydrogeologic Regime
CY	calendar year
DOE	U.S. Department of Energy
DQO	data quality objective
ft	feet
ft/d	feet per day
GWMR	Groundwater Monitoring Report
GWPP	Groundwater Protection Program
HSW	HSW Environmental Consultants, Inc.
MCL	maximum contaminant level (for drinking water)
MDA	minimum detectable activity
µg/L	micrograms per liter
mg/L	milligrams per liter
msl	mean sea level
OF	outfall (surface water sampling location)
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PCE	tetrachloroethene
pCi/L	picoCuries per liter
PCP	post closure permit (RCRA)
RCRA	Resource Conservation and Recovery Act
Security Pits	Chestnut Ridge Security Pits
Sediment Disposal Basin	Chestnut Ridge Sediment Disposal Basin
SDWA	Safe Drinking Water Act
TCE	trichloroethene
TDEC	Tennessee Department of Environment and Conservation
TDS	total dissolved solids
UNCS	United Nuclear Corporation Site
UTL	upper tolerance limit
VOC	volatile organic compound
11DCA	1,1-dichloroethane
11DCE	1,1-dichloroethene
12DCE	1,2-dichloroethene
c12DCE	cis-1,2-dichloroethene
111TCA	1,1,1-trichloroethane

1.0 INTRODUCTION

This report presents an evaluation of the water quality monitoring data obtained by the Y-12 Plant Groundwater Protection Program (GWPP) in the Chestnut Ridge Hydrogeologic Regime (Chestnut Ridge Regime) during calendar year (CY) 1999. Groundwater and surface water monitoring is performed in the Chestnut Regime at several hazardous and nonhazardous waste management facilities associated with the U.S. Department of Energy (DOE) Oak Ridge Y-12 Plant. Applicable provisions of DOE Order 5400.1A - *General Environmental Protection Program* - require evaluation of available monitoring data with regard to: (1) groundwater quality in areas that are, or could be, affected by Y-12 Plant operations, (2) the quality of surface water and groundwater where contaminants are most likely to migrate beyond the DOE Oak Ridge Reservation (ORR) property line, and (3) long-term trends in groundwater quality at the Y-12 Plant.

The CY 1999 monitoring data that were evaluated for DOE Order 5400.1A purposes were collected by the Y-12 Plant GWPP managed by Lockheed Martin Energy Systems, Inc. and the Integrated Water Quality Program managed by Bechtel Jacobs Company LLC. During CY 1999, the Y-12 Plant GWPP monitored groundwater and surface water quality in the Chestnut Ridge Regime for the purposes of DOE Order 5400.1A and for detection monitoring at Industrial Landfills II, IV, and V, and Construction/Demolition Landfill VI in accordance with the regulations governing nonhazardous solid waste management and disposal and applicable conditions of operating permits issued by the Tennessee Department of Environment and Conservation (TDEC). The Integrated Water Quality Program monitors groundwater and surface water quality in the regime for the purposes of: (1) post closure corrective action monitoring at the Chestnut Ridge Security Pits (Security Pits) as specified in the Resource Conservation and Recovery Act (RCRA) post closure permit (PCP) for the Chestnut Ridge Regime; (2) post closure detection monitoring at the Chestnut Ridge Sediment Disposal Basin (Sediment Disposal Basin) and Kerr Hollow Quarry as required under the RCRA PCP; and (3) requirements of the Comprehensive Environmental Response, Compensation, and Liability Act Records of Decision for the United Nuclear Corporation Site (UNCS), Kerr Hollow Quarry, and the Filled Coal Ash Pond (DOE 1999).

The following sections of this report contain relevant background information (Section 2.0); describe the results of the respective data evaluations required under DOE Order 5400.1A (Section 3.0); summarize significant findings of each evaluation (Section 4.0); and list the technical reports and regulatory documents cited for more detailed information (Section 5.0). All of the illustrations (maps and trend graphs) and data tables (more than one page in length) referenced in each section are presented in Appendix A and Appendix B, respectively.

2.0 BACKGROUND INFORMATION

The Chestnut Ridge Regime is one of three hydrogeologic regimes defined for the purposes of groundwater quality monitoring at the Y-12 Plant (Figure 1). Several waste management sites are located in the Chestnut Ridge Regime (Figure 2), including closed hazardous waste sites and operating nonhazardous solid waste landfills (Table B.1). The following sections contain background information regarding the Chestnut Ridge Regime, including a brief description of topography and bedrock geology in the regime, an overview of the hydrogeologic characteristics and groundwater flow patterns in the Knox aquifer, and a short description of surface water drainage features.

2.1 TOPOGRAPHY AND BEDROCK GEOLOGY

The Chestnut Ridge Regime encompasses a section of Chestnut Ridge bordered by the Y-12 Plant in Bear Creek Valley (BCV) to the north, Scarboro Road to the east, Bethel Valley Road to the south, and an unnamed surface drainage feature to the west (Figure 3). The northern flank of the ridge forms a steep slope rising more than 200 feet (ft) above the floor of BCV. The ridge crest slopes toward the east from an elevation of about 1200 ft above mean sea level (msl) southwest of the Y-12 Plant to about 1060 ft msl east of the Sediment Disposal Basin. A series of prominent hills dominates the central part of the broad southern flank of Chestnut Ridge, which is dissected by several tributaries, including McCoy Branch in the middle of the regime.

Bedrock geology in the vicinity of the Chestnut Ridge Regime is generally characterized by thrust-faulted sequences of southeast-dipping, clastic (primarily shale and siltstone) and carbonate (limestone and dolostone) strata of Lower Cambrian to Upper Ordovician age. Interbedded limestone and shale formations of the Conasauga Group directly underlie the Y-12 Plant in BCV, primarily dolostone strata of the Knox Group form Chestnut Ridge, and the argillaceous limestones and interbedded shales of the Chickamauga Group underlie Bethel Valley (Figure 3). Strike and dip of bedding in the area is generally N55^{N}E and 45^{N}SE, respectively (as referenced to true north).

Many waste sites in the Chestnut Ridge Regime are directly underlain by red-brown to yellow-orange residuum overlying the Knox Group. The residuum is characteristically acidic, predominantly composed of clays and iron sesquioxides, and contains semicontinuous, relict beds of fractured chert and other lithologic inhomogeneities (such as silt bodies) that provide a weakly connected network through which saturated flow can occur (Solomon et al. 1992). The residuum is thin or nonexistent near karst features such as dolines (sink holes), swallets (sinking streams), and solution pan features (Ketelle and Huff 1984). Depth to bedrock varies throughout the Chestnut Ridge Regime but is usually less than 100 ft below ground surface (bgs).

Residuum throughout all but the southernmost portion of the Chestnut Ridge Regime is underlain by the Knox Group (Figure 3). The Knox Group, which consists of about 2600 to 3300 ft of gray to blue-gray, thin- to thick-bedded cherty dolostone with interbedded limestone, is divided into five formations (listed from oldest to youngest): Copper Ridge Dolomite, Chepultepec Dolomite, Longview Dolomite, Kingsport Formation, and Mascot Dolomite (Figure 3). Topographic and stratigraphic relationships suggest that the Copper Ridge Dolomite underlies the steep northern flank of the ridge, the Longview Dolomite forms the series of prominent hills across the middle of the southern flank of the ridge, and the Mascot Dolomite disconformably underlies the Chickamauga Group along the southern boundary of the regime (Hatcher et al. 1992).

The most pervasive structural features in the Chestnut Ridge Regime are extensional, hybrid, and shear fractures (Solomon et al. 1992). Three major fracture orientations are evident: one that roughly parallels bedding, one steeply dipping set that parallels geologic strike, and one steeply dipping set oriented perpendicular to strike (Dreier et al. 1987). Most fractures are short, ranging from tenths of inches to a few feet in length (Solomon et al. 1992). Dissolution of carbonates along fractures has produced many surface karst features on Chestnut Ridge, including a series of sinkholes along the crest of the ridge that show a prominent alignment parallel to strike. This linear trend may result from dissolution along a bedding plane or fracture set (Ketelle and Huff 1984; Smith et al. 1983).

2.2 GROUNDWATER SYSTEM

The Knox aquifer, consisting of the Knox Group and the underlying Maynardville Limestone formation (Conasauga Group), is the principal hydrogeologic unit in the Chestnut Ridge Regime. Overall, groundwater flow in the Knox aquifer is characterized by conduit flow that discharges at springs located along drainage features. The groundwater flow system in the Knox aquifer generally consists of three vertically gradational subsystems: (1) the stormflow zone, (2) the vadose zone, and (3) the groundwater zone. The subsystems are distinguished by groundwater flux, which decreases with depth (Solomon et al. 1992).

Although detailed studies have not been conducted in the Chestnut Ridge Regime, investigations on Chestnut Ridge approximately 4000 ft west of the regime in the Walker Branch watershed show that groundwater occurs intermittently above the water table in a shallow "stormflow zone" that extends to a depth of about 8 ft bgs (Wilson et al. 1990). Macropores and mesopores provide the primary channels for lateral flow in the stormflow zone, which lasts only a few days or weeks after rainfall. Most groundwater within the stormflow zone is either lost to evapotranspiration or recharge to the water table, and the remaining water discharges at nearby seeps, springs, or streams (Moore 1989).

The vadose zone occurs between the stormflow zone and the water table, which typically occurs near the bedrock/residuum interface. Soil moisture content in the vadose zone is below the saturation limit except in the capillary fringe above the water table and within wetting fronts during periods of vertical percolation from the stormflow zone (Moore 1989). Most recharge through the vadose zone is episodic and occurs along discrete permeable fractures that become saturated, although surrounding micropores remain unsaturated (Solomon et al. 1992). Moore (1988) determined a geometric mean hydraulic conductivity of about 0.006 feet per day (ft/d) for residuum on Chestnut Ridge near the Oak Ridge National Laboratory (ORNL). However, the residuum is hydrologically heterogeneous with quickflow via dolines to conduits in the subsurface.

Groundwater below the vadose zone occurs within orthogonal sets of permeable, planar fractures that form water-producing zones within an essentially impermeable matrix. Dissolution of bedrock carbonates has enlarged fractures and produced an interconnected conduit-flow system characteristic of karst aquifers. Because the occurrence of solution features and the frequency, aperture, and connectivity of permeable fractures decrease with depth, the bulk hydraulic conductivity of the groundwater zone is vertically gradational. Most groundwater flux occurs within the transitional horizon between residuum and unweathered bedrock (water table interval); lower flux (and longer solute residence times) occurs at successively greater depths in the bedrock (Solomon et al. 1992).

The water table in the Chestnut Ridge Regime is a subdued replica of surface topography and occurs at the greatest depth (>100 ft bgs) along the crest of Chestnut Ridge, which is a groundwater flow divide and a recharge area. Groundwater generally flows from west to east parallel to the flow divide across the northern part of the regime, with radial components of flow north into BCV and south toward tributary headwaters on the southern flank of the ridge (Figure 4). The central part of the regime is characterized by radial flow directions from local groundwater flow divides along hilltops between tributaries. Groundwater flow directions in the southern part of the regime are generally south toward Melton Hill Reservoir. The overall directions of groundwater flow throughout the Chestnut Ridge Regime do not significantly change during seasonal groundwater flow conditions (Figure 4). Horizontal hydraulic gradients throughout the year are highest along the steep northern flank of Chestnut Ridge (i.e., across geologic strike) and in the upper reaches of tributaries on the southern ridge flank, and are nearly flat along the southern boundary of the regime.

Available data show that hydraulic conductivity in the Knox Group varies over multiple orders of magnitude, which is typical of karst aquifers. Results of straddle packer tests in core holes indicate hydraulic conductivity ranging from 0.0002 to 3.1 ft/d at depths generally less than 600 ft bgs in the lower Knox Group (King and Haase 1988). Average hydraulic conductivity values calculated from results of 122 falling-head slug tests performed between July 1994 and October 1997 in 17 monitoring wells completed at shallow depths (60 to 195 ft bgs) in the middle Knox Group range from about 0.003 to 14 ft/d (GW-560) (Jones 1998). Results of a preliminary dye-tracer test at the Security Pits indicate flow rates of about 100 to 300 ft/d (Geraghty & Miller, Inc. 1990). Although not confirmed by a second test using different tracers (Science Applications International Corporation 1993), these findings are supported by the range of flow rates (490 to 1250 ft/d) indicated by results of a dye-tracer test performed on Chestnut Ridge near ORNL (Ketelle and Huff 1984).

The geochemistry of the groundwater in the Knox aquifer is fairly homogeneous. Most wells yield calcium-magnesium bicarbonate groundwater with pH of 7.5 to 8.0; total dissolved solids (TDS) above 150 milligrams per liter (mg/L); equal or nearly equal molar concentrations of calcium and magnesium; low proportions (<5%) of chloride, sodium, sulfate, and potassium; and very low (i.e., <1 mg/L) carbonate alkalinity and nitrate (as N) concentrations. Some wells yield groundwater with enriched chloride and sulfate concentrations that probably reflect the geochemical influence of locally disseminated sulfides (e.g., pyrite) or evaporites (e.g., gypsum). Additionally, groundwater within low permeability (matrix) intervals in the upper Knox Group (e.g., Mascot Dolomite), as indicated by data for several wells at Kerr Hollow Quarry, has greater proportions of sulfate and potassium and higher trace metal concentrations (e.g., strontium) than typical of the groundwater from low yield intervals within the lower Knox Group formations (e.g., Copper Ridge Dolomite). These geochemical differences potentially reflect corresponding differences between carbonate mineralogies in the upper and lower sections of the Knox Group or the proximity to and types of disseminated secondary minerals (AJA Technical Services, Inc. [AJA] 1996).

2.3 CONTAMINANT SOURCE AREAS

Monitoring data obtained since the mid-1980s indicate that groundwater contamination is fairly limited in the Chestnut Ridge Regime and that volatile organic compounds (VOCs) are the most common groundwater contaminant. Dissolved VOCs (primarily chloroethanes and chloroethenes) have been detected in the groundwater samples collected from monitoring wells downgradient from the Security Pits, Industrial Landfill IV, and Kerr Hollow Quarry. However, a clearly distinct plume of dissolved VOCs is indicated only by the data for wells at the Security Pits.

The Security Pits are located on the crest of Chestnut Ridge directly south of the central portion of the Y-12 Plant (Figure 2), and consist of two areas, each containing a series of east-west oriented trenches that are about 8 to 10 feet (ft) wide, 10 to 18 ft deep, and 700 to 800 ft long. This site was used for disposal of hazardous waste until December 1984, and for disposal of nonhazardous waste until the site was closed in

November 1988. Data obtained from monitoring wells at the Security Pits indicate that a narrow, elongated plume of dissolved VOCs extends parallel with geologic strike for at least 2600 ft downgradient to the east, and perpendicular to strike for at least 500 ft downgradient to the north and south. The primary components of the plume are 1,1-dichloroethene (11DCE), 1,1-dichloroethane (11DCA), and 1,1,1-trichloroethane (111TCA) in the western trench area; and tetrachloroethene (PCE), trichloroethene (TCE), and 1,2-dichloroethene (12DCE) isomers in the eastern trench area.

Data obtained since the early 1990s indicate very low concentrations (1 to 2 micrograms per liter [μg/L]) of 111TCA in the groundwater at two wells downgradient of the western disposal trenches at the Security Pits: well GW-796, located at Industrial Landfill V about 400 ft south of the disposal trenches, and well GW-514, located at the Filled Coal Ash Pond about 900 ft south of the disposal trenches. Although the concentrations are estimated (i.e., less than the analytical reporting limit), the repeated detection of this compound in the groundwater samples from both wells probably reflects southward migration from the Security Pits, possibly along “quickflow” conduits oriented perpendicular to geologic strike.

Industrial Landfill IV, located along the crest of Chestnut Ridge in the northwest corner of the regime (Figure 2), has received waste since October 1989 and is a suspected source of 111TCA, 11DCA, 11DCE, and boron. Elevated total boron concentrations have consistently been reported in samples from a well located downgradient to the east of the site (GW-217), while VOCs have been reported in samples from a well located south of the eastern portion of the site (GW-305). These results indicate groundwater transport along permeable flowpaths from the unlined portion (about 150 ft X 150 ft) of Industrial Landfill IV. Although the source of these contaminants has not been formally confirmed, no other waste management facility is located upgradient of these wells.

Kerr Hollow Quarry is located in the southeast corner of the Chestnut Ridge Regime (Figure 2) and served as a source of stone construction material until it filled with water and was abandoned in the late 1940's. From the early 1950's until November 1988, the quarry was used for the disposal of reactive materials from the Y-12 Plant and the ORNL. Wastes were removed from the quarry between mid-1990 and late-1993 to obtain certified clean-closure status from the TDEC, but the site was finally closed with some wastes remaining in place. Historically (before 1997), low levels (<5 μg/L) of carbon tetrachloride, chloroform, and PCE were reported in the groundwater at monitoring wells located to the south (GW-144) and southeast (GW-142) of Kerr Hollow Quarry. Each of these VOCs are probably present at low concentrations in the groundwater downgradient of the site as a consequence of wastes being disturbed during attempts to obtain clean closure of the site.

2.4 SURFACE WATER SYSTEM

Surface streams in the Chestnut Ridge Regime include four primary drainage basins on the southern flank of Chestnut Ridge: two unnamed tributaries located west and east of Industrial Landfill II in the western part of the regime; the McCoy Branch drainage basin in the central part of the regime; and an unnamed drainage basin in the eastern part of the regime (Figure 3). These tributaries are mainly intermittent above an elevation of 900 ft msl and receive flow via surface runoff, stormflow discharge, and groundwater baseflow. Baseflow contributions increase downstream along the length of the streams, and spring discharge represents substantial contributions to the total flow in most of the tributaries. All of the tributaries discharge into Melton Hill Reservoir (Clinch River) south of the Chestnut Ridge Regime.

3.0 CY 1999 MONITORING DATA EVALUATION

An evaluation of the monitoring data for the network of CY 1999 sampling locations in the Chestnut Ridge Regime, as reported in the CY 1999 Groundwater Monitoring Report (GWMR) issued by the Y-12 Plant GWPP in March 2000 (AJA 2000a), is provided in the following sections. This evaluation mirrors the applicable requirements of DOE Order 5400.1A. Section 3.1 contains an evaluation of groundwater quality in areas within the Chestnut Ridge Regime that are, or could be, affected by Y-12 Plant operations (hereafter referenced as Surveillance Monitoring). Section 3.2 contains an evaluation of surface water/groundwater quality where contaminants from sources in the Chestnut Ridge Regime are most likely to migrate beyond the ORR property line (hereafter referenced as Exit Pathway/Perimeter Monitoring). Long-term groundwater quality trends near the Y-12 Plant, based on data for selected sampling locations in the Chestnut Ridge Regime, are described in Section 3.3. Each evaluation is based on historical data (if available) and CY 1999 results that meet the applicable data quality objectives (DQOs) defined in: *Y-12 Plant Groundwater Protection Program - Groundwater Monitoring Program Data Management Plan* (Science Applications International Corporation 2000). Descriptions of the DQO criteria and associated data screening process, along with summaries of the CY 1999 data that do not meet applicable DQOs, are provided in Section 2.6 of the CY 1999 GWMR.

3.1 SURVEILLANCE MONITORING

The CY 1999 monitoring results reported for 36 monitoring wells (Figure 5) were evaluated for the purposes of Surveillance Monitoring. Groundwater samples were collected semiannually from each well except GW-305 at Industrial Landfill IV; this well was sampled in the first, third, and fourth quarters of the year (Table B.2). Additionally, four replicate samples were collected during each semiannual sampling event from each of the RCRA post closure detection monitoring wells at the Sediment Disposal Basin (GW-156, GW-159, GW-731, and GW-732) and Kerr Hollow Quarry (GW-142, GW-143, GW-144, GW-145, and GW-231).

Dedicated bladder pumps (Well Wizards™) were used to collect filtered and unfiltered groundwater samples from each well in accordance with the Y-12 Plant GWPP technical procedure (SESD-TP-8204, Rev.3) for low-flow minimal drawdown sampling (hereafter referenced as low-flow sampling). Under this procedure, samples (including duplicates) are collected immediately after field measurements show stable (minimal variation over four consecutive readings) pH, conductivity, water temperature, oxidation-reduction potential, and dissolved oxygen values in the groundwater purged from the well at a rate low enough (<300 milliliters per minute) to ensure minimal drawdown of the water level in the well (<0.1 ft per quarter-hour). This differs from the groundwater sampling method used by the Y-12 Plant GWPP until October 1997, which involved pumping at least three well volumes (if the well did not purge dry) before collecting samples from each well (hereafter referenced as conventional sampling). To help determine if the low-flow and conventional sampling methods yield widely divergent monitoring results, the Y-12 Plant GWPP collected groundwater samples from well GW-305 on November 3, 1999 using the low-flow sampling method and again on November 4, 1999 using the conventional sampling method.

Depending on the requirements of the governing monitoring program, the filtered and/or unfiltered groundwater samples from each well were analyzed for inorganics (major ions and trace metals), VOCs, gross alpha and beta activities, and several miscellaneous laboratory analyses, including TDS, total suspended solids, and turbidity. Analytical results for each sample are reported in Appendix E of the CY 1999 GWMR.

Based on evaluation of the CY 1999 monitoring data with respect to historical monitoring results, one or more groundwater contaminants were detected in at least one of the groundwater samples collected from nine of the monitoring wells used for Surveillance Monitoring purposes in the Chestnut Ridge Regime.

Table 1. Types of groundwater contaminants detected in monitoring wells used for Surveillance Monitoring during CY 1999

Well Number and Monitored Interval Depth (ft bgs)		Contaminant Type		
		Inorganics	VOCs	Radioactivity
1090	? - 96.7	!	.	.
GW-144	148.0 - 195.0	!	!	.
GW-145		.	!	.
GW-205	154.0 - 164.0	!	.	.
GW-217	165.2 - 180.0	!	.	.
GW-302	121.5 - 134.8	!	.	.
GW-305	165.3 - 179.6	!	!	.
GW-339	101.0 - 114.0	!	.	.
GW-609	256.4 - 269.0	.	!	.
GW-757	134.0 - 166.7	!	.	.

An evaluation of the CY 1999 Surveillance Monitoring results for inorganic contaminants, VOCs, and radioactivity is provided in the following sections.

3.1.1 Inorganics

Data obtained from the network of wells used for Surveillance Monitoring during CY 1999 are consistent with historical results and show that most of the wells continue to yield uncontaminated, calcium-magnesium-bicarbonate groundwater. Analytical results for these wells are generally characterized by: (1) equal or nearly equal molar concentrations of calcium and magnesium, which is typical of water in contact with dolomite; (2) low molar proportions (<5%) of chloride, potassium, sodium, and sulfate; (3) carbonate alkalinity, fluoride, and nitrate as N (hereafter synonymous with "nitrate") concentrations below 1 mg/L or the respective analytical reporting limit; and (4) very low levels (<0.5 mg/L) of several trace metals, primarily barium, iron, and strontium. However, the concentrations of some inorganic analytes reported for several of the monitoring wells exceed background levels expected in the Knox aquifer, as defined by the respective upper tolerance limit (UTL) reported in *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee* (HSW Environmental Consultants, Inc. [HSW] et al. 1995). Based on review of the CY 1999 results with respect to historical data, the elevated concentrations of boron, chloride, chromium, nitrate, nickel, potassium, and sodium potentially reflect groundwater contamination in the wells listed in the following data summary.

Table 2. Maximum concentrations of inorganic contaminants detected in wells used for CY 1999 Surveillance Monitoring

Well	Maximum Concentration (mg/L)						
	Boron	Chloride	Chromium	Nitrate	Nickel	Potassium	Sodium
1090	.	22.6	.	.	.	.	11.0
GW-144	.	.	.	3.4	.	.	.
GW-205	.	.	.	.	.	63.5	10.0
GW-217	0.124	.	.	.	.	.	.
GW-302	.	51.2	**0.365**	.	**0.233**	.	17.3
GW-305	.	.	.	.	**0.689**	.	.
GW-339	.	24.0	.	.	**0.322**	.	12.0
GW-757	.	.	.	.	.	14	26.7
UTL (mg/L)	0.028	2	0.029	2.7	0.02	5.0	9.7
MCL (mg/L)	NA	NA	0.1	10	0.1	NA	NA

Note: "." = Less than UTL; NA = Not applicable;
BOLD = Exceeds maximum contaminant level (MCL) for drinking water.

Elevated concentrations of the specified inorganics potentially reflect: (1) migration of boron wastes (or waste constituents) from the Industrial Landfill IV (GW-217); (2) inflow of recharge impacted by dissolved road de-icing salt (1090, GW-302, and GW-339); (3) migration of municipal sewage sludge constituents from surficial application areas near Kerr Hollow Quarry (GW-144); (4) localized grout contamination (GW-205 and GW-757); and (5) corrosion of the stainless steel well casing and screen (GW-302, GW-305, and GW-339).

Total (and dissolved) boron concentrations reported for the groundwater samples collected from well GW-217 in January (0.124 mg/L) and July 1999 (0.117 mg/L) significantly exceed the applicable UTL (0.028 mg/L). This well is hydraulically downgradient (along geologic strike) of Industrial Landfill IV (Figure 4), approximately 100 ft east of an unlined portion (about 22,500 ft^2) of the landfill that began receiving waste in October 1989 (Figure 2). Because the significant boron solute species are anionic (uncharged), they are probably not extensively absorbed onto mineral surfaces and are therefore highly mobile in groundwater (Hem 1985). Results of falling head hydraulic conductivity tests indicate that the monitored interval in well GW-217 intercepts moderately permeable (0.01 - 0.2 ft/d) flowpaths 165 to 180 ft bgs (Jones 1998). These hydraulic conductivity values generally support advective transport of boron to well GW-217 within the time period between initial disposal of wastes in October 1989 and a conspicuous concentration "spike" (0.69 mg/L) in January 1992 (see Section 3.3). Moreover, historical data show that three of the four lowest boron concentrations (i.e., #0.0074 mg/L) were reported for samples collected from the well before Industrial Landfill IV began receiving wastes in October 1989. Thus, the elevated boron concentrations in the groundwater at well GW-217 potentially reflect migration of boron originating from wastes disposed in the unlined portion of the landfill.

Historical data show that elevated concentrations of chloride (>20 mg/L) and sodium (>10 mg/L) are a defining characteristic of the groundwater samples from wells 1090, GW-302, and GW-339 at the UNCS. As shown above in Table 2, results obtained during CY 1999 data show that highest chloride (51.2 mg/L) and sodium (17.3 mg/L) levels were reported for well GW-302. Elevated concentrations of these ions may reflect recharge of surface water containing dissolved salt used to de-ice the South Patrol Road and Mt. Vernon Road; well 1090 is located at the intersection of these roads, and wells GW-302 and GW-339 are immediately south of the South Patrol Road (Figure 5). These elevated chloride levels may be corrosive to stainless steel well casing and screen. As shown above in Table 2, samples from wells GW-302 and GW-339 (stainless steel well screens) also contain potential corrosion products of stainless steel (elevated nickel and/or chromium concentrations) while samples from well 1090 (polyvinyl chloride well screen) do not have these corrosion products. Additionally, elevated chloride levels in wells GW-302 and GW-339 may play a role in maintaining elevated trace metal concentrations in the wells because chloride may combine with available metal cations (e.g., nickel) to form complexes that significantly reduce adsorption of the metals and consequently increase their relative mobility in groundwater (McLean and Bledsoe 1992).

Extensive historical data show that nitrate concentrations in the Knox aquifer in the Chestnut Ridge Regime rarely exceed 1 mg/L, and the CY 1999 monitoring results are consistent with the historical data. Nitrate levels above 1 mg/L were detected only in six of the Surveillance Monitoring wells (GW-144, GW-203, GW-231, GW-302, GW-609, and GW-799), with the highest nitrate levels (3.2 - 3.4 mg/L) reported for the replicate groundwater samples collected from well GW-144 in April 1999 (seasonally high groundwater flow). Elevated nitrate levels in this well potentially indicate transport of nitrate from municipal sewage sludge application sites (AJA 1998) located in hayfields about 800 ft west-northwest of Kerr Hollow Quarry (Figure 2). Aside from the elevated nitrate concentrations in the well, however, available data for other indicator parameters (ammonia, fecal coliform, and total phosphate) do not indicate impacts from the sludge application sites (AJA 1999). Regardless of the potential source of the nitrate, the CY 1999 data indicate that the maximum nitrate concentrations remain substantially below the MCL for drinking water (10 mg/L).

Atypically high concentrations of potassium and sodium, along with unusually high pH (field measurements), were reported for each of the groundwater samples (including duplicates) collected from well GW-757 at Industrial Landfill II. These unusual potassium, sodium, and pH results strongly indicate localized contamination from cement grout circulated into fractures and solution features in the surrounding bedrock during the installation of the well. Moreover, as shown in the following summary, comparison with historical data for well GW-757 shows that the increased potassium, sodium, and pH levels coincide with the change from conventional sampling to low-flow sampling.

Table 3. Potassium, sodium, and pH in well GW-757, 1996-1999

Analyte	Conventional Sampling			Low-Flow Sampling				
	Apr. 1996	Nov. 1996	Apr. 1997	Oct. 1997	Apr. 1998	Oct. 1998	Apr. 1999	Oct. 1999
Total Potassium (mg/L)	1.3	3.1	6.2	9.1	14	15.8	8.28	14.0
Total Sodium (mg/L)	2.1	5.8	6.7	14	26	35.3	16.7	26.7
pH (standard units)	8.13	8.3	7.9	9	9.44	9.41	9.39	9.94

Apparently, the conventional sampling method induced flow of clean groundwater into the well, which diluted the grout-contaminated groundwater near the well screen. This suggests that well GW-757 may need to be redeveloped prior to low-flow sampling to ensure that representative groundwater samples are collected from the well.

Very high concentrations of potassium were reported for the groundwater samples collected from well GW-205 in February 1999 (49.4 mg/L) and August 1999 (63.5 mg/L). This well was last sampled in April 1997, and as shown in the following summary, not only are the potassium concentrations substantially higher than previously evident in the well, the CY 1999 data differ from historical results with respect to elevated sodium levels, more basic pH, and unusually low concentrations of calcium and magnesium.

Table 4. Calcium, magnesium, potassium, and sodium in well GW-205, 1996-1999

Inorganic Analyte	Concentration (mg/L)						
	Conventional Sampling					Low-Flow Sampling	
	July 1991	May 1993	Oct. 1994	Oct. 1995	Apr. 1997	Feb. 1999	Aug. 1999
Calcium	31	35	20	24	38	1.45	1.32
Magnesium	17	19	18	19	22	13.6	12.6
Potassium	0.74	0.87	19	4.9	<0.6	49.4	63.5
Sodium	0.68	0.56	2.9	1.3	0.74	7.79	10
pH (field)	7.7	7.8	8.8	8.1	7.9	9.3	9.7

These results suggest grout contamination of the well, and as noted previously with well GW-757, also indicate that the conventional sampling method may induce flow of clean groundwater into the well. Accordingly, well GW-205 may need to be redeveloped prior to low-flow sampling to ensure that representative groundwater samples are collected from the well.

As shown in preceding summary of CY 1999 data (Table 2), the maximum total chromium concentration reported for well GW-302 and the maximum total nickel concentrations reported for wells GW-302, GW-305, and GW-339 exceed the respective MCL for drinking water (0.1 mg/L). Corrosion of the stainless steel well casing and screen in these wells is the suspected source of the elevated chromium and/or nickel concentrations because none of the wells are located near known or suspected sources of chromium or nickel and geochemical conditions that are corrosive to stainless steel (e.g., dissolved oxygen >1 mg/L; Driscoll 1986) are evident in each of these wells (HSW 1995; AJA 1998). Preliminary sampling results obtained in November 1999 indicate that the groundwater in well GW-305 contains microorganisms (including iron-related bacteria and sulfate-reducing bacteria) which may induce corrosion of the stainless steel (Sarouhan et al 1998). Iron-related bacteria use iron from the environment and generate iron oxides and hydroxides which may be bound within the organism or precipitated as a capsule around the colony (Cullimore 1993). Sulfate-reducing bacteria are anaerobic and may release potentially corrosive hydrogen sulfide during sulfate reduction (Cullimore 1993). Although direct visual evidence of microbially induced corrosion (e.g., capsule formations) was not observed during a borehole camera survey of the well casing and screen (Jones 1999), the bacteria colonies may reside in the filter pack outside the well screen. Also, two unidentified cylindrical objects were observed at the bottom of the well, and if either of these objects is metallic (the composition of the objects could not be determined from the camera survey; Jones 1999), then galvanic corrosion may also be occurring in well GW-305.

As noted in Section 3.1, filtered and unfiltered groundwater samples were collected from well GW-305 in November 1999 to help evaluate potential differences between analytical results obtained with the low-flow and conventional sampling methods. As shown in the following data summary, these results indicate that the conventional and low-flow sampling methods yield filtered and unfiltered samples that contain similar concentrations of trace metals (barium and strontium) which are minor components of the calcium-magnesium-bicarbonate groundwater in the Knox Group, but substantially different concentrations of potential stainless steel corrosion products (chromium iron, manganese, and nickel; Driscoll 1986).

Table 5. Summary of trace metal results for well GW-305, November 3-4, 1999

Trace Metal	Total Concentration (mg/L)		Dissolved Concentration (mg/L)	
	Low-Flow Sampling	Conventional Sampling	Low-Flow Sampling	Conventional Sampling
Barium	0.012	0.0214	0.011	0.0108
Chromium	<0.02	0.0216	<0.02	<0.02
Iron	<0.05	1.31	<0.05	<0.05
Manganese	0.0101	0.13	0.00593	0.00877
Nickel	0.229	0.689	0.137	0.0701
Strontium	0.0187	0.024	0.0157	0.0133
Uranium	0.00122	<0.0005	0.000591	<0.0005

Assuming the concentrations of nickel, iron, and manganese (and chromium) reflect corrosion of the stainless steel casing and screen, the higher concentrations evident in the unfiltered sample obtained with the conventional sampling method suggest that the more aggressive purging of the well for conventional sampling may draw the corrosion products from areas of the well screen and filter pack farther from the pump intake.

3.1.2 Volatile Organic Compounds

Excluding a few spurious results for common laboratory reagents (e.g., acetone and 2-butanone), one or more of the following VOCs were detected in five of the wells used for Surveillance Monitoring during CY 1999: PCE, cis-1,2-dichloroethene (c12DCE), 11DCE, 111TCA, 11DCA, chloromethane, and carbon disulfide. As shown in the following summary, these compounds were detected in wells located at Kerr Hollow Quarry (GW-144 and GW-145), Industrial Landfill II (GW-757), Industrial Landfill IV (GW-305), and the Security Pits (GW-609).

Table 6. Maximum concentrations of VOCs detected in wells used for CY 1999 Surveillance Monitoring

Monitoring Well	Concentration (µg/L)						
	PCE	c12DCE	11DCE	111TCA	11DCA	Chloromethane	Carbon disulfide
GW-144	.	.	.	.	.	(3)	.
GW-145	.	.	.	.	.	(3)	.
GW-305	.	.	(4)	19	7	.	(2)
GW-609	(3)	(1)	.	.	.	.	.
GW-757	.	.	.	(4)	.	.	.
MCL (µg/L)	**5**	**70**	**7**	**200**	**NA**	**NA**	**NA**

Note: "." = Not detected; ( ) = Estimated concentration below the reporting limit; NA = Not applicable

Note that most of these results are estimated values below the respective analytical reporting limit for each compound, and that all of these results are less than applicable MCLs for drinking water. Historical data confirm that the Security Pits are the source of the VOCs in the groundwater at well GW-609. Industrial Landfill IV is the most likely source of the chloroethanes and chloroethenes in the groundwater at well

GW-305. Sporadic detection of VOCs in wells GW-144 and GW-145 is consistent with historical data for these wells at Kerr Hollow Quarry. However, the trace level of 111TCA detected in the sample collected from well GW-757 in April 1999 is not supported by historical results for the well (VOCs have not been detected in any of the 21 groundwater samples collected from this well between June 1992 and October 1999) and is probably an analytical artifact.

Monitoring results obtained from the network of monitoring wells at the Security Pits generally define a narrow, elongated plume of dissolved chloroethanes and chloroethenes extending parallel with geologic strike for at least 2600 ft downgradient to the east, and perpendicular to strike for at least 500 ft downgradient to the north and south. The primary components of the plume include 111TCA, 11DCA, and 11DCE in the western trench area and PCE, TCE, and c12DCE in the eastern trench area. The distribution of the plume constituents relative to the respective source areas and elongation of the plume along the axis of Chestnut Ridge, despite steeper hydraulic gradients toward the ridge flanks, suggest primarily eastward strike-parallel horizontal transport in the groundwater. The maximum depth of vertical transport has not been conclusively determined, however, available monitoring data show that VOCs occur at least 150 ft bgs in the western trench area, 250 ft bgs near the middle of the site, and 270 ft bgs downgradient of the eastern trench area (AJA 1997).

Historical data show that well GW-609, which is located about 800 ft east (along geologic strike) of the Security Pits (Figure 5), yields calcium-magnesium-bicarbonate groundwater containing relatively low concentrations of dissolved chloroethenes. Similar concentrations of PCE (3 µg/L), and c12DCE (1 µg/L) were detected in both groundwater samples collected from well GW-609 during CY 1999. These results are consistent with historical VOC data, and generally show decreasing long-term concentration trends that began after the disposal trenches at the Security Pits were closed and capped in the mid to late 1980s. Additionally, the VOC concentrations exhibit substantial temporal fluctuations that frequently correspond with season groundwater elevations. This suggests variable flux of VOCs and cyclic flushing by seasonal (and episodic) recharge/discharge. Additionally, the historical data show that PCE levels decreased from more than 50 µg/L in April 1991 to 5 µg/L in June 1993, steadily increased to almost 40 µg/L in May 1994, and subsequently decreased below 5 µg/L through July 1999. This overall trend suggests that a "pulse" of PCE, possibly related to corresponding disposal(s) of chlorinated solvents in the eastern trench area during operation of the Security Pits, may have passed the well during the peak concentration in April 1991 (AJA 2000b).

Historical data show that well GW-305, which is located directly south (hydraulically downgradient) of the eastern (unlined) portion of Industrial Landfill IV (Figure 5) and has been sampled on a quarterly or semiannual basis since March 1990, yields groundwater containing relatively low levels of 111TCA, 11DCA, and 11DCE. Along with the historical data, the CY 1999 monitoring results for this well show that: (1) 111TCA concentrations steadily increased following the initial detection in January 1992 (0.6 µg/L) to a peak of 20 µg/L in July 1999 (duplicate sample result); (2) 11DCA concentrations increased following the initial detection in July 1996 (1 µg/L) to a peak of 8 µg/L in July 1999 (duplicate sample result); and (3) 11DCE concentrations increased following the initial detection in January 1997 (1 µg/L) to a peak of 4 µg/L in July1999. These results suggest the breakthrough of a dissolved VOC plume, beginning with the arrival of the parent compound (111TCA), followed by the arrival of potential degradation products (11DCA and 11DCE) several years later.

Industrial Landfill IV is the suspected source of the VOCs detected in well GW-305 because it is the only potential contaminant source area that is hydraulically upgradient of the well, and the screened interval for the well (165.3 - 179.6 ft bgs) potentially intercepts dip-parallel groundwater flowpaths that subcrop below the unlined eastern portion of the landfill. Industrial Landfill IV initially received wastes in October 1989, yet none of the documentation for the site indicates disposal of 111TCA or related wastes. However, assuming rapid migration to the saturated zone and unimpeded advective transport in the groundwater, the range of hydraulic conductivity values (0.025 - 0.028 ft/d) indicated by falling head tests in well GW-305 (Jones 1998) do not support transport of 111TCA to the well within the time period between the initial disposal of waste at Industrial Landfill IV (October 1989) and the first-time detection of 111TCA on January 4, 1992 (795 to 825 days). Moreover, the low hydraulic conductivity values also do not support vertical migration from the water table (about 120 ft bgs) to the monitored interval in the well GW-305 during this time frame. Therefore, the repeated detection of 111TCA (and the associated degradation products) despite the apparently low permeability of the flowpaths intercepted by the well suggest: (1) 111TCA was present in the well before January 1992 but was not detected in the samples collected from the well, perhaps because purging the well for conventional sampling volatilized the compound; (2) the hydraulic conductivity test results do not account for localized stratigraphic and lithologic features (e.g., chert layers) in the residuum which could provide more permeable pathways from the landfill to the water table; (3) the hydraulic conductivity test results are representative and the presence of VOCs reflect migration from an unknown source area located very close to the well; or (4) the hydraulic conductivity test results are representative and the presence of VOCs reflect migration from Industrial Landfill IV via a combination of mechanisms (e.g., vapor phase transport) that greatly increase the relative rate of transport to the well.

Trace levels of chloromethane (the end degradation product of carbon tetrachloride) were detected in one of the replicate groundwater samples collected in April 1999 from Kerr Hollow Quarry wells GW-144 (3 µg/L) and GW-145 (3 µg/L). Although both results may be analytical artifacts (chloromethane has not been detected in samples from either of these wells before or since the April 15 sample), historical data for these wells show sporadic detection of very low concentrations (less than respective analytical reporting limits) of several related VOCs, including carbon tetrachloride, chloroform, and methylene chloride. These compounds (particularly carbon tetrachloride) were detected most frequently in the groundwater samples collected between the first quarter of 1990 and the fourth quarter of 1993, which suggests a causal relationship with the closure activities performed at the site during that time (HSW 1995). In addition to the closure activities as the site, the occurrence of VOCs in samples from the wells may, to some extent, reflect the method used to collect the samples. The sporadic detection of VOCs from 1990 to 1997 may reflect volatilization, rather than the absence of the compounds, during sample collection using the conventional sampling method. Additionally, the aggressive purging used for conventional sampling may have induced flow of more contaminated groundwater to the wells than the purging for low-flow sampling. For example, carbon tetrachloride was detected in 17 of the 31 samples collected from well GW-144 between September 1990 and May 1997, but has been undetected in the 20 samples collected since low-flow sampling began in October 1997 (Figure 6).

3.1.3 Radioactivity

Historical monitoring data for the bulk of the monitoring wells in the Chestnut Ridge Regime do not indicate radiological contamination, and the CY 1999 monitoring results are consistent with these findings. Although gross alpha and gross beta results reported for at least one groundwater sample collected from 21 of the 36 Surveillance Monitoring wells exceed the corresponding minimum detectable activity (MDA), most of these gross alpha and gross beta results are less than 10 pCi/L and have high proportional counting errors (i.e., a high degree of analytical uncertainty). Additionally, all of the gross alpha results that exceed MDAs are less than the 15 picoCuries per liter (pCi/L) MCL for drinking water except the result for one of the replicate samples collected from well GW-145 (15.48 ± 2.89 pCi/L) in April 1999. The annual average gross alpha activity for well GW-145 (10.95 pCi/L) is less than the MCL. Similarly, only one gross beta result exceeds the Safe Drinking Water Act (SDWA) screening value of 50 pCi/L: the August sample from well GW-205 had gross beta activity of 71.88 ± 2.89 pCi/L. However, this result is unsupported by historic data and the February sample from well GW-205 had gross beta activity that was less than the MDA (1.66 pCi/L). None of these results are clearly indicative of groundwater contamination.

3.2 EXIT PATHWAY/PERIMETER MONITORING

The CY 1999 monitoring results reported for eight springs, two surface water sampling stations in McCoy Branch, and the outfall (OF) for Kerr Hollow Quarry (OF 301) were evaluated for the purposes of Exit Pathway/Perimeter Monitoring in the Chestnut Ridge Regime. The springs are located near surface drainage features that exit the ORR and flow into the Clinch River (Melton Hill Lake) south of the Chestnut Ridge Regime. As shown on Figure 5, two of the springs are in Bethel Valley, one about 2000 ft west of Rogers Quarry (SCR2.2SP) and one about 1500 ft south of Kerr Hollow Quarry (SCR5.4SP). The other six springs are located in the five surface drainage features (numbered from west to east: SCR1, SCR2, etc.) that traverse the southern flank of Chestnut Ridge in the regime: SCR1.25SP and SCR2.1SP are in the western creeks; SCR3.4SP and SCR3.5SP are in McCoy Branch; and SCR4.3SP and SCR5.1SP are in the eastern creeks (Figure 5). The two surface water sampling stations (MCK2.0 and MCK2.05) are located along the main channel of McCoy Branch directly downstream of the Filled Coal Ash Pond, and OF 301 is located where the water in Kerr Hollow Quarry discharges into an unnamed drainage feature (Figure 5).

Grab samples (including duplicates) were collected semiannually during CY 1999 from each spring and surface water sampling station except for OF 301 which was sampled in March, July, and October (Table B.2). The samples were analyzed for inorganics (major ions and trace metals), VOCs, gross alpha and gross beta activity, and several miscellaneous field (e.g., water temperature) and laboratory analytes (e.g., TDS). Analytical results are reported in Appendix E of the CY 1999 GWMR.

Each of the springs that were sampled during CY 1999 discharge calcium-magnesium-bicarbonate groundwater characterized by: (1) a wide range of calcium to magnesium ratios; (2) variable but generally low molar proportions (<10%) of chloride, potassium, sodium, and sulfate; (3) nitrate concentrations below 1 mg/L; (4) carbonate alkalinity and fluoride concentrations below respective analytical reporting limits; (5) low total concentrations (<0.5 mg/L) of barium, strontium, and iron; and (6) TDS below 200 mg/L. Results for several of the springs show distinctly seasonal geochemical changes. For instance, chloride concentrations in the samples collected from springs SCR2.1SP (11.6 mg/L) and SCR4.3SP (6.87 mg/L) during January 1999 (seasonally high flow) are two to four times higher than respective chloride levels in the samples collected from each spring during July 1999 (seasonally low flow). Also, nitrate concentrations above 1 mg/L were reported for several of the springs, with the highest concentrations reported for the samples from spring SCR5.1SP in January (2.89 mg/L) and July 1999 (2.47 mg/L). Spring SCR5.1SP discharges into an unnamed drainage feature about 750 ft downstream of the Upper Hayfield sludge application site east of Construction Demolition Landfill VII (Figure 5). Elevated nitrate concentrations in the spring may therefore reflect migration of nitrate leached from the sludge at this site, although the nitrate levels are substantially below the 10 mg/L MCL for drinking water.

Analytical results for the surface water samples collected from MCK2.0, MCK2.05, and OF 301 during CY 1999 generally reflect geochemical characteristics that are similar to those of the springs (and monitoring wells) in the Chestnut Ridge Regime. However, the surface water samples (including duplicates) collected from MCK2.0 and MCK2.05 are clearly distinguished by elevated sulfate concentrations ranging from 22.5 to 23.3 mg/L. Elevated levels of sulfate at these sampling locations potentially reflects the impact of the Filled Coal Ash Pond on downstream water quality in McCoy Branch.

Elevated total concentrations (i.e., >UTL) of one or more of five trace metals (arsenic, boron, manganese, strontium, and zinc) reported for at least one sample collected during CY 1999 from MCK2.0, MCK2.05, OF 301, and springs SCR3.4SP, SCR3.5SP, and SCR5.4SP. Only the trace metal (arsenic, boron, and manganese) results for MCK2.0 and MCK2.05, however, potentially reflect contamination from waste management activities; the other elevated trace metal concentrations most likely reflect analytical variability (zinc) or ambient levels (strontium). Surface water samples collected from MCK2.0 and MCK2.05 contained elevated (total) concentrations of arsenic, boron, and manganese. The arsenic concentrations at MCK2.05 (0.0446 - 0.0663 mg/L) were at or above the MCL (0.05 mg/L) and were higher than the arsenic concentrations downstream at MCK2.0 (0.0154 - 0.0254 mg/L). Total manganese concentrations likewise exceed the groundwater UTL (0.13 mg/L) with the highest concentration (1.16 mg/L) reported for the sample collected from MCK2.05 in August 1999. Total boron concentrations ranged from 0.206 mg/L (MCK2.05) to 0.241 mg/L (MCK2.0), which are almost an order of magnitude above the UTL for groundwater in the Knox Group (0.028 mg/L). Along with the elevated sulfate levels, the elevated arsenic, boron, and manganese concentrations potentially reflect the impact of the Filled Coal Ash Pond on surface water quality in McCoy Branch.

Volatile organic compounds detected in samples collected from the springs used for Exit Pathway/Perimeter Monitoring during CY 1999 were potentially analytical artifacts and not representative of actual groundwater quality. The VOCs detected were acetone at SCR2.1SP and SCR5.1SP (10 µg/L and 16 µg/L, respectively) and carbon disulfide (1 µg/L) and 111TCA (2 µg/L) at SCR5.4SP. These compounds are known laboratory contaminants and were detected only in the February 1999 samples from the springs (they were undetected in the July 1999 samples). Accordingly, the monitoring data do not indicate VOC contamination at any of the sampling locations used for the purposes of Exit Pathway/Perimeter Monitoring during CY 1999.

Gross alpha and/or gross beta above the associated MDA was reported for at least one sample collected during CY 1999 from OF 301, surface water stations MCK2.0 and MCK2.05, and springs SCR1.25SP, SCR2.1SP, SCR3.4SP, SCR3.5SP,and SCR4.3SP. All of the gross alpha results that exceed the MDA are less than 10 pCi/L and are generally characterized by large proportional counting errors (which indicates a high degree of analytical uncertainty). Additionally the highest CY 1999 gross alpha levels, which were reported for samples collected from OF 301 in March 1999 (6.98 ± 1.37 pCi/L) and from SCR2.1SP in July 1999 (5.8 ± 3.7 pCi/L), are substantially below the MCL for drinking water (15 pCi/L). Similarly, all but one of the gross beta results that exceed the associated MDA are below 10 pCi/L and have large proportional counting errors. The highest CY 1999 gross beta level, which was reported for the sample collected from SCR3.4SP in February 1999 (27 ± 6.7 pCi/L), is substantially below the SDWA screening level (50 pCi/L). Accordingly, the monitoring data do not indicate radiological contamination at any of the sampling locations used for the purposes of Exit Pathway/Perimeter Monitoring during CY 1999.

3.3 CONTAMINANT CONCENTRATION TRENDS

As noted in Section 2.4, monitoring data obtained since the mid-1980s indicate that groundwater contamination is fairly limited in the Chestnut Ridge Regime and, as indicated by the CY 1999 monitoring results, contaminant concentrations in most wells reflect decreasing or indeterminate long-term trends. Decreasing concentration trends probably reflect a combination of several factors, including compliance with waste management regulations, waste minimization and source control measures, natural attenuation in the Knox aquifer, and, in some cases, changes in sampling procedures and analytical methods. Indeterminate trends occur where insufficient data are available, the trend is fairly stable, or the concentrations fluctuate with no apparent linear trend over time. For the purposes of DOE Order 5400.1A requirements, the following discussion is focused on CY 1999 sampling locations that exhibit increasing long-term contaminant concentration trends. Increasing trends are indicated by the monitoring results for well GW-144 (nitrate) at Kerr Hollow Quarry and wells GW-217 (boron) and GW-305 (VOCs) at Industrial Landfill IV.

Nitrate levels in well GW-144 have increased from less than 1 mg/L during the early 1990s to more than 3 mg/L in 1999 (Figure 7), with sharp concentration spikes evident in April 1996 (6.21 mg/L) and April 1998 (4.63 mg/L). The nitrate concentrations also show generally seasonal concentration fluctuations, with higher concentrations unusually evident during winter and spring (seasonally high flow) and lower concentrations evident during summer and fall (seasonally low flow). The seasonal nitrate fluctuations may be partially attributed to nitrate uptake by vegetation, as plants consume more nitrate during the growing season (summer and fall) than in the non-growing season (winter and spring). As noted in Section 3.1.1, the elevated nitrate concentrations in the groundwater at well GW-144 potentially reflect migration of nitrate leached from municipal sewage sludge application sites to the northeast and northwest of the well, and the increasing concentration trend may indicate increase flux of nitrate, which is highly mobile and chemically stable in groundwater.

As noted in Section 3.1.1, total (and dissolved) boron concentrations in the groundwater at well GW-217 substantially exceed the applicable UTL (0.028 mg/L) and are more than an order of magnitude higher than the results reported for all of the other monitoring wells in the Chestnut Ridge Regime except those at Kerr Hollow Quarry. Historical boron results for this well show a conspicuous concentration spike (0.69 mg/L) in January 1992 followed by a steadily increasing trend through October 1994 and a generally decreasing trend through July 1999 (Figure 8). These results potentially reflect a “pulse” of boron-enriched groundwater that may coincide with one or more disposals of boron wastes at Industrial Landfill IV.

Historical results for well GW-305 show that the concentration of 111TCA increased from 0.6 μg/L in January 1992 to 19 μg/L in July 1999 (Figure 9). The July 1999 sampling results also suggest that concentrations of 11DCA (7 μg/L) and 11DCE (4 μg/L) continue to increase over time (Figure 9). The sequential detection of 111TCA (January 1992), 11DCA (July 1996), and 11DCE (January 1997) and the subsequent increases in the concentration of each compound potentially reflect eastward (parallel with geologic strike) migration of the center of mass of a dissolved VOC plume comprised primarily of 111TCA, with 11DCA and 11DCE present as degradation products. Biotic degradation of 111TCA is supported by the preliminary sampling results obtained in November 1999 that indicate the groundwater in this well contains a complex bacterial consortium (see Section 3.1.1).

Historical data for the well GW-305 generally show total (and dissolved) nickel concentrations near the analytical reporting limit punctuated by several concentration spikes (e.g., 0.39 mg/L in August 1990), with a clearly increasing concentration trend evident between January 1996 and July 1999 (Figure 9). Moreover, the total nickel concentrations obtained from low-flow sampling (0.229 mg/L) and conventional sampling (0.689 mg/L) in November 1999 reflect the highest nickel concentrations evident in the well since January 1992 (0.6 mg/L). As discussed in Section 3.1.1, corrosion of the stainless steel well casing and screen is the suspected source of the elevated and increasing nickel concentrations in well GW-305 (Jones 1999).

4.0 CONCLUSIONS AND RECOMMENDATIONS

Monitoring data obtained in the Chestnut Ridge Regime during CY 1999 are consistent with historical results regarding the known sources of groundwater contamination in the regime, the primary types of groundwater contaminants, and the extent of contaminant transport in the Knox aquifer.

Based on evaluation of the CY 1999 monitoring results for the purposes of DOE Order 5400.1A Surveillance Monitoring, groundwater samples from five monitoring wells may reflect contamination from three waste management sites in the Chestnut Ridge Regime. Elevated boron concentrations at well GW-217 and VOCs (111TCA, 11DCA, and 11DCE) at well GW-305 potentially reflect migration from the unlined portion of Industrial Landfill IV. The VOCs (PCE and c12DCE) detected in groundwater at well GW-609 were transported from the eastern portion of the Security Pits. Kerr Hollow quarry is the likely source of trace levels of chloromethane detected in wells GW-144 and GW-145. Additionally, elevated nitrate concentrations reported for well GW-144 may reflect migration from sewage sludge disposal sites located upgradient of Kerr Hollow Quarry.

The CY 1999 monitoring results for the majority of sampling locations used for the purposes of DOE Order 5400.1A Exit Pathway/Perimeter Monitoring during CY 1999 do not indicate the presence of anthropogenic contaminants in the surface drainage features that traverse the Chestnut Ridge Regime and ultimately exit the ORR. Only three locations had indications of at least one inorganic contaminant and only one result (arsenic at MCK2.05) exceeds an MCL: spring SCR5.1SP had elevated nitrate levels (which may reflect migration from a nearby sewage sludge disposal site) and surface water stations MCK2.0 and MCK2.05 had elevated arsenic, boron, manganese, and sulfate concentrations (which may reflect localized impacts from the Filled Coal Ash Pond).

Along with historical data, evaluation of the CY 1999 monitoring results indicates increasing long-term concentrations of known or suspected groundwater contaminants in wells GW-144 (nitrate), GW-217 (boron) and GW-305 (VOCs and nickel) at Industrial Landfill IV.

Based on review of the CY 1999 monitoring data, the following actions are recommended:

- Discontinue collection of filtered samples for metals analyses from spring stations. Samples from these locations typically have low suspended solids concentration. Unfiltered samples with higher suspended solids normally have higher concentrations of trace metals commonly found in uncontaminated sediment (e.g., aluminum and iron). Additionally, comparison of filtered to unfiltered results has little effect on data evaluation.

- Collect unfiltered samples using the low-flow sampling method from several wells at the Chestnut Ridge Security Pits during the first and third quarters of CY 2001. Samples from wells GW-174, GW-175, GW-177, GW-180, and GW-612 were last collected 1996 and all available data for these wells were obtained using the conventional sampling method.

- Collect samples from five wells with little or no historical data: well 1084 south of Industrial Landfill II, wells GW-673 and GW-674 downgradient (south) of the Filled Coal Ash Pond, and wells GW-568 and GW-569 downgradient (east) of the Security Pits. These wells should be inspected and redeveloped to remove all stagnant groundwater and ensure collection of representative samples. No well construction information is available for well GW-568 and a well inspection would determine the well depth.

- Wells GW-205 and GW-757 should be redeveloped to help mitigate localized grout contamination, as indicated by the unusually high pH and potassium levels in the samples from the wells. Redevelopment should occur within a week before collecting low-flow samples to ensure collection of more representative samples.

5.0 REFERENCES

AJA Technical Services, Inc. 1996. *Calendar Year 1995 Groundwater Quality Report for the Chestnut Ridge Hydrogeologic Regime, Y-12 Plant, Oak Ridge, Tennessee*; Part 2: 1995 Groundwater Quality Data Interpretations and Proposed Program Modifications. Prepared for Lockheed Martin Energy Systems, Inc. (Y/SUB/96-KDS15V/2).

AJA Technical Services, Inc. 1997. *Evaluation of Calendar Year 1996 Groundwater and Surface Water Quality Data for the Chestnut Ridge Hydrogeologic Regime at the U.S. Department of Energy Y-12 Plant, Oak Ridge, Tennessee*. Prepared for Lockheed Martin Energy Systems, Inc. (Y/SUB/97-KDS15V/5).

AJA Technical Services, Inc. 1998. *Evaluation of Calendar Year 1997 Groundwater and Surface Water Quality Data for the Chestnut Ridge Hydrogeologic Regime at the U.S. Department of Energy Y-12 Plant, Oak Ridge, Tennessee*. Prepared for Lockheed Martin Energy Systems, Inc. (Y/SUB/98-MVM64/2).

AJA Technical Services, Inc. 1999. *Groundwater Protection Program Calendar Year 1998 Evaluation of Groundwater Quality Data for the Chestnut Ridge Hydrogeologic Regime at the U.S. Department of Energy Y-12 Plant, Oak Ridge, Tennessee*. Prepared for Lockheed Martin Energy Systems, Inc. (Y/SUB/99-MVM64V/3).

AJA Technical Services, Inc. 2000a. *Calendar Year 1999 Groundwater Monitoring Report for the Groundwater Protection Program, U.S. Department of Energy Y-12 Plant, Oak Ridge, Tennessee*. Prepared for Lockheed Martin Energy Systems, Inc. (Y/SUB/00-MVM64V/1).

AJA Technical Services, Inc. 2000b. *Calendar Year 1999, Annual Resource Conservation and Recovery Act Groundwater Monitoring Report for the Chestnut Ridge Hydrogeologic Regime at the U.S. Department of Energy Y-12 Plant, Oak Ridge, Tennessee*. Prepared for Bechtel Jacobs Company LLC. (BJC/OR-520).

Cullimore, D.R. 1993. *Practical Manual of Groundwater Microbiology*. CRC Press LLC, Boca Raton , Florida.

Driscoll, F.G. 1986. *Groundwater and Wells*. Johnson Division, St. Paul, Minnesota.

Geraghty & Miller, Inc. 1990. *A Study of Ground-Water Flow from Chestnut Ridge Security Pits Using a Fluorescent Dye Tracer*. Prepared for Martin Marietta Energy Systems, Inc. (Y/SUB/90-00206C/6).

Hatcher, R.D., Jr., P.J. Lemiszki, R.B. Dreier, R.H. Ketelle, R.R. Lee, D.A. Leitzke, W.M. McMaster, J.L. Foreman, and S.Y. Lee. 1992. *Status Report on the Geology of the Oak Ridge Reservation.* (ORNL/TM-12074).

HSW Environmental Consultants, Inc. 1995. *Calendar Year 1994 Groundwater Quality Report for the Chestnut Ridge Hydrogeologic Regime, Y-12 Plant, Oak Ridge, Tennessee*; Part 2: 1994 Groundwater Quality Data Interpretations and Proposed Program Modifications. Prepared for Lockheed Martin Energy Systems, Inc. (Y/SUB/95-EAQ10C/3/P2).

HSW Environmental Consultants, Inc. and Paradigm Data Services, Inc. 1995. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Y-12 Plant, Oak Ridge, Tennessee*. Prepared in conjunction with the Oak Ridge National Laboratory Environmental Sciences Division, Computer Science and Mathematics Division, Office of Environmental Compliance and Documentation, and Energy Division. (Y/ER-234).

Hem, J.D. 1985. *Study and Interpretation of the Chemical Characteristics of Natural Water*. U.S. Geological Survey Water-Supply Paper 2254.

Jones, S.B. 1998. *Hydraulic Conductivity Estimates from Landfills in the Chestnut Ridge Hydrogeologic Regime at the Y-12 Plant, 1994-1997*. Letter to AJA Technical Services, Inc. February 12, 1998.

Jones, S.B. 1999. *Technical Explanation for the Detected Increase in Nickel in Groundwater Monitoring Well GW-305 at the Industrial Landfill IV, IDL-47-103-0075, Department of Energy Y-12 Plant, Anderson County, TN*. Lockheed Martin Energy Systems, Inc. (Y/TS-1774).

Ketelle, R.H. and D.D. Huff. 1984. *Site Characterization of the West Chestnut Ridge Site*. Oak Ridge National Laboratory. (ORNL/TM-9229).

King, H.L. and C.S. Haase. 1987. *Subsurface-Controlled Geological Maps for the Y-12 Plant and Adjacent Areas of Bear Creek Valley*. Oak Ridge National Laboratory (TM-10112).

King, H.L. and C.S. Haase. 1988. *Summary of Results and Preliminary Interpretation of Hydrogeologic Packer Testing in Core Holes GW-131 Through GW-135 and CH-157, Oak Ridge Y-12 Plant*. Prepared for Martin Marietta Energy Systems by E.C. Jordan Company. (Y/TS-495).

McLean, J.E., and B.E. Bledsoe. 1992. *Behavior of Metals in Soils*. U.S. Environmental Protection Agency, Office of Research and Development (EPA/540/S-92/018).

Moore, G.K. 1988. *Concepts of Groundwater Flow and Occurrence Near Oak Ridge National Laboratory, Tennessee*. Oak Ridge National Laboratory. (ORNL/TM-10969).

Moore, G.K. 1989. *Groundwater Parameters and Flow System Near Oak Ridge National Laboratory*. Oak Ridge National Laboratory. (ORNL/TM-11368).

Sarouhan, B.J., D. Tedaldi, B. Lindsey, and A. Piszkin. 1998. *Microbiologically Induced Corrosion in Stainless Steel Groundwater Wells.* Bechtel National Inc., San Diego, CA.

Science Applications International Corporation. 1993. *Final Report of the Second Dye-Trace Test at the Chestnut Ridge Security Pits, Y-12 Plant, Oak Ridge, Tennessee.* Prepared for Martin Marietta Energy Systems, Inc. (Y/SUB/93-99928C/Y10/1).

Science Applications International Corporation. 2000. *Y-12 Plant Groundwater Protection Program Data Management Plan*. Prepared for Lockheed Martin Energy Systems, Inc.(Y/SUB/00-KFX63/C/1).

Smith, R.E., N.J. Gilbert, and C.E. Sams. 1983. *Stability Analysis of Waste Disposal Facilities at the Y-12 Plant*. Prepared for Martin Marietta Energy Systems, Inc. (Y/SUB/83-49712/1).

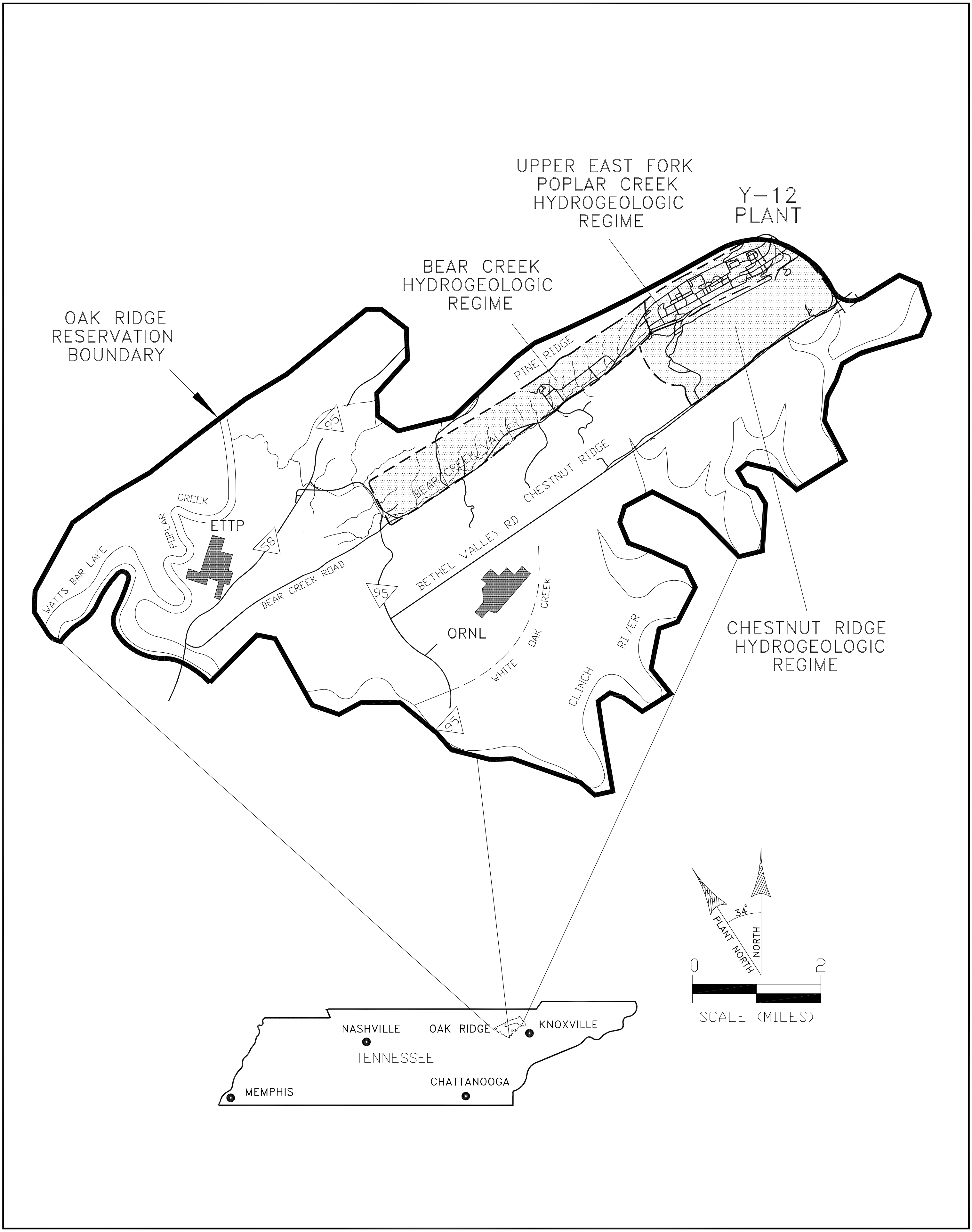
Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report A Hydrologic Framework for the Oak Ridge Reservation*. Oak Ridge National Laboratory. (ORNL/TM 12053).

Wilson, G.V., P.M. Jardine, R.J. Luxmoore, and J.R. Jones. 1990. *Hydrology of a Forested Hillslope During Storm Events*. Geoderma, v. 46, p. 119-138.

U.S. Department of Energy. 1999. *1999 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge Tennessee*. DOE/OR/01-1790&D2.

APPENDIX A

FIGURES



DER99C_1 06/01/00

Fig. 1. Hydrogeologic regimes at the Y-12 Plant.

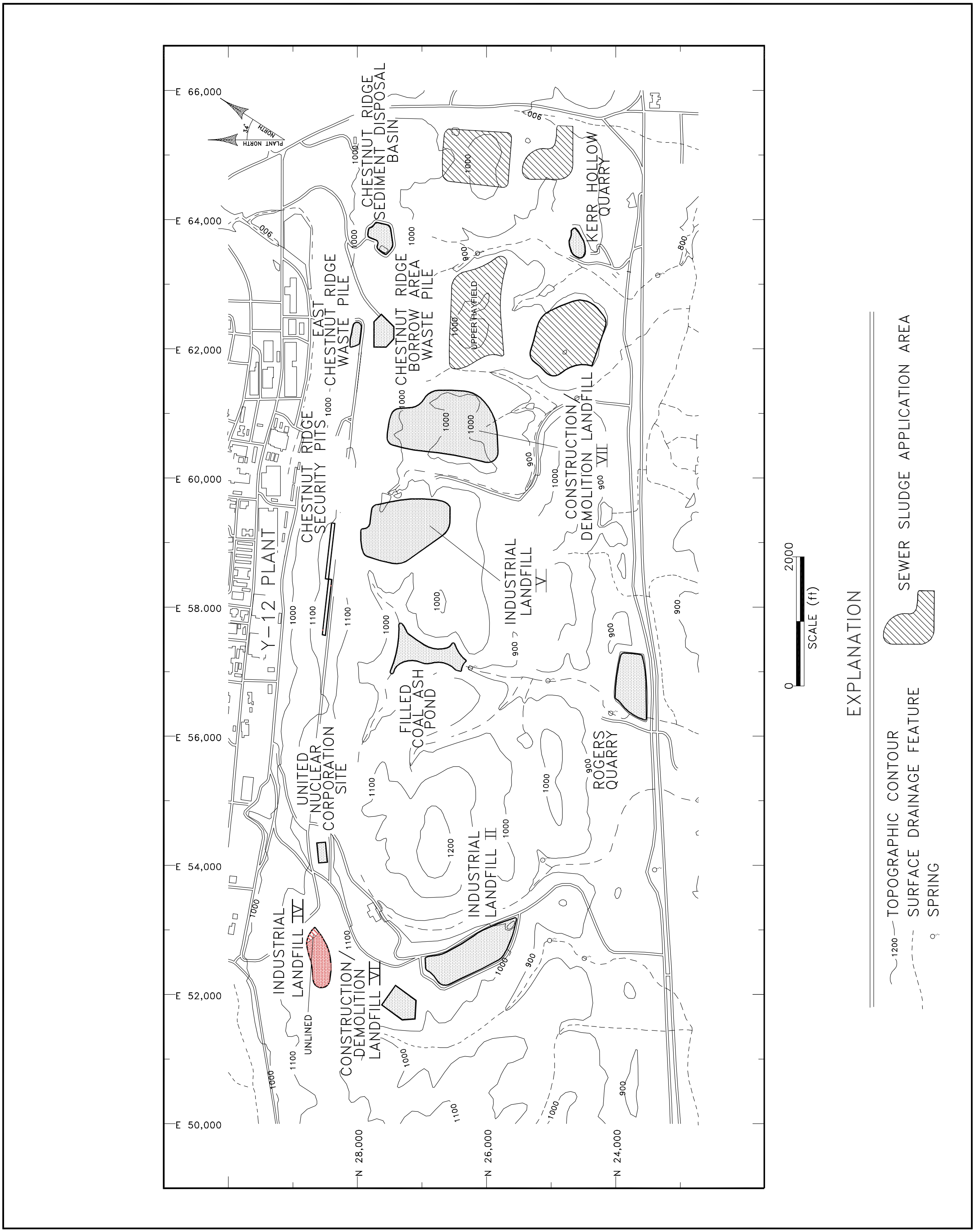


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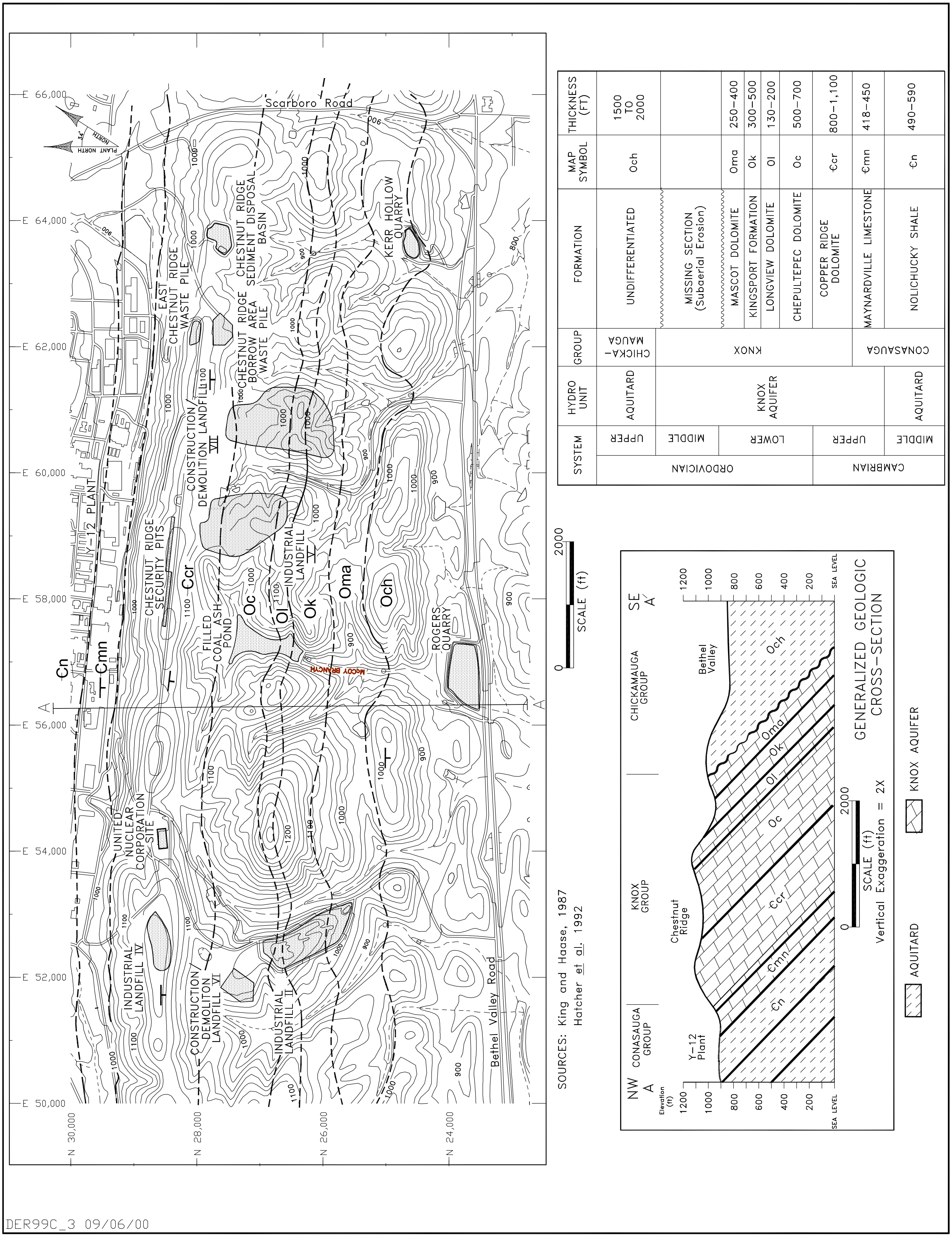
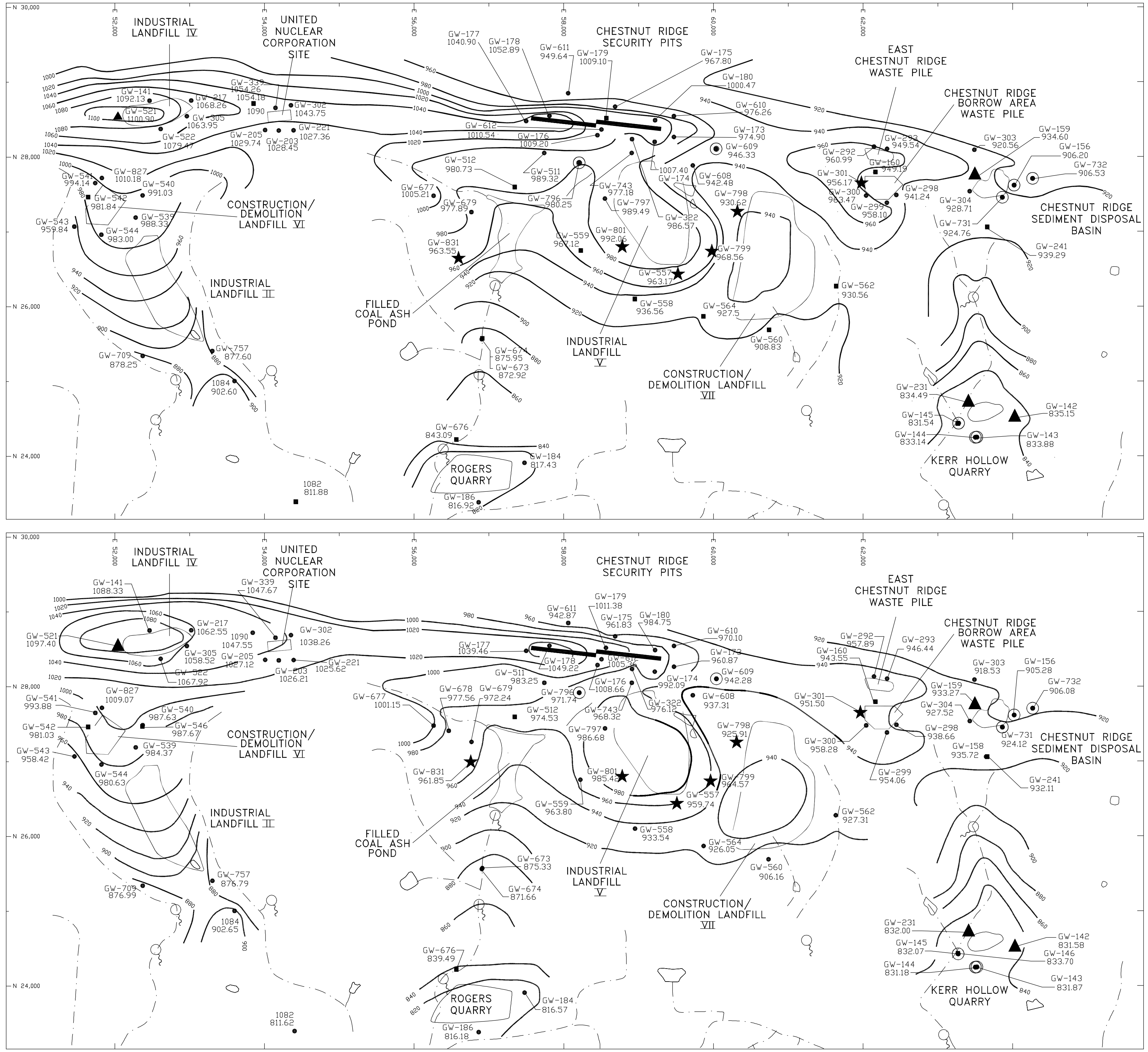
Fig. 2. Waste management sites in the Chestnut Ridge Hydrogeologic Regime.



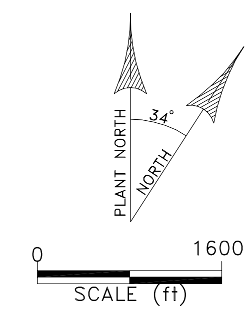
SYSTEM		HYDRO UNIT	GROUP	FORMATION	MAP SYMBOL	THICKNESS (FT)
ORDOVICIAN	UPPER	AQUITARD	CHICKA-MAUGA	UNDIFFERENTIATED	Och	1500 TO 2000
ORDOVICIAN	MIDDLE	KNOX AQUIFER	KNOX	MISSING SECTION (Subaerial Erosion)		
ORDOVICIAN	LOWER	KNOX AQUIFER	KNOX	MASCOT DOLOMITE	Oma	250–400
ORDOVICIAN	LOWER	KNOX AQUIFER	KNOX	KINGSPORT FORMATION	Ok	300–500
ORDOVICIAN	LOWER	KNOX AQUIFER	KNOX	LONGVIEW DOLOMITE	Ol	130–200
ORDOVICIAN	LOWER	KNOX AQUIFER	KNOX	CHEPULTEPEC DOLOMITE	Oc	500–700
CAMBRIAN	UPPER	KNOX AQUIFER	KNOX	COPPER RIDGE DOLOMITE	Ꞓcr	800–1,100
CAMBRIAN	UPPER	KNOX AQUIFER	CONASAUGA	MAYNARDVILLE LIMESTONE	Ꞓmn	418–450
CAMBRIAN	MIDDLE	AQUITARD	CONASAUGA	NOLICHUCKY SHALE	Ꞓn	490–590

Fig. 3. Topography and bedrock geology in the Chestnut Ridge Hydrogeologic Regime.



GROUNDWATER ELEVATIONS
APRIL 4 - 8, 1999

GROUNDWATER ELEVATIONS
SEPTEMBER 13 - 27, 1999



EXPLANATION

- ▪ WATER TABLE INTERVAL MONITORING WELL
- • BEDROCK INTERVAL MONITORING WELL
- ★ RCRA PLUME DELINEATION MONITORING WELL
- ▲ RCRA BACKGROUND / UPGRADIENT MONITORING WELL
- ⊙ RCRA POINT-OF-COMPLIANCE MONITORING WELL
- 920 WATER-LEVEL ISOPLETH (ft msl)
- SURFACE DRAINAGE FEATURE
- SPRING

DER99C_4 09/06/00

Fig. 4. Seasonal groundwater elevations in the Chestnut Ridge Hydrogeologic Regime, 1999.

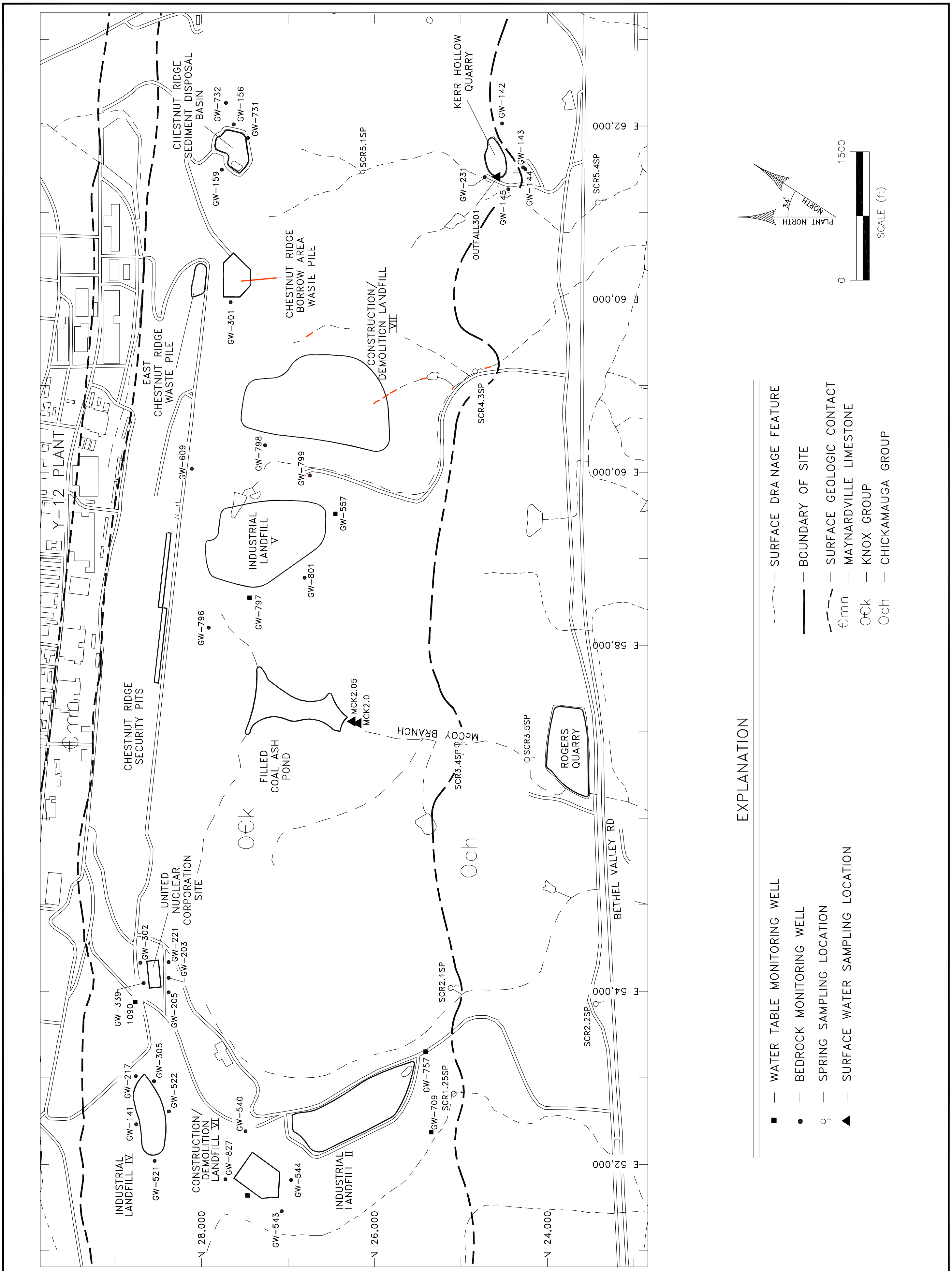


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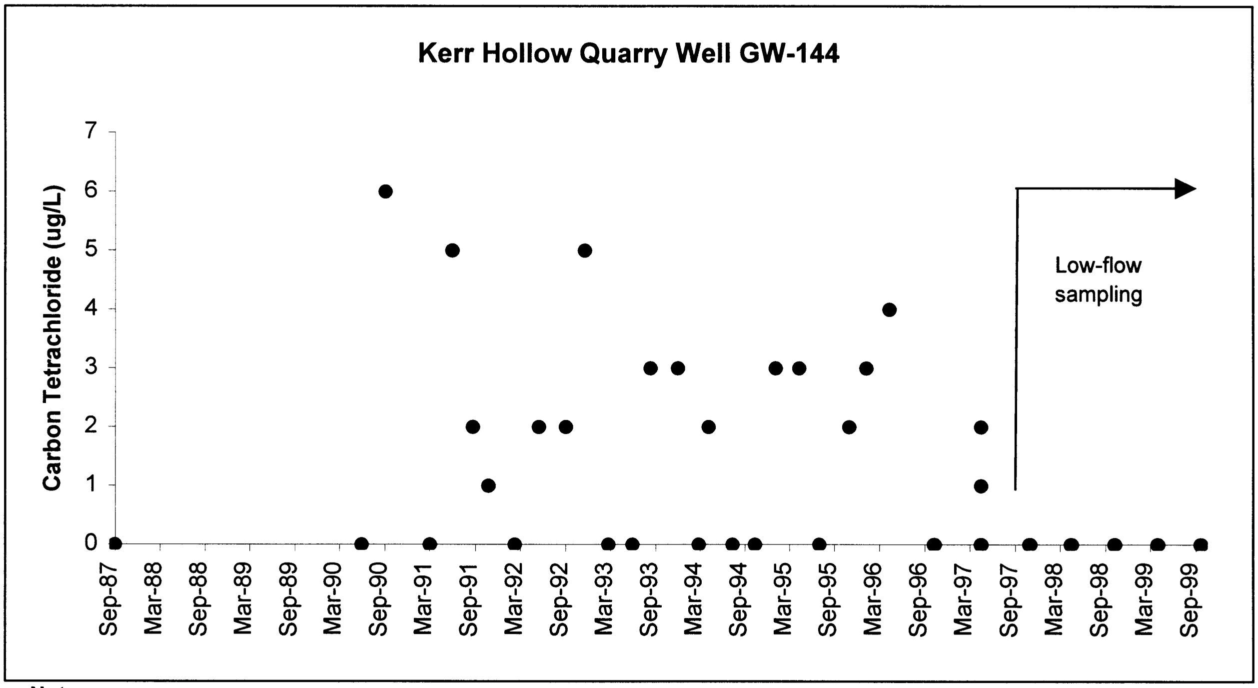
Fig. 5. CY 1999 sampling locations in the Chestnut Ridge Hydrogeologic Regime.



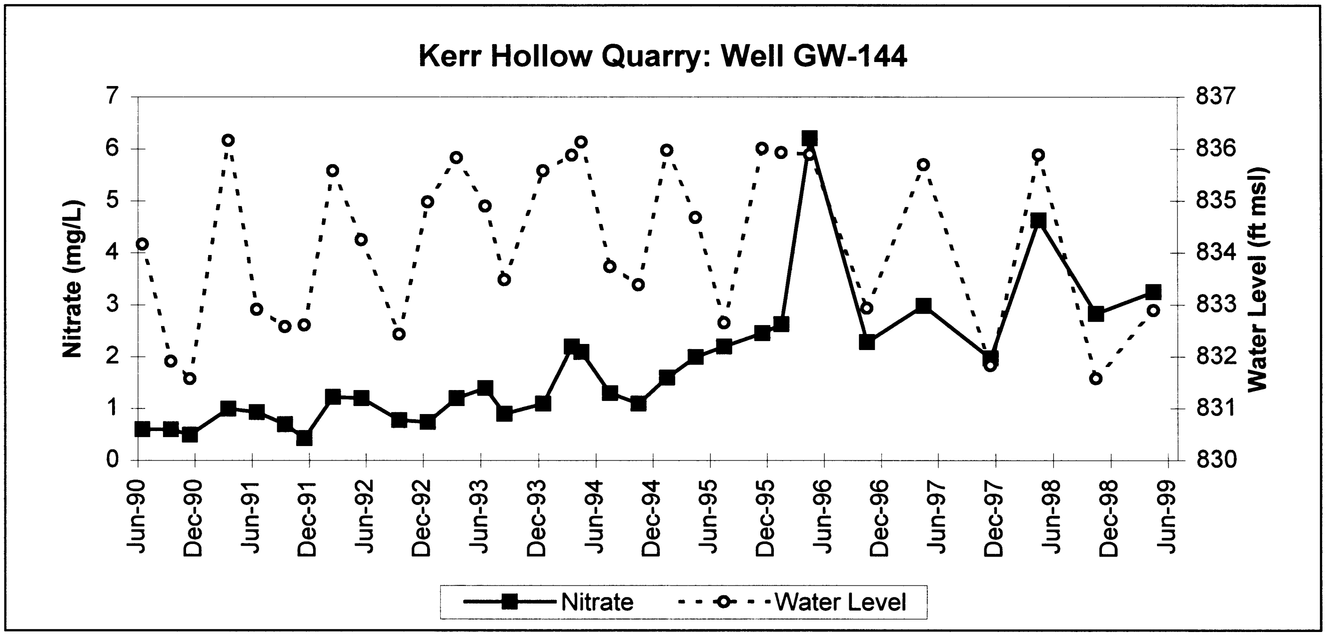
Notes: The MCL for both compounds is 5 ug/L.

Nondetected results are shown with a value of zero.

All detected results < 5 ug/L are estimated values below the reporting limit.

CR2_99 09/18/00

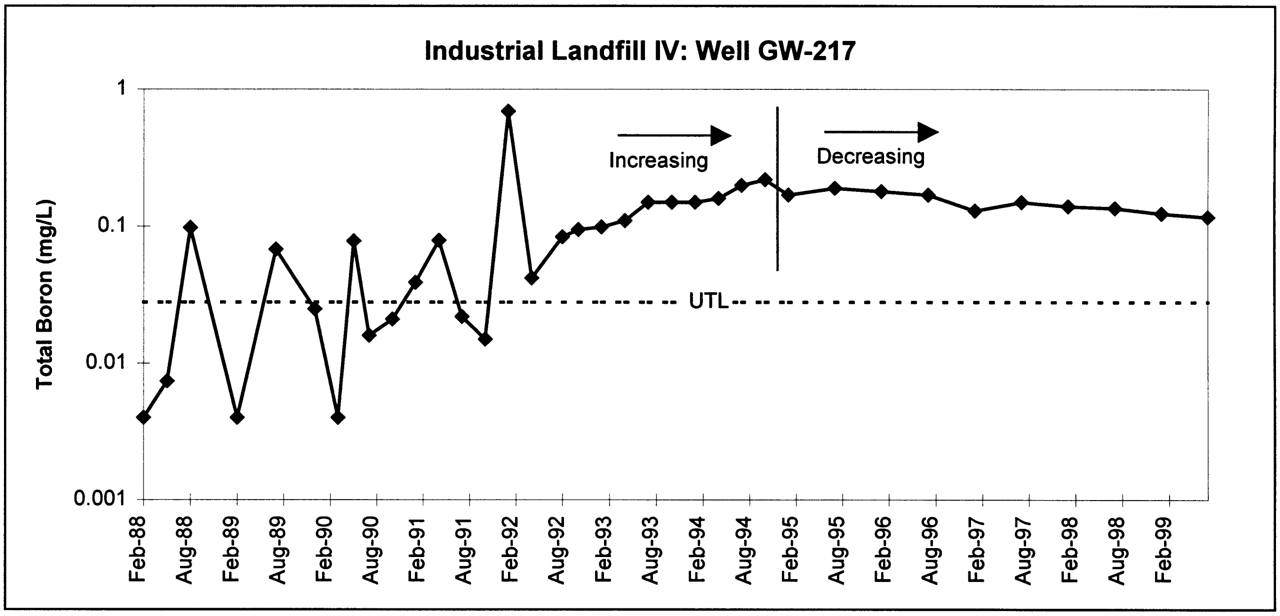
Fig. 6. Carbon tetrachloride concentrations in well GW-144.



Note: The median value of four replicate results are shown beginning in October 1996.

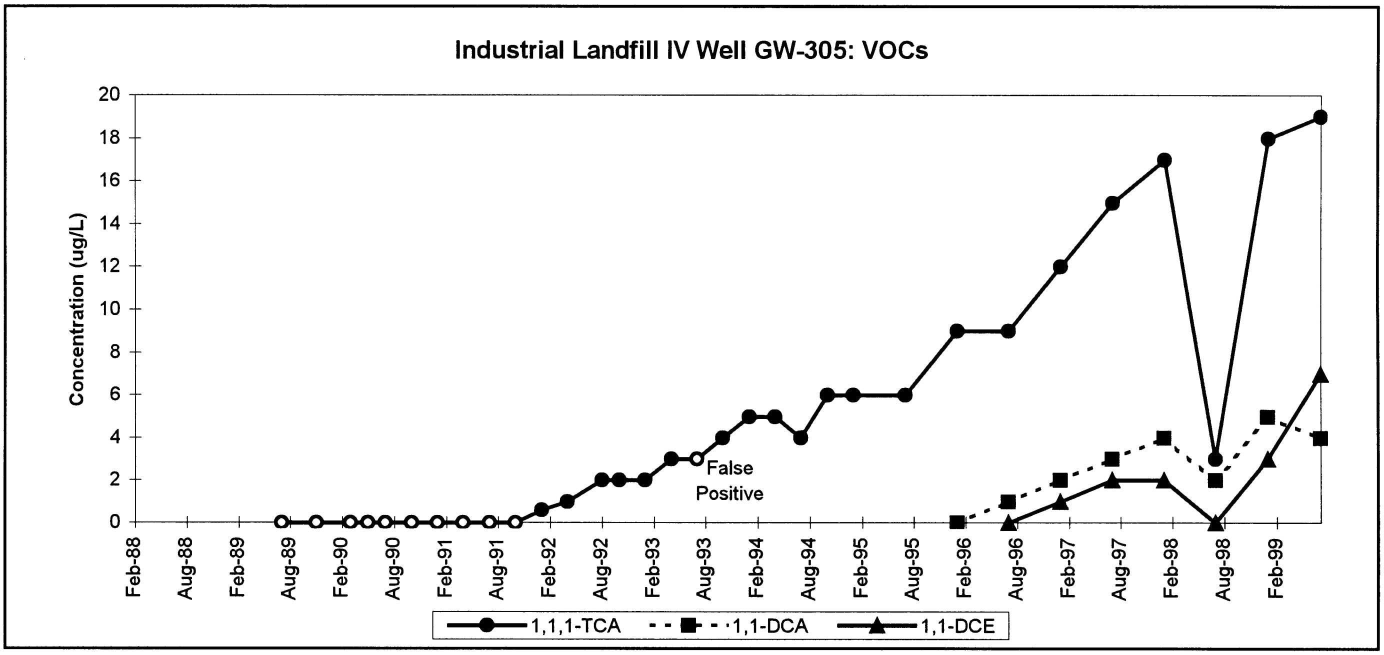
CR2_99 08/09/00

Fig. 7. Presampling groundwater elevations and nitrate concentrations in well GW-144.

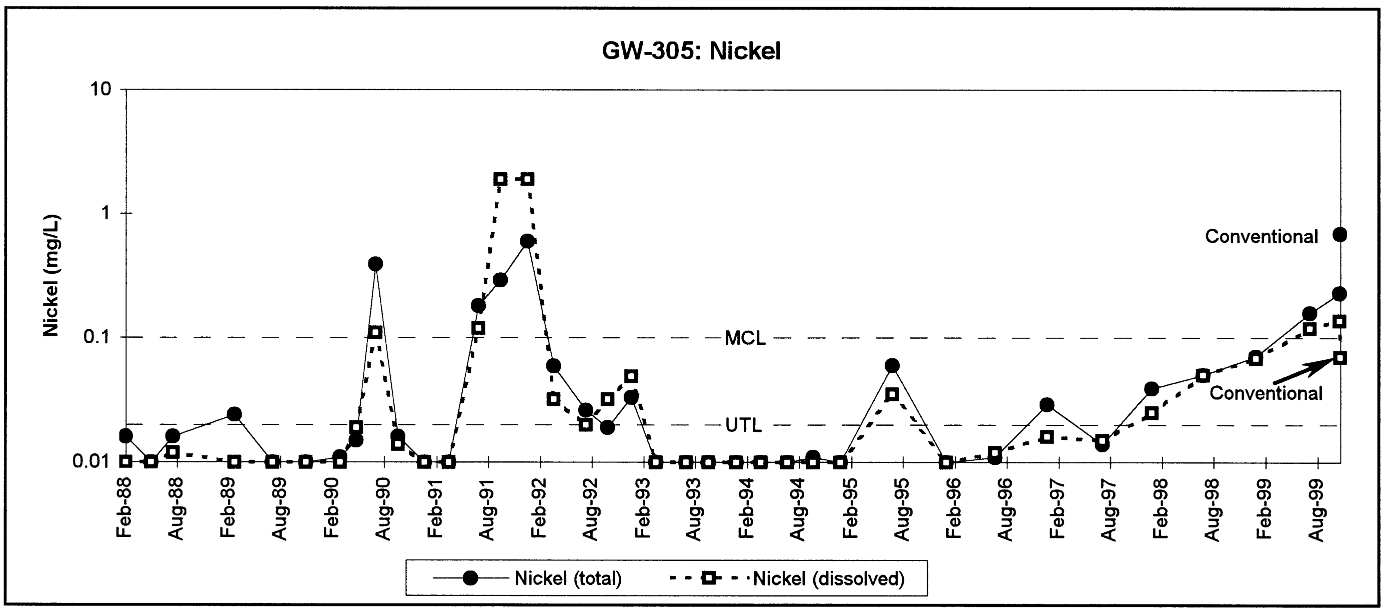


CR2_99 08/09/00

Fig. 8. Boron concentrations in well GW-217.



Note: 1,1,1-TCA MCL = 200 ug/L; 1,1-DCE MCL = 7 ug/L.



CR2_99 08/09/00

Fig. 9. VOC and nickel concentrations in well GW-305.

APPENDIX B

TABLES

Table B.1. Waste management sites and associated groundwater monitoring programs in the Chestnut Ridge Hydrogeologic Regime

Waste Management Site	Regulatory Classification	General Waste Inventory	Status: Operation	Status: Active	Status: Closed	DOE Order 5400.1A Monitoring [5]	CERCLA Monitoring [4]	SWDF Detection Monitoring [3]	RCRA Post Closure Detection Monitoring [2]	RCRA Post Closure Corrective Action Monitoring [1]
Chestnut Ridge Sediment Disposal Basin	RCRA/ CERCLA	Approximately 11,100 yd^3 of sediments and soils from the Y-12 Plant containing heavy metals; approximately 100,000 gallons of methanol-brine waste (70/30% water/methyl alcohol); and 55-110 gallons of toluene.	1973-1987		–				–	
East Chestnut Ridge Waste Pile	RCRA/ CERCLA	Contaminated soil from the Y-12 Plant.	1987							
Kerr Hollow Quarry	RCRA/ CERCLA	Approximately 50 tons of water-reactive materials (alkali metals, metal hydrides); unstable organic materials (picric acid, ethers, peroxides, and hydrazone); reactive metals (phosphorous and magnesium); potentially explosive materials (e.g., gas cylinders); ammonia; and inorganic acids.	1951-1988		–		–		–	
Chestnut Ridge Security Pits	RCRA/ CERCLA	Metals (lead); reactive materials (lithium hydride, lithium deuteride, zirconium); corrosive materials (acids); ignitable materials (alcohols); and chlorinated solvents.	1973-1988		–					–
Filled Coal Ash Pond (formerly the Ash Disposal Basin)	CERCLA	Coal fly-ash slurry from the Y-12 Steam Plant.	1955-1967		–		–			
United Nuclear Corporation Site	CERCLA	Approximately 11,000 drums (55-gallon) of sludge fixed in cement, 18,000 drums of contaminated soil, and 288 boxes of contaminated process and demolition material.	1982-1992		–		–			

Table B.1 (continued)

GROUNDWATER MONITORING PROGRAM			Status			DOE Order 5400.1A Monitoring [5]	CERCLA Monitoring [4]	SWDF Detection Monitoring [3]	RCRA Post Closure Detection Monitoring [2]	RCRA Post Closure Corrective Action Monitoring [1]
Waste Management Site	**Regulatory Classification**	**General Waste Inventory**	**Operation**	**Active**	**Closed**					
Rogers Quarry	CERCLA	Coal fly-ash slurry that bypassed the Filled Coal Ash Pond via spillway into McCoy Branch.	1967-1993		–	–				
Chestnut Ridge Borrow Area Waste Pile	CERCLA	Soils removed from the Oak Ridge Civic Center properties and the Oak Ridge Sewer Line Beltway contaminated with mercury and other metals, and possibly some organic compounds that originated from the Y-12 Plant.	Mid-1980							
Industrial Landfill II	SWDF	Combustible and decomposable solid waste and construction spoil material including scrap metal, glass, paper products, plastics, wood, organic garbage, textile products, asphalt roofing materials, and special wastes such as asbestos and beryllium oxide.	1983-1996		–			–		
Industrial Landfill IV	SWDF	Approximately 12,000 ft^3 per year of non-hazardous, nonradioactive industrial wastes including cardboard, plastics, rubber, scrap metal, wood, paper, and special waste.	1989-	–				–		
Industrial Landfill V	SWDF	Combustible/decomposable solid wastes.	1994-	–				–		
Construction/Demolition Landfill VI	SWDF	Construction spoil: concrete, wood, metal, plastic, roofing materials, and soil.	1994-	–				–		
Construction/Demolition Landfill VII	SWDF	No wastes emplaced to date. On standby until Construction/Demolition Landfill VI is closed.	1994-					–		
Receptor Media	Not Regulated	Groundwater and surface water exiting the Chestnut Ridge Hydrogeologic Regime.	Not Applicable			–	–			

Table B.1 (continued)

Notes:

1 Resource Conservation and Recovery Act (RCRA) post-closure corrective action monitoring in accordance with the requirements specified in the RCRA post-closure permit for the Chestnut Ridge Regime (Permit No. TNHW-088).

2 RCRA post-closure detection monitoring in accordance with the applicable requirements of the RCRA post closure permit for the Chestnut Ridge Regime (Permit No. TNHW-088).

3 Detection monitoring in accordance with operating permits issued by the Tennessee Department of Environment and Conservation (TDEC) for the specified non-hazardous solid waste disposal facility (SWDF) and applicable TDEC solid waste management regulations. Groundwater monitoring has been suspended at Construction/Demolition Landfill VII until the site begins accepting waste.

4 Monitoring in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Record of Decision for the specified facility or for baseline (pre-remediation) monitoring.

5 Monitoring performed in accordance with U.S. Department of Energy Order 5400.1A.

Table B.2. CY 1999 groundwater and surface water sampling locations and dates

EVALUATION PURPOSE [1]						DOE Order 5400.1A Surveillance Monitoring	DOE Order 5400.1A Exit Pathway/Perimeter Monitoring	Increasing Contaminant Trend
Sampling Point [2]	Sampling Location [3]	CY 1999 Sampling Date [4] 1st Quarter	2nd Quarter	3rd Quarter	4th Quarter			
1090	UNCS	02/04/99	.	**08/09/99 D**	.	!		
GW-141	LIV	01/12/99	.	07/15/99	.	!		
GW-142	KHQ	.	04/12-15/99 **REP**	.	10/04-07/99 REP	!		
GW-143	KHQ	.	04/12-15/99 REP	.	10/04-07/99 **REP**	!		
GW-144	KHQ	.	04/12-15/99 **REP**	.	10/04-07/99 **REP**	!		!
GW-145	KHQ	.	04/13-16/99 REP	.	10/04-07/99 REP	!		
GW-156	CRSDB	.	04/19-22/99 REP	.	10/11-14/99 **REP**	!		
GW-159	CRSDB	.	04/27-30/99 **REP**	.	10/11-14/99 REP	!		
GW-203	UNCS	02/04/99	.	08/09/99	.	!		
GW-205	UNCS	02/04/99	.	08/10/99	.	!		
GW-217	LIV	**01/12/99 D**	.	07/14/99	.	!		!
GW-221	UNCS	02/05/99	.	08/10/99	.	!		
GW-231	KHQ	.	04/12-15/99 REP	.	10/04-07/99 REP	!		
GW-301	CRBAWP	01/20/99	.	07/14/99	.	!		
GW-302	UNCS	02/05/99	.	08/11/99	.	!		
GW-305	LIV	01/14/99	.	**07/20/99 D**	11/3-4/99	!		!
GW-339	UNCS	02/04/99	.	**08/11/99 D**	.			
GW-521	LIV	01/19/99	.	07/15/99	.	!		
GW-522	LIV	01/14/99	.	07/20/99	.	!		
GW-540	LII / CDLVI	.	**04/05/99 D**	.	10/13/99	!		
GW-542	CDLVI	.	04/07/99	.	**10/18/99 D**	!		
GW-543	CDLVI	.	04/08/99	.	10/19/99	!		
GW-544	CDLVI	.	04/08/99	.	10/19/99	!		
GW-557	LV	01/20/99	.	07/12/99	.	!		
GW-609	CRSP	01/20/99	.	07/16/99	.	!		
GW-709	LII	.	04/05/99	.	**10/14/99 D**	!		
GW-731	CRSDB	.	04/19-22/99 REP	.	10/11-14/99 REP	!		
GW-732	CRSDB	.	04/19-22/99 **REP**	.	10/11-14/99 **REP**	!		
GW-757	LII	.	04/06/99	.	10/14/99	!		
GW-796	LV	01/21/99	.	07/13/99	.	!		
GW-797	LV	**01/20/99 D**	.	07/13/99	.	!		
GW-798	CDLVII	01/19/99	.	07/13/99	.	!		
GW-799	LV	01/20/99	.	07/12/99	.	!		
GW-801	LV	01/21/99	.	**07/14/99 D**	.	!		
GW-827	CDLVI	.	**04/07/99 D**	.	10/18/99	!		

Table B.2 (continued)

Sampling Point[2]	Sampling Location[3]	CY 1999 Sampling Date[4] 1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	EVALUATION PURPOSE[1]: DOE Order 5400.1A Surveillance Monitoring	DOE Order 5400.1A Exit Pathway/Perimeter Monitoring	Increasing Contaminant Trend
GW-831	FCAP	01/19/99	.	07/13/99	.	!		
MCK 2.0	FCAP	02/16/99	.	08/18/99	.		!	
MCK 2.05	FCAP	02/16/99	.	**08/18/99 D**	.		!	
OF 301	KHQ	03/03/99		07/20/99	10/12/99		!	
SCR1.25SP	EXP	02/16/99	.	08/11/99	.		!	
SCR2.1SP	EXP	**02/02/99 D**	.	07/21/99	.		!	
SCR2.2SP	EXP	02/02/99	.	**07/21/99 D**	.		!	
SCR3.4SP	EXP	02/03/99	.	07/21/99	.		!	
SCR3.5SP	EXP	02/16/99	.	08/11/99	.		!	
SCR4.3SP	LV	01/19/99	.	07/14/99	.		!	
SCR5.1SP	EXP	02/03/99	.	07/21/99	.		!	
SCR5.4SP	EXP	02/03/99	.	07/21/99	.		!	

Notes:

1 The DOE Order 5400.1A data evaluation purpose of the sampling location for this report, regardless of the groundwater monitoring program for which the data were obtained (see Table B.1).

2 GW - Groundwater monitoring well (well 1090 does not have the "GW-" prefix)
MCK - McCoy Branch Kilometer
OF 301 - Outfall 301: located where surface water exits Kerr Hollow Quarry
SCR - South Chestnut Ridge (tributary prefix)
SP - Spring location (suffix)

3 CDLVI - Construction/Demolition Landfill VI
CDLVII - Construction/Demolition Landfill VII
CRBAWP - Chestnut Ridge Borrow Area Waste Pile
CRSDB - Chestnut Ridge Sediment Disposal Basin
CRSP - Chestnut Ridge Security Pits
EXP - Exit Pathway (spring sampling location)
FCAP - Filled Coal Ash Pond
KHQ - Kerr Hollow Quarry
LII - Industrial Landfill II
LIV - Industrial Landfill IV
LV - Industrial Landfill V
UNCS - United Nuclear Corporation Site

Table B.2 (continued)

Notes: (continued)

4 . - Not Sampled.

D - Duplicate sample was collected (shown in bold typeface).

REP - Four replicate groundwater samples were collected from the well over the specified date range. **BOLD** indicates that duplicate groundwater samples were collected from the specified well on the following replicate sampling dates: 04/12/99 (GW-144), 04/14/99 (GW-142), 04/22/99 (GW-732), 04/28/99 (GW-159), 10/04/99 (GW-143), 10/06/99 (GW-144), 10/12/99 (GW-732) and 10/14/99 (GW-156).

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