Y/SUB/99-MVM64V/2

Y-12

OAK RIDGE
Y-12
PLANT

LOCKHEED MARTIN

GROUNDWATER PROTECTION PROGRAM CALENDAR YEAR 1998 EVALUATION OF GROUNDWATER QUALITY DATA FOR THE UPPER EAST FORK POPLAR CREEK HYDROGEOLOGIC REGIME AT THE U.S. DEPARTMENT OF ENERGY Y-12 PLANT, OAK RIDGE, TENNESSEE

September 1999

Prepared by

AJA TECHNICAL SERVICES, INC.
Under Subcontract No. 70Y-KDS15V

for the

Environmental Compliance Department
Environment, Safety, and Health Organization
Oak Ridge Y-12 Plant
Oak Ridge, Tennessee 37831

Managed by

LOCKHEED MARTIN ENERGY SYSTEMS, INC.
for the U.S. Department of Energy
Under Contract No. DE-AC05-84OR21400

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

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List of Acronyms and Abbreviations

BCV	Bear Creek Valley
bgs	below ground surface
BT	buried tributary
Cl	chloride
CY	calendar year
DNAPL	dense, nonaqueous phase liquids
DOE	U.S. Department of Energy
DQO	data quality objective
East Fork Regime	Upper East Fork Poplar Creek Hydrogeologic Regime
ft	feet
gpm	gallons per minute
GWMR	Groundwater Monitoring Report
GWPP	(Y-12 Plant) Groundwater Protection Program
LRSPW	Lake Reality Emergency Spillway (sampling station)
MCL	maximum contaminant level (for drinking water)
MDA	minimum detectable activity
mgd	million gallons per day
MIC	microbiologically induced corrosion
µg/L	micrograms per liter
mg/L	milligrams per liter
msl	mean sea level
mV	millivolts
NPDES	National Pollution Discharge Elimination System
ORR	Oak Ridge Reservation
PCE	tetrachloroethene
pCi/L	picoCuries per liter
REDOX	oxidation-reduction potential
RI	Remedial Investigation
TCE	trichloroethene
UEFPC	Upper East Fork Poplar Creek
VOC	volatile organic compound
WCPA	Waste Coolant Processing Area
1,1-DCA	1,1-dichloroethane
1,1-DCE	1,1-dichloroethene
1,2-DCE	1,2-dichloroethene (total)
cis-1,2-DCE	cis-1,2-dichloroethene
trans-1,2-DCE	trans-1,2-dichloroethene
1,1,1-TCA	1,1,1-trichloroethane
^{99}Tc	technetium-99
^{234}U	uranium-234
^{238}U	uranium-238

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 Upper East Fork Poplar Creek Hydrogeologic Regime (East Fork Regime) during calendar year (CY) 1998. The East Fork Regime contains many confirmed and potential sources of groundwater and surface water contamination 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 groundwater and surface water quality near the Y-12 Plant to: (1) gauge groundwater quality in areas that are, or could be, affected by plant operations, (2) determine 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) identify and characterize long-term trends in groundwater quality at the Y-12 Plant. 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 summary tables referenced in each section are presented in Appendix A and Appendix B, respectively.

2.0 BACKGROUND INFORMATION

The boundaries of the East Fork Regime, which encompass the main Y-12 Plant area in Bear Creek Valley (BCV), extend along the base of Pine Ridge to the north, the base of Chestnut Ridge to the south, the eastern boundary of the Bear Creek watershed to the west, and the ORR property line to the east (Figure 1). For the purposes of this report, the regime is divided into three major areas: the western plant area between the Bear Creek watershed boundary and Y-12 Plant grid coordinate easting 55,000, the central plant area between grid coordinate eastings 55,000 and 62,000, and the eastern plant area between grid coordinate easting 62,000 and the ORR property line (Figure 2). The following discussion provides brief descriptions of the geology and groundwater flow system in BCV, the contaminant source areas within the Y-12 Plant, and the extent of groundwater contamination in the East Fork Regime.

2.1 Topography and Bedrock Geology

Ground elevations in BCV within the boundaries of the East Fork Regime range from about 1020 feet (ft) above mean sea level (msl) along the base of Pine Ridge and Chestnut Ridge in the Western plant area, to 900 ft msl along the axis of BCV in the exposed channel of Upper East Fork Poplar Creek (UEFPC) in the eastern plant area downstream of Lake Reality (Figure 2). Most of the regime is heavily industrialized and highly congested; the most prominent local topographic feature is the gap in Pine Ridge cut by UEFPC northeast of the Y-12 Plant. This gap roughly corresponds with a less prominent divide in Chestnut Ridge to the southeast of the plant and may indicate some type of structural or stratigraphic discontinuity near Scarboro Road.

Alternating sequences of clastic and carbonate strata that form the distinctive topography of the Valley and Ridge Physiographic Province comprise the bedrock geology in the East Fork Regime. Shale and siltstone beds of the Rome Formation form Pine Ridge to the north, limestone and shale formations of the Conasauga Group form BCV, and the primarily dolostone formations of the Knox Group form Chestnut Ridge to the south (Figure 2). Strike and dip of bedding are generally N 55°E and 45°SE, respectively (as referenced to true north). Bedrock is overlain by up to 40 ft of several unconsolidated materials, including man-made fill, alluvium, colluvium, fine-grained residuum from the weathering of the bedrock, and saprolite (weathered bedrock). Where undisturbed, the saprolite often retains primary textural features of the unweathered bedrock, including fractures (Solomon et al. 1992).

Extensive cut-and-fill areas within the Y-12 Plant have substantially altered the shallow subsurface throughout much of the East Fork Regime (Figure 3). Most of the fill, which contains many voids and generally consists of a heterogeneous mixture of building debris and recompacted soil/residuum, was placed in the tributaries and main channel of UEFPC (Sutton and Field 1995). The numerous voids, heterogeneous composition, and varying thickness (5 to 25 ft) significantly influence shallow groundwater flow directions and contaminant migration patterns.

2.2 Surface Water System

Surface water in the East Fork Regime is drained by UEFPC, which was extensively modified during construction of the Y-12 Plant. The headwaters and several thousand feet of the main channel in the upper reach of the creek, including all the northern tributaries of the creek in the western and central plant areas (Figure 3), were filled and replaced with an extensive network of underground storm drains. For reference purposes, each buried tributary (BT) of UEFPC is designated with a value (e.g., BT-1) representing the tributary number counted downstream (west to east) from the headwaters. Also, drainage patterns in the eastern plant area were extensively modified during closure of New Hope Pond in 1988, an unlined surface impoundment constructed in 1963 to regulate the quantity and quality of surface water exiting the Y-12 Plant, and the subsequent operation of Lake Reality, a lined surface impoundment built to replace New Hope Pond.

The underground network of storm drains in the western and central plant areas direct surface runoff into the exposed portion of the UEFPC channel at a number of outfalls. The westernmost extent of the exposed portion of the UEFPC channel is Outfall 200, about 6000 ft upstream of New Hope Pond/Lake Reality (Figure 3). During normal operations, flow in UEFPC is directed through a concrete-lined distribution channel located around the south and east side of Lake Reality. Also, a gravel and perforated pipe underdrain beneath portions of the distribution channel captures shallow groundwater. Until December 1996 when a temporary a siphon system was used to bypass Lake Reality, surface flow in the UEFPC distribution channel discharged into Lake Reality (and exited through a weir in the western berm). Beginning in July 1998, flow in the UEFPC distribution channel was permanently diverted through the Lake Reality emergency spillway (LRSPW), which discharges into the mainstem of UEFPC directly north of Lake Reality. Bypassing Lake Reality reduces mercury contributions to dry-weather flow in UEFPC.

About 70% of dry-weather flow in UEFPC, excluding flow management, is attributable to once-through non-contact cooling water, condensate, and cooling tower blowdown, and the remaining 30% is from groundwater discharge (CDM Federal Programs Corporation 1994). Beginning in July 1996, raw water (i.e., Clinch River water from the intake lines to the DOE water treatment plant that supplies potable water to the Y-12 Plant, the Oak Ridge National Laboratory, and the City of Oak Ridge) has been discharged near Outfall 200 to augment flow in UEFPC, which decreased from 10-15 million gallons per day (mgd) to about 2.5 mgd because of reduced operations at the Y-12 Plant in recent years. Flow management is needed to achieve the National Pollution Discharge Elimination System (NPDES) minimum daily flow requirement of 7 mgd at Station 17, where UEFPC exits the ORR downstream from Lake Reality. Flow management also allows compliance with NPDES toxicity requirements and helps lower the otherwise elevated water temperature in UEFPC.

2.3 Groundwater System

The following overview of the groundwater system in the East Fork Regime is based on the conceptual hydrogeologic models described in: *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee* (U.S. Department of Energy 1998), which is referenced hereafter as the Remedial Investigation (RI) report. This conceptual model incorporates: (1) the general hydrologic framework described in

Solomon et al. (1992); (2) groundwater flow characteristics presented in Moore (1988 and 1989) and Moore and Toran (1992); (3) results of numerous hydrologic studies and investigations in BCV, including Dreier et al. (1987) and Shevenell (1994); and (4) findings of monitoring activities performed specifically for RI purposes (U.S. Department of Energy 1998).

On the ORR in the vicinity of BCV, the Rome Formation, the Conasauga Group, and the Knox Group comprise two basic hydrogeologic units: (1) the Aquifer, consisting of the Maynardville Limestone (upper Conasauga Group) and Knox Group, and (2) the Aquitard, consisting of the remaining Conasauga Group formations (Nolichucky Shale, Maryville Limestone, Rogersville Shale, Rutledge Limestone, and Pumpkin Valley Shale) and the Rome Formation (Figure 2). The Maynardville Limestone functions as a hydrologic drain in BCV and provides the principal avenues for contaminant transport in the East Fork Regime. The Aquitard formations underlie many of the contaminant source areas in the regime and are hydraulically upgradient of the Aquifer.

Fractures provide the primary groundwater flowpaths in the Aquitard and the Aquifer, but dissolution of carbonates in the Aquifer has enlarged fractures and produced solution cavities and conduits that greatly enhance its hydraulic conductivity relative to the Aquitard. Although negligible in both units, flow through the rock matrix plays an important role in contaminant migration because of matrix diffusion processes. Most of the flow in both units is primarily parallel to bedding (along strike and dip), which in the Aquitard may or may not coincide with the direction of maximum horizontal hydraulic gradient inferred from groundwater elevation isopleths. In the Aquitard, the bulk of flow occurs within the shallow bedrock interval less than 70 ft below ground surface (bgs). Flow across bedding occurs primarily along permeable zones formed by cross-cutting fractures or fracture zones (and possibly small faults). Some of these cross-cutting structures may act as barriers to lateral flow, causing groundwater from deeper intervals to upwell and discharge to the shallower flow system in each hydrogeologic unit. Others may serve as preferential pathways for migration of contaminants from the Aquitard into the Aquifer.

Most groundwater flow in the Aquifer is thought to occur at shallow depths, typically less than 100 ft bgs in an extensively interconnected karst network of solution conduits and cavities. Flow in the shallow karst network is relatively rapid, and during rainfall may occur as "quickflow" recharge/discharge toward springs or nearby surface drainage features (Shevenell 1994). Below the shallow karst network, fractures provide the primary flowpaths, and there are important lithologic controls on groundwater flow (Goldstrand 1995). Lithologic characteristics differentiate seven distinct stratigraphic zones (numbered from bottom to top) in the Maynardville Limestone. The more permeable zones lie at the bottom (Zone 2) and top (Zone 6) of the formation (Shevenell et al. 1993). Because of vugular porosity related to dissolution of gypsum nodules, Zone 6 is the most permeable interval and probably transmits the bulk of the groundwater in the Maynardville Limestone (Goldstrand 1995).

In both the western plant area and central plant area, groundwater generally flows south (across strike) from the Aquitard toward the Aquifer (Maynardville Limestone) and eastward along strike in the Maynardville Limestone toward the east end of the Y-12 Plant (Figure 4). However, the extensive network of basement dewatering sumps, storm drains, process lines, pipes, and outfalls in the shallow subsurface throughout much of the western and central plant areas strongly influences the movement and discharge of shallow groundwater, as well as the migration of groundwater

contaminants. For instance, operation of sumps to suppress the local water table below the basement floor of Buildings 9204-4, 9201-5, and 9201-4 (Figure 3) strongly influences local groundwater flow and contaminant transport patterns (U.S. Department of Energy 1998). In the eastern plant area, flow in the Aquitard is more directly east (along strike) toward UEFPC, and flow in the Aquifer is primarily to the east (along strike) toward Union Valley. However, groundwater flow directions at shallow depths in the Maynardville Limestone in the eastern plant area are strongly influenced by the UEFPC distribution channel underdrain, which apparently functions as a highly permeable groundwater flow path and a constant head (recharge) boundary (Science Applications International Corporation [SAIC] 1998). Additionally, operation of the Lake Reality Sump, which is a 6-ft diameter, 20-ft deep sump installed to reduce hydraulic pressure on the synthetic liner in Lake Reality, creates an elongated cone of depression in the Aquitard (Nolichucky Shale) oriented parallel with strike and decreases water levels in the Aquifer (Maynardville Limestone) along the main channel of UEFPC. The sump is activated manually as required (very infrequently) to reduce pressure head and stop lake liner flotation. Once activated, the sump pump operates on an automatic level switch.

An Aquifer pumping test and associated dye-trace test that were completed in July 1998 provide the most recent data regarding the hydrologic characteristics of the intermediate and deep groundwater flowpaths in the Maynardville Limestone and the degree of hydraulic connection between the shallow and deep flow systems in the eastern plant area (SAIC 1998). A stepped pump test was performed using a well (GW-845, monitored interval = 156.8 to 438.3 ft bgs) installed in the Maynardville Limestone about 250 ft southeast of New Hope Pond. Beginning on July 9, 1998, groundwater was continuously pumped from the well at progressively increased discharge rates: 25 gallons per minute (gpm) for 24 hours, 50 gpm for 24 hours, and 100 gpm for seven days (pumping stopped on July 18, 1998). Water level drawdown and recovery data obtained from nearby monitoring wells indicated: (1) rapid, large responses in wells located along strike to the east and across strike to the north of the pumping well, (2) more moderate responses in wells located oblique to strike near the contact with the Nolichucky Shale to the east of the pumping well, (3) weak responses in upgradient wells in the Maynardville Limestone to the west of the pumping well, and (4) little if any response in wells located adjacent to Lake Reality and the UEFPC distribution channel underdrain to the north and northeast of the pumping well. The maximum observed radius of influence from the pumping well encompassed the entire subcrop of the Maynardville Limestone in the eastern plant area, with particularly strong anisotropies to the east (along strike) and north (up-dip) of the well and low-permeability boundary effects evident along the contact with the Nolichucky Shale. Additionally, the UEFPC distribution channel underdrain, the original UEFPC mainstem, and Lake Reality apparently represent constant head (recharge) sources to the shallow groundwater and may collectively function as a hydraulic boundary to the west and northwest of New Hope Pond. The UEFPC distribution channel underdrain in particular appears to function as a separate hydraulic system that may be at least partially connected to surface water flow in UEFPC (SAIC 1998).

In conjunction with the pumping test, Eosine dye was injected in a shallow (60 ft bgs) well (GW-153) located about 450 ft southwest (upgradient) of the pumping well (GW-845). Rapid breakthrough of the dye observed in the pumping well clearly demonstrated the hydraulic connection between the shallow and intermediate/deep groundwater flowpaths along strike in the Maynardville Limestone. Additionally, confirmed detection of the dye in two shallow wells (GW-220 and GW-832) located about 600 ft northeast (across geologic strike) of the injection well (and about

300 ft northwest of the pumping well) suggests that the degree of hydrologic connection with the UEFPC distribution channel underdrain and groundwater movement along dip parallel or conjugate fracture flowpaths in the shallow flow system are strong enough to overcome the hydraulic capture zone created at the 100 gpm pumping rate in the intermediate to deep flow systems (SAIC 1998).

2.4 Contaminant Source Areas

Sources of groundwater contamination in the East Fork Regime include: hazardous and nonhazardous waste treatment, storage, or disposal sites; bulk product transfer, storage, and use areas; petroleum-fuel underground storage tanks and associated dispensing facilities; industrial process buildings; waste and product spill areas; and the many process pipelines, effluent drains, and utilities associated with the industrial operations at the Y-12 Plant (Table 1). Also, operation of the S-3 Ponds, a closed Resource Conservation and Recovery Act regulated surface impoundment located in the Bear Creek Hydrogeologic Regime near the west end of the Y-12 Plant, emplaced a large reservoir of contamination in the western plant area. It is more difficult to conclusively identify other sources of groundwater contamination elsewhere in the regime because of extensive intermingling of contaminants, but groundwater contaminant signatures (i.e., specific contaminants or distinct groups of contaminants) can be related to one or more of the source areas.

2.5 Extent of Groundwater Contamination

The following overview of the extent of groundwater and surface water contamination in the East Fork Regime in based on the comprehensive description presented in the RI report. Principal groundwater contaminants in the regime are inorganic compounds (primarily nitrate); trace metals (notably uranium); volatile organic compounds (VOCs), including chlorinated solvents and petroleum hydrocarbons; and several radionuclides, chiefly technetium-99 (^{99}Tc) and uranium isotopes. Intermingling of contaminants from multiple source areas has produced an extensive, essentially continuous groundwater contaminant plume of varying composition that extends from the western plant area through the southern part of the central and eastern plant areas and into Union Valley east of the ORR (Figure 5).

A plume of nitrate contamination originating from the S-3 Ponds extends vertically in the Aquitard at least 150 ft bgs and laterally at least 5,000 ft into the western plant area. Nitrate (as N) concentrations (hereafter synonymous with "nitrate" concentrations) within the plume exceed 10,000 milligrams per liter (mg/L). Because it is chemically stable and highly mobile in groundwater, nitrate probably traces the overall migration pattern for other groundwater contaminants from the S-3 Ponds. The geometry of the nitrate plume indicates two principal migration pathways: (1) relatively rapid migration along fairly short, shallow pathways (<30 ft bgs) that typically terminate in storm drains or other utilities, building sumps, and the buried tributaries and original mainstem of UEFPC; and (2) much slower migration along much longer strike-parallel pathways at greater depths in the bedrock toward basement sumps in Buildings 9204-4, 9201-4, and 9201-5 (U.S. Department of Energy 1998).

The low pH groundwater within the contaminant plume adjacent to the S-3 Ponds contains a diverse mix of metal ions and/or ion-complexes (beryllium, cadmium, cobalt, manganese, mercury, and nickel) that are usually not mobile (or are more readily attenuated) in less acidic groundwater, as well as metals that are mobile under a wider range of groundwater pH conditions (barium, boron,

strontium, and uranium). Some of these metals were entrained in the acidic wastes disposed at the site (e.g., uranium), and others were dissolved from the underlying saprolite and bedrock (e.g., barium). Trace metal concentrations within the plume exceed applicable maximum contaminant levels (MCLs) for drinking water by an order of magnitude or more. Similarly elevated concentrations of several other trace metals (including boron, cadmium, cobalt, copper, mercury, and uranium) occur in the groundwater elsewhere in the East Fork Regime, notably the S-2 Site, but available data do not indicate that extensive plumes of metal ions and/or ion-complexes have developed in the groundwater beyond the immediate vicinity of these sites (Table 1).

Volatile organic compounds are the most pervasive groundwater contaminants in the East Fork Regime. Chloroethenes, primarily tetrachloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (cis-1,2-DCE), 1,1-dichloroethene (1,1-DCE), and vinyl chloride, are the principal components of dissolved VOC plumes in the western plant area and the central plant area. Chloroethanes, primarily 1,1,1-trichloroethane (1,1,1-TCA) and 1,1-dichloroethane (1,1-DCA), are also major components of several plumes in the central plant area. Chloromethanes (carbon tetrachloride, chloroform, and methylene chloride) are primary plume components in the eastern plant area. Additionally, residual plumes of dissolved petroleum hydrocarbons (benzene, ethylbenzene, dimethylbenzene, and toluene) occur in shallow groundwater near former petroleum fuel underground storage tanks located in each plant area. Concentrations of individual plume constituents in the Aquitard near the Waste Coolant Processing Area (WCPA), Building 9212, and Tank T0134_U (Figure 5) exceed 1,000 micrograms per liter (μg/L) and indicate the presence of dense, nonaqueous phase liquids (DNAPL) in the subsurface. Data for the existing network of Aquifer monitoring wells generally define a relatively continuous plume of dissolved VOCs in the water table interval/shallow bedrock (<100 ft bgs) that extends eastward from the Fire Training Facility in the western plant area, intermingles with plumes from several sources in the central plant area, and extends underneath New Hope Pond in the eastern plant area (Figure 5). The extent of the plume at intermediate (>200 ft bgs) and deep (>400 ft bgs) intervals in the Maynardville Limestone is not well defined in the western and central plant areas because of limited well coverage, but data from the network of wells in the eastern plant area shows that a plume of dissolved chloromethanes (primarily carbon tetrachloride), which is believed to originate from suspected DNAPL in the Maynardville Limestone west of New Hope Pond, extends vertically more than 400 ft bgs and laterally (parallel with geologic strike) into Union Valley at least 2,000 ft east of the ORR boundary (Figure 5).

Groundwater with radiological contamination occurs primarily in the Aquitard east of the former S-3 Ponds, at Tank 0134-U, and Buildings 9204-4 and 9201-5, and the Salvage Yard; and in the Aquifer near the S-2 Site and upgradient of New Hope Pond (the uranium oxide vault, wells GW-605 and GW-606, and the former Oil Skimmer Basin) (Table 1 and Figure 5). The S-3 Ponds are confirmed sources of uranium isotopes, primarily uranium-234 (^{234}U) and uranium-238 (^{238}U), and ^{99}Tc; the migration of ^{99}Tc generally mirrors that of nitrate from the site. Limited influx of radiological contamination into the Aquifer (or extensive dilution) is indicated by the greatly decreased gross alpha, gross beta, and isotopic uranium activity in the groundwater downgradient of confirmed source areas (e.g., S-2 Site and the former Oil Skimmer Basin). This pattern suggests that the alpha activity in the groundwater at Aquifer wells GW-605 and GW-606 and the area upgradient of New Hope Pond reflects similarly limited migration of uranium isotopes from relatively nearby upgradient source areas.

3.0 CY 1998 MONITORING DATA EVALUATION

This section provides an evaluation of the monitoring data for the network of CY 1998 sampling locations in the East Fork Regime, as reported in the Groundwater Monitoring Report (GWMR) issued by the Lockheed Martin Energy Systems, Inc. Y-12 Plant GWPP in March 1999 (AJA Technical Services, Inc. 1999a). The discussion mirrors the applicable requirements of DOE Order 5400.1A. Section 3.1 contains an evaluation of groundwater quality in areas 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 and groundwater quality where contaminants are most likely to migrate beyond the ORR property line (hereafter referenced as Exit Pathway/Perimeter Monitoring). Long-term trends in groundwater quality at the Y-12 Plant, based on data for selected wells in the western, central, and eastern plant areas, are described in Section 3.3. Each evaluation is based on historical and CY 1998 results that meet the applicable data quality objectives (DQOs) defined in: *Y-12 Plant Groundwater Protection Program - Groundwater Monitoring Program Data Management Plan* (Martin Marietta Energy Systems, Inc. 1993). Detailed descriptions of the DQO criteria and associated data screening process, along with summaries of the CY 1998 data that do not meet applicable DQOs, are provided in Section 2.6 of the CY 1998 GWMR.

3.1 Surveillance Monitoring

The CY 1998 monitoring results reported for 38 monitoring wells were evaluated for the purposes of Surveillance Monitoring in the East Fork Regime (Table 2). As shown in the following summary, six of these wells are located in the western plant area, 24 of the wells are located in the central plant area, and eight wells are located in the eastern plant area (Figure 6).

CY 1998 Surveillance Monitoring Well Network			
Western Plant Area	**Central Plant Area**		**Eastern Plant Area**
GW-108	56-2A	GW-775	GW-148
GW-192	56-2B	GW-776	GW-153
GW-251	56-2C	GW-781	GW-380
GW-332	59-1A	GW-782	GW-383
GW-618	59-1B	GW-783	GW-605
GW-620	59-1C	GW-788	GW-606
	GW-193	GW-789	GW-763
	GW-219	GW-791	GW-845
	GW-686	GW-792	
	GW-687	GW-818	
	GW-769	GW-819	
	GW-770	GW-820	

Twenty-four of these wells were sampled twice (semiannually) and the remaining 14 wells were sampled only once during CY 1998 (Table 2). Samples were collected from each of the above listed wells in accordance with the Y-12 Plant GWPP technical procedures (SESD-TP-8204 Rev.3) for low-flow minimal drawdown sampling (hereafter referenced as low-flow sampling). Under this method, groundwater samples (including duplicates) are collected immediately after field

measurements (pH, conductivity, temperature, oxidation-reduction potential [REDOX], and dissolved oxygen) show stable values (minimal variation over four consecutive readings) 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). Low-flow sampling differs from the sampling method used by the Y-12 Plant GWPP before October 1997 which involved pumping at least three well volumes (if the well did not purge dry) at a much higher rate (1.0 to 1.8 gallons per minute) before collecting samples from each well (hereafter referenced as conventional sampling).

Groundwater samples from each well were analyzed for inorganics (major ions and trace metals), VOCs, and selected radioanalytes (Table 3); analytical results are presented in Appendix F of the CY 1998 GWMR. Respective analytical results for the Surveillance Monitoring wells located in western, central, and eastern plant areas are discussed in the following sections.

3.1.1 Western Plant Area

As shown in the following summary, one or more groundwater contaminants, including inorganics (barium, cadmium, cobalt, copper, chloride, manganese, nitrate, potassium, strontium, and uranium), VOCs (PCE, TCE, cis-1,2-DCE, trans-1,2-dichloroethene (trans-1,2-DCE), 1,1-DCE, 1,1-DCA, 1,1,1-TCA, carbon tetrachloride, chloroform, methylene chloride, dimethylbenzene, and toluene), and radioactivity (gross alpha, gross beta, and ^{99}Tc), were detected in at least one of the groundwater samples collected during CY 1998 from each of six wells used for Surveillance Monitoring purposes in the western plant area.

Well	Hydrogeologic Unit and Monitored Interval Depth (ft bgs)		Contaminant Type		
	Aquitard	Aquifer	Inorganics	VOCs	Radioactivity
GW-108	41.0 - 58.6	. . .	●	●	●
GW-192	6.5 - 17.5	. . .	.	●	.
GW-251	. . .	35.0 - 51.0	●	●	●
GW-332	16.8 - 24.1	. . .	.	●	.
GW-618	. . .	26.0 - 37.0	●	●	.
GW-620	. . .	61.7 - 75.0	●	●	.

Results for these wells are generally consistent with respective historical data and reflect migration of contaminants from the S-3 Site, the Beta-4 Security Pits, the S-2 Site, the WCPA, the Salvage Yard, the Fire Training Facility, or a combination of source areas.

3.1.1.1 Inorganic Contaminants

Aquitard monitoring well GW-108 yields acidic, highly contaminated calcium-magnesium bicarbonate groundwater from a depth of 58.6 ft bgs in the Nolichucky Shale about 800 ft southeast of the former S-3 Ponds (Figure 6). Contaminant concentrations in the well are probably

representative of conditions within the strike-parallel migration pathways in the Nolichucky Shale (U.S. Department of Energy 1998). Historical data show that groundwater samples from this well are characterized by acidic pH and very high levels of several inorganic contaminants, primarily nitrate. The CY 1998 data are consistent with these historical findings and show that the groundwater remains moderately acidic (pH 5.01 - 5.66) with nitrate levels (10,500 - 11,800 mg/L) and total and dissolved barium concentrations (108 - 120 mg/L) substantially above the respective MCLs for drinking water (10 and 2 mg/L). Manganese (131 - 140 mg/L) and strontium (37.4 - 40 mg/L) levels remain more than an order-of-magnitude higher than typical of all other wells in the East Fork Regime. Uranium concentrations (0.0157 - 0.02 mg/L) are at or below the proposed (federal) MCL for uranium (0.02 mg/L). Aside from nitrate and some metal ions (e.g., barium) and/or ion-complexes that are mobile under a wide range of pH conditions, most of the inorganic components of the S-3 contaminant plume have not migrated extensively beyond the low-pH groundwater within the Nolichucky Shale (U.S. Department of Energy 1998).

Aquifer monitoring well GW-251 yields contaminated calcium-magnesium-bicarbonate groundwater from a depth of 51 ft bgs in the upper Maynardville Limestone about 100 ft west of the S-2 Site (Figure 6). Historical data show that nitrate and trace metals (notably cadmium) are the primary inorganic contaminants in the groundwater at the site, and the CY 1998 results for well GW-251 show that nitrate levels (31.6 - 89.5 mg/L) and total/dissolved cadmium concentrations (0.047 - 0.164 mg/L) remain well above respective MCLs of 10 and 0.005 mg/L. These contaminants probably leach directly from the S-2 Site into the shallow groundwater in the Maynardville Limestone and are transported via karst flow downgradient (along strike) to the east and west. However, dilution during transport in the shallow karst network is indicated by the frequently inverse relationship between contaminant concentrations and presampling water level elevations in well GW-251. Discharge from the shallow karst system into UEFPC combined with dilution during transport substantially reduces contaminant concentrations in the groundwater downgradient of the site (U.S. Department of Energy 1998).

Aquifer well GW-618 yields moderately contaminated calcium-magnesium-bicarbonate groundwater from the shallow bedrock (37 ft bgs) in the lower Maynardville Limestone about 750 ft northeast (downgradient) of the S-2 Site (Figure 6). Historical data show that chloride and cadmium are the principal inorganic contaminants in the groundwater at this well. Results for the filtered and unfiltered samples collected from the well in June and November 1998 show that chloride levels remain above 15 mg/L, which is about ten times higher than typical of most other shallow Aquifer wells in the East Fork Regime. Also, the total and dissolved cadmium concentrations range from slightly below (0.0039 mg/L) to slightly above (0.0078 mg/L) the MCL (0.005 mg/L). These results seem to confirm the disparity evident between the cadmium results obtained from conventional sampling in May 1997 (0.021 mg/L total and dissolved) and initial low-flow sampling in November 1997 (<0.003 mg/L total and dissolved). This finding suggests that the cadmium results obtained between January 1991 and May 1997, which show total concentrations ranging from 0.014 to 0.045 mg/L, may be artifacts of the conventional sampling method, whereby purging the required three-well volumes of groundwater from the well may have induced migration of cadmium (and other contaminants) into the well. The S-2 Site may be the source of the cadmium.

Respective total and dissolved potassium concentrations reported for the groundwater samples collected from Aquifer well GW-620 in May (14.2 and 13.4 mg/L) and December (12.4 and

11.8 mg/L) 1998 are substantially higher than typical of samples from other Aquifer wells in the East Fork Regime. Completed at a depth of 75 ft bgs in the upper Maynardville Limestone about 100 ft east (downgradient) of the Fire Training Facility (Figure 6), this well often yields geochemically distinctive groundwater samples with unusually low calcium (<70 mg/L), low magnesium (<5 mg/L), and bicarbonate alkalinity (<1 mg/L), along with atypically high carbonate alkalinity (>20 mg/L) and pH (>10). The source of the potassium may be ash and/or inorganic flame retardants that may have been used to extinguish fires at existing and former burn areas in the western part of the Fire Training Facility, which are the likely source of dissolved VOCs in the groundwater at the well (see Section 3.1.1.2).

3.1.1.2 Volatile Organic Compounds

Excluding false-positive results, one or more of the following VOCs were detected in at least one groundwater sample collected during CY 1998 from Aquitard wells GW-108 and GW-332, and Aquifer wells GW-251, GW-618, and GW-620: PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE, vinyl chloride, carbon tetrachloride, chloroform, methylene chloride, 1,1,1-TCA, 1,1-DCA, dimethylbenzene, toluene, acetone, and bromoform. Maximum summed concentrations of the VOCs detected in the groundwater samples from each well range from 60 µg/L (GW-618) to 1880 µg/L (GW-332). As shown in the following summary, the maximum concentrations of PCE, TCE, cis-1,2-DCE, vinyl chloride, carbon tetrachloride, and methylene chloride exceed applicable MCLs.

Well	Maximum CY 1998 Concentration and MCL (µg/L)					
	PCE	TCE	cis-1,2-DCE	Vinyl Chloride	Carbon Tetrachloride	Methylene Chloride
GW-108	(1)	(3)	<5	<10	<5	**53**
GW-192	(4)	7	22	<10	<5	<5
GW-251	**410**	**200**	11	<10	**19**	<5
GW-332	**660**	**120**	**990**	**20**	<5	<5
GW-618	**19**	**16**	23	(2)	<5	<5
GW-620	**110**	**32**	**94**	<10	<5	<5
MCL	5	5	70	2	5	5

Note: ( ) = Estimated concentration below the reporting limit; Bold = Exceeds MCL.

The presence of dissolved VOCs in the groundwater at these wells reflects migration from the following source areas: the S-3 Ponds (GW-108), the Oil/Solvent Drum Storage Area and/or Salvage Yard Drum Deheader (GW-192), the WCPA (GW-332), the S-2 Site (GW-251), the Fire Training Facility (GW-620), and a combination of these and other VOC source areas in the western plant area (GW-618).

Maximum summed concentrations of VOCs detected in the duplicate groundwater samples collected from well GW-108 range from 83 µg/L in March 1998 to 129 µg/L in July 1998 (Table 4). Chloroform and methylene chloride are the principal components of the dissolved VOC plume in the groundwater at the well (note that methylene chloride concentrations remain well above the MCL). Compared to other components (e.g., nitrate) of the contaminant plume originating from

the S-3 Ponds, the relatively low VOC concentrations in the groundwater at well GW-108 probably reflect the smaller volume of organic wastes disposed at the site combined with lower relative mobility in groundwater (U.S. Department of Energy 1998).

The Oil/Solvent Drum Storage Area and/or Salvage Yard Drum Deheader is the suspected source of the dissolved chloroethenes in the groundwater at well GW-192 (U.S. Department of Energy 1998). This water table interval well (17 ft bgs) comprises a well cluster with shallow bedrock well GW-191 (60 ft bgs, not sampled in CY 1998) in the Maryville Limestone near the east side of the Beta-4 Security Pits (Figure 6). Groundwater elevations in these wells indicate vertically upward hydraulic gradients from the shallow bedrock to the water table interval during seasonally high and low groundwater flow conditions (Figure 4). Considering the upward hydraulic gradients in light of the historical data showing a lack of VOCs in the groundwater at well GW-191, the presence of dissolved chloroethenes in the groundwater at well GW-192 suggests strike-parallel transport in the water table interval toward discharge areas in the upper reach of BT-1 (AJA Technical Services, Inc. 1996). Additionally, the preponderance of cis-1,2-DCE relative to PCE and TCE suggests natural biodegradation. As shown in the following summary, several geochemical characteristics of the groundwater are within the optimum range for anaerobic reductive dechlorination of PCE.

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)	Well GW-192			
	April 1997	October 1997	May 1998	November 1998
Nitrate < 1 mg/L	<0.028 mg/L	<0.028 mg/L	0.072 mg/L	0.03 mg/L
Iron (II) > 1 mg/L	3 mg/L*	11 mg/L*	2.62 mg/L*	4.44 mg/L*
Sulfate < 20 mg/L	2.85 mg/L	1.78 mg/L	6.53 mg/L	3.78 mg/L
REDOX < 50 millivolts (mV)	43 mV**	-86 mV**	24 mV**	-64 mV**
pH 5 < pH < 9	6.76**	6.92**	6.44**	7.02**
Note: *Results are for total iron; **Field measurement.				

Under anaerobic conditions, reductive dechlorination of PCE occurs according to the following sequence:

PCE → TCE + Chloride (Cl) → DCE isomers + 2Cl → vinyl chloride + 3Cl → ethene + 4Cl

(Hinchee et al. 1995). Several factors influence this process, including the availability of electron donors (e.g., hydrogen), and the efficiency of the process differs under methanogenic, sulfate-reducing, iron-reducing, and nitrate-reducing conditions (Chapelle 1996). The apparent lack of vinyl chloride in the groundwater at well GW-192 suggests that the strongly reducing (methanogenic) conditions necessary to transform 1,2-dichloroethene (1,2-DCE) to vinyl chloride either do not occur or that the vinyl chloride is oxidized to carbon dioxide (Wilson et al. 1996). In either case, natural biodegradation probably at least partially explains the decreasing long-term VOC concentration trend indicated by historical data for the well.

Some of the highest VOC concentrations (>10,000 µg/L) in the East Fork Regime occur in the Aquitard near the WCPA. Historical data for several wells at the site, including well GW-332, show that the groundwater contains a fairly heterogeneous mixture of chloroethenes and chloroethanes. Well GW-332, which was last sampled in January and April 1991, yields highly contaminated calcium-magnesium-bicarbonate groundwater from less than 25 ft bgs in the Nolichucky Shale about 200 ft east-southeast of the site (Figure 6). As shown in the following data summary, the CY 1998 VOC results for the duplicate samples collected from well GW-332 in March 1998 show that the concentrations of parent compounds (e.g., PCE), intermediate degradation products (e.g., TCE), and end degradation products (e.g., vinyl chloride) have decreased substantially, although maximum summed VOC concentrations remain above 2000 µg/L.

VOC	Well GW-332 VOC Concentration (µg/L)			
	January 1991 (Diluted Sample)	April 1991 (Diluted Sample)	March 1998 (Duplicate Samples)	
Chloroethenes				
PCE	1400	1100	660	610
TCE	710	520	120	120
1,2-DCE (total)	4000	3500	1001	909
cis-1,2-DCE	NA	NA	990	900
trans-1,2-DCE	NA	NA	11	9
1,1-DCE	160	130	28	23
Vinyl chloride	180	<250	20	18
Chloroethanes				
1,1,1-TCA	76	53	16	14
1,1-DCA	58	<125	20	19

Note: NA = Not analyzed.

Results for the duplicate samples collected in March 1998 also show that only sulfate levels (8.02 and 7.89 mg/L) and pH (5.85) are within the optimal range for reductive dechlorination of PCE: the nitrate levels (1.78 and 1.79 mg/L), total iron concentrations (0.026 and 0.042 mg/L), REDOX (212 mV) are not within the respective optimal anaerobic ranges (Wilson et al. 1996). Thus, it is not clear from the available data if hydrologic (e.g., dilution and dispersion) or biological mechanisms are the primary attenuation processes working to decrease VOC concentrations in the groundwater at well GW-332. Additionally, the apparent decrease in the VOC concentrations may at least partially reflect the change from conventional sampling (January and April 1991) to low-flow sampling (March 1998).

Historical data show that Aquifer well GW-251 monitors the dissolved plume of chloroethenes (primarily PCE and TCE) and chloromethanes (carbon tetrachloride and chloroform) that originates from the S-2 Site. Several characteristics of the CY 1998 VOC results are consistent with historical data for the well, including: (1) higher summed concentrations of chloroethenes (621 µg/L) relative

to chloromethanes (33 µg/L), (2) substantially higher maximum concentrations of PCE (410 µg/L) and TCE (200 µg/L) relative to 1,2-DCE isomers (11 µg/L), (3) large proportions (>50%) of chloroform relative to carbon tetrachloride (particularly during the dry season), (4) strongly seasonal VOC concentration fluctuations that probably reflect contaminant flushing, with the highest summed concentration (655 µg/L) evident during seasonally high groundwater flow conditions (May 1998), and (5) decreasing long-term concentration trends, with summed VOC concentrations in December 1998 (102 µg/L) the lowest evident since May 1995 (89 µg/L). The decreasing concentration trends may at least partially reflect relatively slow co-metabolic transformation of TCE (rather than reductive dechlorination of PCE) and carbon tetrachloride, which is possible under a wider range of anaerobic conditions (McCarty 1996).

Maximum summed VOC concentrations determined from CY 1998 data for Aquifer well GW-618 (46 µg/L) are generally consistent with historical data for the well (Table 4). This well intercepts bedrock interval migration pathways for the dissolved plume(s) of chloroethenes (primarily PCE and its degradation products) originating from one or more upgradient sources in the western plant area (U.S. Department of Energy 1998). As noted previously, the CY 1998 results for the well also show that maximum concentrations of PCE (19 µg/L), TCE (16 µg/L), and vinyl chloride (2 µg/L) remain at or above respective MCLs.

As noted in Section 3.1.1.1, Aquifer well GW-620 yields geochemically distinctive groundwater from the upper Maynardville Limestone downgradient of the Fire Training Facility. This well monitors a plume of dissolved VOCs, consisting primarily of chloroethenes along with lesser amounts of chloroethanes and petroleum hydrocarbons, that originates from former burn areas in the western part of the site (U.S. Department of Energy 1998). Summed concentrations of VOCs detected in the samples collected from the well during May 1998 (107 µg/L) and December 1998 (38 µg/L) are consistent with historical data for the well. Although several geochemical characteristics of the groundwater in the well (such as the very high pH) are not within the optimum range for reductive dechlorination of PCE, the high proportion of cis-1,2-DCE (about 50% of summed VOCs) relative to PCE and TCE nevertheless suggests biodegradation. One possible biodegradation process occurring is co-metabolism, where TCE can be indirectly transformed by bacteria that use petroleum hydrocarbons as a primary substrate (Wiedemeier et al. 1996). These compounds have been repeatedly detected in the groundwater samples from well GW-620 (e.g., 1 µg/L toluene in May 1998).

3.1.1.3 Radioactivity

Radiological results (gross alpha, gross beta, and radionuclides) for the CY 1998 Surveillance Monitoring well network are consistent with historical data showing that radiological contamination in the western plant area occurs primarily in the Nolichucky Shale east of the S-3 Site and in the Maynardville Limestone near the S-2 Site. The CY 1998 gross alpha and gross beta results for wells GW-192, GW-332, and GW-618 do not exceed the associated minimum detectable activity (MDA) and are therefore considered nondetects. As shown in the following summary, low levels of gross

alpha in the groundwater at well GW-251 remain below the 15 picoCurie per Liter (pCi/L) MCL; similarly low levels of gross beta occur in the groundwater at well GW-620; and gross beta in groundwater at well GW-108 remains substantially above the threshold level (50 pCi/L) for a dose equivalent that exceeds the MCL (4 millirems per year).

Well	Date Sampled	Gross Alpha (pCi/L)		Gross Beta (pCi/L)	
		MDA	Activity ± Counting Error	MDA	Activity ± Counting Error
GW-108	03/16/98	320	<MDA	1200	10,000 ± 1,200
	(Duplicate)	380	<MDA	1200	10,000 ± 990
	07/28/98	400	<MDA	870	14,000 ± 1,200
	(Duplicate)	610	<MDA	810	14,000 ± 1,200
GW-251	09/04/98	7	8.5 ± 5.7	8.1	8.7 ± 5.3
	11/11/98	3.4	8.3 ± 4	8.1	<MDA
GW-620	05/26/98	3.5	<MDA	7.6	14 ± 5.5
	12/02/98	2.6	<MDA	8.7	<MDA

Although historical monitoring data and operational information indicate a diverse population of alpha- and beta-emitting radioisotopes originating from the former S-3 Ponds, the beta radioactivity in the groundwater at well GW-108 is primarily from ^{99}Tc. Results for the duplicate samples collected from the well during CY 1998 show ^{99}Tc concentrations ranging from 21,000 ± 81 pCi/L (March 1998) to 23,000 ± 85 pCi/L (July 1998), and reflect a clearly increasing long-term concentration trend (see Section 3.3). Under oxidizing conditions, ^{99}Tc occurs as the pertechnetate anion (TcO_4^-) which is soluble and highly mobile in groundwater (Gee et al. 1983). This high mobility explains the similar distribution of gross beta activity and nitrate from the S-3 Ponds and likewise reflects primarily strike- and dip-parallel transport of ^{99}Tc (U.S. Department of Energy 1998).

3.1.2 Central Plant Area

As shown in the following summary, one or more groundwater contaminants, including inorganics (chloride, chromium, nickel, sulfate, and uranium), VOCs (PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE, vinyl chloride, carbon tetrachloride, chloroform, methylene chloride, 1,1,1-TCA, 1,1-DCA, chloroethane, benzene, dimethylbenzene, ethylbenzene, and toluene), and radioactivity (gross alpha, gross beta, and uranium isotopes) were detected in at least one groundwater sample collected during CY 1998 from each of the 24 wells used for Surveillance Monitoring purposes in the central plant area.

Well	Hydrogeologic Unit/ Monitored Interval Depth (ft bgs)		Contaminant Type		
	Aquitard	Aquifer	Inorganics	VOCs	Radioactivity
56-2A	9.0 - 15.1	.	●	●	.
56-2B	32.0 - 38.8	.	●	●	.
56-2C	77.3 - 71.0	.	●	●	.
59-1A	15.0 - 7.0	.	●	.	.
59-1B	30.0 - 36.9	.	●	.	.
59-1C	73.9 - 67.0	.	●	●	.
GW-193	5.5 - 18.4	.	.	●	.
GW-219	.	4.3 - 11.3	●	.	●
GW-686	.	4.0 - 16.0	●	●	.
GW-687	.	20.0 - 32.0	●	.	.
GW-769	48.2 - 60.3	.	.	●	.
GW-770	7.5 - 19.0	.	.	●	.
GW-775	45.0 - 56.4	.	●	●	.
GW-776	10.6 - 23.0	.	●	●	.
GW-781	56.0 69.3	.	●	●	.
GW-782	23.8 35.9	.	.	●	●
GW-783	3.6 - 16.3	.	●	●	.
GW-788	55.9 - 67.8	.	●	.	.
GW-789	10.7 - 23.8	.	.	●	.
GW-791	57.5 - 70.6	.	.	●	.
GW-792	17.0 - 29.0	.	●	●	.
GW-818	.	? - 20.4	●	●	.
GW-819	.	? - 15.5	●	.	.
GW-820	.	? - 17.3	●	●	.

The extent of groundwater contamination in the central plant area reflects intermixing of contaminants from multiple sources (including DNAPL in the subsurface at several sites), and the substantial hydrologic influence exerted by the extensive areas of anthropogenic fill, subsurface drains and utilities, surface drainage conveyances, and operation of basement sumps in several of the process buildings within the Y-12 Plant (U.S. Department of Energy 1998).

3.1.2.1 Inorganic Contaminants

Results for inorganic analytes (major ions and trace metals) reported for most of the Surveillance Monitoring wells in the central plant area reflect the calcium-magnesium-bicarbonate chemistry of shallow groundwater in the Aquitard (Figure 7) and the Aquifer (Figure 8). Also, several of the deeper wells (e.g., 56-2C, GW-781, and GW-788) yield the sodium-bicarbonate groundwater typically encountered at greater depth in the Aquitard throughout BCV. However, atypically high concentrations of chloride and sulfate in several wells, summarized below, potentially reflect groundwater contamination in the central plant area.

Well Number	CY 1998 Concentration (mg/L)					
	Chloride			Sulfate		
	1st Qtr.	2nd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.	4th Qtr.
56-2A	33.6	NS	NS	61.8	NS	NS
56-2B	.	NS	NS	119	NS	NS
59-1B	51.7	NS	NS	.	NS	NS
GW-686	.	NS	NS	128	.	NS
GW-687	.	NS	NS	1920	.	NS
GW-775	NS	39.1	34.3	NS	34.4	29.7
GW-776	NS	46.9	45.3	NS	43.2	38.4
GW-783	NS	41.4	48.2	NS	.	.
GW-792	NS	26	44.6	NS	26.7	22.1
GW-818	.	NS	NS	50.5	NS	NS
GW-819	53	NS	NS	.	NS	NS
GW-820	15.1	NS	NS	33.7	NS	NS

Note: "." = Typical concentration, not elevated; NS = Not sampled.

Leaking industrial process lines, sanitary sewers, or subsurface drains and may be the source(s) of the chloride and/or sulfate in the shallow groundwater at several of these wells. For instance, historical chloride data for well GW-792 show an increasing long-term concentration trend that generally coincides with a sharp rise in the groundwater elevation in the well that may correspond to a leak in a nearby sanitary sewer (see Section 3.3). However, because inorganic chloride accumulates during anoxic dechlorination of PCE, the elevated chloride concentrations in some of these wells may be at least partially attributable to degradation of dissolved chloroethenes in the groundwater (see Section 3.1.2.2).

Aside from non-specific sources of inorganic contaminants in the central plant area, the CY 1998 monitoring results suggest that the coal stockpile overlying the Coal Pile Trench is a source of sulfate in the shallow groundwater at Aquifer wells GW-686 and GW-687, and that the Uranium Oxide Vault is a potential source of elevated uranium levels in the shallow groundwater at Aquifer well GW-219.

Aquifer wells GW-686 and GW-687 are located in the vicinity of the coal stockpile overlying the Coal Pile Trench (Figure 6), with well GW-687 located within the drainage culvert surrounding the site and well GW-686 located about 500 ft to the east (along geologic strike) of the site. Sulfur leached from the coal is the probable source of the elevated sulfate levels in the shallow groundwater at these wells, particularly the very high concentrations (>1000 mg/L) in well GW-687, which may intercept groundwater flow paths that subcrop beneath the coal stockpile. Historical sulfate data are not available for either well (both were sampled for the first time in March 1998), but similarly elevated sulfate levels reported for samples collected in June 1996 from Aquifer wells GW-690 (775 mg/L) and GW-692 (328 mg/L), which are located about 400 ft directly north of GW-686, also suggest that the coal stockpile is a significant local source of sulfate in the shallow groundwater downgradient of the Coal Pile Trench (AJA Technical Services, Inc. 1998).

The highest total and/or dissolved nickel concentration reported for the filtered and/or unfiltered groundwater samples collected during CY 1998 from wells 59-1A (0.24 mg/L), 59-1B (0.28 mg/L), GW-776 (0.736 mg/L), and GW-783 (0.635 mg/L) exceed the drinking water MCL of 0.1 mg/L. Total chromium concentrations reported for several of these wells, notably GW-776 (1.75 mg/L), also exceed the MCL (0.1 mg/L), although dissolved chromium concentrations in the filtered samples from each well do not exceed analytical reporting limits. Because each of these wells yield groundwater with fairly neutral pH and none of the wells are located near confirmed or suspected sources of nickel or chromium contamination, elevated concentrations of these metals have been interpreted to potentially reflect corrosion of the stainless steel well casing and screen (HSW Environmental Consultants, Inc. 1994; AJA Technical Services, Inc. 1998). However, these interpretations recognized that the geochemical conditions known to be corrosive to stainless steel (e.g., dissolved oxygen >2 mg/L; Driscoll 1986) are not evident in all of the wells with elevated nickel and/or chromium concentrations. Instead of chemical corrosion, bacteria in the groundwater may be the chief corrosive agent in these wells. Microbiologically induced corrosion (MIC) of stainless steel may be caused by many different species of bacteria, including iron-reducing and sulfate-reducing organisms, that typically attack the area near welds. Once a colony attaches to the metal it forms a nodule in which to live. The micro-environment within the nodule creates conditions (e.g., acidic pH) that enable the colony to expand and deepen the nodule, which eventually creates a pit or crevice in the metal and facilitates corrosion per the mechanisms described by Driscoll (1986). As shown in the following summary, indicator parameters reported for these wells are within the optimum range for MIC.

Indicator Parameter/Optimal Range (Sarouhan et al. 1998)	CY 1998 Field Measurement Data			
	59-1A	58-1B	GW-776	GW-783
Dissolved Oxygen > 1mg/L (iron-reducing bacteria) < 1mg/L (sulfate-reducing bacteria)	3.71	9.15	2.13 0.73	1.93 0.91
REDOX - 50 to 150 mV	137	73	132 225	24 79
pH 5.5 < pH < 9.0	7.27	7.0	7.36 7.39	7.17 7.21

Visual inspection of the well casing and screen is the only direct means of confirming the presence of MIC in these (and other) wells. If MIC is confirmed, periodic mechanical and chemical cleaning may be necessary to rehabilitate the wells (Sarouhan et al. 1998).

Aquifer well GW-219 is completed at a depth of about 11 ft bgs in the water table interval about 50 ft northeast of the Uranium Oxide Vault (Figure 6). Filtered and unfiltered groundwater samples were collected from the well in August 1998 (seasonally low flow); the well was sampled only once previously, in CY 1997 to collect data for the RI. Analytical results for the August 1998 samples indicate that well GW-219 yields calcium-magnesium-bicarbonate groundwater with very high total (0.229 mg/L) and dissolved (0.264 mg/L) uranium concentrations. These concentrations are consistent with previous monitoring results (U.S. Department of Energy 1998) and exceed the proposed MCL for uranium (0.02 mg/L). Uranium concentrations at well GW-219 are among the

highest levels observed outside the boundaries of the S-3 Ponds groundwater contaminant plume (note that total and dissolved uranium concentrations in well GW-219 are an order-of-magnitude higher than corresponding levels in well GW-108). The very high total and dissolved uranium levels in the shallow groundwater at this well suggest that the Uranium Oxide Vault may be a significant source of uranium contamination.

3.1.2.2 Volatile Organic Compounds

Excluding false-positive results, at least one VOC was detected in at least one groundwater sample collected during CY 1998 from 15 Aquitard wells and three Aquifer wells (GW-686, GW-818, and GW-820) used for Surveillance Monitoring in the central plant area (Table 4). Maximum summed VOC concentrations are less than 10 µg/L in wells 59-1C, GW-686, GW-775, GW-776, GW-789, GW-792, and GW-818; range between 10 and 100 µg/L in wells 59-2A, GW-769, GW-770, GW-781, and GW-783; range between 100 and 500 µg/L in wells GW-193, GW-782, and GW-791; and exceed 500 µg/L in well 56-2B, 1000 µg/L in well 56-2C, and 5000 µg/L in well GW-820. As shown in the following summary, the maximum concentrations of PCE, TCE, cis-1,2-DCE, 1,1-DCE, vinyl chloride, carbon tetrachloride, and benzene exceed respective MCLs.

Monitoring Well	Maximum CY 1998 Concentration and MCL (µg/L)						
	PCE	TCE	cis-1,2-DCE	1,1-DCE	Vinyl Chloride	Carbon Tetrachloride	Benzene
56-2A	**48**	**7**	(4)	<5	<10	<5	<5
56-2B	**870**	**50**	**74**	(3)	<10	<5	<5
56-2C	**1400**	**380**	**180**	**7**	**(6)**	<5	<5
59-1C	<5	**7**	<5	<5	<10	<5	<5
GW-193	<5	<5	<5	<5	<10	<5	**120**
GW-769	**7**	(2)	(2)	(1)	<10	**12**	<5
GW-770	<5	<5	<5	<5	<10	**7**	<5
GW-775	<5	**6**	<5	<5	<10	<5	<5
GW-781	**46**	5	<5	<5	<10	<5	<5
GW-782	**230**	**64**	15	**37**	**(4)**	<5	<5
GW-783	**24**	**12**	13	(4)	<10	(2)	<5
GW-791	**330**	(2)	<5	<5	<10	<5	<5
GW-792	**6**	<5	<5	<5	<10	<5	<5
GW-818	<5	**6**	(1)	<5	<10	<5	<5
GW-820	**7300**	**590**	**870**	(4)	**65**	<5	<5
MCL	5	5	70	7	2	5	5

Note: ( ) = Estimated concentration below the reporting limit; Bold = Exceeds MCL.

Suspected sources of the VOCs detected in the network of wells sampled during CY 1998 include Buildings 9204-4, 9201-4, and 9201-5 (56-2A, 56-2B, and 56-2C); the Building 9212 vicinity (GW-791 and GW-792); several potential sites in the vicinity of Buildings 9204-2 and 9731 (GW-781, GW-782, and GW-783); Building 9201-2 (GW-818 and GW-820), and Tank 2331-U (GW-193) (Figure 5).

Aquitard wells 56-2A, 56-2B, and 56-2C comprise a well cluster in the upper Nolichucky Shale near the southwest corner of Building 9201-4 (Figure 6). Historical data for these wells show that they yield calcium-magnesium-bicarbonate (56-2A and 56-2B) or sodium-bicarbonate (56-2C) groundwater containing dissolved chloroethenes (primarily PCE). Results for the samples collected in March 1998 confirm the groundwater geochemistry in each well (Figure 7) in addition to the presence of dissolved chloroethenes (Table 4). The VOCs are believed to originate from spills and leaks of chlorinated solvents during historical production and machining operations in Buildings 9201-4 and 9201-5 (U.S. Department of Energy 1998). Strike-parallel transport commonly observed in the Aquitard would suggest that the WCPA also could be a source of the VOCs in groundwater near these wells. These results show that summed VOC concentrations increase with depth from less than 100 µg/L in well 56-2A (15 ft bgs) to almost 1000 µg/L in well 56-2B (39 ft bgs) and about 2000 µg/L in well 56-2C (77 ft bgs). Presampling groundwater elevations in these wells indicate an upward hydraulic gradient from the deeper bedrock to the shallow bedrock (0.015 between 56-2C and 56-2B) and a downward vertical gradient from the water table to the shallow bedrock (0.014 between 56-2A and 56-2B). These gradients suggest that chloroethene concentrations in the shallower groundwater at wells 56-2A and 56-2B may at least partially reflect upward migration from the deeper flow system, where the PCE concentration in well 56-2C (1400 µg/L) suggests the presence of DNAPL. Additionally, the dissolved TCE, cis-1,2-DCE, and trans-1,2-DCE in the groundwater at each of these wells may reflect reductive dechlorination of the PCE, with the low level of vinyl chloride in well 56-2C potentially indicating more strongly reducing conditions in the deeper groundwater.

The production complex in the vicinity of Building 9212 is the suspected source of the dissolved PCE plume in the groundwater at Aquitard wells GW-791 and GW-792 (Figure 6). Historical data for these wells show maximum PCE concentrations above 1000 µg/L in the groundwater at shallow bedrock well GW-791 (71 ft bgs), which may indicate the presence of DNAPL (U.S. Department of Energy 1998). Considerably lower PCE levels (typically below 25 µg/L) have been reported for the shallower groundwater at water table well GW-792 (29 ft bgs). Results for both wells also show a general lack of PCE degradation products (particularly DCE isomers), indicating little if any natural biodegradation of the PCE. Also, the upward hydraulic gradients indicated by presampling groundwater elevations in these wells (see Section 3.3) indicate that dissolved PCE migrates upward from the shallow bedrock into the water table interval. The CY 1998 data are consistent with respective historical results for each well, although the PCE levels reported for well GW-791 are the lowest ever reported for the well. As shown in the following data summary, PCE concentrations in well GW-791 appear to have decreased substantially following the change to low-flow sampling in November 1997, whereas a similar decrease in PCE levels is not generally evident for well GW-792.

PCE (µg/L)							
Conventional Sampling		Low-Flow Sampling					
April 1997		November 1997		May 1998		November 1998	
GW-791	GW-792	GW-791	GW-792	GW-791	GW-792	GW-791	GW-792
2100	8	710	9	330	6	70	5

The apparent correlation between the low-flow sampling method and the significantly lower PCE concentrations in well GW-791 suggests that the conventional sampling method may have induced advective migration of dissolved PCE into the well. The hydrologic response to conventional sampling may be less pronounced in the more permeable and interconnected flowpaths in the shallow flow system, consequently there is less difference between the low-flow and conventional sampling PCE results for well GW-792.

Aquitard wells GW-781, GW-782, and GW-783 comprise a well cluster in the upper Nolichucky Shale at depths of about 63 ft, 36 ft, and 16 ft bgs, respectively, about 100 ft southwest of Building 9731 (Figure 6). Historical data show that these wells yield calcium-magnesium-bicarbonate (GW-782 and GW-783) and sodium-bicarbonate groundwater (GW-781) containing a mixed plume of dissolved chloroethenes, chloroethanes, and chloromethanes. The plume is believed to originate from sources in the vicinity of Building 9204-2 and Building 9731 (U.S. Department of Energy 1998). The CY 1998 VOC results for these wells, summarized below, are consistent with respective historical data showing higher VOC concentrations in well GW-782 compared to deeper well GW-781 and shallower well GW-783.

VOC and Associated Reporting Limit (µg/L)		Concentration (µg/L)					
		May 1998			November 1998		
		GW-781	GW-782	GW-783	GW-781	GW-782	GW-783
PCE	5	46	230	6	11	210	24
TCE	5	5	64	(2)	.	64	12
cis-1,2-DCE	5	.	15	(3)	.	14	13
trans-1,2-DCE	5	.	5	(1)	.	4	6
Vinyl chloride	10	.	(1)	.	.	(4)	.
1,1,1-TCA	5	(1)	(2)	.	.	8	(2)
1,1-DCA	5	.	99	(1)	.	150	12
1,1-DCE	5	.	29	.	.	37	(4)
Chloroethane	10	.	(1)	.	.	(4)	.
Carbon Tetrachloride	5	.	.	(1)	.	.	(2)

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

Substantially higher VOC concentrations in well GW-782 compared with wells GW-781 and GW-783 suggest somewhat stratabound transport pathways. The dominantly upward hydraulic gradients indicated by presampling groundwater elevations in these wells (see Section 3.3) also indicates vertically upward migration patterns. Additionally, several natural attenuation processes are potentially indicated by the data for these wells. For instance, biotic and/or abiotic degradation of 1,1,1-TCA, which is the only major chlorinated solvent that can be transformed chemically in groundwater under all likely conditions (McCarty 1996), is indicated by the preponderance of 1,1-DCA and 1,1-DCE in well GW-782. Biodegradation of PCE is suggested by the presence of degradation products (e.g., cis-1,2-DCE), with the indicator parameters (e.g., REDOX <50 mV) showing geochemical conditions within the optimum range for reductive dechlorination (Wilson

et al. 1996). As noted in Section 3.1.2.1, the potential MIC of the stainless steel well screen also supports the presence of anaerobic bacteria in groundwater near the well.

Aquitard wells GW-788 and GW-789 comprise a well cluster located about 1000 ft east (along geologic strike) of wells GW-781/782/783 (Figure 6). The deeper well in this cluster (GW-788) yields relatively uncontaminated sodium-bicarbonate groundwater from a depth of about 68 ft bgs in the Nolichucky Shale (Figure 7). Chlorinated solvents (and other contaminants) were not detected in the groundwater samples collected from well GW-788 during CY 1998. In contrast, well GW-789 yields calcium-magnesium-bicarbonate groundwater from a depth of about 24 ft bgs in the Nolichucky Shale, and the groundwater samples collected from the well during CY 1998 contained trace levels of chloroform (1 µg/L), PCE (3 µg/L), and TCE (3 µg/L). Additionally, results obtained during CY 1998 continue the generally increasing VOC concentration trend evident in well GW-789 (see Section 3.3). Because presampling groundwater elevations in these wells indicate vertically upward hydraulic gradients during seasonally high and low flow conditions, the overall lack of VOCs in the deeper groundwater at well GW-788 suggests that the low levels of dissolved VOCs in well GW-789 probably reflect transport in the shallow flow system from an upgradient source area to the north (across geologic strike) or west (along geologic strike).

Aquitard wells GW-769 and GW-770 comprise a well cluster completed at depths of 60 ft and 19 ft bgs, respectively, in the Nolichucky Shale about 200 ft northeast of Building 9201-2 (Figure 6). Historical data show that these wells yield calcium-magnesium-bicarbonate groundwater containing several dissolved chloroethenes (PCE, TCE, and cis-1,2-DCE) and/or chloromethanes (carbon tetrachloride and chloroform). Because basement sumps in Building 9201-2 strongly influence local groundwater flow and contaminant transport patterns, the source(s) of these VOCs may be located to the north of the wells, possibly Buildings 9202, 9203, and 9205 where large amounts of carbon tetrachloride were used to convert uranium trioxide to uranium tetrachloride (U.S. Department of Energy 1998). The VOC results for the groundwater samples collected from these wells in CY 1998 are consistent with respective historical data and show that concentrations of individual compounds in either well rarely exceed 10 µg/L. However, maximum summed VOC concentrations are higher in well GW-769 (26 µg/L) than in well GW-770 (14 µg/L) (Table 4) and historic data indicate long-term increasing concentration trends in the groundwater at each well (see Section 3.3).

Aquitard wells GW-775 and GW-776 comprise a well cluster located near the Nolichucky Shale/Maynardville Limestone contact about 1500 ft east of Aquitard wells GW-769 and GW-770 (Figure 6). Historical data show that these wells yield calcium-magnesium-bicarbonate groundwater containing atypically high levels of chloride and sulfate along with low levels (<10 µg/L) of chloroethenes (primarily TCE) and chloromethanes (primarily chloroform). The CY 1998 results for these wells are consistent with historical VOC data showing stable long-term concentration trends less than 10 µg/L; very low concentrations of TCE (2 - 6 µg/L) were detected in the groundwater samples from both wells. As noted in Section 3.1.2.1, the elevated chloride and sulfate concentrations in the groundwater at these wells possibly originate from leaking sewer lines and/or storm drains. Transport of TCE from one or more upgradient source areas was probably facilitated by subsurface utilities.

Aquitard well GW-193 is located near the eastern end of Building 9201-1 in the south-central part of the central plant area (Figure 6). Historical data show that this well yields calcium-magnesium-

bicarbonate groundwater containing a residual plume of dissolved petroleum hydrocarbons (benzene, chlorobenzene, dimethylbenzene, ethylbenzene, and toluene) originating from a petroleum fuel underground storage tank (Tank 2331-U) that was excavated and removed in December 1988 (U.S. Department of Energy 1998). Summed concentrations of these compounds in the groundwater samples collected from the well in March 1998 (144 µg/L) and July 1997 (100 µg/L) are consistent with historical data showing long-term decreasing concentration trends. Although the concentrations have decreased, the CY 1998 results show that the benzene levels in the well (89 - 120 µg/L) remain substantially above the 5 µg/L MCL.

Aquifer wells GW-818, GW-819, and GW-820 are located along the south side of Building 9201-2, with well GW-820 located near the southwest (upgradient) corner of the building and wells GW-818 and GW-819 located closer to the southeast (downgradient) corner of the building (Figure 6). Complete construction details are not available for these wells, but available data indicate that they are completed at shallow depths (<25 ft bgs) in the Maynardville Limestone. These wells have been sampled only twice; once in March 1997 to obtain data for the RI and once in March 1998 under the auspices of the Y-12 Plant GWPP. The VOC results for these samples, summarized below, show: (1) groundwater in well GW-819 is not contaminated with VOCs, (2) well GW-818 yields groundwater containing relatively low concentrations of PCE degradation products (primarily TCE), and (3) well GW-820 clearly monitors a plume of dissolved chloroethenes, although there are significant differences between the concentrations of PCE and cis-1,2-DCE obtained during the RI and GWPP sampling events.

Chloroethene	Concentration (µg/L)					
	March 1997 (RI Sampling)			March 1998 (GWPP Sampling)		
	GW-818	GW-819	GW-820	GW-818	GW-819	GW-820
PCE	.	.	5	.	.	7300
TCE	5	.	600	6	.	590
cis-1,2-DCE	.	.	5000	(1)	.	870
trans-1,2-DCE	NR	NR	NR	.	.	6
Vinyl Chloride	NR	NR	NR	.	.	65

Note: "." = Not Detected; NR = Not Reported; ( ) = Estimated concentration below reporting limit.

The reason for the disparity between the PCE and 1,2-DCE results for well GW-820 is not clear from the available data. However, if future sampling confirm the March 1998 PCE concentration, which exceeds 1% of pure-phase solubility (1500 µg/L), DNAPL is probably present in the subsurface near the western (upgradient) end of Building 9201-2. Nevertheless, the March 1998 sampling results for wells GW-818 and GW-819 support the previous RI data indicating limited strike-parallel migration downgradient to the east of well GW-820. This is primarily because the operation of de-watering sumps in the basement of Building 9201-2 probably captures the bulk of the contaminant mass in the shallow flow system (U.S. Department of Energy 1998).

3.1.2.3 Radioactivity

Historical monitoring data do not indicate widespread radiological contamination in the central plant area. The CY 1998 monitoring results are consistent with these historical findings; gross alpha and gross beta results reported for the groundwater samples collected from all but 8 of the 24 Surveillance Monitoring wells are less than the corresponding MDA for each result. Of the CY 1998 gross alpha and gross beta results that exceed the corresponding MDA, summarized below, most just slightly exceed the applicable MDA and have high proportional counting errors (i.e., a high degree of analytical uncertainty).

Well	Date Sampled	Gross Alpha (pCi/L)		Gross Beta (pCi/L)	
		MDA	Activity ± Counting Error	MDA	Activity ± Counting Error
59-1A	03/17/98	3.4	6.9 ± 3.4	44	<MDA
59-1B	03/18/98	3.7	5.5 ± 3.2	14	<MDA
GW-193	07/28/98	4	<MDA	7.2	9.3 ± 4.9
GW-219	09/04/98	7.6	**90** ± 14	9.1	48 ± 8.3
GW-781	11/11/98	3.6	<MDA	6.8	9.4 ± 4.7
GW-782	05/20/98	8.7	**64** ± 14	15	<MDA
	11/12/98	3.5	**53** ± 9.9	8	15 ± 5.8
GW-783	11/12/98	1.2	2.7 ± 2.2	7.6	<MDA
GW-792	05/20/98	1.9	4.2 ± 3.4	16	<MDA

Note: Bold = Activity exceeds MCL.

As shown above, the highest gross alpha and gross beta activities were reported for the groundwater samples from Aquitard well GW-782 and Aquifer well GW-219, with gross alpha results that exceed the 15 pCi/L MCL reported for both wells.

Elevated gross alpha activity (i.e., >15 pCi/L) in the groundwater at Aquitard well GW-782 is consistent with historical data as well as data obtained during the RI identifying ^{234}U (81 pCi/L) as the principal radionuclide in the well (U.S. Department of Energy 1998). In contrast, the CY 1998 and historical data (including RI results) show essentially background levels of gross alpha activity in the shallower (GW-783) and deeper (GW-781) wells clustered with GW-782. Background gross alpha levels in the shallower and deeper groundwater suggest stratabound (strike- or dip-parallel) migration of ^{234}U (and other uranium isotopes/daughter products) along the groundwater flowpaths intercepted by well GW-782. Moreover, the CY 1998 gross alpha results for well GW-782 continue the increasing long-term concentration trend evident since the early 1990s (see Section 3.3). The source of the uranium is believed to be historical spills and leaks from nearby process buildings where large amounts of radionuclides were routinely handled (U.S. Department of Energy 1998).

The elevated gross alpha and gross beta activities reported for September 1998 sample from well GW-219 are supported by isotopic analyses showing ^{234}U (14 ± 2 pCi/L) and ^{238}U (98 ± 11 pCi/L) in the sample. These results are significantly lower than the gross alpha (585 pCi/L), gross beta (837 pCi/L), ^{234}U (53.9 pCi/L), and ^{238}U (293 pCi/L) results reported for the RI sampling event performed in CY 1997 (U.S. Department of Energy 1998). The September 1998 sample results

probably represent actual groundwater quality because this sample was not turbid (suspended solids = 4 mg/L), whereas the CY 1997 was extremely turbid (suspended solids = 7,860 mg/L). The presence of uranium isotopes in the groundwater at the well suggests a relatively nearby source (possibly the Uranium Oxide Vault) because these isotopes probably occur as uranyl cations, which are prone to pH-sensitive sorption reactions and consequently are not usually highly mobile in groundwater (Fetter 1993). Also, considering the shallow depth of the well (11 ft bgs) and its proximity to UEFPC, the presence of uranium isotopes (and elevated elemental uranium concentrations) may primarily reflect localized inflow of contaminated surface water rather than subsurface migration from the source area(s). A fairly direct hydraulic connection with UEFPC may be indicated by the unusually high temperature of the groundwater sample collected from the well in March 1998 (23.7° C): as noted in Section 2.3, flow in UEFPC is augmented in part to reduce the otherwise elevated temperature of the water in the creek.

3.1.3 Eastern Plant Area

As shown in the following summary, one or more contaminants, including inorganics (chloride, nickel, nitrate, sodium, sulfate, and uranium), VOCs (PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE, vinyl chloride, carbon tetrachloride, chloroform, and methylene chloride), and radioactivity (gross alpha and gross beta) were detected in at least one of the samples collected during CY 1998 from each of the wells used for Surveillance Monitoring purposes in the eastern plant area.

Well	Hydrogeologic Unit and Monitored Interval Depth (ft bgs)		Contaminant Type		
	Aquitard	Aquifer	Inorganics	VOCs	Radioactivity
GW-148	. . .	4.6 - 11.1	●	●	.
GW-153	. . .	45.0 - 60.0	●	●	.
GW-380	. . .	2.8 - 15.5	●	.	.
GW-383	16.6 - 23.6	. . .	●	●	.
GW-605	. . .	28.2 - 39.9	●	●	●
GW-606	. . .	155.0 - 171.0	●	●	.
GW-763	4.0 - 16.0	. . .	●	●	.
GW-845	. . .	156.9 - 438.3	.	●	.

Results for these wells are generally consistent with respective historical data and reflect transport of contaminants from upgradient sources within the Y-12 Plant.

3.1.3.1 Inorganic Contaminants

The network of wells used for Surveillance Monitoring in the eastern plant area during CY 1998 monitor groundwater containing several inorganic contaminants, primarily chloride, sodium, sulfate, and uranium. As shown in the following summary, the concentrations of one or more of these inorganics reported for the groundwater samples collected from Aquitard wells GW-383 and

GW-763 and Aquifer wells GW-148, GW-153, GW-380, GW-605 and GW-606 probably reflect groundwater contamination in the eastern plant area.

Well Number	CY 1998 Concentration (mg/L)							
	Chloride		Sodium		Sulfate		Uranium (total)	
	1st/2nd Qtr.	3rd/4th Qtr.	1st/2nd Qtr.	3rd/4th Qtr.	1st/2nd Qtr.	3rd/4th Qtr.	1st/2nd Qtr.	3rd/4th Qtr.
GW-148	75.3	77.6	.	.	33.4	32.6	.	.
GW-153	15.9	54.1	.	.	.	.	.	.
GW-380	144	46.5	105	52.2	.	.	.	.
GW-383	37.3	43.2	.	.	.	.	.	.
GW-605	44.1	12.8			33.2	36	0.33	0.046
GW-606	51.9	41.5	.	.	43.9	48.1	.	.
GW-763	55.9	57.1	.	.	.	.	.	.

Atypically high concentrations of chloride, sodium, and sulfate probably reflect transport in groundwater and surface water from sources (e.g., leaking process lines or subsurface drains) in the Y-12 Plant upgradient of New Hope Pond/Lake Reality. However, the elevated chloride concentrations in the groundwater at several of these wells also may reflect some natural attenuation of dissolved chloroethenes in the groundwater. As illustrated by the following summary of CY 1997 and CY 1998 data for Aquitard well GW-763, for example, several geochemical parameters for these wells are within the optimum range for biodegradation of chlorinated solvents.

Geochemical Parameter/ Optimum Range (Wilson et al. 1996)	GW-763			
	May 1997	Dec 1997	May 1998	Dec 1998
Nitrate < 1 mg/L	<0.028 mg/L	<0.028 mg/L	<0.028 mg/L	<0.028 mg/L
Iron (II) > 1 mg/L	15 mg/L*	24 mg/L*	24.5 mg/L*	21.3 mg/L*
Sulfate < 20 mg/L	2.68 mg/L	2.34 mg/L	3.26 mg/L	2.78 mg/L
REDOX < 50 mV	-79 mV**	-60 mV**	-116 mV**	-77 mV**
Dissolved Oxygen < 0.5 ppm	2 ppm**	3.24 ppm**	0.48 ppm**	0.37 ppm**
pH 5 < pH < 9	7**	6.6**	6.98**	6.66**
Notes: *Results are for total iron; **Field measurement.				

Aquifer wells GW-605 and GW-606 comprise a well cluster completed at respective depths of 40 ft and 171 ft bgs in the lower Maynardville Limestone about 1200 ft west (hydraulically upgradient) of New Hope Pond (Figure 6). Extensive historical data for these wells, which have been sampled on a continuous quarterly or semiannual frequency since August 1991, show that both wells yield sulfate-enriched calcium-magnesium-bicarbonate groundwater containing a mixture of dissolved chloroethenes and chloromethanes (see Section 3.1.3.2). In addition to dissolved VOCs, historical data for well GW-605 show elevated total (and dissolved) concentrations of elemental uranium (and uranium isotopes). The specific source of the elemental and/or isotopic uranium has not been identified, but the well may penetrate fill material containing low-level radioactive materials potentially derived from historical uranium enrichment activities performed in Buildings 9201-1, 9201-2, and 9201-3 (U.S. Department of Energy 1998). The CY 1998 uranium results for well GW-605 are consistent with these historical findings and show that total and dissolved uranium

concentrations remain above the proposed MCL for uranium (0.02 mg/L), although the uranium results reported for the filtered (0.0468 mg/L) and unfiltered (0.0464 mg/L) samples collected in July 1998 are substantially lower than previously evident in the well. Considering that the total and dissolved uranium concentrations evident in March 1998 (low-flow sampling) continue the increasing long-term concentration trends indicated by historical (conventional sampling) data (see Section 3.3), the July 1998 uranium results do not appear to be a sampling artifact. For example, the total uranium concentration in August 1997 (0.23 mg/L), which was the last time well GW-605 was sampled in accordance with the conventional sampling method, is the same order-of-magnitude as the total uranium concentration in March 1998 (0.33 mg/L), which was the first time the well was sampled in accordance with the low-flow sampling method. Both of these results are almost an order-of-magnitude higher than the total uranium concentration in July 1998. The sharply decreased uranium concentration reported for the July 1998 sample potentially reflects the influence of the stepped pumping test (see Section 2.3), which was completed nine days before the well was sampled. Manual monitoring in well GW-605 during the pumping test showed only a slight water level decrease (0.11 ft) at the end of the 7-day 100 gpm pumping interval, which may indicate constant head recharge from UEFPC (SAIC 1998). If so, increased relative flux of recharge from UEFPC in response to the pumping test may have diluted the uranium concentration in the shallow flow system near the well. The preliminary total uranium results (0.0875 mg/L) for the sample collected from well GW-605 in February 1999 suggest a partial rebound toward the uranium concentrations evident before July 1998.

Although significantly below the MCL (10 mg/L), nitrate concentrations reported for the samples collected from well GW-606 in March 1998 (4.67 mg/L) and July 1998 (4.69 mg/L) are unusually high compared to other nearby wells in the Maynardville Limestone (e.g., <1 mg/L in well GW-605). Moreover, these elevated nitrate levels differ from historical results for well GW-606; nitrate concentrations below 1 mg/L were reported for 13 of the 23 groundwater samples previously collected from the well, and the maximum pre-1998 concentration (1.7 mg/L in March 1995) is less than half the nitrate levels evident during CY 1998. This disparity with historical nitrate data coincides with the change from conventional sampling to low-flow sampling, although it is not clear how the latter sampling method would increase nitrate concentrations in the well. Perhaps the historically low nitrate levels reflect dilution via relatively nitrate-free inflow when the well was purged for conventional sampling purposes. If confirmed by future (low-flow) sampling results, atypically high nitrate concentrations in the groundwater at well GW-606 may indicate substantial (>5000 ft) strike-parallel migration of nitrate from the contaminant plume emplaced during operation of the former S-3 Ponds or the S-2 Site (Figure 5).

3.1.3.2 Volatile Organic Compounds

Volatile organic compounds are the most pervasive groundwater contaminants in the eastern plant area. However, closure of New Hope Pond and construction of Lake Reality has strongly influenced the distribution of dissolved VOCs in the eastern plant area, with increasing concentration trends generally evident in wells currently influenced by the UEFPC underdrain and leakage from Lake Reality (U.S. Department of Energy 1998).

Excluding false-positive results, a mixture of one or more chloromethanes (carbon tetrachloride, chloroform, and methylene chloride), chloroethenes (PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE, and vinyl chloride), and chloroethanes (1,1,1-TCA and 1,1-DCA) were detected in at least one groundwater sample collected during CY 1998 from seven of the wells used for Surveillance Monitoring in the eastern plant area (Table 4). Four of these wells are west (along geologic strike) of New Hope Pond/Lake Reality (GW-383, GW-605, GW-606, and GW-763), one well is located between New Hope Pond and Lake Reality (GW-148), and two wells are south (across geologic strike) of New Hope Pond (GW-153 and GW-845) (Figure 6). Maximum summed concentrations of chloroethenes range from 9 µg/L (GW-153) to 737 µg/L (GW-383) and maximum summed concentrations of chloromethanes range from 53 µg/L (GW-605) to 1660 µg/L (GW-845); very low summed concentrations of chloroethanes were detected only in well GW-845 (8 µg/L) (Table 4). As shown in the following summary, maximum concentrations of PCE, TCE, cis-1,2-DCE, and carbon tetrachloride exceed respective MCLs.

Well Number	CY 1998 Maximum Concentration and MCL (µg/L)			
	PCE	TCE	cis-1,2-DCE	Carbon Tetrachloride
GW-153	**7**	(2)	<5	**270**
GW-383	**440**	**170**	**120**	<5
GW-605	**35**	**43**	**79**	**42**
GW-606	**8**	<5	<5	**130**
GW-845	**85**	**12**	10	**1600**
MCL	5	5	70	5

Note: ( ) = Estimated concentration below the reporting limit; Bold = Exceeds MCL.

An evaluation of the CY 1998 VOC data for the network of Surveillance Monitoring wells in the eastern plant area, presented in order from west (upgradient) to east (downgradient) of New Hope Pond/Lake Reality, is provided in the following discussion.

As noted previously, Aquifer wells GW-605 and GW-606 yield groundwater containing a mixture of dissolved chloroethenes and chloromethanes. The choroethenes in the groundwater at these wells, which are believed to originate from upgradient sources in the Y-12 Plant, have commingled with a plume of dissolved chloromethanes partitioning from DNAPL believed to be more than 500 ft bgs in the Maynardville Limestone upgradient (west) of these wells (U.S. Department of Energy 1998); the DNAPL may originate from a historical spill along the rail line south of Building 9720-6 and west of New Hope Pond (SAIC 1998).

The CY 1998 VOC results for Aquifer well GW-606 are consistent with historical data showing that carbon tetrachloride and chloroform, along with trace levels of PCE, are the principal components of the dissolved VOC plume at intermediate depths in the Maynardville Limestone and, as noted previously, maximum carbon tetrachloride and PCE concentrations remain above respective MCLs. Also, the CY 1998 results continue the decreasing long-term concentration trends indicated by historical carbon tetrachloride and chloroform data for the well. These decreasing trends are accompanied by widely fluctuating but generally increasing proportions of chloroform relative to

carbon tetrachloride; chloroform concentrations in March 1998 (150 µg/L) and July 1998 (140 µg/L) are the first to exceed respective carbon tetrachloride levels (130 µg/L and 120 µg/L). Increasing proportions of chloroform indicate that the decreasing carbon tetrachloride concentrations are at least partially attributable to biotic and/or abiotic degradation. However, considering the evidence of a direct hydraulic connection with UEFPC observed during installation of well GW-606, and the long-term rise in the groundwater elevation in the well, which has increased about 1 ft since the early 1990s, dilution is probably the primary natural attenuation mechanism (U.S. Department of Energy 1998).

The CY 1998 results for Aquifer well GW-605 differ substantially from historical VOC data for the well. Historical data for the well show that the concentrations of PCE (65 µg/L), TCE (25 µg/L), and cis-1,2-DCE (54 µg/L) in September 1995 steadily decreased to levels near respective analytical reporting limits (5 µg/L) in August 1997. No chloroethenes were detected in the sample collected from the well in March 1998, but the sample collected in July 1998 had the highest PCE (35 µg/L) and TCE (43 µg/L) concentrations evident since September 1995 and the highest 1,2-DCE (79 µg/L) level ever reported for the well (see Section 3.3). Sharply increased concentrations of these compounds potentially reflect the influence of the stepped pumping test (see Sections 2.3 and 3.1.3.1), which was completed nine days before the well was sampled (July 27, 1998). Increased relative flux of shallow groundwater in response to the pumping test may have flushed chloroethenes into the flow system near the well. This interpretation is generally supported by preliminary data for the sample collected from the well in February 1999, which show substantially (>50%) decreased PCE (12 µg/L), TCE (14 µg/L), and 1,2-DCE (24 µg/L) concentrations relative to respective levels evident in July 1998 (i.e., a partial return to pre-July 1998 concentrations).

Historical data for well GW-605 show that carbon tetrachloride concentrations steadily increased from 26 µg/L in August 1991 to a peak concentration of 320 µg/L in June 1995 and subsequently decreased to 170 µg/L in August 1997. However, the March 1998 carbon tetrachloride concentration (4 µg/L) is the lowest ever reported for the well and the July 1998 result (43 µg/L) is the lowest concentration evident since October 1991 (21 µg/L). Additionally, preliminary low-flow sampling results obtained in February 1999 indicate similarly low carbon tetrachloride concentrations (10 µg/L). This abrupt concentration decrease coincides with the change from conventional sampling (August 1997) to low-flow sampling (March 1998). If results of future low-flow sampling indicate similarly low carbon tetrachloride concentrations, it is possible that the bulk of the historical carbon tetrachloride data are sampling artifacts related to purging the well for conventional sampling purposes.

The DNAPL believed to be present in the subsurface near Building 9720-6 is the suspected source of the dissolved chloroethenes in the groundwater at Aquitard wells GW-383, which is located near the northwest corner of New Hope Pond (Figure 6), and well GW-763, which is located about 500 ft west-southwest of well GW-383 (U.S. Department of Energy 1998). Historical data show that the dissolved plume of chloroethenes in the groundwater at these wells is generally characterized by relatively large proportions of PCE degradation products, including low levels of vinyl chloride. Not only are the CY 1998 results generally consistent with these historical data, but the CY 1998 results also confirm the substantial disparity evident between the conventional sampling and low-flow sampling data obtained from well GW-763 during CY 1997. As shown in the following summary of CY 1997 and CY 1998 data, VOC concentrations in samples obtained from well GW-763 using

the conventional sampling method are substantially higher than concentrations in samples obtained using the low-flow sampling method.

VOC	Concentration (µg/L)							
	Conventional Sampling		Low-Flow Sampling					
	May 1997		December 1997		May/June 1998		December 1998	
	GW-383	GW-763	GW-383	GW-763	GW-383	GW-763	GW-383	GW-763
PCE	350	35	310	<5	400	<5	440	<5
TCE	180	8	100	<5	150	<5	170	<5
cis-1,2-DCE	130	170	100	<5	110	<5	120	<5
trans-1,2-DCE	(2)	(3)	(1)	<5	(1)	<5	(2)	<5
Vinyl chloride	(4)	24	<10	(2)	(2)	(2)	(2)	(2)
Note: ( ) = Estimated concentration below the reporting limit.								

The much lower VOC concentrations in samples collected from well GW-763 using the low-flow sampling method suggest that the historical VOC results for the well may be artifacts of the conventional sampling method that substantially overstate the severity of VOC contamination in the shallow groundwater near the well. Nevertheless, the consistent detection of vinyl chloride in well GW-763 (which is the only VOC detected in samples collected from the well using the low-flow sampling method) and the large relative proportion of PCE degradation products in well GW-383 suggest natural biodegradation in the groundwater at each well. As noted in Section 3.1.3.1, elevated chloride concentrations in each well may also reflect biodegradation of PCE, and several geochemical characteristics (e.g., strongly negative REDOX) of the groundwater in each well are within the optimum range for reductive dechlorination.

Aquifer well GW-148 is located between New Hope Pond and Lake Reality near the geologic contact between the Nolichucky Shale and Maynardville Limestone (Figure 6). This well yields calcium-magnesium-bicarbonate from less than 12 ft bgs (Figure 8). Historical data show that the estimated levels of 1,2-DCE initially detected in the well in November 1994 (3 µg/L) subsequently increased above 10 µg/L in May and December 1998 (see Section 3.3). The CY 1998 results show that the maximum cis-1,2-DCE concentration (13 µg/L) remain substantially below the applicable MCL (70 µg/L).

Aquifer well GW-153 is located about 200 ft directly south (across geologic strike) of New Hope Pond (Figure 6). Historical data show that this well yields calcium-magnesium-bicarbonate groundwater from the shallow (<100 ft bgs) flow system in the Maynardville Limestone, but as noted in Section 2.3, the dye-trace test performed in July 1998 demonstrated a hydraulic connection between the shallow flowpaths intercepted by well GW-153 and the deeper (157 to 438 ft bgs) flowpaths intercepted by well GW-845. The CY 1998 results for well GW-153 are consistent with historical data and show that carbon tetrachloride is the principal component of the dissolved VOC plume in the groundwater at the well, and that the maximum concentrations of carbon tetrachloride (270 µg/L) and PCE (7 µg/L) remain above the respective MCL.

As noted in Section 2.3, Aquifer well GW-845 was installed to serve as the pumping well for the stepped pump test performed in July 1998. The location of the well was selected such that it was along the strike-parallel axis of the dissolved plume of chloromethanes and chloroethenes in the Maynardville Limestone and downgradient of the suspected carbon tetrachloride DNAPL west of New Hope Pond. The total depth (438 ft bgs) and length of the open-hole interval (281 ft) were selected to ensure that suspected primary transport zones in the Maynardville Limestone were intercepted. Results of baseline sampling performed in May 1998 confirmed that the well intercepted the carbon tetrachloride (1600 µg/L) dominated plume of dissolved VOCs in the intermediate and deep groundwater intervals. Also, samples obtained during the pump test contained substantially lower VOC concentrations relative to the baseline sampling results, with relatively asymptotic levels evident during the last two days of the 100 gpm pumping rate (SAIC 1998).

3.1.3.3 Radioactivity

Historical monitoring data do not indicate widespread radiological contamination in the eastern plant area. Results for the network of Surveillance Monitoring wells sampled during CY 1998 are consistent with these historical findings; gross alpha and gross beta results reported for all of the Surveillance Monitoring wells except GW-605 and GW-606 are less than the corresponding MDA and, as shown in the following summary, only the gross alpha results for well GW-605 exceed the 15 pCi/L MCL.

Well	Date Sampled	Gross Alpha (pCi/L)		Gross Beta (pCi/L)	
		MDA	Activity ± Counting Error	MDA	Activity ± Counting Error
GW-605	02/08/98	3.2	**130 ± 15**	14	35 ± 6.4
	03/12/98	3.3	**29 ± 7.1**	8	<MDA
GW-606	07/27/98	1	5 ± 2.7	13	<MDA
Note: Bold = Activity exceeds MCL.					

As noted in Section 3.1.3.1, Aquifer well GW-605 monitors a distinctive plume of radiological contamination in the Maynardville Limestone that originates from an unidentified but presumably nearby source area (U.S. Department of Energy 1998). Historical data for this well show that alpha (and beta) radioactivity is from uranium isotopes (^{234}U and ^{238}U). These isotopes probably occur as uranyl cations, which are prone to pH-sensitive sorption reactions and consequently are not usually highly mobile in groundwater (Fetter 1993), further indicating that the source of the uranium isotopes is probably not far from the well. The March 1998 gross alpha result (130 ± 15 pCi/L) continues an increasing long-term trend (see Section 3.3), but the July 1998 gross alpha result (29 ± 7.1 pCi/L) is the lowest level reported since the well was first sampled in August 1991 (47 pCi/L). As noted in Section 3.1.3.1, a similarly sharp decrease in total (and dissolved) uranium concentrations also is indicated by the July 1998 sampling results for well GW-605. Additionally, as noted in Section 3.1.3.1, dilution from increased flux of recharge from UEFPC in response to the pumping test (well GW-845) which ended nine days before the July sample was collected may have resulted in the unusually low total uranium and gross alpha activity.

3.2 Exit Pathway/Perimeter Monitoring Evaluation

The CY 1998 monitoring results reported for a surface water sampling station (LRSPW) and 10 wells in the eastern plant area were evaluated for the purposes of Exit Pathway/Perimeter Monitoring at the Y-12 Plant. The LRSPW discharges into the mainstem of UEFPC directly north of Lake Reality about 1000 ft upstream of Bear Creek Road (Figure 6). All of the wells are hydraulically downgradient to the north/northeast or east/southeast of New Hope Pond/Lake Reality, and all but one of the wells (GW-220) are located within 500 ft of the ORR boundary along Scarboro Road (Figure 6).

The LRSPW and all of the monitoring wells were sampled semiannually during CY 1998 (Table 2). The low-flow sampling procedure described in Section 3.1 was used to obtain samples from all of the wells except GW-722, which was sampled in accordance with the operating instructions for the dedicated multi-port sampling equipment (Westbay™) in the well. Samples from each of the wells and the LRSPW were analyzed for inorganics (major ions and trace metals), VOCs, and selected radioanalytes (Table 3). These analytical results, along with historical data for each sampling location, serve as the basis for the following evaluation of surface water and groundwater quality where contaminants from the Y-12 Plant are most likely to migrate beyond the ORR property line.

As shown in the following summary, contaminants originating from sources within the Y-12 Plant were detected in samples collected during CY 1998 from the LRSPW (uranium, PCE, carbon tetrachloride, and chloroform) and the groundwater samples from three wells that were used for Exit Pathway/Perimeter Monitoring during CY 1998: Aquifer wells GW-220 (PCE, TCE, cis-1,2-DCE, carbon tetrachloride, and chloroform), GW-722 (nitrate, PCE, TCE, cis-1,2-DCE, 1,1-DCE, vinyl chloride, carbon tetrachloride, chloroform, 1,1,1-TCA, 1,1-DCA, benzene, ethylbenzene, toluene, dimethylbenzene, and styrene), and GW-733 (PCE, carbon tetrachloride, and chloroform).

Exit Pathway/ Perimeter Monitoring Sampling Location	Hydrogeologic Unit and Monitored Interval Depth (ft bgs)		Contaminant Type		
	Aquitard	Aquifer	Inorganics	VOCs	Radioactivity
GW-207	100.0 - 109.6	. . .	.	.	.
GW-208	404.0 - 412.8	. . .	.	.	.
GW-220	. . .	31.0 - 45.2	.	●	.
GW-722	. . .	95.0 - 562.6	●	●	.
GW-733	. . .	240.1 - 256.5	.	●	.
GW-735	67.5 - 79.2	. . .	.	.	.
GW-744	55.0 - 69.5	. . .	.	.	.
GW-747	67.4 - 79.6	. . .	.	.	.
GW-750	61.2 - 72.7	. . .	.	.	.
GW-816	2.9 - 15.8	. . .	.	.	.
LRSPW	Surface Water		●	●	.

Dissolved VOCs in the shallow groundwater at well GW-220 originate from one or more of the source areas within the Y-12 Plant, and the concentration and distribution of these VOCs was

substantially influenced by the closure of New Hope Pond and the construction/operation of Lake Reality. Wells GW-722 and GW-733 monitor the carbon tetrachloride dominated plume of dissolved VOCs in the Maynardville Limestone that originates upgradient (west) of wells GW-605 and GW-606 (see Section 3.1.3.3) and extends along geologic strike into Union Valley east of the ORR boundary along Scarboro Road (Figure 5). Elevated uranium concentrations in the surface water samples from the LRSPW also suggest relatively low-level contamination from one or more sources within the eastern and central plant areas.

Aquifer well GW-220 yields calcium-magnesium-bicarbonate groundwater from the shallow bedrock interval in the lower Maynardville Limestone about 200 ft east (downgradient) of New Hope Pond/Lake Reality (Figure 6). Historical data show that the groundwater in the well contains a mixture of dissolved chloroethenes (primarily PCE) and chloromethanes (primarily carbon tetrachloride). The VOC results reported for the groundwater samples collected from the well during CY 1998 are consistent with historical data and show that the maximum concentrations of PCE (53 µg/L), TCE (13 µg/L), and carbon tetrachloride (600 µg/L) remain above respective MCLs. Additionally, the CY 1998 results for well GW-220 continue the increasing PCE and carbon tetrachloride concentration trends evident since these compounds were initially detected in the well (see Section 3.3).

Aquifer well GW-722 is located about 1,000 ft east (downgradient) of New Hope Pond/Lake Reality approximately 500 ft west (upgradient) of the ORR boundary (Figure 6). This well is completed with a 500 ft open-hole interval in the Maynardville Limestone and, as noted previously, is equipped with a dedicated multi-port sampling system that enables collection of discrete groundwater samples from multiple depths within the open-hole interval. In CY 1998, samples were collected from 10 sampling ports (numbered in ascending order from deepest to shallowest) ranging in depth from 90 to about 563 ft bgs (Table 2). As shown in the following summary, groundwater samples from several of the sampling ports contained a variety of dissolved VOCs, with the highest summed concentrations (>500 µg/L) evident in sampling ports 14, 17, 20, and 22 (i.e., between 300 ft and 450 ft bgs) and the lowest summed VOC concentrations (<5 µg/L) evident in the deepest (port 06) and shallowest (ports 30, 32, and 33) sampling ports in the well.

Sampling Port No. and Depth (ft bgs)		CY 1998 Maximum Summed Concentration (µg/L)				
		Chloroethenes	Chloromethanes	Chloroethanes	Petroleum Hydrocarbons	Misc. Compounds
33	90	(2)	(3)	.	(1)	(1)
32	110	.	(2)	.	.	.
30	153.9	.	(1)	.	.	(2)
26	218.9	.	(1)	.	12	32
22	315.8	60	718	(4)	.	15
20	335.8	93	686	7	.	16
17	387.7	100	1151	7	.	13
14	427.7	77	1018	(5)	.	22
10	502.6	14	112	.	.	(8)
06	562.6	.	.	.	(1)	

Note: ( ) = Estimated concentration below analytical reporting limit.

Excluding false-positive results, compounds detected in at least one sample collected from these sampling ports include PCE, TCE, cis-1,2-DCE, 1,1-DCE, carbon tetrachloride, chloroform, 1,1,1-TCA, 1,1-DCA, benzene, ethylbenzene, dimethylbenzene, toluene, acetone, acrylonitrile, 2-butanone, carbon disulfide, styrene, and trichloroflouromethane. As shown in the following summary, maximum concentrations of PCE, TCE, and carbon tetrachloride remain above respective MCLs.

Sampling Port	CY 1998 Maximum Concentration and MCL (µg/L)		
	PCE	TCE	Carbon Tetrachloride
22	**47**	**6**	**680**
20	**71**	**9**	**630**
17	**75**	**10**	**1100**
14	**59**	**8**	**970**
10	**10**	(2)	**86**
MCL	5	5	5
Note: "." = Not Detected; ( ) = Estimated concentration; Bold = Exceeds MCL.			

These results show that the sampling ports in well GW-722 intercept some of the primary strike-parallel migration pathways for the carbon tetrachloride plume that originates upgradient (west) of wells GW-605 and GW-606 and extends along strike beneath New Hope Pond into Union Valley east of the ORR boundary (Figure 5). As noted in the brief description of the pump test performed in July 1998 (see Section 2.3), GW-722 was included in a group of wells that exhibited rapid and significant water-level responses to initial pumping and stepped changes in discharge rates, indicating a high degree of hydraulic connection with the pumping well (GW-845), which is located about 750 ft east (along geologic strike) of GW-722 (Figure 6). Moreover, water level elevations in well GW-722 were nearly equal to those in the pumping well throughout the stepped pumping test, which may be an indication of partial dewatering or low storage capacity of the aquifer (SAIC 1998).

Along with the highest summed VOC concentrations in well GW-722, groundwater samples from sampling ports 14, 17, 20, and 22 are also distinguished by elevated nitrate concentrations; results for each of the samples collected from these ports during CY 1998 show nitrate concentrations above 2 mg/L, with the highest levels reported for samples collected in February 1998 (i.e., seasonally high flow) from ports 14 (3.09 mg/L in) and 17 (3.36 mg/L). Although these nitrate concentrations do not exceed the MCL (10 mg/L), they are at least an order-of-magnitude higher than background levels in the Maynardville Limestone (e.g., <0.028 mg/L in sampling port 33). As noted in Section 2.4, elevated nitrate concentrations in the East Fork Regime are believed to reflect migration from the contaminant plume emplaced in the western plant area during operation of the former S-3 Ponds and/or the S-2 Site.

In addition to dissolved chlorinated solvents, the groundwater samples collected during CY 1998 from sampling ports 26 and 33 in well GW-722 contained acrylonitrile concentrations ranging from 1 µg/L (port 33) to 32 µg/L (port 26). Samples collected from ports 06, 20, 26, and 30 during CY 1997 also contained this compound. Acrylonitrile has been detected (20 - 32 µg/L) in all samples collecting during both years from port 26. According to the manufacturer, the Westbay™ sampling

system contains several components made with acrylonitrile, and detection of this compound is often an artifact from sampling ports in low permeability zones (Westbay Instruments, Inc. 1999). Detection of acrylonitrile in the groundwater from these sampling ports in well GW-722 (particularly the high concentrations in the samples from sampling port 26) suggests that they monitor low-permeability intervals in the Maynardville Limestone. Conversely, sampling ports that continue to yield samples which do not contain acrylonitrile may indicate that they monitor comparably more permeable intervals.

The persistent detection of dissolved petroleum hydrocarbons in the groundwater from sampling port 26 is another conspicuous characteristic of the VOC data for well GW-722. Trace levels (2 - 5 μg/L) of benzene, dimethylbenzene, ethylbenzene and an associated biodegradation product (styrene), and toluene were detected in the groundwater samples collected from the port during CY 1998. These petroleum hydrocarbons (and styrene) also were detected in the samples collected from this port during CY 1997. It is difficult to explain the presence of dissolved petroleum hydrocarbons in the groundwater from sampling port 26 considering: (1) the depth of the port in well GW-722 (about 219 ft bgs); (2) the distance to well GW-722 from known sources of petroleum hydrocarbons (e.g., Tank 2331-U in the central plant area) and the substantial attenuation that would be expected during transport from the source area(s); (3) the general lack of chloroethenes and chloromethanes in samples from this port (i.e., the primary VOCs in groundwater from deeper sampling ports in the well); (4) the low permeability of the monitored interval potentially indicated by the consistent detection of acrylonitrile in the samples from the port; and (5) the overall lack of petroleum hydrocarbons in other shallow and intermediate depth Maynardville Limestone wells upgradient to the west (along geologic strike) of New Hope Pond.

Aquifer well GW-733 is located southeast (across geologic strike) of well GW-722 about 500 ft west of the ORR property boundary along Scarboro Road (Figure 6). Historical data show that this well yields calcium-magnesium-bicarbonate groundwater from the upper Maynardville Limestone that sporadically contains trace levels (<5 μg/L) of dissolved chloroethenes (primarily PCE) along with much higher (<100 μg/L) but generally decreasing concentrations of dissolved chloromethanes (primarily carbon tetrachloride). The CY 1998 results for well GW-733 are consistent with these historical findings and continue the decreasing VOC concentration trends evident since the mid 1990s. For example, carbon tetrachloride concentrations decreased almost 90% between November 1993 (87 μg/L) and July 1998 (11 μg/L). Decreasing VOC concentrations in well GW-733 may be primarily attributable to hydrologic attenuation mechanisms (e.g., dilution and dispersion) because the consistently low proportions of chloroform relative to carbon tetrachloride (and infrequent detection of PCE degradation products) suggest minimal biotic and/or abiotic degradation in the groundwater.

Total uranium concentrations reported for the unfiltered surface water samples collected from the LRSPW during CY 1998 range from slightly below (0.0197 mg/L) to slightly above (0.0335 mg/L) the proposed MCL for uranium (0.02 mg/L) and dissolved uranium concentrations in the corresponding filtered samples (0.0206 and 0.0326 mg/L) exceed the proposed MCL. In addition to elevated uranium concentrations, elevated nitrate and total mercury concentrations also were reported for the samples collected from LRSPW during the CY 1998. The nitrate concentration in the sample collected in December 1998 (4.84 mg/L) was the highest level reported for LRSPW since it was first sampled in September 1994. Total mercury was detected in the September 1994 sample

from LRSPW (0.00035 mg/L), but was not detected again until CY 1998 when low concentrations were reported for both the June (0.0003 mg/L) and December (0.000521 mg/L) 1998 samples. These concentrations are nearly an order of magnitude less than the 0.002 mg/L MCL for mercury.

In addition to elevated uranium concentrations, the sample collected in June 1998 from LRSPW had carbon tetrachloride concentration (16 µg/L) that exceeded the 5 µg/L MCL. Carbon tetrachloride ranged from 12 to 29 µg/L in samples collected from September 1994 to September 1996. Since September 1996, carbon tetrachloride was not detected in any samples except the June 1998 sample.

3.3 Contaminant Concentration Trends

Monitoring data obtained since the late 1980s and early 1990s show indeterminant or generally decreasing long-term contaminant concentration trends for the majority of sampling locations in the East Fork Regime, including most of the CY 1998 sampling locations in the western, central, and eastern plant areas (Table 5). Indeterminant trends occur at monitoring locations where insufficient data are available, the trend is fairly stable, or concentrations fluctuate with no apparent linear trend over time. The decreasing concentration trends probably reflect a combination of several factors, including compliance with waste management regulations, waste minimization and source control measures, remedial actions, natural attenuation mechanisms, and, in some cases, changes in sampling procedures and analytical methods. For the purposes of DOE Order 5400.1A requirements, the following discussion is focused on CY 1998 sampling locations that clearly exhibit increasing long-term contaminant concentration trends.

As shown in the following summary, increasing long-term contaminant concentration trends are indicated by the monitoring data for 11 of the CY 1998 sampling locations in the East Fork Regime, including one well in the western plant area, five wells in the central plant area, and four wells and the LRSPW in the eastern plant area.

CY 1998 Sampling Location	Increasing Long-Term Concentration Trends			Figure Number
	Inorganics	VOCs	Radioactivity	
Western Plant Area				
GW-108	.	.	●	9
Central Plant Area				
GW-769	.	●	.	10
GW-770	.	●	.	10
GW-782	.	●	●	11
GW-789	.	●	.	12
GW-792	●	.	.	13
Eastern Plant Area				
GW-148	.	●	.	14
GW-220	.	●	.	14
GW-383	.	●	.	14
GW-605	●	.	●	15
LRSPW	●	.	.	16

Results for each of these sampling locations are described in the following discussion.

Monitoring results for well GW-108 show that ^{99}Tc activities increased more than 500% between March 1988 (4444 pCi/L) and July 1998 (23,000 ± 85 pCi/L) (Figure 9). As noted in Section 2.3, available data indicate that ^{99}Tc and nitrate share similar transport characteristics and migration patterns in the East Fork Regime. In contrast to ^{99}Tc levels, however, nitrate concentrations have decreased over the past 10 years (Figure 9). These divergent long-term concentration trends possibly reflect corresponding differences related to the history of waste disposal in the former S-3 Ponds. Assuming the decreasing nitrate trend indicates that the center of mass of the nitrate plume emplaced during routine operation of the S-3 Ponds has already migrated to the east of well GW-108, then the increasing ^{99}Tc trend may indicate similar strike-parallel migration of a "pulse" of ^{99}Tc from one or more of the periodic disposals of ^{99}Tc wastes in the S-3 Ponds (AJA Technical Services, Inc. 1999b).

Monitoring results for Aquitard wells GW-769 and GW-770 show that summed VOC concentrations in these wells have steadily increased over the past two years (Figure 10). Presampling groundwater elevations and summed VOC concentrations in well GW-770 show frequently concurrent seasonal fluctuations, with sharply decreasing trends evident between November 1995 and October 1996 followed by steadily increasing water level elevations and summed VOC concentrations through November 1998. Data for well GW-769 show a less direct correlation between water level elevations and summed VOC concentrations, which steadily increased to a peak of 38 µg/L in November 1995 before dropping below 10 µg/L in May 1997 (5 µg/L). However, the subsequently increasing summed VOC concentration trend through November 1998 (23 µg/L) is mirrored by a groundwater elevation increase of almost 3.5 ft in the well. The higher summed VOC concentrations in well GW-769 relative to well GW-770 and the strongly upward vertical hydraulic gradients evident during seasonally high and low groundwater flow conditions, suggest migration of dissolved VOCs from deeper (GW-769) to shallower (GW-770) groundwater flowpaths in the Nolichucky Shale.

Monitoring results for Aquitard well GW-782 show increasing concentrations of VOCs (Figure 11). As noted in Section 3.1.2.2, this well monitors a plume of dissolved VOCs containing a mixture of chloroethenes and chloroethanes, including parent compounds (PCE and 1,1,1-TCA), intermediate degradation products (TCE, cis-1,2-DCE, 1,1-DCE, and 1,1-DCA), and end degradation products (vinyl chloride and chloroethane). Concentrations of parent compounds and intermediate degradation products have increased slightly, whereas the concentrations of end degradation products have more clearly increased since the mid 1990s. For instance, vinyl chloride was detected in all five of the groundwater samples collected from the well between November 1996 (5 µg/L) and November 1998 (4 µg/L), but was detected in only three of the nine samples collected between June 1994 (1 µg/L) and May 1996 (not detected). Increasing concentrations of vinyl chloride and chloroethane suggest biotic degradation of PCE and 1,1,1-TCA (and/or abiotic degradation of 1,1,1-TCA).

Monitoring results for Aquitard well GW-782 also show fluctuating but clearly increasing gross alpha activity in the groundwater at the well (Figure 11). As noted in Section 3.1.2.3, the overall lack of gross alpha activity in the shallower (GW-783) and deeper (GW-781) wells clustered with GW-782 indicate stratabound migration of alpha-emitting isotopes, particularly considering the upward vertical hydraulic gradients indicated by presampling groundwater elevations in these wells (Figure 11). Increasing gross alpha activity in the groundwater at well GW-782 indicates increased flux of radiological contaminants in the strike-parallel flowpaths intercepted by the well.

Monitoring results for Aquitard well GW-789 show that summed VOC concentrations have increased fairly steadily since the well was first sampled in June 1994 (Figure 12). However, because the VOC concentrations are very low (most results are estimated values below the respective analytical detection limit), it is possible that the increasing trend is a sampling artifact. If the trend is verified by subsequent sampling results, the strongly upward veritical hydraulic gradients indicated by presampling groundwater elevations in well GW-788 and GW-789 (Figure 12) and the fact that chlorinated solvents have never been detected in samples from deeper well GW-788 suggest stratabound migration of dissolved VOCs along strike from the west or shallow cross-strike transport along buried tributary BT-7 (Figure 3).

Monitoring results for Aquitard well GW-792 show that total and dissolved nickel concentrations increased from slightly above the analytical detection limit (0.01 mg/L) in November 1996 to just below the 0.1 mg/L MCL in November 1998 (Figure 13). As noted in Section 3.1.2.1, MIC of the stainless steel well casing and screen may explain the presense of nickel in the well, which was not detected in any of the filtered or unfiltered samples collected from the well between June 1994 and May 1996. Monitoring results also show that presampling groundwater elevations increased almost 3 ft between August 1995 (965.23 ft above msl) and March 1996 (968.14 ft above msl), and that chloride concentrations increased from less than 5 mg/L in August 1995 to more than 40 mg/L in November 1998 (Figure 13).

Monitoring results for Aquifer well GW-148 show that concentrations of 1,2-DCE steadily increased from undetected results through January 1990, to an estimated value (i.e., less than the analytical detection limit) of 3 µg/L in November 1994, to 13 µg/L in December 1998 (Figure 14). If the increasing concentration trend continues at the rate indicated by historical data, which show that the 1,2-DCE levels have increased 10 µg/L over the past 4 years, the projected cis-1,2-DCE concentrations in well GW-148 would not be expected to exceed the MCL (70 µg/L) for about 20 years.

Monitoring results for Aquifer well GW-220 show clearly increasing concentrations of dissolved chloromethanes and chloroethenes. For example, carbon tetrachloride and PCE concentrations steadily increased following their initial detection in August 1988 (5 µg/L) and October 1988 (2 µg/L), respectively, (Figure 14). Additionally, the concentrations of these compounds are typically highest during seasonally high flow, with particularly sharp concentration increases evident between May 1994 and February 1995. The detection of these VOCs and the subsequent increasing concentration trends are believed to be a direct result of reduced recharge following closure of New Hope Pond and the strong local hydrologic influence of the UEFPC distribution channel underdrain installed during construction of Lake Reality (U.S. Department of Energy 1998).

As illustrated by data for PCE, the monitoring results for Aquifer well GW-383 show widely fluctuating but generally increasing concentrations of dissolved chloroethenes (Figure 14). Increasing concentrations of chloroethenes in the groundwater at this well potentially reflect increasing northward migration toward the former channel of UEFPC (U.S. Department of Energy 1998). In contrast, dissolved chloromethane concentrations in well GW-383 have decreased substantially. For instance, carbon tetrachloride concentrations decreased from more than 20 µg/L in the early 1990s to less than the analytical detection limit (5 µg/L) in December 1998. The decreasing concentrations of carbon tetrachloride may be caused by an artificial hydraulic gradient

created by the UEFPC underdrain system that induces inflow of shallow groundwater in the Maynardville Limestone south and east of New Hope Pond (U.S. Department of Energy 1998).

Aside from the unusually low concentrations in July 1998, historical data for well GW-605 show that elemental uranium concentrations (total and dissolved) and gross alpha activity have generally increased since the early 1990s (Figure 15). Total uranium concentrations, for instance, increased from about 0.1 mg/L in August 1991 to about 0.25 mg/L in September 1994, decreased to less than 0.15 mg/L in February 1996, and subseqently increased to the highest level reported for the well (0.33 mg/L) in March 1998. Although results for gross alpha activity more clearly show an increasing trend, a fluctuating pattern similar to the uranium concentrations also is evident (Figure 15). Gross alpha activity increased from less than 50 pCi/L in August 1991 to almost 130 pCi/L in September 1994, then decreased below 100 pCi/L through February 1996 before again increasing through March 1998 (130 ± 15 pCi/L). As noted previously, however, the July 1998 results for total uranium (0.464 mg/l) and gross alpha (29 ± 7.1 pCi/L) reflect the lowest respective levels evident since the well was first sampled and potentially reflect the influence of the stepped pumping test (i.e., dilution via increased inflow of groundwater in response to pumping may have reduced uranium and gross alpha concentrations relative to respective levels evident before July 1998). In contrast, chloroethene concentrations (especially 1,2-DCE) showed a substantial increase in the July 1998 sample (Figure 15), which suggests that the shallow groundwater that diluted the uranium and gross alpha concentrations was contaminated with VOCs.

Monitoring results for samples collected from the LRSPW show that uranium concentrations and nitrate levels have generally increased since the mid-1990s (Figure 16). Increasing concentrations of these contaminants may be related to flow management in UEFPC, which began in July 1996 (see Section 2.3), as well as efforts to bypass Lake Reality; in July 1997, flow in UEFPC began to be discharged directly into UEFPC via the LRSPW.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Groundwater and surface water quality data obtained during CY 1998 are generally consistent with previous monitoring results showing that VOCs, nitrate and other inorganics (e.g., chloride), and radioactivity are the primary groundwater contaminants in the East Fork Regime. The bulk of the results for the network of monitoring wells sampled during CY 1998 are consistent with historical data with respect to the types of contaminants detected, the concentrations of the contaminants, and long-term increasing or decreasing contaminant concentration trends. A summary of significant findings based on evaluation of these CY 1998 results for the purposes of DOE Order 5400.1A is provided below.

4.1 Surveillance Monitoring

The CY 1998 monitoring results reported for 38 monitoring wells were evaluated for the purposes of Surveillance Monitoring in the East Fork Regime. Evaluation of the monitoring data for these wells shows the following new or significant findings.

- The CY 1998 VOC results for the duplicate samples collected from well GW-332 at the WCPA, which is one of the primary sources of VOCs in the western plant area, show that the concentrations of parent compounds (e.g., PCE), intermediate degradation products (e.g., TCE), and end degradation products (e.g., vinyl chloride) have decreased substantially since the well was last sampled during CY 1991, although maximum summed VOC concentrations remain above 2000 µg/L and the concentration of several compounds exceed applicable MCLs.

- The CY 1998 monitoring results for Aquifer wells GW-686 and GW-687 in the central plant area suggest that the coal stockpile overlying the Coal Pile Trench is a significant local source of sulfate in the shallow groundwater in the Maynardville Limestone.

- Elevated concentrations of nickel and/or chromium reported for the groundwater samples collected from several wells in the central plant area (59-1A, 59-1B, GW-776, GW-783, and GW-792) and well GW-380 in the eastern plant area potentially reflect MIC of the stainless steel well casing and screen rather than migration from potential contaminant source areas.

- The very high total and dissolved uranium levels indicated by the CY 1998 monitoring results for Aquifer well GW-219 and the presence of uranium isotopes in the groundwater at the well suggest that the Uranium Oxide Vault may be a significant source of uranium contamination.

- The CY 1998 monitoring results for Aquitard wells 56-2A, 56-2B, and 56-2C, which comprise a well cluster in the upper Nolichucky Shale near the southwest corner of Building 9201-4 in the central plant area, show that summed VOC concentrations increase with depth from less than 100 µg/L in well 56-2A (15 ft bgs) to almost 1000 µg/L in well 56-2B (39 ft bgs) and about 2000 µg/L in well 56-2C (77 ft bgs). Presampling groundwater elevations in these wells indicate an upward hydraulic gradient from the deeper bedrock to the shallow bedrock (0.015 between 56-2C and 56-2B) and a downward vertical gradient from the water

table to the shallow bedrock (0.014 between 56-2A and 56-2B). These gradients suggest that chloroethene concentrations in the shallower groundwater at wells 56-2A and 56-2B may at least partially reflect upward migration from the deeper flow system, where the PCE concentration in well 56-2C (1400 µg/L) suggests the presence of DNAPL.

- Monitoring results obtained during CY 1998 show that Aquifer well GW-820 clearly monitors a plume of dissolved chloroethenes in the groundwater near Building 9201-2, although there are significant differences between the concentrations of PCE and 1,2-DCE obtained during the CY 1998 RI and GWPP sampling events. However, if future sampling confirms the March 1998 PCE concentration, which exceeds 1% of pure-phase solubility (1500 µg/L), DNAPL is probably present in the subsurface near the western (upgradient) end of Building 9201-2.

4.2 Exit Pathway/Perimeter Monitoring

The CY 1998 monitoring results reported for a surface water sampling station in the LRSPW and 10 wells in the eastern plant area were evaluated for the Exit Pathway/Perimeter Monitoring purposes of DOE Order 5400.1A. Contaminants originating from sources within the Y-12 Plant were detected in samples collected during CY 1998 from the LRSPW (nitrate and uranium) and the groundwater samples from Aquifer well GW-220 (PCE, TCE, cis-1,2-DCE, carbon tetrachloride, and chloroform), Aquifer well GW-722 (PCE, TCE, cis-1,2-DCE, 1,1-DCE, vinyl chloride, carbon tetrachloride, chloroform, 1,1,1-TCA, 1,1-DCA, benzene, ethylbenzene, toluene, dimethylbenzene, and styrene), and Aquifer well GW-733 (PCE, carbon tetrachloride, and chloroform). Results for these wells are consistent with respective historical data and show:

- Dissolved chloroethene and chloromethane concentrations in the shallow groundwater at well GW-220 continue to be influenced by the UEFPC distribution channel underdrain and leakage from Lake Reality.

- Dissolved chloromethane concentrations in the groundwater collected from several of the sampling ports at depths from about 300 to 450 ft bgs in well GW-722 remain above 1000 µg/L.

- According to the manufacturer, the Westbay™ sampling system in well GW-722 contains several components made with acrylonitrile, and detection of this compound is often an artifact from sampling ports in low permeability zones (e.g., port 26).

- Dissolved chloromethane concentrations in well GW-733 have generally decreased over the past several years but nonetheless reflect continued strike-parallel migration in the Maynardville Limestone toward Union Valley east of the ORR property boundary.

4.3 Contaminant Concentration Trends

Increasing long-term contaminant concentration trends are indicated by the monitoring data for 11 of the CY 1998 sampling locations in the East Fork Regime, including one well in the western plant area (GW-108), five wells in the central plant area (GW-769, GW-770, GW-782, GW-789, and

GW-792), and four wells (GW-148, GW-220, GW-383, and GW-605) and the LRSPW in the eastern plant area. For the most part, the increasing contaminant concentrations reflect the hydrochemical dynamics within the groundwater contaminant plumes. Monitoring results for the remaining CY 1998 sampling locations generally continue the decreasing contaminant concentration trends evident since the late 1980s and early 1990s and probably reflect a combination of several factors, including compliance with waste management regulations, waste minimization and source control measures, remedial actions, natural attentuation mechanisms, and, in some cases, changes in sampling procedures and analytical methods.

4.4 Recommendations

Based on evaluation of the CY 1998 groundwater monitoring data, the following actions are recommended:

- Groundwater monitoring activities in the East Fork Regime should be focused on bedrock interval sampling locations within the Eastern Plant Area, the exit-pathway for groundwater contaminants in the regime. The following modifications should be made to the CY 1999 monitoring location network:

Modification/ Plant Area	Sampling Point	Rationale	
Drop from Network: Western	GW-618	Decreasing Contaminants	
Central	GW-775	Flat trend, low VOCs	
	GW-776	Flat trend, low VOCs	
	GW-778	Flat trend, low VOCs	
	GW-781	Decreasing Contaminants	
	GW-783	Decreasing Contaminants	
	GW-792	Decreasing Contaminants	
Eastern	GW-148	Shallow, low Contaminants	
	GW-207*	Artesian, no Contaminants	
	GW-208*	Artesian, no Contaminants	
	GW-380	Shallow, low Contaminants	
	GW-735*	Shallow, no Contaminants	
	GW-763	Shallow, low Contaminants	
Add to Network: Eastern		Last Sampled	Summed VOCs
	GW-150*	Mar 88	< 1 µg/L
	GW-151*	Nov 96	871 µg/L
	GW-240	Nov 96	20 µg/L
	GW-381	May 95	4,100 µg/L
	GW-382	May 95	4,900 µg/L
Note: * = Exit Pathway/Perimeter Monitoring well.			

A standardized Exit Pathway/Perimeter Monitoring network should be established which provides the best coverage of areas where contaminants are most likely to migrate beyond the ORR boundary.

- Annual Surveillance Monitoring should be augmented by triennial sampling of a standardized network of internal plume wells. Data from these wells will be used to determine/confirm long-term contaminant concentration trends near source areas and along migration pathways. Samples should be collected semiannually (wet and dry season) from each location, and CY 2000 could be the initial sampling year. The following wells are candidates for the triennial monitoring network:

Plant Area	Sampling Point	Contaminants of Concern		
		Inorganic	Organic	Radiologic
Western	55-2C	●	●	
	GW-109	●	●	●
	GW-253	●	●	●
	GW-274	●	●	●
	GW-337		●	
	GW-633	●	●	●
Central	GW-204	●		●
	GW-219	●		●
	GW-656		●	
	GW-690	●	●	●
	GW-700	●	●	
	GW-820		●	
	56-2C		●	
Eastern	GW-154	●	●	●
	GW-222	●	●	●
	GW-223	●	●	●
	GW-762		●	

- Collection of filtered samples could be discontinued at monitoring wells where the low-flow sampling method is used. Analytical results for the filtered samples are used primarily to qualify (discount) the corresponding trace metal results for turbid unfiltered samples. As shown in the following data summary, the general occurrence and concentration of suspended solids in samples decreased significantly with the change from conventional sampling to low-flow sampling.

	Results for Suspended Solids		
	Percent Detected	Mean (mg/L)	Maximum (mg/L)
Conventional Method (280 samples) January - September 1997	65	50.5	2,750
Low-flow Method (407 samples) October 1997 - December 1998	48	12.2	391

Because the low-flow sampling method results in the collection of fewer turbid unfiltered samples, the dissolved concentrations reported for filtered samples generally correspond with the total concentrations reported for unfiltered samples. The concentration of suspended solids, turbidity, and commonly associated trace metal artifacts (e.g., aluminum, iron) should provide ample data to qualify other trace metal results.

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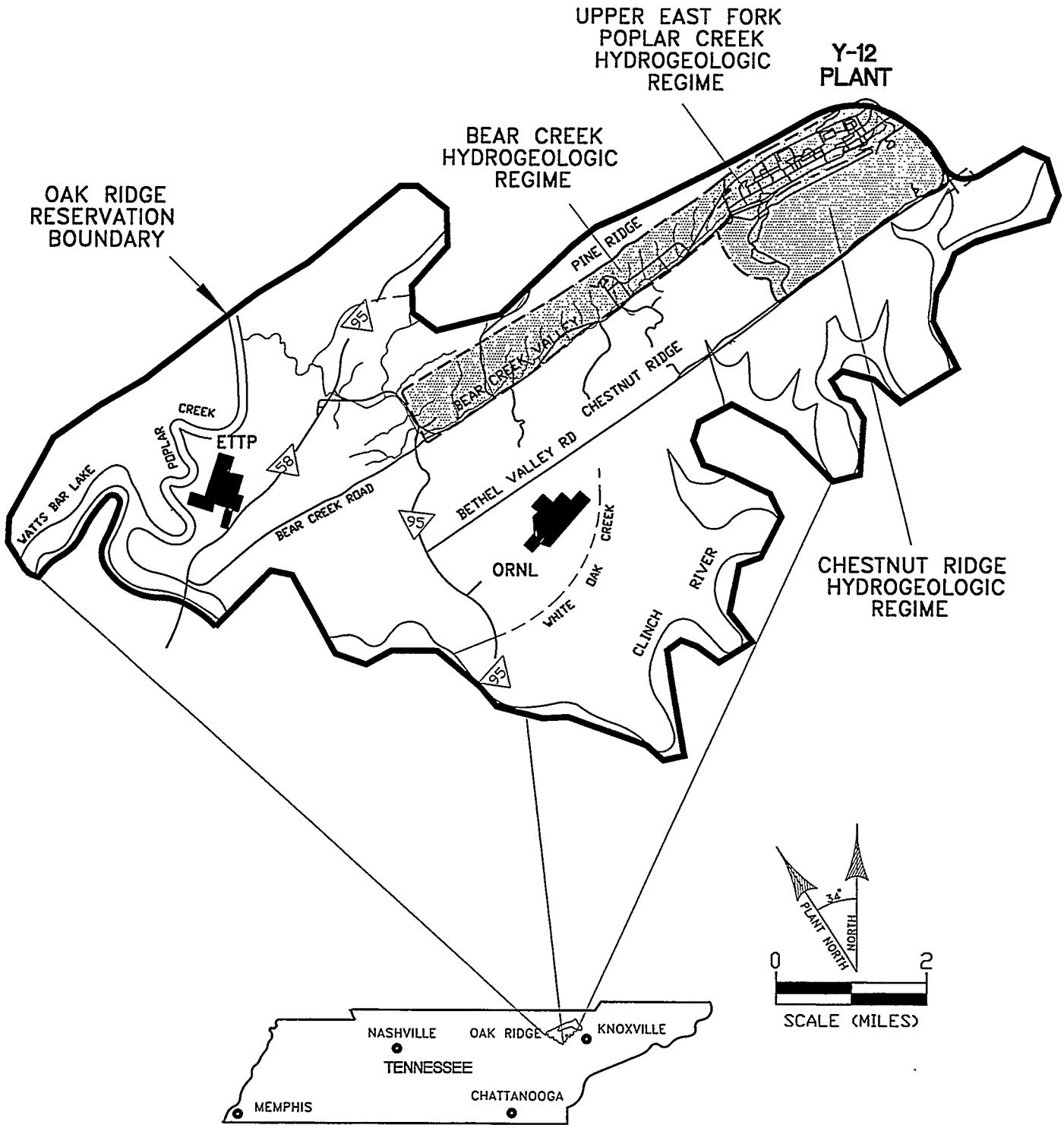
APPENDIX A

FIGURES



97-007 7/7/99

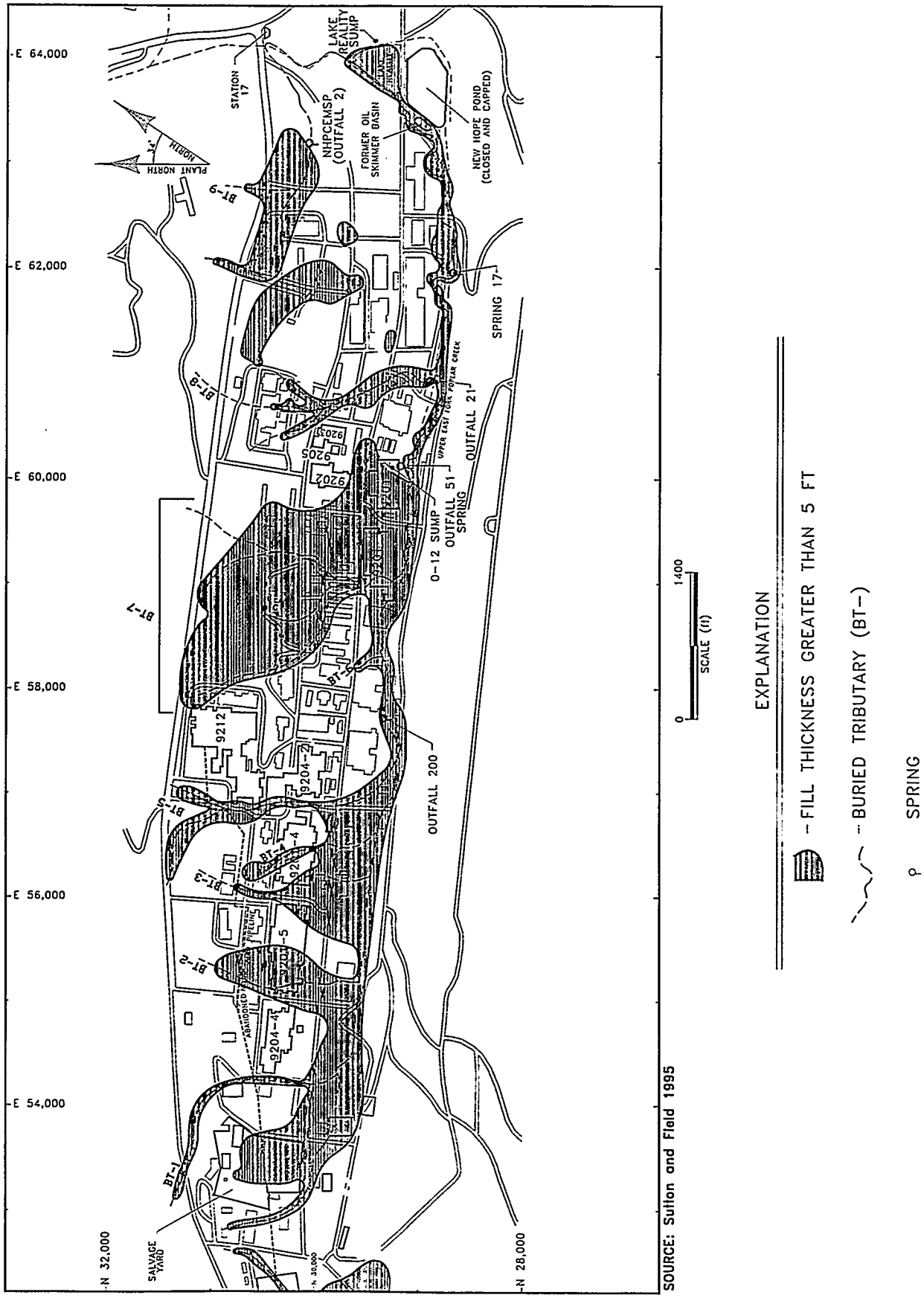
Fig. 1. Hydrogeologic regimes at the Y-12 Plant.

SOURCE: King and Haase, 1987

SYSTEM	GROUP	HYDRO UNIT	FORMATION	MAP SYMBOL	THICKNESS (ft)
CAMBRIAN	UPPER	AQUIFER	COPPER RIDGE DOLOMITE	Ock	NOT DETERMINED
		AQUITARD	MAYNARDVILLE LIMESTONE	Cmn	418–450
	MIDDLE		NOLICHUCKY SHALE	Cn	422–550
			MARYVILLE LIMESTONE	Cm	346–445
	LOWER		ROGERSVILLE SHALE	Crg	90–120
			RUTLEDGE LIMESTONE	Crl	90–120
			PUMPKIN VALLEY SHALE	Cpv	260–320
			ROME FORMATION	Cr	NOT DETERMINED

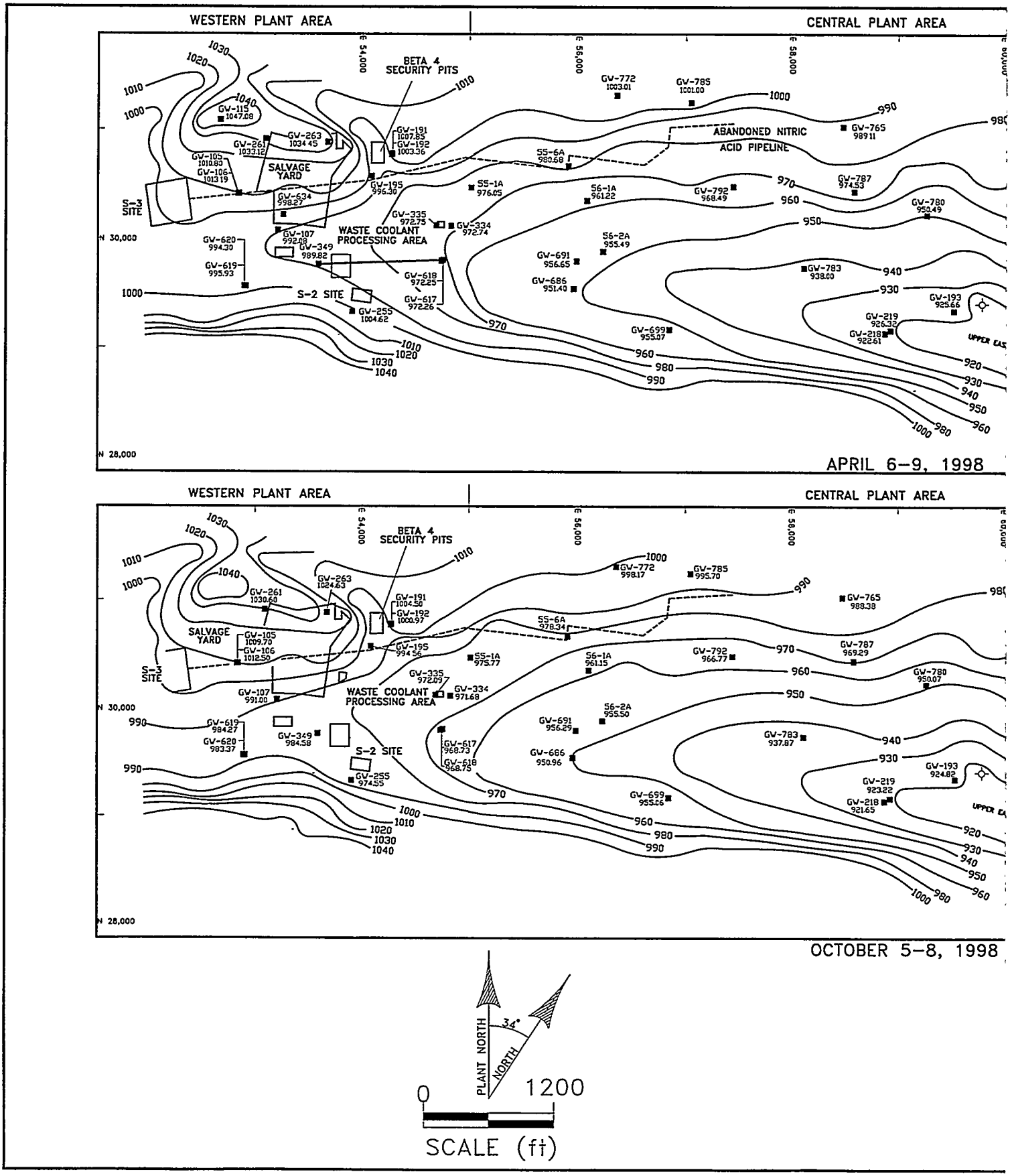
96-071 5/12-99

Fig. 2. Topography and bedrock geology in the Upper East Fork Poplar Creek Hydrogeologic Regime.



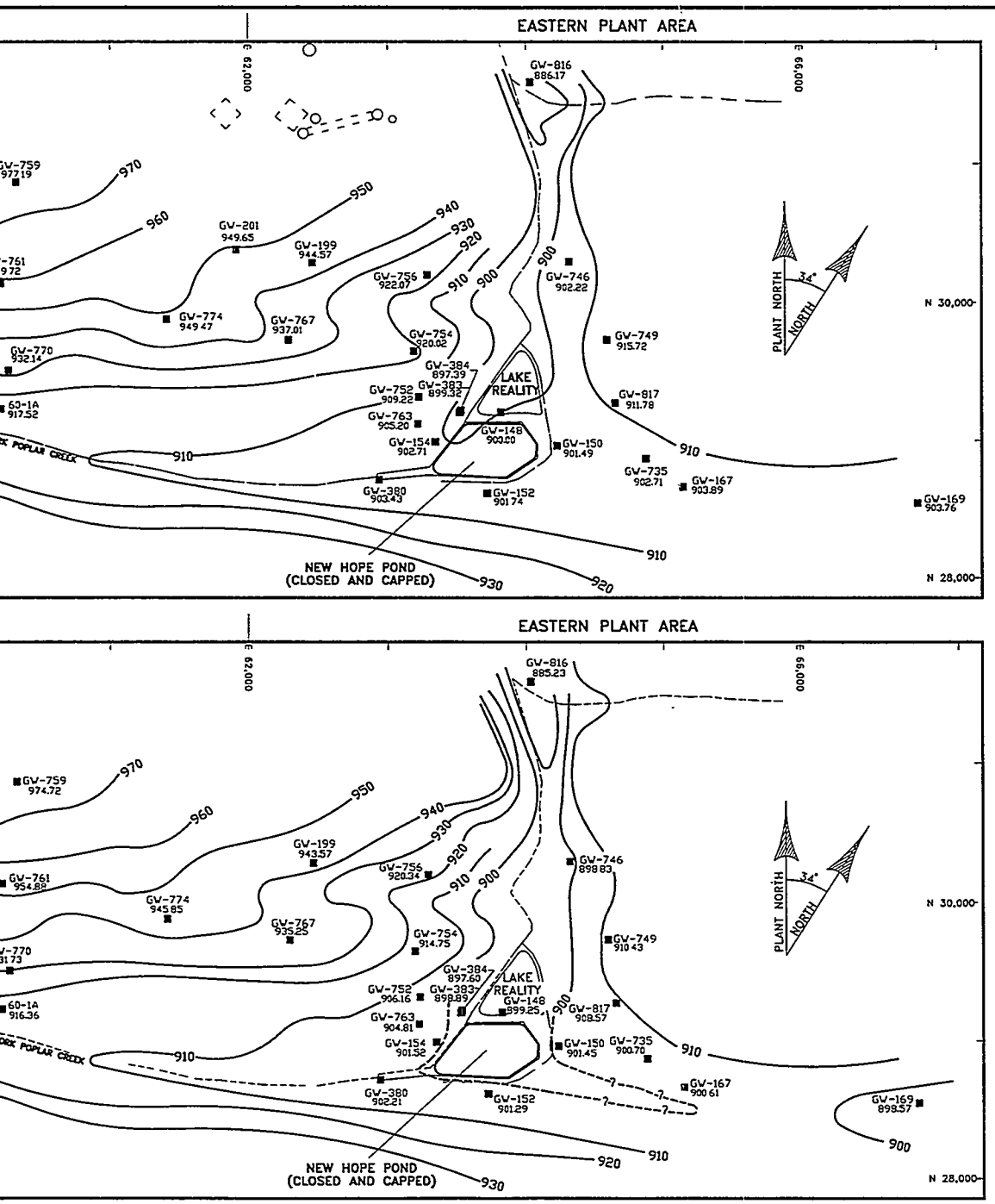
96-068 5/13/99

Fig. 3. Fill areas in the Y-12 Plant and preconstruction drainage features.



97-1010 5/15/99

Fig. 4. Seasonal groundwater elevations in the Upper East R



EXPLANATION

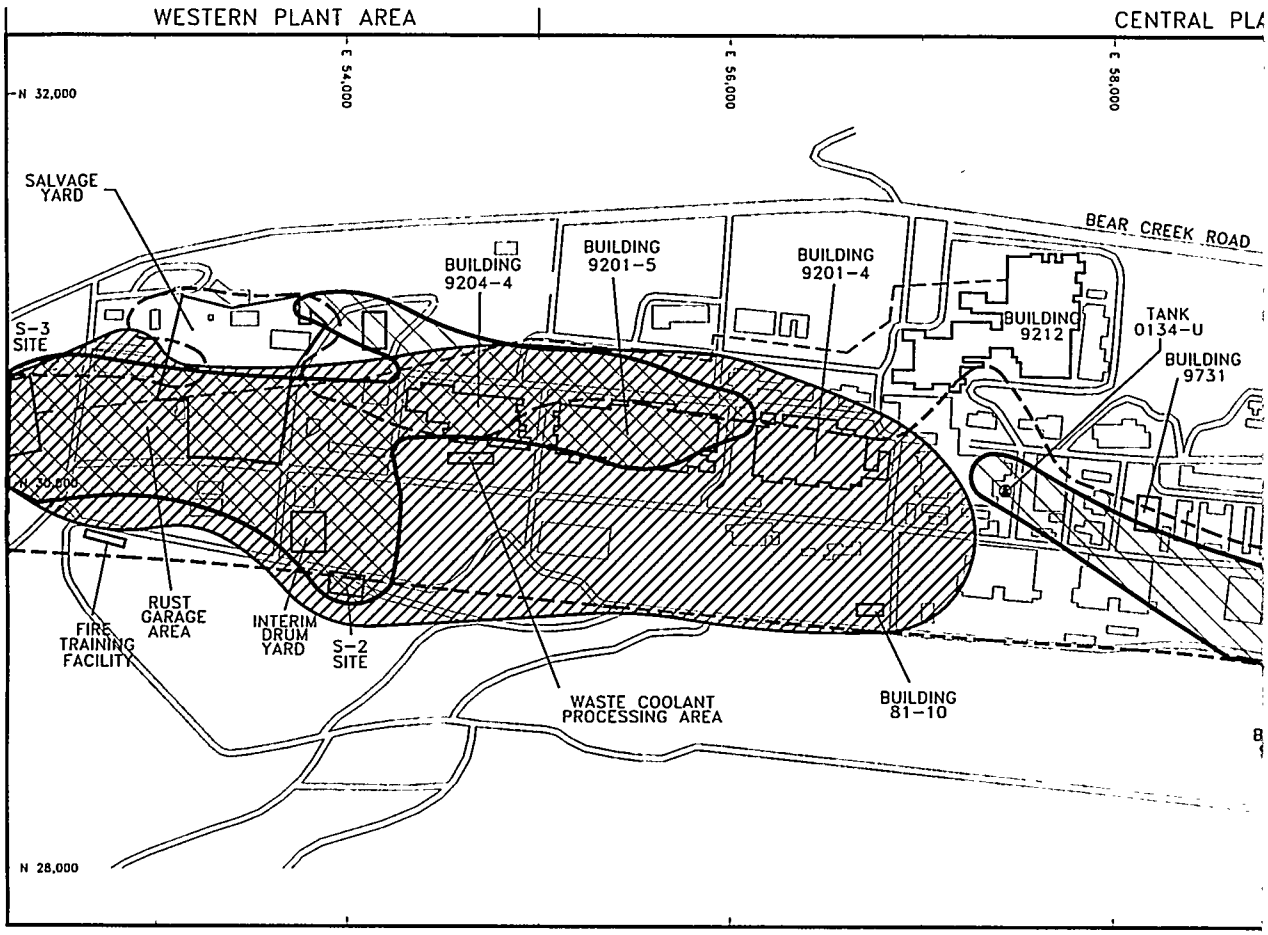
■ — Water Table Interval Monitoring Well and Water-Level Elevation (ft msl)

980 — Approximate Water-Level Isopleth (ft msl)

---------- — Surface Drainage Feature

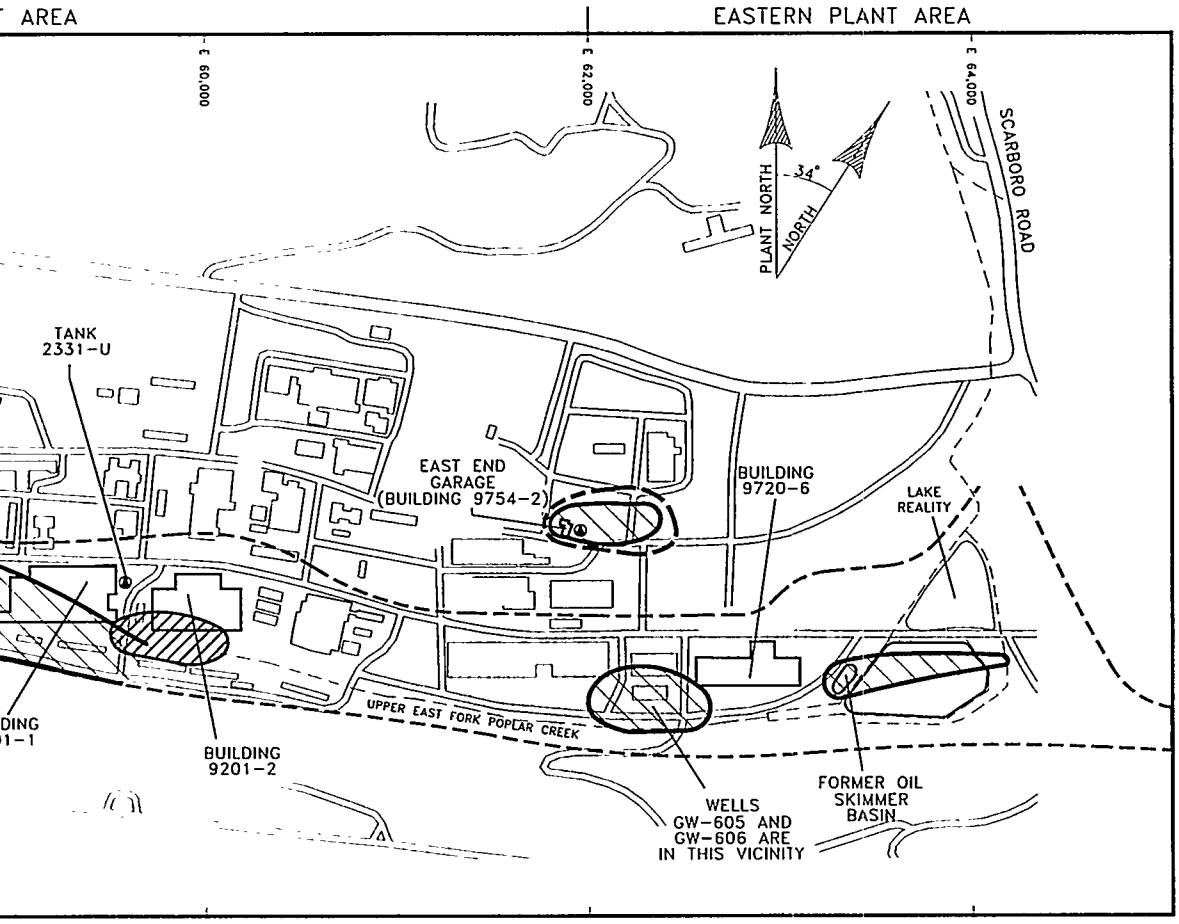
— Building 9201-2 Sump

ork Poplar Creek Hydrogeologic Regime, 1998.



98 075 5/15/98

Fig. 5. Source areas and generalized extent of groundwater contamina



NATION

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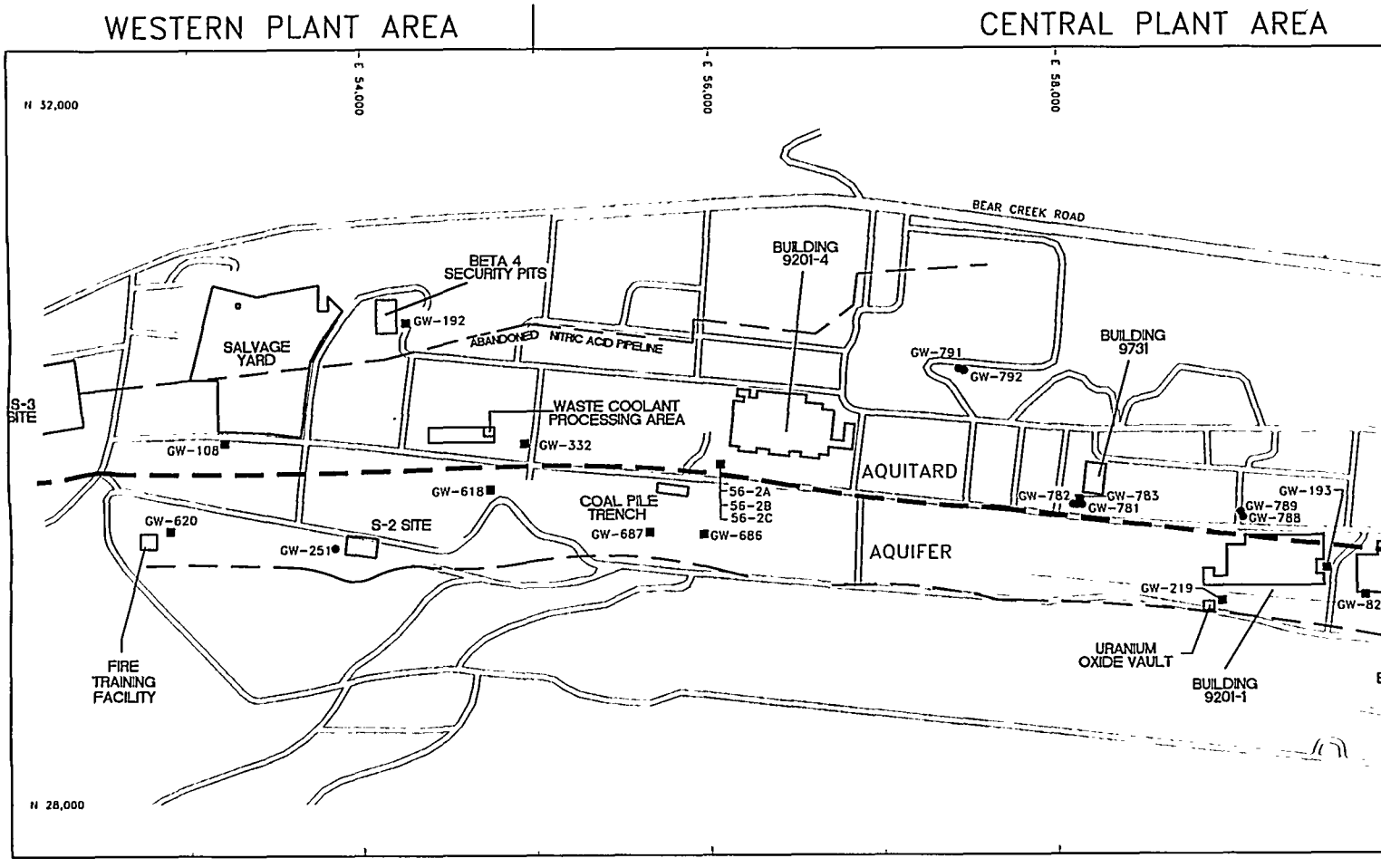
on in the Upper East Fork Poplar Creek Hydrogeologic Regime.



EXPLANATION

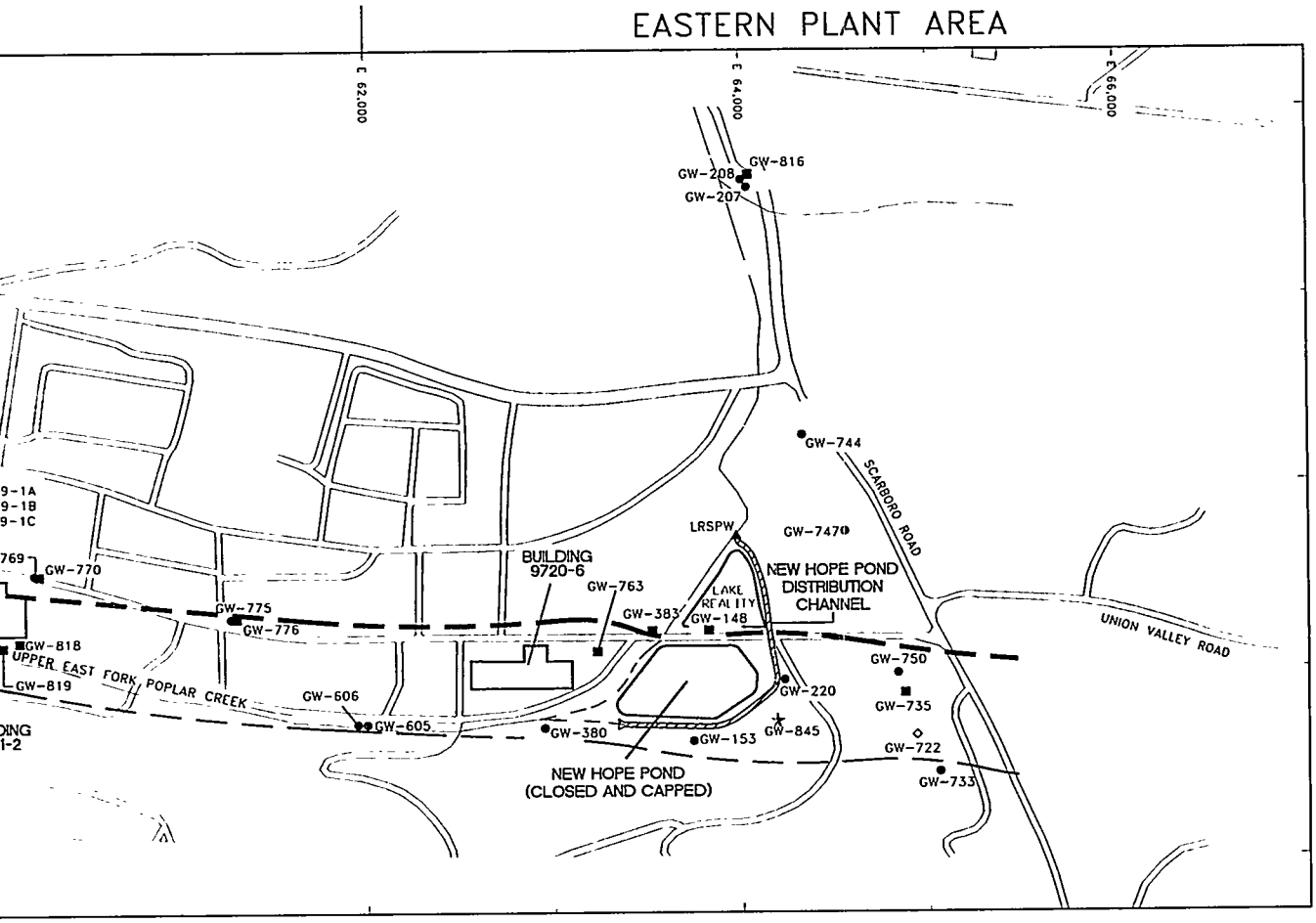
- ■ Water Table Monitoring Well
- • Bedrock Monitoring Well
- ◇ Well With Westbay Multiport Sampling System
- ▲ Surface Water Sampling Location
- ★ July 1998 Aquifer Test Pumping Well
- LRSPW Lake Reality Emergency Spillway

AQUITARD
- NOLICHUCKY SHALE
- MARYVILLE LIMESTONE
- ROGERSVILLE SHALE
- RUTLEDGE LIMESTONE
- PUMPKIN VALLEY SHALE
- ROME FORMATION

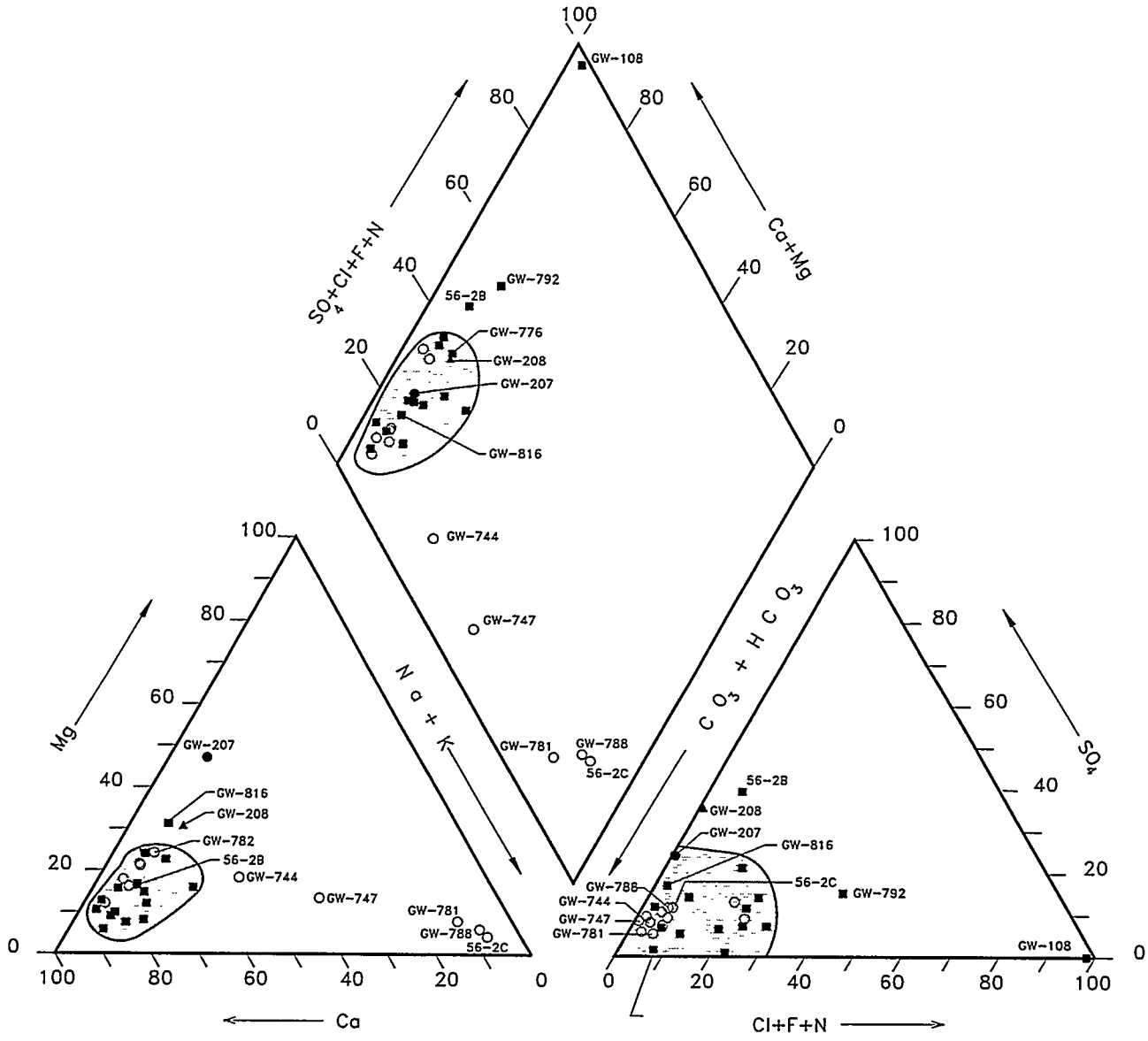
AQUIFER
- COPPER RIDGE DOLOMITE
- MAYNARDVILLE LIMESTONE

96-075 5/20/99

Fig. 6. CY 1998 sampling locations in the Upper East F



rk Poplar Creek Hydrogeologic Regime.



EXPLANATION

— GROUNDWATER COMPOSITIONS CLUSTER IN THESE AREAS.

■ — WATER TABLE MONITORING WELL

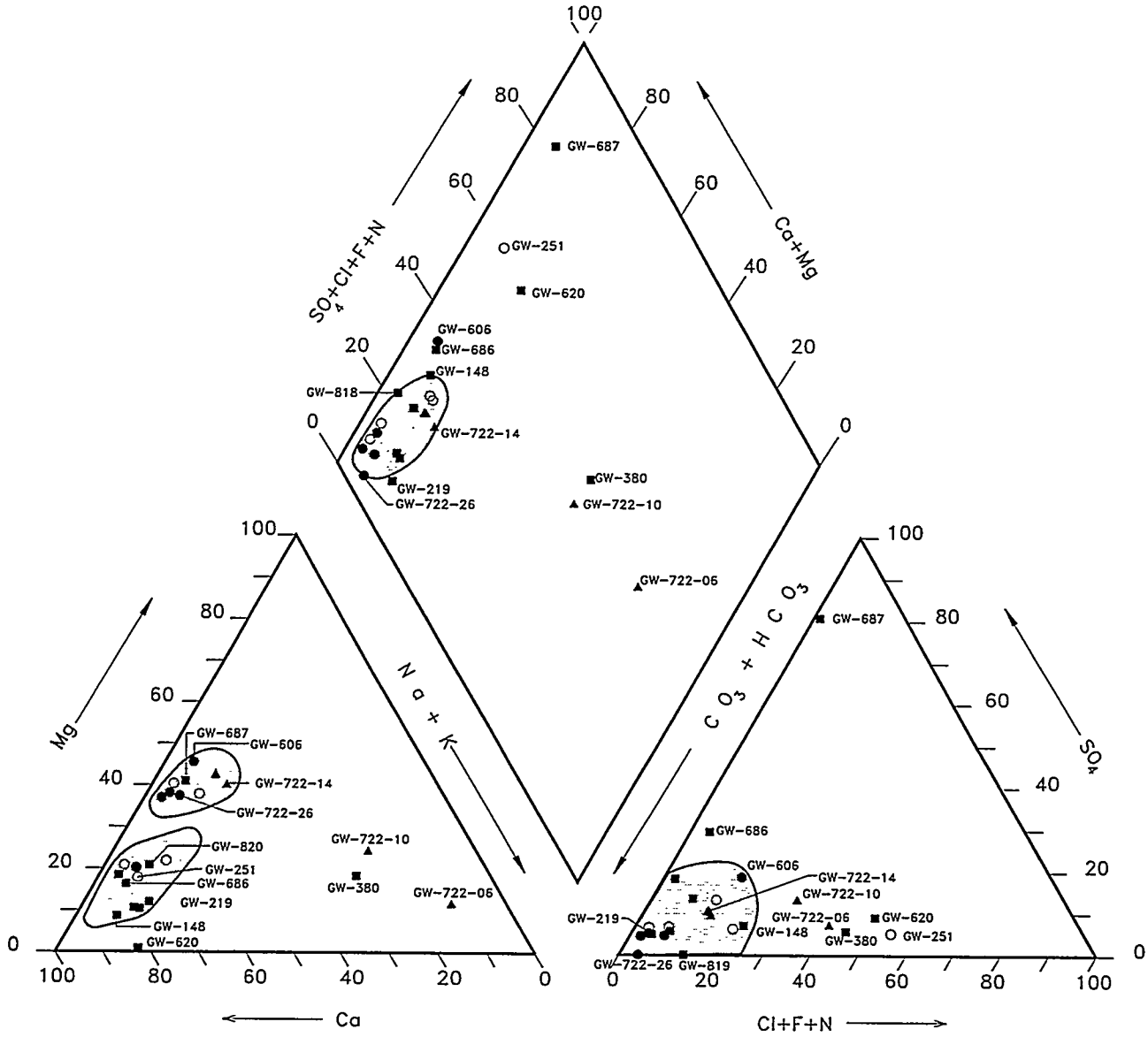
○ — BEDROCK MONITORING WELL, LESS THAN 100 FT DEEP

● — BEDROCK MONITORING WELL, 100 TO 300 FT DEEP

▲ — BEDROCK MONITORING WELL, GREATER THAN 300 FT DEEP

96-073 6-20-99

Fig. 7. Major ion chemistry of CY 1998 groundwater samples from Aquitard wells.



EXPLANATION

— GROUNDWATER COMPOSITIONS CLUSTER IN THESE AREAS

■ — WATER TABLE MONITORING WELL

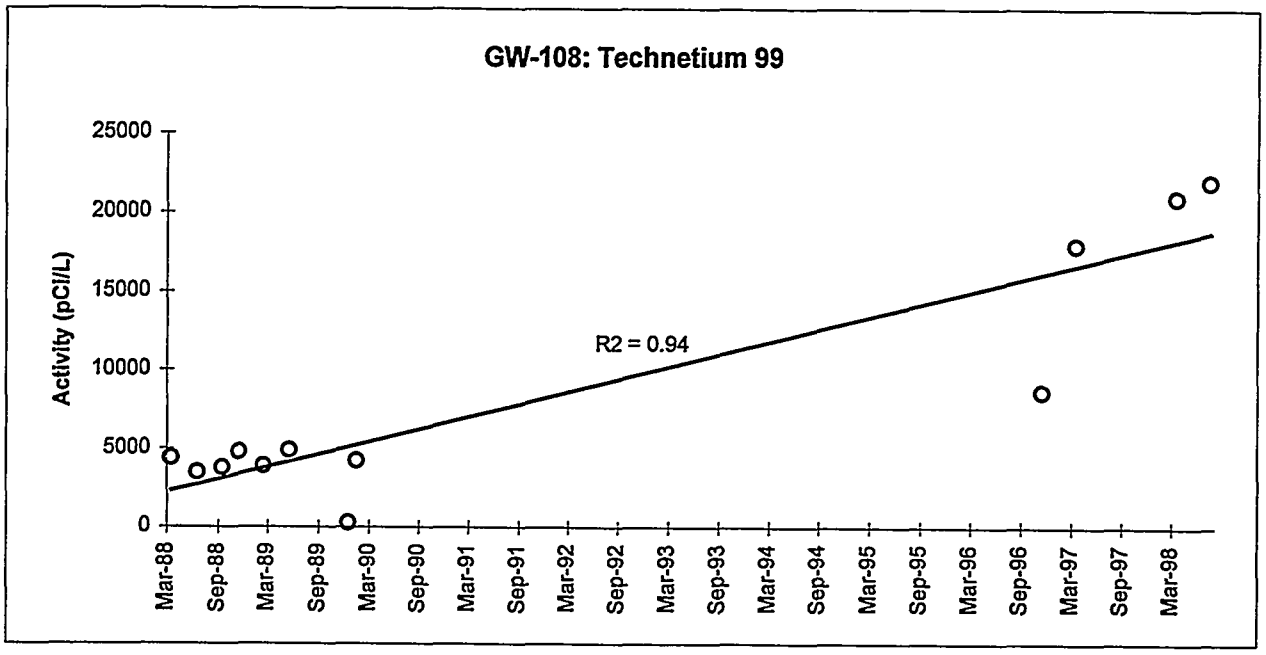
○ — BEDROCK MONITORING WELL, LESS THAN 100 FT DEEP

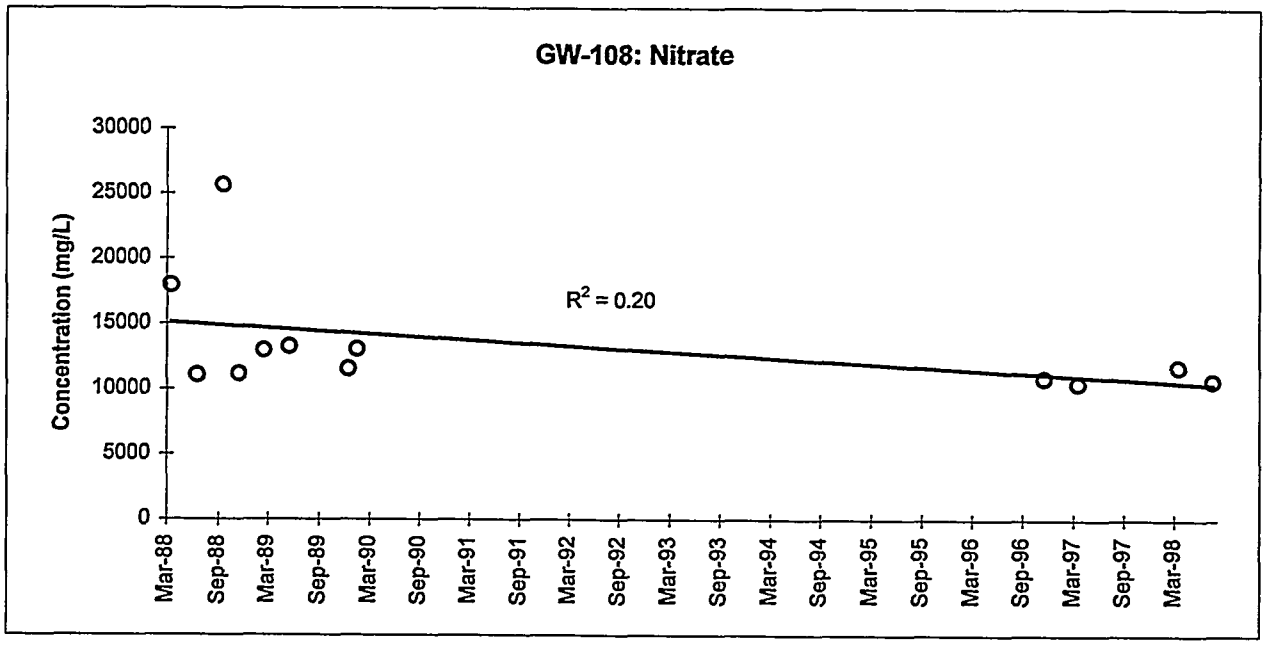
● — BEDROCK MONITORING WELL, 100 TO 300 FT DEEP

▲ — BEDROCK MONITORING WELL, GREATER THAN 300 FT DEEP

96-054 6-20-99

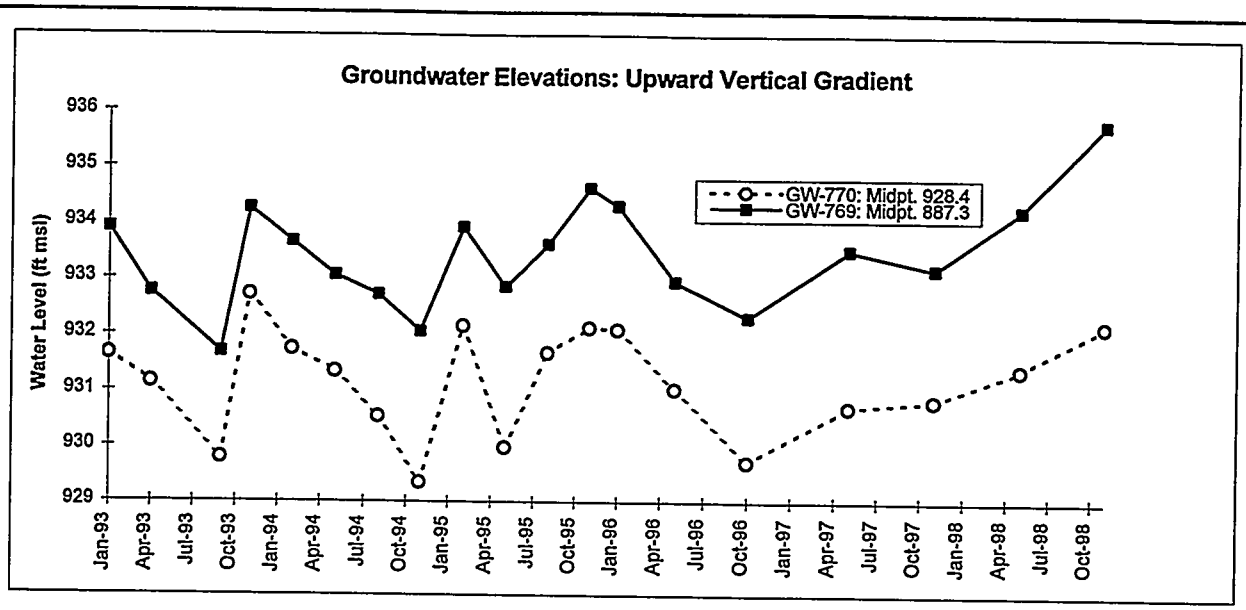
Fig. 8. Major ion chemistry of CY 1998 groundwater samples from Aquifer wells.

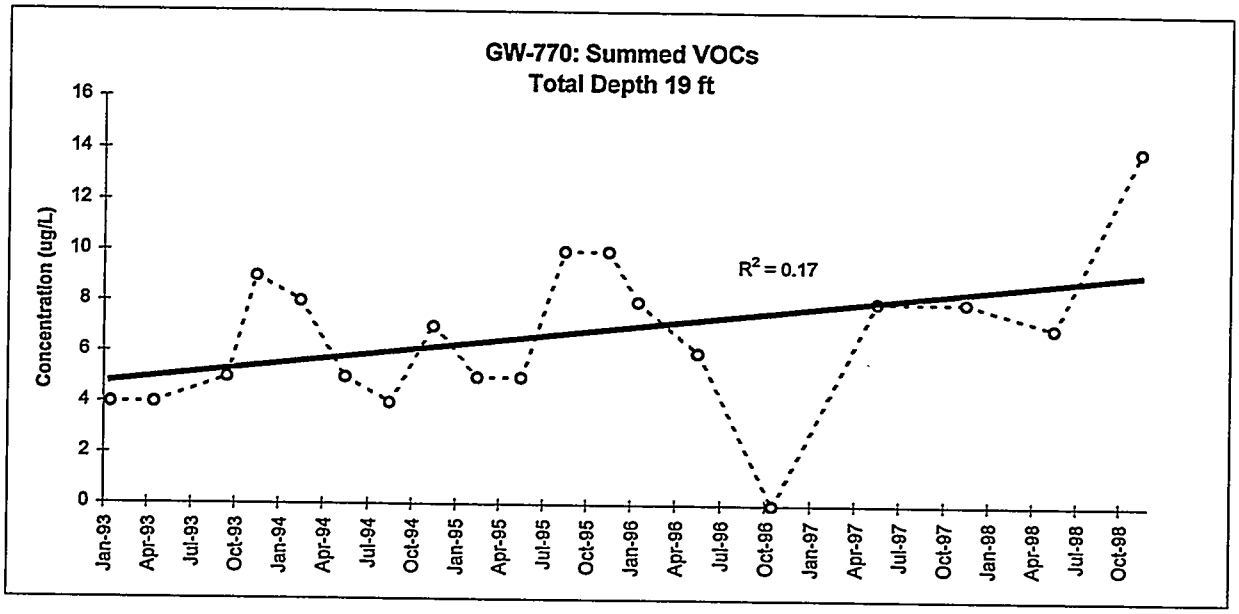


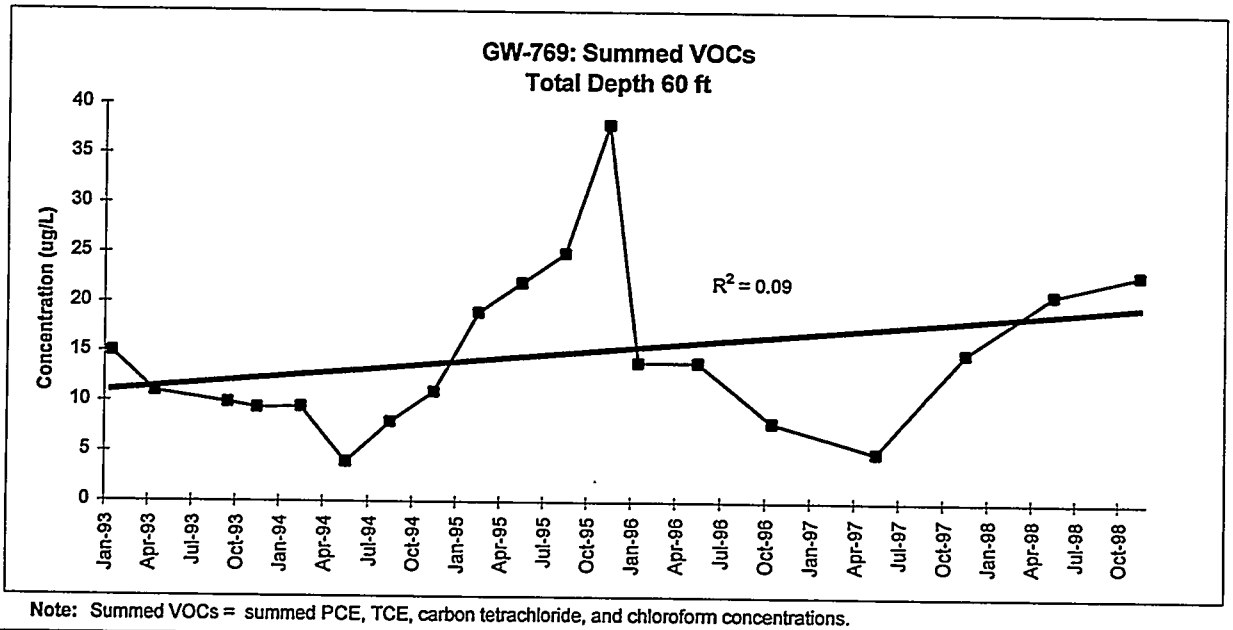


EF2_98 06/28/99

Fig. 9. Technetium activities and nitrate concentrations in well GW-108.



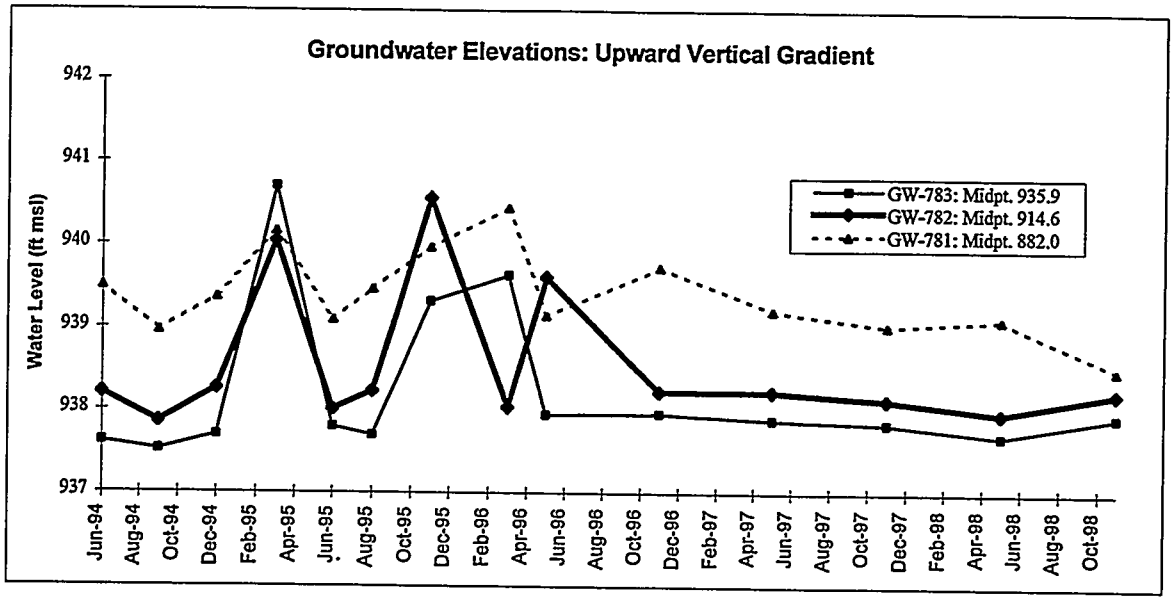


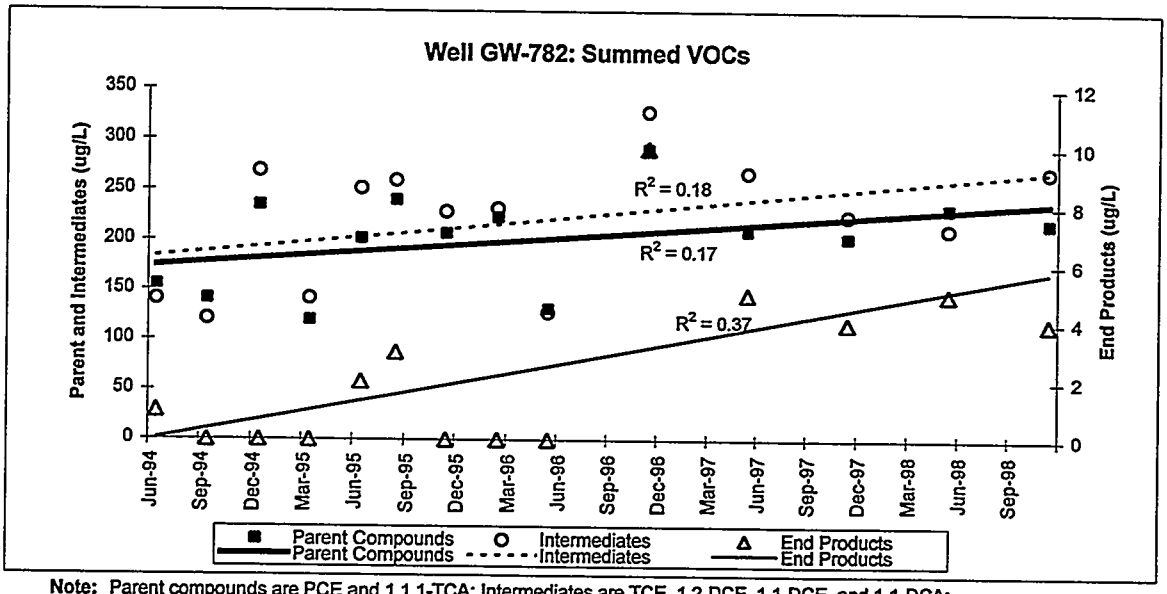


Note: Summed VOCs = summed PCE, TCE, carbon tetrachloride, and chloroform concentrations.

EF2_98 6/28/99

Fig. 10. Presampling groundwater elevations and summed VOC concentrations in wells GW-769 and GW-770.





Note: Parent compounds are PCE and 1,1,1-TCA; Intermediates are TCE, 1,2-DCE, 1,1-DCE, and 1,1-DCA; End products are vinyl chloride and chloroethane.

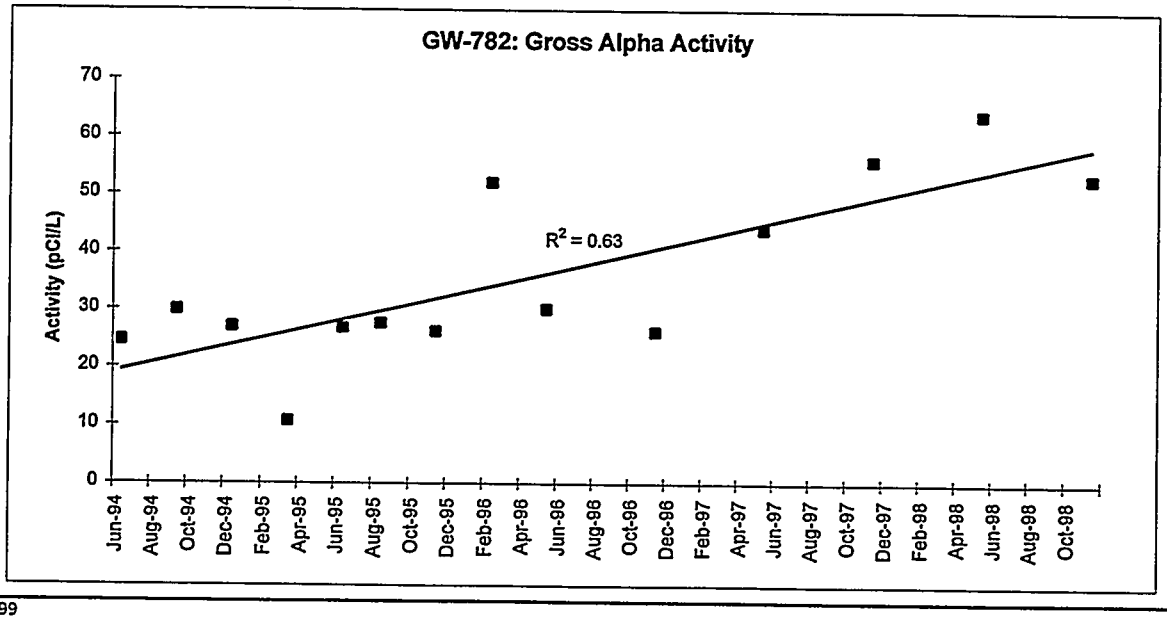


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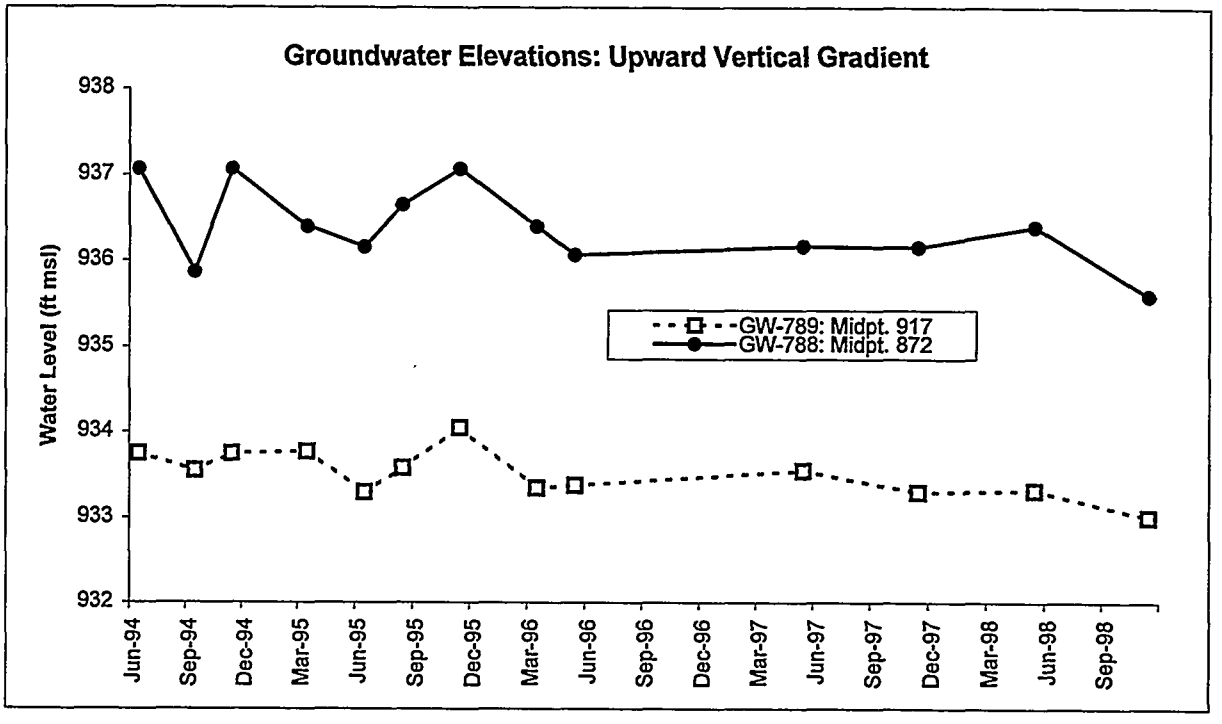
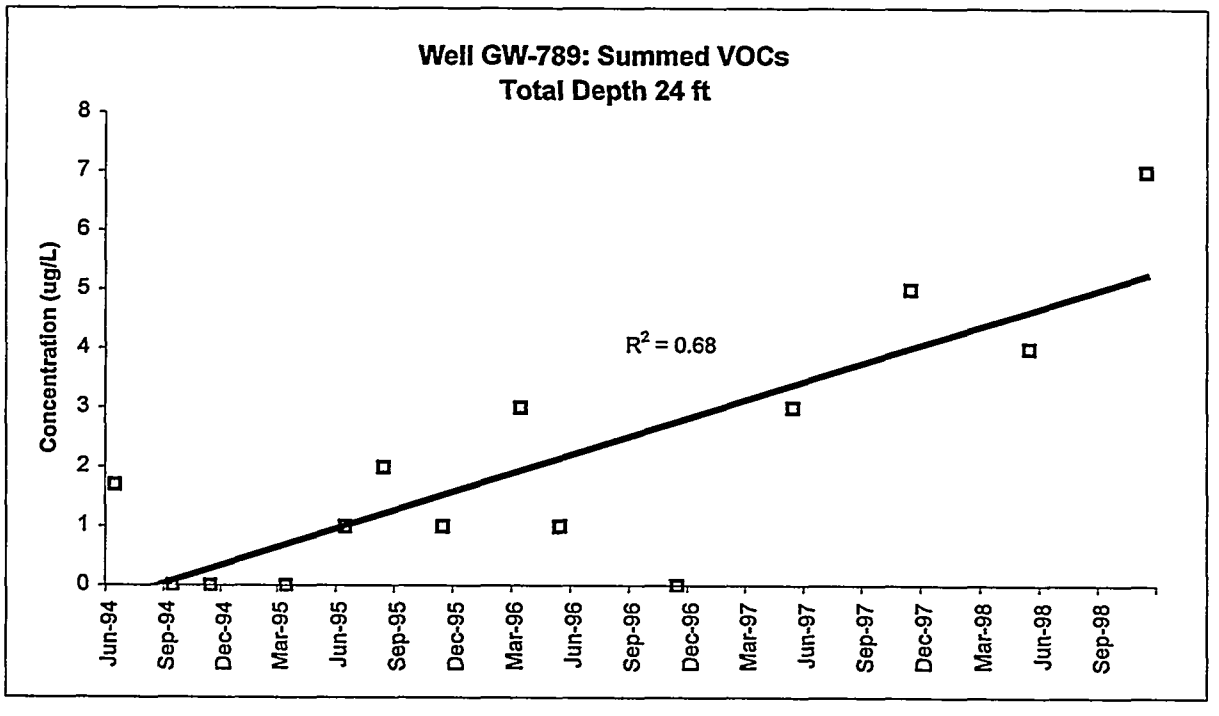
Fig. 11. Presampling groundwater elevations, summed VOC concentrations, and gross alpha activities in well GW-782.





Note: Summed VOCs = summed PCE, TCE, and chloroform concentrations.

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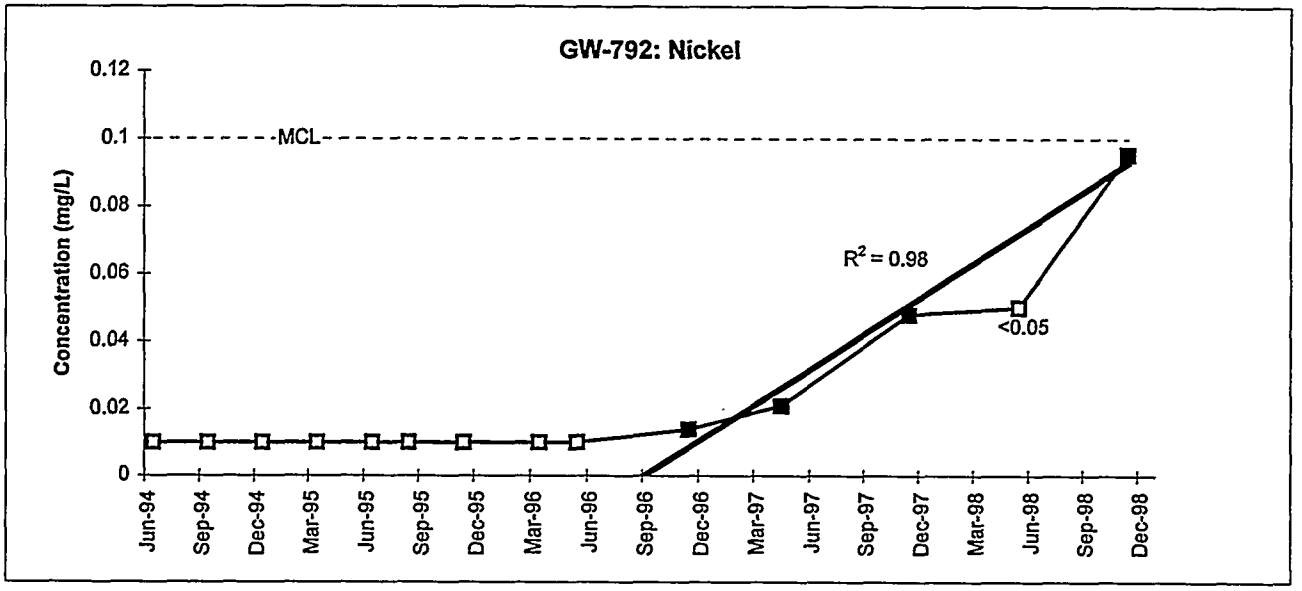
Fig. 12. Presampling groundwater elevations and summed VOC concentrations in well GW-789.



Notes: In March 1998 the detection limit for nickel changed from 0.01mg/L to 0.05 mg/L. Nondetects are shown with an open symbol. The linear regression line applies to total nickel results beginning in November 1996 and excludes the <0.05 mg/L result.

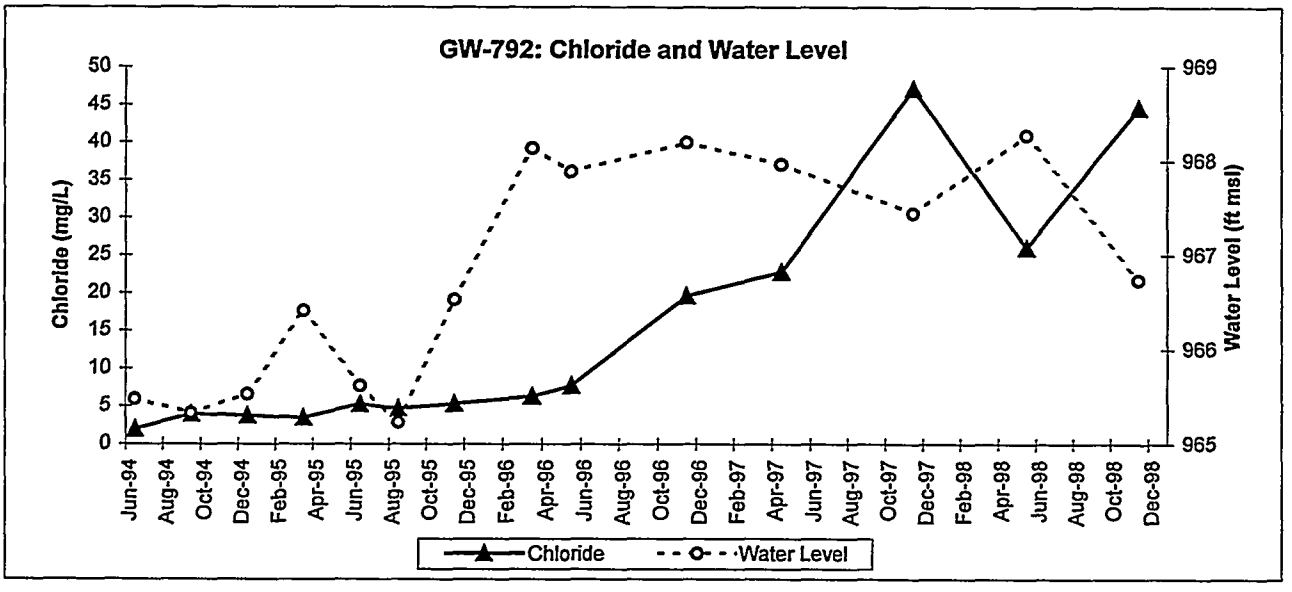


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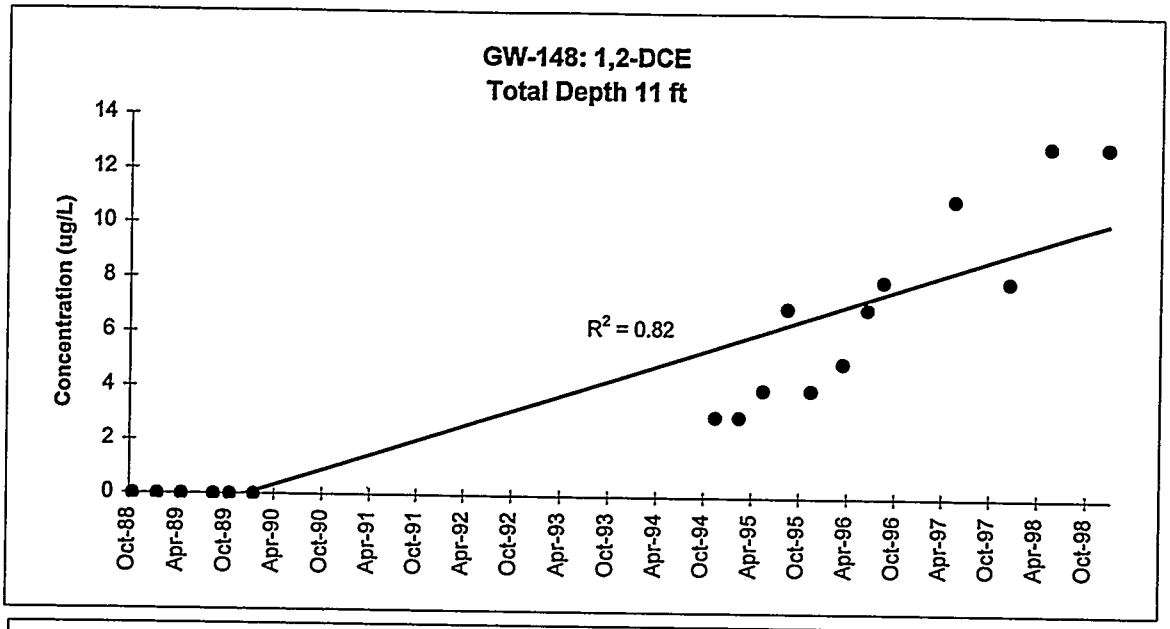
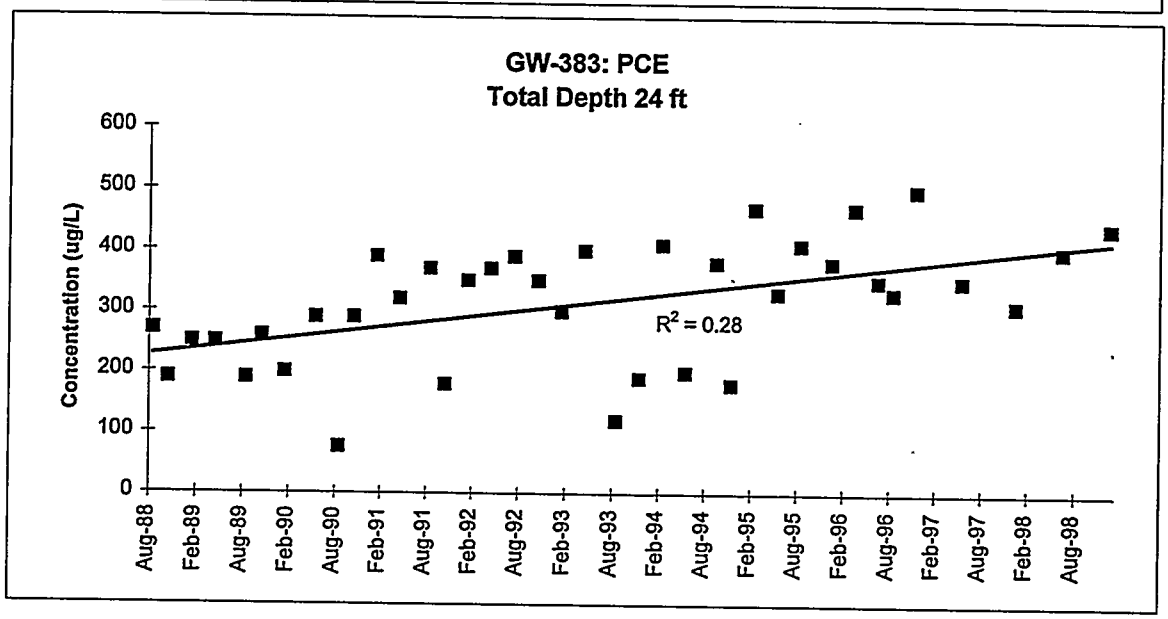
Fig. 13. Presampling groundwater elevations, chloride levels, and nickel concentrations in well GW-792.





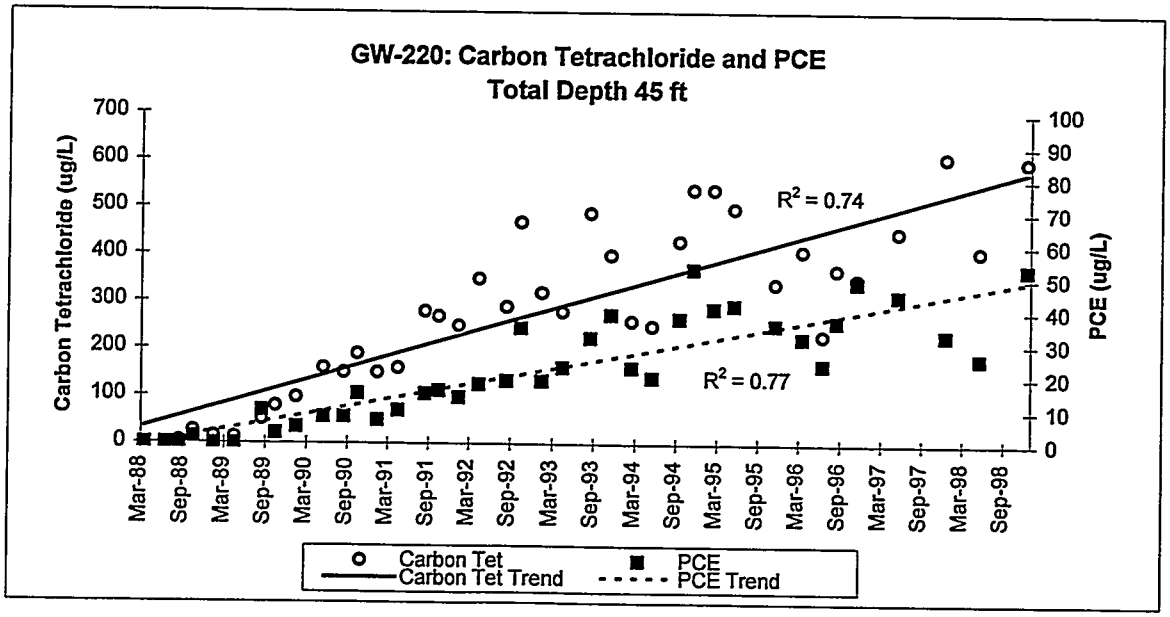


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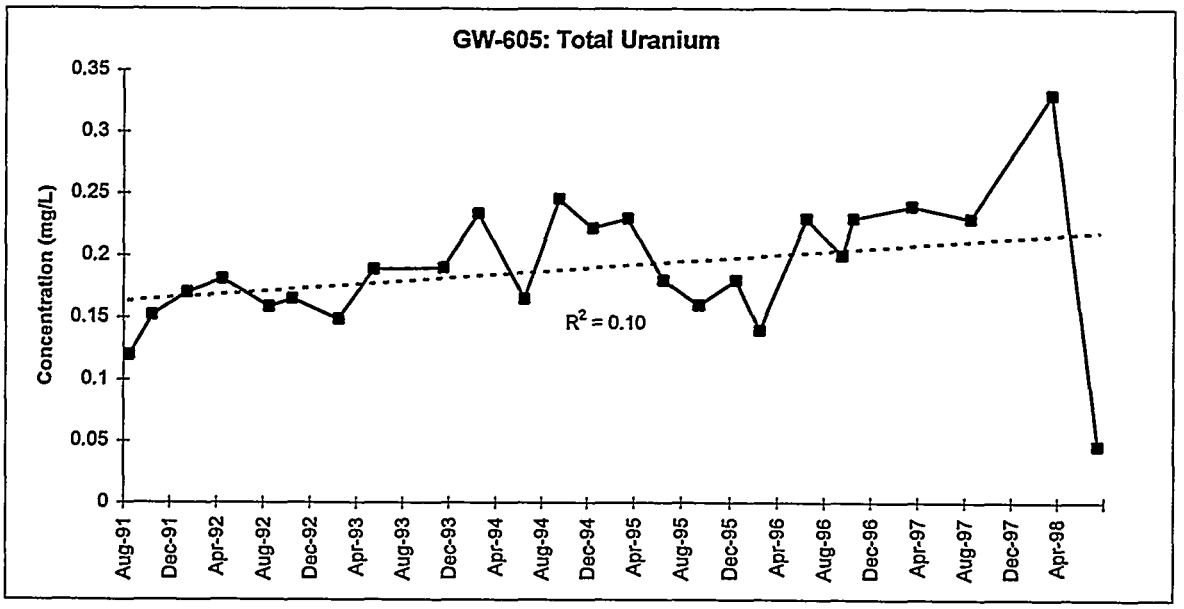
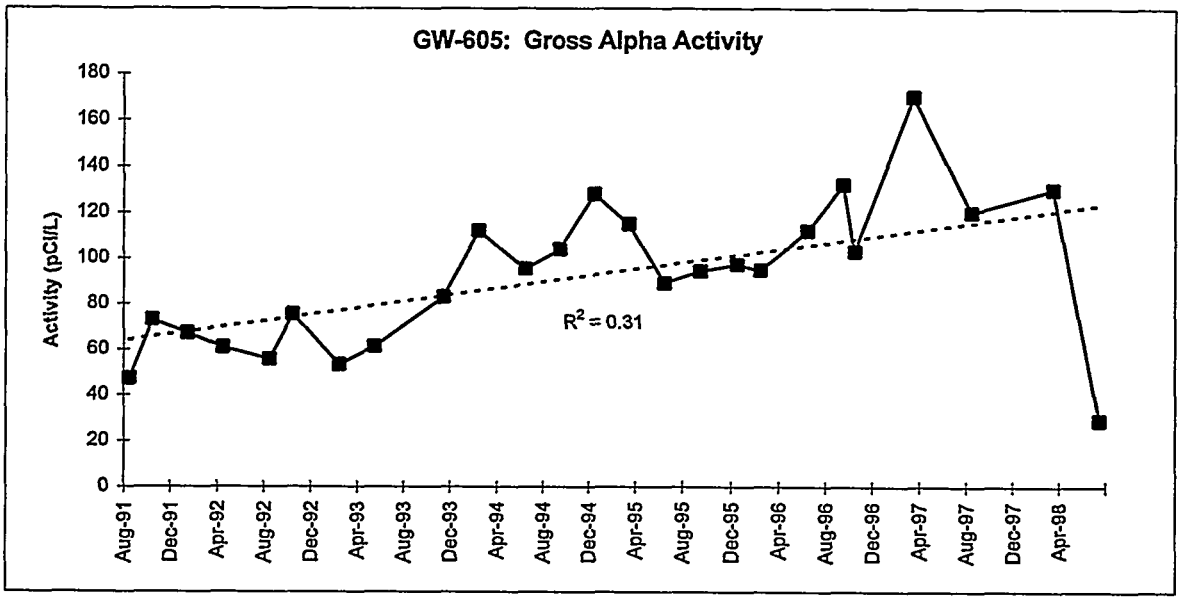
Fig. 14. Concentrations of selected VOCs in wells GW-148, GW-220, and GW-383.





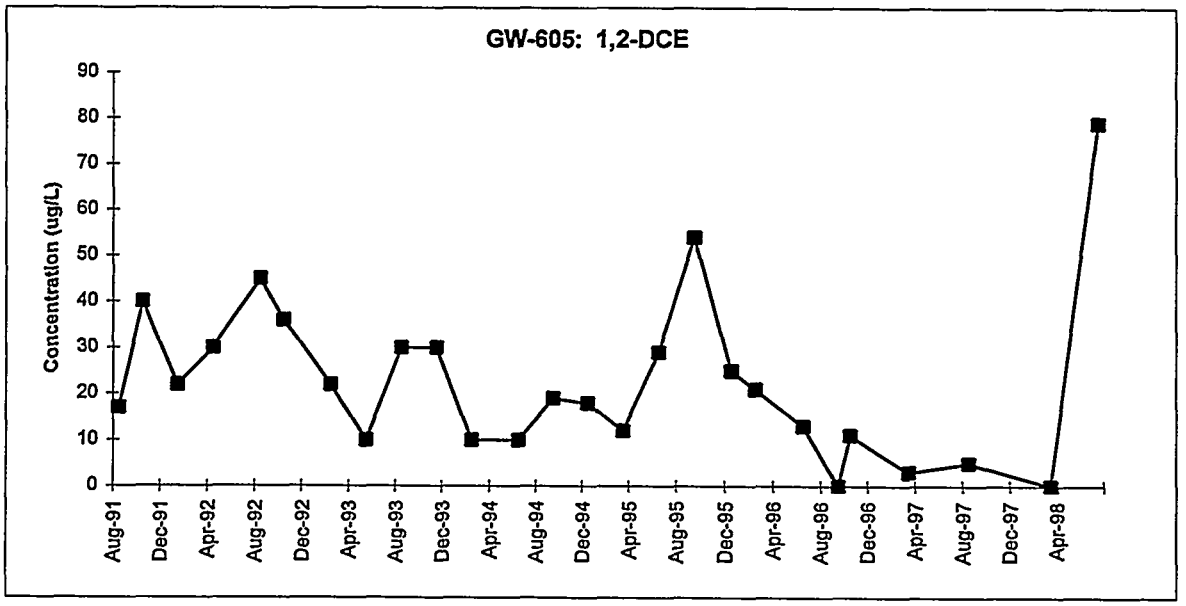


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Fig. 15. Total uranium, gross alpha, and 1,2-DCE concentrations in well GW-605.

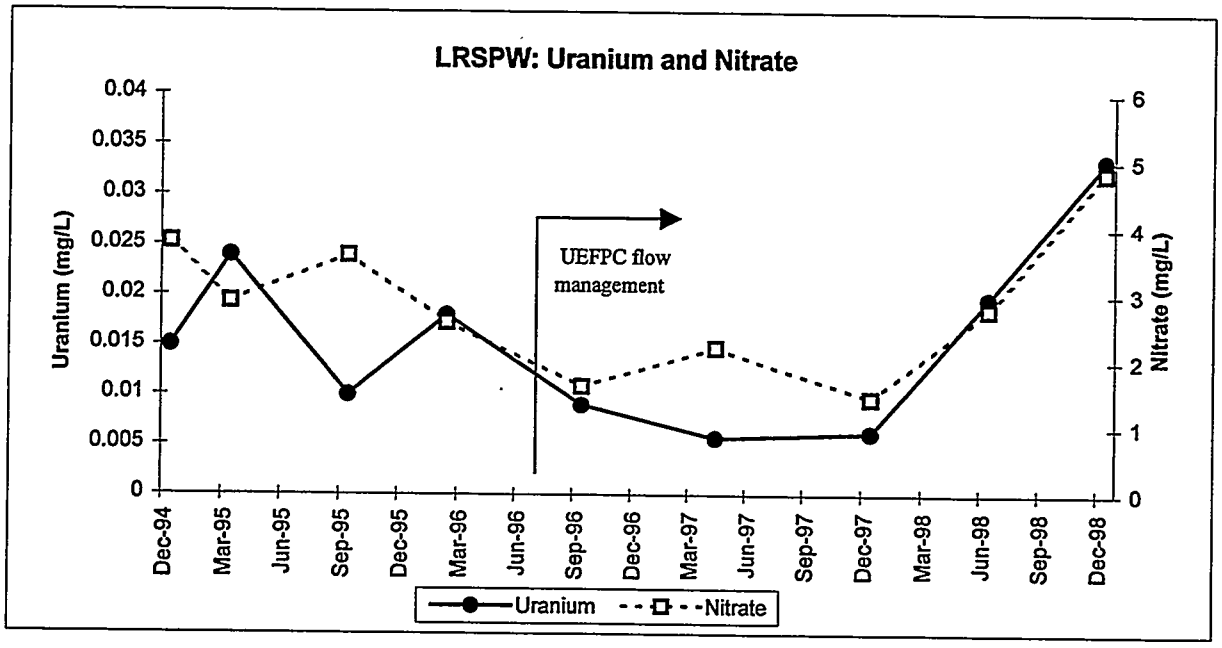

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Fig. 16. Nitrate and total uranium concentrations in LRSPW.

APPENDIX B

TABLES

Table 1. Sources of groundwater contaminant signatures in the East Fork Regime.

Confirmed and Suspected Sources of Contamination[1]	Groundwater Contaminant Signature			
	Inorganics	Organics	Metals	Radionuclides
WESTERN PLANT AREA				
S-3 Ponds	●	●	●	●
Salvage Yard		●	●	●
Rust Garage Area		●		
Waste Coolant Processing Area		●	●	●
Building 9204-4		●	●	
Fire Training Facility		●		
Interim Drum Yard Vicinity		●		
S-2 Site	●	●	●	●
CENTRAL PLANT AREA				
Buildings 9201-4 and 9201-5		●	●	
Building 9731 Vicinity		●		●
Building 9212		●		
Tank 0134-U		●	●	●
Building 81-10			●	●
Buildings 9201-1 and 9201-2		●	●	
Tank 2331-U		●	●	
EASTERN PLANT AREA				
East End Garage (Building 9754-2)		●		
Uranium Oxide Vault			●	●
Wells GW-605 and GW-606 Vicinity				●
Former Oil Skimmer Basin			●	●
East End Carbon Tetrachloride Plume		●		
Building 9720-6		●		

Note:

1 Modified from: U.S. Department of Energy. 1998. *Report on the Remedial Investigation of the Upper East Fork Poplar Creek Characterization Area at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee.* Volume 3, Appendix D, Section D.5 - Nature and Extent of Site-Related Contaminants in Groundwater. The table includes contaminant sources relevant to discussions in this report.

Table 2. CY 1998 groundwater and surface water sampling locations and dates

MONITORING PROGRAM		DOE Order 5400.1 Exit Pathway/Perimeter Monitoring								
		DOE Order 5400.1 Surveillance Monitoring								
Sampling Point		Y-12 Plant Area[3]			CY 1998 Sampling Date[4]					
No.[1]	Location[2]	W	C	E	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.		
56-2A	GRIDC3		●		03/23/98	.	.	.	●	
56-2B	GRIDC3		●		03/23/98	.	.	.	●	
56-2C	GRIDC3		●		03/24/98	.	.	.	●	
59-1A	B9202		●		03/17/98	.	.	.	●	
59-1B	B9202		●		03/18/98	.	.	.	●	
59-1C	B9202		●		03/18/98	.	.	.	●	
GW-108	S3	●			**03/16/98 D**	.	**07/28/98 D**	.	●	
GW-148	NHP			●	.	05/27/98	.	12/03/98	●	
GW-153	NHP			●	.	05/28/98	.	12/07/98	●	
GW-192	B4	●			.	05/26/98	.	11/30/98	●	
GW-193	T2331		●		03/16/98	.	07/28/98	.	●	
GW-207	EXP-SR			●	.	06/24/98	.	12/09/98		●
GW-208	EXP-SR			●	.	06/09/98	.	12/09/98		●
GW-219	UOV		●		.	.	09/04/98	.	●	
GW-220	NHP			●	.	05/28/98	.	12/07/98		●
GW-251	S2	●			.	05/26/98	.	12/02/98	●	
GW-332	WCPA	●			**03/24/98 D**	.	.	.	●	
GW-380	NHP			●	.	06/02/98	.	12/10/98	●	
GW-383	NHP			●	.	06/01/98	.	12/08/98	●	
GW-605	EXP-I			●	03/12/98	.	07/27/98	.	●	
GW-606	EXP-I			●	03/12/98	.	07/28/98	.	●	
GW-618	EXP-E	●			.	06/01/98	.	11/30/98	●	
GW-620	FTF	●			.	05/26/98	.	12/02/98	●	
GW-686	CPT		●		03/23/98	.	.	.	●	
GW-687	CPT		●		03/24/98	.	.	.	●	
GW-722-06	EXP-J			●	02/17/98	.	07/29/98	.		●
GW-722-10	EXP-J			●	02/18/98	.	08/03/98	.		●
GW-722-14	EXP-J			●	02/19/98	.	08/04/98	.		●
GW-722-17	EXP-J			●	02/25/98	.	08/11/98	.		●
GW-722-20	EXP-J			●	02/24/98	.	08/18/98	.		●
GW-722-22	EXP-J			●	02/26/98	.	08/19/98	.		●
GW-722-26	EXP-J			●	02/26/98	.	08/25/98	.		●
GW-722-30	EXP-J			●	02/25/98[5]	.	**08/26/98 D**	.		●
GW-722-32	EXP-J			●	03/05/98[5]	.	09/03/98	.		●
GW-722-33	EXP-J			●	03/05/98[5]	.	09/03/98	.		●

Table 2 (continued)

MONITORING PROGRAM		DOE Order 5400.1 Exit Pathway/Perimeter Monitoring								
		DOE Order 5400.1 Surveillance Monitoring								
Sampling Point		Y-12 Plant Area[3]			CY 1998 Sampling Date[4]					
No.[1]	Location[2]	W	C	E	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.		
GW-733	EXP-J			●	03/12/98	.	07/27/98	.		●
GW-735	EXP-J			●	.	**06/04/98 D**	.	**12/14/98 D**		●
GW-744	GRIDK1			●	.	06/03/98	.	12/10/98		●
GW-747	GRIDK2			●	.	06/03/98	.	12/15/98		●
GW-750	EXP-J			●	.	06/04/98	.	12/14/98		●
GW-763	GRIDJ3			●	.	05/27/98	.	12/03/98	●	
GW-769	GRIDG3		●		.	**05/19/98 D**	.	**11/11/98 D**	●	
GW-770	GRIDG3		●		.	05/19/98	.	11/10/98	●	
GW-775	GRIDH3		●		.	06/17/98	.	11/18/98	●	
GW-776	GRIDH3		●		.	06/17/98	.	11/18/98	●	
GW-781	GRIDE3		●		.	05/20/98	.	11/11/98	●	
GW-782	GRIDE3		●		.	05/20/98	.	11/12/98	●	
GW-783	GRIDE3		●		.	05/20/98	.	11/12/98	●	
GW-788	GRIDF3		●		.	05/14/98	.	11/09/98	●	
GW-789	GRIDF3		●		.	05/18/98	.	11/09/98	●	
GW-791	GRIDD2		●		.	05/20/98	.	11/16/98	●	
GW-792	GRIDD2		●		.	05/20/98	.	11/16/98	●	
GW-816	EXP-SR			●	.	06/03/98	.	12/08/98		●
GW-818	B9201-2		●		03/26/98	.	.	.	●	
GW-819	B9201-2		●		03/26/98	.	.	.	●	
GW-820	B9201-2		●		03/26/98	.	.	.	●	
GW-845	EXP			●	.	05/21/98	.	.	●	
LRSPW	EXP-SW			●	.	06/02/98	.	12/10/98		●

Notes:

1 GW - Groundwater Monitoring Well (also the 56- and 59- series)
GW-722- - Westbay™ sampling port in well GW-722
LRSPW - Lake Reality Emergency Spillway (surface water station)

Table 2 (continued)

Notes: (continued)

2
- B4 - Beta-4 Security Pits
- B9201-2 - Building 9201-2
- B9202 - Building 9202
- CPT - Coal Pile Trench
- EXP - Exit Pathway (Maynardville Limestone) monitoring location:
  - -E, -I, or -J: Maynardville Limestone Picket monitoring well
  - -SW: Onsite spring or surface water station
  - -SR: Along Scarboro Road in the gap through Pine Ridge
- FTF - Fire Training Facility
- GRID - Comprehensive Groundwater Monitoring Plan Grid Location
- NHP - New Hope Pond
- S2 - S-2 Site
- S3 - S-3 Ponds Site
- T2331 - Tank 2331-U
- UOV - Uranium Oxide Vault
- WCPA - Waste Coolant Processing Area

3
- W - Western, west of Y-12 Plant Grid east coordinate 55,000
- C - Central, between east coordinates 55,000 and 62,000
- E - Eastern, east of 62,000

4
- . - Not sampled.
- **D** - Duplicate samples were collected.

5 Westbay™ port GW-722-33 was resampled January 21 due to equipment failure during the fourth quarter of CY 1997. Ports GW-722-30 and -32 were resampled February 2 for anions analysis because samples for the fourth quarter of CY 1997 missed holding times.

Table 3. Field measurements and laboratory analytes for CY 1998 groundwater and surface water samples

Field Measurements	Analytical Method[1]	Detection Limit[2]	Units[3]
Depth to Water	ESP 302-1	NA	ft
Water Temperature	ESP 307-1	NA	centigrade
pH	ESP 307-1	NA	pH units
Conductivity	ESP 307-1	NA	µmho/cm
Dissolved Oxygen	ESP 307-3	NA	ppm
Oxidation-Reduction Potential	ESP 307-5	NA	mV
Miscellaneous Laboratory Analytes			
pH	EPA-9040	NA	pH units
Conductivity	EPA-9050	NA	µmho/cm
Total Dissolved Solids	EPA-160.1	1	mg/L
Total Suspended Solids	EPA-160.2	1	mg/L
Turbidity	EPA-180.1	0.1	NTU
Anions			
Alkalinity - HCO3	EPA-310.1	1.0	mg/L
Alkalinity - CO3	EPA-310.1	1.0	mg/L
Chloride	EPA-300.0	0.2	mg/L
Fluoride	EPA-340.2	0.1	mg/L
Nitrate (as Nitrogen)	EPA-300.0	0.028	mg/L
Sulfate	EPA-300.0	0.25	mg/L
Metals/Cations: Unfiltered & Filtered[4]			
Aluminum	EPA-6010A	0.02 / 0.2	mg/L
Antimony	EPA-6010A/ -200.8	0.05 / 0.0005	mg/L
Arsenic	EPA-200.8	0.005	mg/L
Barium	EPA-6010A	0.001 / 0.004	mg/L
Beryllium	EPA-6010A	0.0003 / 0.001	mg/L
Boron	EPA-6010A	0.004 / 0.1	mg/L
Cadmium	EPA-6010A/ -200.8	0.003 / 0.0005	mg/L
Calcium	EPA-6010A	0.008 / 0.2	mg/L
Chromium	EPA-6010A	0.01 / 0.02	mg/L
Cobalt	EPA-6010A	0.005 / 0.02	mg/L
Copper	EPA-6010A	0.004 / 0.02	mg/L
Iron	EPA-6010A	0.005 / 0.05	mg/L
Lead	EPA-200.8	0.0005	mg/L
Lithium	EPA-6010A	0.004 / 0.01	mg/L
Magnesium	EPA-6010A	0.003 / 0.2	mg/L
Manganese	EPA-6010A	0.001 / 0.005	mg/L
Mercury	EPA-7470	0.0002	mg/L
Molybdenum	EPA-6010A	0.01 / 0.05	mg/L

Table 3 (continued)

Metals/Cations (continued)	Analytical Method [1]	Detection Limit [2]	Units [3]
Nickel	EPA-6010A	0.01 / 0.05	mg/L
Potassium	EPA-6010A	0.6 / 2	mg/L
Selenium	EPA-6010A/ -200.8	0.05 / 0.01	mg/L
Silver	EPA-6010A	0.006 / 0.02	mg/L
Sodium	EPA-6010A	0.02 / 0.2	mg/L
Strontium	EPA-6010A	0.0004 / 0.005	mg/L
Thallium	EPA-200.8	0.0005	mg/L
Thorium	EPA-6010A	0.2	mg/L
Uranium	EPA-200.8	0.0005	mg/L
Vanadium	EPA-6010A	0.005 / 0.02	mg/L
Zinc	EPA-6010A	0.002 / 0.05	mg/L
Volatile Organic Compounds		**CRQL [5]**	
Acetone	EPA-8260	10	µg/L
Acrolein	EPA-8260	10	µg/L
Acrylonitrile	EPA-8260	10	µg/L
Benzene	EPA-8260	5	µg/L
Bromochloromethane	EPA-8260	10	µg/L
Bromodichloromethane	EPA-8260	5	µg/L
Bromoform	EPA-8260	5	µg/L
Bromomethane	EPA-8260	10	µg/L
2-Butanone	EPA-8260	10	µg/L
Carbon disulfide	EPA-8260	5	µg/L
Carbon tetrachloride	EPA-8260	5	µg/L
Chlorobenzene	EPA-8260	5	µg/L
Chloroethane	EPA-8260	10	µg/L
2-Chloroethyl vinyl ether	EPA-8260	10	µg/L
Chloroform	EPA-8260	5	µg/L
Chloromethane	EPA-8260	10	µg/L
Dibromochloromethane	EPA-8260	5	µg/L
1,2-Dibromo-3-chloropropane	EPA-8260	10	µg/L
1,2-Dibromoethane	EPA-8260	5	µg/L
Dibromomethane	EPA-8260	10	µg/L
1,2-Dichlorobenzene	EPA-8260	5	µg/L
1,4-Dichlorobenzene	EPA-8260	5	µg/L
1,4-Dichloro-2-butene	EPA-8260	5	µg/L
trans-1,4-Dichloro-2-butene	EPA-8260	5	µg/L
Dichlorodifluoromethane	EPA-8260	5	µg/L
1,1-Dichloroethane	EPA-8260	5	µg/L
1,2-Dichloroethane	EPA-8260	5	µg/L
1,1-Dichloroethene	EPA-8260	5	µg/L
1,2-Dichloroethene	EPA-8260	5	µg/L

Table 3 (continued)

Volatile Organic Compounds (cont'd)	Analytical Method [1]	CRQL [2]	Units [3]
cis-1,2-Dichloroethene	EPA-8260	5	µg/L
trans-1,2-Dichloroethene	EPA-8260	5	µg/L
1,2-Dichloropropane	EPA-8260	5	µg/L
cis-1,3-Dichloropropene	EPA-8260	5	µg/L
trans-1,3-Dichloropropene	EPA-8260	5	µg/L
Dimethylbenzene	EPA-8260	5	µg/L
Ethanol	EPA-8260	500	µg/L
Ethylbenzene	EPA-8260	5	µg/L
Ethyl methacrylate	EPA-8260	5	µg/L
2-Hexanone	EPA-8260	10	µg/L
Iodomethane	EPA-8260	5	µg/L
4-Methyl-2-pentanone	EPA-8260	10	µg/L
Methylene chloride	EPA-8260	5	µg/L
Styrene	EPA-8260	5	µg/L
1,1,1,2-Tetrachloroethane	EPA-8260	10	µg/L
1,1,2,2-Tetrachloroethane	EPA-8260	5	µg/L
Tetrachloroethene	EPA-8260	5	µg/L
Toluene	EPA-8260	5	µg/L
1,1,1-Trichloroethane	EPA-8260	5	µg/L
1,1,2-Trichloroethane	EPA-8260	5	µg/L
Trichloroethene	EPA-8260	5	µg/L
Trichlorofluoromethane	EPA-8260	5	µg/L
1,2,3-Trichloropropane	EPA-8260	5	µg/L
Vinyl acetate	EPA-8260	10	µg/L
Vinyl chloride	EPA-8260	10	µg/L
Radiological Analytes (pCi/L)		**Target MDA [6]**	
Gross Alpha Activity	EPA-900.0	3.5	pCi/L
Gross Beta Activity	EPA-900.0	7.0	pCi/L
Americium-241	AC-MM-2-22012	0.4	pCi/L
Iodine-129	EPA-901.1	3.0	pCi/L
Neptunium-237	Y/P65-7206	0.4	pCi/L
Plutonium-238 & -239/240	AC-MM-2-22012	0.4	pCi/L
Radium-223/224/226	EPA-903.0	0.5	pCi/L
Strontium-89/90	EPA-905.0	4.0	pCi/L
Technetium-99	Y/P65-7154	10	pCi/L
Tritium	EPA-906.0	300	pCi/L
Uranium-234, 235, & 238	AC-MM-2-22012	0.4	pCi/L

Table 3 (continued)

Notes:

1 The analytical method for three trace metals (antimony, cadmium, and selenium) changed from inductively coupled plasma spectroscopy to inductively coupled plasma mass spectroscopy, effective April 1, 1998, to obtain lower detection limits. Analytical/field methods/procedures from:

- *Test Methods for Evaluating Solid Waste Physical/Chemical Methods* (U.S. Environmental Protection Agency 1986)
- *Methods for Chemical Analysis of Water and Wastes* (U.S. Environmental Protection Agency 1983)
- *Environmental Surveillance Procedures Quality Control Manual* (Lockheed Martin Energy Systems, Inc. 1988)
- Lockheed Martin Energy Systems ASO radiological methods

2 NA - not applicable
Detection limits for metals/cations by inductively coupled plasma spectroscopy changed during the second quarter sampling event. The first detection limit was used until April; the second one listed was used thereafter.

3
ft - feet
µg/L - micrograms per liter
µmho/cm - micromhos per centimeter
mg/L - milligrams per liter
mV - millivolts
NTU - nephelometric turbidity units
ppm - parts per million
pCi/L - picoCuries per liter

4 Samples for dissolved metals analysis were collected using a 0.45-micron filter.

5 CRQL - contract-required quantitation limit

6 MDA - minimum detectable activity. The target MDA may be obtained under optimal analytical conditions; actual MDAs are sample-specific and may vary significantly from the target value.

Table 4. Summary of CY 1998 VOC results

Sampling Point			Summed VOCs[3]	Chlorinated Solvents[4]			Petroleum Hydrocarb.[5]	Misc. Compounds[6]
Identity[1]	Location[2]	Date		Ethenes	Ethanes	Methanes		
WESTERN PLANT AREA								
GW-108	S3	03/16/98	87	4	0	80	0	3
GW-108	S3	07/28/98	108	3	0	81	0	24
GW-192	B4	05/26/98	35	33	2	0	0	0
GW-192	B4	11/30/98	6	6	0	0	0	0
GW-251	S2	05/26/98	654	621	0	33	0	0
GW-251	S2	12/02/98	102	95	0	7	0	0
GW-332	WCPA	03/24/98	1880	1829	36	0	0	15
GW-618	EXP-E	06/01/98	35	35	0	0	0	0
GW-618	EXP-E	11/30/98	60	60	0	0	0	0
GW-620	FTF	05/26/98	107	105	0	0	2	0
GW-620	FTF	12/02/98	38	38	0	0	0	0
CENTRAL PLANT AREA								
56-2A	GRIDC3	03/23/98	59	59	0	0	0	0
56-2B	GRIDC3	03/23/98	999	998	1	0	0	0
56-2C	GRIDC3	03/24/98	1977	1977	0	0	0	0
59-1C	B9202	03/18/98	7	7	0	0	0	0
GW-193	T2331	03/16/98	144	0	0	0	144	0
GW-193	T2331	07/28/98	100	0	0	0	100	0
GW-686	CPT	03/23/98	7	7	0	0	0	0
GW-769	GRIDG3	05/19/98	23	10	0	13	0	0
GW-769	GRIDG3	11/11/98	26	12	0	14	0	0
GW-770	GRIDG3	05/19/98	7	0	0	7	0	0
GW-770	GRIDG3	11/10/98	14	0	0	14	0	0
GW-775	GRIDH3	06/17/98	6	6	0	0	0	0
GW-775	GRIDH3	11/18/98	4	4	0	0	0	0
GW-776	GRIDH3	06/17/98	2	2	0	0	0	0
GW-776	GRIDH3	11/18/98	5	5	0	0	0	0
GW-781	GRIDE3	05/20/98	52	51	1	0	0	0
GW-781	GRIDE3	11/11/98	11	11	0	0	0	0
GW-782	GRIDE3	05/20/98	446	344	102	0	0	0
GW-782	GRIDE3	11/12/98	495	333	162	0	0	0
GW-783	GRIDE3	05/20/98	14	12	1	1	0	0
GW-783	GRIDE3	11/12/98	75	59	14	2	0	0
GW-789	GRIDF3	05/18/98	4	3	0	1	0	0
GW-789	GRIDF3	11/09/98	7	6	0	1	0	0
GW-791	GRIDD2	05/20/98	332	332	0	0	0	0
GW-791	GRIDD2	11/16/98	70	70	0	0	0	0
GW-792	GRIDD2	05/20/98	6	6	0	0	0	0
GW-792	GRIDD2	11/16/98	5	5	0	0	0	0
GW-818	B9201-2	03/26/98	7	7	0	0	0	0
GW-820	B9201-2	03/26/98	8836	8835	1	0	0	0

Table 4 (continued)

Sampling Point			Summed VOCs[3]	Chlorinated Solvents[4]			Petroleum Hydrocarb.[5]	Misc. Compounds[6]
Identity[1]	Location[2]	Date		Ethenes	Ethanes	Methanes		
EASTERN PLANT AREA								
GW-148	NHP	05/27/98	13	13	0	0	0	0
GW-148	NHP	12/03/98	13	13	0	0	0	0
GW-153	NHP	05/28/98	93	3	0	90	0	0
GW-153	NHP	12/07/98	293	9	0	284	0	0
GW-383	NHP	06/01/98	666	666	0	0	0	0
GW-383	NHP	12/08/98	737	737	0	0	0	0
GW-605	EXP-I	03/12/98	4	0	0	4	0	0
GW-605	EXP-I	07/27/98	211	158	0	53	0	0
GW-606	EXP-I	03/12/98	288	8	0	280	0	0
GW-606	EXP-I	07/28/98	267	7	0	260	0	0
GW-763	GRIDJ3	05/27/98	2	2	0	0	0	0
GW-763	GRIDJ3	12/03/98	2	2	0	0	0	0
GW-845	EXP	05/21/98	1799	112	8	1660	0	19
PERIMETER MONITORING								
GW-220	NHP	05/28/98	467	33	0	433	0	1
GW-220	NHP	12/07/98	710	70	0	638	0	2
GW-722-10	EXP-J	02/18/98	128	14	0	112	0	2
GW-722-10	EXP-J	08/03/98	92	12	0	79	0	1
GW-722-14	EXP-J	02/19/98	1113	77	5	1018	0	13
GW-722-14	EXP-J	08/04/98	488	40	2	440	0	6
GW-722-17	EXP-J	02/25/98	1274	100	7	1151	0	16
GW-722-17	EXP-J	08/11/98	652	56	3	585	0	8
GW-722-20	EXP-J	02/24/98	801	93	7	686	0	15
GW-722-20	EXP-J	08/18/98	590	66	4	511	0	9
GW-722-22	EXP-J	02/26/98	539	60	4	468	0	7
GW-722-22	EXP-J	08/19/98	790	60	4	718	0	8
GW-722-26	EXP-J	02/26/98	15	0	0	0	15	0
GW-722-26	EXP-J	08/25/98	13	0	0	0	13	0
GW-722-32	EXP-J	03/05/98	2	0	0	2	0	0
GW-722-32	EXP-J	09/03/98	2	0	0	2	0	0
GW-722-33	EXP-J	01/21/98	2	0	0	2	0	0
GW-722-33	EXP-J	03/05/98	6	2	0	3	1	0
GW-722-33	EXP-J	09/03/98	2	0	0	2	0	0
GW-733	EXP-J	03/12/98	11	0	0	11	0	0
GW-733	EXP-J	07/27/98	14	1	0	13	0	0
LRSPW	EXP-SW	06/02/98	22	3	0	19	0	0

Table 4 (continued)

Notes:

1 GW - Groundwater Monitoring Well (also the 56- and 59- series)
GW-722- - Westbay™ sampling port in well GW-722
LRSPW - Lake Reality Emergency Spillway (surface water station)

2 B4 - Beta-4 Security Pits
B9201-2 - Building 9201-2
CPT - Coal Pile Trench
EXP - Exit Pathway (Maynardville Limestone) monitoring location:
- -E, -I, or -J: Maynardville Limestone Picket monitoring well
- -SW: Onsite spring or surface water station

FTF - Fire Training Facility
GRID - Comprehensive Groundwater Monitoring Plan Grid Location
NHP - New Hope Pond
S2 - S-2 Site
S3 - S-3 Ponds Site
T2331 - Tank 2331-U
WCPA - Waste Coolant Processing Area

3 Sum of all VOCs, in micrograms per milliliter. Only results with a sum greater than zero are shown on the table.

4 Ethenes = Summed chloroethenes (PCE, TCE, 1,2-DCE, 1,1-DCE, 1,1-DCE, vinyl chloride)
Ethanes = Summed chloroethanes (1,1,1-TCA, 1,1-DCA, chloroethane)
Methanes = Summed chloromethanes (carbon tetrachloride, chloroform, methylene chloride)

5 Petroleum hydrocarbons = summed benzene, ethylbenzene, toluene, xylenes (dimethylbenzene), and stryrene (degradation product of ethylbenzene).

6 Miscellaneous compounds = trichlorofluoromethane in all samples except for GW-108, which are acetone, bromoform, and 2-butanone (commonly detected in samples from this well). Anomalous results and/or artifacts (e.g., acrylonitrile) are not included.

Table 5. Long-term contaminant trends observed at monitoring locations sampled in CY 1998

Sampling Location[1]	Contaminant Type and Long-Term Trend[2]						
	Inorganics[3]		VOCs[4]			Radioactivity[5]	
	Nitrate	Uranium	Ethenes	Ethanes	Methanes	Alpha	Beta
Western Plant Area							
GW-108	●	○	.	.	○	.	✚
GW-192	.	.	●	.	.	.	.
GW-251	●	.	○	○	○	.	.
GW-332	○	.	●	●	.	.	.
GW-618	.	○	○	.	.	.	.
GW-620	○	.	●	.	.	.	.
Central Plant Area							
56-2A	.	.	○	.	.	.	.
56-2B	○	.	○	.	.	.	.
56-2C	.	.	○	.	.	.	.
59-1B	○	.	.	.	.	.	.
59-1C	.	.	○	.	.	.	.
GW-219	.	○	.	.	.	○	.
GW-686	.	.	○	.	.	.	.
GW-769	.	.	○	.	✚	.	.
GW-770	○	.	.	.	✚	.	.
GW-775	.	.	○	.	.	.	.
GW-776	○	.	○	.	.	.	.
GW-781	.	.	○	.	.	.	.
GW-782	.	.	✚	✚	.	✚	.
GW-783	.	.	○	○	.	.	.
GW-789	.	.	✚	.	.	.	.
GW-791	.	.	●	.	.	.	.
GW-792	○	.	○	.	.	.	.
GW-818	.	.	○	.	.	.	.
GW-820	.	.	○	.	.	.	.
Eastern Plant Area							
GW-148	.	.	✚	.	.	.	.
GW-220	.	.	✚	.	✚	.	.
GW-153	.	.	○	.	○	.	.
GW-380	○	.	.	.	.	.	.
GW-383	.	.	✚	.	.	.	.
GW-605	.	✚	○	.	○	✚	.
GW-606	○	.	○	.	●	.	.
GW-722	○	.	○	○	○		
GW-733	.	.	.	.	●	.	.
GW-845	.	.	○	○	○	.	.
LRSPW	✚	✚	○	.	○	.	.

Table 5 (continued)

Notes:

1 Only the CY 1998 sampling locations with elevated concentrations of the principal contaminants are included on the table. Data for 13 wells do not meet this criteria: 59-1A, GW-193, GW-207, GW-208, GW-687, GW-735, GW-744, GW-747, GW-750, GW-763, GW-788, GW-816, and GW-819. Howwever, samples from well GW-193 contain petroleum hydrocarbons (e.g., benzene) with a clearly decreasing long-term trend.

2 Trend types were interpreted from plots of concentration changes over time.

- ● - Generally decreasing trend.
- o - Indeterminant trend: insufficient data, fairly stable trend, or highly fluctuating with no clear upward or downward trend.
- ✚ - Generally increasing tend.
- . - Not a contaminant.

3 Nitrate concentration greater than or equal to 1 mg/L.
Total uranium concentration greater than or equal to 0.02 mg/L (proposed MCL).

4 Summed solvent concentration greater than or equal to 5 µg/L.

Ethenes = Summed chloroethenes (PCE, TCE, 12DCE, 11DCE, 11DCE, vinyl chloride)
Ethanes = Summed chloroethanes (111TCA, 11DCA, chloroethane)
Methanes = Summed chloromethanes (carbon tetrachloride, chloroform, methylene chloride)

5 Gross alpha activity greater than or equal to 15 pCi/L.
Gross beta activity greater than or equal to 50 pCi/L.

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