Y/SUB/96-KDS15V/3

Y-12

OAK RIDGE
Y-12
PLANT

LOCKHEED MARTIN

RECEIVED
DEC 20 1996
OSTI

CALENDAR YEAR 1995 GROUNDWATER QUALITY REPORT FOR THE BEAR CREEK HYDROGEOLOGIC REGIME Y-12 PLANT, OAK RIDGE, TENNESSEE

Part 2: 1995 Groundwater Quality Data Interpretations

August 1996

Prepared by

AJA TECHNICAL SERVICES, INC.
Under Subcontract 70Y-KDS15V

for the

Y-12 Plant Surveillance and Maintenance Program,
Environmental Restoration Division,
and the
Environmental Management Department
Health, Safety, Environment, and Accountability 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

8

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

UCN-13672 (26 6-95)

Y/SUB/96-KDS15V/3

CALENDAR YEAR 1995
GROUNDWATER QUALITY REPORT FOR THE BEAR CREEK HYDROGEOLOGIC REGIME Y-12 PLANT, OAK RIDGE, TENNESSEE

Part 2: 1995 Groundwater Quality Data Interpretations

August 1996

Prepared by

AJA TECHNICAL SERVICES, INC.
Under Purchase Order 70Y-KDS15V

for the

Y-12 Surveillance and Maintenance Program,
Environmental Restoration Division
and the
Y-12 Plant Environmental Management Department
Health, Safety, Environment, and Accountability 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

CONTENTS

List of Figures

List of Figures (cont'd)

List of Tables

List of Acronyms and Abbreviations

ASO	Analytical Services Organization
BCV	Bear Creek Valley
BCK	Bear Creek Kilometer
BG	Burial Grounds
bgs	below ground surface
Bear Creek Regime	Bear Creek Hydrogeologic Regime
CA	Characterization Area
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CY	Calendar Year
DNAPL	Dense, Non-Aqueous Phase Liquids
DOE	U.S. Department of Energy
East Fork Regime	Upper East Fork Poplar Creek Hydrogeologic Regime
Energy Systems	Lockheed Martin Energy Systems, Inc. (formerly Martin Marietta Energy Systems, Inc.)
EPA	U.S. Environmental Protection Agency
ft	feet
GWPP	Groundwater Protection Program
GWQR	Groundwater Quality Report
HCDA	Hazardous Chemical Disposal Area
HSEA	Health, Safety, Environment, and Accountability
ICP	Inductively Coupled Plasma (spectroscopy)
K-25	Oak Ridge K-25 Site
MCL	Maximum Contaminant Level
MDA	minimum detectable activity
msl	mean sea level
mrem/yr	millirem per year
µg/L	micrograms per liter
mg/L	milligrams per liter
NT	north tributary (Bear Creek)
PCE	Tetrachloroethene
pCi/L	picoCuries per liter
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation (CERCLA)
SESD	Sampling and Environmental Support Department
SS	South Side (Bear Creek)
TCE	Trichloroethene
TDEC	Tennessee Department of Environment and Conservation
TDS	Total Dissolved Solids
TSS	Total Suspended Solids

List of Acronyms and Abbreviations (cont'd.)

UTL	Upper Tolerance Limit
VOC	Volatile Organic Compound
WMA	Waste Management Area
yd^3	cubic yards
1,1-DCA	1,1-dichloroethane
1,1-DCE	1,1-dichloroethene
1,2-DCA	1,2-dichloroethane
1,2-DCE	1,2-dichloroethene
1,1,1-TCA	1,1,1-trichloroethane
^{99}Tc	Technetium-99
^{234}U	Uranium-234
^{235}U	Uranium-235
^{238}U	Uranium-238

1.0 INTRODUCTION

This annual groundwater quality report (GWQR) contains an evaluation of the groundwater and surface water monitoring data obtained during the 1995 calendar year (CY) for several hazardous and nonhazardous waste management facilities associated with the U.S. Department of Energy (DOE) Y-12 Plant located on the DOE Oak Ridge Reservation southeast of Oak Ridge, Tennessee (Figure 1). The U.S. Environmental Protection Agency (EPA) identification number for the Y-12 Plant is TN3 89 009 0001.

The sites addressed by this document are located in Bear Creek Valley (BCV) west of the Y-12 Plant complex (directions in this report are in reference to the Y-12 administrative grid system) within the Bear Creek Hydrogeologic Regime (Bear Creek Regime). The Bear Creek Regime is one of three hydrogeologic regimes defined for the purposes of groundwater and surface water quality monitoring at the Y-12 Plant (Figure 2).

The Environmental Management Department of the Y-12 Plant Health, Safety, Environment, and Accountability (HSEA) Organization manages the groundwater and surface water monitoring activities in the Bear Creek Regime under the auspices of the Y-12 Plant Groundwater Protection Program (GWPP). The purpose of the GWPP is to characterize the hydrogeology and to monitor groundwater quality at the Y-12 Plant and surrounding area to provide for protection of groundwater resources consistent with federal, state, and local requirements and in accordance with DOE Orders and Lockheed Martin Energy Systems, Inc. (Energy Systems) corporate policy.

Two-part GWQRs for the Bear Creek Regime have been issued annually by the Y-12 Plant HSEA Organization since 1989 (GWQRs for individual waste sites were issued from 1986 to 1988). Each annual Part 1 GWQR consists primarily of data appendices, and serves as a consolidated reference for the groundwater and surface water monitoring data obtained each CY under the lead of the Y-12 Plant GWPP. Part 1 GWQRs contain information needed to comply with Resource Conservation and Recovery Act (RCRA) reporting requirements and have been submitted to the Tennessee Department of Environment and Conservation (TDEC) by the RCRA reporting deadline (March 1 of the following CY). Each annual Part 2 GWQR addresses RCRA interim status reporting requirements regarding assessment of the horizontal and vertical extent of groundwater contamination. Part 2 GWQRs typically include a data quality evaluation, a regime-wide assessment of groundwater and surface water contamination, a summary of the findings and status of ongoing hydrogeologic studies, a description of regulatory developments and changes in monitoring priorities, and an outline of modifications planned for the Y-12 Plant GWPP during the following CY. These historical functions of the Part 1 and Part 2 GWQRs have been substantially changed by two key developments: the RCRA post-closure permit issued by the TDEC for the Bear Creek Regime, and completion of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) remedial investigation (RI) for the BCV Characterization Area.

The final RCRA post-closure permit modification for the Bear Creek Regime established groundwater monitoring and data reporting requirements for RCRA interim status sites effective September 12, 1995. In lieu of continued quarterly RCRA interim status assessment monitoring and annual data reporting, the post-closure permit requires long-term semiannual surveillance/corrective action monitoring and semiannual data reporting. Because the permit modification was not effective until late in the year, the CY 1995 Part 1 GWQR submitted to the TDEC in February 1996 met the data reporting requirements of both RCRA interim status assessment monitoring, and RCRA post-closure monitoring (Energy Systems 1996).

The draft RI report for the Bear Creek CA contains detailed conceptual hydrologic and contaminant transport models that largely explain the observed extent of groundwater (and surface water) contamination in the Bear Creek Regime (Science Applications International Corporation, Inc. 1996). These conceptual models, which incorporate the bulk of the geologic, hydrologic, and water quality databases maintained by the Y-12 Plant GWPP, essentially represent the culmination of hydrogeologic characterization and contamination assessment efforts performed since the mid-1980s.

The format of this report has been modified to accommodate the transition to the RCRA post-closure data reporting requirements, and to reflect the results of the RI for the Bear Creek CA. This report includes background information regarding the extent of groundwater and surface water contamination in the Bear Creek Regime based on the conceptual models described in the RI report (Section 2); a summary of the groundwater and surface water monitoring activities performed during CY 1995 (Section 3.0); analysis and interpretation of the CY 1995 monitoring data for groundwater

(Section 4.0) and surface water (Section 5.0); a summary of conclusions and recommendations (Section 6.0); and a list of cited references (Section 7.0). Appendix A contains supporting maps, diagrams, and graphs; data tables and summaries are in Appendix B. Appendix C describes the evaluation and decision criteria for data screening.

2.0 BACKGROUND INFORMATION

The following sections provide a general overview regarding the extent of groundwater and surface water contamination the Bear Creek Regime. Included are a summary of the key hydrologic characteristics of the groundwater and surface water flow systems, brief descriptions of the primary sources of groundwater and surface water contamination, and an overview of the current conceptual models for contaminant migration and transport.

2.1 Hydrologic Framework

The RI report for the Bear Creek CA presents a conceptual hydrologic model for BCV that incorporates: (1) the general hydrologic framework and associated nomenclature described in Solomon et al. (1992); (2) groundwater flow characteristics presented in Moore (1988 and 1992) and Moore and Toran (1992); (3) results of hydrologic studies and investigations in BCV, including Dreier et al. (1987), Shevenell (1994), and Turner et al.(1991); and (4) findings of sampling and analysis activities performed specifically for RI purposes (Science Applications International Corporation, 1996). Key aspects of the conceptual hydrologic model, including the geology of the Bear Creek Regime, the principal hydrogeologic units and respective groundwater flow characteristics, and the general hydrology of Bear Creek are summarized in the following discussion.

Geology

The geology of the Bear Creek Regime is characterized by alternating sequences of clastic and carbonate strata that form the distinctive topography of the Valley and Ridge Physiographic Province. Near the Y-12 Plant, 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 3). 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 50 feet (ft) of several materials, including man-made fill, alluvium, colluvium, fine-grained residuum from the weathering of the bedrock, and saprolite (weathered bedrock). In some areas the saprolite retains primary textural features of the bedrock.

Groundwater System

The Rome Formation, Conasauga Group, and Knox Group comprise two basic hydrogeologic units: (1) the Aquifer, consisting of the Maynardville Limestone (upper Conasauga Group) and Copper Ridge Dolomite (lower 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 Rome Formation (Figure 3). The Aquifer floors the southern portion of BCV (Maynardville Limestone) and forms the steep flank of Chestnut Ridge (Copper Ridge Dolomite), and the Aquitard formations form the northern slope of BCV toward Pine Ridge (Figure 3). The Aquitard, which underlies the primary contaminant source areas in the Bear Creek Regime, is hydraulically upgradient of the Aquifer, which functions as a hydrologic drain in BCV and provides the principal avenues for contaminant transport. Fractures provide the principal groundwater flowpaths in both units, 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 porous rock matrix plays an important role in contaminant migration because of matrix diffusion processes.

The water table in the Bear Creek Regime, under both seasonally high and low flow conditions, is a subdued replica of surface topography, with steep gradients along the flanks of Pine Ridge and Chestnut Ridge and a gentle slope down the axis of BCV (Figure 4). Horizontal hydraulic gradients average about 0.038 across BCV (strike-normal) in the Aquitard, and about 0.011 along the axis of BCV (strike-parallel) in the Aquifer (Maynardville Limestone). Groundwater 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 hydraulic gradient inferred from water level isopleths. Flow tangent to bedding occurs primarily along permeable zones formed by cross-cutting fractures or fracture zones (and possibly small faults). The northern tributaries of Bear Creek are probably the surficial expression of these cross-cutting structures, which provide preferred flowpaths that channel groundwater from the Aquitard to the Aquifer. Additionally, 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.

In the Aquitard, most groundwater flow occurs in a highly conductive interval near the bedrock/residuum interface (the water table interval). Below the water table interval, flow is most active at depths less than 100-ft below ground surface (bgs); however, contaminants in groundwater more than 200-ft bgs in the Nolichucky Shale clearly indicate permeable flowpaths at depth. Flow occurs in response to precipitation when flowpaths in the residual soils become saturated and rapidly transmit water laterally (stormflow) down slope toward springs and seeps in drainage features, and vertically (recharge) to the water table interval. Inflow into the water table interval promotes strike-parallel groundwater flow toward discharge areas in nearby cross-cutting streams. Only a small percentage of total flow ultimately recharges to the deeper bedrock, where upward hydraulic gradients predominate. Overall, about 94% of the available groundwater in the Aquitard discharges to Bear Creek tributaries, about 5% flows along cross-cutting fractures into the Aquifer, and about 1% flows through strike-parallel pathways in the deeper subsurface (Science Applications International Corporation 1996).

Decreasing groundwater flux with depth in the Aquitard also is reflected by distinct changes in groundwater geochemistry. Most water table interval and shallow (i.e., <100-ft bgs) bedrock wells monitor calcium-magnesium-bicarbonate groundwater. A fairly abrupt change to sodium-bicarbonate groundwater occurs at a depth of about 100-ft bgs, and is interpreted to be a function of longer groundwater residence time related to reduced fracture aperture or increased fracture spacing (Solomon et. al. 1992). Further reduced groundwater flux is indicated by a transitional change from sodium-bicarbonate groundwater to sodium-chloride groundwater that occurs at a depth of about 400-ft bgs. The transition to the sodium-chloride groundwater is accompanied by a general increase in total dissolved solids (TDS).

Most groundwater flow in the Aquifer occurs at shallow depths (i.e., <100-ft bgs) in an extensively interconnected maze of solution conduits and cavities (karst network). Below the shallow karst network, fractures provide the primary flowpaths. Flow in the shallow karst network is relatively rapid, and during rainfall, occurs as quickflow discharge to Bear Creek. Active groundwater circulation occurs at greater depth than in the Aquitard, and groundwater from the deeper flow system discharges along major gaining (influent) reaches of Bear Creek channel. These discharge areas are probably related to large-scale structural (e.g., cross-strike faults) or stratigraphic discontinuities in the Maynardville Limestone. Overall, about 81% of the available groundwater in the Aquifer (Maynardville Limestone) discharges directly to Bear Creek, 16% flows into the creek from spring SS-5, and 3% follows strike parallel flowpaths in the subsurface (Science Applications International Corporation, Inc. 1996).

Groundwater geochemistry is more homogeneous in the Aquifer; virtually every monitoring well in the Maynardville Limestone, regardless of depth, monitors calcium-magnesium-bicarbonate groundwater. Some shallow wells monitor sulfate-enriched groundwater, which probably reflects dissolution of locally disseminated sulfides, and several deep wells monitor calcium-magnesium-sulfate groundwater with very high TDS (i.e., >1,000 mg/L). Overall, however, the higher hydraulic conductivity and greater depth of active groundwater circulation in the Aquifer impart more geochemical homogeneity in comparison to that of the Aquitard.

Surface Water System

Surface water is drained by Bear Creek and its tributaries (Figure 3). Locations along the main channel are specified by the Bear Creek kilometer (BCK) value corresponding to the distance from the confluence with East Fork Poplar Creek (e.g., BCK-09.40). Tributaries are designated as north (e.g., NT), or south, along with a value representing the tributary number counted downstream from the headwaters (e.g., NT-1). Major springs along the south side of Bear Creek are numbered in ascending order from the headwaters (e.g., south side [SS]-1).

Approximately half of the annual precipitation in BCV exits via surface water flow in Bear Creek, and possibly higher proportions during winter and early spring. Flow in the creek increases rapidly during rainfall, and afterward reflects the relative contributions of overland flow, stormflow, and groundwater discharge. Flow in the main channel and tributaries generally returns to pre-precipitation levels within one or two days. The main channel between NT-3 and NT-8 is seasonally dry, but flow is perennial in the channel downstream from the primary gauging station (BCK-09.40).

The main channel of Bear Creek functions as a major conduit of the shallow karst network within the Maynardville Limestone. Discharge from numerous springs located along the Maynardville Limestone/Copper Ridge Dolomite boundary on the north slope of Chestnut Ridge dominate the hydrology of the creek, especially during droughts when they provide most of the flow in the main channel. Additionally, the main channel contains alternating gaining and losing reaches. Each gaining reach generally correlates with a major Aquifer discharge area. Losing reaches in the upper part of BCV, particularly south of Sanitary Landfill I, play an important role in transferring contaminants from Bear Creek to the Aquifer.

2.2 Contaminant Source Areas

Table 1 lists all of the waste management sites in the Bear Creek Regime and their current regulatory status. Figure 5 shows the location of each site. Principal sources of groundwater and surface water contamination in the regime are the S-3 Site, the Rust Spoil Area, the Oil Landfarm Waste Management Area (WMA), and the Bear Creek Burial Grounds WMA. Each of these sites has been inactive since the late 1980s, and most have undergone some level of engineered closure (e.g., installation of multilayer covers). Brief descriptions of these sites are provided below; detailed descriptions of all the sites in the regime are provided in the Part 1 GWQR.

S-3 Site

The S-3 Site (formerly the S-3 Ponds) is a closed RCRA surface impoundment near the headwaters of Bear Creek and the groundwater flow divide between the Bear Creek Regime and the Upper East Fork Poplar Creek Hydrogeologic Regime (East Fork Regime) (Figure 5). The site consisted of four unlined ponds used between 1951 and 1984 for disposal of acidic, radioactive liquid wastes. Each 400 x 400-ft pond was about 17-ft deep and had a storage capacity of about 2.5 million gallons.

Rust Spoil Area

The Rust Spoil Area is a 5.4-acre site located southwest of the S-3 Site (Figure 5) that was used between 1975 and 1983 for disposal of approximately 100,000 cubic yards (yd^3) of solid wastes (spoil) generated during various renovation, maintenance, and construction operations at the Y-12 Plant. Waste materials were primarily nonradioactive soil, masonry, and concrete with steel rebar, but also may have included materials containing solvents, asbestos, mercury, and uranium. Closure of the site was completed in 1984.

Oil Landfarm WMA

The Oil Landfarm WMA consists of the Oil Landfarm, the Boneyard/Burnyard, and Sanitary Landfill I (Figure 6). The Oil Landfarm was used between 1973 and 1982 for the biodegradation of about one million gallons of waste oil and machine coolants via landfarming, a process involving application of the wastes to nutrient-adjusted soil during the dry months of the year (April to October).

The Boneyard/Burnyard was an active waste disposal site from 1943 to 1981. It consists of three waste disposal sites: the Boneyard, the Burnyard, and the Hazardous Chemical Disposal Area (HCDA), which was constructed over top of the Boneyard/Burnyard in 1975. These sites received an unknown quantity of various inorganic, organic, and radioactive wastes, including solids, liquids, and sludges.

Sanitary Landfill I was used between 1968 and 1980 for disposal of approximately 105,000 yd^3 of combustible and decomposable solid wastes from the Y-12 Plant, some of which may have included toxic chemicals. Disposal trenches at the landfill were excavated to depths of about 20-ft and backfilled to about 15-ft above grade. The landfill was graded and capped in 1985.

Bear Creek Burial Grounds WMA

The Burial Grounds WMA consists of several waste disposal areas designated Burial Grounds (BG)-A, -B, -C, -D, -E, and -J; the Walk-In Pits; the Uranium Vaults; and the Oil Retention Ponds (Figure 7). Each waste disposal area consisted of shallow (i.e., <25-ft bgs) trenches. During operations, a variety of disposal practices were used for a diverse mixture of solid wastes (1955 to 1993) and liquid wastes (1959 to 1979) from the Y-12 Plant, all or most of which contained varying amounts of radioisotopic contamination.

2.3 Groundwater Contamination

The RI for the Bear Creek CA describes contaminant transport models for the primary source areas: the S-3 Site, the Oil Landfarm WMA, and the Bear Creek Burial Grounds WMA; and the principal contaminant migration pathway: the Maynardville Limestone and Bear Creek (Science

Applications International Corporation, Inc. 1996). Key components of each conceptual model are summarized below; aspects regarding surface water are described in Section 2.4.

S-3 Site

Operation of the S-3 Site emplaced a large reservoir of contamination in the Aquitard (Nolichucky Shale) driven downward by the elevated hydraulic head in the ponds and the higher density of the acidic liquid wastes, which locally enlarged migration pathways in carbonate-rich horizons. The principal contaminants are nitrate, technetium-99 (^{99}Tc), uranium isotopes (^{234}U, ^{235}U, and ^{238}U), trace metals (e.g., cadmium), and volatile organic compounds (VOCs). These contaminants were transported along preferred migration pathways in the shallow subsurface (water table interval) toward the upper reaches of Bear Creek, and along deeper, strike-and dip-parallel pathways in bedrock.

As indicated by the distribution of nitrate, a highly mobile and chemically stable contaminant that delineates the maximum extent of transport in the Aquitard and effectively traces the principal migration pathways, operation of the S-3 Site produced an intermingled contaminant plume that extends downdip at least 400-ft bgs, and along strike at depth for over 3,000-ft to the west (Figure 8). Nitrate (as N) concentrations (hereafter synonymous with "nitrate" concentrations) within the plume exceed 10,000 milligrams per liter (mg/L) in the shallow groundwater near the site, and 10 mg/L near the plume boundaries. Gross alpha activity and gross beta activity within the plume exceeds 1,000 picoCuries per liter (pCi/L) in the groundwater near the site. Although a diverse population of radioisotopes may be present in the groundwater closest to the site, elevated gross alpha and gross beta activity in the groundwater (Figure 8) probably delineate migration of uranium isotopes, and Tc^{99}, respectively. The distribution of trace metals is less than that of nitrate and radioactivity, and concentrations are generally highest in the low pH groundwater within about 500-ft of the site. Also, acetone and tetrachloroethene (PCE) are the principal VOCs, and concentrations in wells adjacent to the site exceed 5,000 micrograms per liter (µg/L), suggesting that dense nonaqueous phase liquids (DNAPLs) are present in the subsurface.

When closed, the S-3 Site contained several feet of sludge produced by denitrification of the waste water. Sludges within the saturated zone may release ^{99}Tc and uranium isotopes to the shallow groundwater flow system in the Aquitard, which then may be transported through the water table interval toward discharge points in NT-1 to the west of the site. Additionally, matrix diffusion and advective transport processes are slowly releasing contaminants (e.g., nitrate) from the deeper reservoir into the more active (shallow) Aquitard flow system.

In the Aquitard, the current plume of groundwater contamination from the S-3 Site is probably at maximum extent, with the center of mass moving slowly along strike towards NT-2. Migration along strike is expected to continue until the plume encounters a cross-cutting structure that forces upward discharge into the shallow flow system in the Aquitard, or cross-strike flow into the Aquifer (Maynardville Limestone).

Oil Landfarm WMA

The primary sources of groundwater contaminants in the Oil Landfarm WMA (listed in order of importance) are the Boneyard/Burnyard, Oil Landfarm, and Sanitary Landfill I (Figure 6). Each is a source of VOCs in the shallow groundwater. The Boneyard/Burnyard also is a major source of elemental uranium and alpha radioactivity.

Uranium isotopes are the principal groundwater radiological contaminants at the Boneyard/Burnyard. Contamination in soils and results of geophysical and radiological surveys indicate a major source area located immediately northwest of the HCDA cap. Wastes in the Boneyard/Burnyard are probably within the saturated zone during seasonally high groundwater levels, and uranium isotopes may be leached and transported with the shallow groundwater that discharges into Bear Creek tributary NT-3 or directly into the Maynardville Limestone. Gross alpha and gross beta activity exceed 1,000 pCi/L in the shallow groundwater along NT-3 from the northwest corner of the site to the confluence of NT-3 and Bear Creek (Figure 8). The site also is the source of a dissolved VOC plume in the shallow groundwater. Primary components of the VOC plume are trichloroethene (TCE), 1,2-dichloroethene (1,2-DCE), and PCE. Concentrations of the VOCs are less than one percent of solubility, indicating that DNAPLs are probably not present in the subsurface. The HCDA is probably the principal source of these VOCs, as indicated by the lack of these constituents in surface water at NT-3, and their areal distribution relative to the radioactivity plume originating from elsewhere in the Boneyard/Burnyard (Figure 8).

Groundwater contaminants at the Oil Landfarm are principally VOCs, and two distinct plumes are evident: one to the northeast dominated by 1,1,1-trichloroethane (1,1,1-TCA), 1,1-dichloroethane (1,1-DCA), and 1,1-dichloroethene (1,1-DCE); and one to the south dominated by PCE, 1,2-DCE, trans-1,2-DCE, and TCE. Concentrations of these compounds exceed 1,000 µg/L in the northeast plume, and 100 µg/L in the southern plume (Figure 8). Both plumes appear to be restricted to the shallow flow system. Maximum concentrations within the plumes do not indicate the presence of DNAPLs in the subsurface.

Sanitary Landfill I is a probable source of 1,1-DCA, 1,2-DCE, and trans-1,2-DCE in the shallow groundwater (Aquitard and Aquifer) downgradient to the south of the site (Figure 8). Maximum VOC concentrations are typically less than 50 µg/L. In the Aquifer (Maynardville Limestone), these constituents have intermingled with the VOC plume (primarily TCE and 1,2-DCE) originating from upgradient sources.

Bear Creek Burial Grounds WMA

Groundwater in the Aquitard underlying the Bear Creek Burial Grounds WMA is extensively contaminated with VOCs at both shallow (water table) and deep (bedrock) intervals (Figure 8). There are five primary source areas: BG-A North, BG-A South, BG-C East, BG-C West, and the Walk-In Pits. Dissolved VOC plumes in the groundwater at several of these source areas are probably related to widespread occurrence of DNAPLs in the subsurface. Contamination in the deeper groundwater flow system reflects density-driven, downward migration of DNAPL.

The disposal trenches comprising BG-A North and BG-A South received almost two million gallons of waste oils and coolants, and DNAPLs have been encountered at 260-ft and 330-ft bgs in monitoring wells downdip of source trenches in BG-A South. Dissolved VOC plumes in the groundwater underlying both areas are dominated by high summed concentrations (i.e., 10,000 µg/L) of PCE, TCE, and 1,2-DCE. Other common plume constituents are 1,1,1-TCA, 1,1-DCA, and 1,2-dichloroethane (1,2-DCA). Groundwater in the shallow water table interval transports the plume constituents along strike toward discharge areas in NT-7. Strike parallel migration also occurs below the water table interval, as reflected by westward (strike-parallel) transport of PCE indicated by data obtained since 1990 from deeper bedrock wells at BG-A South.

Separate plumes of dissolved VOCs apparently occur in the shallow groundwater at BG-C East and BG-C West (Figure 8), both dominated by 1,2-DCE with lesser amounts of vinyl chloride. Concentrations within the plume are generally less than 500 µg/L. Groundwater containing these VOCs (and their degradation products) discharges to the NT-8 catchment on the northwest side of the Burial Grounds WMA. Data for both source areas do not clearly indicate the presence of DNAPLs in the subsurface.

Groundwater near the Walk-In Pits contains a distinct plume of dissolved VOCs dominated by PCE. Concentrations exceed 2,000 µg/L, which is about 1% of the maximum PCE solubility and possibly indicates DNAPLs in the subsurface. Contaminants in the shallow groundwater flow system may not discharge extensively to surface water.

Although large quantities of uranium wastes were disposed in the Bear Creek Burial Grounds WMA, few monitoring wells in the area yield radioactive groundwater samples (Figure 8). However, RI data for soil samples, and surface water samples collected from Bear Creek tributaries NT-6, NT-7, and NT-8 indicate that BG-A South and BG-C East are probable sources of radioactivity. Maximum gross alpha and gross beta activities in the samples from these tributaries ranged from about 20 pCi/L to more than 100 pCi/L. The disparity with the groundwater sample data is probably an artifact of the monitoring well network; none of the wells are screened within the shallowest water table interval where radioactive contamination likely occurs.

Boron is the primary trace metal contaminant in the groundwater at the Bear Creek Burial Grounds WMA. Elevated boron concentrations occur primarily in the shallow groundwater near BG-A (South) and BG-C (East and West), and resulted from disposal of borax waste waters from the Y-12 Plant. The boron is probably present in the groundwater as borate [$B(OH)_3$], which is chemically stable and relatively mobile, and is transported toward discharge points in Bear Creek tributaries NT-7 and NT-8.

Maynardville Limestone Exit Pathway

Primary groundwater contaminants in the Maynardville Limestone are nitrate, VOCs, radioactivity, and trace metals. As summarized below, these contaminants originate from several sources and enter the Maynardville Limestone via direct recharge, hydrologic communication with surface water in Bear Creek, inflow of shallow groundwater from the Aquitard, or a combination of these factors.

Source Area	Primary Contaminants	Maynardville Input Pathway
S-3 Site	Nitrate, ^{99}Tc, Uranium isotopes, Boron, Strontium, Uranium (total) VOCs (acetone and PCE)	Infiltration of surface water from NT-1 and NT-2, and shallow (Aquitard) groundwater inflow.
Rust Spoil Area	VOCs (TCE and 1,2-DCE)	Direct recharge.
Boneyard/Burnyard	Uranium isotopes, VOCs (TCE and 1,2-DCE)	Direct recharge, and inflow/recharge of shallow (Aquitard) groundwater/surface water via the from NT-3 catchment.
Sanitary Landfill I	VOCs (1,1,1-TCA and 1,1-DCA)	Inflow of shallow (Aquitard) groundwater.
Burial Grounds WMA	VOCs (TCE, 1,2-DCE and 1,1-DCA), Boron	Infiltration of surface water and inflow of shallow (Aquitard) groundwater from NT-7 and NT-8 catchments.

Contributions from the source areas have generally produced two primary plumes of contamination in the groundwater: one containing nitrate and radioactivity, and another containing VOCs (trace metal contaminants are more sporadic and chiefly occur close to the primary source areas). Both plumes occur in the shallow karst network and the deeper fracture flowpaths, and are commingled throughout much of the Bear Creek Regime.

The nitrate plume originates from the S-3 Site and extends along strike in the Maynardville Limestone for more than 9,000-ft down BCV to the west (Figure 8). Nitrate essentially delineates the maximum extent of contaminant transport in the Aquifer, and the plume effectively traces the primary migration pathways followed by all groundwater contaminants. Concentrations within the plume exceed 500 mg/L south of the S-3 Site, but rapidly decrease to less than 50 mg/L south of the Oil Landfarm WMA. Additionally, concentrations are highest in the deeper, fracture-dominated groundwater flow system. Lower concentrations in the shallow karst network are probably the combined effect of greater groundwater circulation, and interaction with the less contaminated surface water in Bear Creek. Downgradient along strike to the west of the S-3 Site, long-term nitrate concentration trends are overshadowed by annual variations related to seasonal groundwater flow conditions.

In the upper part of BCV, the distribution of gross alpha and gross beta activity in the Maynardville Limestone tends to mirror that of nitrate, indicating both a common source area (the S-3 Site) and migration along common flowpaths (Figure 8). Increased gross alpha activity in the groundwater downstream of the NT-3 catchment reflects inputs of uranium isotopes from sources in the Boneyard/Burnyard.

The distribution of VOCs in the Maynardville Limestone reflects the relative contributions of several source areas, and commingling during downgradient transport along strike (Figure 8). Plume constituents in the upper part of BCV are TCE, 1,2-DCE, and PCE; probable source areas are Spoil Area I, the S-3 Site, and possibly the Fire Training Facility (located in the East Fork Regime). Additional inputs to the plume occur from the Rust Spoil Area (TCE), Boneyard/Burnyard (TCE and 1,2-DCE), Sanitary Landfill I (1,1,1-TCA and 1,1-DCA), and discharge from the Bear Creek tributary (NT-7) that traverses BG-A North and A South (1,2-DCE and 1,2-DCA). The highest concentrations within the plume (i.e., >300 µg/L) occur in the deeper groundwater south (down dip) of the Boneyard/Burnyard. These high concentrations coincide with the downward vertical hydraulic gradients in the Maynardville Limestone in this area, and the major losing reach of Bear Creek south of Sanitary Landfill I.

Trace metal contamination is not extensive in the Maynardville Limestone. Most of the contamination occurs near the S-3 Site and the Boneyard/Burnyard. The principal trace metal contaminants are barium, boron, cadmium, copper, lead, mercury, strontium, and uranium. Of these, boron and uranium are the most widespread, indicating that relatively mobile, ionic species of both metals are present in the groundwater.

2.4 Surface Water Contamination

As summarized below, nitrate and radioactivity are the principal surface water contaminants in Bear Creek and its tributaries (sampling points are listed in order downstream of the headwaters).

Sampling Point	Surface Water Contaminants	Contaminant Source Area(s)
NT-1	Nitrate, alpha and beta radioactivity, trace metals, PCE.	Shallow groundwater (Aquitard) plume from the S-3 Site.
SS-1	Nitrate, alpha and beta radioactivity, barium, cadmium, manganese, uranium isotopes, ^{99}Tc, TCE and PCE.	Shallow groundwater (Aquifer) plume from the S-3 Site.
NT-2	Nitrate, beta radioactivity.	Upward migration of groundwater (Aquitard) plume from the S-3 Site.
BCK-11.97	Nitrate, alpha and beta radioactivity, uranium.	Surface water discharge from NT-1 and NT-2, and shallow groundwater (Aquifer/Aquitard) plume from the S-3 Site.
NT-3	Alpha radioactivity, lithium, uranium isotopes.	Shallow groundwater (Aquitard) plume from the Boneyard/Burnyard.
SS-4	Nitrate, alpha and beta radioactivity, boron, lithium, strontium, uranium isotopes, ^{99}Tc, TCE and 1,2-DCE.	Deep groundwater (Aquifer) plume from the S-3 Site, and shallow groundwater plume from the Boneyard/Burnyard.
NT-6	Alpha and beta radioactivity, TCE and 1,2-DCE.	Shallow groundwater (Aquitard) plume from BG-A North and BG-A South.
NT-7	Alpha and beta radioactivity, PCE, TCE, and 1,2-DCE.	Same as NT-6.
NT-8	Alpha and beta radioactivity, beryllium, mercury, and 1,2-DCE.	Shallow groundwater (Aquitard) plume from BG-C East and BG-C West.
SS-5	Nitrate, alpha and beta radioactivity, boron, strontium, uranium isotopes, TCE, and 1,2-DCE.	Deep groundwater (Aquifer) plume from the S-3 Site.
BCK-09.40	Nitrate, alpha and beta radioactivity, boron, lithium, strontium, uranium isotopes, PCE, TCE, and 1,2-DCE.	Downstream contaminant transport in Bear Creek, discharge from NT-7 and NT-8.

The water quality in Bear Creek improved dramatically after disposal operations at the S-3 Site ceased in 1983. Nitrate concentrations in upper Bear Creek at BCK-12.46, for example, exceeded 1,000 mg/L in 1983, but were less than 200 mg/L in 1994. Additionally, input from several northern tributaries (primarily NT-1, NT-2, NT-3, and NT-8) currently contribute the bulk of the contamination to the creek during seasonally high flow conditions. During dry periods, contaminant flux into Bear Creek is generally controlled by groundwater discharge from springs SS-4 and SS-5.

3.0 CY 1995 GROUNDWATER AND SURFACE WATER SAMPLING

Groundwater and surface water sampling in the Bear Creek Regime during CY 1995 was performed in general accordance with the *Sampling and Analysis Plan for Groundwater and Surface Water Monitoring at the Y-12 Plant during Calendar Year 1995* (Sampling and Analysis Plan) (HSW Environmental Consultants, Inc. 1994). Deviations from the Sampling and Analysis Plan were documented in addenda issued by the Y-12 Plant GWPP Manager throughout the year. The following sections provide an overview of these sampling and analysis activities, including information regarding the sampling locations, frequency, and procedures, analytical parameters, and a discussion of the results of quality assurance/quality control (QA/QC) sampling.

3.1 Sampling Locations

Groundwater and surface water samples were collected from a total 91 monitoring wells, ten springs, three seeps, and nine surface water stations (Table 2). As described in Section 3.1 of the Part 1 GWQR, sampling was performed for the purposes of the monitoring programs listed below, with some wells, springs/seeps, and surface water sampling stations serving multiple programmatic purposes (Energy Systems 1996).

Monitoring Programs	Monitoring wells	Spring/Seeps	Surface Water Stations
RCRA Corrective Action Monitoring	23	.	.
RCRA Interim Status Assessment Monitoring	5	.	.
DOE 5400.1 Exit Pathway and Perimeter Monitoring	10	9	6
DOE Order 5400.1 Surveillance Monitoring	18	.	.
Best-Management Practice Monitoring	20	.	.
BCV RI Special Sampling	23	8	5

Locations of the monitoring stations are shown on Figure 9. Selected construction information for the monitoring wells is summarized on Table 3; detailed well construction data are provided in Appendix C of the Part 1 GWQR. Approximately 20 monitoring wells in the Maynardville Limestone comprise exit pathway pickets, each of which consist of a series of wells completed at various depths along a strike-normal transect across the formation. Four pickets (designated Exit Pathway Picket A, B, C, and W) are located in the Bear Creek Regime (Figure 9).

Figure 9 also shows the locations of the surface water sampling stations, springs, and seeps. As part of a field survey performed in July 1996 by the Y-12 Plant GWPP personnel to verify all spring and surface water sampling stations along Bear Creek, it was determined that sampling station BCK-00.63 had been incorrectly designated when it was first included in routine GWPP monitoring in CY 1990, and that the sampling station was actually located at BCK-03.87 (Figure 9). Although the CY 1995 data was reported with the BCK-00.63 designation, evaluation and presentation of the data was based on the corrected sampling point designation (BCK-03.87).

3.2 Sampling Frequency

Groundwater and surface water samples were collected during each quarter of CY 1995; first through fourth quarter sampling events were performed January 11 to March 31, May 3 to June 28, July 19 to September 27, and October 10 to December 11, respectively. The number of monitoring wells, springs/seeps, and surface water sampling stations included in each quarterly sampling event varied depending on the requirements of the governing monitoring programs, or the targeted sampling objectives (Table 2). Overall, groundwater samples were collected quarterly from 39 wells; semiannually from 29 wells and eight springs; and once from 23 wells, three seeps, and two springs. Surface water samples were collected semiannually from six stations, and once from three stations.

3.3 Sample Collection

Personnel from the Oak Ridge K-25 Site (K-25) Sampling and Environmental Support Department (SESD) collected groundwater samples from the monitoring wells; personnel from the Y-12 Plant Compliance Monitoring Services Section of the HSEA Organization assisted with collection of samples from some springs, seeps, and surface water stations. Sampling was performed in accordance with the most recent version of the technical procedure for groundwater sampling (SESD-TP-8204) and surface water sampling approved by the Y-12 Plant GWPP Manager.

Filtered and unfiltered samples were collected from each location; filtering was performed in the field with an in-line 0.45 micron filter. To reduce the potential for cross-contamination, samples were generally collected in sequence from the least contaminated wells to the most contaminated wells in each sampling group (a series of monitoring wells grouped for sampling and data-tracking purposes). Samples for the springs and surface water stations were collected from the farthest downstream (least contaminated) location (BCK-00.63) to the farthest upstream location (NT-01).

Quality assurance/quality control samples included 89 laboratory blanks, 137 trip blanks, two field blanks, 40 equipment rinsate samples, and 26 duplicate groundwater samples. Laboratory blanks were samples of deionized water analyzed along with a specific number of associated groundwater and surface water samples. Trip blanks were samples of deionized water transported in each cooler containing groundwater and surface water samples scheduled for VOC analysis. Field blanks were samples of deionized water collected at the well head before samples were collected from selected wells. Equipment rinsates were samples of the deionized water that was used to decontaminate the groundwater sampling equipment, and were collected after a sampling team had completed sampling at a site or finished a sampling group. If more than one pump was used to collect the groundwater samples within a sampling group, an equipment rinsate sample was collected from each pump.

3.4 Laboratory Analysis

The bulk of the groundwater and surface water samples collected during CY 1995 were analyzed for a standard suite of analytes that included:

- principal cations (calcium, magnesium, potassium, and sodium) and anions (carbonate and bicarbonate alkalinity, chloride, fluoride, nitrate, and sulfate);
- trace metals (the term used to differentiate metals that are typically minor groundwater constituents, such as cobalt and nickel, from metals that occur as principal ionic constituents, such as magnesium and sodium);
- VOCs;

- gross alpha activity and gross beta activity;
- total suspended solids (TSS), TDS, and turbidity;
- field and laboratory determinations of pH and specific conductance, and;
- field determinations of temperature, dissolved oxygen, and oxidation-reduction potential.

Unfiltered groundwater and surface water samples were analyzed for the entire standard suite of constituents and parameters; filtered samples were analyzed only for the principal cations and trace metals. Also, groundwater samples from wells with elevated gross alpha or gross beta activity (based on CY 1993 data) were analyzed for specified radionuclides (HSW Environmental Consultants, Inc. 1994). Selected monitoring wells used for RCRA corrective action monitoring also were sampled for radiochemical analyses to provide data needed for RCRA post-closure permits. Analytical results for all groundwater and surface water samples are presented in Appendix E of the Part 1 GWQR.

Laboratory blanks, trip blanks, field blanks, and equipment rinsate samples were analyzed for VOCs; selected equipment rinsates also were analyzed for nitrate, trace metals, gross alpha and gross beta activity, and selected radionuclides. Analytical results are summarized in Appendix L of the Part 1 GWQR. Duplicate groundwater samples were analyzed for the constituents and parameters specified for the well from which the duplicate sample was collected. Analytical results for the duplicate samples are presented in Appendix F of the Part 1 GWQR. Most of the laboratory analyses were performed by the K-25 Analytical Services Organization (ASO). Selected radiochemical analyses were performed by the Y-12 Plant ASO and the Oak Ridge National Laboratory ASO.

3.5 Quality Assurance/Quality Control Sampling

Review of the CY 1995 data reported for the laboratory blanks, trip blanks, field blanks, and equipment rinsate samples shows continued improvement by the K-25 ASO with regard to laboratory contamination of QA/QC samples, but also indicates systemic problems with VOC contamination of the source of deionized water used to prepare trip blanks and decontaminate sampling equipment, and one instance of insufficient equipment decontamination.

One or more of eleven VOCs were detected in 15 (17%) of the laboratory blanks, 114 (83%) of the trip blanks, one of two field blanks, and 27 (68%) of the equipment rinsate samples (Table 4). These compounds included: (1) four common laboratory reagents (acetone, 2-butanone, methylene chloride, and toluene), (2) four compounds (chloroform, 1,1,1,-TCA, PCE, and 1,2-DCA) which are present in the groundwater in the Bear Creek Regime (VOC plume constituents), and (3) three miscellaneous compounds (bromodichloromethane, 1,2-dichloropropane, and xylenes).

Common laboratory reagents were detected in 13 (14%) of the laboratory blanks, 26 (19%) of the trip blanks, and six (15%) of the equipment rinsate samples. As in previous years, acetone, 2-butanone, and methylene chloride were detected most frequently (Table 4). However, as summarized below, the very low percentages of laboratory blanks and trip blanks with methylene chloride contrast with respective historical results.

Calendar Year	Percent of Samples with Methylene Chloride		
	Laboratory Blanks	Trip Blanks	Equipment Rinsates
1992	36	43	28
1993	48	51	62
1994	18	14	9
1995	3	8	15

The overall reduction in the number of QA/QC samples containing methylene chloride (and other laboratory reagents) illustrates improved performance of the K-25 ASO with regard to laboratory contamination of QA/QC samples.

Four VOC plume constituents were detected in the QA/QC samples: 1,1,1-TCA in 107 (78%) of the trip blanks and 26 (65%) of the equipment rinsate samples; PCE in one laboratory blank, two trip blanks, and one equipment rinsate sample; 1,2-DCA in two laboratory blanks and six trip blanks; and chloroform in one equipment rinsate sample (Table 4). As summarized below, 1,1,1-TCA was detected in at least half of trip blanks and equipment rinsate samples analyzed each quarter of CY

1995, including all but seven of the trip blanks and one of the equipment rinsate samples that contained any VOCs.

Type of QA/QC Sample	Number of Samples				
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Total
Laboratory Blanks					
Total:	30	14	35	10	89
with VOCs:	5	0	5	5	15
with 1,1,1-TCA:	0	0	0	0	0
Trip Blanks					
Total:	46	20	54	17	137
with VOCs:	40	17	42	15	114
with 1,1,1-TCA:	40	16	36	15	107
Equipment Rinsates					
Total:	14	5	16	5	40
with VOCs:	11	4	8	4	27
with 1,1,1-TCA:	10	4	8	4	26
Field Blanks					
Total:	1	0	1	0	2
with VOCs:	1	0	0	0	1
with 1,1,1-TCA:	0	0	0	0	0

The lack of 1,1,1-TCA in the laboratory blanks discounts the analytical environment as a source of the contamination in the trip blanks and equipment rinsate samples. Cross contamination during sample handling and transportation and procedural deficiencies with equipment decontamination are not indicated because 1,1,1-TCA was detected in trip blanks and equipment rinsate samples associated with wells that monitor uncontaminated groundwater. Contamination of the deionized water used by the K-25 ASO was identified as the cause of the 1,1,1-TCA in these QA/QC samples. Similar "source water" contamination with chloroform and 1,2-dichloropropane occurred during CYs 1991 and 1992 (HSW Environmental Consultants, Inc. 1993), and was determined by the K-25 ASO to have resulted from: (1) an insufficient replacement frequency for the ionization columns, (2) improper flushing of the deionized water system, and (3) problems with system handling and maintenance (Buckley 1992). In CY 1996, routine QA/QC sampling was initiated by the K-25 ASO to monitor the quality of the deionized water.

Review of the data for PCE, toluene, xylenes, and 1,2-DCA detected in the QA/QC samples clearly indicates laboratory contamination. All these compounds in the trip blanks and rinsates were detected in the associated laboratory blanks, and are probably analytical artifacts. Results of Inductively Coupled Plasma (ICP) analyses reported for two equipment rinsate samples also indicate that the deionized water equipment was not always kept in proper working order. As summarized below, the calcium, magnesium, potassium, and sodium concentrations reported for these samples are not characteristic of deionized water.

Sample Number	Associated Well	Date Sampled	Concentration (mg/L)			
			Calcium	Magnesium	Potassium	Sodium
ER-BC-1	GW-276	01/24/95	27	7.9	1.6	5.5
ER-BC-1	GW-715	01/14/95	5	7.3	9.9	38

Data for the rinsate associated with well GW-276 also indicates problems with sampling equipment decontamination. The gross beta activity reported for the groundwater sample collected from the well on July 29, 1995 was 1,130 ±120 pCi/L, and the activity reported for the equipment rinsate sample (96.7 ±19 pCi/L) strongly indicates residual contamination of the sampling equipment. This equipment was next used to collect samples from well GW-685 on August 5, 1995, but results for the samples do not indicate cross contamination of the well.

4.0 GROUNDWATER QUALITY DATA

This section presents a review of the CY 1995 groundwater monitoring data with respect to the key components of the conceptual model for groundwater flow and contaminant transport outlined in Section 2.0. It is based on the underlying assumptions and outcome of the respective data screening and evaluation procedures described in Appendix C for principal ions, trace metals, VOCs, and radiological parameters. Results of the analysis and interpretation of the screened data for the Aquitard and Aquifer monitoring wells are described separately for each group of analytes.

4.1 Principal Ions

Principal ion results for most of the monitoring wells sampled during CY 1995 generally reflect the respective geochemical characteristics of uncontaminated groundwater in the Aquitard and the Aquifer. Additionally, results indicative of groundwater contamination are consistent with most key aspects of the conceptual transport models for the S-3 Site, Oil Landfarm WMA, Bear Creek Burial Grounds WMA, and Maynardville Limestone.

4.1.1 Aquitard

Samples of uncontaminated, calcium-magnesium-bicarbonate groundwater were collected from most of the Aquitard monitoring wells (Figure 10). These samples typically exhibited carbonate alkalinity, fluoride, and nitrate concentrations below respective analytical reporting limits; low proportions (<10%) of chloride, potassium, sodium, and sulfate; pH between 6.5 and 8.0; and TDS of 125 to 325 mg/L. A number of wells (i.e., GW-069, GW-095, GW-363, GW-373, GW-627 and GW-828) monitor uncontaminated sodium-bicarbonate groundwater usually encountered at depth (i.e., >100-ft bgs) in the Aquitard (Figure 10). These wells typically yield groundwater with fluoride and nitrate levels below respective analytical reporting limits, carbonate alkalinity above 5 mg/L; low proportions (<5%) of calcium, magnesium, and potassium; pH of about 9; and TDS of 250 to 300 mg/L.

Most variations from the typical Aquitard groundwater geochemistry reflect nitrate contamination from the S-3 Site (Figure 11), which dominated the ion chemistry of the groundwater samples collected from wells GW-085, GW-276, GW-346, GW-537, and GW-829 (Figure 10). Data summarized below show nitrate concentrations in the groundwater at each of these wells exceed the 10 mg/L maximum contaminant level (MCL) for drinking water.

Well Number	Depth (ft bgs)	Nitrate (mg/L)				Annual Average (mg/L)
		1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	
GW-085	58.8	180	17*	220*	191	186
GW-276	18.5	151*	NS	220*	NS	>150*
GW-346	64.9	NS	NS	830	NS	830
GW-537	23.3	760	980*	900	771	810
GW-829	114.6	NS	200*	59	54.3	57

NS = not sampled; * = qualitative (ion-charge balance error >10%)

Although considered qualitative because of ion charge balance errors (see discussion in Section C.2.5 of Appendix C), the CY 1995 results for well GW-276 show nitrate concentrations above 150 mg/L in the shallow Aquitard groundwater (<20-ft bgs) about 250-ft south of the S-3 Site (Figure 11). These data indicate an order-of-magnitude decrease from nitrate levels in the groundwater at the well during the middle to late 1980s. Decreased nitrate concentrations in the groundwater reflect the combined effects of closing and capping the S-3 Site and contaminant flushing by seasonal recharge/discharge cycles (Shevenell and Goldstrand 1994).

As noted in Section 2.3, the bulk of the nitrate plume lies in the Aquitard and is slowly moving westward and southward from the S-3 Site toward discharge areas in Bear Creek tributaries NT-1 and NT-2, and the Maynardville Limestone (Science Applications International Corporation 1996). Westward migration of the plume along strike-parallel flowpaths in the water table interval, shallow bedrock, and deep bedrock is indicated by the nitrate data for wells GW-345, GW-346, and GW-526, respectively. These wells comprise a well cluster about 100-ft west of NT-1 where, as shown by the data summarized below, the nitrate plume is characterized by decreasing concentrations in the water table interval (GW-345), stable concentrations above 800 mg/L in the shallow bedrock (GW-346), and similar but more variable concentrations in the deeper bedrock (GW-526).

Well Number	Depth (ft bgs)	Annual average nitrate concentration (mg/L)					
		1990	1991	1992	1993	1994	1995
GW-345	26	398	85	NS	10	2	NS
GW-346	65	811	NS	NS	NS	NS	830
GW-526	126	845	786	1,043	893	NS	NS
NS = not sampled							

Substantially decreased nitrate concentrations in the groundwater at well GW-345 suggest that NT-1 functions as a passive drain, which effectively intercepts the bulk of the nitrate transported by groundwater in the water table interval west of the S-3 Site (Figure 11). The more stable concentrations in the groundwater at wells GW-346 and GW-526 suggest that nitrate in the shallow and deep bedrock does not extensively discharge upward into NT-1. This interpretation is supported by the vertical hydraulic gradients shown below, which are upward from the deeper bedrock (GW-526) to the shallow bedrock (GW-346), but downward from the water table interval (GW-345) to the shallow bedrock (GW-346), particularly during seasonally low groundwater flow.

Well Number	Monitored Interval Center-Point Elevation ft above mean sea level	Water Level Elevation ft above mean sea level		Upward (+)/Downward(-) Hydraulic Gradient	
		Jan. 1995	Aug. 1995	Jan. 1995	Aug. 1995
GW-345	974.2	982.2	987.5		
GW-346	936.9	978.5	978.4	- 0.10	- 0.25
GW-526	883.3	985.6	985.1	+ 0.13	+ 0.13

Considering the vertical hydraulic gradients and nitrate concentration trends in wells GW-345, GW-346, and GW-526, nitrate results for these wells are consistent with upward migration from the deeper bedrock to the shallow bedrock near NT-1.

Bedrock wells GW-828 and GW-829 monitor sodium-bicarbonate groundwater in the Aquitard at 168 and 115-ft bgs, respectively, approximately 800-ft west of NT-1 (GW-828 is about 100-ft north of GW-829) (Figure 11). As shown in the following summary, preliminary results for nitrate, acetone, and beta radioactivity (i.e., "signature" S-3 Site contaminants) obtained during installation of these wells in February and March 1995 strongly indicated strike-parallel migration west of NT-1 in the water table interval (GW-829; 29-ft bgs), shallow bedrock (GW-828; 83-ft bgs), and deep bedrock (GW-828; 168-ft bgs).

Well Number	Depth (ft bgs)	Date Sampled	TSS (mg/L)	Nitrate (mg/L)	Acetone (µg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
GW-828	83	02/14/95	NA	43*	ND	NA	NA
	168	02/18/95	NA	623*	ND	NA	NA
		06/27/95	980	2.8	FP	13.6 ± 3.8	9.17 ± 3.5
		08/24/95	5,550	11	ND	33 ± 20	30.6 ± 25
		12/08/95	20	0.87	ND	2.29 ± 1.9	2.09 ± 2.4
GW-829	29	03/01/95	NA	259*	49	FS	65.7 ± 30
	115	03/07/95	NA	2,210*	173	70.4 ± 35	535 ± 49
		06/27/95	227	200*	ND	80.9 ± 15	71.2 ± 15
		08/30/95	570	59	ND	FS	FS
		12/10/95	16.5	54.3	ND	2.94 ± 2.1	5.92 ± 2.7

FP=false positive; FS=failed screening criteria; NA= not analyzed; ND=not detected; NS=not sampled;
* = qualitative

Upward hydraulic gradients in the area (well GW-828 was artesian in April 1995) also indicated vertical migration from the deeper bedrock to the shallow bedrock. However, samples collected from each well in June, August, and December 1995 did not contain acetone (note the false positive result for well GW-828) and exhibited substantially lower nitrate concentrations, as well as background gross alpha and gross beta activities (results reported for the samples collected in June and August were probably inaccurate because of the high TSS). Both wells appear to have initially contained residual contamination from shallow groundwater intercepted during their installation, most of which was progressively flushed during subsequent groundwater purging and sampling. Results for the samples collected in December 1995 suggest: (1) the bedrock structure at NT-1 promotes upward migration from the deep bedrock to the shallow bedrock, and migration west of the tributary occurs primarily in the shallow bedrock (i.e. <100-ft bgs), (2) the monitored interval for well GW-829 may be near the base of the nitrate plume west of NT-1, and (3) well GW-828 monitors uncontaminated sodium-bicarbonate groundwater below the nitrate plume west of NT-1.

Surface water quality data obtained during the RI for the Bear Creek CA clearly show that nitrate-contaminated groundwater discharges into Bear Creek tributary NT-2 (Science Applications

International Corporation 1996). Upward migration from the shallow bedrock to the water table interval near NT-2 also is indicated by the high nitrate concentrations (i.e., >750 mg/L) in the groundwater at well GW-537, which is completed at a depth of 25-ft bgs about 200-ft west of the tributary (Figure 11). Additionally, sodium concentrations in the unfiltered samples from well GW-537 exceed 30 mg/L, which is at least an order-of-magnitude higher than concentrations typical of shallow groundwater in the Aquitard, and may reflect upward migration of the sodium-bicarbonate groundwater deeper in the bedrock. Nitrate concentration trends over the past five years suggest variable flux in the groundwater at GW-537, as indicated by inverse (dilution-related) water level/nitrate concentration relationships through May 1993, and generally concurrent (transport-related) relationships through October 1995 (Figure 12).

Nitrate concentrations toward the leading western edge of the plume are indicated by data for well GW-085, which is completed at a depth of 58.8-ft bgs about 500-ft west of well GW-537 (Figure 11). Nitrate concentrations in the groundwater samples collected during CY 1995 exceeded 100 mg/L (results for two samples were considered qualitative because of ion charge balance errors), and along with the results obtained since January 1990, show dilution-related concentration/water level relationships and a generally increasing concentration trend (Figure 12). These results suggest that the leading edge of the nitrate plume in the Aquitard is further west toward Bear Creek tributary NT-3.

4.1.2 Aquifer

Samples of uncontaminated, calcium-magnesium-bicarbonate groundwater were collected from most of the Aquifer monitoring wells sampled during CY 1995 (Figure 13). These samples typically had carbonate alkalinity and fluoride below respective analytical reporting limits; low proportions (<10%) of chloride, potassium, sodium, and sulfate; pH between 7.2 and 8.0; and TDS of 220 to 700 mg/L. Groundwater samples from many of the Aquifer monitoring wells exhibit distinctive proportions of magnesium that probably reflect inflow from the Aquitard and the Copper Ridge Dolomite. Magnesium proportions below 30% of total cations are generally characteristic of the shallow groundwater inflow from the Aquitard, whereas proportions of 35 to 45% indicate influx of groundwater from the Copper Ridge Dolomite. Additionally, several deep wells (GW-710, GW-711, GW-712, and GW-713) monitor a highly mineralized (TDS >1,000 mg/L) calcium-magnesium-sulfate groundwater (Figure 13).

Most variations from the typical Aquifer groundwater geochemistry are caused by nitrate contamination from the S-3 Site, although results for a few wells indicate localized contamination with other ionic species (e.g., chloride and sodium in well GW-057). Groundwater samples from 27 Aquifer monitoring wells had nitrate concentrations above 1 mg/L, and annual average concentrations determined for 15 of these wells exceeded the 10 mg/L MCL for drinking water (Table 5). The highest nitrate concentrations were reported for the groundwater samples collected in September 1995 from wells GW-100 (190 mg/L), GW-124 (51 mg/L), and GW-236 (65 mg/L), all of which are within 2,000-ft of the S-3 Site (Figure 11). Nitrate concentrations were below 50 mg/L in the Aquifer downgradient of these wells, and concentrations in the groundwater downgradient of Exit Pathway Picket B, which is about 7,000-ft west of the S-3 Site, were below 10 mg/L.

Results for wells GW-100, GW-124, and GW-236 show decreasing nitrate concentrations in the Aquifer near the S-3 Site. Wells GW-100 and GW-236 are about 1,000 and 1,500-ft west (along strike) of the S-3 Site, respectively, and monitor groundwater in the water table interval less than 25-ft bgs. Nitrate in the shallow groundwater at these wells reflects transport in the water table interval from the Aquitard to the Aquifer, and at well GW-236 probably includes influx from the NT-1 catchment (Figure 11). Bedrock well GW-124 is completed at a depth of 150-ft bgs about 500-ft to the south of the S-3 Site, and nitrate in the well suggests downward migration from the water table interval and shallow bedrock, and possibly cross-strike inflow from the Aquitard. Based on comparison to the nitrate concentrations in the groundwater at wells GW-100, GW-124, and GW-236 in January 1990 (160, 388, and 421 mg/L, respectively), the CY 1995 results indicate a greater concentration decrease (49 to 85%) in the water table interval than in the deeper bedrock (32%). This is because more active groundwater circulation in the highly permeable water table interval promotes more rapid flushing of nitrate (and other contaminants) from the shallow flow system (Shevenell and Goldstrand 1994).

Data for the eight Aquifer wells that comprise Exit Pathway Picket C (GW-723, GW-724, GW-725, GW-736, GW-737, GW-738, GW-739, and GW-740) reflect strike-parallel transport in the bedrock downgradient from the S-3 Site and influx of nitrate from the NT-1 and NT-2 catchments (Figure 11). Annual average nitrate concentrations in the groundwater at these wells ranged from 4 to 42 mg/L (Table 5), and were highest (i.e., >30 mg/L) in the samples from shallow and deep wells completed in the lower portion of the Maynardville Limestone (GW-724, GW-725, GW-736, and GW-737). The Maynardville Limestone has seven distinct stratigraphic zones (numbered from bottom to top), differentiated by lithologic and hydrologic characteristics, with the more permeable zones at the bottom (Zone 2) and top (Zone 6) of the formation (Shevenell et al. 1994; Goldstrand 1995). Nitrate in the groundwater at well GW-740 (4 mg/L) reflects strike-parallel transport in Zone 6, which is the most permeable interval in the Maynardville Limestone and probably transmits the bulk of the groundwater in the formation (Goldstrand 1995). Seasonal, flow-related concentration fluctuations in the basal part of the Maynardville Limestone, as illustrated by nitrate data for well GW-724 (Figure 14), reflect influx of nitrate during seasonal discharge from the NT-1 and NT-2 catchments.

Downgradient (west) of the Picket C monitoring wells, nitrate concentrations in the Aquifer were highest (40 mg/L) in the groundwater sample collected from well GW-228 in September 1995 (Table 5). Located south of Sanitary Landfill I about 4,500-ft west of the S-3 Site (Figure 11), well GW-228 is completed at a depth of 100-ft bgs within a section of the Aquifer that underlies a major losing reach of Bear Creek and exhibits strongly downward hydraulic gradients. Inflow of nitrate-contaminated shallow groundwater and surface water in this area, a key component of the conceptual model for contaminant transport in the Maynardville Limestone, explains the high nitrate concentration in the groundwater at well GW-228, and the 37 mg/L nitrate concentration in the sample collected from the well in January 1990 indicates a fairly stable long-term concentration trend. Additionally, background nitrate levels (i.e.,<1 mg/L) in the groundwater at well GW-229, which is completed at a depth of 55-ft bgs about 700-ft west of GW-228, suggest primary migration pathways are deeper in the Aquifer south of the Oil Landfarm WMA.

Nitrate concentrations in the Aquifer downgradient of the Oil Landfarm WMA ranged from approximately 4 mg/L (GW-621) to 22 mg/L (GW-703) in the groundwater at Exit Pathway Picket B, and were below the 10 mg/L MCL in the groundwater at Exit Pathway Picket A (Figure 11). Results for exit pathway wells reflect nitrate migration from the lower to the upper stratigraphic zones in the Maynardville Limestone, and overall westward migration. As noted in the preceding discussion, nitrate concentrations are highest in Zone 2 at Picket C, but at Picket B are highest in wells completed in Zone 4 (GW-694, GW-703, and GW-706), and are highest in Zone 6 at Picket A (GW-684) (Table 5). Additionally, nitrate concentrations in the groundwater at Picket A show migration into the basal Copper Ridge Dolomite (e.g., GW-683). As illustrated by data for wells GW-694 and GW-684, nitrate concentrations in the groundwater at Pickets A and B generally show seasonal, dilution-related concentration fluctuations (Figure 14). These results indicate an overall migration pattern toward the high permeability zone near the Maynardville Limestone/Copper Ridge Dolomite contact, as well as dilution by seasonal recharge of uncontaminated shallow groundwater and surface water.

4.2 Trace Metals

Interpretation of the CY 1995 groundwater data for trace metals focused on representative total concentrations that exceeded MCLs for drinking water, or upper tolerance limits (UTLs) assumed to reflect concentrations in uncontaminated groundwater at the Y-12 Plant (see discussion in Appendix C). A total of 132 unfiltered groundwater samples collected from 39 monitoring wells had elevated concentrations of several trace metals, but as in previous years, most of these results were sampling and/or analytical artifacts caused by preservation of highly turbid groundwater samples. The following sections describe the results that most likely reflect groundwater contamination.

4.2.1 Aquitard

Review and analysis of the CY 1995 trace metal data for the Aquitard monitoring wells indicates elevated concentrations of relatively immobile trace metals (beryllium, cadmium, cobalt, manganese, mercury, and nickel) in the groundwater at the S-3 Site, and elevated concentrations of more mobile trace metals (barium, boron, strontium, and uranium) in the groundwater at the S-3 Site, the Burnyard/Boneyard, and the Bear Creek Burial Grounds WMA (Figure 15).

A heterogeneous mixture of trace metals, including some that were entrained in the acidic wastewater disposed at the site (e.g., uranium) and others dissolved from the underlying saprolite and bedrock (e.g., barium), occurs in shallow and deep groundwater in the Aquitard near the S-3 Site (Figure 15). Concentrations within the shallow groundwater south of the site are indicated by the data for unfiltered samples collected from well GW-276 in January and July 1995. As shown in the following data summary, total concentrations of beryllium, boron, cobalt, cadmium, manganese, nickel, and uranium exceed the applicable water quality standards, but several constituents (barium and cadmium) have decreased substantially over the past five years and concentrations of other metals have remained relatively constant.

Well GW-276								
Trace Metal	**Water Quality Standard (mg/L)**		**Total Concentration (mg/L)**					
	MCL	**UTL**	**October 1988**	**January 1990**	**March 1994**	**August 1994**	**January 1995**	**July 1995**
Barium	2.0		3.6	2.3	0.61	0.73	0.66	0.83
Boron	.	0.041	NA	NA	0.036	0.068	0.068	0.051
Beryllium	0.004	.	NA	NA	0.0099	0.012	0.011	0.012
Cadmium	0.005	.	0.26	0.15	0.074	0.06	0.053	0.058
Cobalt	.	0.019	NA	NA	0.21	0.21	0.23	0.21
Manganese	.	1.7	NA	NA	9.5	11	11	10
Nickel	0.1	.	NA	NA	0.6	0.66	0.64	0.61
Uranium	.	0.005	5.99	3.11	1.16	1.55	1.6	2
pH			3.6	3.7	4.2	4.2	4.3	5.6
NA = not analyzed								

As with nitrate in the groundwater at GW-276, reduced concentrations of some trace metals (and the increased groundwater pH) reflect the closure of the S-3 Site and subsequent flushing by natural recharge/discharge cycles. Apparently asymptotic concentration trends evident since March 1994 for all of the trace metals except uranium indicate steady influx from the contamination reservoir in the Aquitard via matrix diffusion/advective transport, and varying degrees of dilution during seasonal groundwater flow conditions (concentrations are usually higher in summer and fall). Additional influx of uranium leached from sludge in the S-3 Site may explain the slightly increasing concentration trend in the shallow groundwater at well GW-276 (Science Applications International Corporation 1996).

The extent of strike-parallel groundwater transport in the Aquitard west of the S-3 Site is indicated by concentrations of the mobile trace metals in the groundwater at GW-346 (September 1995), GW-829 (December 1995), GW-537 (annual median concentrations), and GW-085 (annual median concentrations).

Monitoring Well	Depth (ft)	Distance from S-3 Site (ft)	Total Concentration (mg/L)				pH
			Barium	Boron	Strontium	Uranium	
GW-346	65	1,500	1.1	**0.13**	**16**	0.0033	7.5
GW-829	115	2,100	0.81	**0.25**	**1.7**	0.0045	8.4
GW-537	23	2,500	**2.45**	0.036	**2.85**	0.0014	6.7 - 7.3
GW-085	59	3,000	0.735	0.024	0.585	0.0005	7.09 - 7.4

ND = not detected; **BOLD** = exceeds applicable water quality standard

Compared to the uranium concentrations in the water table interval at well GW-276, the extremely low levels in the groundwater at these wells (none exceeded the applicable UTL) indicate limited transport in the bedrock beyond the low pH groundwater near the S-3 Site. Uranium is in the acidic groundwater as oxidized cations, primarily the uranyl (UO_2^{2+}) ion, which are considerably retarded by pH-sensitive sorption reactions (Science Applications International Corporation 1996). Conversely, the elevated concentrations of barium, boron, and strontium in the groundwater at well GW-346 indicate strike-parallel migration in the shallow bedrock at least 1,500-ft west of the S-3 Site. Of these, barium may be the most mobile, as indicated by the elevated concentrations in the shallow groundwater at well GW-537. Additionally, low (i.e., background) trace metal concentrations indicated by the December 1995 data for well GW-828 do not support migration of trace metals in the deep groundwater (i.e., >150-ft bgs) west of Bear Creek tributary NT-1.

Barium and strontium concentrations in the groundwater at well GW-537 generally fluctuate directly with the water level in the well (Figure 16). These concentration/water level fluctuations may indicate flow-related, colloidal co-transport of these metals. Results of on-going studies in BCV indicate that colloids are more prevalent in groundwater with sodium as the dominant anion. As noted in Section 4.1.1, the shallow groundwater at well GW-537 has atypically high sodium concentrations. Elevated barium and strontium concentrations in the sodium-enriched shallow groundwater at GW-537 potentially indicate sodium colloid-facilitated, strike-parallel transport in the sodium-bicarbonate groundwater more than 100-ft bgs in the Aquitard, and upward migration into the water table interval near the bedrock structure at NT-2.

Data obtained during the RI for the Bear Creek CA confirmed the Burnyard/Boneyard as a primary source of uranium in the groundwater at the east end of the Oil Landfarm WMA and in Bear Creek downstream of tributary NT-3 (Science Applications International Corporation 1996). September 1995 results for well GW-087, which is completed at a depth of 19-ft bgs about 100-ft west of the HCDA cap (Figure 15), show total (0.87 mg/L) and dissolved (0.5 mg/L) uranium concentrations are two orders-of-magnitude above the 0.005 mg/L UTL. As noted in Section 2.3, the uranium leached from source area(s) in the Boneyard/Burnyard migrates in shallow (water table interval) groundwater toward discharge areas in Bear Creek tributary NT-3.

The Bear Creek Burial Grounds WMA received substantial volumes of borax (hydrated sodium borate) waste water from the Y-12 Plant, and the CY 1995 data for several wells indicate boron contamination in the shallow groundwater near BG-A South (GW-014, GW-046, and GW-653), BG-C East (GW-291), and BG-C West (GW-654) (Table 6). The highest boron concentrations occur in the groundwater at wells GW-014 (4.8 mg/L) and GW-291 (2.2 mg/L) (Figure 15). These results reflect strike parallel migration in the water table interval toward discharge areas in the Bear Creek tributaries (NT-6, NT-7, and NT-8) that traverse the Bear Creek Burial Grounds WMA. Additionally, both transport-related (GW-653) and dilution-related (GW-654) concentration/water level relationships are evident (Figure 17). Flow-related boron concentrations in the groundwater at well GW-653 are supported by the characteristically low TDS (i.e., <100 mg/L) of the groundwater samples from the well, which is considered to be an indicator of short residence time within quickflow discharge flowpaths (Shevenell 1994).

Total cadmium concentrations in all but two of the unfiltered groundwater samples collected from well GW-042 since January 1990 have exceeded the 0.005 mg/L MCL for drinking water, and ranged from 0.0075 to 0.46 mg/L in the four samples collected in CY 1995. No clear concentration trends are evident. This well is completed at a depth of 28-ft bgs in the water table interval upgradient of the waste disposal areas at the Bear Creek Burial Grounds (Figure 15). The source of the cadmium has not been determined.

4.2.2 Aquifer

Elevated concentrations determined from the CY 1995 data for several trace metals, primarily boron and uranium, probably reflect influx of contaminated groundwater from the S-3 Site, the Boneyard/Burnyard, and BG-A South (Figure 15). Moreover, results that most likely represent groundwater contamination generally reflect the close hydrologic interaction with surface water in Bear Creek, as described in the conceptual model for contaminant transport in the Maynardville Limestone.

Although the reservoir of highly contaminated groundwater in the Aquitard at the S-3 Site is a major source of trace metals, and nitrate in the groundwater at wells GW-100 and GW-124 indicates transport into the Aquifer, generally low total and dissolved trace metal concentrations in the filtered and unfiltered samples from wells GW-100, GW-124, and GW-348 suggest limited transport in the groundwater. Aside from elevated selenium (GW-100) and strontium (GW-100 and GW-348), total metal concentrations in the groundwater samples from these wells were below the applicable water quality standards (Table 6). The low trace metal concentrations reflect lower mobility in groundwater relative to nitrate, as well as greater attenuation/retardation in the subsurface.

Influx of contaminants into the Aquifer via inflow/recharge of groundwater/surface water from the Bear Creek tributary NT-1 catchment is indicated by the elevated manganese concentrations in the groundwater at well GW-236, which is located north of Bear Creek about 200-ft downstream from the confluence with the NT-1 (Figure 15). Total and dissolved manganese concentrations exceeded 5 mg/L in the surface water samples collected from NT-1 in July 1995 (see Section 5.2 or Table 6). Similarly high (>3 mg/L) manganese concentrations were reported for the filtered and unfiltered groundwater samples collected in September 1995 from well GW-236.

Elevated total uranium concentrations in the Aquifer are indicated by the CY 1995 data for monitoring wells GW-061, GW-229, GW-683, GW-684, GW-694, and GW-706 (Table 6). Total uranium concentrations in unfiltered groundwater samples from these wells ranged from 0.006 to 0.13 mg/L, and as illustrated by historical data for wells GW-694 (Picket B) and GW-684 (Picket A), are usually highest during seasonally low groundwater flow conditions (Figure 18). Uranium is mobilized by forming stable ions with carbonate (Science Applications International Corporation

1996), and the elevated uranium concentrations in the groundwater at these wells suggest the following transport/migration pattern:

- direct recharge into the Aquifer from the source area(s) at the Burnyard/Boneyard overlying the Maynardville Limestone, and influx of uranium-contaminated shallow groundwater/surface water from the NT-3 catchment;
- shallow groundwater/surface water transport into Bear Creek via NT-3, and inflow/recharge to the Aquifer, particularly along the major losing reach of Bear Creek south of Sanitary Landfill I;
- westward (strike parallel) groundwater transport in water table interval (GW-061), shallow bedrock (GW-229 and GW-684), and deep bedrock (GW-683 and GW-706); and
- as illustrated by data for wells GW-684 and GW-694, dilution by recharge of uncontaminated groundwater/surface water during seasonally high flow conditions (Figure 18).

Elevated total boron concentrations in the groundwater samples from Aquifer monitoring wells GW-053, GW-229, GW-683, GW-694, GW-706, GW-714, and GW-800 suggest a migration pattern similar to that of uranium (Figure 15). High boron concentrations in the shallow groundwater at well GW-229 (>2 mg/L), but low concentrations (typically <0.05 mg/L) in the groundwater samples from upgradient Aquifer monitoring wells (e.g., GW-228, GW-100, GW-236, and GW-124), suggest a source area(s) in the Oil Landfarm WMA, potentially Sanitary Landfill I. Concentrations in the groundwater at well GW-053 also indicate influx of boron-contaminated groundwater/surface water from sources in the Bear Creek Burial Grounds WMA (probably BG-A south). As illustrated by the boron data for wells GW-694 (Picket B) and GW-684 (Picket A), concentration fluctuations generally mirror those for uranium and likewise show relationships with water levels indicative of dilution during seasonally high groundwater flow conditions (Figure 18).

4.3 Volatile Organic Compounds

Results for the groundwater samples collected during CY 1995 show VOCs in the groundwater at 14 Aquitard monitoring wells (Table 7), and 24 Aquifer monitoring wells (Table 8).

Data for the Aquitard wells show VOC concentrations below 50 µg/L in the shallow groundwater (water table interval and shallow bedrock) downgradient of the S-3 Site, but above 500 µg/L west of the Boneyard/Burnyard, and above 1,000 µg/L in the southern portion of the Bear Creek Burial Grounds WMA (Figure 19). In contrast, VOC concentrations were typically less than 50 µg/L in the groundwater samples from the Aquifer monitoring wells, with the highest summed concentrations (>150 µg/L) downgradient of the Rust Spoil Area and the Boneyard/Burnyard.

4.3.1 Aquitard

Review of the screened VOC data for the Aquitard monitoring wells sampled during CY 1995 show primarily dissolved chloroethenes (PCE, TCE, and 1,2-DCE) in the groundwater at the S-3 Site, the Boneyard/Burnyard, and the Bear Creek Burial Grounds WMA (Table 7). Concentrations of PCE and TCE in the groundwater at each site exceed applicable MCLs for drinking water, with the highest concentration (>400 µg/L) of each compound in the wells at BG-A South (Figure 19).

As noted in Section 2.3, dissolved PCE concentrations exceed 5,000 µg/L in the groundwater at the S-3 Site, and indicate DNAPL in the subsurface. The PCE results for samples collected in March (37 µg/L) and September (32 µg/L) 1995 from well GW-276 show substantially decreased concentrations in the groundwater only 250-ft south of the site. This probably reflects significant attenuation in the subsurface. Additionally, the PCE results for well GW-276 are only about 15% of the concentrations in samples collected in the late 1980s, which mirrors the decreasing trends evident for nitrate and trace metals in the groundwater at the well. Similarly limited strike-parallel transport in the shallow groundwater west of the site is indicated by the lack of PCE (or degradation products) in the groundwater samples from wells GW-346 and GW-537.

Data for well GW-087 show summed concentrations of PCE, TCE, and 1,2-DCE exceeding 100 µg/L in the water table interval at the east end of the Oil Landfarm WMA (Figure 19). Results for this well (Table 7) reflect strike-parallel groundwater transport of VOCs from the source area(s) in the Burnyard/Boneyard which , based on information obtained during the RI for the Bear Creek CA, may not coincide with the source of the uranium in the groundwater at the well (Science Applications International Corporation 1996). As shown in the following data summary, summed

VOC concentrations in the groundwater at GW-087 (other compounds detected in the samples from the well are benzene, chloroform, 1,1-DCA, 1,2-DCA, and 1,1-DCE) suggest a relatively stable, if not slightly increasing trend.

Compound	**Concentration (µg/L)**		**Percent Change**
	March 1990	**September 1995**	
PCE:	240	220	-8%
TCE:	330	410	+24%
1,2-DCE:	98	120	+22%
Other (total):	76	38	-50%
Summed total:	**744**	**788**	**+6%**

Additionally, the decreased PCE concentrations coupled with the increased concentrations of daughter compounds (TCE and 1,2-DCE) indicate degradation in the subsurface.

As noted in Section 2.3, very high VOC concentrations in the groundwater at the Bear Creek Burial Grounds WMA reflect widespread occurrence of DNAPLs consisting primarily of PCE and TCE. Both of these major plume components, the primary degradation product (1,2-DCE), and other minor plume constituents occur in the groundwater at ten Aquitard monitoring wells sampled during CY 1995 (Table 7). Results for these wells reflect the PCE/TCE/1,2-DCE composition of the plume in the shallow groundwater near BG-A South, and the PCE-dominated plume near the Walk-In Pits (Figure 19).

Results for wells GW-014 and GW-046 show that PCE, TCE, and 1,2-DCE dominate the VOC plume in the shallow groundwater adjacent to the disposal trenches in the northeast and southwest corner of BG-A South, respectively, and that other (secondary) plume constituents primarily include degradation products (1,1-DCE, 1,1-DCA, 1,2-DCA, and vinyl chloride) (Table 7). As shown in the following summary, summed VOC concentrations exceeded 1,000 µg/L in the (diluted) groundwater samples collected from both wells, but have generally decreased over the past several years.

Well Number	Depth (ft bgs)	Annual Average Concentration (µg/L)							
		PCE		TCE		1,2-DCE		Other (total)	
		1990/91	1995	1990/91	1995	1990/91	1995	1990/91	1995
GW-014	13.2	160*	ND*	670*	410*	2,600*	2,300*	1,430*	793*
GW-046	20.3	2,000*	460*	800	ND*	2,600*	ND*	1,988*	38*
GW-069	99.2	ND	ND	ND	ND	ND	ND	ND	0.5*
GW-627	270.0	2*	55.5	ND	8.3*	ND	ND	1*	4.5*
GW-653	39.0	3*	2.8*	0.3*	1*	9	21	ND	1.1*

ND = not detected; * = qualitative (results below reporting limits, or results for diluted samples)

Data for these wells are consistent with the migration patterns described in the conceptual model for contaminant transport at the Bear Creek Burial Grounds WMA. Results for wells GW-014 and GW-046 reflect eastward strike-parallel transport in the water table interval toward the NT-6 catchment, and westward transport toward the NT-7 catchment, respectively (Figure 19). Transport of plume constituents in the shallow bedrock west of NT-7 is indicated by trace levels of parent compounds (e.g., PCE) and increasing concentrations of daughter products (e.g., 1,2-DCE) in the groundwater at well GW-653 (Figure 20). Additionally, increasing PCE and TCE concentrations in the groundwater at well GW-627 reflect strike-parallel migration in the deep bedrock (Figure 20). Conversely, only trace levels (i.e., <1 µg/L) of vinyl chloride in the groundwater south of the site at GW-069 suggest limited cross-strike transport in the bedrock.

The CY 1995 VOC results for Aquitard monitoring wells at the North Walk-In Pits (GW-291) and South Walk-In Pits (GW-257, GW-288, and GW-289) reflect the PCE-dominated composition of the VOC plume in the groundwater at both sites, and as shown in the following summary, at concentrations (<1,000 µg/L) which do not indicate widespread DNAPL in the subsurface.

Well Number	Depth (ft bgs)	Annual Average Concentration (µg/L)							
		PCE		TCE		1,2-DCE		Other (total)	
		1990	1995	1990	1995	1990	1995	1990	1995
GW-257	33.7	130	140	1*	3*	ND	ND	ND	ND
GW-287	12.5	ND	1*	ND	ND*	ND	ND	ND	ND
GW-288	60.0	1,200*	690*	12*	ND*	ND*	ND*	ND	ND*
GW-289	40.8	590*	930*	ND*	ND*	ND*	ND*	ND	ND*
GW-291	17.0	370*	460*	45*	ND*	ND	ND*	ND	38*
ND = not detected; * = qualitative (results below reporting limits, or results for diluted samples)									

Results for these wells generally reflect decreasing concentrations and strike-parallel groundwater transport from both sites toward the eastern fork of tributary NT-8, and from the South Walk-In Pits toward tributary NT-7 (Figure 19). Trace levels of PCE in the groundwater at well GW-287, which is about 600-ft west of the South Walk-In Pits, reflect the leading edge of the dissolved PCE plume migrating towards NT-8. Additionally, opposing PCE concentration trends in the groundwater at wells GW-288 (decreasing) and GW-289 (increasing), which comprise a two-well cluster downgradient of the South Walk-In Pits (Figure 19), may indicated upward migration from the deeper groundwater. As shown below, slight upward vertical hydraulic gradients occur during both seasonally high and low groundwater flow conditions.

Well Number	Monitored Interval Center-Point Elevation (ft msl)	Water Level Elevation (ft msl)		Upward (+)/Downward(-) Hydraulic Gradient	
		Jan. 1995	Aug. 1995	Jan. 1995	Aug. 1995
GW-289	911.5	930.57	929.87		
GW-288	893.1	931.06	930.16	+ 0.026	+ 0.015

Similar upward migration from the bedrock to the water table interval may also explain the increasing PCE concentrations in the shallow groundwater at wells GW-257 and GW-291.

4.3.2 Aquifer

As noted in Section 2.3, VOCs from several sources in the Bear Creek Regime have intermingled in the Aquifer and produced a TCE-dominated plume extending past Exit Pathway Picket A (GW-056, GW-057, GW-683, GW-684, and GW-685; Figure 19). Results obtained during CY 1995 generally reflect source inputs from the S-3 Site, Spoil Area I, the Rust Spoil Area, the Boneyard/Burnyard, and the Bear Creek Burial grounds WMA.

Trace levels (i.e., <2 µg/L) of PCE and chloroform in the groundwater at Aquifer monitoring well GW-124, along with similarly low 1,1-DCA concentrations (5 µg/L) in the groundwater at Aquifer monitoring well GW-236, suggest limited transport from the VOC plume in the Aquitard near the S-3 Site (Table 8). As with other S-3 Site contaminants in the groundwater at these wells, the CY 1995 VOC results reflect decreased concentrations over the past five years. Dissolved PCE in the groundwater at well GW-124, for example, averaged 30 µg/L in the samples collected from the well in 1990. Additionally, results for well GW-236 suggest that VOCs in the water table interval in the Aquitard west of the S-3 Site (e.g., PCE and acetone) volatilize when discharged into tributary NT-1 or during downstream transport toward Bear Creek.

Data for the groundwater samples collected from well GW-315 reflect input of VOCs from Spoil Area I, or possibly the Fire Training Facility, a confirmed source of PCE and 1,2-DCE in the East Fork Regime about 1,000-ft east of the well. The VOCs in the groundwater at the well, which is completed at a depth of 104-ft bgs in the upper part of the Maynardville Limestone, are PCE, TCE, 1,2-DCE, and chloroform (Table 8). Concentrations of the chloroethenes ranged from 6 µg/L (TCE) to 27 µg/L (PCE), which exceed applicable MCLs for drinking water, but each sample from the well exhibited only trace levels (1-2 µg/L) of chloroform.

Direct input of VOCs (primarily TCE) from the Rust Spoil Area is shown by data for Aquifer monitoring wells GW-311 and GW-312 (Figure 19). Groundwater samples collected from these wells during CY 1995 contained TCE concentrations that exceeded the 5 µg/L MCL for drinking water, as well as trace levels of carbon tetrachloride (GW-311) and chloroform (GW-312) (Table 8). Results for these samples show that TCE concentrations in the shallow groundwater are lower at upgradient well GW-311 (11-18 µg/L) and higher at downgradient well GW-312 (56-74 µg/L). These CY 1995 data for these wells are consistent with respective historical results showing seasonally fluctuating but relatively stable concentrations trends.

The CY 1995 data for well GW-064 and the Exit Pathway Picket C monitoring wells primarily show downgradient transport of TCE from the Rust Spoil Area, but low concentrations of carbon tetrachloride, chloroform, PCE, 1,2-DCE, and 1,1-DCE in some wells, particularly GW-064, also indicate transport from other upgradient source areas (Figure 19). The VOC data for the Picket C wells generally mirror the nitrate data for the wells (Table 8). Concentrations of TCE, for example, are generally highest (i.e., >50 µg/L) in the groundwater samples from wells completed in the lowermost stratigraphic zones within the Maynardville Limestone (GW-724, GW-725, and GW-738). High TCE concentrations (76 µg/L) in the groundwater at well GW-740 contrast with low nitrate concentrations (4 mg/L) at the well and possibly indicate transport along separate strike-parallel pathways in the upper Maynardville Limestone. Additionally, relationships between TCE concentrations and static water levels in these wells, as illustrated by the data for GW-724, generally indicate increased flux of VOCs during seasonally high groundwater flow conditions (Figure 21).

Influx of VOCs via direct recharge from the Boneyard/Burnyard about 300-ft downgradient (west) of Exit Pathway Picket C is indicated by PCE in the TCE-contaminated groundwater at well GW-066 (Figure 19); PCE was not detected in any of the groundwater samples collected from the Picket C monitoring wells (Table 8). Well GW-066 is between Bear Creek and the southeast corner of the HCDA cap, and is completed at a depth of 55-ft bgs in the lower Maynardville Limestone. Summed VOC concentrations in the groundwater sample collected from the well in September 1995 (39 µg/L) reflect little change in VOC levels since the late 1980s, which suggests limited influence of the HCDA cap and possibly indicates VOC source(s) below the saturated zone.

The CY 1995 data for wells GW-228 and GW-229 show that the TCE-dominated plume occurs primarily in the deeper groundwater downgradient of Exit Pathway Picket C. As noted previously, the reach of Bear Creek south of the Oil Landfarm WMA near GW-228 is a major area of groundwater recharge to the Aquifer. The 1,2-DCE in the TCE-contaminated groundwater at the well probably reflects influx of VOCs from the source area(s) in the Burnyard/Boneyard. Transport in the deeper groundwater is supported by the lack of TCE and (other VOCs) in the shallow groundwater at well GW-229 (as indicated by September 1995 data). Results for well GW-229 also indicate limited influx of VOCs from the west end of the Oil Landfarm and Sanitary Landfill I.

Results obtained during CY 1995 show primarily TCE and 1,2-DCE in the groundwater downgradient of the Oil Landfarm WMA (Figure 19). Although data for well GW-053 indicate influx of VOCs in the water table interval from BG-A South, results for wells comprising Exit Pathway pickets A and B generally reflect strike-parallel transport of TCE and 1,2-DCE from upgradient source areas (Table 8). As with the nitrate data for these wells, the TCE and 1,2-DCE indicate migration from the lower to the upper stratigraphic zones in the Maynardville Limestone. For example, the highest TCE concentrations (50-145 µg/L) in groundwater at Picket C occur in the monitoring wells completed in Zones 2 and 3 (GW-724, GW-725, and GW-738), but at Picket B are generally highest (19-94 µg/L) in the monitoring wells completed in Zone 4 (GW-694, GW-703, GW-704, and GW-706).. Additionally, trace levels (i.e. 1 µg/L) of TCE detected in the groundwater samples collected from Picket A monitoring well GW-683 after January 1994 reflect migration of the TCE plume into the basal Copper Ridge Dolomite. As illustrated by the TCE data for wells GW-684 and GW-704, VOC concentrations in the groundwater at pickets A and B generally show dilution-related seasonal fluctuations (Figure 21).

4.4 Radioactivity

As noted in Section 3.5, the CY 1995 radioanalyte data for groundwater include: (1) gross alpha and gross beta results for each Aquitard and Aquifer monitoring well sampled during the year, (2) radionuclide results for selected wells with elevated gross alpha or gross beta, as determined from CY 1993 data , and (3) gross alpha, gross beta, and radionuclide results for samples collected from selected corrective action monitoring wells.

4.4.1 Aquitard

Gross alpha and gross beta activities were below applicable minimum detectable activities (MDAs) in the groundwater samples from most of the Aquitard monitoring. The bulk of the respective results that exceeded the MDAs were below either the 15 pCi/L MCL for gross alpha activity, or the 50 pCi/L threshold value for gross beta activity (see discussion in sections C.2.1 and

C.2.8 in Appendix C). Activities that indicate groundwater contamination were reported for samples collected from five Aquitard monitoring wells: GW-085, GW-087, GW-243, GW-276, GW-537, and GW-615.

Gross Alpha Activity

As summarized below, gross alpha results for Aquitard monitoring wells GW-276 (Table 9), GW-243 (Table 10), and GW-615 (Table 10) show gross alpha activity above 500 pCi/L in the shallow and deep groundwater at the S-3 Site (Figure 22), although the result for well GW-243 may be inaccurate based on the high proportional counting error (44% of the reported activity) and the elevated MDA (310 pCi/L).

Radioanalyte	Data Source	CY 1995 Activity ± Counting Error (pCi/L)		
		GW-243	GW-276	GW-615
Gross Alpha	GWPP Monitoring: Special Sampling:	NS 550 ± 240	661 ± 57* NS	NS <MDA
Uranium-234	GWPP Monitoring: Special Sampling:	NS 88 ± 16	266 ± 8* NS	NS 80 ± 14
Uranium-235	GWPP Monitoring: Special Sampling:	NS 5.2 ± 1.6	19 ± 8* NS	NS 3.6 ± 1.2
Uranium-238	GWPP Monitoring: Special Sampling:	NS 230 ± 40	578 ± 11* NS	NS 190 ± 33

NS=not sampled; <MDA=below minimum detectable activity; *=annual average activity

Radiochemical results for well GW-243 indicate several alpha-emitting radionuclides (e.g., neptunium-237) in the shallow groundwater at the S-3 Site (Table 11), but the data summarized above shows that the gross alpha activity is primarily from ^{234}U and ^{238}U. Additionally, micro-purge (i.e., low-flow) sampling protocols were used for Aquitard monitoring wells included in the BCV RI special radiological sampling program, and may explain the substantially lower gross alpha activity compared to that reported for the groundwater sample (3,530 ± 440 pCi/L) collected from the well in March 1994 using standard GWPP sampling protocols. Special sampling results for well

GW-615 also show uranium isotopes in the deeper groundwater directly downdip (south) of the S-3 Site (gross alpha activity for the sample was below the MDA).

Annual average gross alpha activity determined from the CY 1995 data for well GW-276 reflects a 50% increase from the annual average activity of 426 ± 39 pCi/L in CY 1994, which coincides with the increasing total uranium concentrations discussed in Section 4.2.1. Increasing gross alpha activity in the shallow groundwater at the well may reflect transport of uranium ions leached from the sludge remaining in the S-3 Site (Science Applications International Corporation 1996). Although the samples from well GW-276 were not analyzed for uranium isotopes, data for wells GW-243 and GW-615 suggest that gross alpha activity in the groundwater at GW-276 is probably from ^{234}U and ^{238}U.

Assuming a migration/transport pattern in the Aquitard similar to that for nitrate from the S-3 Site, gross alpha results for wells GW-346, GW-828, and GW-829 suggest more limited groundwater transport of alpha-emitting radionuclides along discreet pathways in the bedrock west of the site (Figure 22). Historically low gross alpha activity (below the applicable MDA in September 1995) in the nitrate-contaminated groundwater at well GW-346, compared to the historically elevated activity (i.e., >15 pCi/L) in the nitrate-contaminated groundwater at well GW-526, indicates westward transport along flowpaths not intercepted by (or hydraulically connected to) the monitored interval of GW-346. These migration pathways were probably intercepted in the shallow bedrock during installation of wells GW-828 and GW-829, as indicated by the gross alpha activity in the groundwater samples collected from the wells in February/March 1995 (13.6 ± 3.8 and 70.4 ± 35 pCi/L, respectively) and June 1995 (33 ± 20 and 80.9 ± 15 pCi/L, respectively). Although probably inaccurate because of high TSS, results for these samples qualitatively indicate that both wells encountered uranium isotopes transported in the shallow bedrock west of NT-1.

Elevated gross alpha activity in the nitrate-contaminated groundwater at well GW-537 reflects continued westward migration of uranium isotopes from the S-3 Site, and upward discharge from the shallow bedrock to the water table interval near Bear Creek tributary NT-2 (Figure 22). Gross alpha results for all the samples collected from the well during CY 1995 (Table 9 and 10) are consistent with historical data that show fairly stable gross alpha activity above 30 pCi/L, and no clear relationship with water levels in the well (Figure 23). Also, the special RI sampling results indicate low levels of ^{234}U (1.5 ± 0.49 pCi/L) and ^{238}U (0.52 ± 0.27 pCi/L) in the groundwater at the well (Table 11). Isotopic data from GWPP monitoring were considered inaccurate because of the elevated MDAs and results that do not exhibit appropriate isotopic decay series relationships (Table 11).

The CY 1995 gross alpha and isotopic uranium activities reported for well GW-087 further confirm the Burnyard/Boneyard as a principal source of uranium in the Bear Creek Regime. These results show gross alpha activity above 100 pCi/L (Tables 9 and 10), which is higher than any other well in the regime except those nearest the S-3 Site, and is more than double the gross alpha activity (54 ± 5 pCi/L) in the groundwater sample collected from the well in March 1990. Additionally, special sampling results for GW-087 indicate slightly higher ^{234}U (130 ± 27 pCi/L), ^{235}U (8.4 ± 2.6 pCi/L), and ^{238}U (380 ± 79 pCi/L) activities than in the groundwater at well GW-243 adjacent to the S-3 Site (Table 11). As noted previously, uranium isotopes from waste sources at the Burnyard/Boneyard are probably mobilized by forming stable ions with carbonate, and the results for well GW-087 reflect strike-parallel migration in the Aquitard toward discharge areas in Bear Creek tributary NT-3.

Gross Beta Activity

Data for the Aquitard monitoring wells sampled during CY 1995 show elevated gross beta activity in the groundwater at the S-3 Site and the Burnyard/Boneyard (Figure 24). Results for the wells at the S-3 Site show gross beta activity in the groundwater is primarily from ^{99}Tc (Table 11), but decay of uranium isotopes may account for the gross beta activity in the groundwater at the Burnyard/Boneyard (Science Applications International Corporation 1996).

Based on comparison with CY 1990 data summarized below, gross beta activity in the groundwater near the S-3 Site has decreased substantially in the water table interval (GW-276) and shallow bedrock (GW-243), but has remained relatively constant in the deep bedrock (GW-615).

Well Number	**Activity ± Counting Error (pCi/L)**			
	CY 1990		**CY 1995**	
	Gross Beta	**^{99}Tc**	**Gross Beta**	**^{99}Tc**
GW-243	60,750 ± 1,345*	60,800*	9,300 ± 1,200	23,108 ± 2,300
GW-276	4,110 ± 320*	NA	1,054 ± 78*	1,315 ± 36*
GW-615	554 ± 173*	NA	510 ± 200	50 ± 7
GW-085	57 ± 3*	NA	108 ± 14*	219 ± 12*
GW-346	0 ± 170	NA	35 ± 26	NA
GW-537	354 ± 48*	NA	529 ± 26*	1,315 ± 17*
			570 ± 79	1,300 ± 130

NA=not analyzed; *=annual average activity

Review of these results suggests the gross beta activity reported for well GW-243 may not be accurate in light of the significantly higher ^{99}Tc activity. Also, the low ^{99}Tc compared to the higher corresponding gross beta activity suggests that other radionuclides (possibly daughter products of uranium) contribute to the gross beta activity in the groundwater at well GW-615. Results for wells GW-085, GW-346, and GW-537 in the Burnyard/Boneyard area clearly indicate increasing gross beta activity in the groundwater west of the S-3 Site. Increasing gross beta activity in the groundwater at wells GW-085 and GW-537, and dilution- and flow-related activity fluctuations (Figure 23), generally mirror the nitrate data for these wells, and support the hypothesis that the center of mass of the nitrate/^{99}Tc plume is slowly moving westward toward NT-2 (Science Applications International Corporation 1996).

The mobility of ^{99}Tc in groundwater is similar to that of nitrate, and gross beta activity in the groundwater indicate a similar migration pattern in the Aquitard west of the S-3 Site (Science Applications International Corporation 1996): (1) strike parallel migration in the water table interval, shallow bedrock, and deep bedrock west of the site, (2) discharge from the water table interval into Bear Creek NT-1; (3) upward migration from the deep bedrock, and strike-parallel transport in the shallow bedrock west of NT-1; (4) upward discharge from the shallow bedrock to the water table interval at Bear Creek NT-2, and (5) continued strike-parallel transport in the shallow bedrock toward Bear Creek NT-3 (Figure 24).

As with gross alpha activity in the groundwater at well GW-087, gross beta activity has increased from less than 50 pCi/L in March 1990 to more than 200 pCi/L in September 1995 (Tables 9 and 10). Gross beta activity in the groundwater may be derived from decay of the ^{238}U daughter isotopes thorium-234 and palladium-234 (Science Applications International Corporation 1996). Special BCV RI sampling results, however, show thorium isotope activities either below (^{228}Th and ^{234}Th) or only slightly above (^{230}Th) the applicable MDAs (analyses for palladium-234 were not performed) (Table 11). These results also indicate ^{99}Tc (36 ± 6.3 pCi/L) in the groundwater at the well, which may reflect migration from the S-3 Site (the only known source of ^{99}Tc in the regime), possibly via groundwater inflow/discharge into Bear Creek NT-3 catchment upstream (north) of well GW-087.

The CY 1995 radionuclide data for Aquitard wells GW-085, GW-087, GW-243, GW-276, GW-537, and GW-615 were used to calculate respective cumulative dose equivalents. Results show the dose equivalent for groundwater at well GW-243 exceeds the 4 millirem per year (mrem/yr) drinking water MCL for gross beta activity (Tables 13 and 14). Cumulative dose equivalents were below 1 mrem/yr for groundwater at each of the remaining wells except GW-276 (1.39 mrem/yr) and GW-537 (1.07 to 1.37 mrem/yr).

4.4.2 Aquifer

Gross alpha and gross beta activities for the groundwater at most of the Aquifer monitoring wells sampled during CY 1995 were below applicable MDAs. The bulk of the respective results that exceeded the MDAs were below either the 15 pCi/L MCL for gross alpha activity, or the 50 pCi/L threshold value for gross beta activity. Activities that indicate groundwater contamination generally reflect downgradient transport from the Boneyard/Burnyard (gross alpha activity) and the S-3 Site (gross beta activity).

Gross Alpha Activity

Gross alpha activity results for the Aquifer monitoring wells generally mirror the uranium concentration trends and migration patterns described in Section 4.2.2, and reflect greater retardation of uranium isotopes relative to nitrate (and ^{99}Tc). The data indicate background activity levels (i.e.

below applicable MDAs) in the groundwater at all but 13 of the Aquifer monitoring wells (Tables 9 and 10), most of which are downgradient of the Boneyard/Burnyard (Figure 22). Groundwater samples from six of these wells had gross alpha activity above the 15 pCi/L, including: GW-061 (18 ± 2 pCi/L) south of BG-A South; Exit Pathway Picket A wells GW-683 (25 ± 5 pCi/L) and GW-684 (18 ± 6 pCi/L); Exit Pathway Picket B wells GW-694 (47 ± 5 pCi/L) and GW-706 (34 ± 4 pCi/L), and Exit Pathway Picket W well GW-712 (21 ± 7 pCi/L).

Gross alpha results for Aquifer monitoring wells near the S-3 Site show background levels in the groundwater at wells GW-100 and GW-124, and minimal activity in the groundwater at wells GW-236 (3.3 ± 2.1 pCi/L) and GW-315 (2 ± 1 pCi/L) (Figure 22). In light of the nitrate levels in the groundwater at these wells, particularly GW-236 (>150 mg/L), the low gross alpha activities reflect significant retardation of uranium isotopes in the Aquitard. Low gross alpha activity in the groundwater at well GW-236, and in the groundwater farther downgradient (the highest activity was 6 ± 3 pCi/L at Picket C well GW-738), also indicates little if any influx of uranium isotopes (or other alpha-emitting radionuclides) from Bear Creek NT-1 and NT-2 catchments. This is supported by low alpha activity in the groundwater at Picket C during both seasonally high and low flow conditions, as illustrated by data for well GW-725 (Figure 25).

Gross alpha activity in the Aquifer downgradient of Picket C reflect influx of uranium isotopes directly from the Burnyard/Boneyard or via discharge from the NT-3 catchment, and migration into the deeper bedrock along the losing reach of Bear Creek south of the Sanitary Landfill I (Figure 22). Migration into the deeper bedrock is indicated by the relatively low gross alpha activity in the groundwater at wells GW-228 (7 ± 3 pCi/L) and GW-229 (6 ± 3 pCi/L).

Elevated gross alpha activity in the groundwater downgradient of the Oil Landfarm WMA, as with nitrate in the groundwater, shows migration of uranium isotopes into higher stratigraphic zones within the Maynardville Limestone, and ultimately into the Knox Group (Figure 22). As noted previously, gross alpha activity exceeds 15 pCi/L in the groundwater at Picket B well GW-706 (Zone 4) and Picket A well GW-684 (Copper Ridge Dolomite), and special sampling results show ^{234}U and ^{238}U in the groundwater at both wells (Table 11). Additionally, gross alpha activity in the groundwater at Picket B and Picket A, as illustrated by data for wells GW-694 and GW-684 (Figure

25), are generally lowest during high-flow periods, which probably reflects seasonal dilution from uncontaminated recharge.

Gross Beta Activity

Results for the Aquifer monitoring wells sampled during CY 1995 show gross beta activity above applicable MDAs in the groundwater at 24 wells, including 14 wells with activity above 25 pCi/L, and four wells with activity above the 50 pCi/L threshold value at four wells (Tables 10 and 12). The highest gross beta activities were reported for wells GW-236 (98 ± 11 pCi/L) and GW-124 (177 ± 19 pCi/L); these results represent substantial (i.e., >50%) decreases from respective activity levels in CY 1990. Downgradient of these wells, gross beta activity in highest in the groundwater at Picket B wells GW-694 (69 ± 5 pCi/L) and GW-706 (52 ± 5 pCi/L) (Figure 24). The gross beta activity in the Aquifer is from ^{99}Tc, as indicated by ^{99}Tc activities in the groundwater at Picket B wells GW-694 (116 ± 40 pCi/L) and GW-706 (39 ± 6 pCi/L), and Picket A well GW-684 (28 ± 6 pCi/L) (Table 11).

As noted previously, ^{99}Tc is almost as mobile in groundwater as nitrate, and gross beta activity in the Aquifer monitoring wells reflect essentially identical migration patterns (Figure 24): (1) recharge from the water table interval south of the S-3 Site, and strike-parallel downgradient transport toward Exit Pathway Picket C, (2) seasonal influx of ^{99}Tc-contaminated groundwater and surface water from the Bear Creek NT-1 and NT-2 catchments, primarily into the basal portion (Zone 2) of the Maynardville Limestone as indicated by results for well GW-725 (Figure 25), (3) shallow groundwater transport downgradient of Picket C (GW-229), as well as migration into the deeper flow system along the losing reach of Bear Creek south of Sanitary Landfill (GW-228), (4) progressive downgradient migration into successively higher stratigraphic zones in the Maynardville Limestone at Picket B (GW-706), and ultimately into the Copper Ridge Dolomite (GW-684) at Picket A, and (5) dilution from seasonal recharge of uncontaminated groundwater downstream of Picket C, as illustrated by gross beta activity trends in groundwater at wells GW-684 and GW-694 (Figure 25).

Although the annual average gross beta activity in the groundwater at well GW-694 exceeded 50 pCi/L, the cummulative dose calculated from the ^{99}Tc data (0.12 mrem/yr) is substantially below the 4 mrem/yr MCL for gross beta activity (Table 13).

5.0 SURFACE WATER QUALITY DATA

This section presents a review and interpretation of surface water quality in Bear Creek, as indicated by the CY 1995 data for samples from the main channel (BCK-03.87, BCK-04.55, BCK-09.40, and BCK-11.97), two major northern tributaries (NT-1 and NT-2), four surface seeps (MS1, TS, Seep 1, and Seep 2), and six springs that discharge to the creek (SS-1, SS-4, SS-5, SS-6, SS-6W, and SS-7) (Figure 9). It is based on the underlying assumptions and outcome of the respective data screening and evaluation procedures described in Appendix C for principal ions, trace metals, VOCs, and radiological parameters. Results for the samples collected upstream of BCK-11.97 (Upper Bear Creek), between BCK-11.97 and BCK-09.40 (Middle Bear Creek), and downstream of BCK-09.40 (Lower Bear Creek) are described separately in the following sections.

5.1 Upper Bear Creek

As noted in Section 2.4, the quality of surface water in the upper reaches of Bear Creek primarily reflects discharge of contaminated groundwater from the water table interval in the Aquitard and Aquifer downgradient of the S-3 Site. Discharge of contaminated groundwater from the Aquitard is demonstrated by CY 1995 results for samples collected from tributaries NT-1 and NT-2; results for seeps MS1 and TS, and spring SS-1 show influx of contaminated groundwater from the Aquifer. Data summarized below clearly show that discharge from the NT-1 catchment is the primary source of contamination in the creek.

Sampling Point	Nitrate (mg/L)	VOCs (µg/L)	Trace Metals (mg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
MS1	6	NA	NA	NA	NA
TS	1	NA	NA	NA	NA
NT-1N	**23**	NA	NA	NA	NA
NT-01	**102***	PCE: 4.0*	Cd: **0.017*** Mn: **3.13*** U: **0.028***	**24 ±6**	**356 ± 36***
NT-1S	**110**	NA	NA	NA	NA
SS-1	26*	PCE: 1.0 TCE: 1.0	U: **0.031***	14 ± 3*	**55 ± 5**
NT-02	**25***	ND	U:	<MDA	25 ± 4*
BCK-11.97	**190***	ND	U: **0.111***	**34 ± 5***	**343 ± 31**
NA=not analyzed; ND=not detected; **BOLD**=exceeds water quality standard;*=annual average or median					

Nitrate concentrations in the tributary at NT-1N, compared to the substantially higher levels at NT-01 and NT-1S, suggest that contaminated groundwater discharges primarily from the water table interval in the upper part of the Nolichucky Shale and/or the basal part of the Maynardville Limestone (Figure 11). Low levels of PCE (below the 5 ug/L MCL) in the samples from NT-01 and SS-1 reflect groundwater transport from the S-3 Site. Results for trace metals indicate primarily elevated uranium concentrations, but as noted in Section 4.2.2, downstream transport of manganese from Bear Creek NT-01 also is indicated by high manganese concentrations in the groundwater at well GW-236. Gross alpha and gross beta activity in the creek is primarily from contaminated surface water discharged by NT-1, and groundwater from spring SS-1. Radioisotope analyses show ^{99}Tc activity above the applicable MDAs in the surface water discharged from NT-1 (165 ± 42 and 956 ± 20 pCi/L) and in Bear Creek at BCK-11.97 (143 ± 41 and 994 ± 20 pCi/L), and isotopic strontium ($^{89/90}$Sr) in the groundwater discharged from SS-1 (60 ± 24 pCi/L) (Table 11). Dose equivalents calculated from the data for each of these sampling locations show the cumulative dose for spring SS-1 (5.74 mrem/yr) is primarily from strontium activity (^{99}Tc was not detected in the samples from the spring) and exceeds the 4 mrem/yr MCL for gross beta activity (Tables 13 and 14).

Results for BCK-11.97 reflect the overall improvement of surface water quality in the upper reach of Bear Creek since closure of the S-3 Site. As indicated by the annual average nitrate concentration (220 mg/L), gross alpha activity (69 ± 4 pCi/L), and gross beta activity (521 ± 10 pCi/L) determined from CY 1990 data, results obtained during CY 1995 reflect overall decreases of 15%, 51%, and 34%, respectively. Decreasing contaminant concentrations in the upper part of Bear Creek mirror the decreasing concentration trends evident in the shallow groundwater near the S-3 Site.

As illustrated by nitrate data, contaminant concentrations in Upper Bear Creek fluctuate seasonally (Figure 26). In general, concentrations are highest during the seasonally dry periods of the year (summer and fall) when the bulk of the flow in the creek is from groundwater discharge. Seasonally fluctuating concentrations also are evident downstream of BCK-11.97 (Figure 26). These results suggest that contaminant concentrations in Bear Creek are generally controlled by varying degrees of seasonal dilution.

5.2 Middle Bear Creek

Surface water quality in Bear Creek downstream of BCK-11.97 reflects transport of nitrate and ^{99}Tc from the upper reaches of the creek and transport of uranium isotopes from the Burnyard/Boneyard. As shown in the following data summary, contaminated groundwater discharged from springs SS-4 and SS-5, which contribute the bulk of the flow in the creek during seasonally low flow periods (Science Applications International Corporation 1996), is the principal source of contamination in the creek downstream of BCK-11.97.

Sampling Point	**Nitrate (mg/L)**	**VOCs (µg/L)**	**Trace Metals (mg/L)**	**Gross Alpha (pCi/L)**	**Gross Beta (pCi/L)**
SS-4	**13***	TCE: 2.5*	**U: 0.095***	**34 ± 5***	**56 ± 6***
		1,2-DCE 2.5*		**49 ± 11**	**110 ± 17**
SS-5	4*	TCE: 1.0*	**U: 0.040***	**16 ± 3***	30 ± 5
				24 ± 8	32 ± 8
BCK-09.40	5*	TCE: 1.0*	**B: 0.184***	**30 ± 4***	35 ± 4*
		1,2-DCE: 3.5*	**U: 0.078***	**38 ± 10**	34 ± 8
BOLD=exceeds water quality standard;*=annual average or median					

Along with nitrate results, the CY 1995 radionuclide data show that the elevated gross beta activity in the groundwater discharged at springs SS-4 and SS-5 is from ^{99}Tc (200 ± 21 pCi/L and 46 ± 7 pCi/L, respectively), which indicates transport in the Aquifer from the S-3 Site. This suggests that the S-3 Site, and not the Boneyard/Burnyard, may be the primary source of the gross alpha activity (i.e., uranium isotopes) in the groundwater discharged from each spring (Table 12).

The quality of surface water in Bear Creek at BCK-9.40 probably reflects downstream transport of contaminants from the S-3 Site (nitrate, ^{99}Tc, and uranium isotopes) and the Boneyard/Burnyard (uranium isotopes), but low levels of TCE and 1,2-DCE and elevated boron concentrations probably reflect an influx of contaminated groundwater from Bear Creek tributaries (NT-6, NT-7, and NT-8) that traverse the Bear Creek Burial Grounds WMA. As noted previously, both TCE and 1,2-DCE are primary components of the VOC plume in the shallow groundwater at BG-A South, and elevated boron concentrations occur in the groundwater near BG-C West (which discharges to NT-8) and BG-A South (which discharges to NT-6 and NT-7).

Radionuclide results for samples collected during CY 1995 from a surface seep near BG-C East (Seep 2) indicates an influx of contaminated surface water from Bear Creek NT-8 catchment. Averaged results for the samples from Seep 2 show ^{234}U (54 ± 9 pCi/L), ^{235}U(4.7 ± 1.2 pCi/L), ^{238}U (330 ± 54 pCi/L), and ^{99}Tc (73 ± 7 pCi/L) in shallow groundwater (water table interval) discharging from BG-C East into the eastern fork of NT-8. Downstream transport of these isotopes in NT-8 probably contributes to the elevated gross alpha and gross beta activity in Bear Creek at BCK-09.40. Discharge from BC-A North into NT-7, as indicated by the data for Seep 1, also contains low levels of each of these radionuclides (Table 12), which likewise may contribute to gross alpha and gross beta activity in Bear Creek at BCK-09.40.

5.3 Lower Bear Creek

Surface water downstream of BCK-09.40 contains slightly elevated concentrations of several contaminants (e.g., gross alpha activity), but as summarized below, are generally below applicable water quality standards.

Sampling Point	Nitrate (mg/L)	Trace Metals (mg/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
SS-6W	2	NA	3 ± 2	7 ± 3
SS-7	2*	U: 0.005*	**16 ± 4**	24 ± 5
BCK-04.55	1*	U: 0.018*	7 ± 2*	<MDA
		0.017*	15 ± 8	<MDA
BCK-03.87	1*	U: 0.017*	8 ± 2*	<MDA

NA=not analyzed; **BOLD**=exceeds water quality standard;*=annual average/median

6.0 CONCLUSIONS AND RECOMMENDATIONS

The bulk of the groundwater and surface water quality data obtained during CY 1995 are consistent with historical results regarding contaminant types, source areas, concentration trends, and contaminant plume boundaries. As summarized below, the data also are consistent with most aspects of the respective conceptual models for contaminant migration/transport described in the RI report for the Bear Creek CA (Science Applications International Corporation 1996).

S-3 Site

- The nitrate plume illustrates the overall patterns of groundwater contaminant transport in the Aquitard, and the CY 1995 nitrate data generally reflect: (1) westward, strike-parallel transport in the water table interval, shallow bedrock (i.e., <100-ft bgs), and deep bedrock (i.e., >150-ft bgs) toward Bear Creek NT-1; (2) discharge from the water table interval into NT-1, and upward migration from the deep bedrock into the shallow bedrock; (3) westward, strike-parallel transport in the shallow bedrock toward Bear Creek NT-2; (4) upward migration from the shallow bedrock into the water table interval, and discharge from the water table interval into NT-2, and (5) strike-parallel migration in the shallow bedrock toward Bear Creek NT-3.

- The western extent of contaminant transport in the water table interval of the Aquitard is essentially defined by Bear Creek NT-1, which intercepts the bulk of the shallow groundwater and channels it into Bear Creek. Downward hydraulic gradients from the water table interval to the shallow bedrock suggest that the contaminated groundwater in the shallow bedrock does not extensively discharge into NT-1. Upward hydraulic gradients from the deep bedrock, however, indicate that the fault or fracture zone associated with NT-1 promotes upward migration into the shallow bedrock. Thus, Bear Creek NT-1 also generally delineates the maximum western extent of contaminant transport in the deep bedrock of the Aquitard.

- Data for surface water samples collected from NT-1 show that the primary groundwater discharge areas are in the upper Nolichucky Shale near the contact with the Maynardville Limestone.

- Concentrations of all contaminants have substantially decreased since CY 1990, and most now reflect fairly asymptotic levels. However, data obtained since March 1994 show increasing uranium and gross alpha activity in the shallow groundwater at well GW-276, which may indicate leaching of uranium isotopes from the sludge remaining in the site (Science Applications International Corporation 1996).

Oil Landfarm WMA

- The Boneyard/Burnyard is a primary source of uranium isotopes and VOCs (primarily PCE and 1,2-DCE) in the Aquifer. These contaminants are transported (from apparently separate source areas) by groundwater in the Aquitard (water table interval) toward discharge areas in Bear Creek NT-3, and recharge directly into the Aquifer from source areas that overly the Maynardville Limestone.

- Elevated gross alpha and gross beta activity in the groundwater at the Boneyard/Burnyard may be attributed primarily to decay of uranium isotopes and daughter products (Science Applications International Corporation 1996). However, results obtained during CY 1995 indicate that gross beta activity in the groundwater at well GW-087 may be partially attributed to ^{99}Tc. The S-3 Site is the only documented source of ^{99}Tc in the Bear Creek Regime, and its detection in groundwater at well GW-087 may reflect discharge from the leading edge of the S-3 plume into Bear Creek NT-3 upstream (north) of the well.

Bear Creek Burial Grounds WMA

- Although slightly decreased since CY 1990, VOC concentrations in the Aquitard at the Bear Creek Burial Grounds WMA are higher than anywhere else in the Bear Creek Regime and reflect widespread DNAPLs in the subsurface. Results obtained during CY 1995 show strike-parallel transport of PCE and 1,2-DCE in the water table interval of the Aquitard from the primary areas (BG-A North and South, Walk-In Pits North and South, and BG-C East and West) toward discharge areas along NT-6, NT-7, and NT-8.

- Shallow groundwater near disposal areas that received large volumes of borax waste water (BG-A South, BG-C East, and BG-C West) has elevated total and dissolved boron concentrations. The CY 1995 data for wells at these sites reflect transport in the shallow groundwater toward NT-6, NT-7, and NT-8.

- The CY 1995 data for several surface seeps show uranium isotopes from BG-C East discharge with shallow groundwater into Bear Creek NT-8.

Maynardville Limestone Exit Pathway

- Nitrate, ^{99}Tc, TCE, and uranium isotopes are the primary groundwater contaminants in the Aquifer. The bulk of the groundwater contamination occurs below the water table interval in the uppermost and lowermost stratigraphic zones in the Maynardville Limestone.

- Nitrate and ^{99}Tc enters the Aquifer primarily via groundwater/surface water discharge from Bear Creek NT-1 and NT-2 catchments.

- The Boneyard/Burnyard is the primary source of uranium isotopes in the Aquifer, as indicated by CY 1995 data showing very high activities in groundwater at well GW-087 (i.e., higher than in groundwater at the S-3 Site) and elevated gross alpha activity in the Aquifer downstream of the Bear Creek NT-3 catchment.

- The plume of dissolved VOCs in the Aquifer primarily reflects transport of TCE from the Rust Spoil Area, and PCE and 1,2-DCE from the Burnyard/Boneyard. Widespread distribution of VOCs in the Aquifer is more a function of multiple source areas than the mobility of these contaminants in the groundwater.

- Data for nitrate and ^{99}Tc indicate the following contaminant transport patterns in the Aquifer: (1) westward, strike parallel transport in the water table interval and in permeable stratigraphic zones in the bedrock at the top and the bottom of the Maynardville Limestone; (2) influx of contaminants (primarily nitrate and ^{99}Tc) into the basal Maynardville Limestone via surface water/groundwater recharge from Bear Creek NT-1; (3) influx of VOCs into the middle and upper Maynardville Limestone via direct recharge from the Rust Spoil Area, (4) influx of nitrate into the basal Maynardville Limestone via surface water/groundwater recharge from Bear Creek NT-2; (5) influx of uranium isotopes and VOCs via direct inflow from the Boneyard/Burnyard, or discharge from Bear Creek NT-3, (6) downward migration into the deep flow system in the Aquifer underlying the losing reach of Bear Creek south of Sanitary Landfill I, (7) strike-parallel transport in the bedrock downgradient of the Oil Landfarm WMA, and progressive migration toward the high permeability zone at the top of the Maynardville Limestone and bottom of the Copper Ridge Dolomite.

Bear Creek

- Surface water in the upper reaches of Bear Creek (i.e., upstream of BCK-11.97) is contaminated with most of the principal groundwater contaminants, including nitrate, ^{99}Tc, and uranium isotopes. Trace metal and VOC concentrations are generally present at trace levels or otherwise less than the applicable water quality standards. Data obtained during CY 1995 generally show decreasing concentration trends and seasonal fluctuations; concentrations are typically highest during seasonally dry periods when groundwater discharge provides the bulk of the flow in the creek.

- Influx of contaminants into Bear Creek is via direct groundwater discharge from springs in the Maynardville Limestone, but mainly from discharge of contaminated groundwater and surface water in NT-1, NT-2, and NT-3.

- Contaminants from the Bear Creek Burial Grounds WMA (PCE, 1,2-DCE, boron, and uranium isotopes) are transported into Bear Creek via NT-6, NT-7, and NT-8.

- Concentrations of most contaminants in Bear Creek downstream of BCK-09.40 are below applicable water quality standards.

Groundwater sampling and analysis activities planned for the Bear Creek Regime during CY 1997 are specified in the *Sampling and Analysis Plan for Groundwater and Surface Water Monitoring at the Y-12 Plant During Calendar Year 1997* (AJA Technical Services, Inc. 1996).

7.0 REFERENCES

Buckley, P. 1992. Letter from K-25 Analytical Services Organization to Paradigm Data Services, Inc., October 21, 1992.

Dreier, R.B., D.K. Solomon, and C.M. Beaudoin. 1987. Fracture Characterization in the Unsaturated Zone of a Shallow Land Burial Facility. *Flow and Transport through Fractured Rock.* American Geophysical Union Monograph 42.

Goldstrand, P.M. 1995. *Stratigraphic variations and secondary porosity within the Maynardville Limestone in Bear Creek Valley, Y-12 Plant, Oak Ridge, Tennessee.* Martin Marietta Energy Systems, Inc. (Y/TS-1093).

HSW Environmental Consultants, Inc. 1993. *Calendar Year 1992 Groundwater Quality Assessment Report for the Bear Creek Hydrogeologic Regime, Y-12 Plant, Oak Ridge, Tennessee: 1992 Groundwater Data Interpretations and Proposed Program Modifications.* Prepared for Martin Marietta Energy Systems, Inc. (Y/SUB/93-YP507C/1/ P2).

HSW Environmental Consultants, Inc. 1994. *Sampling and Analysis Plan for Groundwater and Surface Water Monitoring at the Y-12 Plant During Calendar Year 1995.* Prepared for Martin Marietta Energy Systems, Inc. (Y/SUB/94-EAQ10C/4).

Lockheed Martin Energy Systems, Inc. 1996. *Calendar Year 1995 Groundwater Quality Report for the Bear Creek Hydrogeologic Regime, Y-12 Plant, Oak Ridge, Tennessee: 1995 Groundwater Quality Data and Calculated Rate of Contaminant Migration.* (Y/TS-1437).

Jones, S.B., B.K. Thompson, and S.M. Field. 1995. *Updated Subsurface Data Base for Bear Creek Valley, Chestnut Ridge, and Parts of Bethel Valley on the U.S. Department of Energy Oak Ridge Reservation.* Martin Marietta Energy Systems, Inc. (Y/TS-881/R3).

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

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

Moore, G.K. 1992. Hydrograph analysis in fractured rock terrain. *Ground Water*, Vol. 30, No. 3, pp. 390-395.

Moore, G.K. and L.E. Toran. 1992. *Supplement to a Hydrogeologic Framework for the Oak Ridge Reservation, Oak Ridge, Tennessee.* Oak Ridge National Laboratory (ORNL/TM-12191).

Science Applications International Corporation. 1996. *Remedial Investigation Report for Bear Creek Valley.* Volume 1. (Draft).

Shevenell, L.A. 1994. *Chemical Characteristics of Waters in Karst Formations at the Oak Ridge Y-12 Plant.* Oak Ridge National Laboratory (Y/TS-1001).

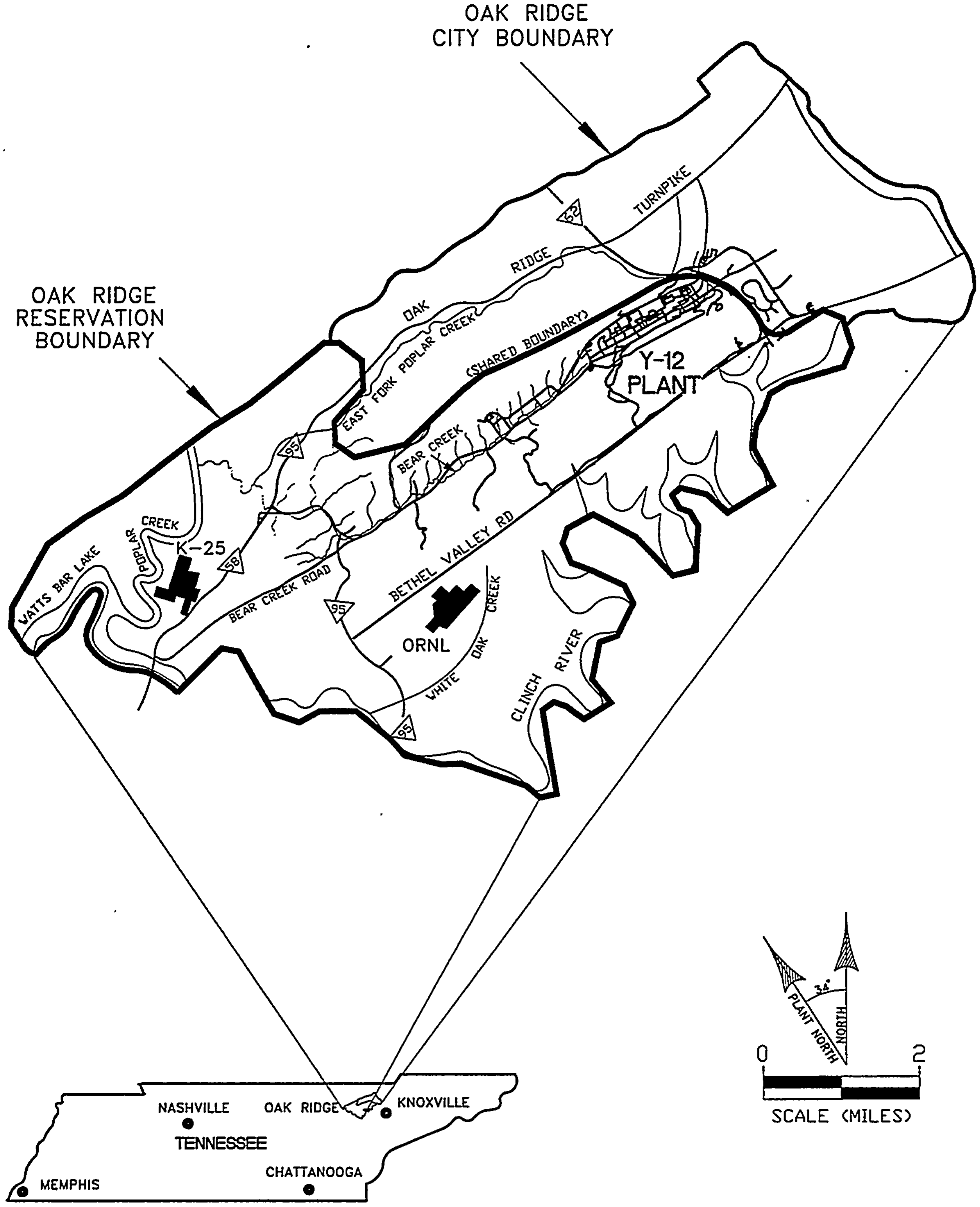
Shevenell, L.A and P.M. Goldstrand. 1994. *Effectiveness Evaluation of Three RCRA Caps at the Y-12 Plant, Oak Ridge, Tennessee.* Oak Ridge National Laboratory (Y/TS-1001).

Shevenell, L.A., R.B Dreier, and W.K. Jago. 1994. *Summary of Fiscal Years 1991 and 1992 Construction, Hydrologic, and Geological Data Obtained from the Maynardville Limestone Exit Pathway Monitoring Program.* Oak Ridge National Laboratory. (Y/TS-814).

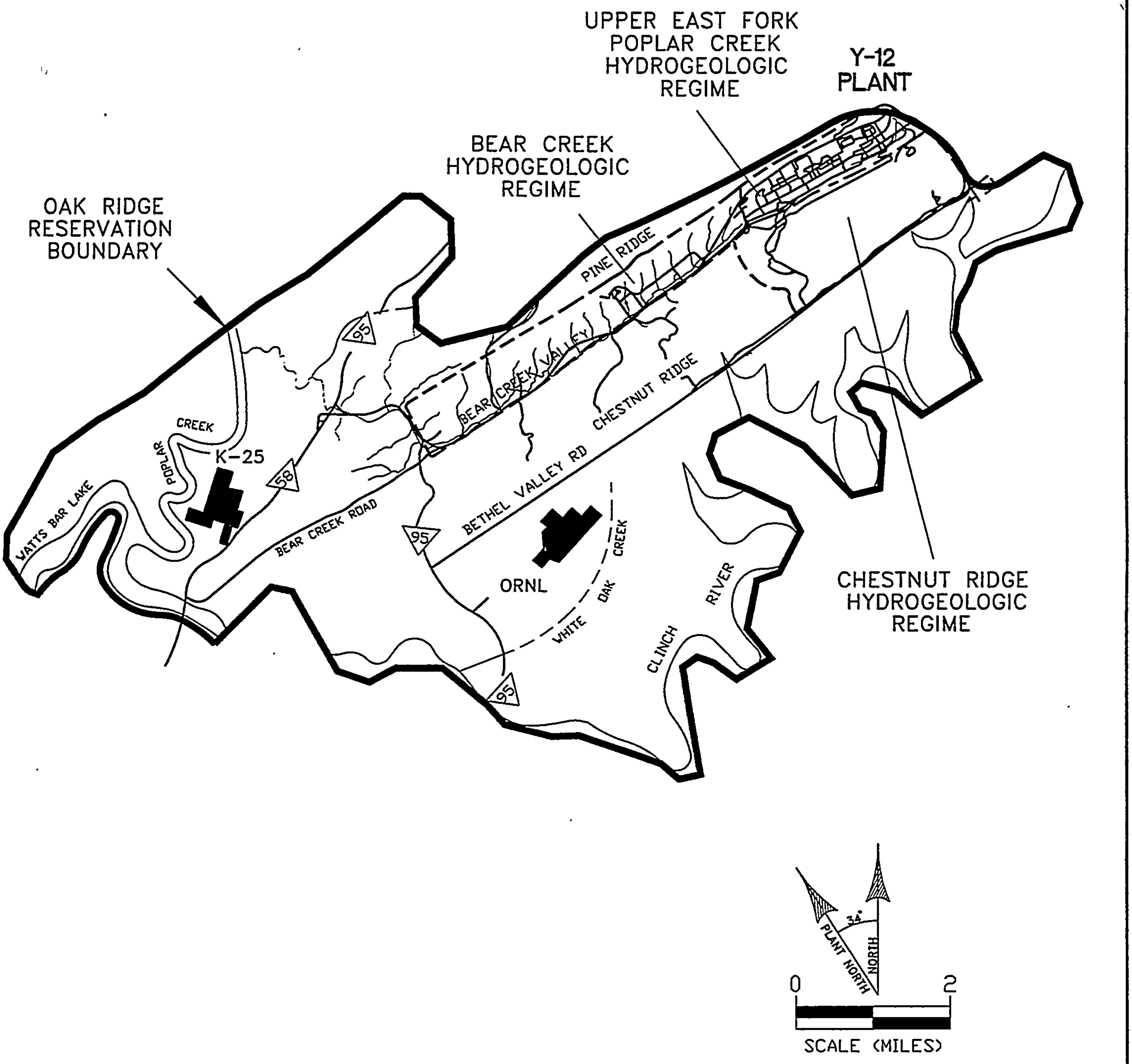
Solomon, D.K., G.K. Moore, L.E. Toran, R.B. Dreier, and W.M. McMaster. 1992. *Status Report - A Hydrologic Framework for the Oak Ridge Reservation.* Oak Ridge National Laboratory (ORNL/TM-12053).

Turner, R.R., M.A. Bogel, R.B. Clamp, K.C. Dearstone, R.B. Drier, T.O. Early, S.E. Herbes, J.M. Loar, P.D. Parr, and G.R. Southworth. 1991. *Remedial Investigation Work Plan for Bear Creek (Y02-S600) at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee.* Martin Marietta Energy Systems, Inc. (ES/ER-19&D2).

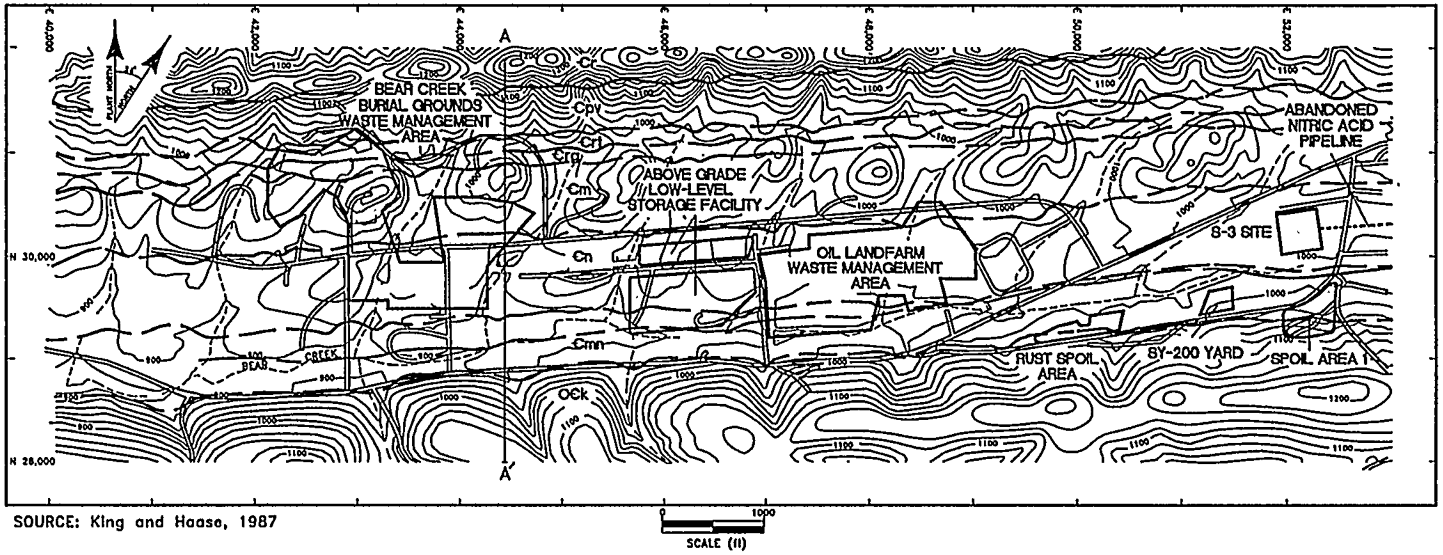
U.S. Department of Energy. 1994. *Oak Ridge Reservation Site Management Plan for the Environmental Restoration Program.* U.S. Department of Energy Oak Ridge Field Office (DOE/OR-1001/R3).



REPARED FOR: *LOCKHEED MARTIN ENERGY SYSTEMS, INC.*	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 1
PREPARED BY: *AJA TECHNICIAL SERVICES, INC.*	DOC NUMBER:	96-D005	REGIONAL LOCATION OF THE Y-12 PLANT
	DWG ID.:	96-020	
	DATE:	6-20-96	

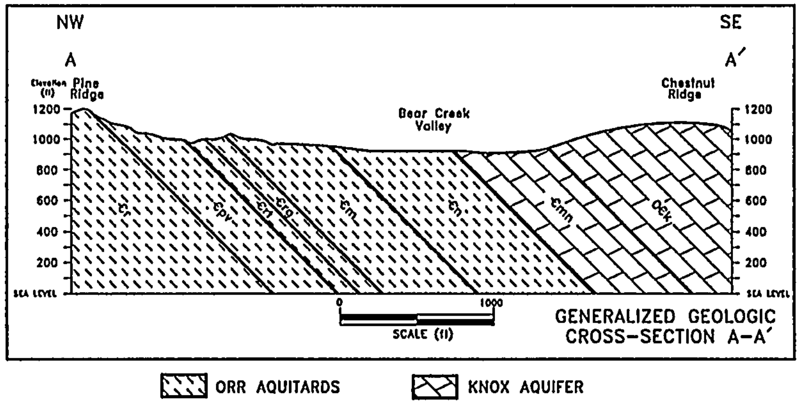


PREPARED FOR: *LOCKHEED MARTIN ENERGY SYSTEMS, INC.*	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 2
PREPARED BY: *AJA TECHNICIAL SERVICES, INC.*	DOC NUMBER:	96-D001	HYDROGEOLOGIC REGIMES AT THE Y-12 PLANT
	DWG ID.:	96-021	
	DATE:	6-20-96	



SOURCE: King and Haase, 1987

SYSTEM		GROUP	HYDRO UNIT	FORMATION	MAP SYMBOL	THICKNESS (ft)
CAMBRIAN	UPPER	KNOX	KNOX AQUIFER	COPPER RIDGE DOLOMITE	OꞒk	NOT DETERMINED
		CONASAUGA		MAYNARDVILLE LIMESTONE	Ꞓmn	418–450
	MIDDLE		ORR AQUITARDS	NOLICHUCKY SHALE	Ꞓn	422–550
				MARYVILLE LIMESTONE	Ꞓm	346–445
				ROGERSVILLE SHALE	Ꞓrg	90–120
				RUTLEDGE LIMESTONE	Ꞓrl	90–120
				PUMPKIN VALLEY SHALE	Ꞓpv	260–320
	LOWER			ROME	Ꞓr	NOT DETERMINED



GENERALIZED GEOLOGIC CROSS-SECTION A–A′

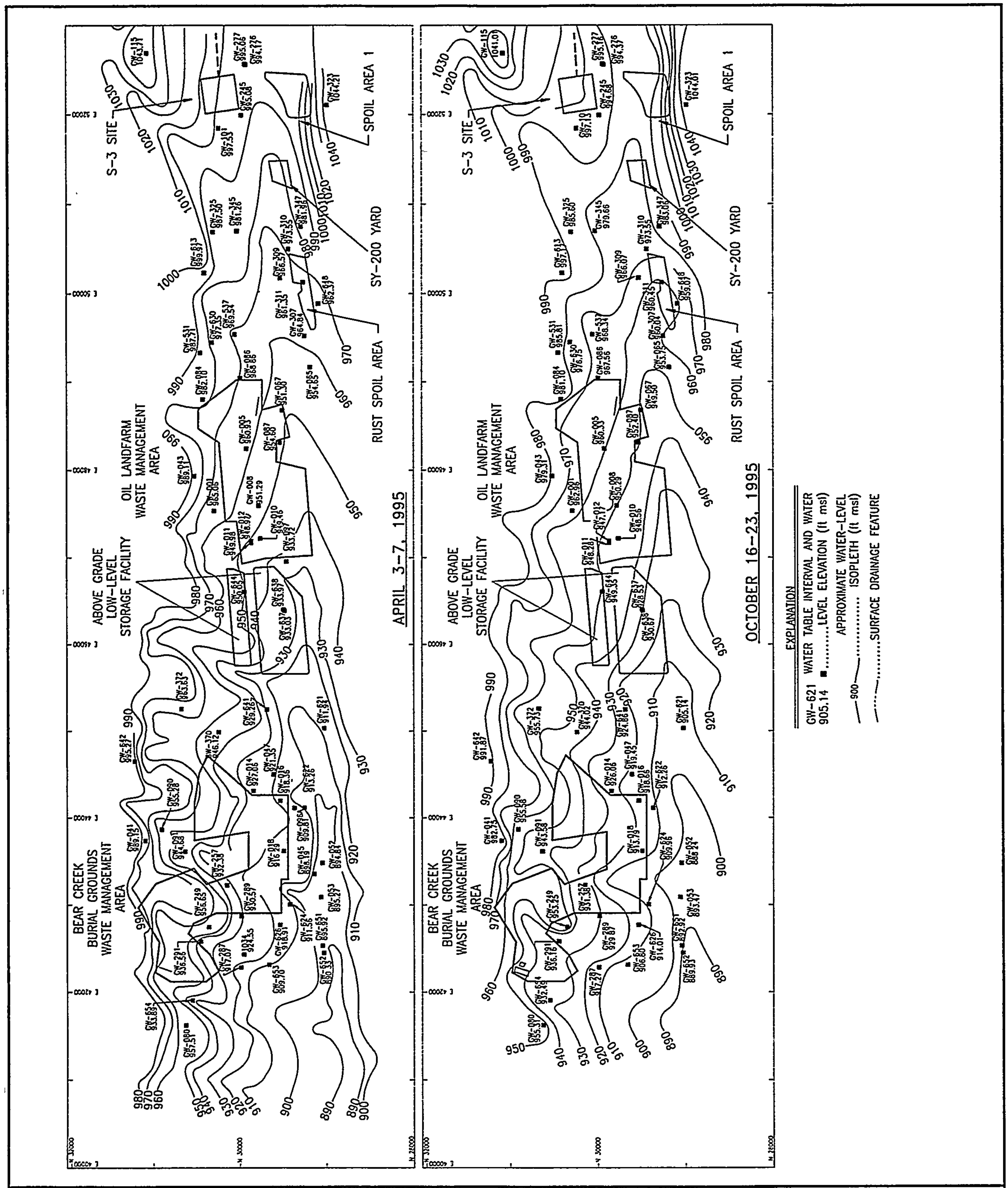
PREPARED FOR:
LOCKHEED MARTIN ENERGY SYSTEMS, INC.

PREPARED BY:
AJA TECHNICIAL SERVICES, INC.

LOCATION:	Y–12 PLANT OAK RIDGE, TN.
DOC NUMBER:	96–D001
DWG ID.:	96–036
DATE:	6–20–96

FIGURE 3

TOPOGRAPHY AND BEDROCK GEOLOGY IN THE BEAR CREEK HYDROGEOLOGIC REGIME



PREPARED FOR:
LOCKHEED MARTIN ENERGY SYSTEMS, INC.

PREPARED BY:
AJA TECHNICIAL SERVICES, INC.

LOCATION: Y-12 PLANT OAK RIDGE, TN.

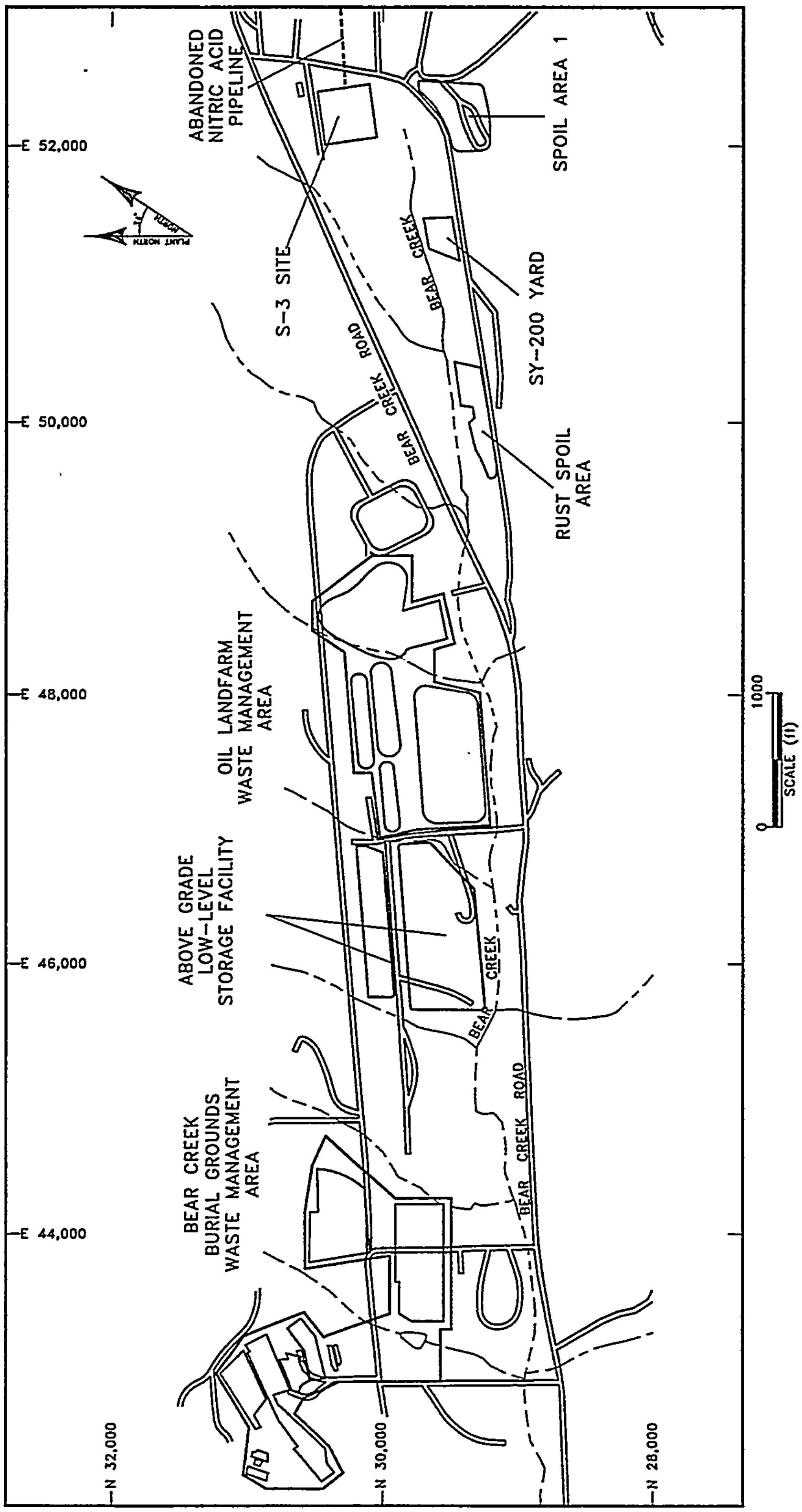
DOC NUMBER: 96-D006

DWG ID.: 96-058

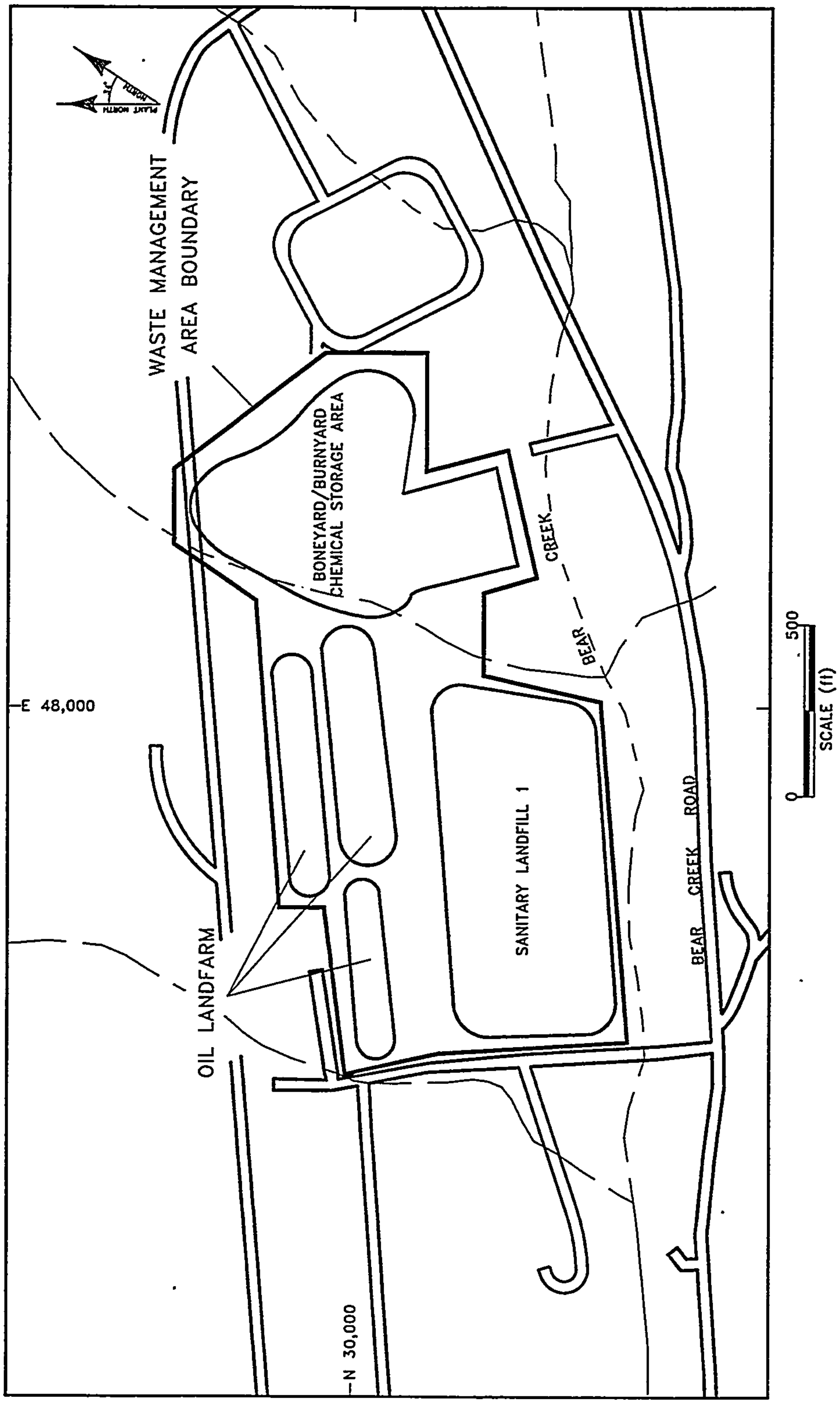
DATE: 6-20-96

FIGURE 4

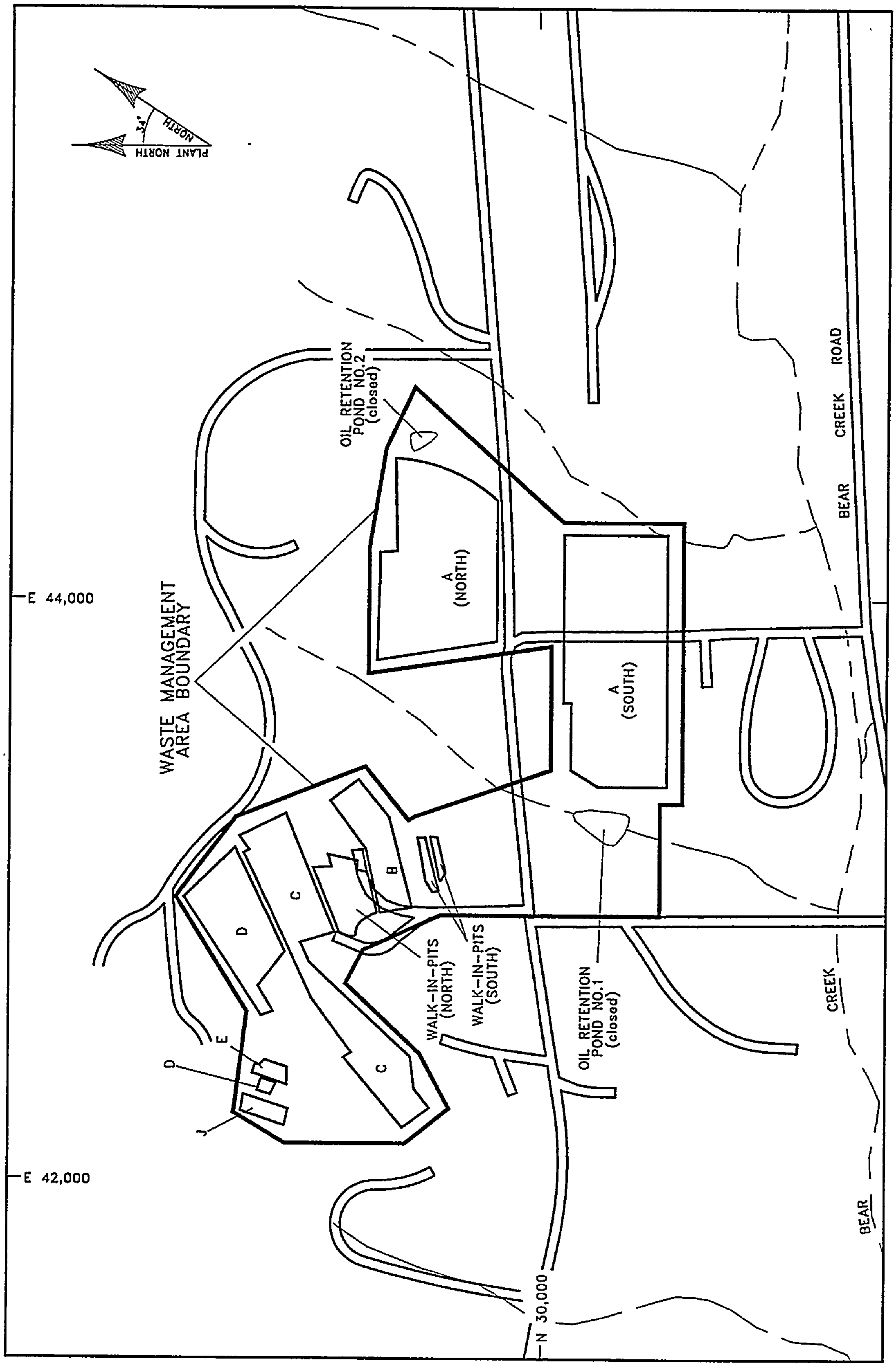
GROUNDWATER ELEVATIONS IN THE BEAR CREEK HYDROGEOLOGIC REGIME



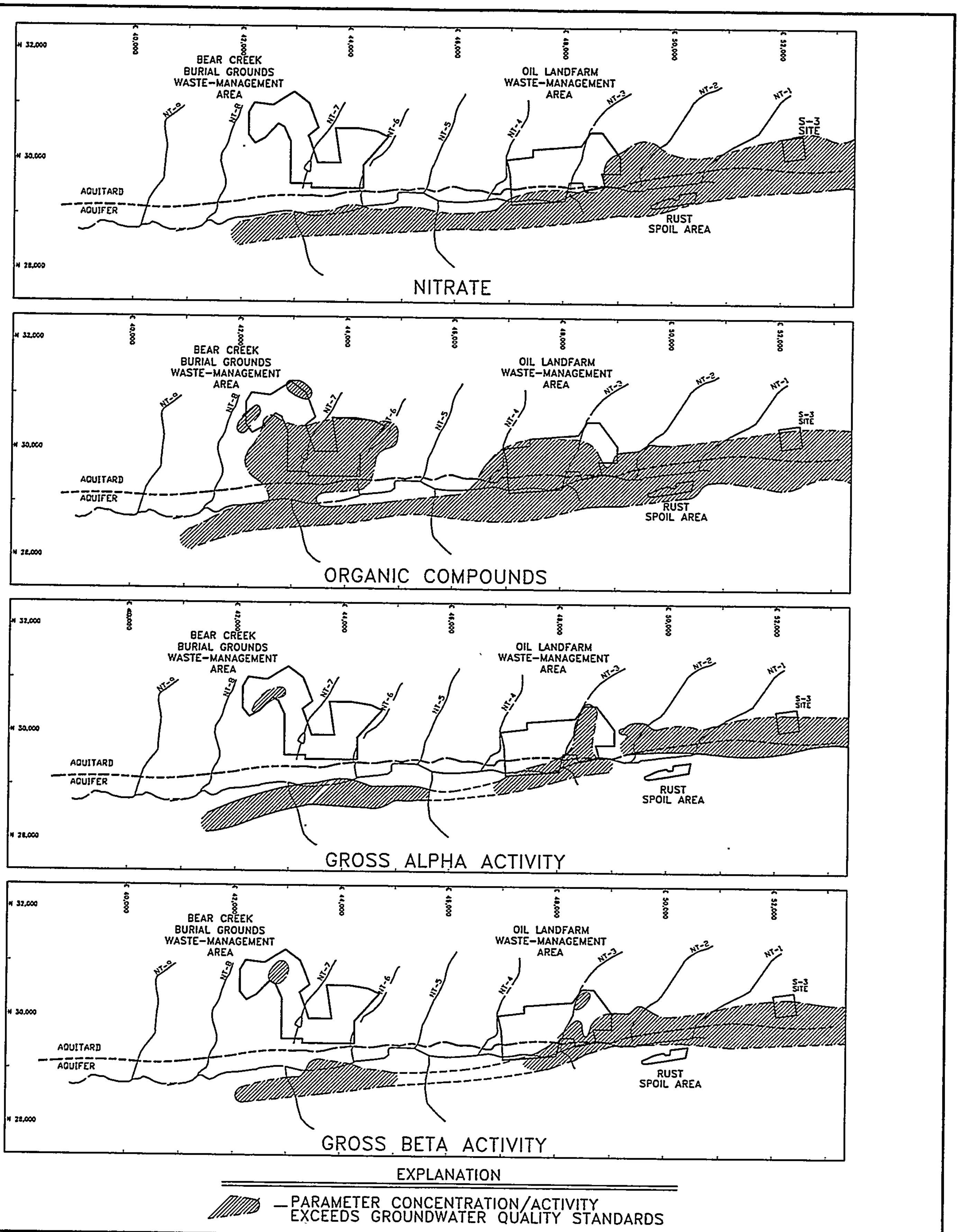
PREPARED FOR: *LOCKHEED MARTIN ENERGY SYSTEMS, INC.*	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 5
PREPARED BY: *AJA TECHNICIAL SERVICES, INC.*	DOC NUMBER:	96-D006	WASTE MANAGEMENT SITES IN THE BEAR CREEK HYDROGEOLOGIC REGIME
	DWG ID.:	96-035	
	DATE:	6-20-96	



PREPARED FOR: *LOCKHEED MARTIN ENERGY SYSTEMS, INC.*	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 6
PREPARED BY: *AJA TECHNICIAL SERVICES, INC.*	DOC NUMBER:	96-D006	COMPONENTS OF THE OIL LANDFARM WMA
	DWG ID.:	96-059	
	DATE:	6-20-96	



PREPARED FOR: *LOCKHEED MARTIN ENERGY SYSTEMS, INC.*	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 7
PREPARED BY: *AJA TECHNICAL SERVICES, INC.*	DOC NUMBER:	96-D006	COMPONENTS OF THE BEAR CREEK BURIAL GROUNDS WMA
	DWG ID.:	96-060	
	DATE:	6-20-96	



PREPARED FOR:
LOCKHEED MARTIN
ENERGY SYSTEMS, INC.

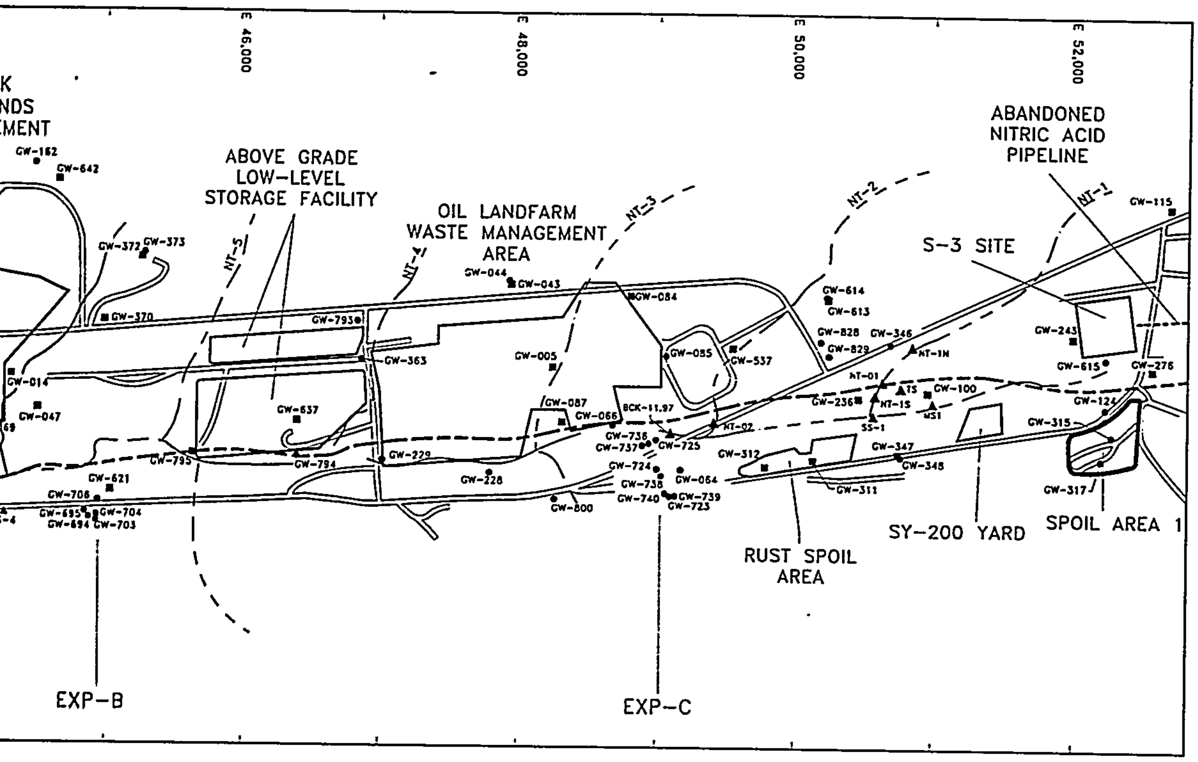
PREPARED BY:
AJA TECHNICIAL
SERVICES, INC.

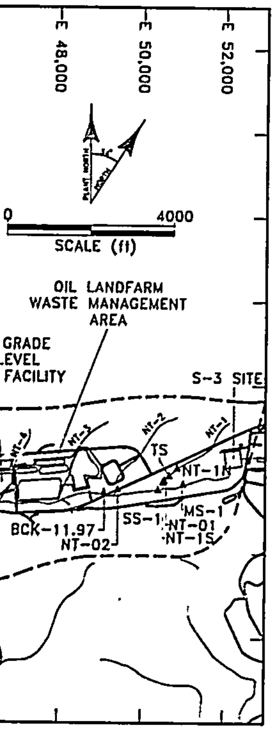
LOCATION: Y-12 PLANT
OAK RIDGE, TN.

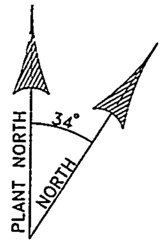
DOC NUMBER: 96-D006
DWG ID.: 96-061
DATE: 6-20-96

FIGURE 8

GROUNDWATER CONTAMINATION
IN THE BEAR CREEK HYDROGEOLOGIC REGIME







EXPLANATION

■ — Water Table Monitoring Well

• — Bedrock Monitoring Well

▲ — Spring, Seep, or Surface Water Sampling Station

EXP–C — Exit Pathway, Maynardville Limestone Traverse (Picket)

——— — Surface Drainage Feature

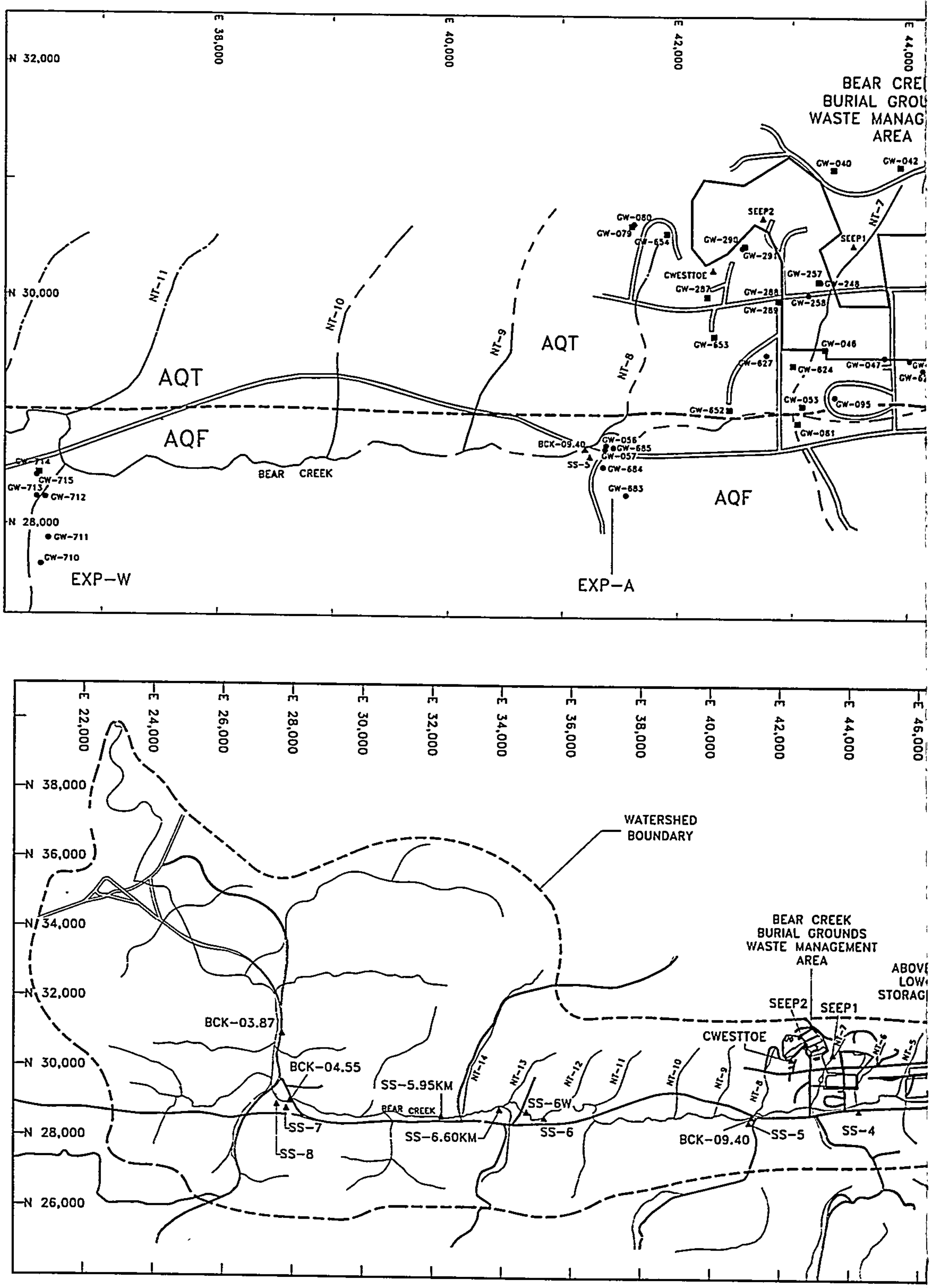
NT–5 — North Tributary

AQT — Aquitards

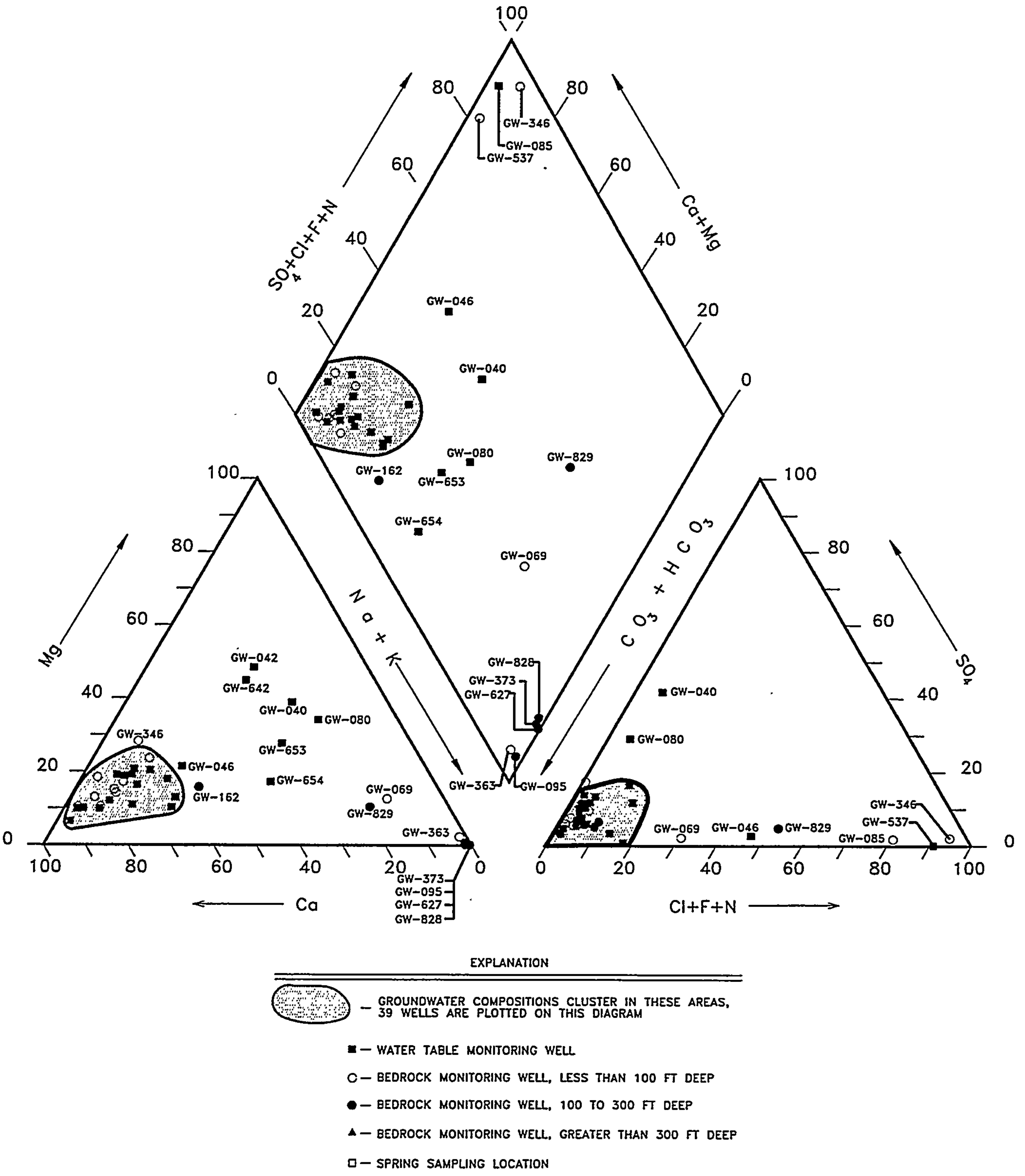
— – — – — Approximate Nolichucky Shale\Maynardville Limestone Contact

AQF — Aquifer

PREPARED FOR: *LOCKHEED MARTIN ENERGY SYSTEMS, INC.*	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 9
PREPARED BY: *AJA TECHNICIAL SERVICES, INC.*	DOC NUMBER:	96-D006	GROUNDWATER AND SURFACE WATER SAMPLING LOCATIONS FOR CY 1995
	DWG ID.:	96-028	
	DATE:	6-20-96	



SPRINGS, SEEPS, AND SURFACE WATER SAMPLING LOCATIONS



EXPLANATION

▨ — GROUNDWATER COMPOSITIONS CLUSTER IN THESE AREAS, 39 WELLS ARE PLOTTED ON THIS DIAGRAM

■ — WATER TABLE MONITORING WELL

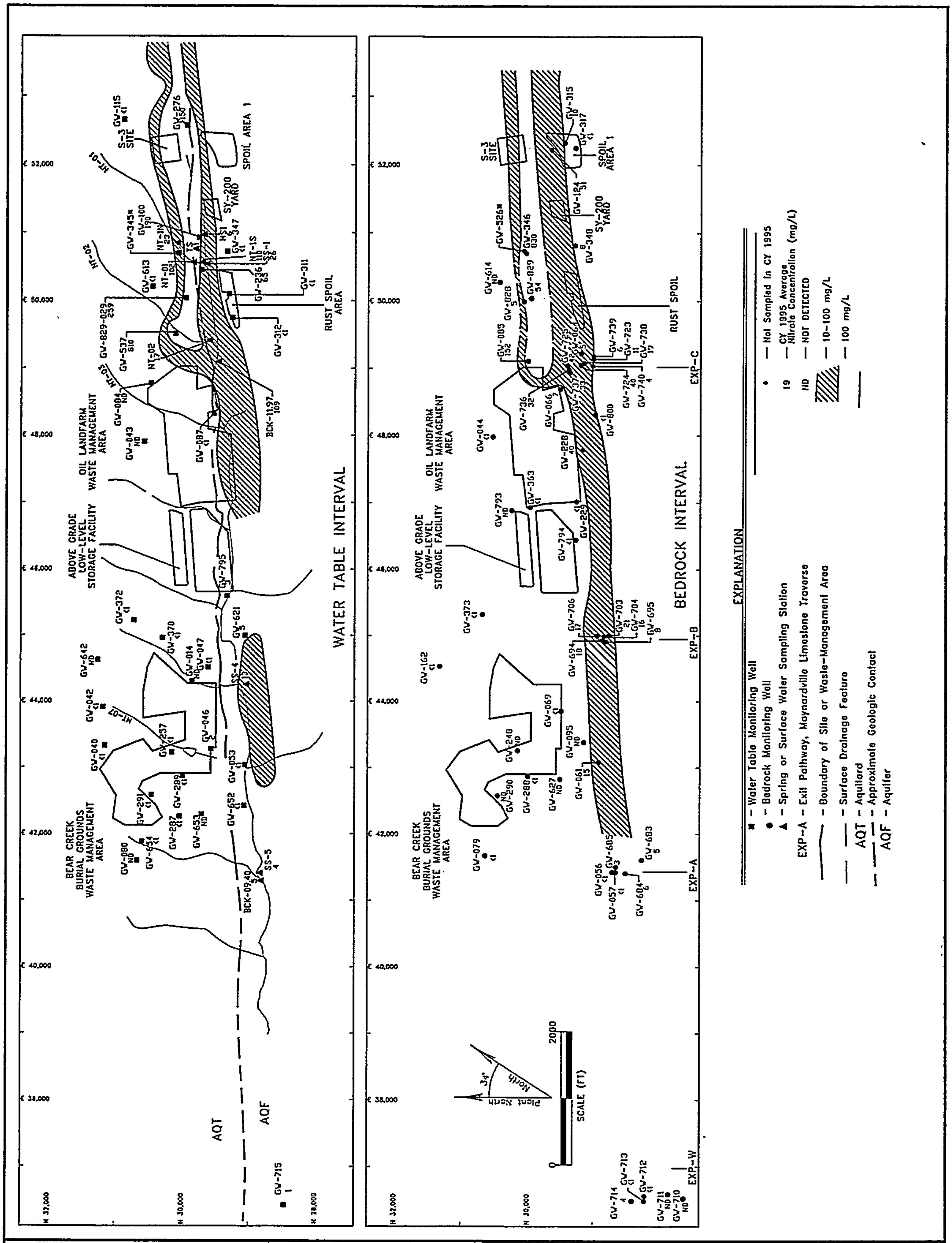
○ — BEDROCK MONITORING WELL, LESS THAN 100 FT DEEP

● — BEDROCK MONITORING WELL, 100 TO 300 FT DEEP

▲ — BEDROCK MONITORING WELL, GREATER THAN 300 FT DEEP

□ — SPRING SAMPLING LOCATION

PREPARED FOR: *LOCKHEED MARTIN ENERGY SYSTEMS, INC.*	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 10
PREPARED BY: *AJA TECHNICIAL SERVICES, INC.*	DOC NUMBER:	96-D006	GROUNDWATER GEOCHEMISTRY IN THE AQUITARD
	DWG ID.:	96-040	
	DATE:	6-20-96	



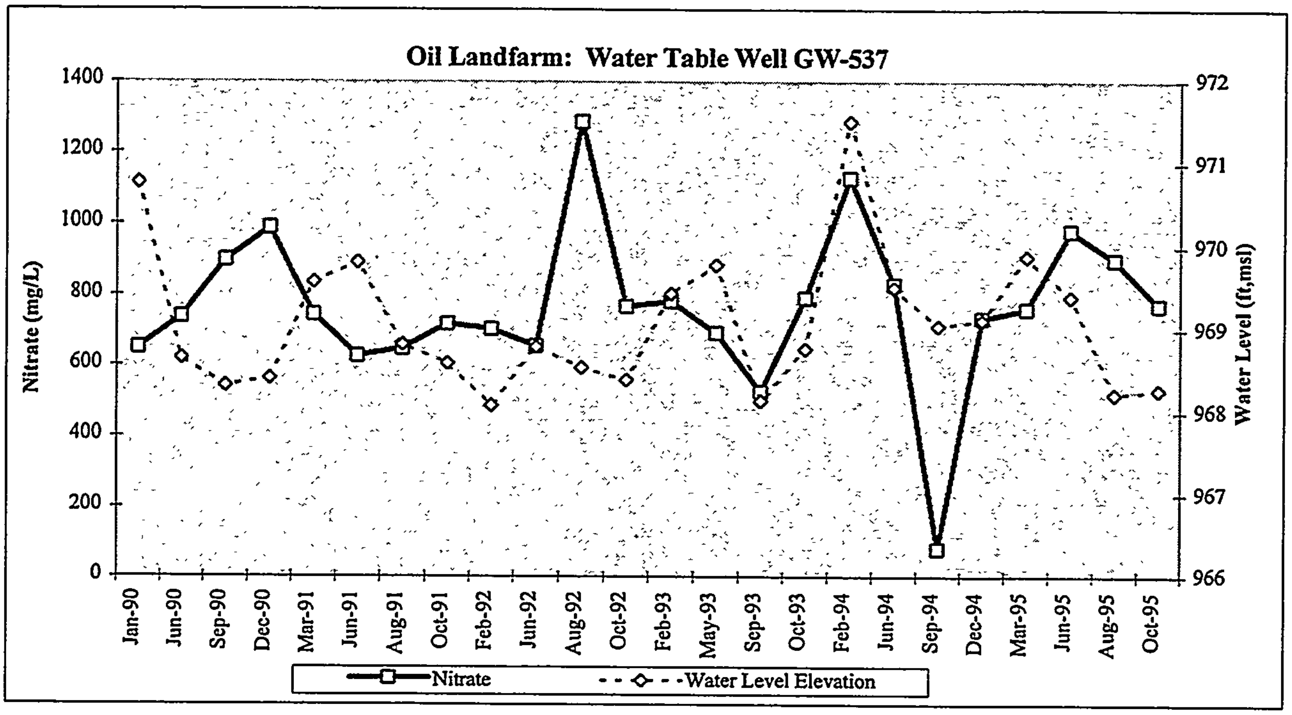
PREPARED FOR:
LOCKHEED MARTIN ENERGY SYSTEMS, INC.

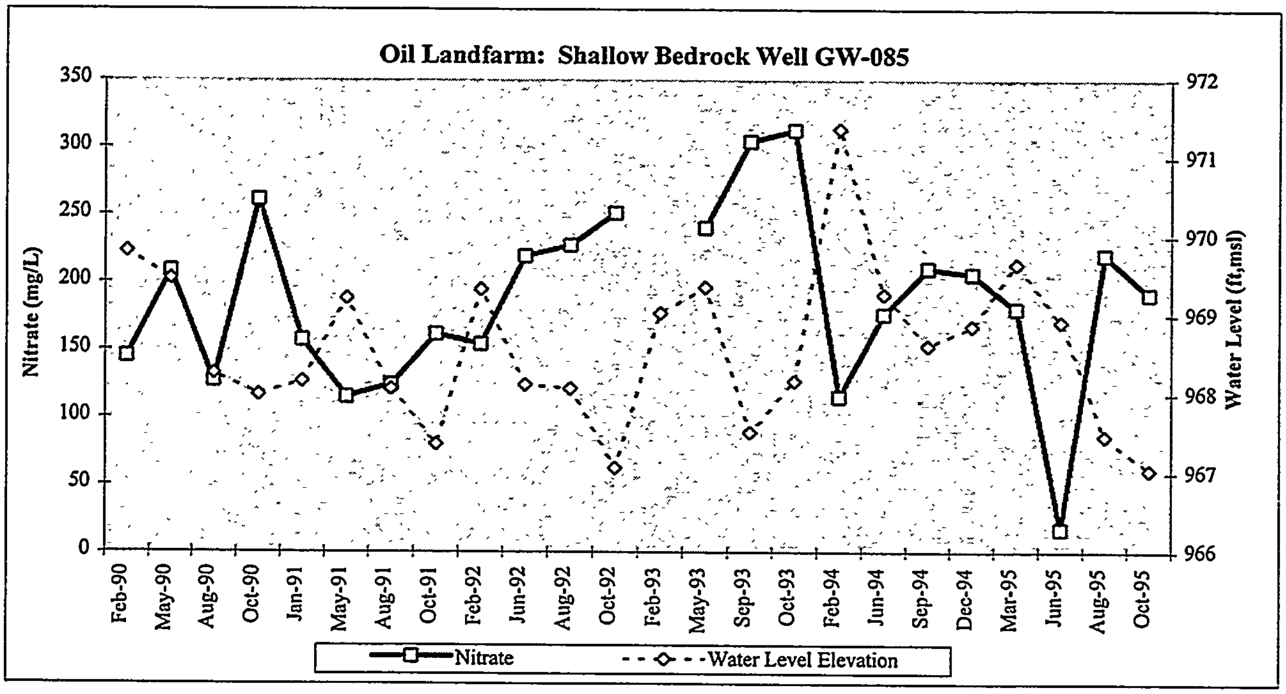
PREPARED BY:
AJA TECHNICIAL SERVICES, INC.

LOCATION: Y-12 PLANT OAK RIDGE, TN.
DOC NUMBER: 96-D006
DWG ID.: 96-042
DATE: 6-20-96

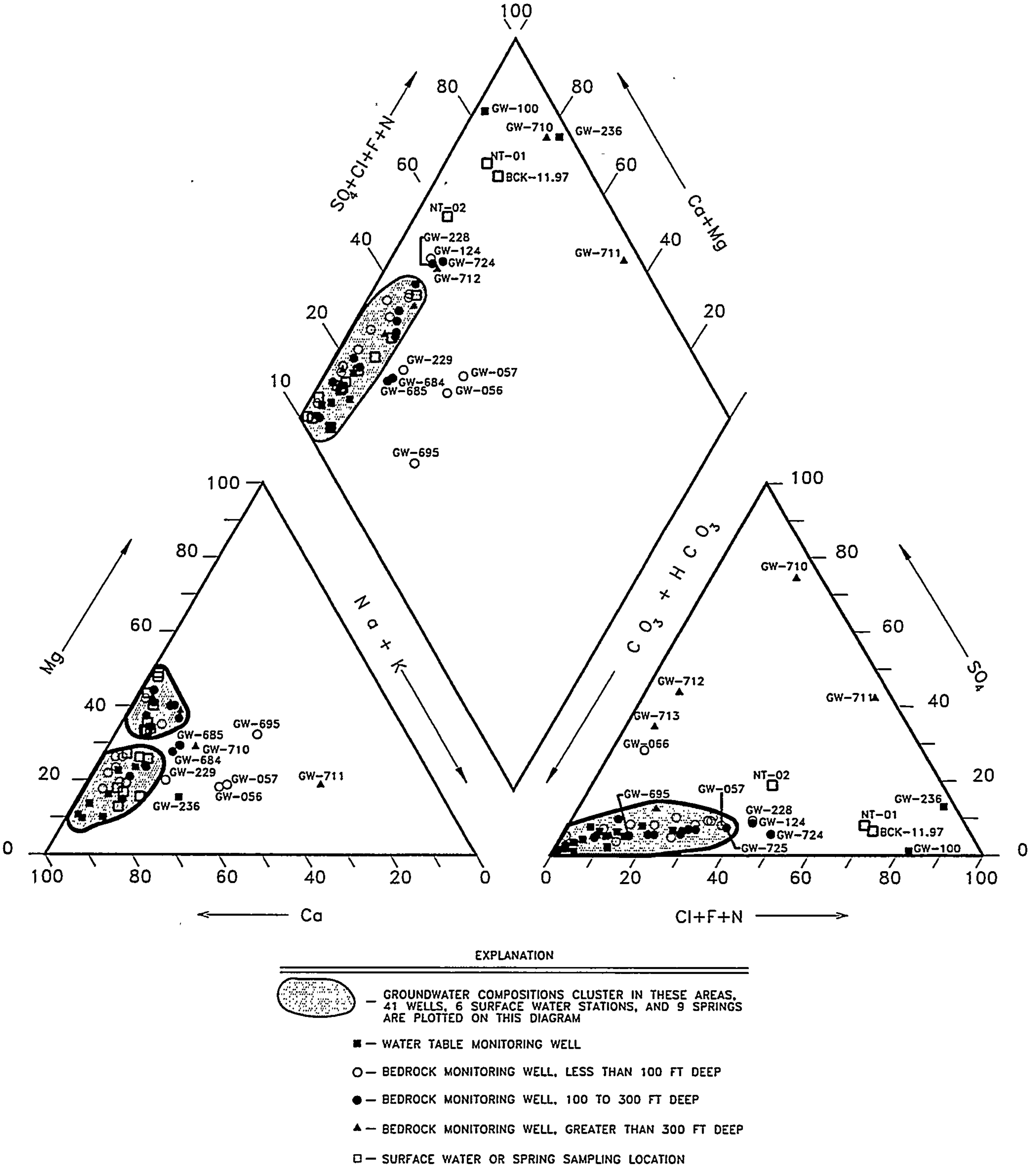
FIGURE 11

NITRATE IN GROUNDWATER AND SURFACE WATER IN THE BEAR CREEK HYDROGEOLOGIC REGIME, 1995

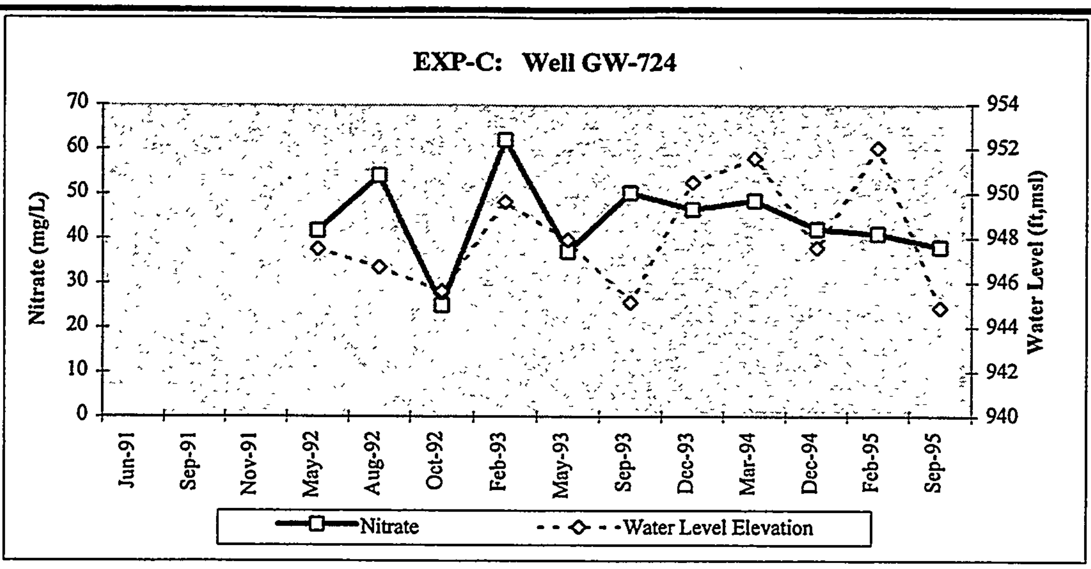

Oil Landfarm: Water Table Well GW-537

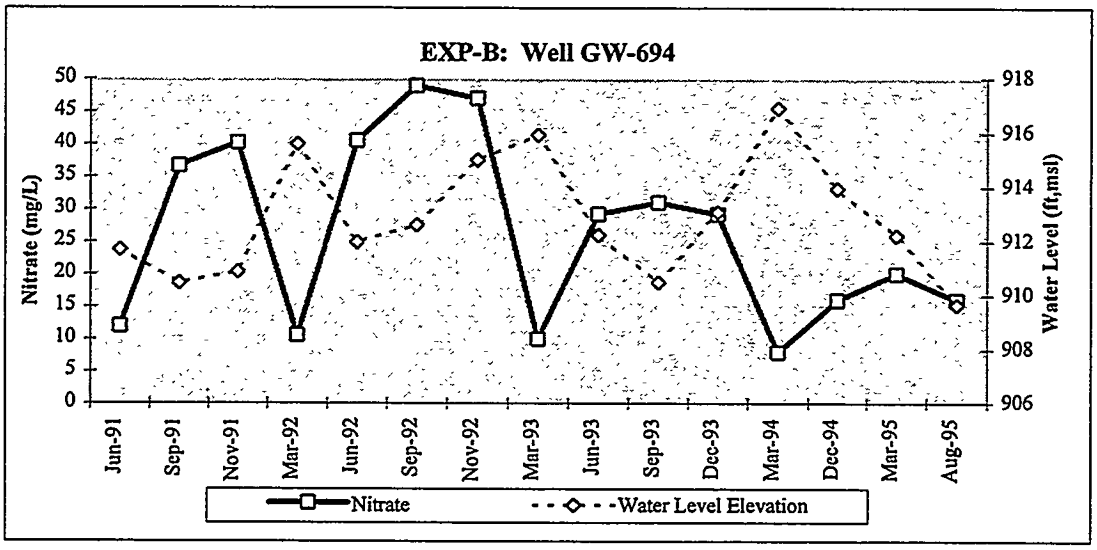

Oil Landfarm: Shallow Bedrock Well GW-085

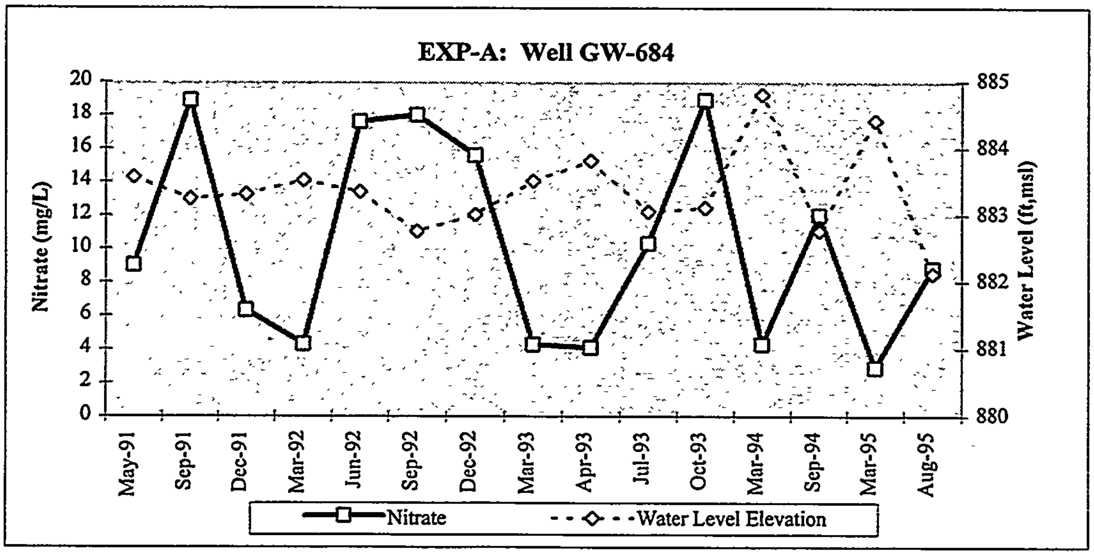
PREPARED FOR: *LOCKHEED MARTIN ENERGY SYSTEMS, INC.*	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 12
PREPARED BY: *AJA TECHNICIAL SERVICES, INC.*	DOC NUMBER:	96-D008	NITRATE CONCENTRATION TRENDS IN WELLS GW-085 AND GW-537
	DWG ID.:	96-062	
	DATE:	6-20-96	



PREPARED FOR: *LOCKHEED MARTIN ENERGY SYSTEMS, INC.*	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 13
PREPARED BY: *AJA TECHNICIAL SERVICES, INC.*	DOC NUMBER:	96-D006	GROUNDWATER GEOCHEMISTY IN THE AQUIFER
	DWG ID.:	96-039N	
	DATE:	6-20-96	







PREPARED FOR:
LOCKHEED MARTIN ENERGY SYSTEMS, INC.

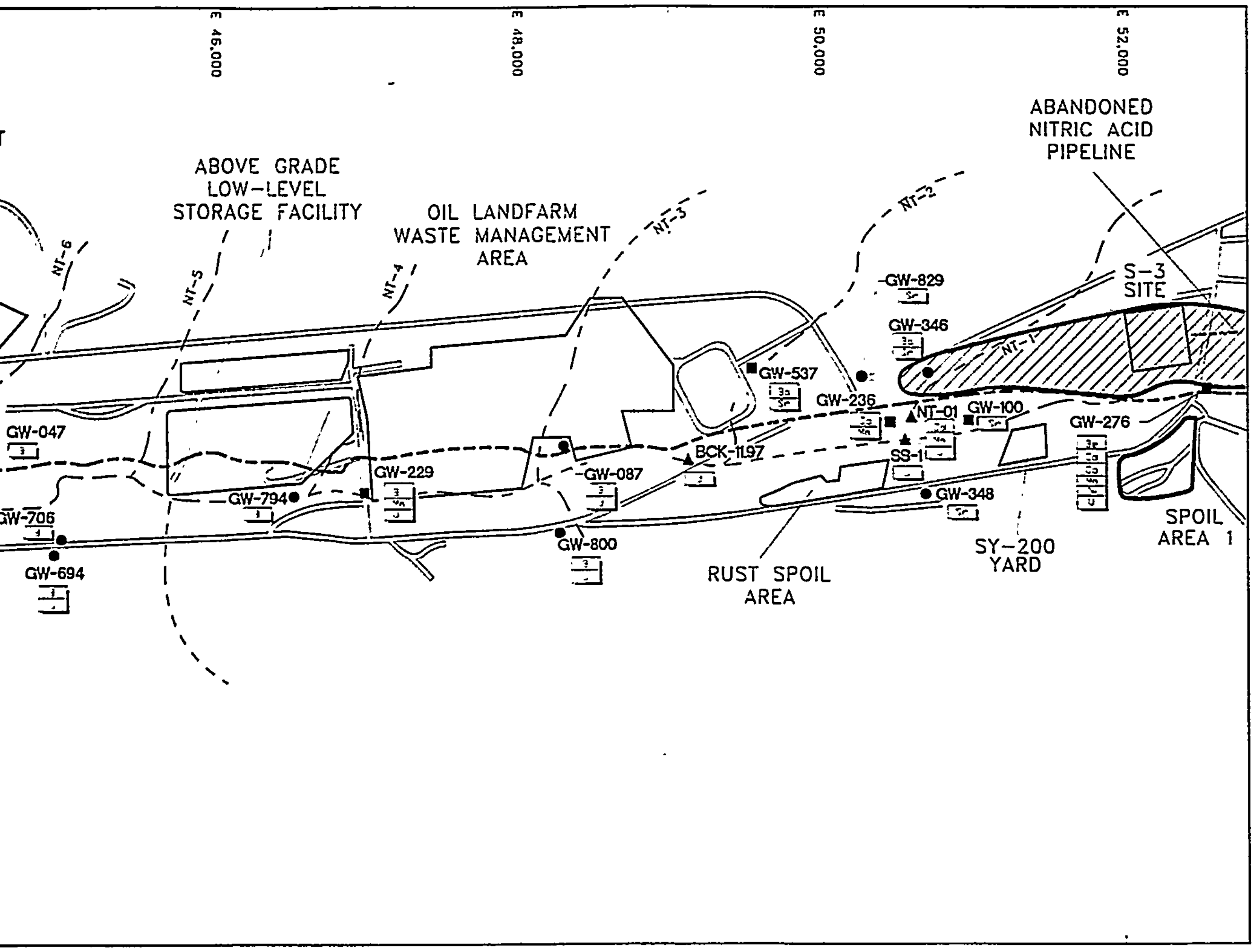
PREPARED BY:
AJA TECHNICIAL SERVICES, INC.

LOCATION: Y-12 PLANT OAK RIDGE, TN.

DOC NUMBER: 96-D008
DWG ID.: 96-062
DATE: 6-20-96

FIGURE 14

NITRATE CONCENTRATION TRENDS IN WELLS GW-724, GW-694, AND GW-684



XPLANATION

on

ille Limestone Contact

Ba — Barium

Be — Beryllium

B — Boron

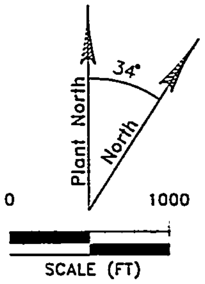
Cd — Cadmium (AAS)

Co — Cobalt

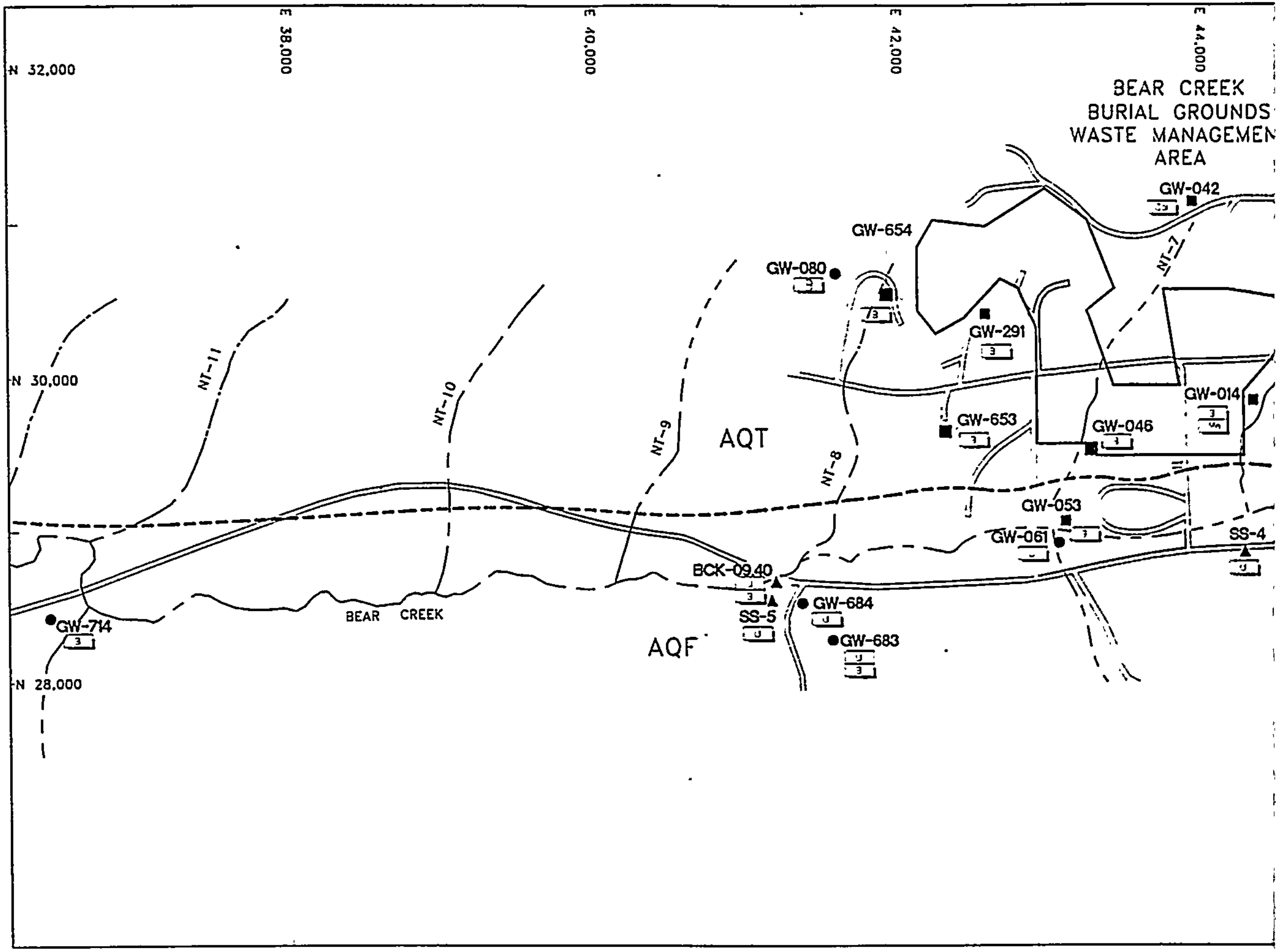
Mn — Manganese

Ni — Nickel

Sr — Strontium



PREPARED FOR: *LOCKHEED MARTIN ENERGY SYSTEMS, INC.*	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 15
PREPARED BY: *AJA TECHNICAL SERVICES, INC.*	DOC NUMBER:	96-0006	TRACE METALS IN GROUNDWATER AND SURFACE WATER IN THE BEAR CREEK REGIME, 1995
	DWG ID.:	96-052	
	DATE:	6-20-96	



Notes: BCK-04.55 ▭ and BCK-03.87 ▭ are located downstream from BCK-09.40, and

Springs SS-6.6K ▭, SS-6W ▭, AND SS-7 ▭ are 2,000 to 8,000 feet west of this map area (See Figure 9)

E

■ – Water Table Monitoring Well

● – Bedrock Monitoring Well

▲ – Spring or Surface Water Sampling Sta

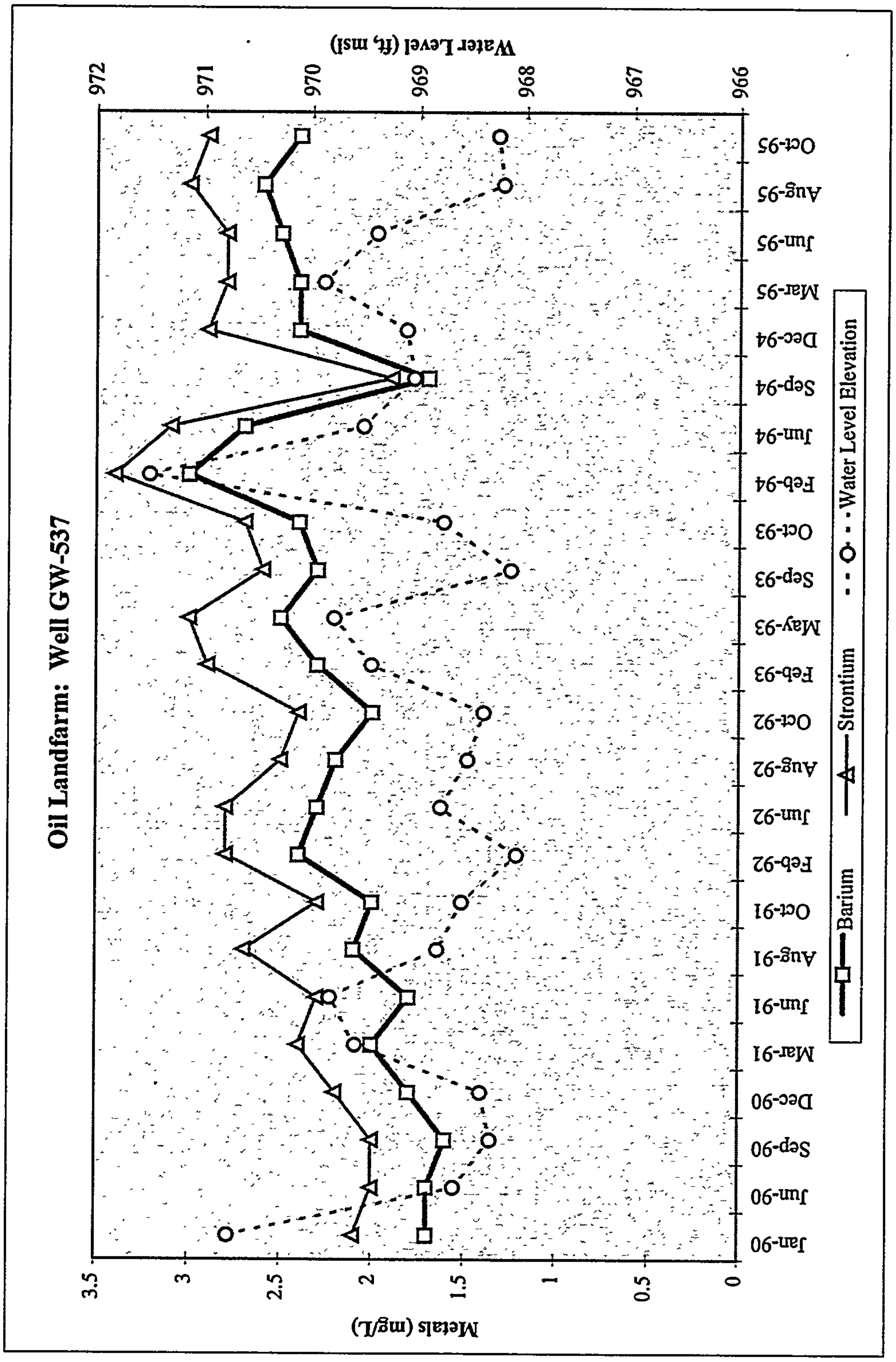
—·—·— – Surface Drainage Feature

AQT – Conasauga Shales

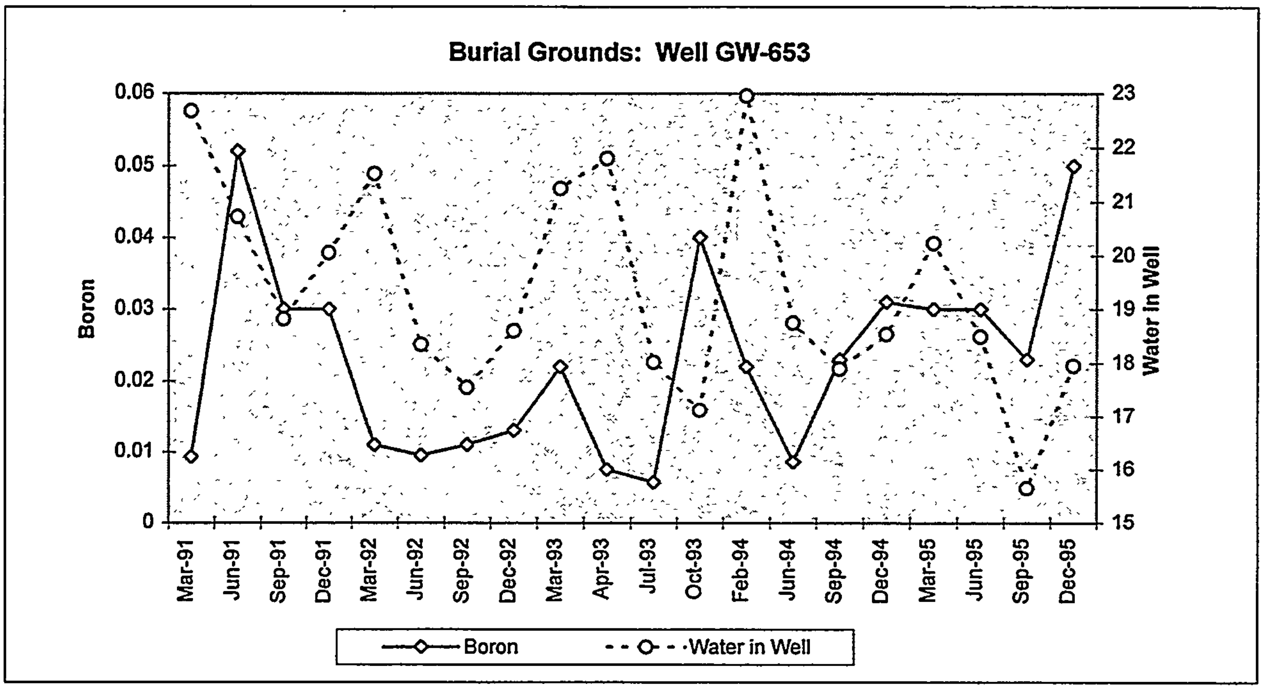
– – – – – Approximate Nolichucky Shale\Maynard

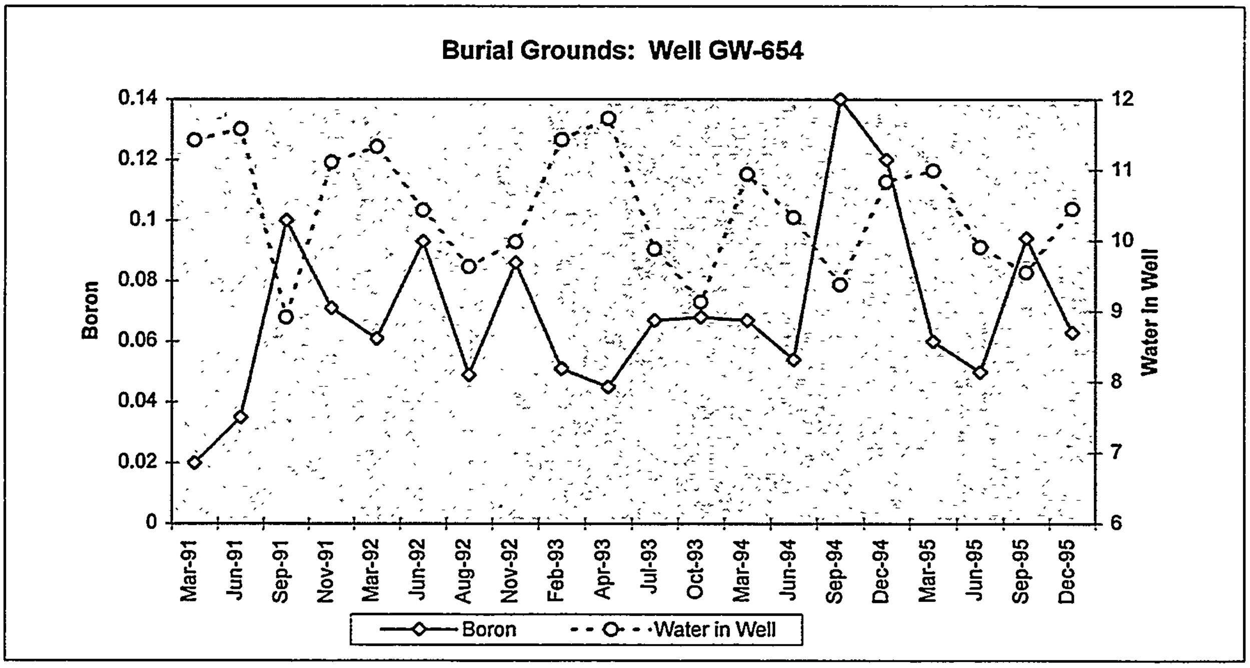
AQF – Maynardville Limestone

▨ – Trace Metal Plume SAIC (1996)

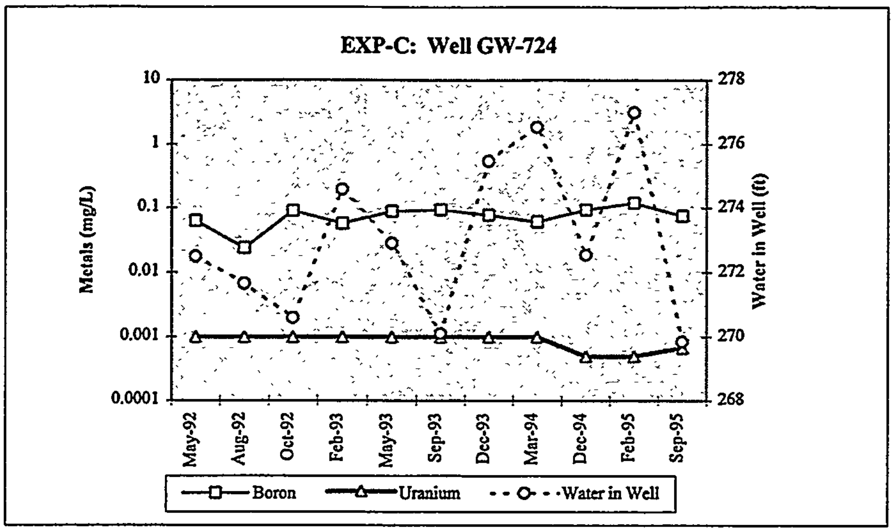


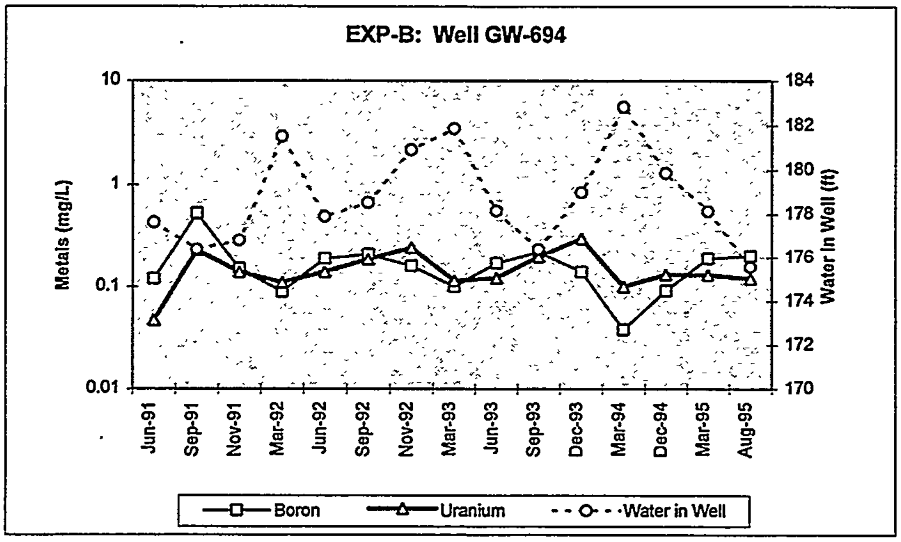
PREPARED FOR: *LOCKHEED MARTIN ENERGY SYSTEMS, INC.*	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 16
PREPARED BY: *AJA TECHNICIAL SERVICES, INC.*	DOC NUMBER:	96-D008	BARIUM AND STRONTIUM CONCENTRATION TRENDS IN WELL GW-537
	DWG ID.:	96-062	
	DATE:	6-20-96	

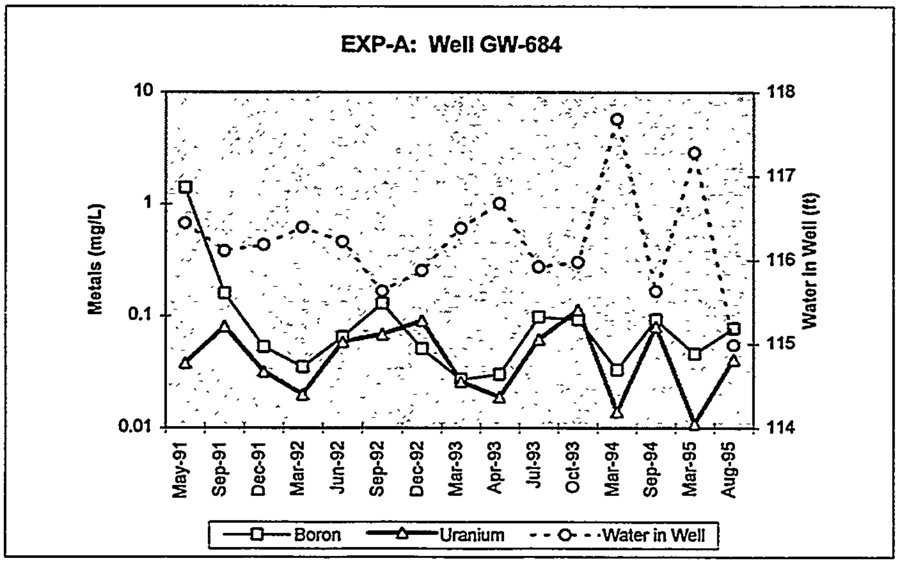




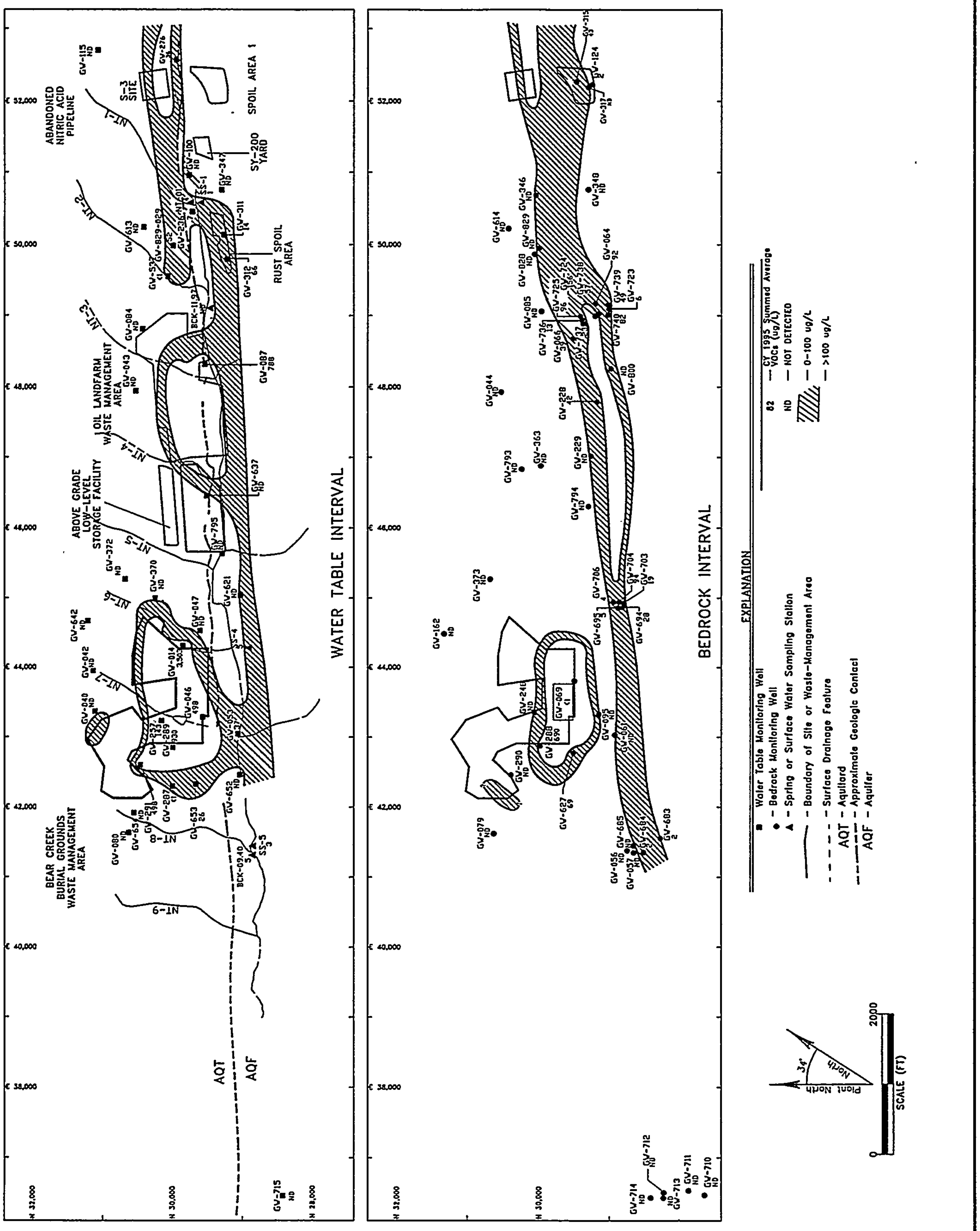
PREPARED FOR: *LOCKHEED MARTIN ENERGY SYSTEMS, INC.*	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 17
PREPARED BY: *AJA TECHNICIAL SERVICES, INC.*	DOC NUMBER:	96-D008	BORON CONCENTRATION TRENDS IN WELLS GW-653 AND GW-654
	DWG ID.:	96-062	
	DATE:	6-20-96	



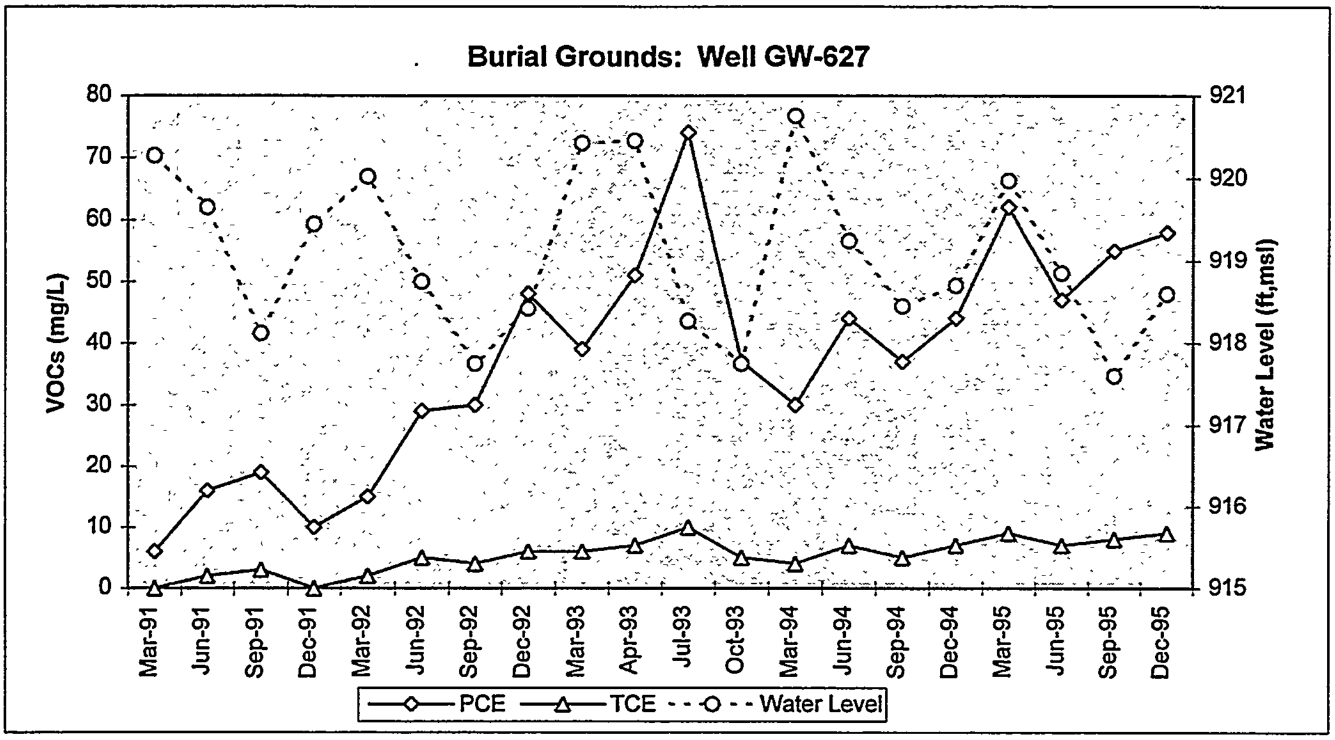


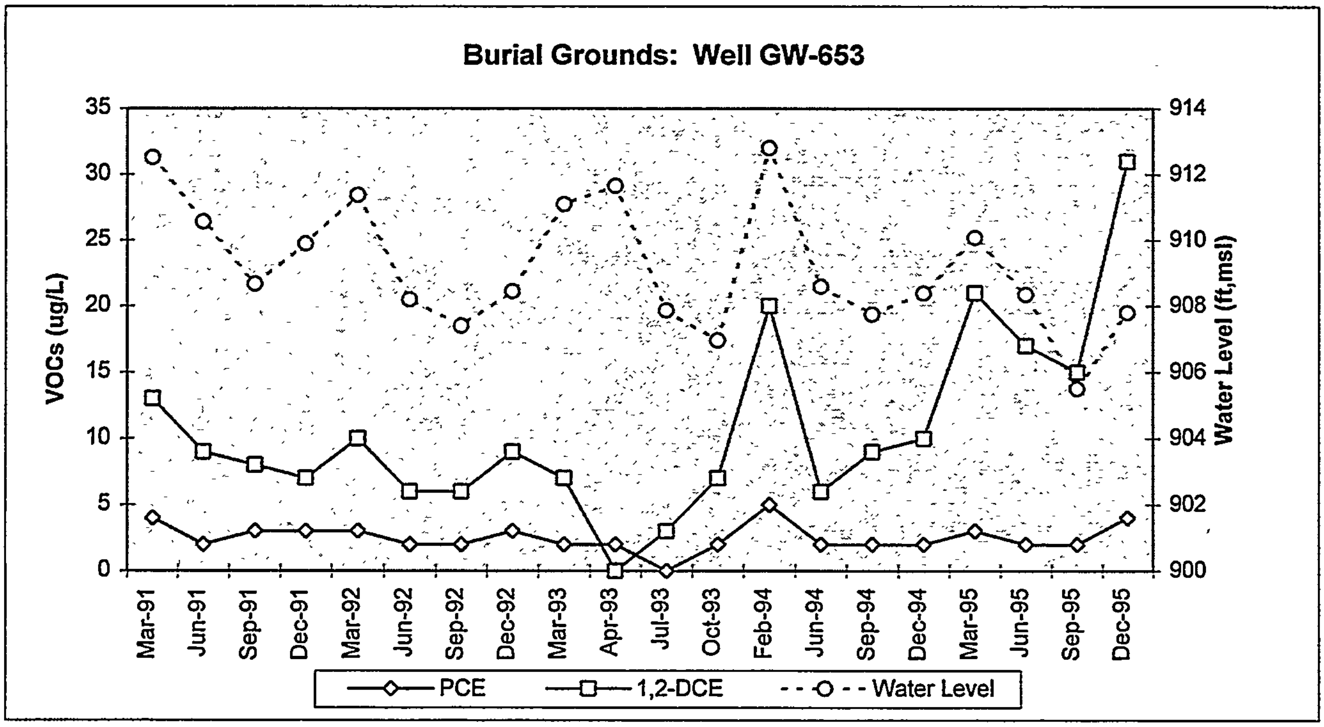


PREPARED FOR: *LOCKHEED MARTIN ENERGY SYSTEMS, INC.*	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 18
PREPARED BY: *AJA TECHNICIAL SERVICES, INC.*	DOC NUMBER:	96-D008	BORON AND URANIUM CONCENTRATION TRENDS IN WELLS GW-724, GW-694, AND GW-684
	DWG ID.:	96-062	
	DATE:	6-20-96	



PREPARED FOR: *LOCKHEED MARTIN ENERGY SYSTEMS, INC.*	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 19
PREPARED BY: *AJA TECHNICIAL SERVICES, INC.*	DOC NUMBER:	96-D006	VOCS IN GROUNDWATER AND SURFACE WATER IN THE BEAR CREEK REGIME, 1995
	DWG ID.:	96-041	
	DATE:	6-20-96	


Burial Grounds: Well GW-627


Burial Grounds: Well GW-653

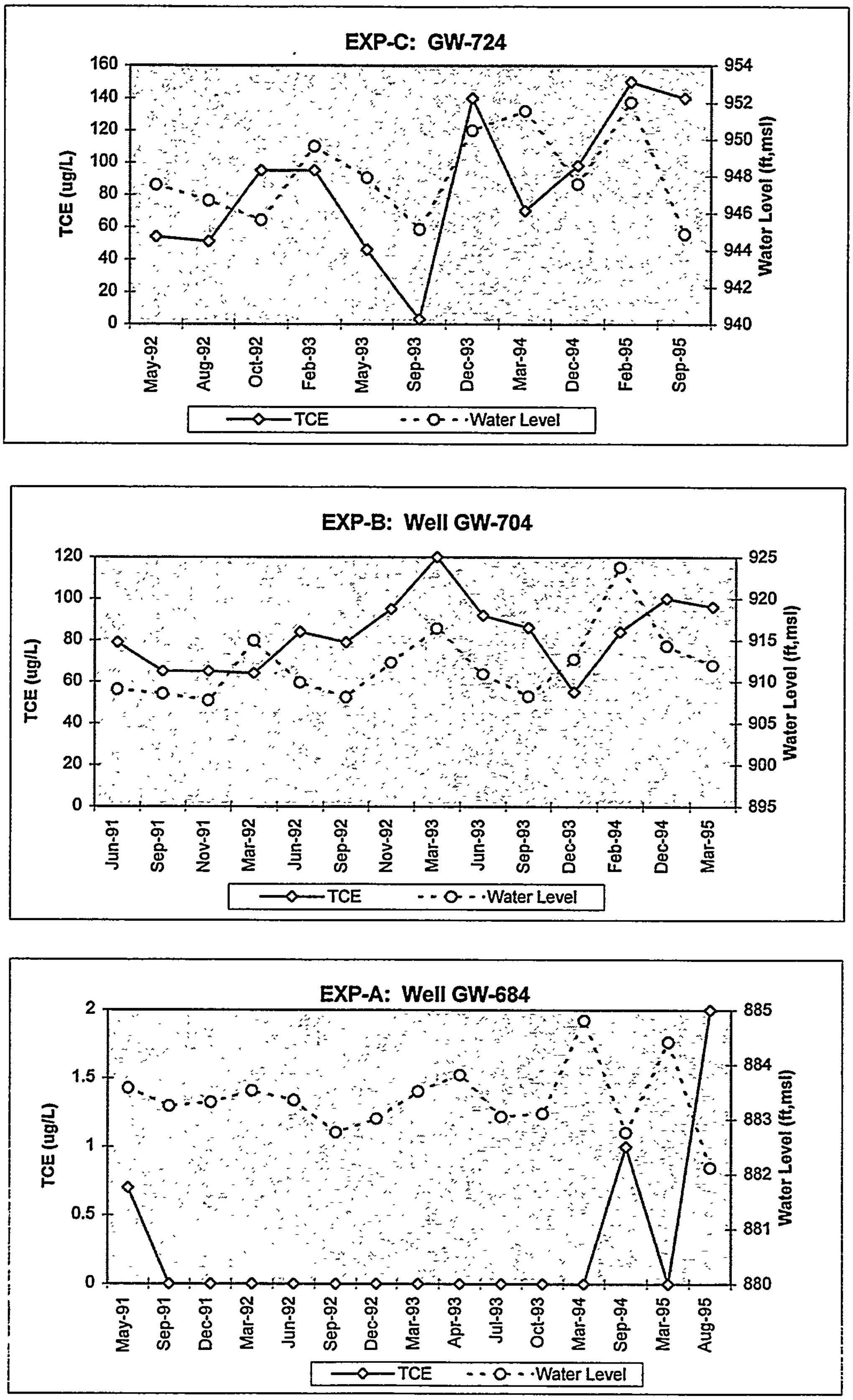
PREPARED FOR:
LOCKHEED MARTIN ENERGY SYSTEMS, INC.

PREPARED BY:
AJA TECHNICIAL SERVICES, INC.

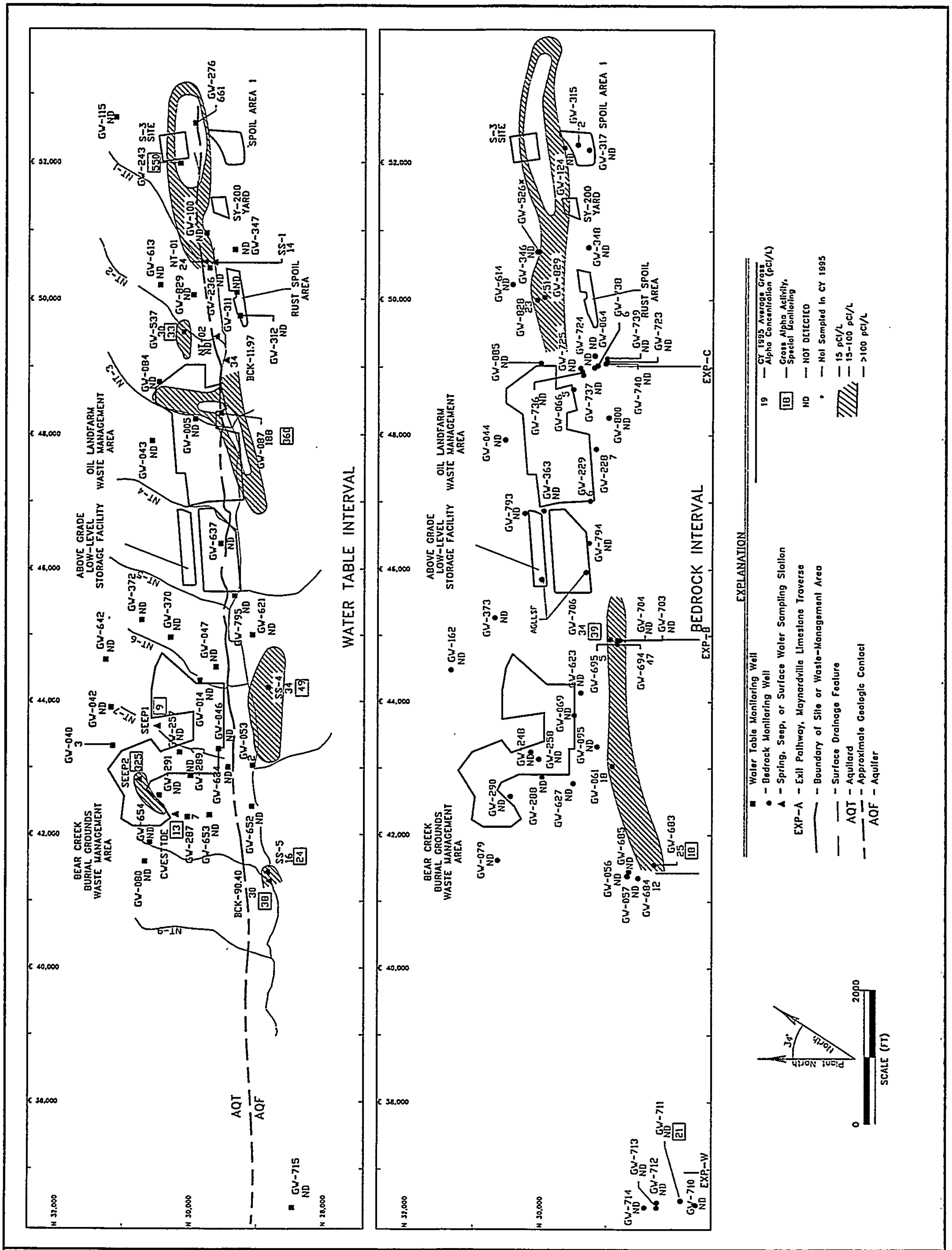
LOCATION: Y-12 PLANT OAK RIDGE, TN.
DOC NUMBER: 96-D008
DWG ID.: 96-062
DATE: 6-20-96

FIGURE 20

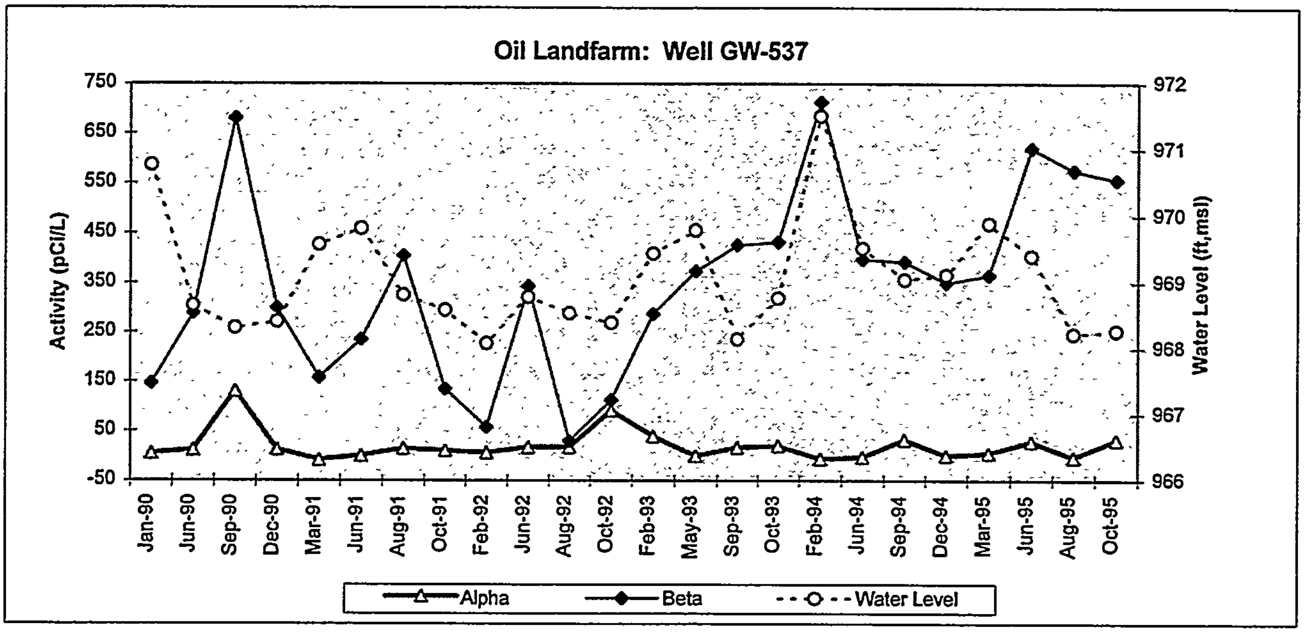
VOC CONCENTRATION TRENDS IN WELLS GW-627 AND GW-653

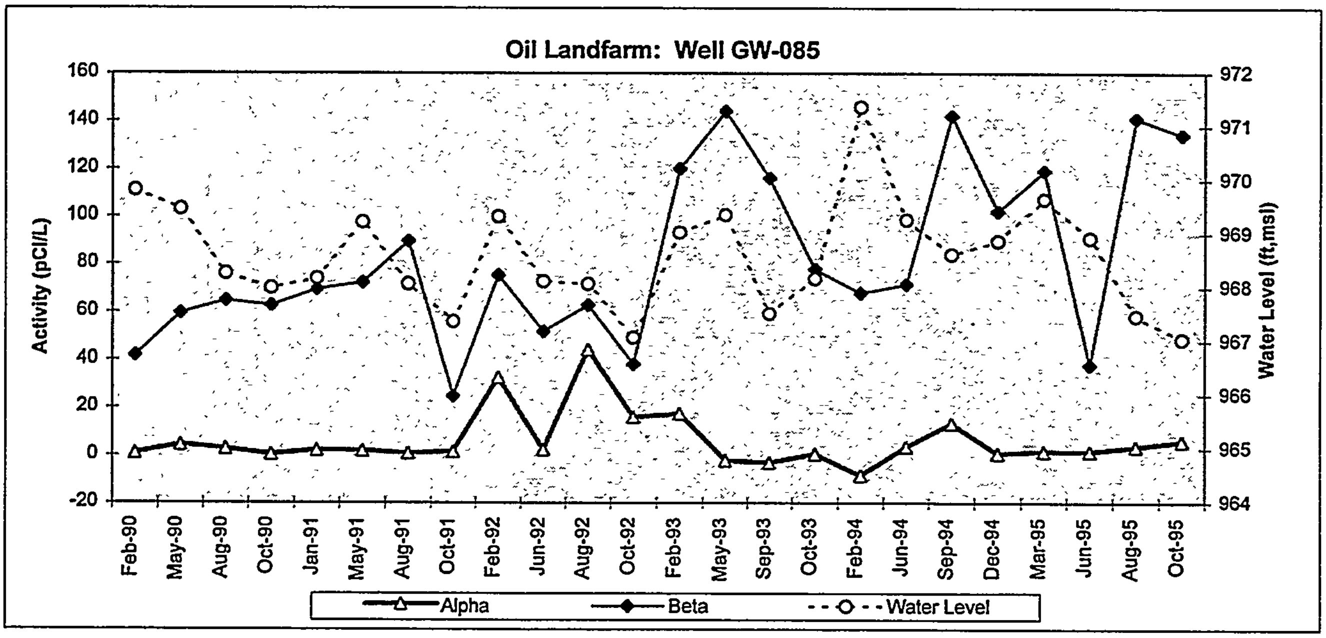


PREPARED FOR: *LOCKHEED MARTIN ENERGY SYSTEMS, INC.*	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 21
PREPARED BY: *AJA TECHNICIAL SERVICES, INC.*	DOC NUMBER:	96-D008	TRICHLOROETHENE CONCENTRATION TRENDS IN WELLS GW-724, GW-704, AND GW-684
	DWG ID.:	96-062	
	DATE:	6-20-96	

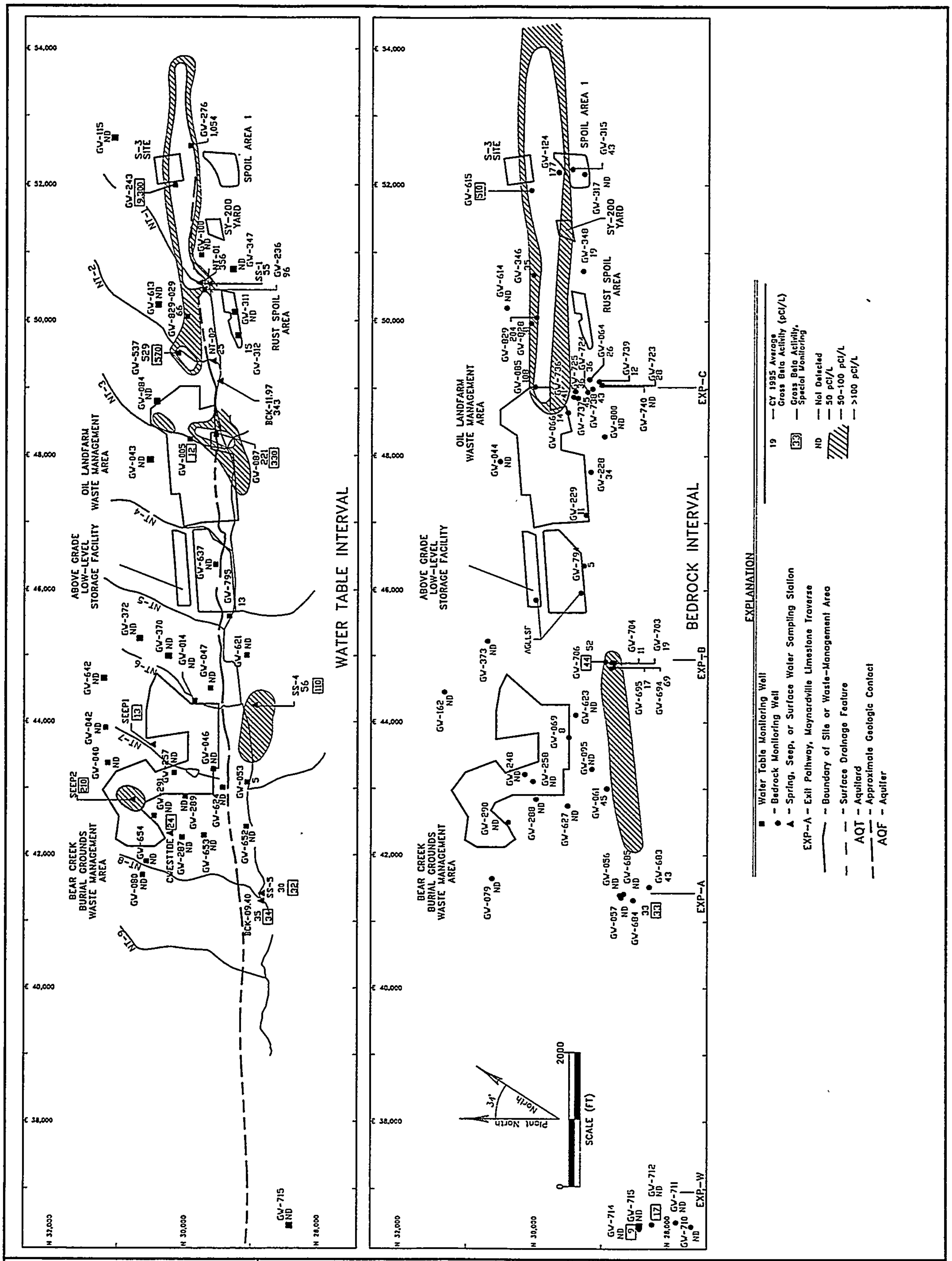


PREPARED FOR: *LOCKHEED MARTIN ENERGY SYSTEMS, INC.*	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 22
PREPARED BY: *AJA TECHNICIAL SERVICES, INC.*	DOC NUMBER:	96-D003	GROSS ALPHA ACTIVITY IN GROUNDWATER AND SURFACE WATER IN THE BEAR CREEK HYDROGEOLOGIC REGIME, 1995
	DWG ID.:	96-050	
	DATE:	6-27-96	





PREPARED FOR: *LOCKHEED MARTIN ENERGY SYSTEMS, INC.*	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 23
PREPARED BY: *AJA TECHNICIAL SERVICES, INC.*	DOC NUMBER:	96-D008	GROSS ALPHA AND GROSS BETA ACTIVITY TRENDS IN WELLS GW-085 AND GW-537
	DWG ID.:	96-062	
	DATE:	6-20-96	



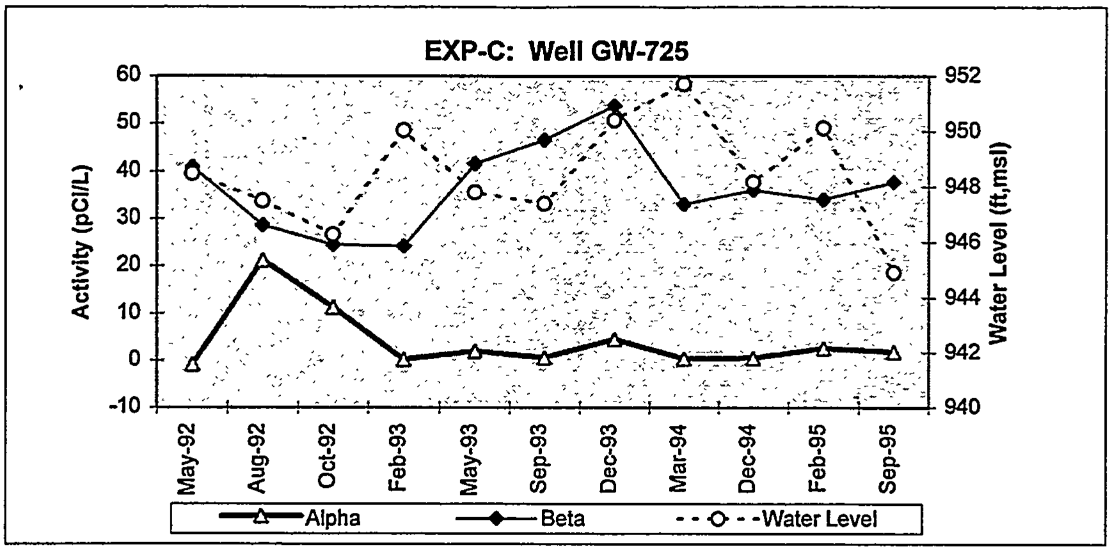
PREPARED FOR:
LOCKHEED MARTIN ENERGY SYSTEMS, INC.

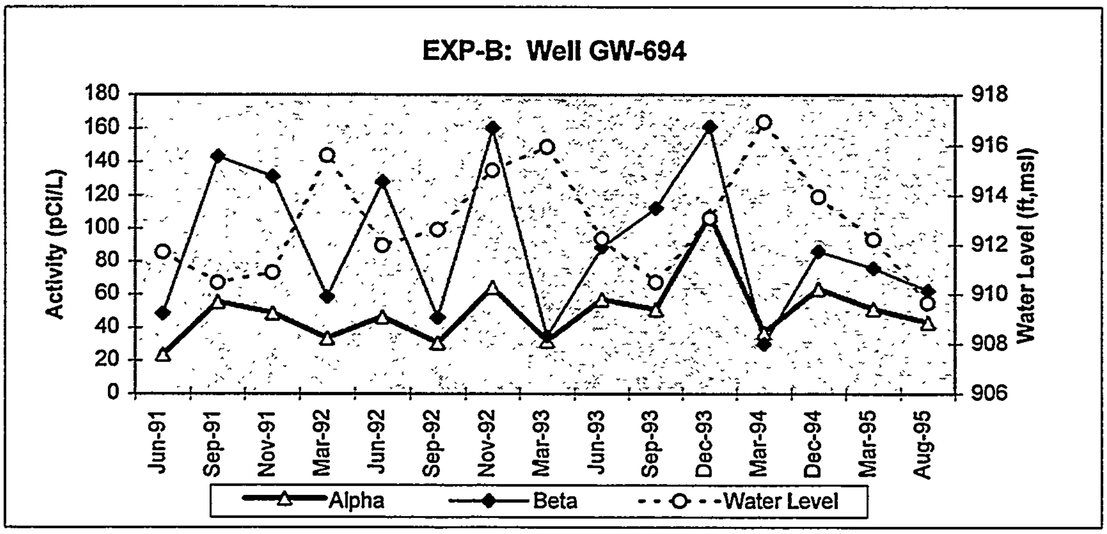
PREPARED BY:
AJA TECHNICIAL SERVICES, INC.

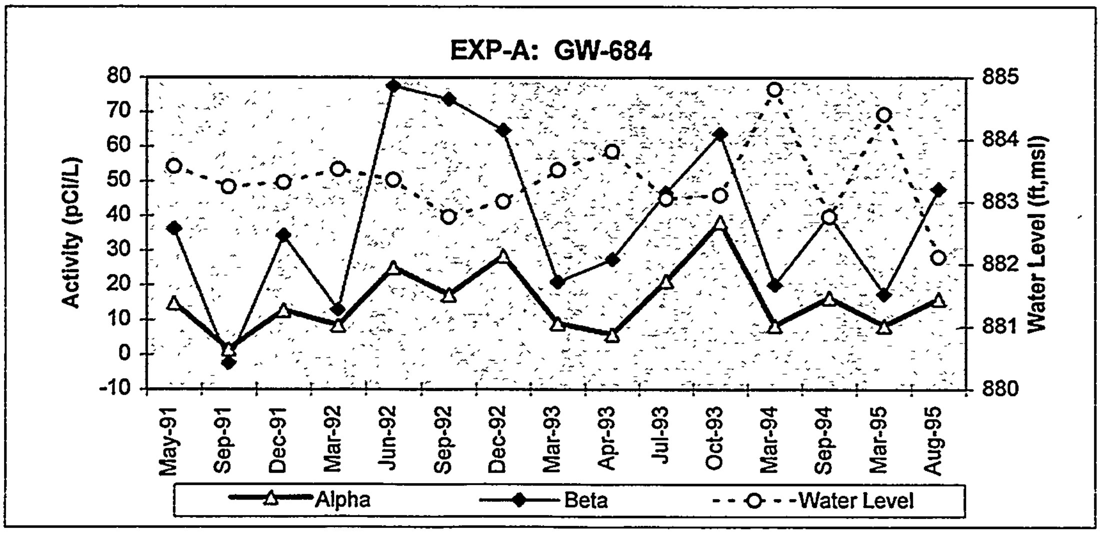
LOCATION:	Y-12 PLANT OAK RIDGE, TN.
DOC NUMBER:	96-D006
DWG ID.:	96-051
DATE:	6-20-96

FIGURE 24

GROSS BETA ACTIVITY
IN GROUNDWATER AND SURFACE WATER IN THE
BEAR CREEK HYDROGEOLOGIC REGIME, 1995


EXP-C: Well GW-725


EXP-B: Well GW-694


EXP-A: GW-684

PREPARED FOR:
LOCKHEED MARTIN
ENERGY SYSTEMS, INC.

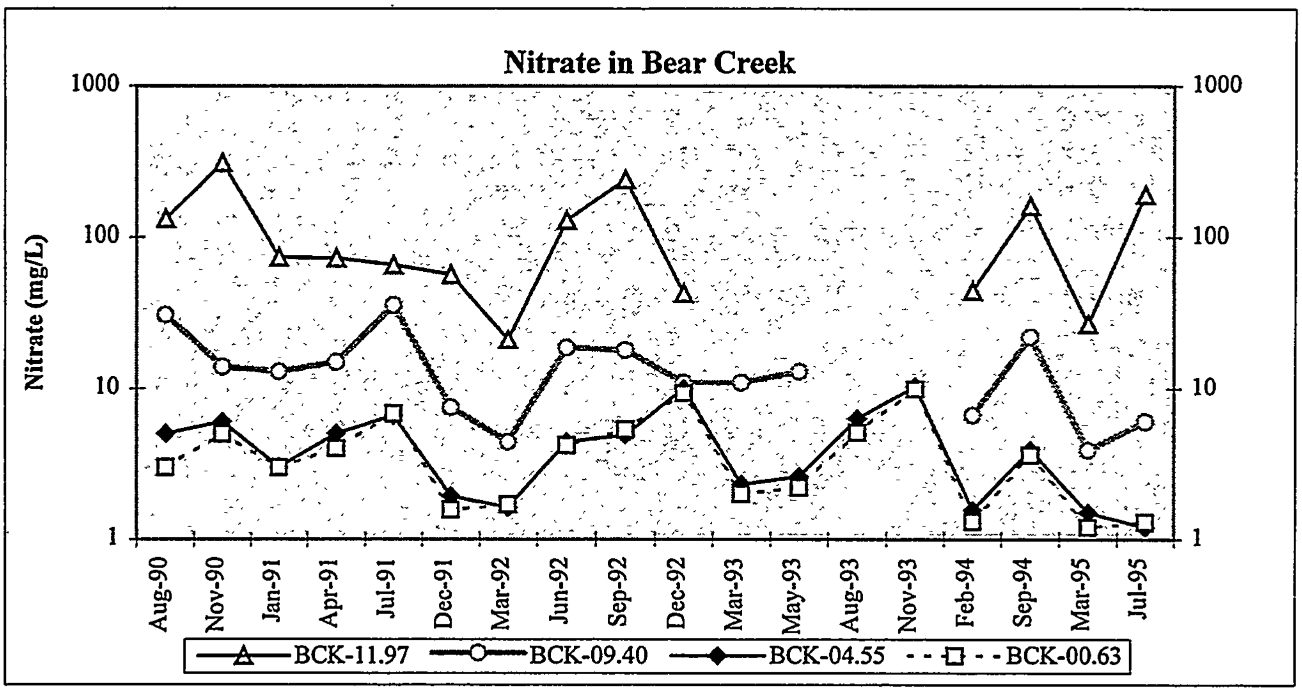
PREPARED BY:
AJA TECHNICIAL
SERVICES, INC.

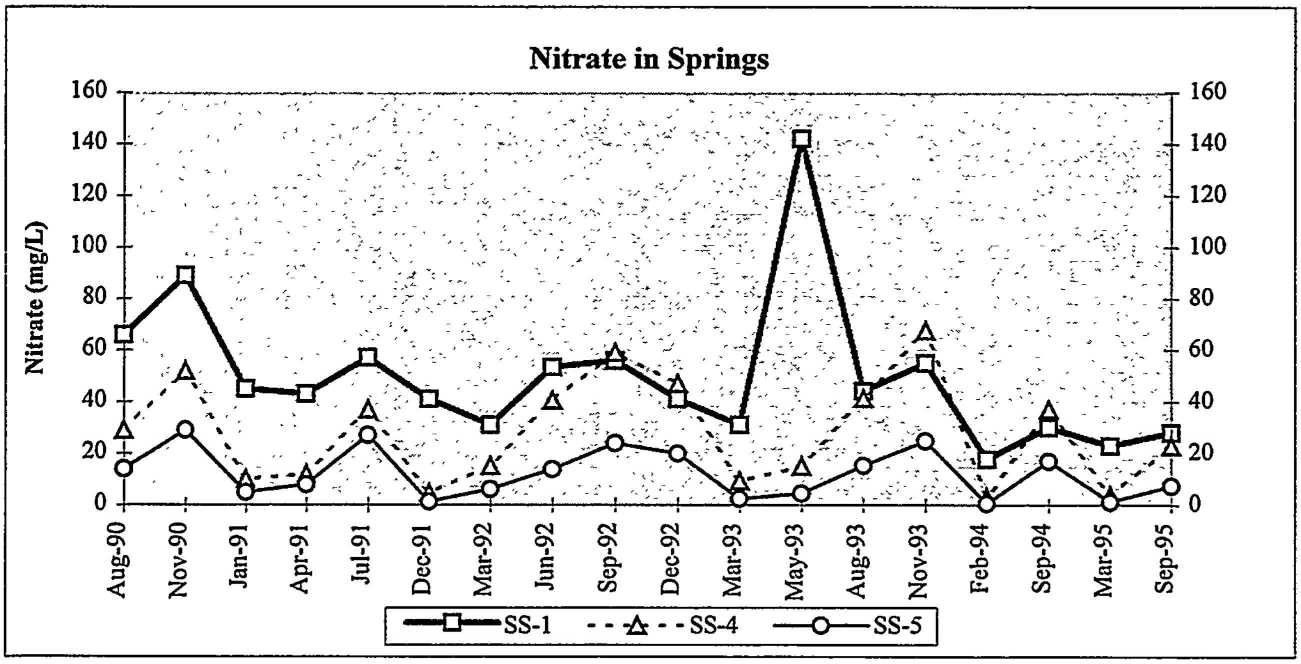
LOCATION: Y-12 PLANT
OAK RIDGE, TN.

DOC NUMBER: 96-D008
DWG ID.: 96-062
DATE: 6-20-96

FIGURE 25

GROSS ALPHA AND GROSS BETA ACTIVITY TRENDS IN WELLS GW-725, GW-694, AND GW-684





PREPARED FOR: *LOCKHEED MARTIN ENERGY SYSTEMS, INC.*	LOCATION:	Y-12 PLANT OAK RIDGE, TN.	FIGURE 26
PREPARED BY: *AJA TECHNICIAL SERVICES, INC.*	DOC NUMBER:	96-D008	NITRATE CONCENTRATION TRENDS IN BEAR CREEK
	DWG ID.:	96-062	
	DATE:	6-27-96	

Table 1. Waste Management Sites in the Bear Creek Hydrogeologic Regime

Site Name	Regulatory Classification	
	Historical[1]	Current[2]
S-3 Site	TSD Unit	TSD/BC OU 01/CA
Oil Landfarm Waste Management Area		
Oil Landfarm	TSD Unit	TSD/BC OU 01/CA
Burnyard, Boneyard, and Hazardous Chemical Storage Area	SWMU	BC OU 01/CA
Sanitary Landfill I	SWMU	BC OU 01/CA
Bear Creek Burial Grounds Waste Management Area		
Burial Grounds A (North and South)	TSD Unit	TSD/BC OU 01/CA
Burial Grounds C	TSD Unit	TSD/BC OU 01/CA
Walk-In Pits	TSD Unit	TSD/BC OU 01/CA
Burial Grounds B, D, E, and J	SWMUs	BC OU 01/CA
Oil Retention Pond No. 1	SWMU	BC OU 01/CA
Oil Retention Pond No. 2	SWMU	BC OU 01/CA
Spoil Area I	SWMU	BC OU 02
SY-200 Yard	SWMU	BC OU 02
Rust Spoil Area	SWMU	BC OU 02/CA
Bear Creek Groundwater, Surface Water, Creek Sediments, and Flood Plain Soils	N/A	BC OU 04/CA
Above Grade Low-Level Storage Facility	N/A	N/A

Notes:

1 Regulatory status before 1992 Federal Facility Agreement.

TSD Unit - RCRA-regulated land-based treatment, storage, or disposal unit.
SWMU - RCRA-regulated solid waste management unit.
N/A - Not Applicable (not previously regulated as a separate unit or not currently regulated).

2 Modified from: *Oak Ridge Reservation Site Management Plan for the Environmental Restoration Program* (U.S. Department of Energy 1994).

BC OU 01 - Former Bear Creek Operable Unit 01 (Source Control OU)
BC OU 02 - Former Bear Creek Operable Unit 02 (Source Control OU)
BC OU 04 - Former Bear Creek Operable Unit 04 (Integrator OU)
CA - Characterization Area

Table 2. Monitoring Programs Implemented During CY 1995[1]

Sampling Point[2]	Location[3]	Date Sampled			
		1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
RCRA Corrective Action Monitoring					
GW-040	BG	02/01/95	06/06/95	08/10/95	10/11/95
GW-042	BG	02/01/95	06/06/95	08/09/95	10/11/95
GW-043	OLF	03/16/95	06/01/95	08/04/95	10/18/95
GW-044	OLF	03/16/95	06/01/95	08/04/95	10/18/95
GW-069	BG	03/25/95	06/27/95	08/15/95	12/07/95
GW-079	BG	03/26/95	06/19/95	09/18/95	12/09/95
GW-080	BG	03/25/95	06/19/95	09/21/95	12/09/95
GW-084	OLF	03/23/95	06/07/95	08/05/95	10/19/95
GW-115	S3	01/14/95	.	07/30/95	.
GW-162	BG	01/26/95	05/31/95	08/03/95	10/11/95
GW-276	S3	01/24/95	.	07/29/95	.
GW-363	OLF	01/23/95	06/17/95	07/19/95	10/19/95
GW-372	BG	01/31/95	06/02/95	08/07/95	10/12/95
GW-373	BG	01/31/95	06/05/95	08/08/95	10/12/95
GW-613	S3	01/11/95	.	07/24/95	.
GW-614	S3	01/11/95	.	07/24/95	.
GW-642	BG	01/31/95	06/02/95	08/07/95	10/10/95
GW-710	EXP-W	01/15/95	.	07/27/95	.
GW-711	EXP-W	01/13/95	.	07/27/95	.
GW-712	EXP-W	01/13/95	.	07/25/95	.
GW-713	EXP-W	01/14/95	.	07/27/95	.
GW-714	EXP-W	01/14/95	.	07/29/95	.
GW-715	EXP-W	01/14/95	.	07/29/95	.
RCRA Interim Status Assessment Monitoring					
GW-064	OLF	03/26/95	06/07/95	08/06/95	.
GW-311	RS	03/25/95	06/06/95	.	10/25/95
GW-312	RS	03/25/95	06/06/95	08/06/95	.
GW-828 (100)[4]	OLF	02/14/95	.	.	.
GW-828	OLF	02/18/95	06/27/95	08/24/95	12/08/95
GW-829 (29)[5]	OLF	03/01/95	.	.	.
GW-829	OLF	03/07/95	06/27/95	08/30/95	12/10/95

Table 2 (cont'd)

Sampling Point[2]	Location[3]	Date Sampled			
		1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
Exit Pathway and Perimeter Monitoring					
BCK-03.87	EXP-SW	03/09/95	.	07/25/95	.
BCK-04.55	EXP-SW	03/09/95	.	07/25/95	.
BCK-09.40	EXP-SW	03/09/95	.	07/25/95	.
BCK-11.97	EXP-SW	03/09/95	.	07/25/95	.
GW-056	EXP-A	03/05/95	.	08/04/95	.
GW-057	EXP-A	03/05/95	.	08/05/95	.
GW-621	EXP-B	03/29/95	.	08/30/95	.
GW-683	EXP-A	03/09/95	.	08/06/95	.
GW-684	EXP-A	03/10/95	.	08/06/95	.
GW-685	EXP-A	03/08/95	.	08/06/95	.
GW-694	EXP-B	03/30/95	.	08/31/95	.
GW-695	EXP-B	03/29/95	.	08/30/95	.
GW-703	EXP-B	03/29/95	.	08/30/95	.
GW-704	EXP-B	03/30/95	.	08/31/95	.
GW-706	EXP-B	03/31/95	.	08/30/95	.
GW-723	EXP-C	02/20/95	.	09/13/95	.
GW-724	EXP-C	02/19/95	.	09/24/95	.
GW-725	EXP-C	02/28/95	.	09/25/95	.
GW-736	EXP-C	02/28/95	.	09/26/95	.
GW-737	EXP-C	03/01/95	.	09/26/95	.
GW-738	EXP-C	02/18/95	.	09/17/95	.
GW-739	EXP-C	02/17/95	.	09/16/95	.
GW-740	EXP-C	02/16/95	.	09/17/95	.
NT-01	EXP-SW	03/09/95	.	07/25/95	.
NT-02	EXP-SW	03/09/95	.	09/22/95	.
SS-1	EXP-SW	03/09/95	.	09/22/95	.
SS-4	EXP-SW	03/09/95	.	07/25/95	.
SS-5	EXP-SW	03/09/95	.	07/25/95	.
SS-6	EXP-SW	03/09/95	.	07/25/95	.
GCS1	EXP-SW	.	05/23/95	.	10/26/95
SS-5.95K	EXP-SW	.	05/23/95	.	10/26/95
SS-6.6K	EXP-SW	.	05/23/95	.	.
SS-6W	EXP-SW	.	05/23/95	.	10/26/95
SS-7	EXP-SW	.	05/23/95	.	10/26/95

Table 2 (cont'd)

Sampling Point[2]	Location[3]	Date Sampled			
		1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
Surveillance Monitoring					
GW-047	BG	01/25/95	06/18/95	07/24/95	.
GW-053	BG	03/28/95	06/28/95	09/25/95	12/10/95
GW-061	BG	03/28/95	06/28/95	09/21/95	.
GW-085	OLF	03/26/95	06/08/95	08/06/95	10/25/95
GW-095	BG	03/27/95	06/20/95	09/20/95	12/11/95
GW-287	BG	03/26/95	06/20/95	09/18/95	12/10/95
GW-315	SPI	03/15/95	06/26/95	08/21/95	12/07/95
GW-317	SPI	03/14/95	06/21/95	08/15/95	.
GW-347	S3	03/15/95	06/21/95	08/15/95	.
GW-348	S3	03/15/95	06/26/95	08/21/95	.
GW-370	BG	02/01/95	06/05/95	08/08/95	.
GW-537	OLF	03/26/95	06/08/95	08/03/95	10/25/95
GW-627	BG	03/28/95	06/22/95	09/25/95	12/10/95
GW-637	OLF	01/24/95	06/17/95	07/19/95	.
GW-652	BG	03/27/95	06/20/95	09/19/95	.
GW-653	BG	03/27/95	06/20/95	09/20/95	12/08/95
GW-654	BG	03/26/95	06/19/95	09/18/95	12/09/95
GW-800	OLF	03/25/95	05/31/95	08/05/95	.
Best-Management Practice Monitoring					
GW-014	BG	.	.	08/04/95	.
GW-046	BG	.	.	08/09/95	.
GW-066	OLF	.	.	09/27/95	.
GW-087	OLF	.	.	09/27/95	.
GW-100	S3	.	.	09/06/95	.
GW-124	S3	.	.	09/16/95	.
GW-228	OLF	.	.	09/17/95	.
GW-229	OLF	.	.	09/17/95	.
GW-236	S3	.	.	09/16/95	.
GW-248	BG	.	.	08/08/95	.
GW-257	BG	.	.	08/08/95	.
GW-288	BG	.	.	08/09/95	.
GW-289	BG	.	.	08/08/95	.
GW-290	BG	.	.	08/07/95	.
GW-291	BG	.	.	08/03/95	.

Table 2 (cont'd)

Sampling Point[2]	Location[3]	Date Sampled			
		1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
Best-Management Practice Monitoring (cont'd)					
GW-346	S3	.	.	08/31/95	.
GW-793	AGLLSF	01/23/95	06/17/95	07/19/95	10/19/95
GW-794	AGLLSF	01/24/95	06/18/95	07/24/95	10/24/95
GW-795	AGLLSF	01/25/95	06/18/95	07/24/95	10/24/95
GW-830	B9714	.	.	09/14/95	.
Special Sampling: CERCLA RI - BCV Characterization Area					
MS1	EXP-SW	.	05/03/95	.	.
NT-1N	EXP-SW	.	05/03/95	.	.
NT-1S	EXP-SW	.	05/03/95	.	.
TS	EXP-SW	.	05/03/95	.	.
BCK-04.55	EXP-SW	.	.	08/02/95	.
BCK-09.40	EXP-SW	.	.	08/02/95	.
C WEST TOE	BG	.	.	08/03/95	.
GW-005	OLF	.	.	08/02/95	.
GW-014	BG	.	.	08/04/95	.
GW-040	BG	.	.	08/10/95	.
GW-044	OLF	.	.	08/04/95	.
GW-087	OLF	.	.	08/09/95	.
GW-162	BG	.	.	08/03/95	.
GW-243	S3	.	.	08/01/95	.
GW-258	BG	.	.	08/04/95	.
GW-291	BG	.	.	08/03/95	.
GW-537	OLF	.	.	08/03/95	.
GW-613	S3	.	.	08/14/95	.
GW-615	S3	.	.	08/02/95	.
GW-623	BG	.	.	08/02/95	.
GW-624	BG	.	.	08/03/95	.
GW-684	EXP-A	.	.	08/06/95	.
GW-706	EXP-B	.	.	08/30/95	.
GW-710	EXP-W	.	.	07/27/95	.
GW-711	EXP-W	.	.	07/27/95	.
GW-712	EXP-W	.	.	07/25/95	.
GW-713	EXP-W	.	.	07/27/95	.
GW-714	EXP-W	.	.	08/29/95	.

Table 2 (cont'd)

Sampling Point[2]	Location[3]	Date Sampled 1st Qtr.	 2nd Qtr.	 3rd Qtr.	 4th Qtr.
Special Sampling: CERCLA RI - BCV Characterization Area (cont'd)					
GW-715	EXP-W	.	.	07/29/95	.
GW-794	AGLLSF	.	.	08/02/95	.
SEEP1	BG	.	.	08/03/95	.
SEEP2	BG	.	.	08/03/95	.
SS-4	EXP-SW	.	.	08/02/95	.
SS-5	EXP-SW	.	.	08/02/95	.
SS-6 WEST	EXP-SW	.	.	08/02/95	.
SS-7	EXP-SW	.	.	08/02/95	.

Notes:

1 Some monitored locations were sampled to meet requirements of more than one programmatic driver during CY 1995.

2 BCK - Bear Creek Kilometer
C WEST TOE - Burial Ground C-West French Drain
GCS1 - Grassy Creek Spring
GW - Monitoring Well
MS - Bear Creek Main Stem Headwaters
NT - North Tributary to Bear Creek
Seep - Burial Grounds A-North (Seep1) and C-East (Seep 2)
SS - Spring
TS - Tank Spring (Bear Creek headwaters)

3 AGLLSF - Above Ground Low-Level Storage Facility
BG - Bear Creek Burial Grounds WMA
EXP - Exit Pathway Monitoring Location:
Maynardville Limestone Traverse (-A, -B, -C, -W)
Spring or Surface Water Sampling Location (-SW)
OLF - Oil Landfarm WMA
RS - Rust Spoil Area
S3 - S-3 Site
SPI - Spoil Area I

4 Groundwater sample collected from temporary well constructed at a depth of 100 ft bgs during well installation of well GW-828.

5 Groundwater sample collected from temporary well constructed at a depth of 29 ft bgs during installation of well GW-829.

Table 3. Construction Information for Monitoring Wells Sampled During CY 1995[1]

Well	Location[2]	Cluster Designation[3]	Aquifer[4]			Monitored Interval Depths[5]
			Unit	Fm.	Interval	
GW-005	OLF	1	AQT	Cn	WT	3.0 - 12.5
GW-014	BG	1	AQT	Cn	WT	5.0 - 13.2
GW-040	BG	3	AQT	Cpv	WT	21.0 - 29.0
GW-042	BG	2	AQT	Cpv	WT	13.4 - 28.2
GW-043	OLF	2	AQT	Cm	WT	10.0 - 40.0
GW-044	OLF	3	AQT	Cm	BDR	42.5 - 70.0
GW-046	BG	2	AQT	Cn	WT	5.0 - 20.3
GW-047	BG	2	AQT	Cn	WT	12.5 - 25.5
GW-053	BG	1	AQF	Cmn	WT	11.4 - 32.8
GW-056	EXP-A	1	AQF	Cmn	BDR	49.1 - 55.2
GW-057	EXP-A	1	AQF	Cmn	BDR	17.5 - 22.8
GW-061	BG	1	AQF	Cmn	BDR	17.5 - 24.6
GW-064	OLF	1	AQF	Cmn	BDR	46.8 - 52.7
GW-066	OLF	1	AQF	Cmn	BDR	50.0 - 54.9
GW-069	BG	10	AQT	Cn	BDR	79.0 - 99.2
GW-079	BG	3	AQT	Crg	BDR	49.9 - 64.9
GW-080	BG	2	AQT	Crg	WT	20.8 - 29.7
GW-084	OLF	3	AQT	Cm	WT	18.5 - 27.8
GW-085	OLF	3	AQT	Cn	BDR	48.4 - 58.8
GW-087	OLF	3	AQT	Cn	WT	7.5 - 19.0
GW-095	BG	10	AQT	Cn	BDR	130.2 - 156.0
GW-100	S3	2	AQF	Cmn	WT	3.8 - 20.7
GW-115	S3	3	AQT	Cm	WT	37.6 - 53.0
GW-124[a]	S3	1	AQF	Cmn	BDR	100.0 - 150.0
GW-162[a]	BG	3	AQT	Cpv	BDR	92.0 - 125.0
GW-228[a]	OLF	1	AQF	Cmn	BDR	80.0 - 100.0
GW-229[a]	OLF	1	AQF	Cmn	BDR	40.0 - 55.0
GW-236	S3	1	AQF	Cmn	WT	10.0 - 18.5
GW-243	S3	3	AQT	Cn	WT	43.2 - 77.0
GW-248	BG	3	AQT	Cm	BDR	49.1 - 62.0
GW-257	BG	3	AQT	Cm	WT	19.0 - 33.7
GW-258	BG	3	AQT	Cm	BDR	37.0 - 50.0
GW-276	S3	3	AQT	Cn	WT	11.3 - 18.5
GW-287	BG	3	AQT	Cn	WT	5.6 - 12.5
GW-288	BG	3	AQT	Cn	BDR	46.0 - 60.0
GW-289	BG	2	AQT	Cn	WT	28.9 - 40.8

Table 3 (cont'd)

Well	Location[2]	Cluster Designation[3]	Aquifer[4]			Monitored Interval Depths[5]
			Unit	Fm.	Interval	
GW-290	BG	3	AQT	Cm	BDR	22.3 - 35.5
GW-291	BG	3	AQT	Cm	WT	9.5 - 17.0
GW-311	RS	3	AQF	Cmn	WT	25.6 - 40.3
GW-312	RS	1	AQF	Cmn	WT	29.6 - 41.0
GW-315	SPI	1	AQF	Cmn	BDR	90.0 - 104.0
GW-317	SPI	4	AQF	Cmn	BDR	117.0 - 132.0
GW-346	S3	3	AQT	Cn	BDR	51.5 - 64.9
GW-347	S3	3	AQF	Cmn	WT	9.5 - 27.8
GW-348	S3	2	AQF	Cmn	BDR	68.1 - 80.9
GW-363[a]	OLF	10	AQT	Cn	BDR	50.0 - 75.0
GW-370	BG	3	AQT	Cm	WT	21.1 - 33.1
GW-372	BG	3	AQT	Cm	WT	39.8 - 51.6
GW-373[a]	BG	10	AQT	Cm	BDR	123.0 - 158.0
GW-537	OLF	3	AQT	Cn	WT	4.8 - 23.3
GW-613	S3	2	AQT	Cn	WT	30.0 - 42.0
GW-614	S3	3	AQT	Cn	BDR	71.6 - 90.2
GW-615[a]	S3	3	AQT	Cn	BDR	222.5 - 245.0
GW-621	EXP-B	3	AQF	Cmn	WT	23.3 - 40.5
GW-623	BG	6	AQT	Cn	BDR	238.1 - 274.2
GW-624	BG	1	AQT	Cn	WT	14.4 - 27.2
GW-627[a]	BG	10	AQT	Cn	BDR	254.0 - 270.0
GW-637	OLF	3	AQT	Cn	WT	14.5 - 27.5
GW-642	BG	2	AQT	Crg	WT	18.5 - 36.9
GW-652	BG	3	AQF	Cmn	WT	13.4 - 31.2
GW-653	BG	2	AQT	Cn	WT	26.3 - 39.0
GW-654	BG	3	AQT	Cm	WT	4.2 - 15.3
GW-683	EXP-A	4	AQF	OCk	BDR	133.9 - 196.8
GW-684	EXP-A	1	AQF	Cmn	BDR	106.4 - 128.4
GW-685[a]	EXP-A	1	AQF	Cmn	BDR	88.5 - 138.3
GW-694[a]	EXP-B	1	AQF	Cmn	BDR	154.0 - 204.5
GW-695	EXP-B	1	AQF	OCk	BDR	50.6 - 62.6
GW-703[a]	EXP-B	1	AQF	Cmn	BDR	135.0 - 182.0
GW-704[a]	EXP-B	1	AQF	Cmn	BDR	246.0 - 256.0
GW-706[a]	EXP-B	1	AQF	Cmn	BDR	157.0 - 182.5
GW-710[a]	EXP-W	1	AQF	OCk	BDR	539.7 - 744.5
GW-711[a]	EXP-W	1	AQF	Cmn	BDR	616.0 - 666.2

Table 3 (cont'd)

Well	Location[2]	Cluster Designation[3]	Aquifer[4]			Monitored Interval Depths[5]
			Unit	Fm.	Interval	
GW-712[a]	EXP-W	1	AQF	OCk	BDR	441.5 - 457.5
GW-713[a]	EXP-W	1	AQF	Cmn	BDR	305.0 - 315.2
GW-714[a]	EXP-W	3	AQF	Cmn	BDR	115.1 - 145.0
GW-715	EXP-W	1	AQF	Cmn	WT	32.0 - 44.0
GW-723[a]	EXP-C	1	AQF	Cmn	BDR	340.6 - 444.5
GW-724[a]	EXP-C	1	AQF	Cmn	BDR	289.6 - 301.6
GW-725[a]	EXP-C	1	AQF	Cmn	BDR	132.5 - 142.5
GW-736	EXP-C	1	AQF	Cmn	BDR	92.0 - 105.0
GW-737	EXP-C	1	AQF	Cmn	BDR	79.0 - 89.5
GW-738	EXP-C	1	AQF	Cmn	BDR	63.5 - 88.0
GW-739[a]	EXP-C	1	AQF	Cmn	BDR	289.2 - 320.0
GW-740[a]	EXP-C	4	AQF	Cmn	BDR	165.6 - 190.0
GW-793	AGLLSF	3	AQT	Cn	BDR	16.9 - 29.0
GW-794	AGLLSF	3	AQT	Cn	BDR	25.8 - 39.3
GW-795	AGLLSF	3	AQT	Cn	WT	7.5 - 20.1
GW-800	OLF	4	AQF	OCk	BDR	19.3 - 31.5
GW-828	OLF	10	AQT	Cn	BDR	153.0 - 168.0
GW-828-100	OLF	.	AQT	Cn	BDR	70.0 - 83.0
GW-829	OLF	10	AQT	Cn	BDR	102.9 - 114.6
GW-829-029	OLF	.	AQT	Cn	WT	18.0 - 29.0
GW-830	B9714	4				unknown - 387.4

Notes:

1 Well construction information compiled from: *Updated Subsurface Data Base for Bear Creek Valley, Chestnut Ridge, and Parts of Bethel Valley on the U.S. Department of Energy Oak Ridge Reservation* (Jones et al. 1995).

2 AGLLSF - Above Ground Low-Level Storage Facility
BG - Bear Creek Burial Grounds WMA
EXP - Exit Pathway Monitoring Location:
Maynardville Limestone Traverse (-A, -B, -C, -W)
OLF - Oil Landfarm WMA
RS - Rust Spoil Area
S3 - S-3 Site
SPI - Spoil Area I

Table 3 (cont'd)

Notes: (cont'd)

3 Cluster designation for trace metal data evaluation purposes. Springs (S-1, S-4, and S-5) and upgradient surface water stations(NT-01, BCK-11.97, and BCK-09.40) were assigned to cluster 1. Downgradient surface water stations (BCK-04.55 and BCK-03.87) were assigned to cluster 3.

4 Unit: Hydrostratigraphic unit
AQF - Aquifer (Maynardville Limestone/Knox Group)
AQT - Aquitard (Conasauga Group and Rome Formation)

Fm: Geologic Formation
Ock - Knox Group
Cmn - Maynardville Limestone
Cn - Nolichucky Shale
Cm - Maryville Limestone
Crg - Rogersville Shale
Cpv - Pumpkin Valley Shale

Interval: determined from the placement of the top of the monitored interval
BDR - Bedrock Interval
WT - Water Table Interval (above unweathered bedrock)

5 Depth in feet below ground surface.

a Open-hole well construction.

b Temporary wells were installed while drilling wells GW-828 (100 ft bgs) and GW-829 (29 ft bgs).

Table 4. VOCs Detected in QA/QC Samples During CY 1995

Compound	Number of QA/QC Samples Containing Specified Compound (by Sample Type)				
	Laboratory Blanks	Trip Blanks	Field Blanks	Equipment Rinsates	Total
Laboratory Reagents					
Acetone	6	15	1	3	25
2-Butanone	6	14	.	2	22
Methylene Chloride	3	11	.	6	20
Toluene	2	6	.	1	9
VOC Plume Constituents					
1,1,1-Trichloroethane	.	107	.	26	133
1,2-Dichloroethane	2	6	.	.	8
Tetrachloroethene	1	2	.	1	4
Chloroform	.	.	.	1	1
Miscellaneous Compounds					
Xylenes	1	2	.	1	4
Bromodichloromethane	.	.	.	1	1
1,2-Dichloropropane	.	.	.	1	1
Data Summary					
Total Samples:	**89**	**137**	**2**	**40**	**268**
Samples with VOCs[1]:	**15**	**114**	**1**	**27**	**157**
Percent of Total Samples with VOCs:	**17%**	**83%**	**50%**	**68%**	**59%**

Notes:

1 Some contaminated samples contain more than one compound.

Table 5. Nitrate Concentrations in Aquifer Groundwater and Surface Water, CY 1995

Distance from the S-3 Site (ft)	Sampling Point[1]	Location[2]	Nitrate Concentration[3] (mg/L)				CY 1995 Average Concentration (mg/L)
			1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	
< 1,000							
	GW-124	S3	NS	NS	51	NS	51
	GW-315	SPI	3.4	12	15	[16.8]	10
1,000 to 2,000							
	MS1	EXP-SW	NS	5.8	NS	NS	6
	GW-100	S3	NS	NS	190	NS	190
	TS	EXP-SW	NS	1.3	NS	NS	1
	NT-1N	EXP-SW	NS	23	NS	NS	23
	NT-01	EXP-SW	34	NS	170	NS	102
	NT-1S	EXP-SW	NS	110	NS	NS	110
	SS-1	EXP-SW	23	NS	28	NS	26
	GW-236	S3	NS	NS	65	NS	65
	GW-348	S3	8.2	7.6	7.6	NS	8
2,000 to 3,000							
	NT-02	EXP-SW	8.1	NS	25	NS	17
	BCK-11.97	EXP-SW	27	NS	190	NS	109
3,000 to 5,000							
	GW-064	OLF	5	4.9	5.4	NS	5
	GW-723	EXP-C	16	NS	6.7	NS	11
	GW-724	EXP-C	41	NS	38	NS	40
	GW-725	EXP-C	49	NS	35	NS	42
	GW-736	EXP-C	32	NS	31	NS	32
	GW-737	EXP-C	33	NS	33	NS	33
	GW-738	EXP-C	18	NS	19	NS	19
	GW-739	EXP-C	7	NS	5.9	NS	6
	GW-740	EXP-C	4.1	NS	3.2	NS	4
	GW-066	OLF	NS	NS	7.4	NS	7
	GW-228	OLF	NS	NS	40	NS	40
7,000 to 9,000							
	GW-621	EXP-B	3.6	NS	5.6	NS	5
	GW-694	EXP-B	20	NS	16	NS	18
	GW-695	EXP-B	8.5	NS	6.8	NS	8
	GW-703	EXP-B	22	NS	19	NS	21
	GW-704	EXP-B	16	NS	15	NS	16

Table 5 (cont'd)

Distance from the S-3 Site (ft)	Sampling Point[1]	Location[2]	Nitrate Concentration[3] (mg/L)				CY 1995 Average Concentration (mg/L)
			1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	
7,000 to 9,000 (cont'd)							
	GW-706	EXP-B	16	NS	18	NS	17
	SS-4	EXP-SW	3.7	NS	23	NS	13
	GW-061	BG	11	15	18	NS	15
10,000 to 11,000							
	GW-683	EXP-A	1.3	NS	9.3	NS	5
	GW-684	EXP-A	2.9	NS	8.8	NS	6
	GW-685	EXP-A	2.4	NS	3	NS	3
	SS-5	EXP-SW	1.2	NS	7.5	NS	4
	BCK-09.40	EXP-SW	3.9	NS	6	NS	5
> 11,000							
	GW-714	EXP-W	4.3	NS	3.9	NS	4
	GW-715	EXP-W	1	NS	1.2	NS	1
	SS-6W	EXP-SW	NS	< 0.2	NS	1.8	2
	SS-7	EXP-SW	NS	0.24	NS	4.74	2
	BCK-04.55	EXP-SW	1.5	NS	1.2	NS	1
	BCK-03.87	EXP-SW	1.2	NS	1.3	NS	1

Notes:

1
BCK - Bear Creek Kilometer (Surface Water Sampling Station)
GW - Groundwater Monitoring Well
MS - Bear Creek Main Stem Headwaters
NT - North Tributary to Bear Creek
SS - Spring
TS - Tank Spring (Bear Creek headwaters)

2
BG - Bear Creek Burial Grounds WMA
EXP - Exit Pathway (Maynardville Limestone, Bear Creek, and Springs)
OLF - Oil Landfarm WMA
RS - Rust Spoil Area
S3 - S-3 Site
SPI - Spoil Area I

3 Nitrate concentrations, in milligrams per liter (mg/L), reported for individual samples collected during CY 1995.
NS - Not Sampled.
[ ] - Qualitative result not used to calculate the annual average because of ion charge imbalance (see Appendix C).

Table 6. Elevated Trace Metal Concentrations in Groundwater and Surface Water, CY 1995

Metal[1]	Sampling Point[2]	Location[3]	Cluster[4]	UTL/ MCL[5] (mg/L)	CY 1995 Median[5] (mg/L)	Number of Results[6]
Aquitard Wells						
Aluminum						
	GW-040	BG	3	2.4	12.50	4
	GW-080	BG	2	6.1	6.90	4
	GW-257	BG	3	2.4	9.50	1
	GW-276	S3	3	2.4	17.50	2
	GW-828	OLF	10	2.4	11.00	3
	GW-829	OLF	10	2.4	3.49	3
Arsenic						
	GW-346	S3	NA	0.05	0.18	1
Barium						
	GW-537	OLF	3	2	2.4	4
Beryllium						
	GW-276	S3	NA	0.004	0.0115	2
Boron						
	GW-014	BG	1	0.12	4.800	1
	GW-046	BG	2	0.028	0.041	1
	GW-047	BG	2	0.028	0.038	3
	GW-080	BG	2	0.028	0.036	4
	GW-087	OLF	3	0.041	0.088	1
	GW-162	BG	3	0.041	0.052	4
	GW-276	S3	3	0.041	0.060	2
	GW-291	BG	3	0.041	2.200	1
	GW-346	S3	3	0.041	0.130	1
	GW-653	BG	2	0.028	0.030	4
	GW-654	BG	3	0.041	0.062	4
	GW-794	AGLLSF	3	0.041	0.070	4
Cadmium (AAS)						
	GW-042	BG	NA	0.005	0.009	4
	GW-276	S3	NA	0.005	0.0555	2
Cobalt						
	GW-276	S3	3	0.019	0.22	2
Copper						
	GW-080	BG	2	0.012	0.022	4

Table 6 (cont'd)

Metal[1]	Sampling Point[2]	Location[3]	Cluster[4]	UTL/ MCL[5] (mg/L)	CY 1995 Median[5] (mg/L)	Number of Results[6]
Aquitard Wells (cont'd)						
Copper (cont'd)						
	GW-276	S3	3	0.012	0.0395	2
	GW-291	BG	3	0.012	0.066	1
	GW-828	OLF	10	0.012	0.013	3
	GW-829	OLF	10	0.012	0.016	3
Iron						
	GW-040	BG	3	8.7	16	4
	GW-257	BG	3	8.7	11	1
	GW-828	OLF	10	6.9	8.1	3
Manganese						
	GW-014	BG	1	1.7	2.3	1
	GW-276	S3	3	1.7	10.5	2
	GW-642	BG	2	1.7	1.75	4
	GW-828	OLF	10	0.13	0.15	3
Selenium						
	GW-046	BG	NA	0.05	0.072	1
	GW-288	BG	NA	0.05	0.087	1
	GW-289	BG	NA	0.05	0.11	1
	GW-346	S3	NA	0.05	0.12	1
Strontium						
	GW-346	S3	3	0.92	16.000	1
	GW-537	OLF	3	0.92	2.900	4
	GW-829	OLF	10	0.92	1.700	3
Uranium (PMS)						
	GW-087	OLF	3	0.005	0.87	1
	GW-276	S3	3	0.005	1.8	2
Vanadium						
	GW-040	BG	3	0.005	0.015	4
	GW-080	BG	2	0.005	0.009	4
	GW-257	BG	3	0.005	0.013	1
	GW-828	OLF	10	0.005	0.008	3
Zinc						
	GW-040	BG	3	0.041	0.050	4
	GW-287	BG	3	0.041	0.048	4
	GW-830	B9714	4	0.041	0.240	1

Table 6 (cont'd)

Metal[1]	Sampling Point[2]	Location[3]	Cluster[4]	UTL/ MCL[5] (mg/L)	CY 1995 Median[5] (mg/L)	Number of Results[6]
Aquifer Wells						
Aluminum						
	GW-061	BG	1	2.4	17.00	3
	GW-236	S3	1	2.4	2.90	1
Arsenic						
	GW-229	OLF	NA	0.05	0.06	1
Boron						
	GW-053	BG	1	0.12	0.350	4
	GW-229	OLF	1	0.12	2.100	1
	GW-683	EXP-A	4	0.028	0.049	2
	GW-694	EXP-B	1	0.12	0.195	2
	GW-706	EXP-B	1	0.12	0.160	2
	GW-710	EXP-W	1	0.12	0.260	2
	GW-711	EXP-W	1	0.12	1.300	2
	GW-714	EXP-W	3	0.041	0.091	2
	GW-800	OLF	4	0.028	0.035	3
Cobalt						
	GW-236	S3	1	0.019	0.029	1
Iron						
	GW-228	OLF	1	8.7	26	1
	GW-229	OLF	1	8.7	11	1
	GW-710	EXP-W	1	8.7	9.85	2
Lead						
	GW-064	OLF	1	NA	0.05	3
Manganese						
	GW-229	OLF	1	1.7	6	1
	GW-236	S3	1	1.7	3.4	1
Selenium						
	GW-100	S3	NA	0.05	0.15	1
Strontium						
	GW-100	S3	2	0.079	0.710	1
	GW-348	S3	2	0.079	0.095	3
	GW-683	EXP-A	4	0.079	0.080	2

Table 6 (cont'd)

Metal[1]	Sampling Point[2]	Location[3]	Cluster[4]	UTL/ MCL[5] (mg/L)	CY 1995 Median[5] (mg/L)	Number of Results[6]
Aquifer Wells (cont'd)						
Strontium (cont'd)						
	GW-710	EXP-W	1	4.4	8.150	2
	GW-711	EXP-W	1	4.4	13.500	2
	GW-800	OLF	4	0.079	0.110	3
Uranium (PMS)						
	GW-061	BG	1	0.012	0.040	3
	GW-229	OLF	1	0.012	0.014	1
	GW-683	EXP-A	4	0.005	0.032	2
	GW-684	EXP-A	1	0.012	0.026	2
	GW-694	EXP-B	1	0.012	0.125	2
	GW-706	EXP-B	1	0.012	0.094	2
Vanadium						
	GW-061	BG	1	0.005	0.019	3
	GW-800	OLF	4	0.005	0.007	3
Zinc						
	GW-236	S3	1	0.041	0.049	1
Surface Water						
Boron						
	BCK-09.40	EXP-SW	1	0.12	0.184	2
Cadmium (AAS)						
	NT-01	EXP-SW	NA	0.005	0.017	2
Manganese						
	NT-01	EXP-SW	1	1.7	3.13	2
Uranium (PMS)						
	NT-01	EXP-SW	1	0.012	0.028	2
	BCK-11.97	EXP-SW	1	0.012	0.111	2
	BCK-09.40	EXP-SW	1	0.012	0.078	2
	BCK-04.55	EXP-SW	3	0.004	0.017	2
	BCK-03.87	EXP-SW	3	0.004	0.017	2
Springs						
Boron						
	SS-6.6K	EXP-SW	4	0.028	0.042	1
	SS-7	EXP-SW	4	0.028	0.037	2

Table 6 (cont'd)

Metal[1]	Sampling Point[2]	Location[3]	Cluster[4]	UTL/ MCL[5] (mg/L)	CY 1995 Median[5] (mg/L)	Number of Results[6]
Springs (cont'd)						
Uranium (PMS)						
	SS-1	EXP-SW	1	0.012	0.031	2
	SS-4	EXP-SW	1	0.012	0.095	2
	SS-5	EXP-SW	1	0.012	0.040	2
	SS-6W	EXP-SW	4	0.005	0.005	2
	SS-7	EXP-SW	4	0.005	0.018	2

Notes:

1 Results obtained by ICP spectroscopy unless otherwise noted.
AAS - Atomic Absorption Spectrometry
PMS - Plasma Mass Spectrometry

2 BCK - Bear Creek Kilometer
GW - Monitoring Well
NT - Northern Tributary
SS - Spring

3 AGLLSF - Above Ground Low-Level Storage Facility
BG - Bear Creek Burial Grounds WMA
EXP - Exit Pathway Monitoring Location:
Maynardville Limestone Traverse (-A, -B, -W)
Spring or Surface Water Sampling Location (-SW)
OLF - Oil Landfarm WMA
RS - Rust Spoil Area
S3 - S-3 Site
SPI - Spoil Area I

4 Cluster designation for trace metal data evaluation purposes (see Appendix C).
N/A - Not applicable for metal concentrations compared to MCLs.

5 Concentrations in milligrams per liter.

6 The number of results used to determine median values.

Table 7. Annual Average VOC Concentrations for Aquitard Monitoring Wells, CY 1995

		CY 1995 Average Concentration[3] (μg/L)				
Sampling Point		GW-014	GW-046	GW-069	GW-087	GW-257
Location[1]	MCL[2]	BG	BG	BG	OLF	BG
Qualitative Results[4]						
Acetone	-	.	.	0	0	0
Benzene	5	.	.	0	5	0
Chloroform	-	.	.	0	0	0
1,1-Dichloroethane	-	450	.	0	4	0
1,2-Dichloroethane	5	73	38	0	7	0
1,1-Dichloroethene	7	100	.	0	4	0
1,2-Dichloroethene	-	2,300	.	0	0	0
Methylene Chloride	5	.	.	0	0	0
Tetrachloroethene	5	.	460	0	0	0
Trichloroethene	5	410	.	0	0	3
Vinyl chloride	2	170	.	0.5	0	0
Summed Average		**3,503**	**498**	**<1**	**20**	**3**
Quantitative Results[5]						
Chloroform	-	.	.	0	18	0
1,2-Dichloroethene	-	.	.	0	120	0
Tetrachloroethene	5	.	.	0	220	140
Trichloroethene	5	.	.	0	410	0
Summed Average		**0**	**0**	**0**	**768**	**140**
Plume Delineation Value		**3,503**	**498**	**<1**	**788**	**143**

Table 7 (cont'd)

		CY 1995 Average Concentration[3] (μg/L)				
Sampling Point Location[1]	MCL[2]	GW-276 S3	GW-287 BG	GW-288 BG	GW-289 BG	GW-291 BG
Qualitative Results[4]						
Acetone	-	0	0	.	.	.
Benzene	5	0	0	.	.	.
Chloroform	-	1	0	.	.	.
1,1-Dichloroethane	-	0	0	.	.	.
1,2-Dichloroethane	5	0	0	.	.	38
1,1-Dichloroethene	7	0	0	.	.	.
1,2-Dichloroethene	-	0	0	.	.	.
Methylene Chloride	5	0	0	.	.	.
Tetrachloroethene	5	0	1	690	930	460
Trichloroethene	5	0	0	.	.	.
Vinyl chloride	2	0	0	.	.	.
Summed Average		**1**	**<1**	**690**	**930**	**498**
Quantitative Results[5]						
Chloroform	-	0	0	.	.	.
1,2-Dichloroethene	-	0	0	.	.	.
Tetrachloroethene	5	34.5	0	.	.	.
Trichloroethene	5	0	0	.	.	.
Summed Average		**35**	**0**	**0**	**0**	**0**
Plume Delineation Value		**36**	**<1**	**690**	**930**	**498**

Table 7 (cont'd)

		CY 1995 Average Concentration[3] (μg/L)			
Sampling Point Location[1]	**MCL[2]**	**GW-537 OLF**	**GW-627 BG**	**GW-653 BG**	**GW-829-029 OLF**
Qualitative Results[4]					
Acetone	-	0	0	0	49
Benzene	5	0	0	0	0
Chloroform	-	0.8	0	0	3
1,1-Dichloroethane	-	0	4.5	0.8	0
1,2-Dichloroethane	5	0	0	0	0
1,1-Dichloroethene	7	0	0	0.3	0
1,2-Dichloroethene	-	0	0	0	0
Methylene Chloride	5	0	0	0	0
Tetrachloroethene	5	0	0	2.8	0
Trichloroethene	5	0	8.25	1	0
Vinyl chloride	2	0	0	0	0
Summed Average		**<1**	**13**	**5**	**52**
Quantitative Results[5]					
Chloroform	-	0	0	0	0
1,2-Dichloroethene	-	0	0	21	0
Tetrachloroethene	5	0	55.5	0	0
Trichloroethene	5	0	0	0	0
Summed Average		**0**	**56**	**21**	**0**
Plume Delineation Value		**<1**	**69**	**26**	**52**

Notes:

1 BG - Bear Creek Burial Grounds WMA
OLF - Oil Landfarm WMA
S3 - S-3 Site

2 MCL - Maximum Contaminant Level

3 All results are in micrograms per liter (μg/L).
0 - Not detected, false positive, or anomalous result
. - Not detected at an elevated detection limit (diluted sample)

4 Qualitative results were determined exclusively from results reported below the analytical detection limit, or from results for diluted samples.

5 Quantitative results were determined from at least one result reported above the analytical detection limit in undiluted samples.

Table 8. Annual Average VOC Concentrations for Aquifer Monitoring Wells, CY 1995

Sampling Point Location[1]	MCL[2]	CY 1995 Average Concentration[3] (μg/L)					
		GW-053 BG	GW-064 OLF	GW-066 OLF	GW-124 S3	GW-228 OLF	GW-236 S3
Qualitative Results[4]							
Carbon tetrachloride	5	0	1.3	0	0	0	0
Chloroform	-	0	2	0	1	0	0
1,1-Dichloroethane	-	0	0	1	0	0	5
1,1-Dichloroethene	7	0	0	2	0	0	0
1,2-Dichloroethene	-	0	0	3	0	0	0
Tetrachloroethene	5	0.8	0.7	0	1	0	2
Trichloroethene	5	2.5	0	0	0	0	0
Vinyl chloride	2	0	0	0	0	0	0
Summed Average		**3**	**4**	**6**	**2**	**0**	**7**
Quantitative Results[5]							
1,1-Dichloroethane	-	8.5	0	0	0	0	0
1,2-Dichloroethene	-	17	8	0	0	14	0
Tetrachloroethene	5	0	0	21	0	0	0
Trichloroethene	5	0	80	12	0	28	0
Vinyl chloride	2	8	0	0	0	0	0
Summed Average		**34**	**88**	**33**	**0**	**42**	**0**
Plume Delineation Value		**37**	**92**	**39**	**2**	**42**	**7**

Table 8 (cont'd)

Sampling Point Location[1]	MCL[2]	CY 1995 Average Concentration[3] (μg/L) GW-311 RS	GW-312 RS	GW-315 SPI	GW-683 EXP-A	GW-684 EXP-A	GW-694 EXP-B
Qualitative Results[4]							
Carbon tetrachloride	5	0.3	0	0	0	0	0
Chloroform	-	0	1.3	1.8	0	0	0
1,1-Dichloroethane	-	0	0	0	0	0	0
1,1-Dichloroethene	7	0	0	0	0	0	0
1,2-Dichloroethene	-	0	0	0	1	1	0
Tetrachloroethene	5	0	0	0	0	0	0
Trichloroethene	5	0	0	0	1	1	0
Vinyl chloride	2	0	0	0	0	0	0
Summed Average		**0**	**1**	**2**	**2**	**2**	**0**
Quantitative Results[5]							
1,1-Dichloroethane	-	0	0	0	0	0	0
1,2-Dichloroethene	-	0	0	11.5	0	0	11.5
Tetrachloroethene	5	0	0	20.5	0	0	0
Trichloroethene	5	14	65	9.3	0	0	16
Vinyl chloride	2	0	0	0.0	0	0	0
Summed Average		**14**	**65**	**41**	**0**	**0**	**28**
Plume Delineation Value		**14**	**66**	**43**	**2**	**2**	**28**

Table 8 (cont'd)

Sampling Point Location[1]	MCL[2]	GW-695 EXP-B	GW-703 EXP-B	GW-704 EXP-B	GW-706 EXP-B	GW-723 EXP-C	GW-724 EXP-C
		CY 1995 Average Concentration[3] (μg/L)					
Qualitative Results[4]							
Carbon tetrachloride	5	0	0	0	0	0	2
Chloroform	-	0	0	0	0	0	1
1,1-Dichloroethane	-	0	0	0	0	0	0
1,1-Dichloroethene	7	0	0	3	0	0	0
1,2-Dichloroethene	-	1	0	0	0	0	4
Tetrachloroethene	5	0	0	0	0	0	4
Trichloroethene	5	3.5	0	0	4	6	0
Vinyl chloride	2	0	0	0	0	0	0
Summed Average		**5**	**0**	**3**	**4**	**6**	**11**
Quantitative Results[5]							
1,1-Dichloroethane	-	0	0	0	0	0	0
1,2-Dichloroethene	-	0	0	0	0	0	0
Tetrachloroethene	5	0	0	0	0	0	0
Trichloroethene	5	0	19	90.5	0	0	145
Vinyl chloride	2	0	0	0	0	0	0
Summed Average		**0**	**19**	**91**	**0**	**0**	**145**
Plume Delineation Value		**5**	**19**	**94**	**4**	**6**	**156**

Table 8 (cont'd)

Sampling Point Location[1]	MCL[2]	CY 1995 Average Concentration[3] (μg/L)					
		GW-725 EXP-C	GW-736 EXP-C	GW-737 EXP-C	GW-738 EXP-C	GW-739 EXP-C	GW-740 EXP-C
Qualitative Results[4]							
Carbon tetrachloride	5	0	0	0	1	1	2
Chloroform	-	1	0	0.5	1	0	1
1,1-Dichloroethane	-	0	0	0	0	0	0
1,1-Dichloroethene	7	0.5	0	0	0	0	0
1,2-Dichloroethene	-	3	3	5	3.5	2	3
Tetrachloroethene	5	2	2	4	1	0	0
Trichloroethene	5	0	0	0	0	0	0
Vinyl chloride	2	0	0	0	0	0	0
Summed Average		**7**	**5**	**10**	**7**	**3**	**6**
Quantitative Results[5]							
1,1-Dichloroethane	-	0	0	0	0	0	0
1,2-Dichloroethene	-	0	0	0	0	0	0
Tetrachloroethene	5	0	0	0	0	0	0
Trichloroethene	5	89	7.5	13	50	46	76
Vinyl chloride	2	0	0	0	0	0	0
Summed Average		**89**	**8**	**13**	**50**	**46**	**76**
Plume Delineation Value		**96**	**13**	**23**	**57**	**49**	**82**

Notes:

1 BG - Bear Creek Burial Grounds WMA
EXP - Exit Pathway Monitoring Well (Picket -A, -B, or -C)
OLF - Oil Landfarm WMA
RS - Rust Spoil Area
S3 - S-3 Site
SPI - Spoil Area I

2 MCL - Maximum Contaminant Level

3 All results are in micrograms per liter (μg/L).
0 - Not detected, false positive, or anomalous result

4 Qualitative: results reported below the analytical detection limit.

5 Quantitative: determined from at least one result reported above the analytical detection limit.

Table 9. Annual Average Gross Alpha Activity in Groundwater and Surface Water, CY 1995 GWPP Monitoring Data

Sampling Point[1]	Location[2]	Gross Alpha		Number of Results	
		Average Activity[3]	Mean Error	Exceeding MDA	Total Analyzed
Aquitard Wells					
GW-040	BG	3	2	1	4
GW-087	OLF	**188**	23	1	1
GW-276	S3	**661**	57	2	2
GW-287	BG	7	3	1	4
GW-537	OLF	**30**	17	2	4
GW-828	OLF	**23**	10	2	3
GW-829	OLF	**51**	13	3	4
Aquifer Wells					
GW-053	BG	2	2	1	4
GW-061	BG	**18**	2	3	3
GW-066	OLF	5	3	1	1
GW-228	OLF	7	3	1	1
GW-229	OLF	6	3	1	1
GW-315	SPI	2	1	1	
GW-683	EXP-A	**25**	5	1	2
GW-684	EXP-A	12	2	2	2
GW-694	EXP-B	**47**	5	2	2
GW-695	EXP-B	5	2	1	2
GW-706	EXP-B	**34**	4	2	2
GW-738	EXP-C	6	3	1	2
Surface Water					
NT-01	EXP-SW	**24**	6	1	2
BCK-11.97	EXP-SW	**34**	5	2	2
BCK-09.40	EXP-SW	**30**	4	2	2
BCK-04.55	EXP-SW	7	2	2	2
BCK-03.87	EXP-SW	8	2	2	2
Springs					
SS-1	EXP-SW	14	3	2	2
SS-4	EXP-SW	**34**	5	2	2
SS-5	EXP-SW	**16**	3	2	2
SS-6W	EXP-SW	3	2	1	2
SS-7	EXP-SW	**16**	4	1	2

Table 9 (cont'd)

Notes:

1 BCK - Bear Creek Kilometer
GW - Monitoring Well
NT - Northern Tributary
SS - Spring

2 BG - Bear Creek Burial Grounds WMA
EXP - Exit Pathway Monitoring Location:
Maynardville Limestone Traverse (-A, -B, -C)
Spring or Surface Water Sampling Location (-SW)
OLF - Oil Landfarm WMA
S3 - S-3 Site
SPI - Spoil Area I

3 Average activity reported in picoCuries per liter. **Boldface type** indicates average activity above the 15 pCi/L MCL. Only results above the Minimum Detectable Activity (MDA) were used to calculate the average activity.

Table 10. Gross Alpha and Gross Beta Activities That Exceed MDAs, CY 1995 BCV RI Radiological Sampling Data

Sampling Point	Location[1]	Gross Alpha			Gross Beta		
		Activity[2]	Error	MDA	Activity[2]	Error	MDA
Aquitard Wells							
GW-005	OLF	<MDA	.	8.3	12	5.5	8.9
GW-040	BG	<MDA	.	15	22	12	17
GW-087	OLF	**360**	49	8.7	**330**	44	9
GW-243	S3	**550**	240	310	**9,300**	1,200	230
GW-537	OLF	**33**	19	28	**570**	79	23
GW-615	S3	<MDA	.	380	**510**	200	310
Aquifer Wells							
GW-684	EXP-A	**18**	6.2	7.7	33	7.9	8.1
GW-706	EXP-B	**39**	10	8.1	44	9.2	8
GW-712	EXP-W	**21**	7	8.4	17	6.3	8.2
GW-714	EXP-W	<MDA	.	7.7	8.6	5.4	8.1
Surface Water							
BCK-09.40	EXP-SW	**38**	9.9	7.8	34	8	8.6
BCK-04.55	EXP-SW	15	8	9.5	<MDA	.	8.8
Leachate							
C WEST TOE	BG	13	6.4	9	22	6.8	8.4
C WEST TOE	BG	<MDA	.	3.3	26	7.2	3.5
SEEP1	BG	8.4	5.2	8	13	5.8	8.3
SEEP1	BG	10	5.5	8	-	-	8.2
SEEP2	BG	**320**	44	8.7	**190**	27	8.4
SEEP2	BG	**330**	45	8.8	**230**	32	8.4
Springs							
SS-4	EXP-SW	**49**	11	8.2	**110**	17	8.6
SS-5	EXP-SW	**24**	8.1	7.8	32	7.8	8.6

Notes:

1
BG - Bear Creek Burial Grounds WMA
EXP - Exit Pathway Monitoring Location:
Maynardville Limestone Traverse (-A, -B, -W)
Spring or Surface Water Sampling Location (-SW)
OLF - Oil Landfarm WMA
S3 - S-3 Site

2 Activity reported in picoCuries per liter. **Boldface type** indicates activities that exceed water quality reference values. MDA = minimum detectable activity.

Table 11. Radionuclide Activities that Exceed MDAs, CY 1995

Isotope	Sampling Point[1]	Purpose[2]	Location[3]	Date Sampled	Activity[4]	Error	MDA[5]
Aquitard Wells							
Americium 231							
	GW-162	✓	BG	10/11/95	0.277	0.26	0.176
	GW-372	✓	BG	10/12/95	0.414	0.32	0.183
	GW-373	✓	BG	10/12/95	0.242	0.23	0.155
Cesium 137							
	GW-014	.	BG	08/04/95	8.7	5.5	4.4
	GW-080	✓	BG	03/25/95	18	14	3.9
	GW-084	✓	OLF	06/07/95	106	9.4	3.9
	GW-085	✓	OLF	06/08/95	6.22	5.2	3.9
	GW-162	.	BG	08/03/95	10	5.1	4
	GW-258	.	BG	08/04/95	4.6	4.2	2.8
	GW-291	.	BG	08/03/95	11	5.7	4.2
	GW-044	.	OLF	08/04/95	7.6	4.3	3
	GW-613	.	S3	08/14/95	9.7	5.8	4.3
	GW-614	✓	S3	01/11/95	14.8	13	3.9
	GW-615	.	S3	08/02/95	6	4.7	3.7
	GW-794	.	AGLLSF	08/02/95	4.6	4.2	3.5
Neptunium 237							
	GW-243	.	S3	08/01/95	40	7.6	3
Plutonium 238							
	GW-080	✓	BG	12/9/95	0.932	0.62	0.297
	GW-363	✓	BG	10/19/95	0.271	0.27	0.195
Radium (total)							
	GW-040	✓	BG	10/11/95	1.51	1.08	1.5
	GW-042	✓	BG	08/09/95	2.24	1.38	1.5
	GW-080	✓	BG	03/25/95	2.08	1.81	1.5
	GW-080	✓	BG	06/19/95	1.78	1.13	1.5
	GW-080	✓	BG	09/21/95	5.94	1.11	1.5
	GW-115	✓	S3	07/30/95	1.51	1.19	1.5
	GW-276	✓	S3	01/24/95	4.86	3.24	1.5
	GW-276	✓	S3	07/29/95	9.18	2.70	1.5
	GW-642	✓	BG	10/10/95	1.62	1.49	1.5
Strontium 89 + 90							
	GW-243	.	S3	08/01/95	7.4	1.2	3.1
	GW-615	.	S3	08/02/95	3.6	0.66	2.8

Table 11 (cont'd)

Isotope	Sampling Point[1]	Purpose[2]	Location[3]	Date Sampled	Activity[4]	Error	MDA[5]
Aquitard Wells (cont'd)							
Strontium (total)							
	GW-043	✓	OLF	10/18/95	10.1	6.2	9.48
	GW-080	✓	BG	06/19/95	51.7	11	33
	GW-084	✓	OLF	10/19/95	12.8	6.5	9.09
	GW-373	✓	BG	08/08/95	36.9	25	33
	GW-642	✓	BG	06/02/95	36.1	10	33
	GW-793	✓	AGLLSF	10/19/95	33	14	17.8
Technetium 99							
	GW-040		OLF	08/10/95	20	15	6.2
	GW-084	✓	OLF	10/19/95	14.2	8.6	13.6
	GW-085	✓	OLF	03/26/95	234	12	110
	GW-085	✓	OLF	06/08/95	212	43	110
	GW-085	✓	OLF	08/06/95	194	12	110
	GW-085	✓	OLF	10/25/95	234	12	110
	GW-087		OLF	08/09/95	36	6.3	6.2
	GW-243		S3	08/01/95	23,108	2,300	6.2
	GW-276	✓	S3	01/24/95	1,350	68	110
	GW-276	✓	S3	07/29/95	1,280	22	110
	GW-537	✓	OLF	03/26/95	1,030	20	110
	GW-537	✓	OLF	06/08/95	837	58	110
	GW-537	✓	OLF	08/03/95	1,160	21	110
	GW-537		OLF	08/03/95	1,300	130	6.2
	GW-537	✓	OLF	10/25/95	1,010	20	110
	GW-615		S3	08/02/95	50	7.2	6.2
Thorium 228							
	GW-005		OLF	08/02/95	0.32	0.31	0.12
	GW-014		BG	08/04/95	0.38	0.28	0.13
	GW-040		BG	08/10/95	0.92	0.5	0.35
	GW-044		OLF	08/04/95	0.26	0.23	0.25
Thorium 230							
	GW-005		OLF	08/02/95	0.44	0.32	0.15
	GW-014		BG	08/04/95	0.74	0.34	0.095
	GW-040		BG	08/10/95	0.28	0.17	0.063
	GW-044		OLF	08/04/95	0.33	0.32	0.26
	GW-087		OLF	08/09/95	0.5	0.31	0.41

Table 11 (cont'd)

Isotope	Sampling Point[1]	Purpose[2]	Location[3]	Date Sampled	Activity[4]	Error	MDA[5]
Aquitard Wells (cont'd)							
Thorium 230 (cont'd)							
	GW-162	.	BG	08/03/95	0.5	0.31	0.34
	GW-243	.	S3	08/01/95	0.59	0.41	0.38
	GW-258	.	BG	08/04/95	0.41	0.32	0.4
	GW-258	.	BG	08/04/95	0.51	0.26	0.31
	GW-291	.	BG	08/03/95	0.17	0.16	0.093
	GW-537	.	OLF	08/03/95	0.32	0.18	0.15
	GW-613	.	S3	08/14/95	0.38	0.31	0.34
	GW-615	.	S3	08/02/95	0.65	0.33	0.1
	GW-624	.	BG	08/03/95	0.49	0.32	0.13
	GW-794	.	AGLLSF	08/02/95	0.53	0.4	0.45
Thorium 234							
	GW-276	✓	S3	07/29/95	490	59	250
Tritium							
	GW-084	✓	OLF	08/05/95	1,026	675	950
Uranium 234							
	GW-005	.	OLF	08/02/95	9.8	2.1	0.13
	GW-014	.	BG	08/04/95	0.48	0.25	0.08
	GW-040	.	BG	08/10/95	0.54	0.32	0.34
	GW-040	✓	BG	10/11/95	0.726	0.4	0.154
	GW-042	✓	BG	10/11/95	0.243	0.23	0.155
	GW-044	✓	OLF	10/18/95	0.247	0.23	0.157
	GW-069	✓	BG	12/7/95	0.796	0.65	0.381
	GW-080	✓	BG	12/9/95	0.583	0.52	0.335
	GW-084	✓	OLF	10/19/95	0.32	0.26	0.153
	GW-085	✓	OLF	06/08/95	219	140	55
	GW-087	.	OLF	08/09/95	130	27	0.23
	GW-243	.	S3	08/01/95	88	16	0.39
	GW-276	✓	S3	01/24/95	271	12	55
	GW-276	✓	S3	07/29/95	260	9.1	55
	GW-258	.	BG	08/04/95	0.16	0.14	0.087
	GW-291	.	BG	08/03/95	0.15	0.14	0.084
	GW-537	✓	OLF	06/08/95	371	190	55
	GW-537	.	OLF	08/03/95	1.5	0.49	0.27
	GW-615	.	S3	08/02/95	80	14	0.15

Table 11 (cont'd)

Isotope	Sampling Point[1]	Purpose[2]	Location[3]	Date Sampled	Activity[4]	Error	MDA[5]
Aquitard Wells (cont'd)							
Uranium 234 (cont'd)							
	GW-623	.	BG	08/02/95	1.7	0.5	0.14
	GW-624	.	BG	08/03/95	0.6	0.27	0.078
	GW-794	.	AGLLSF	08/02/95	0.26	0.18	0.078
Uranium 235							
	GW-040	✓	BG	06/06/95	15.1	12	14
	GW-087	.	OLF	08/09/95	8.4	2.6	0.29
	GW-243	.	S3	08/01/95	5.2	1.6	0.49
	GW-276	✓	S3	01/24/95	23.9	13	14
	GW-276	✓	S3	07/29/95	14.7	7.3	14
	GW-615	.	S3	08/02/95	3.6	1.2	0.19
Uranium 238							
	GW-005	.	OLF	08/02/95	3.5	1	0.39
	GW-014	.	BG	08/04/95	0.89	0.35	0.081
	GW-040	✓	BG	10/11/95	1.42	0.55	0.154
	GW-087	.	OLF	08/09/95	380	79	0.57
	GW-243	.	S3	08/01/95	230	40	0.49
	GW-276	✓	S3	01/24/95	603	18	22
	GW-276	✓	S3	07/29/95	552	13	22
	GW-537	.	OLF	08/03/95	0.52	0.27	0.089
	GW-537	✓	OLF	10/25/95	0.679	0.45	0
	GW-615	.	S3	08/02/95	190	33	0.15
	GW-623	.	BG	08/02/95	0.79	0.32	0.14
	GW-624	.	BG	08/03/95	0.46	0.24	0.078
	GW-829	✓	OLF	12/10/95	0.666	0.6	0.00382
Aquifer Wells							
Cesium 137							
	GW-710	.	EXP-W	07/27/95	8.8	5	4.7
	GW-712	.	EXP-W	07/25/95	4.4	4.1	3.6
	GW-714	.	EXP-W	08/29/95	5.6	3.8	2.9
	GW-715	.	EXP-W	07/29/95	6.4	3.8	3
Radium 228							
	GW-710	.	EXP-W	07/27/95	2.4	1.1	1
	GW-711	.	EXP-W	07/27/95	7.8	2.2	1.2

Table 11 (cont'd)

Isotope	Sampling Point[1]	Purpose[2]	Location[3]	Date Sampled	Activity[4]	Error	MDA[5]
Aquifer Wells (cont'd)							
Radium (total)							
	GW-710	✓	EXP-W	01/15/95	2.97	1.62	1.5
	GW-710	✓	EXP-W	07/27/95	4.05	1.89	1.5
	GW-711	✓	EXP-W	01/13/95	3.24	1.62	1.5
	GW-711	✓	EXP-W	07/27/95	5.94	2.43	1.5
	GW-712	✓	EXP-W	01/13/95	1.54	1.11	1.5
	GW-713	✓	EXP-W	07/27/95	5.94	2.43	1.5
Technetium 99							
	GW-684	.	EXP-A	08/06/95	28	5.8	6.6
	GW-694	✓	EXP-B	03/30/95	116	40	110
	GW-706	.	EXP-B	08/30/95	39	6.4	6.4
	GW-714	.	EXP-W	08/29/95	8	4.8	6.6
Thorium 230							
	GW-684	.	EXP-A	08/06/95	0.4	0.23	0.2
	GW-706	.	EXP-B	08/30/95	0.35	0.25	0.3
	GW-710	.	EXP-W	07/27/95	0.32	0.25	0.23
	GW-711	.	EXP-W	07/27/95	0.54	0.27	0.24
	GW-712	.	EXP-W	07/25/95	0.34	0.23	0.1
	GW-712	.	EXP-W	07/25/95	0.72	0.48	0.51
	GW-713	.	EXP-W	07/27/95	0.59	0.38	0.38
	GW-714	.	EXP-W	08/29/95	0.38	0.3	0.15
	GW-715	.	EXP-W	07/29/95	0.6	0.4	0.19
Uranium 234							
	GW-684	.	EXP-A	08/06/95	7.4	1.5	0.1
	GW-706	.	EXP-B	08/30/95	22	3.9	0.29
	GW-712	.	EXP-W	07/25/95	0.68	0.39	0.14
	GW-712	.	EXP-W	07/25/95	0.83	0.42	0.24
	GW-713	.	EXP-W	07/27/95	0.58	0.33	0.12
	GW-714	.	EXP-W	08/29/95	1.5	0.68	0.5
Uranium 235							
	GW-706	.	EXP-B	08/30/95	0.89	0.47	0.15
Uranium 238							
	GW-684	.	EXP-A	08/06/95	14	2.6	0.1
	GW-706	.	EXP-B	08/30/95	42	7.1	0.12
	GW-714	.	EXP-W	08/29/95	1	0.56	0.5
	GW-715	.	EXP-W	07/29/95	0.34	0.25	0.12

Table 11 (cont'd)

Isotope	Sampling Point[1]	Purpose[2]	Location[3]	Date Sampled	Activity[4]	Error	MDA[5]
Surface Water							
Cesium 137							
	BCK-04.55	.	EXP-SW	08/02/95	7.5	3.4	3.1
Technetium 99							
	NT-01	✓	EXP-SW	03/09/95	165	42	110
	NT-01	✓	EXP-SW	07/25/95	956	20	110
	BCK-11.97	✓	EXP-SW	03/09/95	143	41	110
	BCK-11.97	✓	EXP-SW	07/25/95	994	20	110
	BCK-09.40	.	EXP-SW	08/02/95	46	6.8	6.4
Thorium 228							
	BCK-09.40	.	EXP-SW	08/02/95	0.32	0.27	0.32
	BCK-04.55	.	EXP-SW	08/02/95	0.18	0.15	0.081
Thorium 230							
	BCK-09.40	.	EXP-SW	08/02/95	0.51	0.33	0.3
	BCK-04.55	.	EXP-SW	08/02/95	0.34	0.26	0.13
Thorium 232							
	BCK-04.55	.	EXP-SW	08/02/95	0.27	0.25	0.15
Uranium 234							
	BCK-09.40	.	EXP-SW	08/02/95	16	2.9	0.26
	BCK-04.55	.	EXP-SW	08/02/95	3.2	0.81	0.23
Uranium 235							
	BCK-09.40	.	EXP-SW	08/02/95	0.35	0.27	0.13
Uranium 238							
	BCK-09.40	.	EXP-SW	08/02/95	31	5	0.26
	BCK-04.55	.	EXP-SW	08/02/95	7.1	1.4	0.23
Leachate							
Cesium 137							
	SEEP1	.	BG	08/03/95	6.1	4.1	3.3
	SEEP2	.	BG	08/03/95	4.4	2.4	4.2
Neptunium 237							
	C WEST TOE	.	BG	08/03/95	0.52	0.25	0.078
	C WEST TOE	.	BG	08/03/95	0.41	0.24	0.22
	SEEP1	.	BG	08/03/95	0.75	0.33	0.084
	SEEP1	.	BG	08/03/95	0.56	0.29	0.23
	SEEP2	.	BG	08/03/95	0.85	0.39	0.28
	SEEP2	.	BG	08/03/95	2.2	0.59	0.087

Table 11 (cont'd)

Isotope	Sampling Point[1]	Purpose[2]	Location[3]	Date Sampled	Activity[4]	Error	MDA[5]
Leachate (cont'd)							
Strontium 89 + 90							
	SEEP2	.	BG	08/03/95	6.3	1.4	5.9
Technetium 99							
	C WEST TOE	.	BG	08/03/95	11	4.5	6
	C WEST TOE	.	BG	08/03/95	9	4.2	6
	SEEP1	.	BG	08/03/95	23	5.4	6.5
	SEEP2	.	BG	08/03/95	110	12	6.5
	SEEP2	.	BG	08/03/95	36	5.9	6
Thorium 228							
	C WEST TOE	.	BG	08/03/95	0.96	0.51	0.36
	C WEST TOE	.	BG	08/03/95	3.2	1.1	0.9
Thorium 230							
	C WEST TOE	.	BG	08/03/95	0.24	0.17	0.08
	C WEST TOE	.	BG	08/03/95	0.29	0.23	0.26
Thorium 232							
	C WEST TOE	.	BG	08/03/95	0.38	0.29	0.3
Uranium 234							
	C WEST TOE	.	BG	08/03/95	3.9	1	0.12
	C WEST TOE	.	BG	08/03/95	5.3	1.3	0.38
	SEEP1	.	BG	08/03/95	6.3	1.2	0.33
	SEEP1	.	BG	08/03/95	4.9	1.1	0.093
	SEEP2	.	BG	08/03/95	58	16	0.47
	SEEP2	.	BG	08/03/95	50	10	0.59
Uranium 235							
	C WEST TOE	.	BG	08/03/95	0.34	0.28	0.15
	SEEP1	.	BG	08/03/95	0.26	0.21	0.12
	SEEP2	.	BG	08/03/95	3.9	1.9	1.8
	SEEP2	.	BG	08/03/95	5.5	1.7	0.24
Uranium 238							
	C WEST TOE	.	BG	08/03/95	6.1	1.4	0.3
	C WEST TOE	.	BG	08/03/95	6.7	1.5	0.38
	SEEP1	.	BG	08/03/95	4.7	0.96	0.11
	SEEP1	.	BG	08/03/95	4.7	1	0.28
	SEEP2	.	BG	08/03/95	350	90	1.2
	SEEP2	.	BG	08/03/95	310	61	0.59

Table 11 (cont'd)

Isotope	Sampling Point[1]	Purpose[2]	Location[3]	Date Sampled	Activity[4]	Error	MDA[5]
Springs							
Cesium 137							
	SS-5	.	EXP-SW	08/02/95	7.9	3.6	2.9
	SS-6 WEST	.	EXP-SW	08/02/95	5.6	5	4.1
	SS-7	.	EXP-SW	08/02/95	6.8	6.5	4.4
Neptunium 237							
	SS-5	.	EXP-SW	08/02/95	0.3	0.2	0.09
Strontium							
	SS-1	✓	EXP-SW	09/22/95	60.3	24	33
Technetium 99							
	SS-4	.	EXP-SW	08/02/95	200	21	6.4
	SS-5	.	EXP-SW	08/02/95	46	6.9	6.4
Uranium 234							
	SS-4	.	EXP-SW	08/02/95	25	4.1	0.11
	SS-5	.	EXP-SW	08/02/95	13	2.6	0.29
	SS-6 WEST	.	EXP-SW	08/02/95	1.1	0.45	0.11
	SS-6 WEST	.	EXP-SW	08/02/95	0.8	0.4	0.12
	SS-7	.	EXP-SW	08/02/95	0.25	0.19	0.097
Uranium 235							
	SS-4	.	EXP-SW	08/02/95	1.4	0.56	0.13
	SS-5	.	EXP-SW	08/02/95	0.51	0.36	0.36
Uranium 238							
	SS-4	.	EXP-SW	08/02/95	48	7.5	0.33
	SS-5	.	EXP-SW	08/02/95	26	4.4	0.29
	SS-6 WEST	.	EXP-SW	08/02/95	1.7	0.57	0.11
	SS-6 WEST	.	EXP-SW	08/02/95	1.8	0.63	0.28
	SS-7	.	EXP-SW	08/02/95	0.22	0.18	0.097

<u>Notes</u>:

1 BCK - Bear Creek Kilometer
GW - Monitoring Well
NT - Northern Tributary to Bear Creek

2 AGLLSF - Above Ground Low-Level Storage Facility
BG - Bear Creek Burial Grounds WMA
EXP - Exit Pathway Monitoring Location:
Maynardville Limestone Traverse (-A, -B, -W)
Spring or Surface Water Sampling Location (-SW)

Table 11 (cont'd)

Notes: (cont'd.)

2 OLF - Oil Landfarm WMA
S3 - S-3 Site

3 Samples collected for Groundwater Protection Program (GWPP) monitoring purposes denoted with "✓"; samples collected for BCV RI radiological sampling purposes denoted with ".".

4 Activity reported in picoCuries per liter. Radium (total) and tritium activities were converted from bequerels per liter to picoCuries per liter.

5 Minimum detectable activity (MDA).

Table 12. Annual Average Gross Beta Activity in Groundwater and Surface Water, CY 1995 GWPP Monitoring Data

Sampling Point[1]	Location[1]	Gross Beta		Number of Results	
		Average Activity[1]	Average Error	Exceeding MDA[4]	Total Analyzed
Aquitard Wells					
GW-069	BG	8	3	1	4
GW-085	OLF	**108**	14	4	4
GW-087	OLF	**221**	24	1	1
GW-276	S3	**1,054**	78	2	2
GW-346	S3	35	26	1	1
GW-537	OLF	**529**	26	4	4
GW-794	AGLLSF	5	3	1	4
GW-795	AGLLSF	13	4	1	4
GW-828	OLF	31	25	1	3
GW-829	OLF	**204**	17	3	4
GW-829-029	OLF	**66**	30	1	1
Aquifer Wells					
GW-053	BG	5	3	1	4
GW-061	BG	45	4	3	3
GW-064	OLF	26	10	3	3
GW-066	OLF	14	3	1	1
GW-124	S3	**177**	19	1	1
GW-228	OLF	34	5	1	1
GW-229	OLF	11	3	1	1
GW-236	S3	**98**	11	1	1
GW-315	SPI	43	4	3	4
GW-348	S3	19	2	3	3
GW-683	EXP-A	43	6	1	2
GW-684	EXP-A	33	4	2	2
GW-694	EXP-B	**69**	5	2	2
GW-695	EXP-B	17	3	2	2
GW-703	EXP-B	19	3	2	2
GW-704	EXP-B	11	3	1	2
GW-706	EXP-B	**52**	5	2	2
GW-723	EXP-C	28	4	1	2
GW-724	EXP-C	42	4	2	2
GW-725	EXP-C	36	4	2	2
GW-736	EXP-C	41	4	2	2

Table 12 (cont'd)

Sampling Point[1]	Location[1]	Gross Beta		Number of Results	
		Average Activity[1]	Average Error	Exceeding MDA[4]	Total Analyzed
Aquifer Wells (cont'd)					
GW-737	EXP-C	45	4	2	2
GW-738	EXP-C	43	4	2	2
GW-739	EXP-C	12	4	1	2
Surface Water					
NT-01	EXP-SW	**356**	36	2	2
BCK-11.97	EXP-SW	**343**	31	2	2
BCK-09.40	EXP-SW	35	4	2	2
NT-02	EXP-SW	25	4	1	2
Springs					
SS-1	EXP-SW	**55**	5	2	2
SS-4	EXP-SW	**56**	6	2	2
SS-5	EXP-SW	30	5	1	2
SS-6W	EXP-SW	7	3	1	2
SS-7	EXP-SW	24	5	1	2

Notes:

1
BCK - Bear Creek Kilometer
GW - Monitoring Well
NT - Northern Tributary
SS - Spring

2
AGLLSF - Above Ground Low-Level Storage Facility
BG - Bear Creek Burial Grounds WMA
EXP - Exit Pathway Monitoring Location:
Maynardville Limestone Traverse (-A, -B, -C)
Spring or Surface Water Sampling Location (-SW)
OLF - Oil Landfarm WMA
S3 - S-3 Site
SPI - Spoil Area I

3 Average activity reported in picoCuries per liter. **Boldface type** indicates average activity above the 50 pCi/L water quality standard.

4 Only results above the Minimum Detectable Activity (MDA) were used to calculate the average activity.

Table 13. Dose Equivalent Calculations, CY 1995 GWPP Monitoring Data

Parameter[1]	Dose Factor[2]	Groundwater Sampling Point[3] GW-085 OLF	GW-276 S-3	GW-537 OLF	GW-694 EXP-B
Gross Beta					
Mean Activity		108	1,054	463	69
Technetium-99	3,790				
Mean Activity		219	1,315	1,009	116
Dose Equivalent		0.23	1.39	1.07	0.12
Strontium (total)	42				
Mean Activity		<MDA	<MDA	<MDA	<MDA
Dose Equivalent		0	0	0	0
Cumulative Dose		**0.23**	**1.39**	**1.07**	**0.12**

Parameter[1]	Dose Factor[2]	Surface Water Sampling Point NT-01 EXP-SW	BCK-11.97 EXP-SW	SS-1 EXP-SW
Gross Beta				
Mean Activity		356	343	55
Technetium-99	3,790			
Mean Activity		561	569	ND
Dose Equivalent		0.59	0.60	0
Strontium (total)	42			
Mean Activity		<MDA	<MDA	60.3
Dose Equivalent		0	0	5.74
Cumulative Dose		**0.59**	**0.69**	**5.74**

Table 13 (cont'd.)

Notes:

1 Dose equivalents are annual mean activities converted to millirems per year (mrem/yr): Activity (pCi/L) ÷ Dose Factor (pCi/L per 4 mrem/yr) x 4 = Dose equivalent (mrem/yr)

The dose equivalent for ^{90}Sr is calculated from the total Sr mean activity.

The cumulative dose is the sum of the isotopic dose equivalents: 4 mrem/yr is the MCL

<MDA - Not Detected above the minimum detectable activity.

2 Radionuclide activity that will yield a 4 mrem/yr dose equivalent assuming a 2-liter per day drinking-water intake. Dose factores are from U.S. Environmental Protection Agency as published in the Federal Register, Vol. 56 No. 138, July 18, 1991.

3 EXP - Exit Pathway (Maynardville Limestone and Bear Creek)
OLF - Oil Landfarm WMA
S3 - S-3 Site

Table 14. Dose Equivalent Calculations, CY 1995
BCV RI Radiological Sampling Data

Parameter[1]	Dose Factor[2]	Sampling Point Location[3]					
		GW-087 OLF	GW-243 S3	GW-537 OLF	GW-615 S3	Seep2 BG	SS-4 EXP-SW
Gross Beta							
Mean Activity		330	9,300	570	510	210	110
Technetium 99	3,790						
Mean Activity		36	23,108	1,300	50	73	200
Dose Equivalent		0.04	24.4	1.37	0.05	0.08	0.21
Strontium (total)	42						
Mean Activity		ND	7.4	ND	3.6	6.3	ND
Dose Equivalent		0	0.7	0	0.34	0.6	0
Cumulative Dose		**0.04**	**25.1**	**1.37**	**0.39**	**0.68**	**0.21**

Notes:

1 Dose equivalents are annual mean activities converted to millirems per year (mrem/yr): Activity (pCi/L) ÷ Dose Factor (pCi/L per 4 mrem/yr) x 4 = Dose equivalent (mrem/yr)

The dose equivalent for ^{90}Sr is calculated from the total Sr mean activity.

The cumulative dose is the sum of the isotopic dose equivalents: 4 mrem/yr is the MCL

ND - Not Detected above the minimum detectable activity.

2 Radionuclide activity that will yield a 4 mrem/yr dose equivalent assuming a 2-liter per day drinking-water intake. Dose factors are from U.S. Environmental Protection Agency as published in the Federal Register, Vol. 56 No. 138, July 18, 1991.

3 BG - Leachate from a seep at the Bear Creek Burial Grounds WMA.
EXP - SW-Exit Pathway (spring)
OLF - Oil Landfarm WMA
S3 - S-3 Site

CONTENTS

List of Tables

List of Acronyms and Abbreviations

AAS	Atomic Absorption Spectroscopy
BQR	blank qualification result
CY	calendar year
DQOs	data quality objectives
GWPP	Groundwater Protection Program
ICP	Inductively Coupled Plasma (spectroscopy)
MCL	maximum contaminant level
MDA	minimum detectable activity
μg/L	micrograms per liter
mg/L	milligrams per liter
mrem/yr	millirem per year
pCi/L	picoCuries per liter
RPD	relative percent difference
TDS	total dissolved solids
UTL	upper tolerance limit
VOC	volatile organic compound
1,1,1-TCA	1,1,1-trichloroethane

C.1 INTRODUCTION

Analysis and interpretation of the calendar year (CY) 1995 groundwater and surface water quality data were based on the standardized data screening and data evaluation process described in the following sections. Developed and refined over the past several years, this process has effectively reduced subjective interpretation of contamination in groundwater and surface water at the Y-12 Plant.

C.2 DATA SCREENING

Data screening refers to the process used to format the groundwater and surface water quality data for quantitative analysis, and exclude from analysis those results that do not meet data quality objectives (DQOs) of the Y-12 Groundwater Protection Program (GWPP). For both purposes, data screening assigns one of three surrogate values to applicable results: zero, the analytical reporting limit (or fraction of it), or a missing value (i.e., no analytical result). Screening criteria and associated surrogate values for each major group of analytical results are summarized in the following table.

Table C-1. Summary of Data Screening Criteria and Surrogate Value Designations.

Data Screening Criteria	Type of Surrogate Value: Zero (❑), Reporting Limit (▲), or Missing Value (●)				
	Principal Ions		Trace Metals	Organic Compounds	Radioanalytes
	Anions	Cations			
Less-than-Reporting-Limit Results	❑	❑	▲	❑	●
Original/Duplicate Sample Results	▲	▲	▲	❑	.
Diluted Sample Results	❑	❑	❑	❑	.
Filtered/Unfiltered Sample Results	.	▲	▲	.	.
Ion Charge Balance	●	●	.	.	.
Analytical Methods	.	.	●	.	.
False Positive Results	.	.	.	❑	.
Counting Errors	.	.	.	.	●

The following sections provide details regarding the screening criteria and the selection of the respective surrogate values.

C.2.1 Less-than-Reporting-Limit Results

Less-than-reporting-limit results (i.e., censored data) for principal ions and volatile organic compounds (VOCs) were replaced with zero for the purposes of calculating ion charge balance errors (Section C.2.5), identifying false positive results for VOCs (Section C.2.7), and determining representative concentrations for each well, spring/seep, and surface water sampling point (Section C.3.1). To identify order-of-magnitude differences between results for original/duplicate samples (Section C.2.2) and filtered/unfiltered samples (Section C.2.4), censored data were replaced with zero (VOCs), or analytical reporting limits (principal ions and trace metals). Similarly, the median concentration of each trace metal (Section C.3.1) was calculated using half the analytical reporting limit as the surrogate value for censored data.

Missing values served as surrogates for radioanalyte results (i.e., gross alpha activity, gross beta activity, and radionuclide activity) that were less than the specified minimum detectable activity (MDA). The suite of MDAs, in picoCuries per liter (pCi/L), applicable to most CY 1995 radiological results obtained for the purposes of the Y-12 Plant GWPP are summarized below.

Table C-2. Radioanalyte MDAs for Y-12 Plant GWPP Monitoring Purposes.

Radioanalyte	MDA (pCi/L)	Radioanalyte	MDA (pCi/L)
Americium-241	17	Ruthenium-106	26
Cesium-137	3.9	Strontium (Total)	33
Iodine-129	35	Technetium-99	110
Iodine-131	35	Thorium-234	250
Neptunium-237	52	Tritium (Total)	950
Plutonium-238	84	Uranium-234	55
Plutonium-239	52	Uranium-235	14
Potassium-40	190	Uranium-238	22
Protactinium-234m	700	Gross Alpha	4.7
Radium	1.5	Gross Beta	11

These MDAs universally apply to radiological analyses for each groundwater and surface water sample collected during the first three quarters of CY 1995. Beginning in October 1995, sample-specific MDAs were reported for each radioanalyte. The sample-specific MDAs were typically lower than those listed above.

C.2.2 Original/Duplicate Sample Results

As noted in Section 3.3 of the report, duplicate groundwater samples were collected from 26 monitoring wells. Data for the original/duplicate samples from each well were compared to identify order-of-magnitude differences between corresponding analytical results. Such differences occurred between original/duplicate results, in milligrams per liter (mg/L), for the samples listed in the following summary.

Table C-3. Screened Results for Original/Duplicate Groundwater Samples.

Well Number	Date Sampled	Analyte	Original Sample (mg/L)	Duplicate Sample (mg/L)
GW-044	03/16/95	Zinc	0.0052	0.064
GW-084	08/05/95	Copper	<0.004	0.051
GW-290	08/07/95	Total Suspended Solids	22	1
GW-653	12/08/95	Total Suspended Solids	1	14
GW-793	01/23/95	Nitrate (as N)	0.42	2,449
GW-793	01/23/95	Chloride	1.6	30

These results were replaced with missing values.

C.2.3 Diluted Sample Results

Groundwater samples collected from the wells listed below were diluted in the laboratory prior to analyses for the specified inorganic or organic analytes.

Table C-4. Groundwater Samples Diluted for Analytical Purposes.

Inorganic Analytes	Date Sampled	Organic Analytes	Date Sampled
GW-236	09/16/95	GW-014	08/04/95
GW-346	08/31/95	GW-046	08/09/95
GW-537	06/08/95	GW-288	08/09/95
GW-537	08/03/95	GW-289	08/08/95
GW-537	10/25/95	GW-291	08/03/95
GW-711	01/13/95		
GW-711	07/27/95		

Because the reporting limits for these samples were much higher than those for undiluted samples, censored data for these samples were replaced with zero or missing values.

C.2.4 Filtered/Unfiltered Sample Results

Filtered and unfiltered groundwater and surface water samples were analyzed for the principal cations (calcium, magnesium, potassium, and sodium) and trace metals. If the dissolved (filtered) cation or trace metal concentration exceeded the corresponding total (unfiltered) concentration by an order-of-magnitude or more, both results were replaced with missing values. As shown below in Table C-5, such differences occurred between the filtered/unfiltered results reported for three monitoring wells.

Table C-5. Screened Results for Filtered/Unfiltered Groundwater Samples.

Sampling Location	Date Sampled	Analyte	Unfiltered Sample (mg/L)	Filtered Sample (mg/L)
GW-053	09/25/95	Zinc	0.011	0.11
GW-115	01/14/95	Aluminum	0.02	0.76
GW-348	06/26/95	Zinc	<0.002	0.027

C.2.5 Ion Charge Balance

The calculated ion charge balance was used to screen the principal ion data. Charge balances were estimated by computing the relative percent difference (RPD) between summed milliequivalent concentrations (i.e., molecular weight of the ion divided by the net ionic charge) of the dissolved cations (which exclude digested cations), and the total anions, respectively. If the summed milliequivalent concentrations of the cations and anions differed by 10% or more, all the principal ion data were replaced with missing values. As summarized below in Table C-6, ion charge balance RPDs greater than 10% were calculated from the principal ion data for 18 groundwater samples collected from 12 monitoring wells.

Table C-6. Groundwater Samples with Unacceptable Charge Balance Errors.

Well Number	Date Sampled	Charge Balance RPD	Comments
GW-047	01/25/95	-72%	High bicarbonate alkalinity (188 mg/L).
GW-085	06/08/95	52%	Low nitrate (17 mg/L).
GW-085	08/06/95	-16%	High nitrate (220 mg/L).
GW-087	09/27/95	-14%	High chloride (20 mg/L).
GW-276	01/24/95	-13%	Bicarbonate alkalinity <1 mg/L; pH 4.3.
GW-276	07/29/95	-19%	No bicarbonate alkalinity result reported.
GW-290	08/07/95	12%	High calcium (62 mg/L).

Table C-6. (cont.'d)

Well Number	Date Sampled	Charge Balance RPD	Comments
GW-290	08/07/95	12%	High calcium (62 mg/L).
GW-312	03/25/95	-20%	Carbonate alkalinity 46 mg/L; pH 11.7
GW-312	06/06/95	-30%	Carbonate alkalinity 54 mg/L; pH 12
GW-312	08/06/95	-23%	Carbonate alkalinity 62 mg/L; pH 12
GW-315	12/07/95	-23%	Sulfate 66 mg/L.
GW-370	06/05/95	-19%	Low calcium (2.8 mg/L).
GW-370	08/08/95	11%	High calcium (37 mg/L).
GW-537	06/08/95	-15%	Nitrate (as N) 980 mg/L.
GW-613	07/24/95	-12%	Low calcium (26 mg/L).
GW-795	01/25/95	62%	Low bicarbonate alkalinity (25 mg/L).
GW-829	06/27/95	-13%	Nitrate (as N) 200 mg/L.

The charge balance errors for these samples probably reflect: analytical or data transcription errors (GW-047, GW-085, GW-276, GW-290, GW-370, GW-613, and GW-795); the effects of inorganic contaminants (GW-085, GW-087, GW-276, GW-315, GW-537, and GW-829); and localized grout contamination (GW-312).

C.2.6 Analytical Methods

Four spectroscopic analytical methods were used to determine concentrations of inorganic analytes: (1) Inductively Coupled Plasma (ICP) spectroscopy for aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, molybdenum, nickel, potassium, selenium, silver, sodium, strontium, thorium, vanadium, and zinc; (2) Cold Vapor Atomic Absorption spectroscopy for mercury; (3) plasma/mass spectroscopy for uranium (total); and (4) Atomic Absorption Spectroscopy (AAS) for cadmium, chromium, and lead. If required for the Y-12 Plant GWPP, the AAS data for cadmium, chromium, and lead were used for quantitative calculations instead of the ICP data, otherwise the ICP results for these metals were used.

C.2.7 False Positive Results

Laboratory blank and trip blank data associated with each groundwater and surface water sample were used to identify false positive VOC results (i.e., sampling and/or analytical artifacts). False positive VOC results were defined as concentrations reported for the groundwater or surface water samples that were less than the blank qualification result (BQR) for each compound. For each VOC detected in a groundwater or surface water sample, the highest concentration in either associated blank sample multiplied by a factor of five or ten served as the BQR. A factor of five was used for all VOCs except acetone, methylene chloride, toluene, and 2-butanone; BQRs for these common laboratory reagents were calculated using a factor of ten (U.S. Environmental Protection Agency 1988). Zero served as the surrogate value for false positive VOC results.

As summarized below in Table C-7, the CY 1995 data included a total of 38 false positive results for eight VOCs.

Table C-7. Summary of False Positive Results for VOCs.

Compound	Number of False Positive Results Identified from:	
	Laboratory BQRs	Trip BQRs
2-Butanone	6	5
Methylene Chloride	5	1
1,1,1-Trichloroethane	0	6
Acetone	2	3
Toluene	4	0
1,2-Dichloroethane	1	3
Tetrachloroethene	1	0
Xylenes	1	0
Total	**20**	**18**

Each of these false positive results were estimated concentrations below respective reporting limits for each compound; the maximum false positive result was 24 micrograms per liter (μg/L) for acetone. The false positive results for 1,1,1-trichloroethane (1,1,1-TCA) probably reflect concentrations in the groundwater samples (1 to 3 μg/L), but were identified as false positives because of 1,1,1-TCA contamination in the deionized water used for trip blank samples throughout the year (see discussion in Section 3.5 of the report).

C.2.8 Counting Errors

The degree of analytical uncertainty associated with each gross alpha, gross beta, and radionuclide result is expressed by the corresponding counting error (defined as twice the sample standard deviation). Groundwater samples with gross alpha, gross beta, and/or radionuclide activities that exceeded the respective MDAs, but were less than the associated counting errors, are listed below.

Table C-8. Screened Results for Radioanalytes.

Radioanalyte	Well Number	Date Sampled	Activity ± Counting Error (pCi/L)
Gross Alpha	GW-064	03/26/95	14.9 ± 21
	GW-085	10/25/95	5.78 ± 18
	GW-654	09/18/95	5.84 ± 11
	GW-710	01/15/95	13.8 ± 16
	GW-711	01/13/95	11.2 ± 20
Gross Beta	GW-710	07/27/95	14.5 ± 27
	GW-711	07/27/95	20.6 ± 28
Cesium-137	GW-714	01/14/95	13 ± 15
Radium (total)	GW-373	08/08/95	1.9 ± 13.5
Uranium-235	GW-162	01/26/95	27.7 ± 44
	GW-711	07/27/95	21.1 ± 39
	GW-712	01/13/95	28.4 ± 91
	GW-713	01/14/95	15.2 ± 44
	GW-715	01/14/95	74.2 ± 91
Uranium-238	GW-085	06/08/95	65.6 ± 76
	GW-537	06/08/95	24.7 ± 49

These results were replaced with missing values.

C.3 DATA EVALUATION

Data evaluation refers to the process used to identify CY 1995 monitoring results that potentially reflect potential groundwater or surface water contamination. As described in the following sections, this process involved: calculating the representative concentration/activity of the inorganics, VOCs, and radioanalytes for each monitoring well, spring/seep, and surface water sampling station; comparing the representative concentration/activity values to designated water-quality standards; and reviewing screened historical data for each applicable analyte and monitored location to corroborate representative values that exceed the specified water-quality standards.

C.3.1 Representative Concentration/Activity Values

Representative concentration/activity values for each monitoring well, spring/seep, and surface water sampling point were: (1) results for individual samples, or (2) calculated from as many as four results depending on the number of samples collected and the outcome of the data screening process. Results for individual samples were the assumed representative values for the two springs, three seeps, and 23 monitoring wells that were sampled only once during CY 1995 (see Table 2 in Appendix B). Singular results also were the assumed representative values if data screening replaced all other results for the analyte with missing values. Also, field data (e.g., depth-to-water) and other selected parameters (e.g., turbidity) were evaluated individually regardless of the number of available results.

For sampling locations with multiple CY 1995 results, representative concentration/activity values for inorganics (principal ions and trace metals), VOCs, and radioanalytes (gross alpha, gross beta, and radionuclides) were calculated as specified below, using the designated surrogate values for censored and screened data.

Table C-9. Methods used to Calculate Representative Concentration/Activity Values.

Analyte	Representative Value	Censored Data	Screened Data
Principal Ions	Annual average concentration.	Zero	Missing Values
Trace Metals	Annual median concentration.	½ Reporting Limits	Missing Values
VOCs	Annual average concentration.	Zero/Missing Values	Zero/Missing Value
Radioactivity	Annual average activity. Individual/summed dose equivalents.	Missing Values	Missing Values

Note that annual average concentrations/activities for principal ions, VOCs, and radioanalytes were used as representative values, but annual median concentrations were used for trace metals. This approach ensured comparability with the upper tolerance limits (UTLs) used as water quality standards for many of the trace metals. Additionally, average counting errors (in pCi/L) associated with each representative radioanalyte activity were calculated using the following formula:

$$e = \sqrt{\frac{E_1^2}{n^2} + \frac{E_2^2}{n^2} \ldots}$$

where $\mathbf{E_1}$, $\mathbf{E_2}$,... are the individual errors reported for each sample, and **n** is the number of samples (Evans 1955). Where applicable, dose equivalents were calculated using representative values for radionuclides, and corresponding dose factors issued by the U.S. Environmental Protection Agency (Federal Register, Vol. 56 No. 138, July 18, 1991). Individual dose equivalents for the radionuclides were summed to determine the cumulative dose for each applicable monitoring well, spring/seep, and surface water sampling point.

C.3.2 Water Quality Standards

Two types of water quality standards were used for comparison to the representative concentration/activity values for each applicable monitoring well, spring/seep, and surface water sampling point: statistically derived upper tolerance limits (UTLs) assumed to reflect uncontaminated groundwater concentrations at the Y-12 Plant, or federal maximum contaminant levels (MCLs) for drinking water.

The UTLs presented in HSW Environmental Consultants, Inc. et al. (1996) were used as the water quality standards for aluminum, antimony, boron, cobalt, copper, iron, manganese, molybdenum, strontium, thorium, uranium, vanadium, and zinc. Each UTL was statistically derived from median concentrations calculated from the groundwater quality data for over 400 monitoring wells at the Y-12 Plant. Based on analysis of the principal sources of geochemical variability, the data for these wells were classified into ten distinct groups (i.e., clusters) which, as summarized below, include six clusters of wells that monitor uncontaminated groundwater, and four clusters of wells that monitor contaminated groundwater.

Table C-10. Summary of UTL Well Cluster Characteristics.

Cluster No.	Description
1	Shallow groundwater with variable calcium-magnesium-bicarbonate geochemistry.
2	Shallow calcium-magnesium-bicarbonate groundwater with very low total dissolved solids (TDS).
3	Shallow groundwater with fairly uniform calcium-magnesium-bicarbonate geochemistry.
4	Calcium-magnesium bicarbonate groundwater with equal or nearly equal proportions of calcium and magnesium.
5	Shallow calcium-magnesium bicarbonate groundwater with nitrate and other inorganic contaminants.
6	Intermediate depth sodium-bicarbonate groundwater.
7	Nitrate-contaminated groundwater.
8	Nitrate-contaminated groundwater.
9	Nitrate-contaminated groundwater.
10	Deep, sodium-chloride bicarbonate groundwater with very high TDS.

Only data for wells assigned to Clusters 1, 2, 3, 4, 6, and 10 were used to calculate the UTLs; those applicable to the wells that comprise these clusters are summarized below.

Table C-11. UTLs used as Water Quality Standards.

Trace Metal	Upper Tolerance Limit (mg/L)					
	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 6	Cluster 10
Aluminum	2.4	6.1	2.4	2.4	2.4	2.4
Antimony	0.05	0.05	0.05	0.05	0.05	0.05
Boron	0.12	0.028	0.041	0.028	3.1	3.1
Cobalt	0.019	0.019	0.019	0.019	0.019	0.019
Copper	0.012	0.012	0.012	0.012	0.012	0.012
Iron	8.7	8.7	8.7	4.6	11	6.9
Manganese	1.7	1.7	1.7	0.13	1.7	0.13
Molybdenum	0.018	0.018	0.018	0.018	0.018	0.018
Strontium	4.4	0.079	0.92	0.079	0.92	0.92
Thorium	0.2	0.2	0.2	0.2	0.2	0.2
Uranium	0.012	0.004	0.005	0.005	0.004	0.005
Vanadium	0.005	0.005	0.005	0.005	0.005	0.005
Zinc	0.041	0.043	0.041	0.041	0.041	0.040

Because they monitor contaminated groundwater, data for wells that comprise clusters 5, 7, 8, and 9 were excluded from the UTL calculations. Wells that comprise these clusters were assigned one of the above values as "surrogate" UTLs based on selected well construction information and water quality data (HSW Environmental Consultants, Inc. et al. 1996).

Federal MCLs adopted by the Tennessee Department of Environment and Conservation were used as water quality standards for the inorganics, organics, and radioanalytes listed below.

Table C-12. MCLs used as Water Quality Standards.

Inorganics (mg/L)		VOCs (µg/L)		Radioanalytes	
Arsenic	0.05	Carbon Tetrachloride	5	Gross Alpha Activity	15 pCi/L
Beryllium	0.004	1,1-dichloroethene	7	Gross Beta Activity	4 mrem/yr
Barium	2.0	Methylene Chloride	5	Radium 226 + 228	5 pCi/L
Cadmium	0.005	Tetrachloroethene	5		
Chromium	0.1	1,1,1-trichloroethene	200		
Fluoride	4	Trichloroethene	5		
Lead	0.05	Vinyl Chloride	2		
Mercury	0.002				
Nickel	0.1				
Nitrate (as N)	10				
Selenium	0.05				
Silver	0.05				

Although MCLs have been adopted for the above listed VOCs, and results that exceed the MCLs were noted, evaluation of groundwater and surface water quality with respect to these compounds was based on representative concentrations that exceeded zero. Also, the four millirem per year (mrem/yr) dose equivalent MCL for gross beta activity applied only if samples were analyzed for radionuclides; otherwise, the Safe Drinking Water Act screening level (50 pCi/L) was used as the water quality standard for gross beta activity.

C.3.3 Data Corroboration

Representative VOC and trace metal concentrations that exceeded water quality standards were corroborated through review of historical data for each applicable well, spring/seep, and surface water sampling point. Historical corroboration focused on VOC results and elevated trace metal concentrations because of the characteristic variability of the data for these analytes. Principal ion data are typically less variable (and the ion charge balance criteria effectively screens spurious data) and problems with DQOs render the bulk of the historical radioanalyte data unsuitable for corroboration purposes.

Frequency-based criteria were used to identify anomalous VOC and trace metal results in the CY 1995 data: the detection frequency for VOCs (determined from the screened data for samples collected since CY 1991), and the frequency of elevated total metal concentrations (determined from screened data for samples collected since CY 1990). Anomalous results were defined as VOC or elevated total metal concentrations detected in 25% or less of the samples from each monitoring well, spring, or surface water sampling point. Depending on the location of the sampling point relative to known or suspected sources of contamination in the Bear Creek Regime, anomalous results were either replaced with zero (VOCs) or missing values (trace metals), or accepted as qualitative data.

As shown in the following summary, the CY 1995 data included a total of 26 anomalous results reported for common laboratory reagents (e.g., 2-butanone and methylene chloride), compounds that are primary components (e.g., trichloroethene) or associated degradation products (e.g., 1,1-dichloroethene and 1,2-dichloroethene) of dissolved VOC plumes in shallow groundwater in the Bear Creek Regime, and compounds that are neither laboratory reagents nor known plume constituents (e.g., ethylbenzene and xylenes).

Table C-13. Anomalous Results for VOCs.

Compound	Sampling Point	Date Sampled	Anomalous Result (µg/L)
1,1-Dichloroethene	GW-312	03/25/95	1
1,1-Dichloroethene	GW-740	02/16/95	1
1,2-Dichloroethene	GW-312	03/25/95	1
1,2-Dichloroethene	GW-683	08/06/95	2*
1,2-Dichloroethene	GW-684	08/06/95	2*
1,1,1-Trichloroethane	GW-725	02/28/95	2
2-Butanone	GW-069	08/15/95	8
2-Butanone	GW-828	12/08/95	10
2-Butanone	NT-01	03/09/95	9
2-Butanone	SS-1	03/09/95	9
Acetone	GW-653	09/20/95	4
Acetone	GW-684	03/10/95	11
Acetone	GW-829	03/07/95	173
Carbon tetrachloride	GW-725	02/28/95	4

Table C-13 (cont'd.)

Compound	Sampling Point	Date Sampled	Anomalous Result (µg/L)
Chloroform	GW-085	03/26/95	2
Chloroform	GW-739	02/17/95	1
Chloroform	GW-828	02/18/95	2
Chloroform	GW-829	03/07/95	4
Ethylbenzene	GW-684	03/10/95	1
Methylene chloride	GW-684	03/10/95	2
Methylene chloride	GW-829	03/07/95	4
Tetrachloroethene	GW-287	03/26/95	2*
Trichloroethene	GW-683	08/06/95	2*
Trichloroethene	GW-684	08/06/95	2*
Vinyl chloride	GW-069	08/15/95	2*
Xylenes	GW-738	02/18/95	1

All of the above VOC results except those flagged with an asterisk were considered probable sampling or analytical artifacts and were replaced with zero as a surrogate value. The flagged results are for samples from wells near the downgradient boundaries of dissolved VOC plumes that contain these constituents. Because these results potentially indicate plume migration, these anomalous VOC results were not replaced with zero.

Sporadically elevated concentrations (i.e., anomalous results) are characteristic of the trace metal data for most wells at the Y-12 Plant, and few of these erratically fluctuating results display any clear spacial patterns or temporal relationships (although required monitoring protocols and sampling procedures may not generate data needed to recognize and characterize such relationships). Data obtained during CY 1995 reflects similar variability, and as summarized below in Table C-14, include a total of 53 anomalous trace metal results reported for 29 unfiltered samples collected from 19 wells and two surface water sampling points.

Table C-14. Anomalous Trace Metal Results

Trace Metal	Date Sampled	Result (mg/L)	Trace Metal	Date Sampled	Result (mg/L)
Aluminum			Iron		
GW-064	03/26/95	34	GW-061	03/28/95	13
GW-064	06/07/95	17	GW-061	06/28/95	33
GW-064	08/06/95	26	GW-064	03/26/95	40
GW-287	03/26/95	19	GW-064	06/07/95	21
GW-287	06/20/95	5.9	GW-064	08/06/95	30
GW-287	09/18/95	6.6	GW-703	08/30/95	13
GW-621	08/30/95	4.9	Selenium		
Arsenic			GW-614	07/24/95	0.098
BCK-09.40	07/25/95	0.088	GW-621	08/30/95	0.082
Boron			GW-710	07/27/95	0.099
GW-115	01/14/95	0.057	GW-713	07/27/95	0.11
GW-115	07/30/95	0.1	GW-715	07/29/95	0.1
GW-287	03/26/95	0.1	NT-01	07/25/95	0.11
GW-287	06/20/95	0.056	Vanadium		
GW-287	12/10/95	0.044	GW-043	08/04/95	0.0064
GW-613	01/11/95	0.033	GW-043	10/18/95	0.0067
GW-703	08/30/95	0.15	GW-064	03/26/95	0.053
GW-795	06/18/95	0.052	GW-064	06/07/95	0.032
GW-795	07/24/95	0.059	GW-064	08/06/95	0.046
Chromium (AAS)			GW-621	08/30/95	0.011
GW-056	08/04/95	0.23	GW-711	07/27/95	0.012
Cobalt			Zinc		
GW-064	03/26/95	0.025	GW-064	03/26/95	0.16
GW-064	08/06/95	0.02	GW-064	06/07/95	0.12
Copper			GW-064	08/06/95	0.15
GW-064	03/26/95	0.042	GW-115	01/14/95	0.1
GW-064	06/07/95	0.032	GW-115	07/30/95	0.0022
GW-064	08/06/95	0.038	GW-706	03/31/95	0.19
GW-115	01/14/95	0.4	GW-706	08/30/95	0.0055
GW-287	03/26/95	0.02			
GW-287	06/20/95	0.015			
GW-704	03/30/95	0.02			

The bulk of these anomalous trace metal results reflect biased total concentrations caused by preservation of turbid groundwater samples; all of the samples from well GW-064, for instance, had TSS above 400 mg/L. Other anomalous results, such as those for wells GW-115, GW-613, and GW-614, which are upgradient of potential sources of trace metal contamination, are possibly analytical or data transcription errors. Of these metals, moreover, only boron and copper are potential contaminants of concern, and only boron likely occurs in the groundwater and surface water as a mobile, ionic species (probably borate) (Science Applications International Corporation

1996). None of these anomalous boron concentrations, however, are potentially indicative of groundwater contamination.

C.4 REFERENCES

Evans, R.D. 1955. *The Atomic Nucleus*. McGraw Hill, New York, N.Y.

HSW Environmental Consultants, Inc. and Paradigm Data Services, Inc. 1996. *Determination of Reference Concentrations for Inorganic Analytes in Groundwater at the Department of Energy Oak Ridge Y-12 Plant, Oak Ridge, Tennessee*. Prepared in conjunction with the Oak Ridge National Laboratory Environmental Sciences Division, Computer Science and Mathematics Division, Energy Division, and Office of Environmental Compliance and Documentation. (Y/ER-234).

Science Applications International Corporation. 1996. *Remedial Investigation Report for Bear Creek Valley*. Volume 1. (Draft).

U.S. Environmental Protection Agency. 1988. *Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses*. U.S. EPA, Office of Solid Waste.

U.S. Environmental Protection Agency. 1991. Federal Register, Vol. 56, No. 138 (July 18, 1991).

DISTRIBUTION

DEPARTMENT OF ENERGY
P.J. Gross
P.A. Hoffman
L.L. Radcliffe
L.M. Sparks
W.B. Mansel

HEALTH, SAFETY, ENVIRONMENT, AND ACCOUNTABILITY ORGANIZATION
W.P. Carlton
C.C. Hill
W.K. Jago
S.B. Jones
J.E. Powell
E.B. Rundle
L.O. Vaughan
GWPP-File (4)

ENVIRONMENTAL RESTORATION PROGRAM
H.L. King (2)
C.S. Walker
File-ERDMC-RC

UNIVERSITY OF TENNESSEE
B.W. McMaster

ORISE
S.M. Field

TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION - DOE OVERSIGHT DIVISION

R. Benfield (3)

ENVIRONMENTAL SCIENCES DIVISION
R.B. Dreier
D.D. Huff
C.T. Rightmire
R.R. Turner
D.B. Watson

WASTE MANAGEMENT ORGANIZATION
K.D. Delius
C.W. Hutzler
I.W. Jeter
J.E. Stone

ENGINEERING ORGANIZATION
W.E. Manrod

K-25 ANALYTICAL SERVICES ORGANIZATION
J.M. LaBauve

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
S. Selecman/W.P. Kegley

CDM FEDERAL PROGRAMS
M. Leslie/C. Lutz

Y-12 Central Files
A.K. Lee/DOE-OSTI (2)