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**Post-Closure
Permit Application
for the
Kerr Hollow Quarry
at the Y-12 Plant**

June 1995

Prepared for
LOCKHEED MARTIN ENERGY SYSTEMS, INC.
Oak Ridge, Tennessee

MASTER

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Prepared by

*Science Applications
International Corporation*

SAIC

P.O. Box 2502
800 Oak Ridge Turnpike
Oak Ridge, Tennessee 37831

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on three sides by 60-foot high cliffs. Access to the quarry is limited by a 7-foot high, chain-link, barbed-wire-topped fence. The gates of the fence are locked at all times except for authorized entry.

Beginning in the early 1950s the quarry was used for waste disposal of a variety of materials, principally water-reactive materials but also shock-sensitive chemicals and compressed gas cylinders. To facilitate this use of the quarry, a metal building and chute were constructed on the southern bluff of the quarry, high above the water surface. Water-reactive materials such as lithium, potassium, calcium, sodium, and sodium-potassium alloy that were to be disposed of were packaged in 5-, 30-, or 55-gallon containers and transported to the quarry (DOE 1993). There the containers were placed in the chute and dropped to the water's surface. In transit to the water's surface, the containers were punctured by rifle fire from Y-12 Plant security guards, allowing the contents of the containers to react with the quarry water. Explosions and violent burning upon impact with the water's surface, or shortly after sinking, indicated that the chemicals inside the containers reacted completely. A limited number of 500-gallon pressure vessels containing sodium was also placed in the quarry. These containers were dropped off the southern bluff and were allowed to vent by opening valves and vent pipes. All of these containers sank as a result of their great weight.

Potentially explosive chemicals, such as picric acid, were transported to the quarry in specially packed containers to minimize shock and possible detonation in transit. The containers were suspended on a cable above the water surface and punctured with rifle fire prior to being released into the water (DOE 1993).

In addition to disposal of water-reactive and explosive chemicals, the quarry was also used to vent gas cylinders with frozen valves. These were placed on the northwest bank of the quarry and punctured with rifle fire. Vented, empty cylinders were typically returned to the main Y-12 Plant for disposal; however, prior to 1970, cylinders were discarded in the quarry (DOE 1993).

Disposal operations at KHQ were terminated on November 7, 1988 (DOE 1993). Termination was in response to an October 11, 1987 determination by the Tennessee Department of Environment and Conservation (TDEC) under the Tennessee Water Quality Control Act that KHQ was a surface impoundment subject to the 1984 Hazardous and Solid Waste Amendments

Date of Issue: June 1995

Y/ER/SUB/95-005MS

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Document Prepared by

SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

P.O. Box 2502

800 Oak Ridge Turnpike

Oak Ridge, Tennessee 37831

for

U.S. Department of Energy

**Office of Environmental Restoration and Waste Management
under budget and reporting code EW20**

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

(HSWA) of the Resource Conservation and Recovery Act (RCRA) (DOE 1993). Under such a determination, the quarry had to satisfy technical requirements of HSWA (i.e., lining) or be closed. Because lining the quarry was impracticable, methods of closure were reviewed. A closure plan was developed for KHQ, submitted to TDEC, and conditionally approved on September 28, 1988 (Fraser et al. 1993). Several revisions of the original closure plan were drafted to account for unanticipated conditions. Most notably, the approved D2 revision of the KHQ Closure Plan identified partial and final closure requirements and changed the KHQ closure from "clean" to "dirty." This change was to allow the sediment and any objects buried by the sediment to remain within the quarry (DOE 1993).

Upon termination of disposal activities, certain actions were initiated to close the quarry in accordance with the closure requirements for interim status surface impoundments specified in Tennessee Rules 1200-1-11-.05(7) and 1200-1-11-.05(11). As part of these actions, efforts were undertaken to characterize the physical and chemical nature of wastes that had been disposed of in the quarry, and to remove any containers or debris that were put in the quarry during waste disposal activities. Closure certification reports (Fraser et al. 1993 and Dames and Moore 1993) document closure activities in detail; a summary is presented in the following paragraphs.

An underwater remote-operated vehicle (ROV) equipped with a video camera was used to survey the bottom of the quarry from February to March 1989. The survey showed that most of the 5-, 30-, and 55-gallon containers visible to the camera appeared to be empty of any residual reactive or explosive materials. Additional surveys were made during the spring and early summer of 1991 to locate the large steel vessels that had also been disposed of in the quarry. By virtue of their design and the method for disposal of these vessels, it was impossible to determine whether their contents had fully reacted with the quarry water. This necessitated using a remote method to confirm that they no longer contained reactive chemicals. The method consisted of detonating explosive charges on the side of the vessel to ensure venting, then viewing the ruptured vessel with a remote-controlled camera aboard an ROV.

Removal of items from the quarry was accomplished using an ROV and a remote-operated barge equipped with a grapple. The ROV was used mainly for small items and the barge and grapple for large items. Except for the large steel vessels, both retrieval systems picked up and placed items into a shredder on the quarry bottom. Shredded debris were collected in a basket

on the bottom of the shredder and the basket was removed when it became full. The debris were then inspected and stored in an area located near the quarry. The explosively breached large steel vessels were removed from the quarry without being shredded using the barge and grapple.

The ROV also identified compressed gas cylinders at the bottom of the quarry. For their removal, the grapple on the barge was replaced with a cylinder breaching grapple. This device had the capability of grasping the cylinders and puncturing the cylinders with a hydraulic punch. Initially, it was assumed that all compressed gas cylinders had been vented prior to disposal in the quarry and breaching was done nonetheless as a precaution. In March 1992, however, pressurized gas cylinders were encountered and breached.

Other containers (e.g., 5-, 30-, and 55-gallon containers) that were not obviously empty were shredded underwater. This process exposed any reactive materials that remained in the containers to water. The shredded material was removed from the quarry. Obviously empty items were inspected and then removed from the quarry as nonhazardous waste.

The final closure action was performed by dividing the quarry bottom into 30-foot square sectors, and mapping and labeling the remaining contents. All visible containers or structures (with two exceptions trapped by rock slides) were removed from the quarry via remote operation. The term "visible" was defined as 3 feet above the bottom of the quarry due to the operational limits of the ROV, and "containers or structures" were defined as any item that might contain reactive material that had not been exposed to or reacted with the quarry water. A final inspection was documented with 80 hours of video tape in October 1993, and the operating equipment was removed from the quarry on November 11, 1993. Seventy-three visible items that met the definition of nonhazardous to human health and the environment were allowed to remain in the quarry.

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ACRONYMS

ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CY	calendar year
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FFA	Federal Facilities Agreement
feet/day	feet per day
GWPP	Groundwater Protection Program
GWPPM	GWPP Manager
GWQAR	Groundwater Quality Assessment Report
GWQRs	Groundwater Quality Reports
HSWA	Hazardous and Solid Waste Amendments
KHQ	Kerr Hollow Quarry
MCLs	maximum contaminant levels
mg/d	million gallons per day
mg/L	milligrams per liter
MOU	Memorandum of Understanding
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
RCRA	Resource Conservation and Recovery Act
ROV	remote-operated vehicle
TCL	Target Compound List
TCLP	toxicity characteristic leaching procedure
TDEC	Tennessee Department of Environment and Conservation
TOC	total organic carbon
TOX	total organic halides
USGS	U.S. Geological Survey
UTL	upper tolerance limit
VOCs	volatile organic compounds
WKUD	West Knox Utility District

A. GENERAL INFORMATION

A.2 WASTE CHARACTERISTICS

Ref: 1200-1-11-.07(5)(a)
40 CFR 270.14(b)(2)

The estimated total weight of hazardous and nonhazardous wastes sent to KHQ since 1962 (no records were kept for treatment or disposal in the quarry before 1962) is approximately 50 tons. Types of wastes disposed of in the quarry are identified in Table A-1.

As described in Section A.1, the waste types treated in the KHQ were largely reactive in nature, and consisted of water-reactive materials and potentially explosive chemicals. Treatment in the quarry of these reactive waste types resulted in rendering the wastes nonreactive. As a result of the time period during which treatment (from 1951 to 1988) in the KHQ occurred and the reactive nature of the wastes treated, no analytical data are available for the wastes treated in the KHQ. Furthermore, because of the nature of treatment and closure activities that occurred at the KHQ, no reactive wastes remained after closure. In lieu of analytical data representative of wastes prior to treatment in the KHQ, this section presents the results of sediment sample analysis that provide an indication of the nature of any treatment residues remaining in the KHQ after closure activities were completed.

Between 1990 and 1992, several sampling events specifically targeting sediments in the KHQ were conducted. Tables A-2 through A-6 present a summary of the data collected for the KHQ sediments. Tables A-2 and A-3 present a list of analytes and parameters in total concentrations. Table A-2 specifically illustrates analytes that were sampled for but were not detected above the detection limit. Table A-3 shows those analytes that were detected above the detection limit and the number of detections versus the total number of samples analyzed for the targeted compound and/or parameter. Table A-4 is a summary of the radionuclides found in the KHQ sediment. Tables A-5 and A-6 present a summary of analyses using the toxicity characteristic leaching procedure (TCLP) method for sample preparation. Table A-5 shows those analytes that were analyzed for but not detected above the detection limit and Table A-6 shows those analytes that were detected by the TCLP method. Analytical results indicate that residual contamination is present in low concentrations within the KHQ sediments. In general, hazardous waste constituents were detected at very low levels, if at all. Although several toxicity characteristic metals were detected by total analysis, subsequent analysis using the TCLP method yielded no concentration in excess of regulatory thresholds.

A.3 FACILITY LOCATION

Ref: 1200-1-11-.07(5)(a)
40 CFR 270.14(b)(11)

The KHQ, occupying about 3 acres, is located along the south side of Chestnut Ridge and in an area located within Y-12 Plant grid coordinates E 63000 to E 64000 and N 24000 to N 25000 (Plates A-1 and A-2). The quarry is about 1½ miles south of the Y-12 Plant site and ~1,000 feet north of Bethel Valley Road. Local relief is ~100 feet with elevations ranging from just under 840 feet above mean sea level at the southwest end of the quarry to over 940 feet on the cliffs immediately northeast of the quarry.

The elevation of the 100-year floodplain for the Clinch River (Melton Hill Lake) is separated in elevation from the KHQ by ~40 feet. Therefore, the KHQ is not located within a 100-year floodplain (Plate A-3). The floodplain elevation of 796 feet mean sea level was interpolated from Tennessee Valley Authority floodplain maps for the intermittent stream that enters the river at river mile 41.19. During periods of high precipitation, KHQ overflows and enters the local surface water system. Immediately upon leaving the quarry, the water enters a sediment collection basin that was constructed to mitigate sediment discharge during remedial activities at the quarry. From the basin, the water enters a nearby stream that flows for ~0.9 km (0.56 mile) then discharges directly into Melton Hill Lake.

A.4 TRAFFIC PATTERNS

Ref: 1200-1-11-.07(5)(a)
40 CFR 270.14(b)(10)

The Y-12 Plant is served by three highways. The highway system in the area is adequate to handle the average number of daily commuters. The major vehicle access routes to the Y-12 Plant are via Bear Creek Road and Scarboro Road. Bear Creek Road runs east and west along the northern side of the Y-12 Plant. Bear Creek Road is closed for all but official uses, and guard portals are installed along the road. Scarboro Road runs north and south from the Y-12 Plant past the Scarboro facility and intersects with Bethel Valley Road, the main route to Oak Ridge National Laboratory (ORNL) (Plate A-1). Access to KHQ is via an unpaved road that connects to Bethel Valley Road. Scarboro and Bethel Valley Roads are state highways located within the DOE Oak Ridge Reservation (ORR).

The anticipated volume of traffic associated with KHQ is minimal and completely dependent upon the required maintenance activities. Light duty service trucks will be primarily used for maintenance purposes.

A.5 SECURITY PROCEDURES AND EQUIPMENT

Ref: 1200-1-11-.07(5)(a)
40 CFR 270.14(b)(4)

The Oak Ridge Y-12 Plant is a DOE facility that produces and handles nuclear materials. There are security procedures and equipment that will minimize the possibility for unauthorized entry into the facility. The Y-12 Plant has 24-hour surveillance and security, which includes patrol of the area where the KHQ is located. All access roads contain lockable gates to prevent unauthorized entry. The area enclosed by the security fence is shown on Figure A-2. The KHQ is posted with signs warning against unauthorized entry. No languages other than English are necessary for the signs and all signs are legible from a distance of at least 25 feet.

A.6 INSPECTION SCHEDULE

Ref: 1200-1-11-.07(5)(a)
40 CFR 270.14(b)(5)
1200-1-11-.06(2)(a)
40 CFR 264.15

Inspections of the KHQ will be conducted to ensure that the integrity of security equipment and groundwater monitoring systems is maintained. The inspections will identify any malfunctions or damage to monitoring wells or equipment, safety equipment, or security devices associated with post-closure care of the property. Throughout the post-closure care period all security and safety components of the KHQ (including well heads) will be inspected quarterly. A comprehensive inspection of monitoring wells will be performed annually. Notification of damage or need of maintenance of the KHQ monitoring wells will be made to the Y-12 Plant Groundwater Protection Program (GWPP). All inspection records and other documentation for the KHQ will be maintained within the Y-12 Plant.

A.7 TRAINING

Ref: 1200-1-11-.07(5)(a)
40 CFR 270.14(b)(12)
1200-1-11-.06(2)(a)
40 CFR 264.16

Training will be provided to employees conducting inspections to satisfy the requirements of the post-closure permit. The Y-12 Plant GWPP Manager (GWPPM) or authorized designee will train the field personnel who will perform the annual monitoring well inspections to familiarize them with: (1) the purpose and objectives of well inspection and maintenance, (2) well inspection items, (3) well inspection procedure(s), (4) well-depth measurement procedure(s), (5) the proper completion of inspection documentation, and (6) conditions that require notification of the Y-12 Plant GWPPM. Training of field personnel will be conducted prior to program initiation and updated on an annual basis.

On-the-job training will be provided to the site inspectors in the following areas:

- examination of signage;
- examination of monitoring well heads and benchmarks;
- identifying unauthorized deliveries or dumpings; and
- examination of security devices (e.g., fencing, gates, and locks).

A checklist will be used to document inspection findings. Copies of the completed inspection checklist(s) will be maintained at the Y-12 Plant. Examples of the checklists to be used during the inspection(s) are included in the KHQ Post-Closure Plan found in Appendix A.2.

A.8 CLOSURE PLAN AND POST-CLOSURE ACTIVITIES

Ref: 1200-1-11-.07(5)(a)
40 CFR 270.14(b)(13)

The closure plan for the KHQ is located in Section A.1 of Appendix A. The approved closure plan describes performance standards and activities conducted during the closure activities at KHQ. On February 22, 1995, TDEC certified the KHQ closed in accordance with the approved closure plan. A copy of this letter is included in Section A.3 of Appendix A.

The closure activities conducted pursuant to the approved closure plan included removal of visible containers or structures found within the KHQ. The Closure Certification Report (Dames and Moore 1993) submitted to TDEC detailed the removal activities conducted and included a discussion of post-closure activities. The post-closure activities described in the Closure Certification Report and Post-Closure Plan included care and maintenance of the fencing and posting. Monitoring of the creek that includes the discharge from the KHQ outfall will be conducted as required by the National Pollutant Discharge Elimination System (NPDES) permit TN0002968. The monitoring point is located south of Bethel Valley Road. The purpose of monitoring activities at the KHQ is to ensure that closure activities were effective and that no impact(s) to groundwater occur in the future. Groundwater monitoring activities will be conducted as described in Section B.5 of this permit application.

A.9 CONTINGENCY PLAN

Ref: 1200-1-11-.07(5)(a)
40 CFR 270.14(b)(7)

A Contingency Plan has been prepared for hazardous waste treatment, storage, and disposal units at the Oak Ridge Y-12 Plant (Skaggs 1993).

A.10 NOTICES REQUIRED FOR DISPOSAL FACILITIES

Ref: 1200-1-11-.07(5)(a)
40 CFR 270.14(b)(14)
1200-1-11-.06(7)(a)
40 CFR 264.119

Within 90 days after completing closure, DOE submitted to the Anderson County, Tennessee Zoning Authority and TDEC a survey plat, prepared and certified by a professional land surveyor, showing the location and dimensions of KHQ with respect to permanently surveyed benchmarks. A copy of the survey plat is included as Plate A-2. A record of the types and approximate quantities of waste placed in the quarry was submitted based on best available knowledge and records.

The DOE ORR property does not have a deed. If, in the future, any Y-12 Plant property on which hazardous waste has been managed is to be released from Federal government

ownership for private development, information regarding these activities will be placed in a legal document that would be examined during a title search.

A.11 CLOSURE AND POST-CLOSURE COST ESTIMATES

Ref: 1200-1-11-.07(5)(a)
40 CFR 270.14(b)(15-16)
1200-1-11-.06(8)(a)
40 CFR 264.142 to 264.145

As stated in Tennessee Rule 1200-1-11-.06(8)(a) and 40 CFR 264.140(c), Federal facilities are exempt from the requirements for closure and post-closure cost estimates of the above-referenced regulations.

A.12 TOPOGRAPHIC MAP

Ref: 1200-1-11-.07(5)(a)
40 CFR 270.14(b)(19)

A topographic map of the KHQ fulfilling all the requirements of the above-referenced regulations is provided on Plate A-1.

A.13 LIABILITY INSURANCE

Ref: 1200-1-11-.07(5)(a)
40 CFR 270.14(b)(17)

As stated in 1200-1-11-.06(8)(a) and 40 CFR 264.140(c), Federal facilities are exempt from the liability insurance requirements of the above-referenced regulations.

A.14 POST-CLOSURE CONTACT

Ref: 1200-1-11-.07(5)(a)
40 CFR 270.14

The address and phone number of the office to contact regarding the KHQ during the post-closure period are listed below:

U.S. Department of Energy, Environmental Restoration Division
P.O. Box 2001
Oak Ridge, Tennessee 37831-8012
(615) 576-0715

B. GROUNDWATER INFORMATION

B. GROUNDWATER INFORMATION

Ref: 1200-1-11-.07(5)(c)
40 CFR 270.14(c)
1200-1-11-.06(6)(a)
40 CFR 264 Subpart F

B.1 SUMMARY OF INTERIM STATUS DATA

Ref: 1200-1-11-.07(5)(c)
40 CFR 270.14(c)(1)

In 1983, a Memorandum of Understanding (MOU) was signed by DOE, the U.S. Environmental Protection Agency (EPA), and TDEC (HSW, Inc. 1993). The MOU required DOE to initiate a remedial investigation of groundwater contamination at the Y-12 Plant, and characterization monitoring was employed to evaluate the extent of contamination in soils, stream sediments, groundwater, and surface water. The KHQ was granted interim status under RCRA in 1986 (HSW, Inc. 1995). In November 1989, the ORR was placed on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List (NPL) (EPA 1992). On January 1, 1992, DOE, TDEC, and EPA entered into a Federal Facilities Agreement (FFA) for the ORR to provide a framework for conducting assessment and remediation of past and present releases on the ORR.

In February 1986, interim status detection monitoring was initiated at KHQ as required under Part 1200-1-11-.07(5)(c)1 of the *Rules Governing Hazardous Waste Management in Tennessee* (Jago 1995). Background groundwater quality in each monitoring well at the site was established through quarterly monitoring during 1986. Semi-annual monitoring for indicator parameters and annual monitoring for water-quality parameters began in 1987. As required under Part 1200-1-11-.05(6)(d)2, analytical results from 1987 and subsequent monitoring years were statistically compared to corresponding background values. Interim status detection monitoring is ongoing at the site.

B.1.1 Monitoring Well Network

Seven monitoring wells, constructed to RCRA specifications, were installed around the KHQ site in 1985. These wells are designated as GW-142, GW-143, GW-144, GW-145, GW-146, GW-147, and GW-231 (Figure B-1). An eighth boring at the site (CH-143) was drilled as an

exploratory core hole used for subsurface characterization. This core hole was not completed as a well and was plugged during drilling operations at the adjacent well sites (Jago 1995). A summary of construction data and aquifer zones monitored by the KHQ wells is presented in Table B-1. Monitoring wells GW-142, GW-143, GW-144, GW-145, GW-146, GW-147, and GW-231 comprise the interim status detection monitoring network for KHQ.

Monitoring wells GW-147 and GW-231 (Figure B-1) form a cluster at the northwestern edge of KHQ that extends through unconsolidated material and the top of bedrock. The remaining wells monitor various fractures and fracture zones that were identified in the exploratory core hole. Monitoring wells GW-143 and GW-144 form a cluster south of KHQ to investigate several small fractures zones occurring in two, 50-foot intervals within shallow bedrock. Monitoring wells GW-145 and GW-146 form a cluster to the southwest of the site designed to investigate fracture zones within both shallow and deep bedrock intervals. Monitoring well GW-142 also monitors several fracture zones within shallow bedrock.

B.1.2 Groundwater Sampling and Analysis

Interim status detection monitoring at KHQ began in 1986. The first-year data were collected and used to establish a baseline for the monitoring system. This information was reported to TDEC (Energy Systems 1987). The baseline data were used for statistical comparison of data acquired through subsequent sampling efforts. Drinking water parameters compiled from calendar year (CY) 1986 sampling results are presented in Table B-2. During CY 1987, the wells were monitored semi-annually for parameters used as indicators of groundwater contaminations as required by TDEC Rule 1200-1-11-.05(6)(c)(2)iii and annually for parameters establishing groundwater quality as required by TDEC Rule 1200-1-11-.05(6)(c)(2)ii. A summary of parameters analyzed as part of the detection monitoring program is presented in Table B-3. The results of the monitoring effort in CY 1987 were submitted to TDEC (Energy Systems 1988). During CY 1988 and CY 1989, the wells were monitored semi-annually for parameters used as indicators of groundwater contamination. These results were reported to TDEC in required annual reports (Energy Systems 1989, 1990).

During CYs 1990, 1991, 1992, 1993, and 1994, the wells were monitored semi-annually for parameters used as indicators of groundwater contamination. These results were provided to TDEC in the form of annual and/or semi-annual reports as required under the interim status

groundwater monitoring requirements (Energy Systems 1991; Shevenell and Switek 1992; McMahon and Mercier 1992; Jago et al. 1993; Jago 1994, 1995).

Additionally, in CY 1990, the wells were incorporated into the Y-12 Plant Comprehensive Groundwater Monitoring Program. In CY 1991, the Groundwater Quality Assessment Report (GWQAR) for the Chestnut Ridge Hydrogeologic Regime (HSW, Inc. 1992) was expanded to include monitoring data throughout the regime to provide a comprehensive picture of groundwater quality throughout the regime. The GWQARs have been provided to TDEC in addition to the annual report that specifically deals with groundwater at the KHQ. As a result of this action, additional locations were sampled and data collected on a quarterly basis, which exceeded RCRA interim status requirements.

In CY 1993, the titles of the GWQARs were changed to Groundwater Quality Reports (GWQRs) to reflect the integration of multiple regulatory, DOE Order, and programmatic requirements into the scope of the Y-12 Plant Comprehensive Groundwater Monitoring Program. The GWQRs continue to be prepared consistent with RCRA interim status assessment reporting requirements. The documents include data necessary to comply with RCRA post-closure permit annual reporting requirements as well as serve as a forum to present data collected under a variety of additional monitoring drivers.

Indicator parameter data from KHQ have been assessed semi-annually using t-test statistical evaluations since the inception of interim status detection monitoring. Formal false-positive demonstrations were prepared in late 1991 (Haase et al. 1991a and 1991b). An initial false-positive demonstration was submitted that pertained only to pH and conductivity. A subsequent false-positive demonstration was submitted for total organic carbon (TOC) and total organic halides (TOX). Data pertaining to pH, TOC, TOX, and specific conductance from the groundwater monitoring wells surrounding the KHQ site were reviewed to determine if the pervasive, statistically significant changes in these parameters obtained using t-test statistics were truly indicative of contaminant releases from KHQ. The false-positive demonstration reports were submitted to TDEC in September 1991 and November 1991, respectively, and were subsequently approved (Lagan 1992). The false-positive demonstrations confirmed that, in CY 1991, statistically significant changes in indicator parameters pH, TOC, TOX, and specific

conductance did not represent a release of contaminants to groundwater from the KHQ site. The false-positive demonstrations are included in Appendix E.

Since 1991, several statistically significant changes resulting from the t-test statistical method have been identified. These statistically significant results have also been considered false-positives based on the premise of the approved false-positive demonstration and historical monitoring data, and do not represent a release of contaminants to the groundwater. The variability of groundwater chemistry over this same time period further emphasizes the conclusions of the false-positive demonstration. A summary of the statistically significant results at the KHQ is presented in Table B-4.

In 1988, analysis for Appendix IX parameters was conducted on groundwater samples taken from monitoring wells GW-142, GW-143, GW-144, GW-145, GW-147, and GW-231 at the KHQ. Analyses included metals, volatile organic compounds (VOCs), semivolatile organics, herbicides/pesticides, and field parameters (e.g., pH, specific conductance, etc.). A summary of the constituents detected is shown in Table B-5. These data are provisional because no validation against laboratory or trip blanks has been conducted.

B.2 HYDROGEOLOGIC FRAMEWORK

Ref: 1200-1-11-.07(5)(c)
40 CFR 270.14(c)(2)

B.2.1 Regional Geology

The KHQ is located in the western portion of the Valley and Ridge Physiographic Province (Figure B-2). The area is comprised of long, narrow ridges underlain by resistant Paleozoic sandstones, siltstones, and siliceous limestones with intermediate valleys of less resistant shales and soluble carbonates (Rodgers 1953). Structurally, the Valley and Ridge is characterized by a series of imbricate thrust faults. The strike of the rocks is toward the northeast and generally parallels the axes of ridges. The dip of the rocks is to the southeast (Moore 1988; Stockdale 1951).

B.2.2 Stratigraphic Units

The KHQ is situated in the Mascot Dolomite of the Knox Group and the lower units of the Chickamauga Group. Five formations of the Knox Group—the Copper Ridge Dolomite, Chepultepec Dolomite, Longview Dolomite, Kingsport Formation, and Mascot Dolomite—comprise the southeast slope of Chestnut Ridge. The Ordovician Chickamauga Group underlies Bethel Valley to the southeast and the Cambrian Maynardville Limestone of the Conasauga Group underlies the lower northwest slope of Chestnut Ridge.

B.2.2.1 Unconsolidated deposits

Unconsolidated deposits in the Chestnut Ridge Regime consist of reddish-brown to yellow-orange residuum overlying the Knox Group. The residuum is characteristically slightly acidic, predominantly composed of clays and iron sesquioxides, and contains semicontinuous, relict beds of fractured chert and other lithologic inhomogeneities (such as silt bodies) that provide a weakly connected network through which saturated flow can occur. However, in the vicinity of KHQ, this residuum is relatively thin or nonexistent (Haase et al. 1987).

B.2.2.2 Bedrock geology

The KHQ is located at the contact between the uppermost Knox Group and basal portion of the Chickamauga Group (Figure B-3). At the quarry site, the contact is an unconformity and exhibits ~50 to 100 feet of topographic relief. The uppermost Knox Group at the site consists of gray to blue-gray, medium-bedded to massive dolostone with locally abundant nodular-to-bedded chert occurring throughout the section. The basal portion of the Chickamauga Group consists of abundant maroon and gray, thin-to-medium bedded siltstone, thin-bedded limestone, and minor-to-rare nodular or bedded chert. Both the upper Knox Group and the basal Chickamauga Group are pervasively jointed, and dip ~40° to 50° to the southeast (Haase et al. 1987).

The KHQ lies at the contact between the Knox Aquifer and the ORR Aquitards, which is coincident with the contact between the Knox and Chickamauga Groups (Solomon et al. 1992). Evaluation of geophysical logs and drill core obtained from boreholes drilled at the quarry site suggests that there are thin (< 1 to 3 feet), relatively permeable, fractured zones occurring within bedrock to depths of at least 600 feet (Haase et al. 1987).

Cavities in carbonate bedrock form by dissolution and abrasion within these fractures (Moore 1988). Enlargement of fractures begins with slow dissolution of rock or cementing materials. Openings enlarged above some critical size permit turbulent groundwater flow. Physical erosion by abrasion then increases the rate of cavity enlargement while turbulent flows remove at least part of the resulting detritus. Remaining detritus accumulates at the bottom of the cavity and partially protects the rock surface from further erosion. Most large cavities develop by abrasion and upward sloping. Solution features encountered in the area during drilling typically were mud-filled or associated with abundant muddy groundwater (Haase et al. 1987). Cavities may also occur in zones of higher water velocity in residuum just above the top of bedrock.

Sinkholes in the KHQ area tend to occur in alignments along certain stratigraphic zones of the Knox Group. One such zone can be found along the crest of Chestnut Ridge. Regional data for the Knox Group in the study area suggest the density of active karst subsidence is on the order of 0.06 to 0.11 per square mile with a frequency of occurrence of 0.01 to 0.02 per square mile per year (Ketelle 1987).

B.2.3 Structural Relationships

The White Oak Mountain thrust sheet underlies Bethel Valley, Chestnut Ridge, and Bear Creek Valley (Rodgers 1953; Moore 1988). The White Oak Mountain thrust fault is one of a series of imbricate thrust faults in the Valley and Ridge Province that trends northeast and dips southeast (Figures B-4 and B-5).

The most pervasive structural features in the Chestnut Ridge Regime are extensional, hybrid, and shear fractures (Solomon et al. 1992). Three major joint orientations are evident: one that roughly parallels bedding, one steeply dipping set that parallels geologic strike (Dreier et al. 1987), and one steeply dipping set oriented perpendicular to strike. Fracture densities ranging from ~1 to 60 per foot have been observed in rock outcrops near ORNL (Dreier et al. 1987). Most fractures are short, ranging from tenths of inches to a few feet in length (Solomon et al. 1992).

Bedding and joint orientations were measured by Smith et al. (1983) at the Y-12 Plant. Eighty-three planar orientations were measured, and the results indicate that the bedding orientation is fairly consistent at north 48° east at 35° dip to the southeast. Joint orientations

exhibit a wide scatter of northwest dipping strike set joints and conjugate northeast-dipping and southwest-dipping joints. An additional joint set trends approximately north-south in the vicinity of KHQ (Smith et al. 1983).

Penetrative faults, fractures, and joints in carbonate bedrock provide locations for enhanced groundwater flow and are the features that control subsurface flow in the bedrock. Data also indicate that groundwater movement within the bedrock occurs principally within fractures and fracture systems and not within any single principal stratigraphic unit (Smith et al. 1983).

B.2.4 Surface Water System

The following sections discuss watershed, surface water use, and precipitation in the vicinity of the KHQ.

B.2.4.1 Southeast Chestnut Ridge Watershed

The KHQ site is located south of the Chestnut Ridge crest, which forms a surface water divide. During periods of high precipitation, KHQ overflows and enters the local surface water system. Immediately upon leaving the quarry, the water enters a sediment collection basin that was constructed to mitigate sediment discharge during the remedial activities at the quarry. From the basin, the water enters a nearby stream that flows for 0.56 mile and finally discharges directly into Melton Hill Lake (Clinch River). Surface water drainage in the vicinity of KHQ is illustrated in Figure B-6. Stream discharge measurements made in the southeast Chestnut Ridge watershed by the U.S. Geological Survey (USGS) indicate the presence of alternating losing and gaining portions of the area streams (Evaldi 1984).

B.2.4.2 Surface water use

Surface water use within the immediate vicinity of KHQ is supplied by the Clinch River. Several pumping stations are located within 5 miles of the KHQ site. Two of these stations are owned by DOE and provide water for both domestic and industrial use at the Y-12 Plant (upstream), ORNL (downstream), and the City of Oak Ridge. Two additional stations are operated by the West Knox Utility District (WKUD) with a total usage of 4 to 5.5 million gallons per day (mg/d). The WKUD stations supply 16,000 meters (more than 50,000 customers) with water for domestic use (Heidel 1994).

B.2.4.3 Precipitation data

The precipitation data for 1993 presented in Figure B-7 were collected from the National Oceanic and Atmospheric Administration (NOAA) Oak Ridge Station located on South Illinois Avenue, ~2 miles north of KHQ.

Maximum and minimum annual precipitation measurements made near ORNL from 1954 to 1983 are 74 inches and 35.3 inches, respectively (Moore 1988). The mean annual precipitation for the same time period was 52.2 inches. The least amount of precipitation usually occurs between the months of August and October (2.9 to 3.8 inches measured at the NOAA Oak Ridge Station). The greatest amount of precipitation usually occurs between the months of January and March (5.3 to 6.2 inches). According to NOAA Oak Ridge Station records, the monthly extremes are 13.3 inches for January 1954 and 0.5 inch for August 1983. From 1986 to 1988, the USGS recorded unusually low annual precipitation readings in the ORNL area (34.5 inches in 1986 and 41.7 inches in 1987).

At the ORR, evapotranspiration consumes on average 30 inches of annual precipitation. Approximately 75% (22.5 inches) of evapotranspiration occurs between the months of April and September (Moore 1988).

B.2.5 Groundwater System

Solomon et al. (1992) divide the groundwater system underlying the ORR into two basic hydrogeologic units with fundamentally different hydrologic characteristics: the Knox Aquifer and the ORR Aquitards. The Knox Aquifer consists of the Knox Group and the underlying Maynardville Limestone formation of the Conasauga Group. The remaining formations of the Conasauga Group, the underlying Rome Formation, and the Chickamauga Group form the ORR Aquitards.

Solomon et al. (1992) divide the Knox Aquifer and the ORR Aquitards into four parts: (1) the stormflow zone; (2) the vadose zone; (3) the groundwater zone which is subdivided into water table, intermediate, and deep intervals; and (4) the aquiclude (Figure B-8). The divisions are based on the amount of water transmitted by each subsystem (i.e., flux), which decreases with depth. The flow system is vertically gradational with no discrete boundaries separating the

subsystems. However, the bulk permeability of the Knox Aquifer is about ten times greater than that of the ORR Aquitards (Solomon et al. 1992).

The stormflow zone occurs in regolith as does much of the vadose zone, although in some areas the vadose zone includes weathered and fresh bedrock. In the bedrock, orthogonal sets of pervious, planar fractures form groundwater flowpaths. Within a fracture, groundwater may flow either downdip, laterally, or in both directions. Changes in flow direction may occur at fracture splits and intersections, and groundwater flowpaths may locally resemble stairsteps in both plan and sectional views (Moore 1989). Intersections of two or more fracture sets form permeable intervals or zones that transmit the bulk of the groundwater flux (Moore and Toran 1992).

Fracture sets comprising the permeable zone in the water table interval are generally nonstratiform, and groundwater generally flows in the direction of maximum hydraulic gradient along multiple, alternative flowpaths (Moore and Toran 1992). Stratiform fracture sets are believed to form permeable zones at deeper intervals in the bedrock, and groundwater in these zones primarily flows in the direction of geologic strike (which may or may not correlate with the maximum hydraulic gradient) toward cross-cutting tributary streams (Moore and Toran 1992). Additionally, the vertical spacing between permeable zones increases with depth, and these zones are poorly connected in three dimensions (Solomon et al. 1992).

B.2.5.1 Stormflow zone

Investigations in Bethel Valley and Melton Valley near ORNL show that groundwater occurs intermittently above the water table in the ORR Aquitards in a shallow "stormflow zone" that extends from the ground surface to a depth of ~6 feet (Moore 1989). Channels for lateral flow in the stormflow zone include macropores and mesopores, which are connected voids created by various processes, including biochanneling, cracking, and soil particle aggregation (Moore 1989). This zone is thicker and more permeable in forested areas than in grassy or brushy areas, and is more permeable near the land surface than at deeper levels (Moore 1989). However, a stormflow zone may not exist in areas that have undergone substantial modification, such as capped portions of waste management areas.

Water is present in the stormflow zone during, and for short periods after, significant rainfall events. Most of the water is lost to evapotranspiration and much of the remaining water

discharges at nearby seeps, springs, and streams. Analysis of infiltrometer test results from Bethel Valley and Melton Valley suggests that the hydraulic conductivity of the stormflow zone averages ~29 feet per day (feet/day) near the top and 0.1 foot/day near the base (Moore 1989). Lateral flow in the stormflow zone is intermittent, lasting a few days to a few weeks after the occurrence of precipitation. Flow is fairly rapid when the zone is saturated with water but is relatively slow when nearly drained (Moore 1989).

B.2.5.2 Vadose zone

The vadose zone occurs between the stormflow zone and the water table. The geometric mean depth to the water table in the Knox Aquifer is ~100 feet. Water is added to the vadose zone by percolation from the stormflow zone and is removed by transpiration and recharge to the water table. The vadose zone is unsaturated except in the capillary fringe above the water table and within wetting fronts during periods of vertical percolation from the stormflow zone (Moore 1989). Most recharge through the vadose zone is episodic and occurs along discrete permeable fractures that become saturated, even though surrounding micropores remain unsaturated (Solomon et al. 1992).

The hydraulic conductivity of the unsaturated residual soils on Chestnut Ridge has been determined from slug tests in wells located at the United Nuclear Corporation Site (Mishu 1982), and in areas several miles west of the Chestnut Ridge Regime (Woodward-Clyde 1984). Little variation was observed with depth, but conductivities determined by field and laboratory tests varied by approximately two orders-of-magnitude for comparable depth intervals. Mean field conductivities ranged from 5.7×10^{-3} to 4.9×10^{-1} feet/day and mean laboratory conductivities ranged from 2.8×10^{-5} to 9.1×10^{-3} feet/day. Results of the slug tests are similar to those obtained from infiltrometer tests. Moore (1988) reported a geometric mean hydraulic conductivity of ~0.006 foot/day for residuum on Chestnut Ridge based on results of infiltrometer studies near ORNL reported by Watson and Luxmoore (1986) and Wilson and Luxmoore (1988).

The hydraulic conductivity of the residuum overlying the Knox Aquifer varies with the degree of saturation (Luxmoore 1982; Daniels and Broderick 1983). Luxmoore (1982) demonstrated that hydraulic conductivity decreases by approximately one order-of-magnitude with a volumetric water content decrease to 90% of saturation, and two orders-of-magnitude with a volumetric water content decrease to 75% of saturation. Daniels and Broderick (1983), as

summarized in Ketelle and Huff (1984), reported that hydraulic conductivity decreases by roughly one order-of-magnitude relative to maximum when saturation is 90%, and three orders-of-magnitude relative to maximum when saturation is 75%. Ketelle and Huff (1984) also noted that wide variations in soil permeability occur over short lateral distances. These findings are consistent with observations of permeability variation in residual soils found in other karst areas (Quinlan and Aley 1987).

B.2.5.3 Groundwater zone

Solomon et al. (1992) divide the saturated zone in the Knox Aquifer and ORR Aquitards into water table, intermediate, and deep intervals based on observed changes in hydrologic characteristics and groundwater geochemistry with depth.

Water Table Interval

A permeable interval 3 to 15 feet thick usually occurs in the transitional horizon between regolith and unweathered bedrock. The water table often occurs within this permeable interval (Solomon et al. 1992). The saturated thickness of this interval changes with cyclic fluctuations in the water table elevation and the interval may be nearly drained during seasonal water table declines. Moore (1989) estimates an average effective porosity of 0.0042 near the water table.

Results of geochemical dating studies of the ORR Aquitards in Melton Valley generally support the concept of a groundwater zone that is most active near the water table and becomes increasingly sluggish with depth (Solomon et al. 1992). Analyses of $^3\text{H}:^3\text{He}$ ratios in groundwater samples collected from 1 to 6 feet below the water table showed ages ranging from 0.09 to 7.23 years, and the presence of large amounts of ^4He in groundwater samples from greater depths [45 to 165 feet below ground surface (bgs)] suggests much greater residence times (Poreda et al. 1988).

Intermediate Interval

Groundwater in the intermediate bedrock interval occurs in relatively permeable fractures in a relatively impermeable matrix, but permeable fractures are poorly connected (Solomon et al. 1992). Enlarged fractures and cavities are the primary water-producing features and solute transport pathways, and are supplied by seepage through fractures in the rock matrix, which

outnumber the enlarged fractures and cavities, are interconnected, and provide the continuity for groundwater flowpaths (Moore 1989).

Estimates of the hydraulic conductivity of the intermediate interval in the Knox Aquifer are provided by results of straddle packer tests performed in three core holes in the Chestnut Ridge Regime: two at the east end of the regime near the Sediment Disposal Basin and one at the west end of the regime near Industrial Landfill IV. The tested intervals were in the Copper Ridge Dolomite of the Knox Group and were generally <600 feet bgs. Calculated hydraulic conductivities ranged from 0.0002 to 3.1 feet/day (King and Haase 1988) and averaged ~0.6 foot/day. The upper population represents more permeable water-producing intervals and the lower population represents less permeable matrix intervals.

The hydraulic conductivity of some water-producing intervals in the Knox Aquifer is much greater than indicated by the straddle packer tests owing to an interconnected network of solution cavities and solutionally enlarged fractures. For instance, groundwater flow rates determined from a tracer test performed by Ketelle and Huff (1984) ranged from 490 to 1,250 feet/day. Preliminary results of a dye-tracer test performed by Geraghty & Miller, Inc. (1990) at the Security Pits indicated flow rates of ~100 to 300 feet/day, although findings of the test were not confirmed by a second test performed at the site (SAIC 1993). However, results of the Ketelle and Huff (1984) and the Geraghty & Miller, Inc. (1990) tracer tests are within the range of conduit-flow rates typical in karst terrains (Quinlan and Ewers 1985).

Deep Interval

Identification of the deep interval is based on hydraulic and geochemical data for several deep (>500 feet) monitoring wells and core holes. Solomon et al. (1992) report that the boundary between the intermediate interval and deep interval in Bear Creek Valley occurs at depths of ~325 feet in the ORR Aquitards and 650 feet in the Knox Aquifer. The boundary is based on lower hydraulic conductivity, although use of hydraulic conductivity may not always be a reliable indicator (Solomon et al. 1992).

In some areas of the Bear Creek Regime, the transition from the intermediate interval to the deep interval in the ORR Aquitards is indicated by a change from sodium-bicarbonate groundwater to sodium-chloride groundwater accompanied by a general increase in specific

conductance and total dissolved solids. This change in groundwater geochemistry probably reflects longer residence times in the deep interval, and usually occurs at depths of >400 feet bgs (Solomon et al. 1992). However, no such change in groundwater geochemistry is generally observed in the Knox Aquifer. Within this aquifer, calcium-magnesium-bicarbonate or calcium-sulfate groundwater occurs to depths of 1,000 feet bgs (Dreier et al. 1993).

Evaluation of data obtained from straddle packer tests and slug tests, and slow-recovery analyses, indicates that the geometric mean hydraulic conductivity of the deep interval is ~0.001 foot/day (Solomon et al. 1992). The low conductivities may reflect reduced fracture apertures or increased fracture spacings (Solomon et al. 1992).

B.2.5.4 Aquiclude

The aquiclude occurs below the deep groundwater interval and is generally marked by the presence of saline water with total dissolved solid concentrations of 40,000 to 300,000 milligrams per liter (mg/L) (Solomon et al. 1992). Information obtained southeast of the Chestnut Ridge Regime in Melton Valley indicates that the saline water typically occurs at depths of ~600 to 700 feet bgs (Solomon et al. 1992). The water in the aquiclude is a sodium-, calcium-, and chloride-rich brine that is chemically similar to brines associated with major sedimentary basins (Solomon et al. 1992).

Saline groundwater has not been encountered at depth in the Chestnut Ridge Regime. However, several wells completed at depths of ~500 to 1,000 feet bgs in Bear Creek Valley monitor groundwater with total dissolved solid concentrations of several thousand mg/L to several tens of thousand mg/L, suggesting that the aquiclude may be present at greater depth near the Y-12 Plant than in Melton Valley (Solomon et al. 1992).

B.2.5.5 Aquifer characteristics

The hydraulic properties of the Knox Group along Chestnut Ridge have been estimated by several investigators (King and Haase 1988; Kettle and Huff 1984; Woodward-Clyde 1984; Mishu 1982). The permeability of the unconsolidated residuum controls the vertical rate of water movement from the land to the water table. The permeability of the unweathered bedrock controls the rate of groundwater movement in the water table portion of the aquifer, and is likely to be attributable to secondary openings in the bedrock.

Both laboratory and in-situ tests have been performed to determine the permeability of the unconsolidated material (Woodward-Clyde 1984; Mishu 1982). Moisture-suction tests were performed on unsaturated laboratory samples using thermocouple psychrometers and tensiometers, and permeability tests were performed on unsaturated samples to determine permeability-suction characteristics of the unconsolidated materials. Permeabilities were determined in the field using falling head permeability tests. Typically, laboratory tests yield lower values than field tests because the macropore system can be tested in the field (Ketelle and Huff 1984). Results of these tests are presented in Table B-6.

Permeability studies conducted in the residuum of the Knox Group at a site several miles southwest of KHQ indicated widely variable permeabilities. At depths of 30 feet or less, permeabilities averaged $\sim 1.41 \times 10^{-9}$ feet/day. At depths > 50 feet, permeability values decreased to 2.11×10^{-11} feet/day on average (Woodward-Clyde 1984). Relatively pervious layers within the residuum with permeability values averaging 1.76×10^{-7} feet/day were identified and are speculated to be continuous over distances of several thousand feet (Woodward-Clyde 1984). Results of another study conducted in Knox Group residuum (Mishu 1982) at a nearby site on Chestnut Ridge indicate permeabilities ranging from 2.89×10^{-10} feet/day to 2.54×10^{-7} feet/day and averaging 7.05×10^{-8} feet/day.

Hydraulic conductivity tests of bedrock along Chestnut Ridge have been conducted by Smith et al. (1983) and King and Haase (1988). A hydraulic conductivity of 0.87 foot/day was calculated by Smith et al. in 1983 using slug test data from monitoring well 1095. King and Haase (1988) conducted straddle packer tests in three core holes completed in the Copper Ridge Dolomite of the Knox Group (Figure B-9). In all, 21 intervals ranging in depth from 120 to 615 feet were individually tested in the Copper Ridge Dolomite. Intervals selected for packer testing were chosen to correspond with highly fractured or solutionally altered sections because these zones were thought to be areas of enhanced groundwater flow. Drill core and geophysical logs of the core holes were examined to identify the zones suitable for packer testing.

Field methods used to conduct the packer tests are described in detail in two reports by Golder & Associates (1987a and 1987b). Essentially, intervals were tested individually within each core hole and hydraulic heads were measured above the top packer, below the bottom packer, and between the packers using pressure transducers. Where appropriate, shut-in data

were analyzed according to the Horner semilog method (Erloughler 1977) to determine values of hydraulic conductivity for the tested intervals. The hydraulic conductivity values measured in the 21 intervals ranged from 2.08×10^{-4} feet/day to 3.2 feet/day (King and Haase 1988). Hydraulic conductivity values for the tested intervals are presented in Table B-7.

B.2.5.6 Flow direction and rate

Figure B-10 illustrates a water table map for KHQ, which was generated from data obtained during the August, CY 1994, comprehensive semi-annual water-level monitoring event at the site. Hydrographs for the water table monitoring wells at KHQ are presented in Figure B-11, and those for the three well clusters are presented in Figures B-12 through B-14. These hydrographs are generated using water level data obtained during quarterly groundwater sampling events.

Throughout most of CY 1994, water levels in all water table wells exhibited similar variations, with water levels rising and falling in response to seasonal changes (Jago 1995). Hydrographs of individual well clusters also show patterns similar to those seen in past years (Figures B-15 through B-17). The hydrographs for the northwestern well cluster (GW-147 and GW-231) indicate hydraulic connection between the unconsolidated and shallow bedrock zones. The hydrographs for the southwestern well cluster (GW-145 and GW-146) indicate a downward vertical hydraulic gradient. However, well GW-146 is not well connected to the shallow groundwater system (emphasized by the lack of recharge to the well between sampling events). In the southern well cluster (GW-143 and GW-144), hydraulic connection between the monitoring intervals is observed based on the similar water level response characteristics of the wells. Reversals in vertical gradient observed in the southern well cluster prior to CY 1993 are not present based on the observed differences in hydraulic head over the course of CY 1993 and CY 1994 (Jago 1995).

The water table elevation map illustrated in Figure B-10 represents conditions that existed on August 29, 1994. Because of the very shallow water table gradient at KHQ, piezometric contours are generalized and subject to some uncertainty. Wells GW-142, GW-145, and GW-231 show negligible difference in piezometric elevation during the third calendar quarter when rainfall is lowest (Figure B-11). Well GW-145 is considered as the formal upgradient well at the site; however, variability in the true upgradient direction has been evident over time with wells GW-231 and GW-142, at times, having the highest water table elevations.

The water table map suggests that there is groundwater flow in a southerly, and locally southwesterly, direction predominantly toward well GW-144, which consistently has the lowest piezometric head. Water level data from other studies suggest that the groundwater table is closely linked to the water level of the quarry and that the quarry reservoir has local control on hydraulic conditions (Haase et al. 1987; Haase et al. 1988; Early and Switek 1989). Although no water level data for the quarry reservoir are available for CY 1994, the configuration of the water table is similar to that observed in CY 1992 and CY 1993 and is consistent with the interpretations of past studies (Shevenell and Switek 1992; Jago et al. 1993; Jago 1994).

On a regional scale, groundwater flow within the Chestnut Ridge Regime is from higher topographic areas toward the lower areas. Ketelle and Huff (1984) in their study of a West Chestnut Ridge site found that in the Copper Ridge Dolomite outcrop belt, the groundwater divide appears to coincide with the topographic divide. In their conceptual model of groundwater flow, flowpaths in the weathered bedrock zone resemble a rectangular or trellis drainage pattern. Flow follows long runs parallel to strike and is diverted by shorter cross-strike channels to other strike-controlled zones or to discharge in a surface stream. Ketelle and Huff based this model on alignment of sinkholes along strike and on knowledge of fracture patterns.

Two types of groundwater flow are typical of karst systems: diffuse flow and conduit flow. Rates for diffuse flow in the Knox Group were determined using the modified Darcy equation given by $v = Ki/n$, where v is the migration rate, K is the hydraulic conductivity, i is the horizontal hydraulic gradient, and n is the effective porosity. Using the range of hydraulic conductivity test results (0.002 to 3.1 feet/day) reported by King and Haase (1988) for wells completed in the Knox Group, an effective porosity of 1% (Smith et al. 1976), and the range of strike-normal and strike-parallel hydraulic gradients for the Chestnut Ridge Regime (0.06 to 0.09 foot/day and 0.02 to 0.05 foot/day, respectively) reported by HSW, Inc. (1995), the Darcy velocity for diffuse flow ranges from <1 foot/year to ~30 feet/year for flow perpendicular to strike, and from <0.5 foot/year to 16 feet/day for strike-parallel flow (HSW, Inc. 1995).

Although the modified Darcy equation can be used to calculate average flow velocities in fractured rock (assuming it is an equivalent porous media), actual velocities in individual fractures may vary over orders-of-magnitude, depending on fracture aperture and wall roughness (Freeze and Cherry 1979). Additionally, the value for effective porosity is representative for fractured

limestones, but the actual value may be different by more than an order-of-magnitude, which would result in an inversely proportional variation in the Darcy velocity.

Migration rates for conduit flow were inferred from the results of dye tracer tests performed on Chestnut Ridge. Results of the Geraghty & Miller, Inc. (1990) and Kettle and Huff (1984) dye tracer tests provide estimates of conduit flow rates in the Knox Group. Although not confirmed by a subsequent dye test (SAIC 1993), results of the Geraghty & Miller, Inc. (1990) tracer test indicated flow velocities of 100 to 300 feet/day. Kettle and Huff (1984) determined flow rates of ~490 to 1,250 feet/day in their tracer test on Chestnut Ridge west of the Chestnut Ridge Regime.

B.2.5.7 Recharge/discharge relationship

Groundwater recharge at Chestnut Ridge is derived from precipitation, which averages ~55 inches per year. A majority of all aquifer recharge occurs during the nongrowing season (i.e., between the months of November and April). Recharge on Chestnut Ridge is via vertical percolation through the regolith and probably includes more direct input via sinkholes. Annual recharge is ~2.6 inches, and it is possible that a portion of the recharge results from delayed unsaturated flow (Solomon et al. 1992). Groundwater discharge pathways from the ridge have not been completely established, but based on knowledge of flow in similar karst systems and the results of dye tracer tests in the Chestnut Ridge Regime, springs, seeps, and streams located along or across strike are the probable discharge points for groundwater (HSW, Inc. 1995).

B.2.5.8 Groundwater quality

Groundwater geochemistry in the Chestnut Ridge Regime was evaluated through a review of dissolved concentrations of the principal cations (calcium, magnesium, sodium, and potassium) and total concentrations of the principal anions (bicarbonate, chloride, fluoride, nitrate, and sulfate) reported for CY 1993 groundwater samples collected from monitoring wells at KHQ (HSW, Inc. 1994). Dissolved cation concentrations exclude digested cations that do not contribute charge to the groundwater. A summary of average anion and cation analytical results for the KHQ monitoring wells is presented in Table B-8. The general groundwater geochemistry for the Chestnut Ridge Hydrogeologic Regime is illustrated by major ion concentrations shown in Figure B-18.

Groundwater geochemistry in the Knox Aquifer is nearly uniform throughout the Chestnut Ridge Regime. The chemical composition is typical of water in contact with dolomite, having the characteristically equivalent molar concentrations of calcium and magnesium with bicarbonate as the predominant anion. However, atypical groundwater geochemistry was observed in samples collected from monitoring wells GW-143 and GW-146 at KHQ (HSW, Inc. 1994). Samples from these wells had higher average sodium, potassium, and sulfate concentrations than the samples from the wells with which they are paired (GW-144 and GW-145, respectively).

The chemistry of the samples from wells GW-143 and GW-146 probably reflects the quality of groundwater in less permeable zones within the Knox Aquifer. Wells GW-143 and GW-146 are completed with deeper monitored intervals than GW-144 and GW-145, and the water level in GW-143 and GW-146 recovers much more slowly after the wells are purged during sampling. The midpoint of the monitored interval for well GW-143 (~229 feet bgs) is ~60 feet deeper than the midpoint in well GW-144 (~171 feet bgs). Similarly, the midpoint of the monitored interval for well GW-146 (~220 feet bgs) is ~122 feet deeper than the midpoint in well GW-145 (~98 feet bgs).

These relationships suggest that the higher average sodium, potassium, and sulfate concentrations in the groundwater monitored by wells GW-143 and GW-146 are a function of longer residence times in deeper aquifer zones with less direct hydraulic communication compared to shallower and more permeable zones in the Knox Aquifer. However, comparison of the analytical results for well GW-142 (midpoint of the monitored interval, ~271 feet bgs) to those for GW-144 suggests that groundwater in fractures monitored by well GW-142 may have a shorter residence time compared to wells GW-143 and GW-146.

B.2.5.9 Groundwater use

The City of Oak Ridge obtains its industrial and drinking water supplies from surface water. Within an ~10-mile radius of the KHQ site there are eight users of groundwater (Table B-9). More than 100 wells and springs service residential use within a 20-mile radius of the KHQ site.

B.3 POST-CLOSURE WASTE MANAGEMENT AREA

Ref: 1200-1-11-.07(5)(c)
40 CFR 270.14(c)(3)

A topographic map and survey plot fulfilling the requirements of the above-referenced regulation are presented in Plates A-1 and A-2. The DOE ORR property line is illustrated on Plate A-1.

B.4 CONTAMINANT PLUME DESCRIPTION

Ref: 1200-1-11-.07(5)(c)
40 CFR 270.14(c)(4)

A groundwater contaminant plume has not been identified at the KHQ; therefore, the site has remained in detection monitoring under interim status. Contaminants have been detected periodically in the groundwater at the KHQ; however, the contaminants appear to be attributable to the variability in groundwater chemistry in the area or to closure activities conducted between 1990 and 1993. A discussion of the constituents detected in the groundwater and apparent trends is presented below.

Contamination of groundwater at the KHQ has not been confirmed. Statistically significant variances in RCRA contamination indicator parameters have been observed in facility monitoring wells over time (Table B-4). Indicator parameter results were evaluated and false-positive demonstrations were prepared and submitted to the TDEC staff (Haase et al. 1991a and 1991b) and subsequently approved (Lagan 1992). These demonstrations are provided in Appendix E. The false positive demonstrations confirmed that statistically significant variances in RCRA detection monitoring parameters TOC, TOX, pH, and specific conductance do not represent a release of contaminants to groundwater at the sites (Jago 1995). The data evaluation presented in the false positive demonstration showed that TOC and TOX concentrations did not exhibit an identifiable trend or relationship to concentrations in other wells in the monitoring system and could not be correlated to the summed chlorinated and aromatic VOC values found within each well. The evaluation of pH data showed that temporal variations apparent in downgradient wells were similar to those exhibited by the upgradient well. The baseline data for pH in well GW-145 and well GW-142 appear to indicate partial contamination associated with fluids remaining in the formation from well construction. Conductivity data trends were found to be similar in well GW-145 and well GW-142. Further, the conductivity values found in well GW-142 were lower

than those associated with the upgradient well. As shown in the false positive demonstrations included in Appendix E, these indicator parameters are unreliable "indicators" of groundwater contamination.

An evaluation of all trace metal data collected at the site from the first quarter of CY 1990 through CY 1993 was conducted, and the results were reported in the *CY 1993 GQWR for the Chestnut Ridge Hydrogeologic Regime, Part 2* (HSW, Inc. 1994). The evaluation indicated that total strontium and total uranium are consistently elevated (> 50% of samples) above Y-12 Plant background screening levels typical for groundwater in uncontaminated areas. Well GW-145 has exhibited both total strontium and total uranium, well GW-142 has exhibited total uranium, and well GW-146 has shown total strontium above screening levels. Given that annual average gross alpha and gross beta results have never exceeded primary drinking water standards, the elevated total uranium and strontium observed in these wells may reflect natural levels of these elements in groundwater at this particular site. Isotopic analyses of groundwater samples were conducted in March 1995 to determine if these two constituents had a radiogenic source. The results indicated no elevated radioisotopes of either parameter in groundwater. Other trace metals have also been found in the groundwater in low concentrations; however, they have not been consistently detected. In addition, trace metal constituents detected in groundwater at the KHQ have not exceeded maximum contaminant levels (MCLs), with the exception of nickel and total uranium, which were detected in the upgradient wells at the site.

Trending of VOC analytical results indicates that very low levels of three VOCs (tetrachloroethene, carbon tetrachloride, and chloroform) have been sporadically observed in two wells (GW-142 and GW-144) over time (Table B-10). Carbon tetrachloride was identified in well GW-144 only. The occurrences of these compounds relate very strongly to the period during which underwater shredding, container breaching, and debris removal actions were being conducted at the quarry (September 1990 through October 1993). Preliminary results of analyses conducted in the first and second quarter of 1995 have shown no VOCs in well GW-142. However, preliminary data for well GW-144 showed trace levels of carbon tetrachloride and chloroform for both quarters and tetrachloroethene in the first quarter only. The chloroform detected in the groundwater may be associated with the carbon tetrachloride since it is a common degradation product of carbon tetrachloride. Because organics have been detected in groundwater

at KHQ, samples will be analyzed for VOCs as a part of the proposed detection monitoring program discussed in Section B.5.

Additional constituents were identified in unvalidated data from an analysis of Appendix IX constituents conducted in 1988. The constituents found in the analysis include barium, chromium, lead, methylene chloride, acetone, chloroform, carbon tetrachloride, benzene, toluene, fluorotrichloromethane, acetonitrile, di-n-butylphthalate, bis-2-ethylhexylphthalate, and beta-BHC. As illustrated in Table B-5, these contaminants were detected in some cases in both upgradient and downgradient monitoring wells. Most of the constituents found in the Appendix IX analysis have not been detected in subsequent samples collected as a part of the interim status groundwater monitoring program.

B.5 GROUNDWATER PROTECTION

Ref: 1200-1-11-.07(5)(c)
40 CFR 270.14(c)(5)

If KHQ is found to be a source of contamination, the priority of the site will be reevaluated under CERCLA, and the regulatory status of the site will be reprioritized and elevated to CERCLA operable unit status. Any remedial measures required at the site will be addressed as part of the CERCLA process. Remedial actions will be performed in accordance with remedial action work plans developed under CERCLA utilizing RCRA as an applicable or relevant and appropriate requirement (ARAR).

To ensure protection of human health and the environment, monitoring wells GW-142, GW-143, GW-144, GW-145, and GW-231 will comprise the detection monitoring network for KHQ and will be sampled on a semi-annual basis. The groundwater samples collected from the detection monitoring wells will be analyzed for the Target Compound List (TCL) presented in Table B-11 and compared to the corresponding tolerance limits to assess if a release of contaminants has occurred. This TCL is comprised of the alternative indicator parameters and comparative values that will be used in the detection monitoring program. The comparative values are based on calculated 95% upper tolerance limits (UTLs) (barium, lead, uranium) or MCLs (cadmium, chromium, mercury, nickel, carbon tetrachloride, tetrachloroethene, chloroform, gross alpha, and gross beta). In addition, as indicated on Table B-11 and discussed in Section B.5.1, annual trending analysis will be conducted for boron and total strontium.

Pursuant to Section IV of the FFA entered into by DOE, EPA, and TDEC, and in light of the requirement in the FFA to achieve a cleanup under CERCLA using a risk-based approach that is protective of human health and the environment, corrective action under this permit shall be determined accordingly. After the work called for in the FFA has been completed, the need for any further corrective action will be addressed under CERCLA and shall be limited to action based on new information or conditions, not available at the time of the remedy selected under the FFA, that render the FFA remedy no longer protective of human health and the environment.

B.5.1 Monitoring Parameters

Alternative indicator parameters will be monitored at the site (Table B-11). Monitoring and reporting frequencies will be semi-annual. Evaluation of groundwater analytical data will be performed by comparing analytical results to the values developed according to the methodology outlined in Appendix F. The results of this comparison will be submitted by the first day of September and March of each year. This evaluation will be conducted by comparing the data against calculated UTLs and MCLs identified in Table B-11 and, for boron and total strontium, annual trending analysis will be performed. The groundwater flow rate and direction in the uppermost aquifer will be determined annually.

Indicator parameters for the proposed detection monitoring program at the KHQ were chosen based upon the wastes treated at the unit and an evaluation of historical groundwater data. The historical data reviewed included data from the Y-12 Plant Groundwater Monitoring Program and the interim status groundwater monitoring efforts at the KHQ. Data from all seven groundwater monitoring wells in the area of KHQ were evaluated. The analytes chosen for the proposed detection monitoring system at the KHQ include: barium, boron, cadmium, chromium, lead, mercury, nickel, strontium (total), uranium (total), gross alpha, gross beta, and selected VOCs of potential concern.

As discussed in Appendix F, UTLs could not be calculated for all parameters of concern. The UTLs were calculated at a 95% confidence level for barium, lead, and uranium. The UTLs could not be calculated for cadmium, chromium, mercury, or nickel because these contaminants were detected in < 10% of the samples for which they were analyzed. Because UTLs could not be calculated, the MCLs for these parameters are proposed as the concentrations to be used for comparative purposes. Historical data have shown that MCLs have not been exceeded for these

proposed trace metal parameters, with the exception of nickel and total uranium, which were detected in the upgradient wells at the site.

In analyzing the historical data, it was noted that boron and strontium were significantly different between individual wells and well groupings (both upgradient and downgradient groups). In addition, strontium is not a hazardous constituent identified in Appendix VIII of 40 CFR Part 261, nor does it have an MCL. Therefore, it is proposed that no comparative concentration (e.g., 95% UTL) be set for total strontium. Instead, analysis of groundwater for strontium will be continued as a part of the detection monitoring program and the annual trend of these results will be evaluated to determine whether a significant change in concentrations is seen over time.

Boron concentrations in groundwater at the site were also significantly different between wells in both the upgradient and downgradient well populations, as well as between the two well groupings. Boron concentrations were found to be higher overall in downgradient wells. Because of the variations in concentrations found within the wells, a 95% UTL was not calculated for this analyte. Although the boron may be attributable to activities at the KHQ, the data do not correspond to a release of any constituent listed in Appendix VIII of 40 CFR Part 261 as incorporated by reference in TN Rule 1200-1-11-.02(5)(a)(1). Because boron is not an Appendix VIII constituent, does not have an associated MCL, and cannot be correlated to a release of any hazardous constituent from the KHQ, it is proposed that no comparative concentration (e.g., 95% UTL) be established for this constituent. Boron, however, will be used as an indicator parameter and groundwater analytical results will be evaluated by annual trending analysis.

In developing the proposed list of parameters for the KHQ detection monitoring program, it was noted that additional parameters have been sporadically detected over time. Beryllium and silver have been detected in groundwater, but were not included in the proposed parameter list because they have not been detected on a consistent basis and, when detected, have never exceeded associated MCLs.

In addition to the constituents discussed above, historical data have shown that certain VOCs have been detected in the groundwater at low concentrations. The VOCs detected in the groundwater included tetrachloroethene, carbon tetrachloride, and chloroform. These VOCs are believed to be attributable to closure activities. The MCLs have not been exceeded for detected

VOCs. Because of the detection of these VOCs, it is proposed that groundwater samples at the KHQ be analyzed for these VOCs. Any VOC detected will be compared to the associated MCL as a part of the detection monitoring program, and any observed trends in VOC concentrations will be evaluated.

It is also proposed that gross alpha and gross beta be included in the detection monitoring program at KHQ. These parameters will be compared to MCLs and, if found to exceed the annual average, will be followed by isotopic analysis. This activity will determine whether radionuclides associated with the operation of KHQ are present within the groundwater.

B.5.2 Groundwater Monitoring System

The proposed groundwater detection monitoring well system includes wells GW-142, GW-143, GW-144, GW-145, and GW-231. Wells GW-142 and GW-231 shall be considered upgradient wells. Wells GW-143, GW-144, and GW-145 are downgradient wells for the site. Aquifer zones monitored by these wells are presented in Table B-12. The locations of wells for the proposed groundwater detection monitoring network are shown on Figure B-19. All of these wells were constructed in accordance with the standards outlined in TN Rule 1200-1-11-.06(6)(a). Well construction diagrams are provided in Appendix B. In addition, construction details of the wells included in the proposed detection monitoring network are also included in Table B-12.

Additional wells may be installed in the area as part of future groundwater investigations under CERCLA or other non-RCRA activities. Construction in the vicinity of KHQ may require that some wells be abandoned and plugged at some point in the future. Prior approval for plugging and abandoning any detection monitoring well will be obtained from TDEC. The most current approved version of the procedure for well plugging and abandonment (Appendix C.1) will be used to decommission any well.

B.5.3 Sampling and Analysis Plan

The procedures for sampling and analysis for the groundwater monitoring program at KHQ are designed to provide representative results of the groundwater quality. The groundwater elevations will be measured in each well before the samples are collected as described in the most current approved version of the standard operating procedure for groundwater monitoring {Appendix D [1200-1-11-.06(a)]}. Wells will be inspected annually according to the most current

approved version of the procedure provided in Appendix C.2. In addition, well depths will be verified annually in accordance with the most current approved version of the Y-12 Plant GWPP well depth measurement procedure (Appendix C.3).

B.5.3.1 Sample collection

Groundwater samples from monitoring wells at KHQ will be collected in accordance with the most current approved version of the procedure presented in Appendix D to ensure that the integrity of the samples is not compromised. Samples will be collected using one of three types of sampling apparatus or an equivalent: dedicated bladder pumps, portable gas piston pumps, or bailers.

A discrete sample will be obtained daily from each well for 4 consecutive days. Each well will be purged prior to collection of the four discrete samples, and field parameters will be monitored in accordance with the most current approved version of procedures outlined in Appendix D. The bladder pumps and bailers can be used for both well purging and sample collection. Likewise, the gas piston pumps can also be used for well purging and sample collection; however, these units are not suitable for collecting samples to be analyzed for VOCs. For this reason, all samples to be analyzed for VOCs will be obtained with either a bladder pump or a bailer. The pumps and bailers will be decontaminated after sampling each well, if not dedicated, in accordance with the most current approved version of procedures outlined in Appendix D.

B.5.3.2 Sample containers, preservation, and transportation

The types of sample containers and preservation methods are contained in the most current approved version of the groundwater sampling and analysis plan (Burnett and Dill 1990). The most current approved version of methods for preservation and transportation of groundwater samples are also presented in Burnett and Dill (1990).

B.5.3.3 Laboratory analytical procedures

Laboratory methods to be used to analyze the groundwater samples are provided in the most current approved version of the groundwater sampling and analysis plan (Burnett and Dill 1990) or the equivalent of those methods.

B.5.3.4 Chain-of-custody control


The current approved protocol for sample chain-of-custody control is presented in Burnett and Dill (1990).

C. CERTIFICATION

C. CERTIFICATION

Ref: 1200-1-11-.07(2)(a)10


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



Department of Energy
Owner and Operator

Date Signed

6/21/95



Lockheed Martin Energy Systems, Inc.
Co-Operator

Date Signed

6/26/95

The Department of Energy and its operating contractor, Lockheed Martin Energy Systems, Inc., have jointly signed this application as the operator of the permitted facility. The Department has determined that dual signatures best reflect the actual apportionment of responsibility under which the Department's RCRA responsibilities are for policy, programmatic, funding and scheduling decisions, as well as general oversight, and the contractor's RCRA responsibilities are for day-to-day operations, including but not limited to the following responsibilities: waste analysis and handling, monitoring, recordkeeping, reporting, and contingency planning. For purposes of the certification required by Tennessee Rule 1200-1-11-.07(2)(a)10, the Department's and Lockheed Martin Energy Systems, Inc.'s representatives certify, to the best of their knowledge and belief, the truth, accuracy, and completeness of the application for their respective areas of responsibility.

This statement is attached hereto for the purpose of clarifying the roles and responsibilities of DOE and Lockheed Martin Energy Systems, Inc. with respect to the permitted facility and it shall not be construed as altering or limiting the certification.

D. REFERENCES

D. REFERENCES

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TABLES

Table A-1. Typical wastes treated in Kerr Hollow Quarry

Waste Type	Examples
Alkali metals and metal hydrides (water reactive)	Lithium and lithium hydride Sodium and sodium hydride Potassium and potassium hydride Calcium and calcium hydride Zirconium hydride Titanium hydride Lithium hydride Lithium aluminum hydride Sodium-potassium (NaK) metal
Unstable organics (explosive)	Picric acid and related compounds Ethers Peroxides Hydrazine
Metals (reactive)	Phosphorous Magnesium
Mechanical hazards (explosive)	Stressed steel parts (shrapnel danger) Vacuum tubes (implosive) Blasting caps Gas cylinders (with frozen/broken valves)
Miscellaneous hazards	Ammonia (irritant) Inorganic acids (corrosive)

Source: DOE 1993

Table A-2. Kerr Hollow Quarry sediment samples taken from 1990 to 1992
(Constituents with total concentration less than detection limit)

Analysis (units)	Number of samples	Minimum detection limit	Average detection limit	Maximum detection limit
Metals				
Arsenic (mg/kg)	18	17	26.7	35
Gallium (mg/kg)	18	7.4	12	16
Molybdenum (mg/kg)	18	2.5	3.99	5.2
Silver (mg/kg)	18	2.5	3.99	5.2
Thallium (mg/kg)	2	18	21	24
Thorium (mg/kg)	18	4.1	6.66	8.7
Pesticides and PCBs				
PCB, Total (mg/kg)	2	1	1	1
Semivolatile Organics				
1,2,4-Trichlorobenzene ($\mu\text{g}/\text{kg}$)	12	10	10	10
1,2-Dichlorobenzene ($\mu\text{g}/\text{kg}$)	12	10	10	10
1,3-Dichlorobenzene ($\mu\text{g}/\text{kg}$)	12	10	10	10
1,4-Dichlorobenzene ($\mu\text{g}/\text{kg}$)	12	10	10	10
2,4,6-Trichlorophenol ($\mu\text{g}/\text{kg}$)	12	30	30	30
2,4-Dichlorophenol ($\mu\text{g}/\text{kg}$)	12	30	30	30
2,4-Dimethylphenol ($\mu\text{g}/\text{kg}$)	12	30	30	30
2,4-Dinitrophenol ($\mu\text{g}/\text{kg}$)	12	30	30	30
2,4-Dinitrotoluene ($\mu\text{g}/\text{kg}$)	12	10	10	10
2,6-Dinitrotoluene ($\mu\text{g}/\text{kg}$)	12	10	10	10
2-Chloronaphthalene ($\mu\text{g}/\text{kg}$)	12	10	10	10
2-Chlorophenol ($\mu\text{g}/\text{kg}$)	12	30	30	30
2-Methyl-4,6-dinitrophenol ($\mu\text{g}/\text{kg}$)	12	30	30	30
2-Nitrophenol ($\mu\text{g}/\text{kg}$)	12	30	30	30
3,3'-Dichlorobenzidine ($\mu\text{g}/\text{kg}$)	12	10	10	10
4-Bromophenyl phenyl ether ($\mu\text{g}/\text{kg}$)	12	10	10	10

Table A-2. (continued)

Analysis (units)	Number of samples	Minimum detection limit	Average detection limit	Maximum detection limit
4-Chloro-3-methylphenol ($\mu\text{g}/\text{kg}$)	12	30	30	30
4-Chlorophenylphenyl ether ($\mu\text{g}/\text{kg}$)	12	10	10	10
4-Nitrophenol ($\mu\text{g}/\text{kg}$)	12	30	30	30
Acenaphthene ($\mu\text{g}/\text{kg}$)	12	10	10	10
Acenaphthylene ($\mu\text{g}/\text{kg}$)	12	10	10	10
Anthracene ($\mu\text{g}/\text{kg}$)	12	10	10	10
Benzidine ($\mu\text{g}/\text{kg}$)	12	30	30	30
Benzo(a)anthracene ($\mu\text{g}/\text{kg}$)	12	10	10	10
Benzo(a)pyrene ($\mu\text{g}/\text{kg}$)	12	10	10	10
Benzo(b)fluoranthene ($\mu\text{g}/\text{kg}$)	12	10	10	10
Benzo(ghi)perylene ($\mu\text{g}/\text{kg}$)	12	10	10	10
Benzo(k)fluoranthene ($\mu\text{g}/\text{kg}$)	12	10	10	10
Bis(2-chloroethoxy)methane ($\mu\text{g}/\text{kg}$)	12	10	10	10
Bis(2-chloroethyl) ether ($\mu\text{g}/\text{kg}$)	12	10	10	10
Butylbenzylphthalate ($\mu\text{g}/\text{kg}$)	12	10	10	10
Chrysene ($\mu\text{g}/\text{kg}$)	12	10	10	10
Di-n-butylphthalate ($\mu\text{g}/\text{kg}$)	12	10	10	10
Dibenzo(a,h)anthracene ($\mu\text{g}/\text{kg}$)	12	10	10	10
Diethylphthalate ($\mu\text{g}/\text{kg}$)	12	10	10	10
Dimethylphthalate ($\mu\text{g}/\text{kg}$)	12	10	10	10
Fluoranthene ($\mu\text{g}/\text{kg}$)	12	10	10	10
Fluorene ($\mu\text{g}/\text{kg}$)	12	10	10	10
Hexachlorobenzene ($\mu\text{g}/\text{kg}$)	12	10	10	10
Hexachlorobutadiene ($\mu\text{g}/\text{kg}$)	12	10	10	10
Hexachlorocyclopentadiene ($\mu\text{g}/\text{kg}$)	12	10	10	10
Hexachloroethane ($\mu\text{g}/\text{kg}$)	12	10	10	10
Indeno(1,2,3-cd)pyrene ($\mu\text{g}/\text{kg}$)	12	10	10	10
Isophorone ($\mu\text{g}/\text{kg}$)	12	10	10	10
N-Nitroso-di-n-propylamine ($\mu\text{g}/\text{kg}$)	12	10	10	10

Table A-2. (continued)

Analysis (units)	Number of samples	Minimum detection limit	Average detection limit	Maximum detection limit
N-Nitrosodimethylamine ($\mu\text{g}/\text{kg}$)	12	10	10	10
N-Nitrosodiphenylamine ($\mu\text{g}/\text{kg}$)	12	10	10	10
Naphthalene ($\mu\text{g}/\text{kg}$)	12	10	10	10
Nitrobenzene ($\mu\text{g}/\text{kg}$)	12	10	10	10
Pentachlorophenol ($\mu\text{g}/\text{kg}$)	12	30	30	30
Phenanthrene ($\mu\text{g}/\text{kg}$)	12	10	10	10
Phenol ($\mu\text{g}/\text{kg}$)	12	30	30	30
Pyrene ($\mu\text{g}/\text{kg}$)	12	10	10	10
bis(2-Chloroisopropyl)ether ($\mu\text{g}/\text{kg}$)	12	10	10	10
Volatile Organics				
1,1,1-Trichloroethane ($\mu\text{g}/\text{kg}$)	12	10	10	10
1,1,2,2-Tetrachloroethane ($\mu\text{g}/\text{kg}$)	12	10	10	10
1,1,2-Trichloroethane ($\mu\text{g}/\text{kg}$)	12	10	10	10
1,1-Dichloroethane ($\mu\text{g}/\text{kg}$)	12	10	10	10
1,1-Dichloroethene ($\mu\text{g}/\text{kg}$)	12	10	10	10
1,2-Dichloroethane ($\mu\text{g}/\text{kg}$)	12	10	10	10
1,2-Dichloropropane ($\mu\text{g}/\text{kg}$)	12	10	10	10
2-Butanone ($\mu\text{g}/\text{kg}$)	12	10	10	10
2-Chloroethylvinyl ether ($\mu\text{g}/\text{kg}$)	12	10	10	10
2-Hexanone ($\mu\text{g}/\text{kg}$)	12	10	10	10
4-Methyl-2-pentanone ($\mu\text{g}/\text{kg}$)	12	10	10	10
Acetone ($\mu\text{g}/\text{kg}$)	12	100	100	100
Benzene ($\mu\text{g}/\text{kg}$)	12	10	10	10
Bromodichloromethane ($\mu\text{g}/\text{kg}$)	12	10	10	10
Bromoform ($\mu\text{g}/\text{kg}$)	12	10	10	10
Bromomethane ($\mu\text{g}/\text{kg}$)	12	10	10	10
Carbon disulfide ($\mu\text{g}/\text{kg}$)	12	10	10	10
Carbon tetrachloride ($\mu\text{g}/\text{kg}$)	12	10	10	10

Table A-2. (continued)

Analysis (units)	Number of samples	Minimum detection limit	Average detection limit	Maximum detection limit
Chlorobenzene ($\mu\text{g}/\text{kg}$)	12	10	10	10
Chloroethane ($\mu\text{g}/\text{kg}$)	12	10	10	10
Chloroform ($\mu\text{g}/\text{kg}$)	12	10	10	10
Chloromethane ($\mu\text{g}/\text{kg}$)	12	10	10	10
Dibromochloromethane ($\mu\text{g}/\text{kg}$)	12	10	10	10
Dimethylbenzene ($\mu\text{g}/\text{kg}$)	12	10	10	10
Ethylbenzene ($\mu\text{g}/\text{kg}$)	12	10	10	10
Styrene ($\mu\text{g}/\text{kg}$)	12	10	10	10
Toluene ($\mu\text{g}/\text{kg}$)	12	10	10	10
Trichlorofluoromethane ($\mu\text{g}/\text{kg}$)	12	10	10	10
Vinyl chloride ($\mu\text{g}/\text{kg}$)	12	10	10	10
cis-1,2-Dichloroethene ($\mu\text{g}/\text{kg}$)	12	10	10	10
cis-1,3-Dichloropropene ($\mu\text{g}/\text{kg}$)	12	10	10	10
trans-1,2-Dichloroethene ($\mu\text{g}/\text{kg}$)	12	10	10	10
trans-1,3-Dichloropropene ($\mu\text{g}/\text{kg}$)	12	10	10	10

**Table A-3. Kerr Hollow Quarry sediment samples taken from 1990 to 1992
(Summary of chemical concentrations with at least one result greater than the detection limit)**

Analysis (units)	Proportion >detection limit	Minimum detected concentration	Maximum detected concentration	Mean ^a	Standard deviation	Detects >reference	Reference criteria ^b
Physical Parameters							
Percent Moisture (%)	14/ 14	54	84	68.07	10.19		
Metals							
Cadmium, AA (mg/kg)	2/ 2	0.98	1.8	1.39	0.5798	2/ 2	0.13
Chromium, AA (mg/kg)	2/ 2	12	13	12.5	0.7071	0/ 2	53
Lead, AA (mg/kg)	18/ 18	11	44	21.72	8.358	0/ 18	57
Mercury (mg/kg)	18/ 18	1.1	34	13.32	11.55	18/ 18	0.38
Aluminum (mg/kg)	18/ 18	3210	15200	8104	3994	0/ 18	42035
Barium (mg/kg)	18/ 18	32.3	115	66.22	24.64	0/ 18	147
Beryllium (mg/kg)	18/ 18	0.3	1.5	0.7167	0.3148	0/ 18	2
Boron (mg/kg)	18/ 18	6	23	11.61	4.06	0/ 18	27
Cadmium (mg/kg)	1/ 18	2	2	1.389	0.2687	1/ 18	0.13
Calcium (mg/kg)	18/ 18	3420	32600	17420	8101	18/ 18	3051
Cerium (mg/kg)	12/ 18	11	50	19.38	14.37		
Chromium (mg/kg)	18/ 18	7	23	14	4.615	0/ 18	53
Cobalt (mg/kg)	18/ 18	2	7	3.778	1.555	0/ 18	30
Copper (mg/kg)	18/ 18	20	1110	301.8	326.7	15/ 18	35
Iron (mg/kg)	18/ 18	3120	15500	6899	3268	0/ 18	57774
Lead (mg/kg)	12/ 18	10	40	18.28	11.1	0/ 18	57
Lithium (mg/kg)	17/ 18	10	52	29.78	13.73	7/ 18	36
Magnesium (mg/kg)	18/ 18	890	8380	3416	2201	6/ 18	4258
Manganese (mg/kg)	18/ 18	27	206	102.5	53.05	0/ 18	1998
Nickel (mg/kg)	18/ 18	7	29	15.22	7.281	0/ 18	35
Niobium (mg/kg)	13/ 18	6	55	12.16	12.76		
Phosphorus (mg/kg)	18/ 18	80	250	142.8	49.09		
Potassium (mg/kg)	17/ 18	300	3300	1288	944.7	0/ 18	4891
Scandium (mg/kg)	12/ 12	0.7	2.6	1.35	0.5317		
Sodium (mg/kg)	9/ 18	30	70	27.25	17.44	0/ 18	502
Strontium (mg/kg)	18/ 18	3.9	30.9	17.73	7.128	4/ 18	22

Table A-3 (continued)

Analysis (units)	Proportion > detection limit	Minimum detected concentration	Maximum detected concentration	Mean ^a	Standard deviation	Detects >reference	Reference criteria ^b
Titanium (mg/kg)	18/ 18	35	110	72.17	23.22		.
Vanadium (mg/kg)	18/ 18	7	36	13	7.178	0/ 18	75
Yttrium (mg/kg)	10/ 10	73	142	99.7	21.27		.
Zinc (mg/kg)	8/ 8	103	354	174.9	78.13	4/ 8	160
Zirconium (mg/kg)	18/ 18	9	131	55.83	39.81		.
Semivolatile Organics							
Bis(2-ethylhexyl) phthalate (µg/kg)	2/ 12	1800	2700	379.2	894.7		.
Di-n-octylphthalate (µg/kg)	2/ 12	1600	2500	345.8	818.8		.
Volatile Organics							
Methylene chloride (µg/kg)	4/ 12	16	19	10.04	6.391		.
Tetrachloroethene (µg/kg)	1/ 12	330	330	32.08	93.82		.
Trichloroethene (µg/kg)	1/ 12	13	13	5.667	2.309		.

^a Non-detects set to 1/2 the reported detection limit.

^b Reference concentration is the smaller of the maximum or 95% upper tolerance limit concentration of soil samples from the Background Soil Characterization Project at the Oak Ridge Reservation.
Output of program kerrsd01 on 08MAR94 at 07:35 using dataset paramtr.

Table A-4. Kerr Hollow Quarry sediment samples taken from 1990 to 1992
(Summary of radionuclide concentrations)

Analysis (units)	Proportion > detection limit ^a	Minimum detected concentration	Maximum detected concentration	Mean	Standard deviation	Standard error of the mean	Counting uncertainty ^b	No. of Results > reference concentration	Reference concentration ^c
Beta activity (pCi/g)	18/ 18	6.7	263	34.74	58.58	13.81	0.3233	.	.
Gamma activity (pCi/g)	16/ 16	6.9	29	15.48	5.598	1.399	0.5287	.	.
Gross Alpha (pCi/g)	18/ 18	5.6	92	29.33	29.59	6.974	0.5135	.	.
Uranium (mg/kg)	18/ 18	3.37	336	42.3	78.99	18.62	0.1722	.	.
Uranium-234 (pCi/g)	6/ 6	7.4	41	19.93	13.34	5.447	0.7902	.	.
Uranium-235 (%)	18/ 18	0.29	1.16	0.6806	0.249	0.05869	.	.	.
Uranium-235 (pCi/g)	6/ 7	0	1.6	0.78	0.6183	0.2337	0.04657	3/ 7	1
Uranium-238 (pCi/g)	6/ 6	6.9	32	16.95	11.75	4.799	0.7133	6/ 6	2

^a Radionuclide results less than the counting uncertainty were considered nondetects.

^b The 1 sigma pooled counting uncertainty was calculated as the square root of the sum of the squared counting errors divided by 2 times the number of observations.

^c Reference concentration is the smaller of the maximum or 95% upper tolerance limit concentration of soil samples from the Background Soil Characterization Project at the Oak Ridge Reservation.

Output of program kerrsd01 on 08MAR94 at 07:35 using dataset paramtr.

**Table A-5. Kerr Hollow Quarry sediment samples taken from 1990 to 1992
(Analytes with TCLP results less than detection limit)**

Analysis (units)	Number of samples	Minimum detection limit	Average detection limit	Maximum detection limit
TCLP Herbicides and Pesticides				
2,4-D ($\mu\text{g/L}$)	2	1000	1000	1000
Chlordane ($\mu\text{g/L}$)	2	3	3	3
Endrin ($\mu\text{g/L}$)	12	2	8.67	10
Heptachlor ($\mu\text{g/L}$)	2	0.8	0.8	0.8
Heptachlor epoxide ($\mu\text{g/L}$)	2	0.8	0.8	0.8
Methoxychlor ($\mu\text{g/L}$)	12	10	175	1000
Silvex ($\mu\text{g/L}$)	2	100	100	100
Toxaphene ($\mu\text{g/L}$)	12	10	16.7	50
gamma-BHC ($\mu\text{g/L}$)	12	10	15	40
TCLP Metals				
Arsenic (mg/L)	18	0.5	0.5	0.5
Chromium (mg/L)	18	0.5	0.5	0.5
Selenium (mg/L)	18	0.1	0.1	0.1
Silver (mg/L)	18	0.5	0.5	0.5
TCLP Semivolatile Organics				
1,2,4-Trichlorobenzene ($\mu\text{g/L}$)	10	10	10	10
1,2-Dichlorobenzene ($\mu\text{g/L}$)	10	10	10	10
1,3-Dichlorobenzene ($\mu\text{g/L}$)	10	10	10	10
1,4-Dichlorobenzene ($\mu\text{g/L}$)	10	10	10	10
2,4,5-Trichlorophenol ($\mu\text{g/L}$)	6	40000	40000	40000
2,4,6-Trichlorophenol ($\mu\text{g/L}$)	16	30	93.8	200
2,4-Dichlorophenol ($\mu\text{g/L}$)	10	30	30	30
2,4-Dimethylphenol ($\mu\text{g/L}$)	10	30	30	30
2,4-Dinitrophenol ($\mu\text{g/L}$)	10	30	30	30
2,4-Dinitrotoluene ($\mu\text{g/L}$)	16	10	11.1	13
2,6-Dinitrotoluene ($\mu\text{g/L}$)	10	10	10	10
2-Chloronaphthalene ($\mu\text{g/L}$)	10	10	10	10
2-Chlorophenol ($\mu\text{g/L}$)	10	30	30	30

Table A-5 (continued)

Analysis (units)	Number of samples	Minimum detection limit	Average detection limit	Maximum detection limit
2-Methyl-4,6-dinitrophenol ($\mu\text{g/L}$)	10	30	30	30
2-Methylphenol ($\mu\text{g/L}$)	6	20000	20000	20000
2-Nitrophenol ($\mu\text{g/L}$)	10	30	30	30
3,3'-Dichlorobenzidine ($\mu\text{g/L}$)	10	10	10	10
3-and/or 4-Methylphenol ($\mu\text{g/L}$)	6	40000	40000	40000
4-Bromophenyl phenyl ether ($\mu\text{g/L}$)	10	10	10	10
4-Chloro-3-methylphenol ($\mu\text{g/L}$)	10	30	30	30
4-Chlorophenylphenyl ether ($\mu\text{g/L}$)	10	10	10	10
4-Nitrophenol ($\mu\text{g/L}$)	10	30	30	30
Acenaphthene ($\mu\text{g/L}$)	10	10	10	10
Acenaphthylene ($\mu\text{g/L}$)	10	10	10	10
Anthracene ($\mu\text{g/L}$)	10	10	10	10
Benzidine ($\mu\text{g/L}$)	10	30	30	30
Benzo(a)anthracene ($\mu\text{g/L}$)	10	10	10	10
Benzo(a)pyrene ($\mu\text{g/L}$)	10	10	10	10
Benzo(b)fluoranthene ($\mu\text{g/L}$)	10	10	10	10
Benzo(ghi)perylene ($\mu\text{g/L}$)	10	10	10	10
Benzo(k)fluoranthene ($\mu\text{g/L}$)	10	10	10	10
Bis(2-chloroethoxy)methane ($\mu\text{g/L}$)	10	10	10	10
Bis(2-chloroethyl) ether ($\mu\text{g/L}$)	10	10	10	10
Bis(2-ethylhexyl)phthalate ($\mu\text{g/L}$)	10	10	10	10
Butylbenzylphthalate ($\mu\text{g/L}$)	10	10	10	10
Chrysene ($\mu\text{g/L}$)	10	10	10	10
Di-n-butylphthalate ($\mu\text{g/L}$)	10	10	10	10
Di-n-octylphthalate ($\mu\text{g/L}$)	10	10	10	10
Dibenzo(a,h)anthracene ($\mu\text{g/L}$)	10	10	10	10
Diethylphthalate ($\mu\text{g/L}$)	10	10	10	10
Dimethylphthalate ($\mu\text{g/L}$)	10	10	10	10
Fluoranthene ($\mu\text{g/L}$)	10	10	10	10
Fluorene ($\mu\text{g/L}$)	10	10	10	10
Hexachlorobenzene ($\mu\text{g/L}$)	16	10	11.1	13

Table A-5 (continued)

Analysis (units)	Number of samples	Minimum detection limit	Average detection limit	Maximum detection limit
Hexachlorobutadiene ($\mu\text{g/L}$)	16	10	25	50
Hexachlorocyclopentadiene ($\mu\text{g/L}$)	10	10	10	10
Hexachloroethane ($\mu\text{g/L}$)	16	10	119	300
Indeno(1,2,3-cd)pyrene ($\mu\text{g/L}$)	10	10	10	10
Isophorone ($\mu\text{g/L}$)	10	10	10	10
N-Nitroso-di-n-propylamine ($\mu\text{g/L}$)	10	10	10	10
N-Nitrosodimethylamine ($\mu\text{g/L}$)	10	10	10	10
N-Nitrosodiphenylamine ($\mu\text{g/L}$)	10	10	10	10
Naphthalene ($\mu\text{g/L}$)	10	10	10	10
Nitrobenzene ($\mu\text{g/L}$)	16	10	81.3	200
Pentachlorophenol ($\mu\text{g/L}$)	16	30	3770	10000
Phenanthrene ($\mu\text{g/L}$)	10	10	10	10
Phenol ($\mu\text{g/L}$)	10	30	30	30
Pyrene ($\mu\text{g/L}$)	10	10	10	10
Pyridine ($\mu\text{g/L}$)	6	500	500	500
bis(2-Chloroisopropyl)ether ($\mu\text{g/L}$)	10	10	10	10
TCLP Volatile Organics				
1,1,1-Trichloroethane ($\mu\text{g/L}$)	10	10	10	10
1,1,2,2-Tetrachloroethane ($\mu\text{g/L}$)	10	10	10	10
1,1,2-Trichloro-1,2,2-trifluoroethane ($\mu\text{g/L}$)	10	10	10	10
1,1,2-Trichloroethane ($\mu\text{g/L}$)	10	10	10	10
1,1-Dichloroethane ($\mu\text{g/L}$)	10	10	10	10
1,1-Dichloroethene ($\mu\text{g/L}$)	18	10	36.7	70
1,2-Dichloroethane ($\mu\text{g/L}$)	18	10	228	500
1,2-Dichloropropane ($\mu\text{g/L}$)	10	10	10	10
1,4-Dichlorobenzene ($\mu\text{g/L}$)	8	750	750	750
2-Butanone ($\mu\text{g/L}$)	18	10	8890	20000
2-Chloroethylvinyl ether ($\mu\text{g/L}$)	10	10	10	10
2-Hexanone ($\mu\text{g/L}$)	10	10	10	10
4-Methyl-2-pentanone ($\mu\text{g/L}$)	10	10	10	10

Table A-5 (continued)

Analysis (units)	Number of samples	Minimum detection limit	Average detection limit	Maximum detection limit
Acetone ($\mu\text{g/L}$)	10	100	100	100
Benzene ($\mu\text{g/L}$)	18	10	27.8	50
Bromodichloromethane ($\mu\text{g/L}$)	10	10	10	10
Bromoform ($\mu\text{g/L}$)	10	10	10	10
Bromomethane ($\mu\text{g/L}$)	10	10	10	10
Carbon disulfide ($\mu\text{g/L}$)	10	10	10	10
Carbon tetrachloride ($\mu\text{g/L}$)	18	10	27.8	50
Chlorobenzene ($\mu\text{g/L}$)	18	10	4450	10000
Chloroethane ($\mu\text{g/L}$)	10	10	10	10
Chloroform ($\mu\text{g/L}$)	18	10	92.2	600
Chloromethane ($\mu\text{g/L}$)	10	10	10	10
Dibromochloromethane ($\mu\text{g/L}$)	10	10	10	10
Dimethylbenzene ($\mu\text{g/L}$)	10	10	10	10
Ethylbenzene ($\mu\text{g/L}$)	10	10	10	10
Methylene chloride ($\mu\text{g/L}$)	10	10	10.9	19
Styrene ($\mu\text{g/L}$)	10	10	10	10
Toluene ($\mu\text{g/L}$)	10	10	10	10
Trichloroethene ($\mu\text{g/L}$)	18	10	27.8	50
Trichlorofluoromethane ($\mu\text{g/L}$)	10	10	10	10
Vinyl chloride ($\mu\text{g/L}$)	18	10	14.4	20
cis-1,2-Dichloroethene ($\mu\text{g/L}$)	10	10	10	10
cis-1,3-Dichloropropene ($\mu\text{g/L}$)	10	10	10	10
trans-1,2-Dichloroethene ($\mu\text{g/L}$)	10	10	10	10

**Table A-6. Kerr Hollow Quarry sediment samples taken from 1990 to 1992
(Analytes with at least one TCLP result greater than the detection limit)**

Analysis (units)	Proportion > detection limit	Minimum detected concentration	Maximum detected concentration	Mean ^a	Standard deviation	Detects >TCLP criteria	TCLP criteria
Barium (mg/L)	1/18	11.8	11.8	5.378	1.603	0/18	100
Cadmium (mg/L)	1/18	0.13	0.13	0.05444	0.01886	0/18	1
Lead (mg/L)	1/18	0.5	0.5	0.2639	0.05893	0/18	5
Mercury (mg/L)	2/18	0.08	0.1	0.01889	0.0261	0/18	0.2
Tetrachloroethene (µg/L)	1/18	88	88	21.28	22.25	0/18	700

^a Nondetects were set to 1/2 the detection limit and included in the average and standard deviation.

Table B-1. Construction data for groundwater monitoring wells located at Kerr Hollow Quarry

Well	North	East	Elevation ^a	TOC ^b	Screened or open interval ^c	TD ^c	Screen present	Aquifer zone
GW 142	24524	64030	968.29	970.35	248.5-295	295	No	BDK
GW 143	24257	63522	911.04	913.18	205-253	253	No	BDK
GW 144	24255	63502	910.48	913.34	150-190	195	Yes	BDK
GW 145	24441	63266	837.92	840.04	88.5-108.5	110	Yes	BDK
GW 146	24432	63272	837.00	838.16	190-220	220	No	BDK
GW 147	24731	63428	848.41	851.62	53-68.1	69	Yes	UNC/BDK
GW 231	24725	63410	846.90	849.47	24.5-34.5	35	Yes	UNC/BDK

^a Elevation reported is ground surface adjacent to well in feet above mean sea level

^b Top of casing measured in feet above mean sea level.

^c All downhole measurements in feet below ground surface.

BDK = Bedrock

UNC = Unconsolidated

Source: Jones et al. 1994

Table B-2. Kerr Hollow Quarry drinking water parameter results for CY 1986

Qtr	GW-142	GW-143	GW-144	GW-145	GW-146	GW-147	GW-231
<i>2,4,5-TP (SILVEX) (UG/L)</i>							
1986Q1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1
1986Q2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
1986Q3	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
1986Q4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
<i>2,4-D (UG/L)</i>							
1986Q1	<1	<2	<1	<1	<1	<1	<1
1986Q2	<2	<2	<2	<2	<2	<2	<2
1986Q3	<2	<2	<2	<2	<2	<2	<2
1986Q4	<1	<1	<1	<1	<1	<1	<1
<i>ARSENIC (MG/L)</i>							
1986Q1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
1986Q2	<0.005	<0.005	<0.005	0.005	<0.005	<0.005	<0.005
1986Q3	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
1986Q4	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
<i>BARIUM (MG/L)</i>							
1986Q1	0.14	0.033	0.034	0.077	0.0024	0.087	0.08
1986Q2	0.13	0.025	0.035	0.065	0.0081	0.059	0.094
1986Q3	0.1	0.014	0.039	0.073	0.019	0.072	0.12
1986Q4	0.19	0.05	0.039	0.098	0.035	0.09	0.15

Table B-2 (continued)

Qtr	GW-142	GW-143	GW-144	GW-145	GW-146	GW-147	GW-231
<i>CADMIUM (MG/L)</i>							
1986Q1	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
1986Q2	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
1986Q3	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
1986Q4	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
<i>CHROMIUM (MG/L)</i>							
1986Q1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1986Q2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1986Q3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
1986Q4	0.011	<0.01	<0.01	0.011	<0.01	<0.01	<0.01
<i>ENDRIN (UG/L)</i>							
1986Q1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
1986Q2	<0.1	<0.1	<0.05	<0.1	<0.1	<0.05	<0.1
1986Q3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1986Q4	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
<i>FLUORIDE (MG/L)</i>							
1986Q1	0.39	3.18	0.15	1.87	1.5	0.27	0.094
1986Q2	0.5	3.5	0.1	1.9	2	0.5	<0.1
1986Q3	0.1	2.7	0.1	1.4	2	<0.1	<0.11
1986Q4	0.3	2.8	0.1	1.9	1.8	0.1	<0.1

Table B-2 (continued)

Qtr	GW-142	GW-143	GW-144	GW-145	GW-146	GW-147	GW-231
<i>GROSS ALPHA (PCIL)</i>							
1986Q1	32	1	2	2	3.9	5	<0.1
1986Q2	<1	<1	<1	2.46	2.16	3.27	<1
1986Q3	<1	<2	5	8	18	<2	<2
1986Q4	13	17	10	14	4	15	12
<i>GROSS BETA (PCIL)</i>							
1986Q1	51	12	3	150	92.4	5	3.5
1986Q2	4.01	16.22	<2	61.13	41.71	13.87	4.14
1986Q3	6	12	9	65	44	8	2
1986Q4	16	33	12	39	43	18	19
<i>LEAD (MG/L)</i>							
1986Q1	0.027	<0.004	<0.004	<0.004	<0.004	0.006	<0.004
1986Q2	0.016	0.019	0.011	0.017	0.008	0.008	0.011
1986Q3	0.004	0.004	0.007	0.004	0.023	<0.004	0.004
1986Q4	0.005	<0.004	0.017	0.009	<0.004	<0.005	<0.004
<i>MERCURY (MG/L)</i>							
1986Q1	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
1986Q2	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
1986Q3	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
1986Q4	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002

Table B-2 (continued)

Qtr	GW-142	GW-143	GW-144	GW-145	GW-146	GW-147	GW-231
<i>METHOXYCHLOR (UG/L)</i>							
1986Q1	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
1986Q2	<0.08	<0.08	<0.04	<0.08	<0.08	<0.04	<0.08
1986Q3	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
1986Q4	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
<i>NITRATE AS N (MG/L)</i>							
1986Q1	0.27	<0.11	0.59	0.11	0.14	0.5	0.21
1986Q2	0.23	<0.11	0.47	<0.11	0.11	0.43	0.16
1986Q3	<0.11	<0.11	0.28	0.25	<0.11	0.75	<0.11
1986Q4	0.33	<0.11	0.41	0.29	<0.11	0.63	<0.11
<i>RADIUM (BQ/L)</i>							
1986Q1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1986Q2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
1986Q3	0.28	<0.1	<0.1	<0.1	0.54	<0.1	0.51
1986Q4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
<i>SELENIUM (MG/L)</i>							
1986Q1	<0.005	<0.005	<0.005	0.009	<0.005	<0.005	<0.005
1986Q2	<0.005	<0.005	<0.005	<0.005	0.006	<0.005	<0.005
1986Q3	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
1986Q4	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

Table B-2 (continued)

Qtr	GW-142	GW-143	GW-144	GW-145	GW-146	GW-147	GW-231
<i>SILVER (MG/L)</i>							
1986Q1	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
1986Q2	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
1986Q3	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
1986Q4	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
<i>TOXAPHENE (UG/L)</i>							
1986Q1	<1	<1	<1	<1	<1	<1	<1
1986Q2	<2	<2	<1	<2	<2	<1	<2
1986Q3	<2	<2	<2	<2	<2	<2	<2
1986Q4	<1	<1	<1	<1	<1	<1	<1

Table B-3. Kerr Hollow Quarry interim status detection monitoring parameters

Parameter	Analyze for
First year (1986)	
Primary drinking water standards	Arsenic
	Barium
	Cadmium
	Chromium
	Fluoride
	Lead
	Mercury
	Nitrate
	Selenium
	Silver
	Endrin
	Lindane
	Methoxychlor
	Toxaphene
	2-4-D
	2,4,5-TP
	Radium
	Gross alpha
	Gross beta
	Indicator parameters
Specific conductance	
Total organic carbon	
Total organic halides	
Parameters establishing groundwater quality	Chloride
	Iron
	Manganese
	Phenols
	Sodium
	Sulfate

Table B-3 (continued)

Parameter	Analyze for
Second and subsequent years (1987 through 1994)	
Indicator parameters ¹	pH Specific Conductance Total Organic Carbon Total Organic Halides
Parameters establishing groundwater quality ²	Chloride Iron Manganese Phenols Sodium Sulfate
Other analytes analyzed (1987)	
Trace metals ³	<i>ICP analysis</i> Potassium <i>Fluorimetric analysis</i> Uranium
Volatile organic compounds	Acetone Benzene Bromodichloromethane Bromoform Bromomethane 2-Butanone Carbon disulfide Carbon tetrachloride Chlorobenzene Chlorodibromomethane Chloroethane 2-Chloroethylvinyl ether Chloroform Chloromethane 1,1-Dichloroethane 1,2-Dichloroethane

Table B-3 (continued)

Parameter	Analyze for
Acid and base neutral extractable organics	1,1-Dichloroethene
	trans-1,2-Dichloroethene
	1,2-Dichloropropane
	cis-1,3-Dichloropropene
	trans-1,3-Dichloropropene
	Ethylbenzene
	2-Hexanone
	4-Methyl-2-pentanone
	Methylene chloride
	Styrene
	1,1,2,2-Tetrachloroethane
	Tetrachloroethene
	Toluene
	1,1,1-Trichloroethane
	1,1,2-Trichloroethane
	Trichloroethene
	Vinyl acetate
	Vinyl chloride
	Xylenes
	Acenaphthylene
	bis (2-Chloroethyl) ether
	2-Chlorophenol
	1,3-Dichlorobenzene
	1,4-Dichlorobenzene
	Benzyl alcohol
	1,2-Dichlorobenzene
	2-Methylphenol
	bis (2-Chloroisopropyl) ether
4-Methylphenol	
N-Nitrosodi-N-propylamine	
Hexachloroethane	
Nitrobenzene	

Table B-3 (continued)

Parameter	Analyze for
	Isophorone
	2-Nitrophenol
	2,4-Dimethylphenol
	Benzoic acid
	bis (2-Chloroethoxy) methane
	2,4-Dichlorophenol
	1,2,4-Trichlorobenzene
	Naphthalene
	4-Chloroaniline
	Hexachlorobutadiene
	4-Chloro-3-methylphenol
	2-Methylnaphthalene
	Hexachlorocyclopentadiene
	2,4,6-Trichlorophenol
	2,4,5-Trichlorophenol
	2-Chloronaphthalene
	2-Nitroaniline
	Dimethylphthalate
Major ions	Alkalinity - carbonate
	Alkalinity - Bicarbonate
	Nitrate (as N)
Field measurements	Temperature
	Dissolved oxygen
	Static water level
	Oxidation reduction potential (REDOX)
Other analytes analyzed (1988)	
Trace metals ³	<i>ICP analysis</i>
	Aluminum
	Antimony
	Arsenic
	Barium

Table B-3 (continued)

Parameter	Analyze for
	Beryllium
	Boron
	Calcium
	Cadmium
	Chromium
	Cobalt
	Copper
	Magnesium
	Molybdenum
	Nickel
	Niobium
	Phosphorous
	Potassium
	Selenium
	Silicon
	Silver
	Strontium
	Thorium
	Titanium
	Vanadium
	Zinc
	Zirconium
	<i>Fluorimetric analysis</i>
	Uranium
Major ions	Alkalinity - carbonate
	Alkalinity - Bicarbonate
	Nitrate (as N)
Miscellaneous parameters	Total suspended solids (TSS)
	Total dissolved solids (TDS)
Field measurements	Temperature
	Dissolved oxygen
	Static water level

Table B-3 (continued)

Parameter	Analyze for
Other analytes analyzed (1989)	Oxidation reduction potential (REDOX)
Trace metals ³	<i>ICP analysis</i>
	Aluminum
	Antimony
	Arsenic
	Barium
	Beryllium
	Boron
	Calcium
	Cadmium
	Chromium
	Cobalt
	Copper
	Lead
	Magnesium
	Molybdenum
	Nickel
	Potassium
	Selenium
	Silicon
	Silver
	Strontium
	Thorium
	Vanadium
	Zinc
	<i>AAS analysis</i>
	Cadmium
	<i>Fluorimetric analysis</i>
	Uranium

Table B-3 (continued)

Parameter	Analyze for
Major ions	Alkalinity - carbonate
	Alkalinity - Bicarbonate
	Nitrate (as N)
Miscellaneous parameters	Total suspended solids (TSS)
	Total dissolved solids (TDS)
	Turbidity
Field measurements	Temperature
	Dissolved oxygen
	Static water level
	Oxidation reduction potential (REDOX)
Other analytes analyzed (1990 through 1994)	<i>ICP analysis</i>
	Trace metals ³
	Aluminum
	Antimony
	Arsenic
	Barium
	Beryllium
	Boron
	Calcium
	Cadmium
	Chromium
	Cobalt
	Copper
	Magnesium
	Molybdenum
	Nickel
	Potassium
	Selenium
	Silicon ⁴
	<i>AAS analysis</i>
	Cadmium

Table B-3 (continued)

Parameter	Analyze for
Volatile organic compounds	Chromium
	Lead
	<i>Cold vapor atomic absorption</i>
	Mercury
	<i>Fluorimetric analysis</i>
	Uranium
	Acetone
	Benzene
	Bromodichloromethane
	Bromoform
	Bromoethane
	2-Butanone
	Carbon disulfide
	Carbon tetrachloride
	Chlorobenzene
	Chlorodibromomethane
	Chloroethane
	Chloroform
	Chloromethane
	1,1-Dichloroethane
	1,2-Dichloroethane
	1,1-Dichloroethene
	1,2-Dichloroethene
	1,2-Dichloropropane
	cis-1,3-Dichloropropene
	trans-1,3-Dichloropropene
	Ethylbenzene
	2-Hexanone
4-Methyl-2-pentanone	
Methylene chloride	
Styrene	
1,1,2,2-Tetrachloroethane	

Table B-3 (continued)

Parameter	Analyze for
	Tetrachloroethene
	Toluene
	1,1,1-Trichloroethane
	1,1,2-Trichloroethane
	Trichloroethene
	Vinyl acetone
	Vinyl chloride
	Xylenes
Major ions	Alkalinity - carbonate
	Alkalinity - Bicarbonate
	Fluoride
	Nitrate (as N)
Miscellaneous parameters	pH
	Total suspended solids (TSS)
	Total dissolved solids (TDS)
	Turbidity
Radiological parameters	Gross alpha activity
	Gross beta activity
Field measurements	Temperature
	Dissolved oxygen
	Static water level
	Oxidation reduction potential (REDOX)

¹ Analyzed semi-annually

² Analyzed annually

³ ICP - Inductively coupled plasma spectroscopy
AAS - Atomic absorption spectroscopy

⁴ Silicon was analyzed for in 1990 and 1991 only

**Table B-4. Summary of statistically significant results at the Kerr Hollow Quarry
for 1987 through 1994**

Test	Results
1987 Results	
Total organic carbon	Unable to perform t-test
pH (pH units)	
GW-142	Significantly less than 1986 upgradient (7.6/8.2), Q4
GW-144	Significantly less than 1986 upgradient (7.6/8.2), Q4
GW-144	Significantly less than 1986 (7.6/7.9), Q4
GW-231	Significantly less than 1986 upgradient (7.6/8.2), Q2 Significantly less than 1986 upgradient (7.5/8.2), Q4
GW-231	Significantly less than 1986 (7.5/7.8), Q4
Conductivity (μ mhos/cm)	
GW-145	Significantly greater than 1986 (783/602), Q2
1988 Results	
Total organic carbon	Unable to perform t-test
pH (pH units)	
GW-142	Significantly less than 1986 (7.1/8.2), Q2
GW-142	Significantly less than 1986 upgradient (7.1/8.3), Q2
GW-144	Significantly less than 1986 (7.4/8.0), Q2 Significantly less than 1986 (7.6/8.0), Q4
GW-144	Significantly less than 1986 upgradient (7.4/8.3), Q2 Significantly less than 1986 upgradient (7.6/8.3), Q4
GW-231	Significantly less than 1986 (7.5/7.9), Q2 Significantly less than 1986 (7.5/7.9), Q4
GW-231	Significantly less than 1986 upgradient (7.5/8.3), Q2 Significantly less than 1986 upgradient (7.5/8.3), Q4
1989 Results	
Total organic carbon	Unable to perform t-test
pH (pH units)	
GW-142	Significantly less than 1986 (6.9/8.2), Q1 Significantly less than 1986 (6.7/8.2), Q3

Table B-4 (continued)

Test	Results
GW-142	Significantly less than 1986 upgradient (6.9/8.3), Q1 Significantly less than 1986 upgradient (6.7/8.3), Q3
GW-144	Significantly less than 1986 (6.6/8.0), Q1 Significantly less than 1986 (6.5/8.0), Q3
GW-144	Significantly less than 1986 upgradient (6.6/8.3), Q1 Significantly less than 1986 upgradient (6.5/8.3), Q3
GW-145	Significantly less than 1986 (7.2/8.2), Q1 Significantly less than 1986 (6.7/8.2), Q3
GW-231	Significantly less than 1986 (6.5/7.9), Q1 Significantly less than 1986 (6.5/7.9), Q3
GW-231	Significantly less than 1986 upgradient (6.5/8.3), Q1 Significantly less than 1986 upgradient (6.5/8.3), Q3
1990 Results	
pH (pH units)	
GW-142	Significantly less than 1986 (7.0/8.2), Q1 Significantly less than 1986 (7.2/8.2), Q4
GW-142	Significantly less than 1986 upgradient (7.0/8.3), Q1 Significantly less than 1986 upgradient (7.2/8.3), Q4
GW-144	Significantly less than 1986 (6.9/8.0), Q1 Significantly less than 1986 (6.9/8.0), Q4
GW-144	Significantly less than 1986 upgradient (6.9/8.3), Q1 Significantly less than 1986 upgradient (6.9/8.3), Q4
GW-145	Significantly less than 1986 (7.2/8.3), Q1 Significantly less than 1986 (7.3/8.3), Q4
GW-231	Significantly less than 1986 (7.0/7.9), Q1 Significantly less than 1986 (6.9/7.9), Q4
GW-231	Significantly less than 1986 upgradient (7.0/8.3), Q1 Significantly less than 1986 upgradient (6.9/8.3), Q4
1991 Results	
Total organic carbon	
GW-142	Significantly greater than 1987 upgradient (3.75/1.43)
pH (pH units)	
GW-142	Significantly less than 1986 (7.1/8.2), Q1
GW-142	Significantly less than 1986 upgradient (7.1/8.3), Q1

Table B-4 (continued)

Test	Results
GW-144	Significantly less than 1986 (6.9/8.0), Q1 Significantly less than 1986 (7.8/8.0), Q3
GW-144	Significantly less than 1986 upgradient (6.9/8.3), Q1
GW-145	Significantly less than 1986 (7.1/8.3), Q1
GW-231	Significantly less than 1986 (6.9/7.9), Q1 Significantly less than 1986 (7.4/7.9), Q3
GW-231	Significantly less than 1986 upgradient (6.9/8.3), Q1 Significantly less than 1986 upgradient (7.4/8.3), Q3
Conductivity (μ mhos/cm)	
GW-142	Significantly greater than 1986 (440/351), Q1 Significantly greater than 1986 (462/351), Q3
1992 Results	
Total organic carbon	
GW-145	Significantly greater than 1987 (9.10/1.43), Q3
pH (pH units)	
GW-142	Significantly less than 1986 upgradient (7.7/8.3), Q3
GW-144	Significantly less than 1986 (7.8/8.0), Q1
GW-231	Significantly less than 1986 upgradient (7.7/8.3), Q3
Conductivity (μ mhos/cm)	
GW-142	Significantly greater than 1986 (447/351), Q1
1993 Results	
Total organic carbon	
GW-142	Significantly greater than 1987 upgradient (3.25/1.43), Q2
GW-145	Significantly greater than 1987 (6.75/1.43), Q2
pH (pH units)	
GW-144	Significantly greater than 1986 (8.3/8.0), Q2
GW-231	Significantly less than 1986 (7.5/7.9), Q1
GW-231	Significantly less than 1986 upgradient (7.5/8.3), Q1 Significantly less than 1986 upgradient (7.7/8.3), Q4

Table B-4 (continued)

Test	Results
Conductivity (μ mhos/cm)	
GW-142	Significantly greater than 1986 (441/351), Q1 Significantly greater than 1986 (446/351), Q2 Significantly greater than 1986 (442/351), Q3
1994 Results	
Total organic carbon (mg/L)	
GW-145	Significantly greater than 1987 (5.50/1.43), Q2 Significantly greater than 1987 (3.68/1.43), Q3 Significantly greater than 1987 (4.00/1.43), Q4
pH (pH units)	
GW-142	Significantly less than 1986 upgradient (7.7/8.3), Q4
GW-144	Significantly greater than 1986 (8.2/8.0), Q1 Significantly less than 1986 (7.8/8.0), Q2 Significantly less than 1986 (7.8/8.0), Q4
GW-231	Significantly less than 1986 (7.4/7.9), Q2 Significantly less than 1986 (7.5/7.9), Q3 Significantly less than 1986 (7.8/7.9), Q4
GW-231	Significantly less than 1986 upgradient (7.7/8.3), Q1 Significantly less than 1986 upgradient (7.4/8.3), Q2 Significantly less than 1986 upgradient (7.5/8.3), Q3 Significantly less than 1986 upgradient (7.5/8.3), Q4
Conductivity (μ mhos/cm)	
GW-142	Significantly greater than 1986 (439/351), Q1 Significantly greater than 1986 (449/351), Q2

Note: Values in parenthesis present the current value compared to the reference value. For example, "significantly less than 1986 upgradient (7.6/8.2), Q4" shows the fourth quarter result of 7.6 compared to the 1986 upgradient reference value of 8.2.

Q1 1st Quarter
Q2 2nd Quarter
Q3 3rd Quarter
Q4 4th Quarter

Table B-5. Kerr Hollow Quarry 1988 Appendix IX constituent detections

	GW-142	GW-143	GW-144	GW-145	GW-147	GW-231
Total Elemental Analysis-Metals (mg/l)						
Barium	0.45	U	U	0.216	0.216	0.253
Chromium	U	U	U	0.011	U	U
Lead	0.0056	U	0.008	0.0408	0.0293	U
HSL VOCs ($\mu\text{g/l}$)						
Methylene Chloride	30	31	2	2	2	2
Acetone	3	3	6	U	U	6
Chloroform	U	U	1	U	U	U
Carbon Tetrachloride	U	U	5		U	U
Benzene	2	U	U	U	U	U
Toluene	23	2	U	U	U	U
Fluorotrichloromethane	5	5	U	U	U	U
VOA—Non-HSL ($\mu\text{g/l}$)						
Acetonitrile	U	U	13	U	U	U
Semi-volatile HSL ($\mu\text{g/l}$)						
Di-n-Butylphthalate	U	U	2	2	1	3
bis-2-Ethylhexylphthalate	2	6	8	13	12	74
Herbicides/Pesticides ($\mu\text{g/l}$)						
beta-BHC	U	U	0.16	U	0.07	0.03

Source: Weston 1989

HSL = Hazardous substance list

U = analyte was analyzed for but not detected

Table B-6. Summary of field and laboratory residuum permeability test results

Range of depth tested (ft)	Typical depth(s) tested (ft)	Mean field hydraulic conductivity (ft/d)	Number of tests	Mean laboratory hydraulic conductivity (ft/d)	Number of tests	Reference
0-25	10	1.7×10^{-2}	21	9.1×10^{-3}	12	^a
	5-25	2.7×10^{-1}	6	6.4×10^{-4}	3	^b
	0-6	1.8	16	No data	0	^c
25-60	40	5.7×10^{-3}	18	2.8×10^{-4}	3	^a
	25-60	4.3×10^{-1}	8	2.8×10^{-5}	7	^b
60-100	70-100	No data	0	1.8×10^{-4}	8	^a
	60-85	4.9×10^{-1}	4	No data	0	^b

^a Woodward Clyde 1984

^b Mishu 1982

^c Results are for vertical permeameter test.

Modified from Ketelle and Huff 1984, Mishu 1982.

Table B-7. Summary of packer test results for core holes GW-131, GW-135, and CH-157^a

Test number	Tested depth interval (ft)	Hydraulic conductivity (ft/d)
CH-157-10	145 - 157	2.4×10^{-1}
CH-157-1	215 - 227	5.01×10^{-1}
CH-157-2	265 - 277	3.03
CH-157-3	282 - 294	5.61×10^{-1}
CH-157-4	314 - 326	9.13×10^{-3}
CH-157-5	326 - 338	8.90×10^{-1}
CH-157-6	344 - 356	2.18×10^{-4}
CH-157-7	392 - 404	8.28×10^{-4}
CH-157-8	432 - 444	2.09×10^{-1}
CH-157-9	468 - 480	4.17×10^{-1}
GW-135-1	190 - 217	1.56×10^{-2}
GW-135-2	324 - 351	2.03×10^{-1}
GW-135-3	397 - 424	2.72×10^{-1}
GW-135-4	446 - 473	2.22×10^{-1}
GW-135-5	588 - 615	1.01×10^{-2}
GW-131-10	120 - 147	1.31
GW-131-1	240 - 267	3.20
GW-131-2	290 - 317	2.08×10^{-4}
GW-131-3	370 - 397	1.24×10^{-1}
GW-131-4	450 - 477	5.44×10^{-1}
GW-131-5	490 - 517	3.23×10^{-3}

^a GW-131 and GW-135 are designated as GW-series wells, as opposed to the CH-classification for core hole CH-157, because they were subsequently equipped with multi-port monitoring devices.

Modified from King and Haase 1988.

Table B-8. Summary of average cation and anion concentrations detected in groundwater samples collected during CY 1994 from Kerr Hollow Quarry monitoring wells

Well no.	Calcium (meq/L)	Magnesium (meq/L)	Potassium (meq/L)	Sodium (meq/L)	
GW-142	2.20	2.57	0.10	0.043	
GW-143	1.54	2.02	0.45	1.05	
GW-144	1.93	1.15	0.05	0.05	
GW-145	2.10	2.82	0.32	0.33	
GW-146	2.04	2.80	0.43	0.55	
GW-147	1.55	1.48	0.18	0.14	
GW-231	1.58	1.31	0.04	0.05	
	HCO ₃ (meq/L)	Chloride (meq/L)	Fluoride (meq/L)	Nitrate-N (meq/L)	Sulfate (meq/L)
GW-142	4.70	0.05	0.03	0.00	0.12
GW-143	4.06	0.19	0.16	0.01	0.80
GW-144	3.04	0.06	0.01	0.12	0.14
GW-145	4.23	0.26	0.14	0.01	0.71
GW-146	4.03	0.35	0.15	0.02	1.38
GW-147	3.14	0.06	0.02	0.09	0.08
GW-231	2.84	0.06	0.00	0.06	0.07

meq/L = milliequivalent per liter

Source: HSW, Inc. 1995

Table B-9. Public users of groundwater within 10 miles of the Kerr Hollow Quarry^a

Public water user	People served	Yield (gpd)	Source	Probable water-bearing formation
Oliver Springs	4,000	2.5×10^5	Spring	Knox
Dutch Valley Elementary School	140	2.7×10^3	Well	Rome
First Utility District of Anderson County	3,600	2.7×10^5	Spring	Conasauga
West Knox Utility District	15,000	1.3×10^6	Well ^b	Knox
Dixie-Lee Utility District	6,700	4.1×10^5	Spring	Knox
Edgewood SE Center	100	4.3×10^3	Well	Knox
Cumberland Utility District of Roane and Morgan Counties	4,300	1.7×10^5	Spring ^c	Knox
Charles H. Bacon Co.		8.4×10^4	Well	Knox

^a Union Carbide Corporation, Nuclear Division (1982) and personal communication between H. King and D. Rosowitz (1994).

^b Half supply.

^c Primary source.

**Table B-10. Validated VOC results from Kerr Hollow Quarry well sampling
since first quarter CY 1990 (in $\mu\text{g/L}$)**

Well	GW-142		GW-144		
	Chloroform	Tetrachloroethene	Carbon Tetrachloride	Chloroform	Tetrachloroethene
Q4/94	U	U	U	U	U
Q3/94	U	U	U	U	U
Q2/94	U	U	2.0	U	U
Q1/94	U	U	U	U	U
Q4/93	4.0	U	3.0	U	U
Q3/93	U	U	3.0	U	U
Q2/93	U	U	U	U	U
Q1/93	U	U	U	U	U
Q4/92	U	U	5.0	0.8	U
Q3/92	U	U	2.0	U	U
Q2/92	U	2.0	2.0	U	U
Q1/92	U	U	U	U	U
Q4/91	U	0.8	1.0	U	1.0
Q3/91	U	0.7	2.0	2.0	2.0
Q2/91	U	U	5.0	1.0	U
Q1/91	U	0.7	U	U	U
Q4/90	U	U	2.0	U	U
Q3/90	U	0.9	6.0	1.0	U
Q2/90	U	U	U	U	U
Q1/90	U	U	U	U	U

U = Not detected

Note: All results validated against laboratory and trip blanks

Table B-11. Monitoring parameters and comparative values
(values are mg/L unless otherwise noted)

Parameter	Tolerance Limit
Barium	0.49 ¹
Boron	— ²
Cadmium	0.005 ³
Chromium	0.1 ³
Lead	0.035 ¹
Mercury	0.002 ³
Nickel	0.1 ³
Strontium (total)	— ²
Uranium (total)	0.019 ¹
Gross Alpha	15 pCi/L ³
Gross Beta	4 mrem/year ³
Carbon Tetrachloride	5 µg/L ³
Tetrachloroethene	5 µg/L ³
Chloroform	100 µg/L ^{3,4}

µg/L micrograms per liter
 mg/L milligram per liter
 pCi/L picoCuries per liter
 mrem millirem
 MCL maximum contaminant level

¹ UTL

² Annual trending analysis

³ MCL

⁴ MCL is for total trihalomethanes

**Table B-12. Construction details of proposed monitoring well network for Kerr Hollow Quarry
Energy Systems, Inc. Y-12 Plant Oak Ridge, Tennessee**

Well Number:	GW-142	GW-143	GW-144	GW-145	GW-231
North Coordinates	24524.00	24257.00	24255.00	24441.00	24725.00
East Coordinates	64030.00	63522.00	63502.00	63266.00	63410.00
Surface Elevation (ft)	968.29	911.04	910.48	837.29	846.90
Measuring Point Elevation (ft)	970.35	913.18	913.34	840.04	849.47
Aquifer Zone	BDR	BDR	BDR	WT	BDR
Geologic Formation	Ock	Ock	Ock	Ock	Ock
Hydrostratigraphic Unit	AQF	AQF	AQF	AQF	AQF
Top of Fresh Bedrock (ft bgs)	NA	18.0	40.0	12.0	10.5
Total Drilled Depth (ft bgs)	295.0	253.0	195.0	110.0	35.0
Screen Or Open	open	open	screened	screened	screened
Top of Monitoring Interval (ft bgs)	248.5	205.0	148.0	86.0	22.8
Bottom of Monitoring Interval (ft bgs)	295.0	253.0	195.0	110.0	35.0
Screen Material	NA	NA	PVC/#40	PVC/#40	PVC/#40
Screen Slot Size (in)	NA	NA	sw/0.01	sw/0.01	sw/0.01
Screen Length (ft)	NA	NA	40.0	20.0	10.0
Top Filter Pack (ft bgs)	NA	NA	148.0	86.0	22.8
Bottom Filter Pack (ft bgs)	NA	NA	195.0	110.0	35.0
Top Filter Pack (ft, msl)	NA	NA	765.34	754.04	826.67
Bottom Filter Pack (ft, msl)	NA	NA	718.34	730.04	814.47
Cond. Borehole Depth (ft bgs)	20.0	20.0	40.0	NA	35.0
Cond. Borehole Diameter (in)	16.75	16.75	15.0	NA	11.00

Table B-12 (continued)

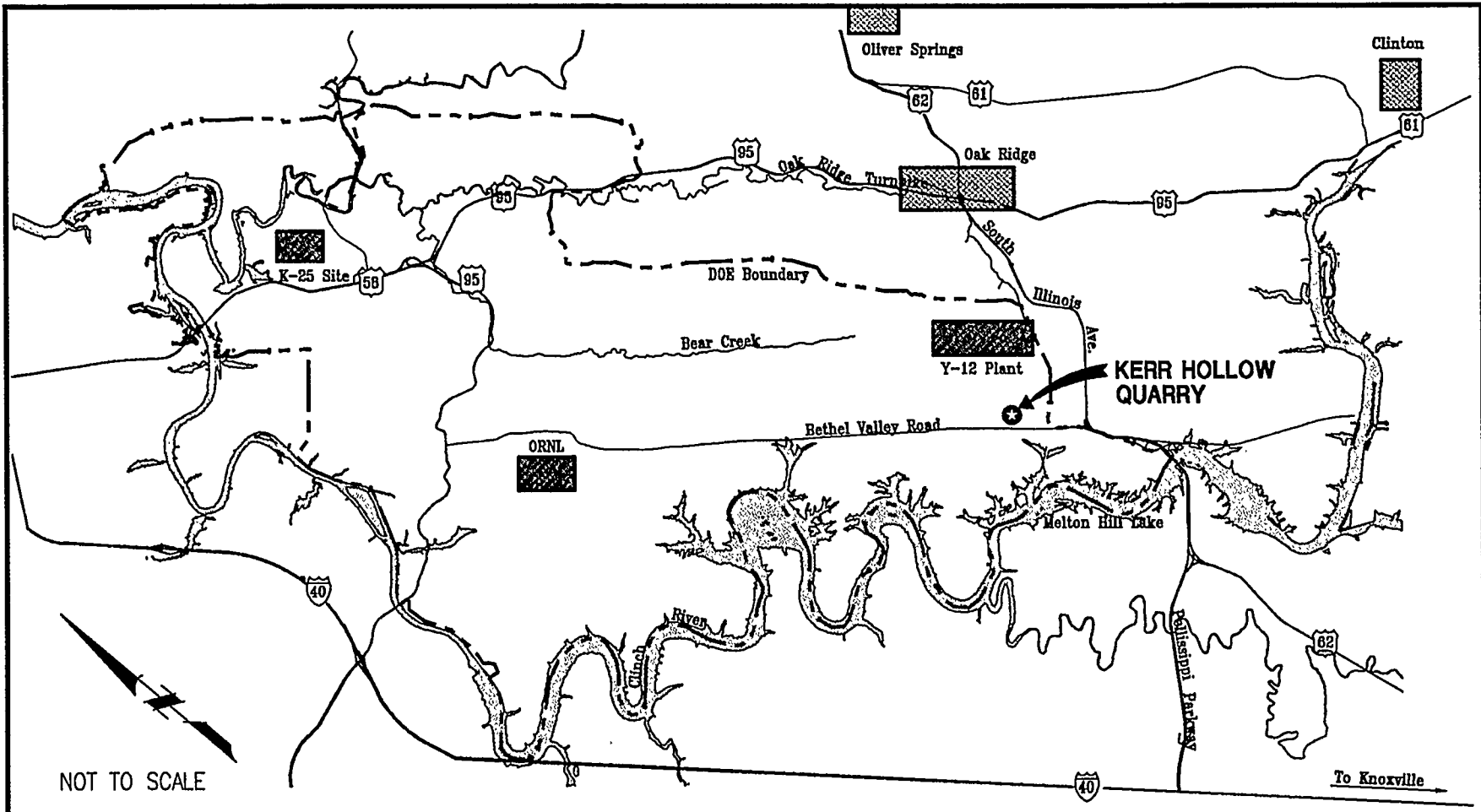
Well Number:	GW-142	GW-143	GW-144	GW-145	GW-231
Conductor Casing Type	PVC/#40	PVC/#40	PVC/#40	PVC/#40	PVC/#40
Conductor Casing O.D. (in)	12.5	10.625	12.5	12.5	10.625
Conductor Casing I.D. (in)	11.75	9.875	11.75	11.75	9.825
Conductor Casing Depth (ft bgs)	20.0	20.0	40.0	12.0	11.0
Pilot Borehole Depth (ft bgs)	NA	NA	NA	NA	NA
Pilot Borehole Diameter (in)	NA	NA	NA	NA	NA
Inner Casing Type	Steel/F25	Steel/F25	PVC/#40	PVC/#40	PVC/#40
Inner Casing O.D. (in)	6.625	6.625	4.5	4.5	4.5
Inner Casing I.D. (in)	6.125	6.125	4.0	4.0	4.0
Inner Casing Depth (ft bgs)	248.5	205.0	150.0	88.5	24.5
Date Completed	03Oct85	24Oct85	24Oct85	14Oct85	02Oct85
Reference	Y/TS-881/R2	Y/TS-881/R2	Y/TS-881/R2	Y/TS-881/R2	Y/TS-881/R2

Abbreviations

BDR	Bedrock Interval
WT	Water Table Interval
ft	feet
AQF	Knox Aquifer
Ock	Knox Group
NA	Not Applicable or Not Available
bgs	below ground surface
in	inches
sw	spiral wound
PVC	polyvinyl chloride
msl	mean sea level

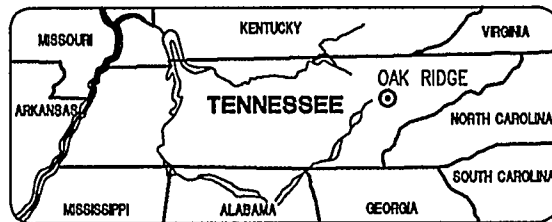
Y/TS-881/R2 Jones et al. 1994

FIGURES



LEGEND:

- ===== ASPHALT ROAD
- STREAM OR SHORELINE
- - - - - OAK RIDGE RESERVATION BOUNDARY

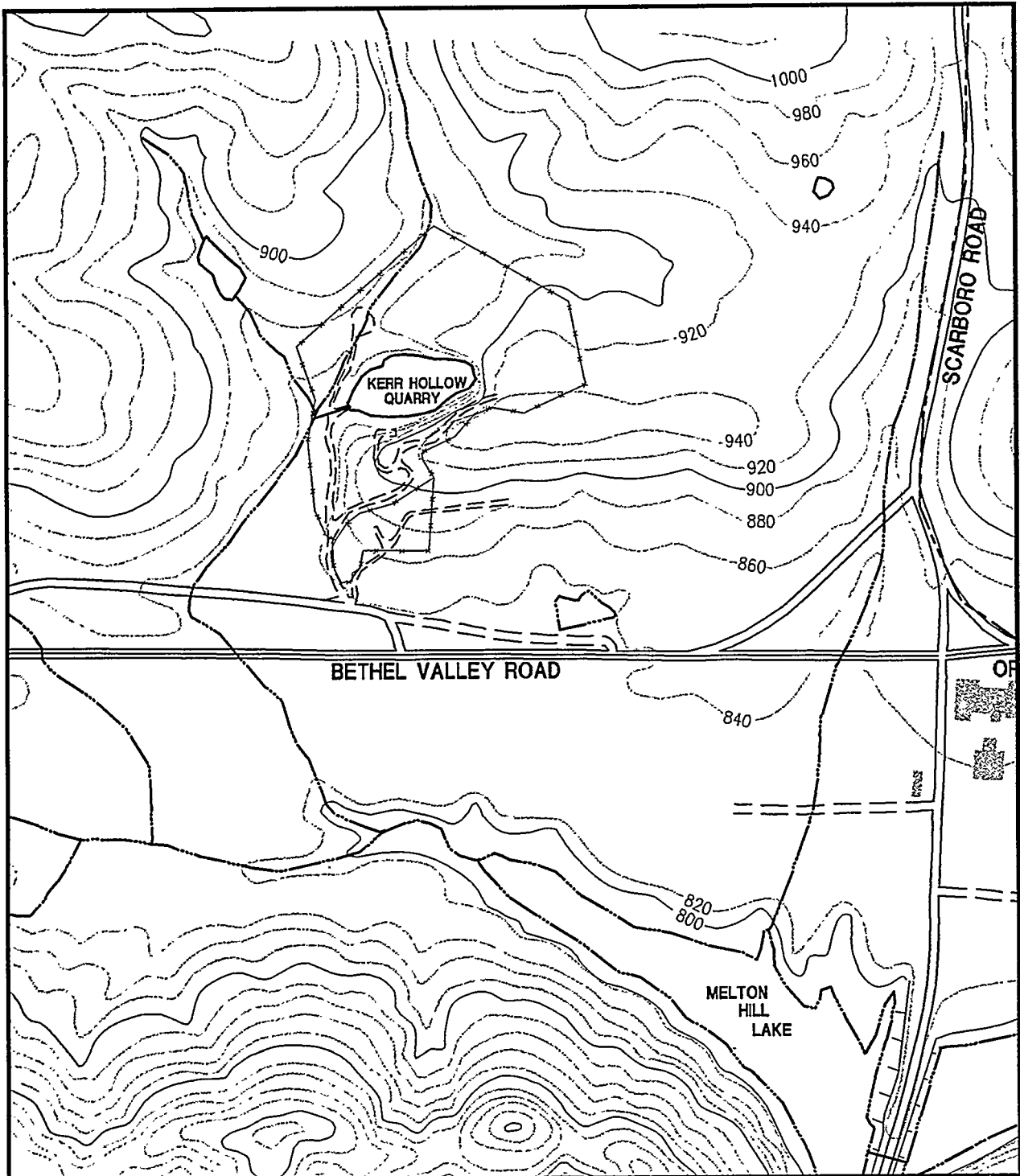


KEY MAP
NOT TO SCALE

Figure A-1.
Regional Location Map

**KERR HOLLOW QUARRY
OAK RIDGE RESERVATION
OAK RIDGE, TENNESSEE**

DRAWN BY: R. BEELER	REV. NO./DATE: REV. 0 / 04-25-85	CAD FILE: /B4014/DWGS/096LOC
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LEGEND:

- ==== PAVED ROADS
- == DIRT ROADS
- ~~~~ CREEKS
- - - - 20' CONTOUR INTERVAL
- DOE BOUNDARY
- x - x - FENCE

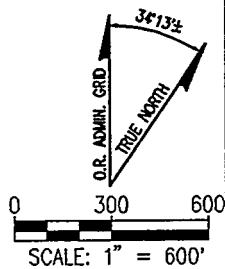


Figure A-2.
Security Map

**KERR HOLLOW QUARRY
OAK RIDGE RESERVATION
OAK RIDGE, TENNESSEE**

94014	DMGSOBSECC	
CAD FILE NAME	DRAWING #	PLOT FILE NAME

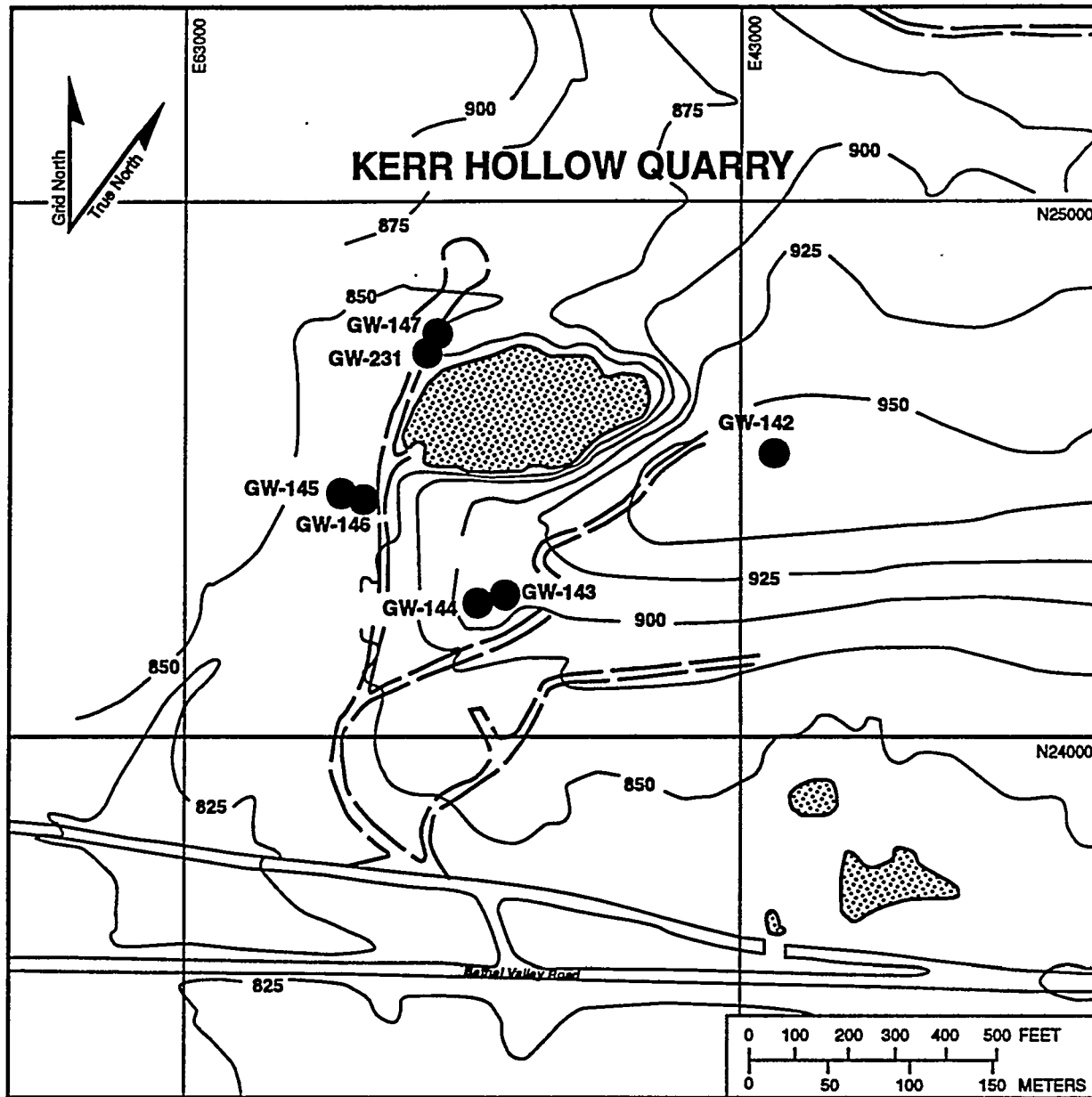
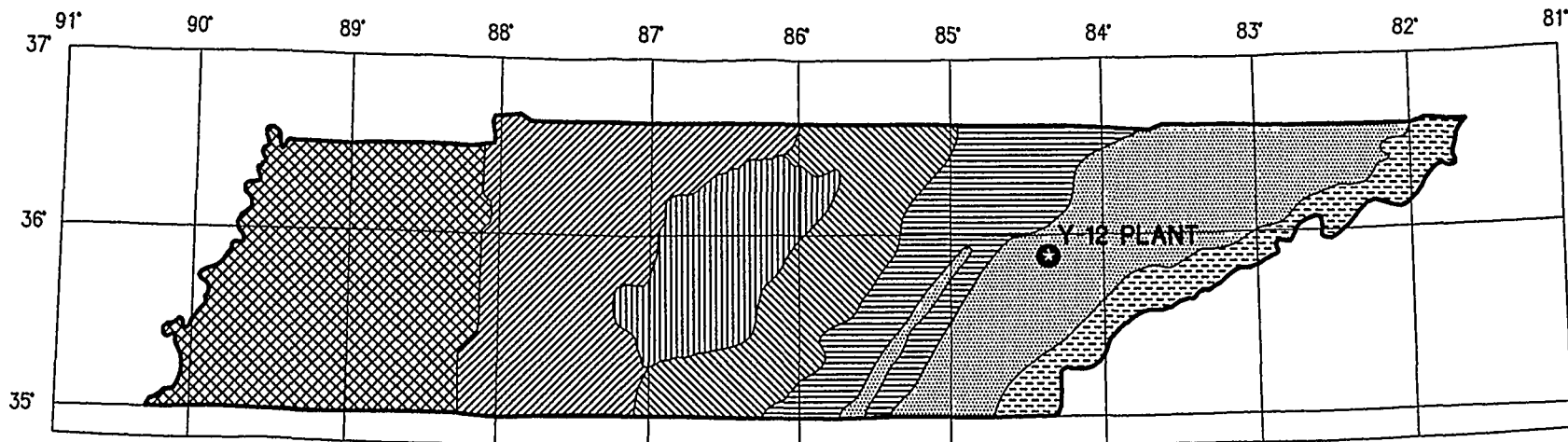









Figure B-1. Location of groundwater monitoring wells at Kerr Hollow Quarry.



PHYSIOGRAPHIC PROVINCES

- MISSISSIPPI EMBAYMENT
- WESTERN HIGHLAND RIM
- EASTERN HIGHLAND RIM
- CENTRAL BASIN
- CUMBERLAND PLATEAU
- VALLEY AND RIDGE
- BLUE RIDGE

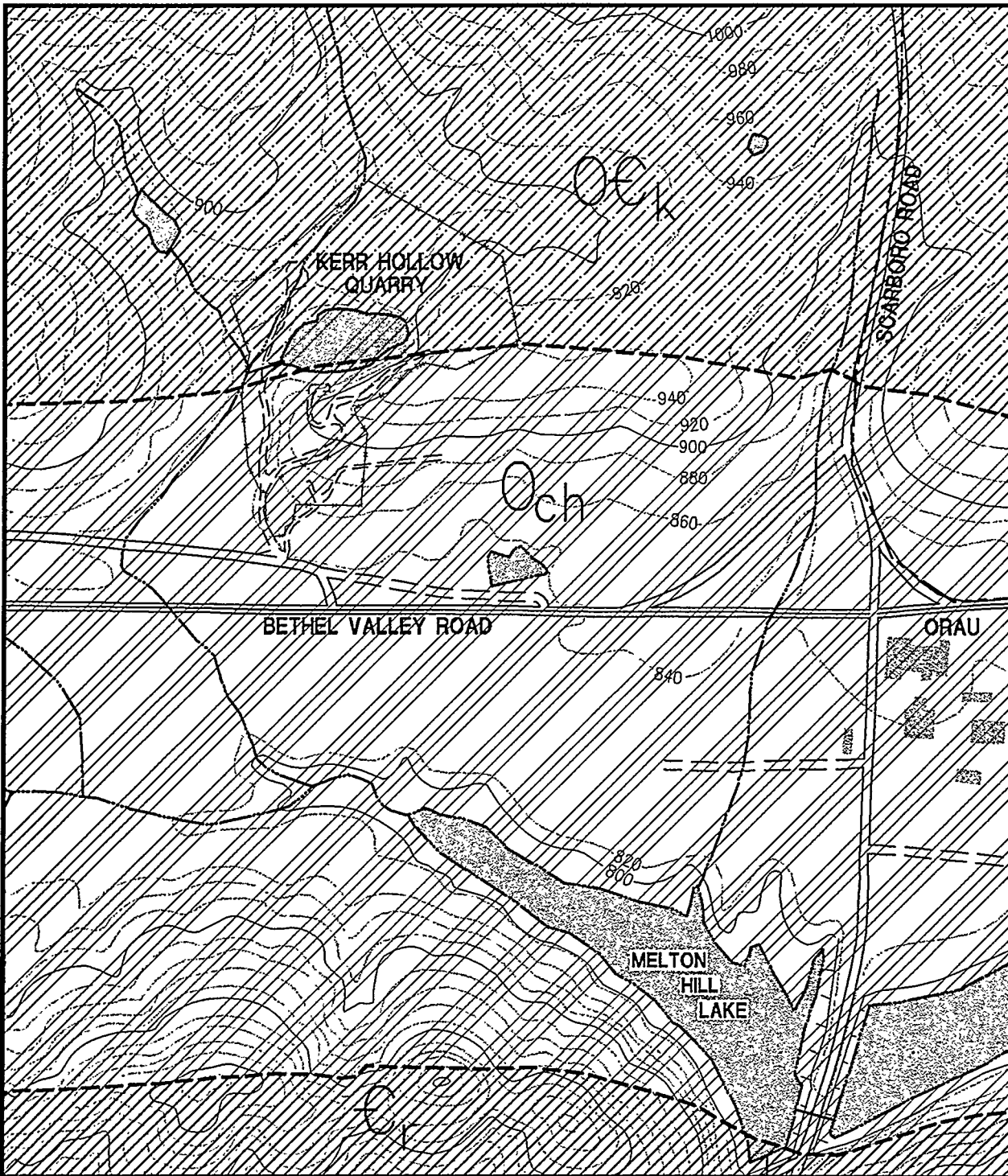


NOT TO SCALE

Figure B-2.
Physiographic Map
of Tennessee.

KERR HOLLOW QUARRY
OAK RIDGE RESERVATION
OAK RIDGE, TENNESSEE

DRAWN BY: R. BEELER	REV. NO./DATE: REV. 0/04-07-95	CAD FILE: /94014/DWGS/084THGEO
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LEGEND:

- PAVED ROADS
- == DIRT ROADS
- ~ CREEKS
- .20' CONTOUR INTERVAL
- - - - - DOE BOUNDARY
- x x FENCE
- - - - - GEOLOGIC CONTACT

- KNOX GROUP
- CHICKAMAUGA GROUP
- ROME FORMATION

SOURCE:

Hatcher et al, 1992.

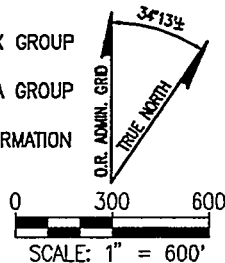
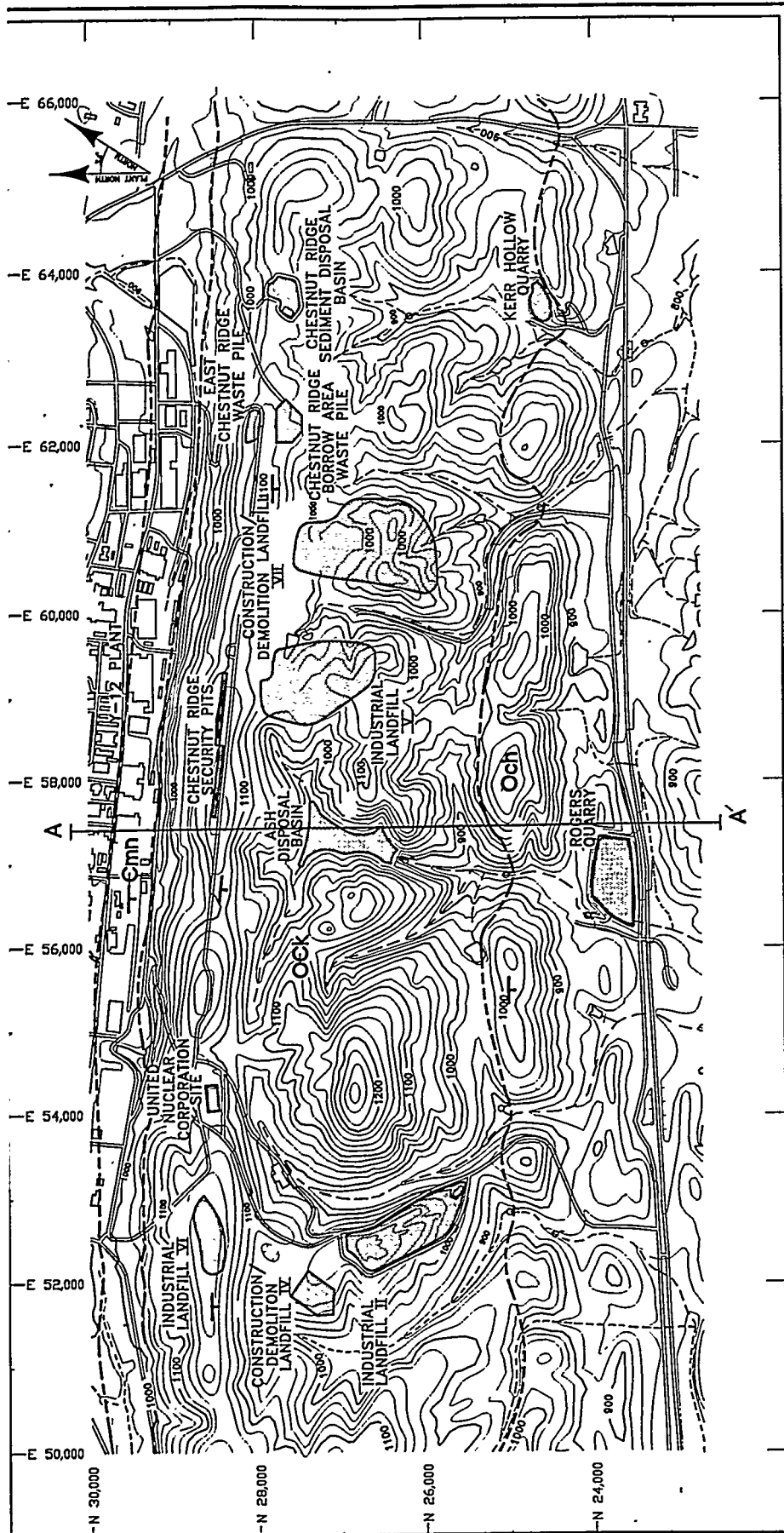


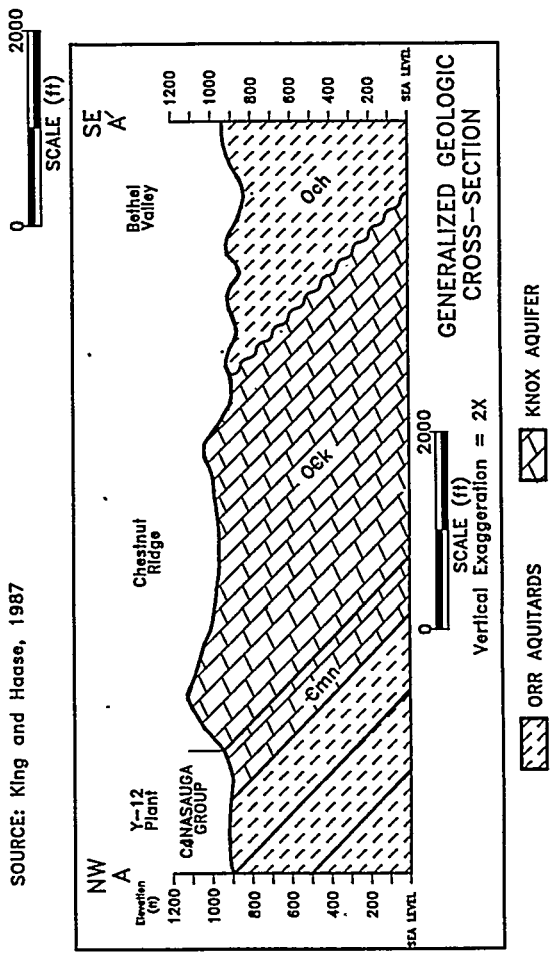
Figure B-3.
Geology in the Vicinity
of Kerr Hollow Quarry

KERR HOLLOW QUARRY
OAK RIDGE RESERVATION
OAK RIDGE, TENNESSEE

94014	\\DWGS\748GEO	\\PLOT\748GEO
CAD FILE NAME	DRAWING #	PLOT FILE NAME



SYSTEM	GROUP (Formation)	HYDRO UNIT	MAP SYMBOL	THICKNESS (FT)
ORDOVICIAN	CHICKAMAUGA (Undifferentiated)	ORR AQUITARDS	Och	1500 TO 2000
	MIDDLE MISSING SECTION (Subaerial Erosion)			
CAMBRIAN	LOWER KNOX (Undifferentiated)	KNOX AQUIFER	Ock	2500 TO 3000
	UPPER CONASAUGA (Maynardville Limestone)		€mn	418 TO 450



LOCATION:	Y-12 PLANT OAK RIDGE, TN.
DATE:	2-13-95
DWG ID.:	OR211-HC

Figure B-4. Generalized geologic map of the Y-12 Plant area.

SOURCE: King and Haase, 1987

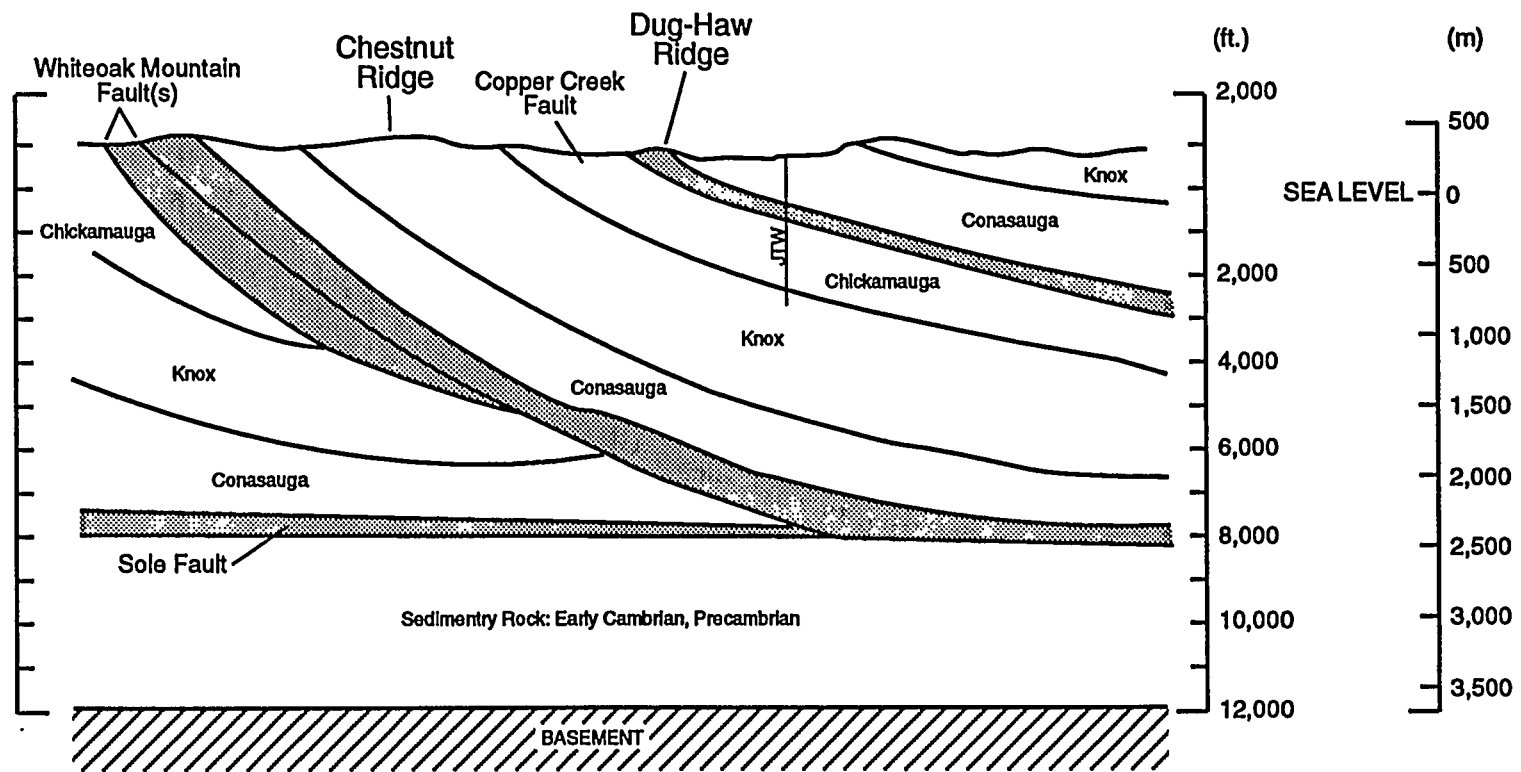
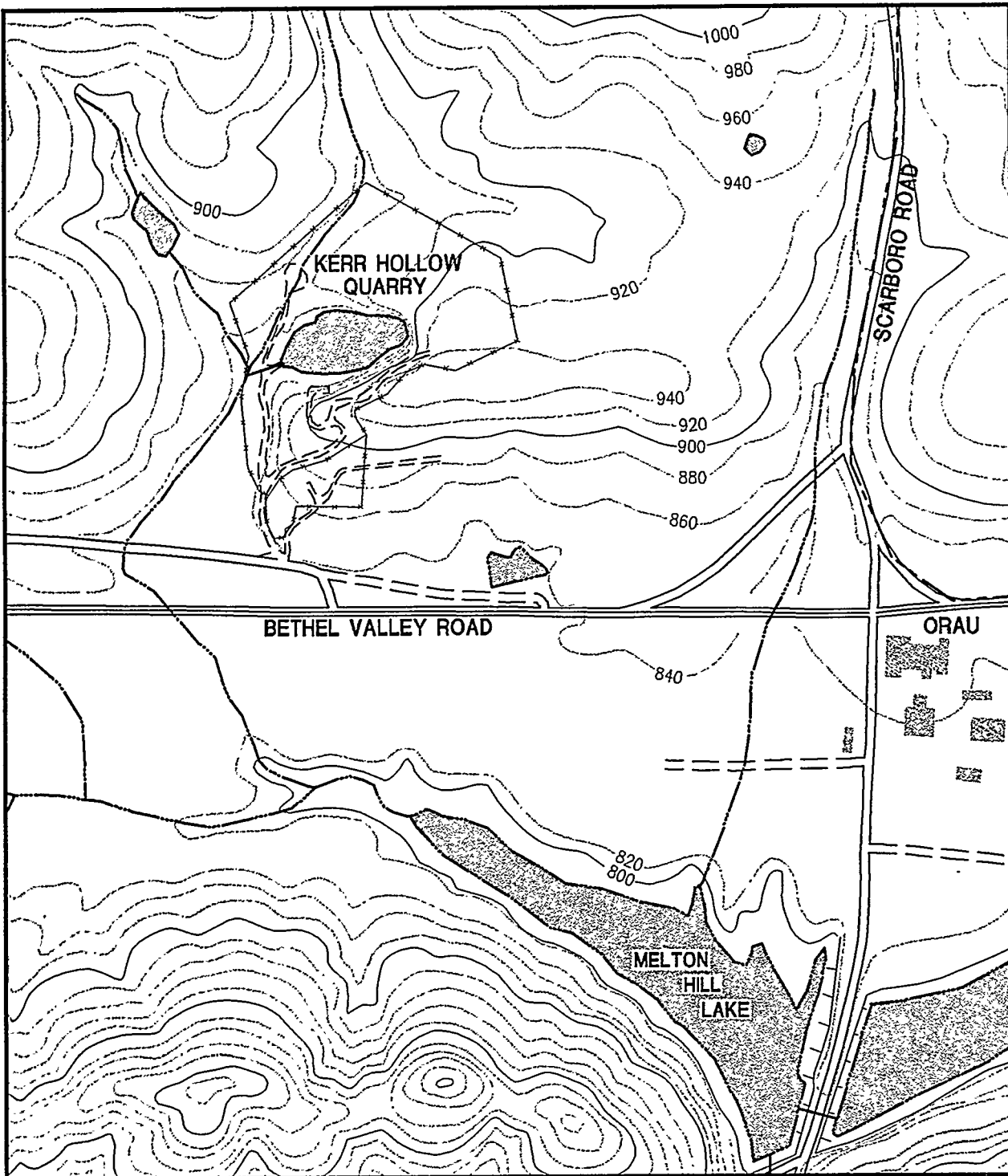


Figure B-5. Geologic cross section through the Chestnut Ridge Hydrogeologic Regime.



LEGEND:

- ==== PAVED ROADS
- DIRT ROADS
- ~~~~ CREEKS
- - - 20' CONTOUR INTERVAL
- - - - - DOE BOUNDARY
- x x FENCE

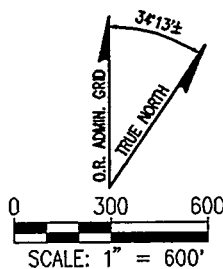


Figure B-6.

**Kerr Hollow Quarry
Surface Drainage Map**

**KERR HOLLOW QUARRY
OAK RIDGE RESERVATION
OAK RIDGE, TENNESSEE**

94014	\\DWG5\623SITE	\\PLOT\623SITE
CAD FILE NAME	DRAWING #	PLOT FILE NAME

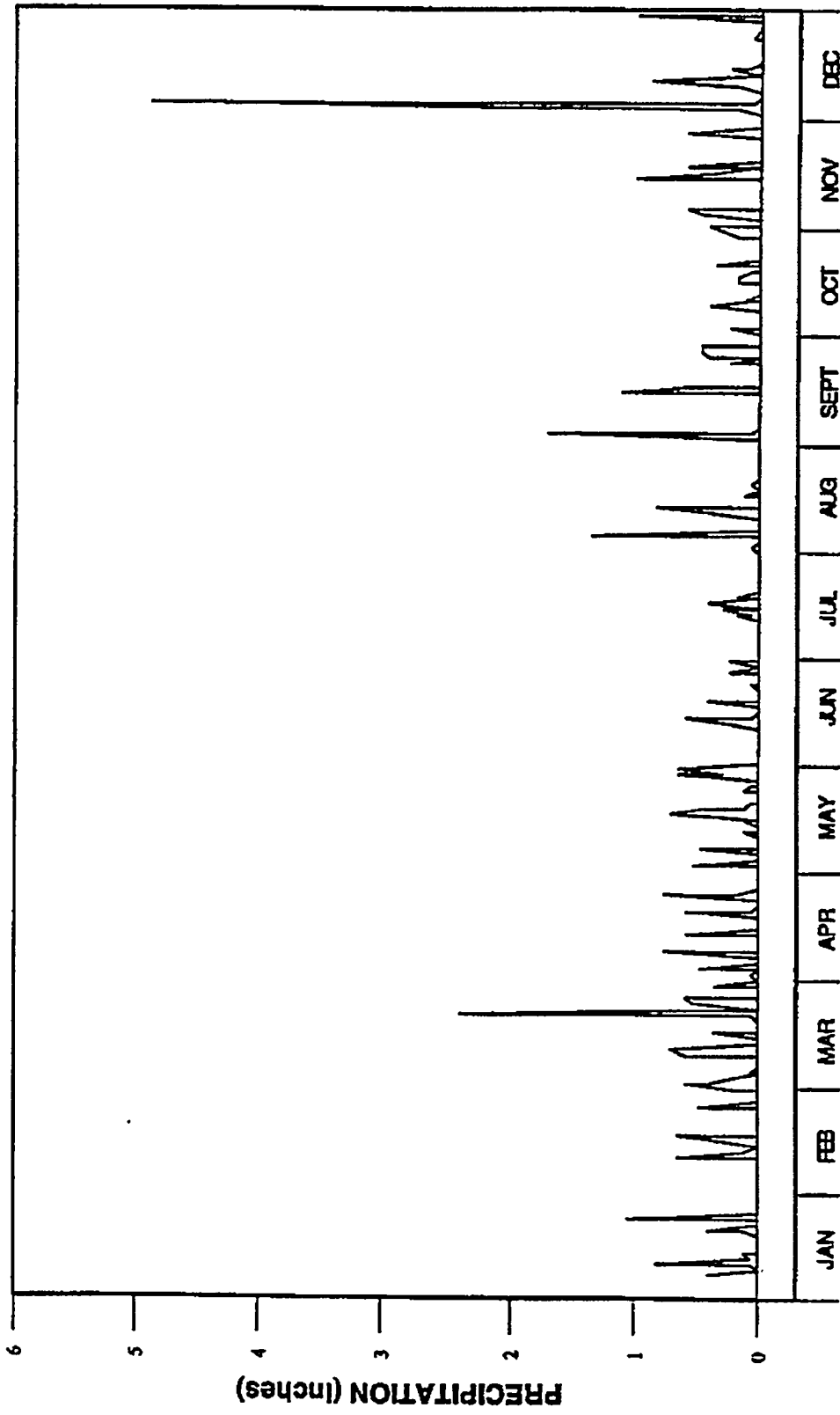
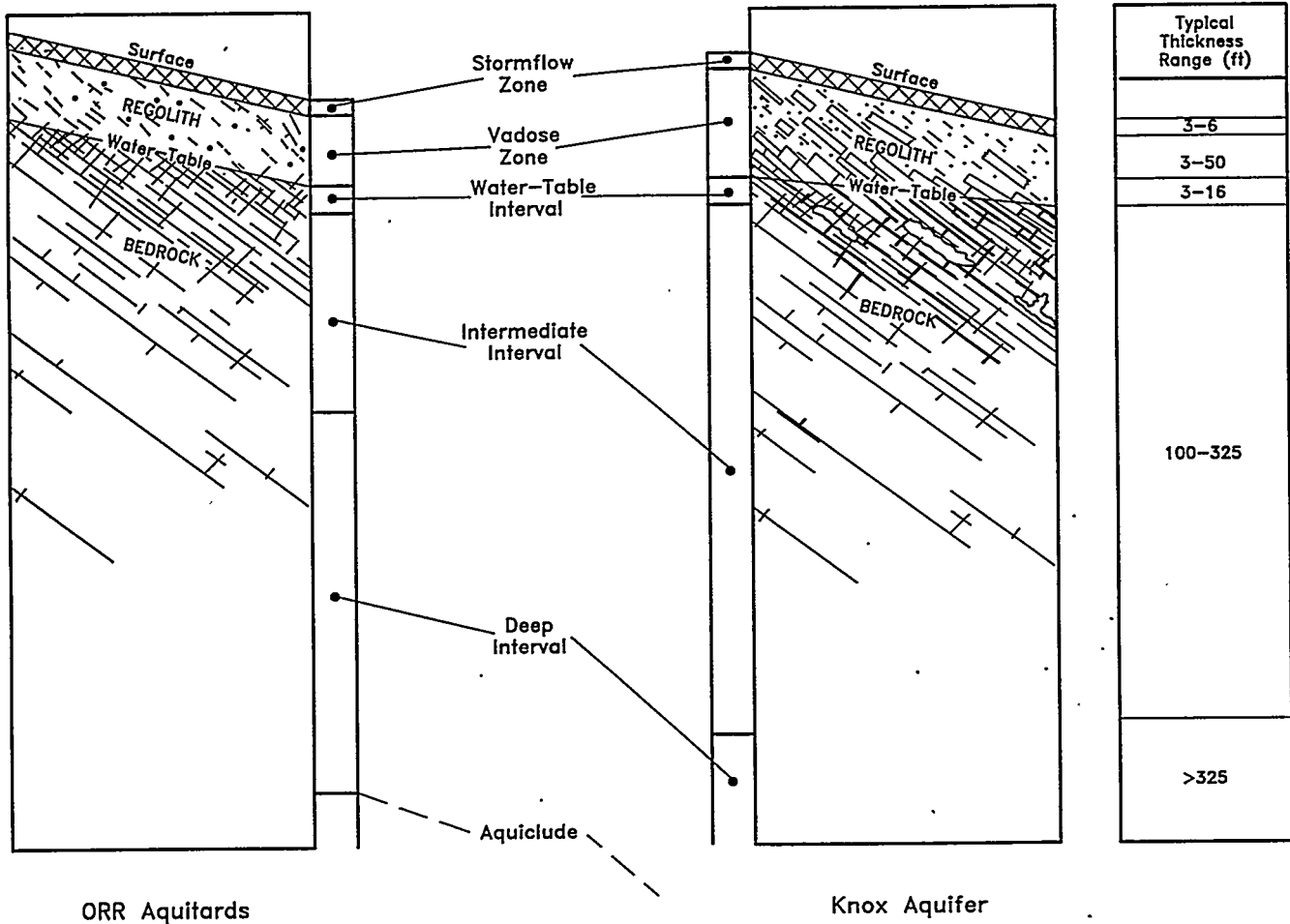


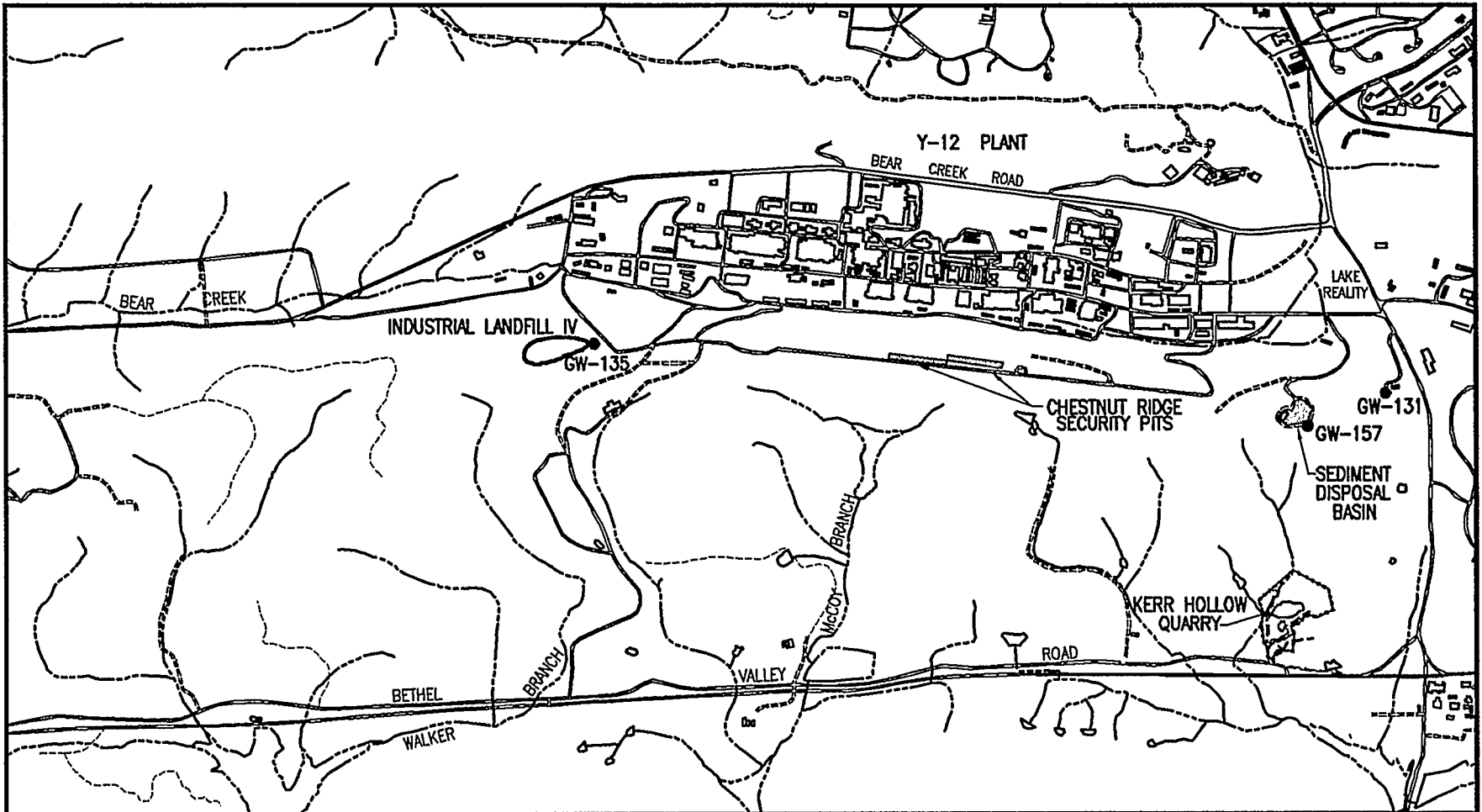
Figure B-7. 1993 precipitation data at the NOAA site.

HYDROSTRATIGRAPHIC UNITS
PROPOSED BY SOLOMON *et al.* (1992)



LOCATION:	Y-12 PLANT OAK RIDGE, TN.
DATE:	1-18-95
DWG ID.:	OR213-HC

Figure B-8. Schematic profile of hydrostratigraphic units in the Chestnut Ridge Hydrogeologic Regime.



LEGEND:

- ==== ASPHALT ROAD
- - - - - STREAM OR SHORELINE
- GW-135 MONITORING WELL LOCATION
- HAZARDOUS-WASTE DISPOSAL UNIT

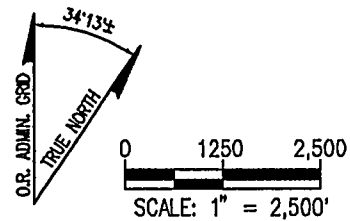
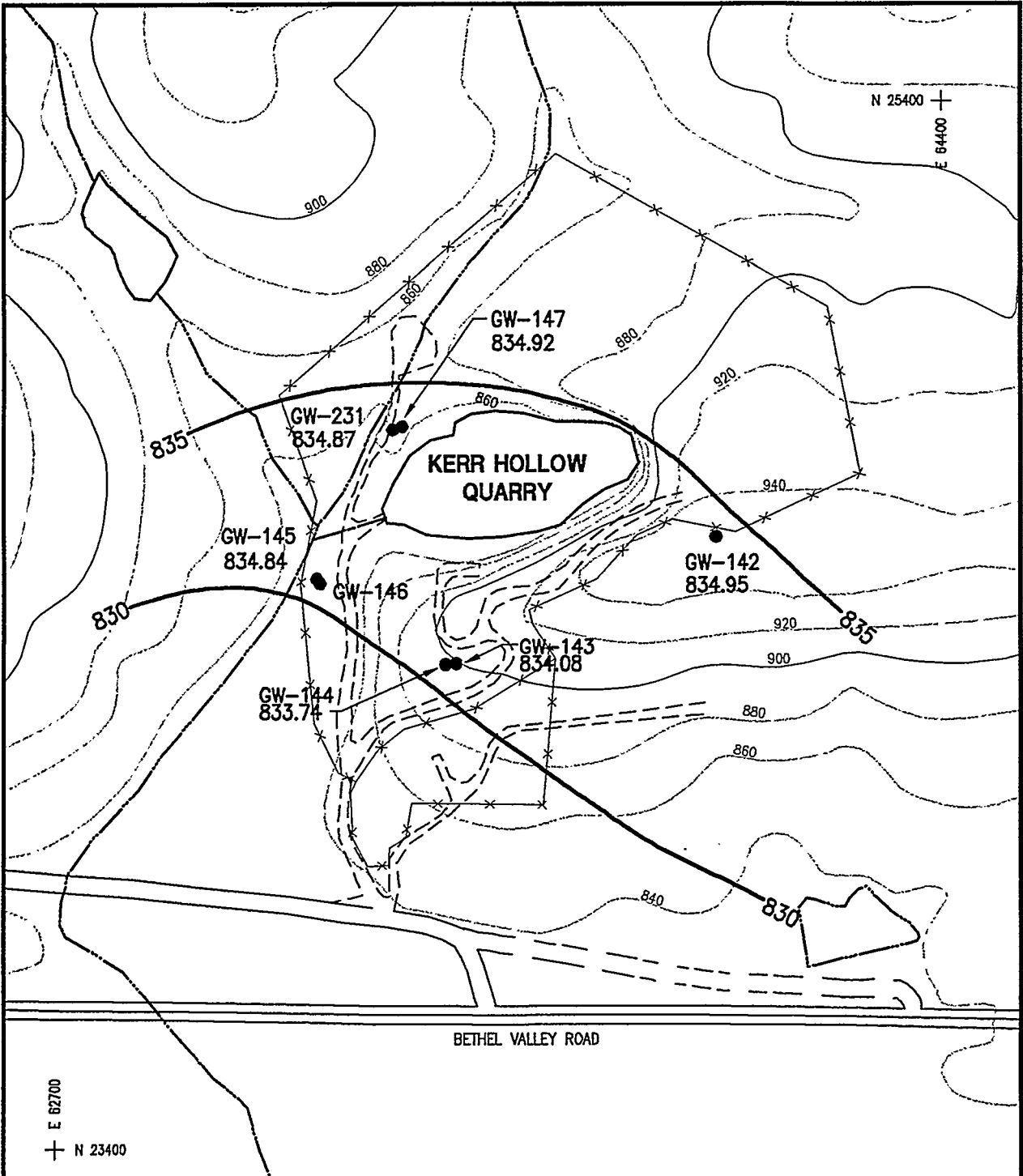


Figure B-9.
Wells used in the packer tests
of the Copper Ridge Dolomite.

**KERR HOLLOW QUARRY
OAK RIDGE RESERVATION
OAK RIDGE, TENNESSEE**

DRAWN BY: P. HOLM	REV. NO./DATE: REV. 0 / 05-18-95	CAD FILE: /94014/DWGS/09BCR
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LEGEND:

-CREEKS
-TOPOGRAPHIC CONTOUR
-FENCE
- BEDROCK MONITOR WELL
- GROUNDWATER ELEVATION
- APPROX. WATER LEVEL
- ISOPLETH (ft, NSL)

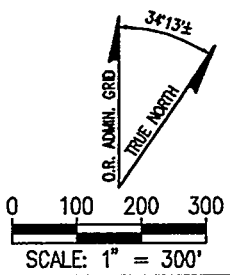


Figure B-10.
Water table map for Kerr Hollow
Quarry for conditions on
August 29, 1994.

**KERR HOLLOW QUARRY
OAK RIDGE RESERVATION
OAK RIDGE, TENNESSEE**

94014 \DWGS\080MT
CAD FILE NAME DRAWING # PLOT FILE NAME

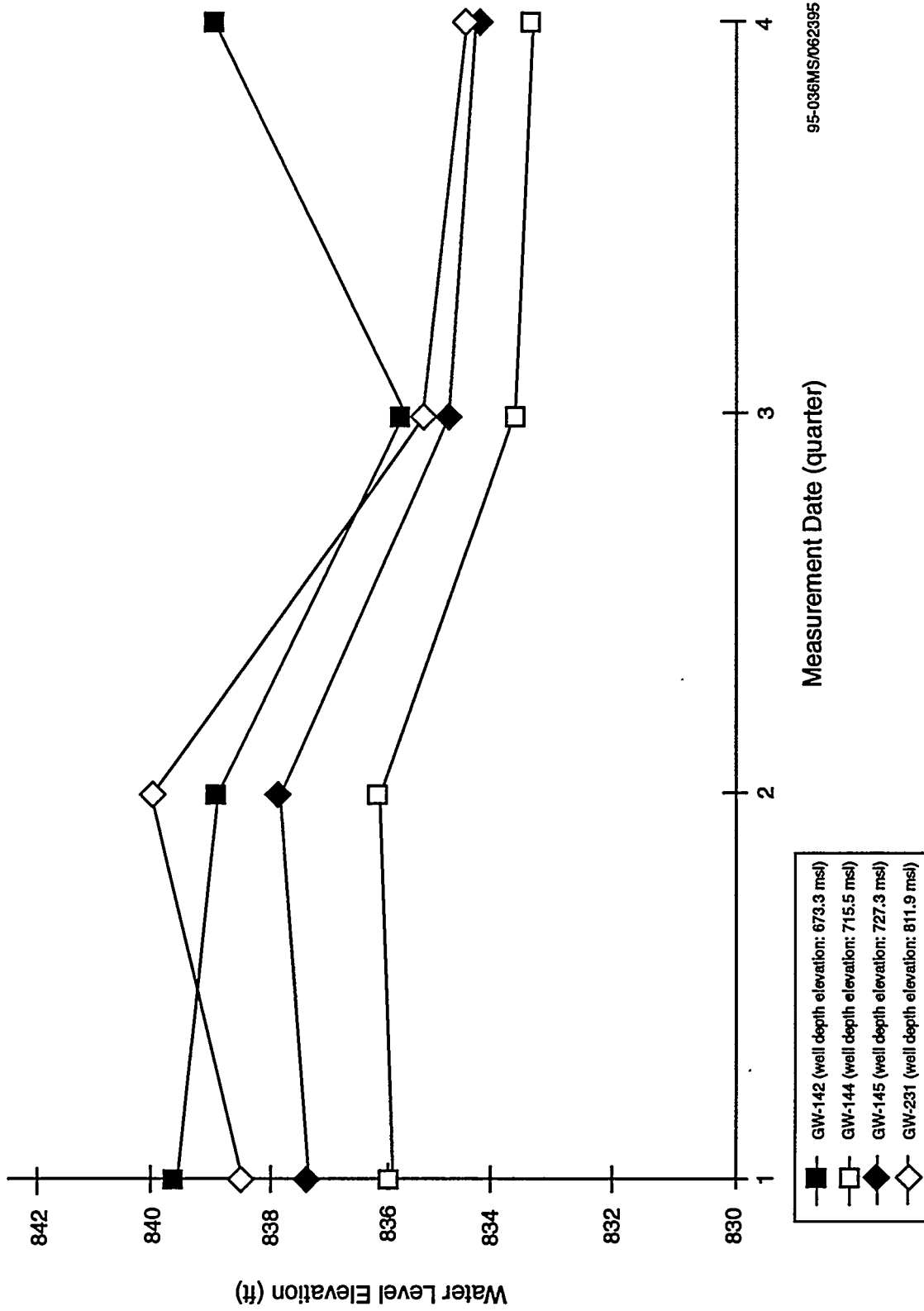


Figure B-11. Hydrographs for water table wells at Kerr Hollow Quarry, CY 1994.

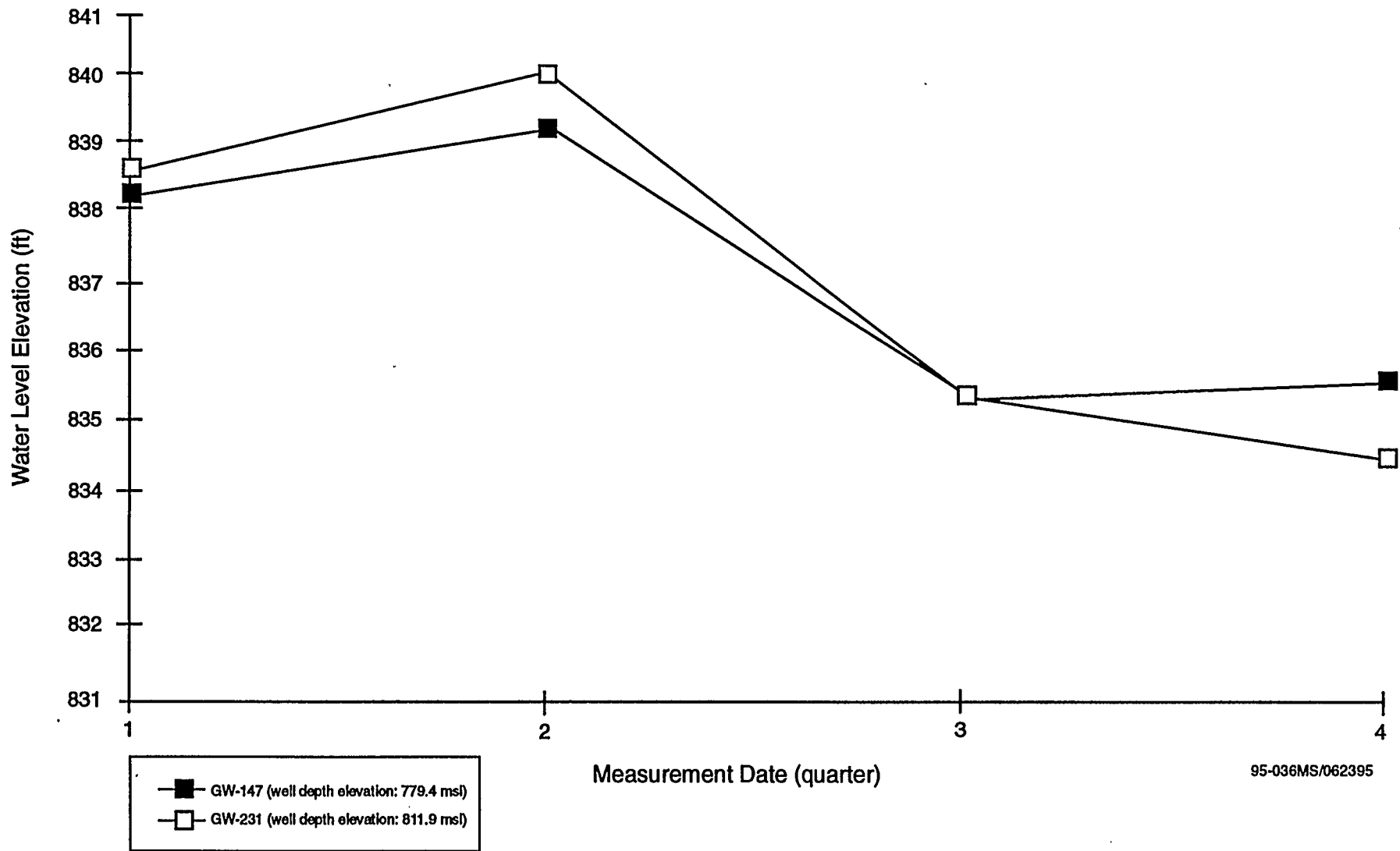
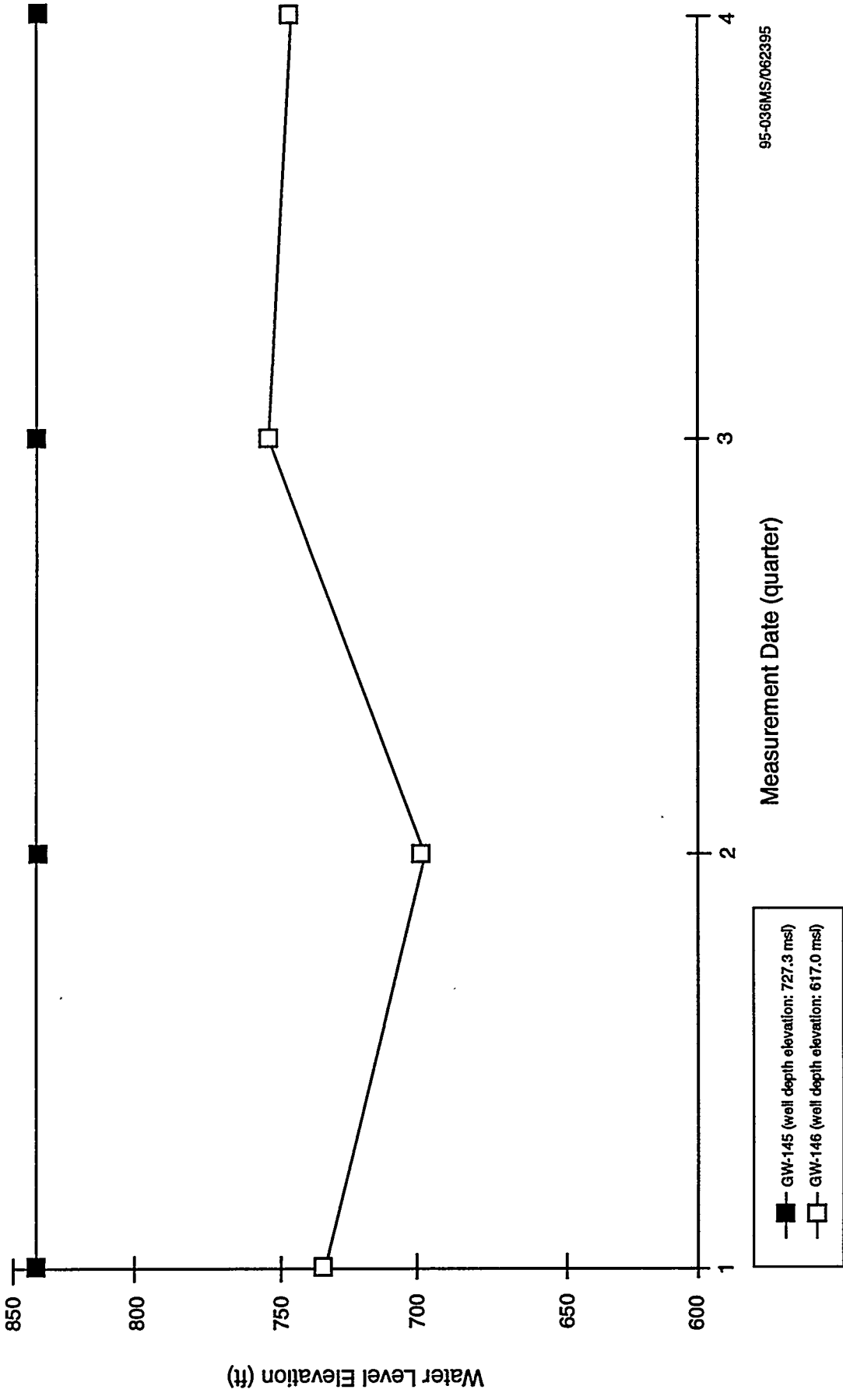


Figure B-12. Hydrographs for Wells GW-147 and GW-231, northwestern well cluster at Kerr Hollow Quarry, CY 1994.



95-036MS/062395

Figure B-13. Hydrographs for Wells GW-145 and GW-146, southwestern well cluster at Kerr Hollow Quarry, CY 1994.

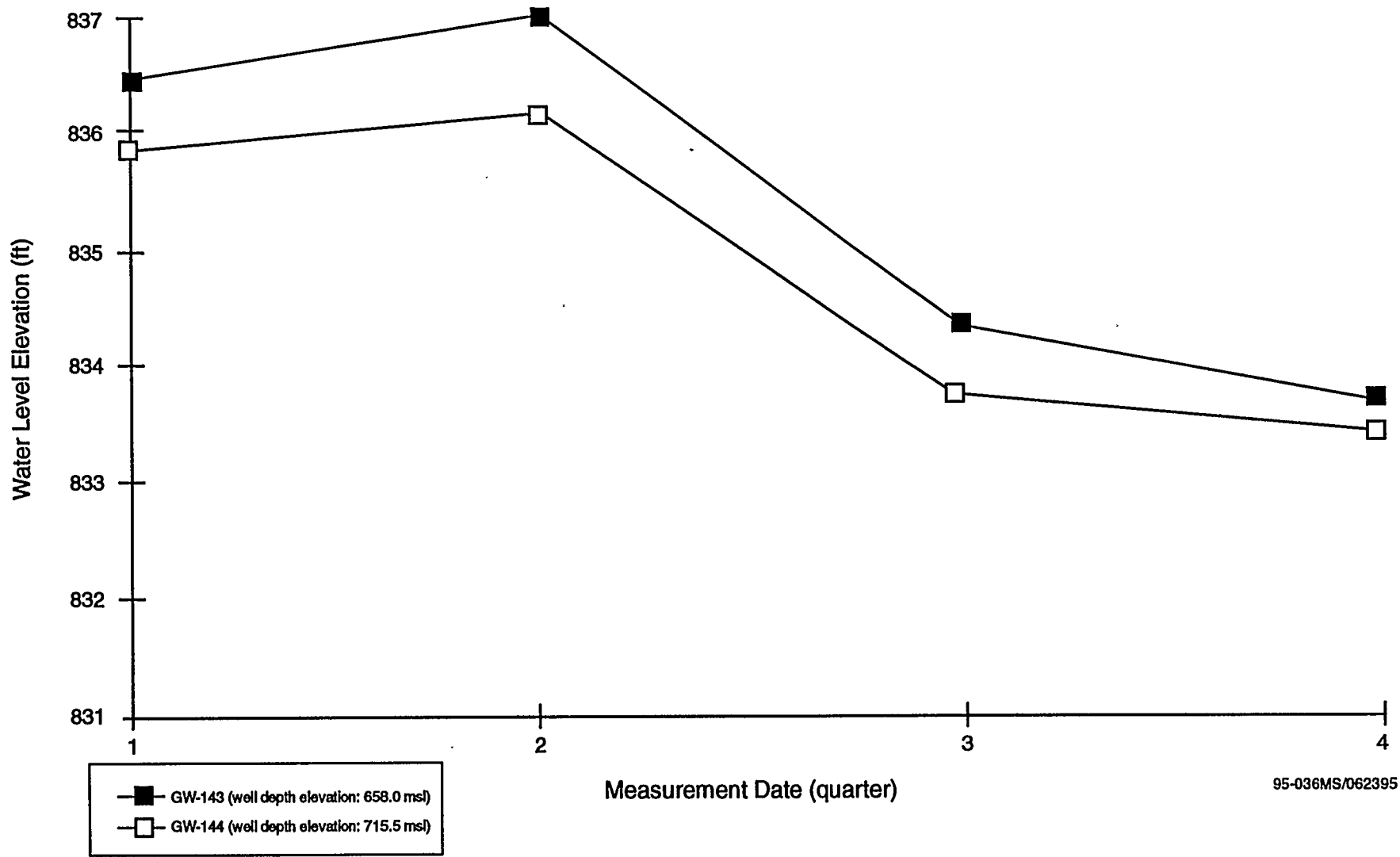


Figure B-14. Hydrographs for Wells GW-143 and GW-144, southern well cluster at Kerr Hollow Quarry, CY 1994.

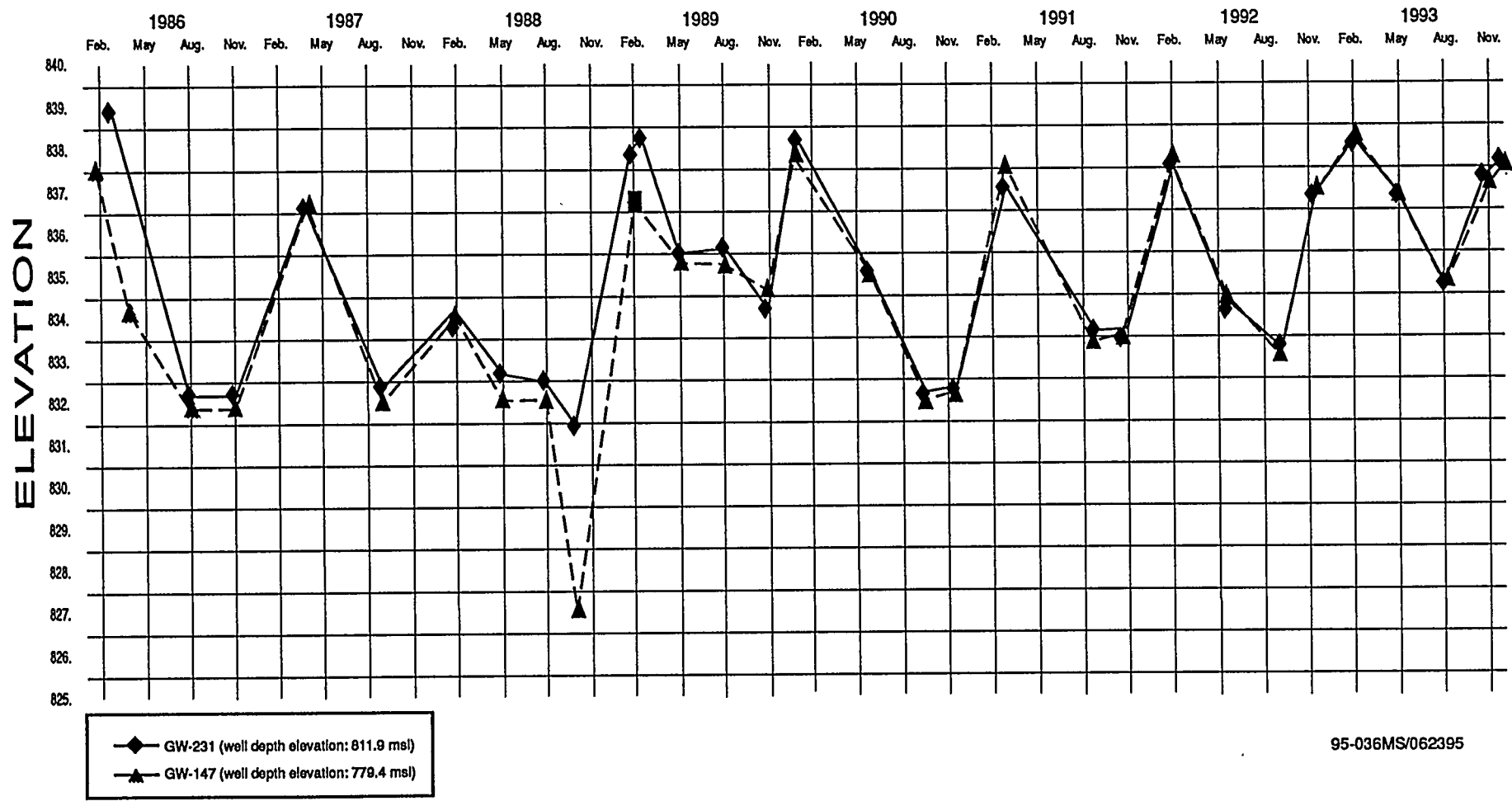


Figure B-15. Hydrographs for Wells GW-147 and GW-231, northwestern well cluster at Kerr Hollow Quarry, CY 1986 through CY 1993.

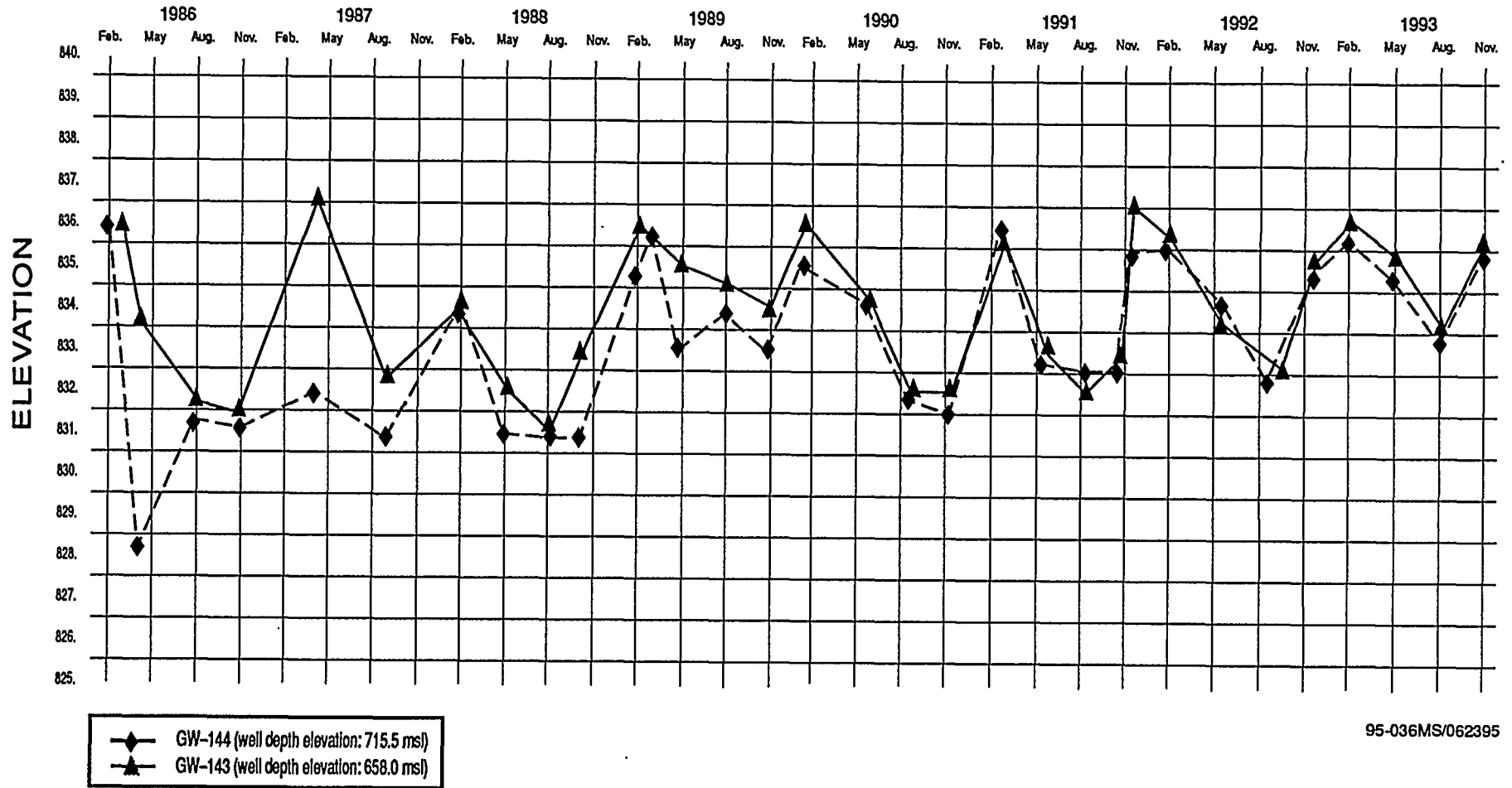
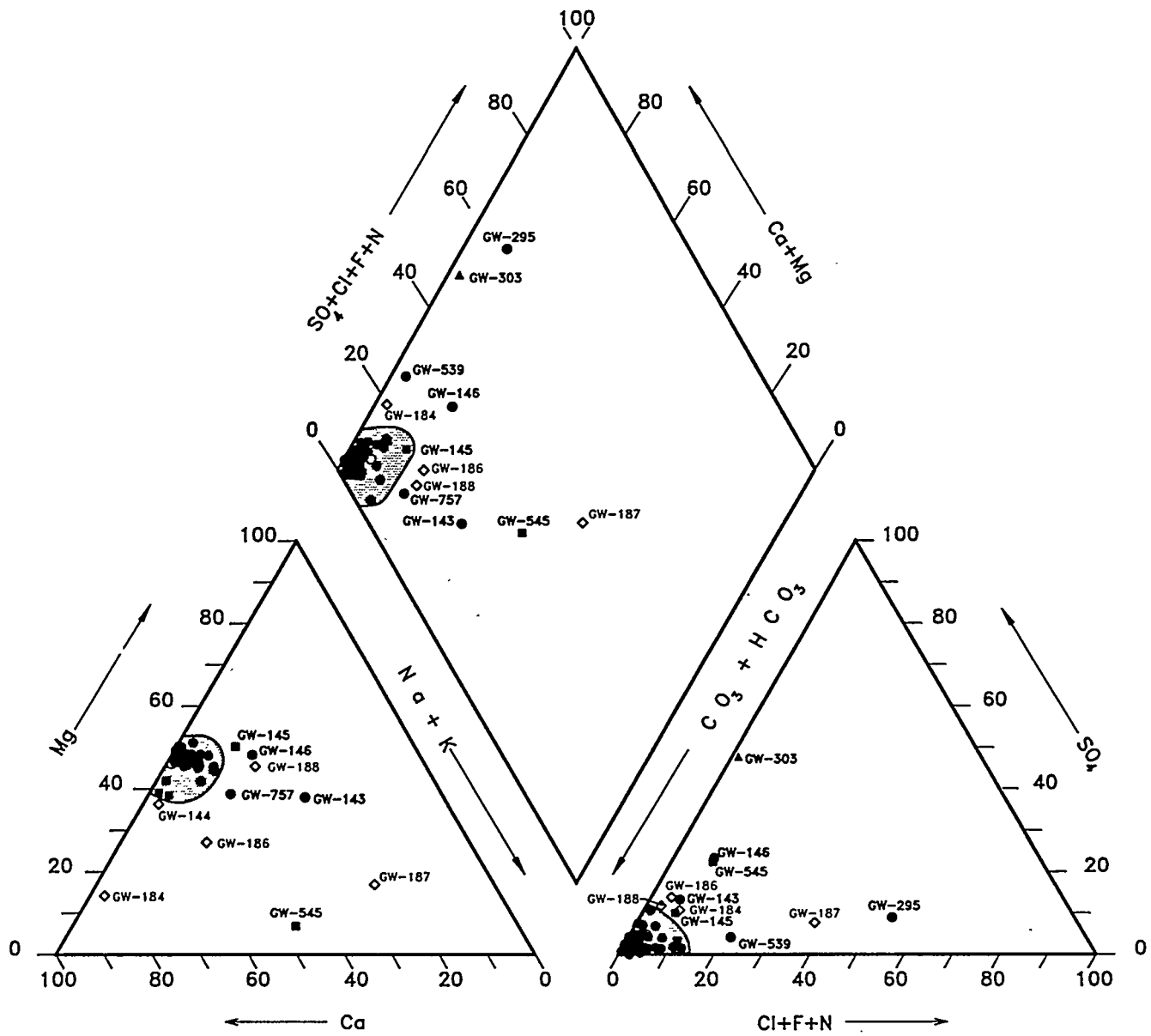


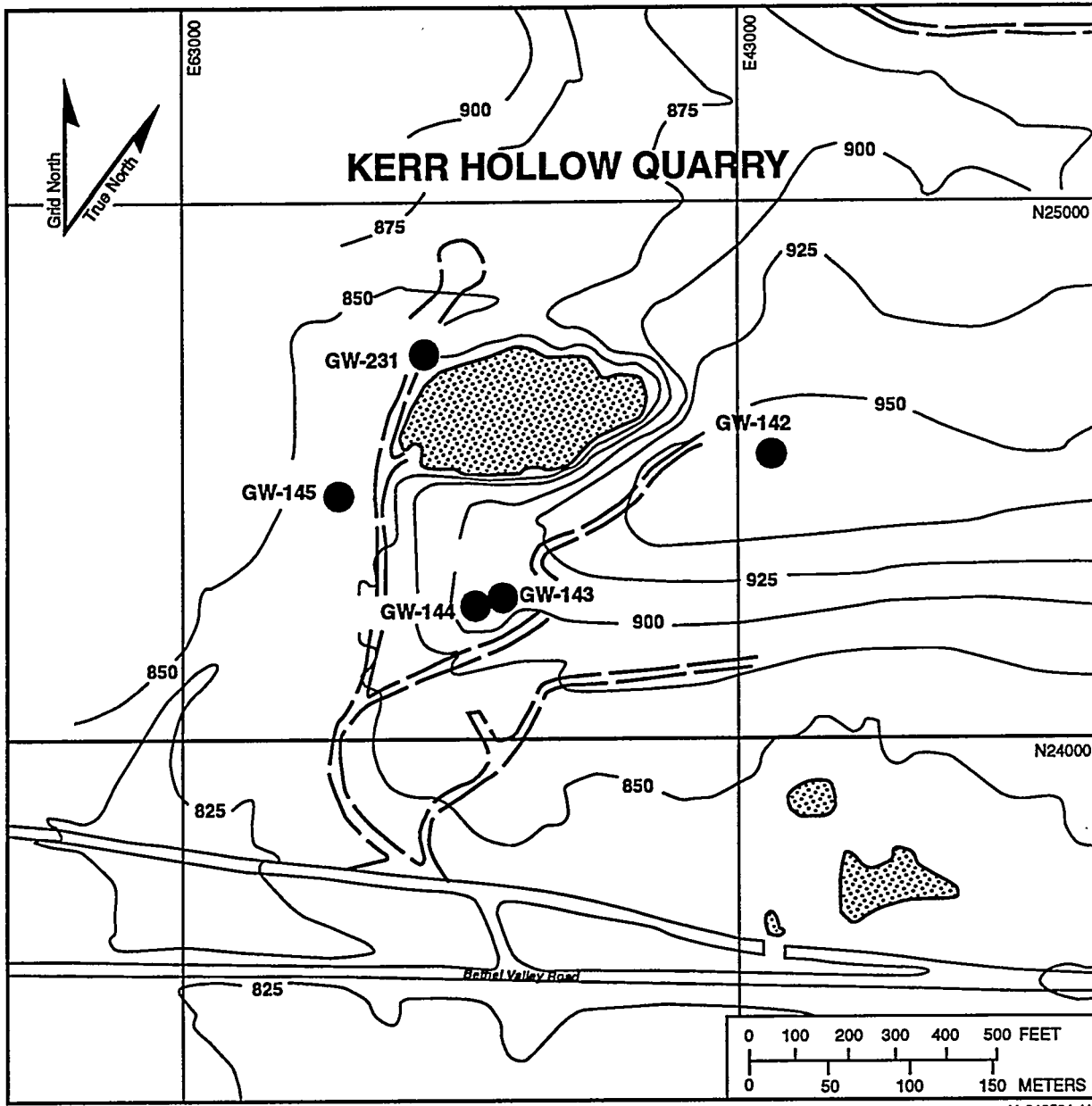
Figure B-17. Hydrographs for Wells GW-143 and GW-144, southern well cluster at Kerr Hollow Quarry, CY 1986 through CY 1993.



EXPLANATION

- GROUNDWATER COMPOSITIONS CLUSTER IN THESE AREAS, 75 WELLS PLOTTED ON DIAGRAM
- GW-545 ■ - WATER-TABLE MONITORING WELL
- GW-755 ○ - BEDROCK MONITORING WELL, LESS THAN 100 FT DEEP
- GW-143 ● - BEDROCK MONITORING WELL, 100 TO 300 FT DEEP
- GW-303 ▲ - BEDROCK MONITORING WELL, GREATER THAN 300 FT DEEP
- GW-188 ◇ - BEDROCK MONITORING WELL, CHICKAMAUGA GROUP

LOCATION:	Y-12 PLANT OAK RIDGE, TN	Figure B-18. Groundwater geochemistry in the Chestnut Ridge Hydrogeologic Regime. Source: HSW 1994.
DATE:	7-26-94	
DWG ID.:	OR365-HC	



11-042594-111

Figure B-19. Location of proposed groundwater monitoring well network at Kerr Hollow Quarry.

APPENDIX A

**RCRA CLOSURE/POST-CLOSURE PLAN
FOR THE KERR HOLLOW QUARRY**

**A.1 REVISED CLOSURE PLAN FOR KERR HOLLOW QUARRY AT
THE OAK RIDGE Y-12 PLANT, OAK RIDGE, TENNESSEE**

A.2 KERR HOLLOW QUARRY POST-CLOSURE PLAN

A.3 CLOSURE CERTIFICATION LETTER

**A.1 REVISED CLOSURE PLAN FOR KERR HOLLOW QUARRY
AT THE OAK RIDGE Y-12 PLANT, OAK RIDGE, TENNESSEE**

N. King

DOE/OR/01-1103&D3

ERO11692



ENVIRONMENT - HEALTH - SAFETY
DEPARTMENT OF ENERGY

Revised Closure Plan for Kerr Hollow Quarry at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee



DOE/OR/01-1103&D3
Y/ER-61&D3

Energy Systems Environmental Restoration Program
Y-12 Environmental Restoration Program

**Revised Closure Plan for Kerr Hollow Quarry
at the Oak Ridge Y-12 Plant, Oak Ridge, Tennessee**

Date Issued—April 1993

Prepared for
U.S. Department of Energy
Office of Environmental Restoration and Waste Management
under budget and reporting code EW 20

Prepared by the
OAK RIDGE Y-12 PLANT
managed by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-84OR21400

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INTRODUCTION

Kerr Hollow Quarry (KHQ) is a rock quarry which was operated in the 1940s as a rock and gravel quarry but was abandoned in the late 1940s when the quarry filled with water. Since at least 1951, the Department of Energy's (DOE's) Oak Ridge Y-12 Plant and the Oak Ridge National Laboratory have used KHQ for the treatment of water-reactive materials, potentially explosive chemicals, and empty compressed gas cylinders. Wastes received at KHQ were defined as hazardous wastes only by the characteristics of reactivity, corrosivity, or ignitability. Treatment of these reactive, corrosive, and ignitable wastes at KHQ effectively eliminated the hazardous characteristics of the wastes. The KHQ facility was not intended for use as a hazardous waste storage or disposal facility. KHQ was used strictly for the emergency handling of these materials when personnel safety was the primary concern. Access to the quarry is limited by an existing 7-ft-high chain-link barbed-wire-topped fence, and the entrance gates are kept locked at all times except for authorized personnel entry and exit. The location of KHQ in relation to the Y-12 Plant is shown in Fig. 1.

KHQ was a permitted facility under the National Pollutant Discharge Elimination System (NPDES), Permit No. TN 0002968-Outfall 301, for the treatment of certain potentially explosive chemicals or water reactive metals. The permit required monitoring the KHQ outfall following a treatment operation, with results reported quarterly to the Tennessee Department of Environment and Conservation (TDEC). Treatment operations at KHQ were not permitted when there was a visible surface discharge at the outfall.

PAST TREATMENT PRACTICES

Because of the hazardous/explosive nature of the materials treated at KHQ, a metal building and chute were constructed on the southern bluff of the quarry, high above the water surface (see Fig. 2). The chute allowed the materials to be deposited directly into the water in the quarry without striking the bank. A separate cleared area exists on the northwest bank of the quarry where compressed-gas cylinders with frozen or leaky valves could be placed to allow penetration by rifle fire to vent the gases. The Y-12 security guards, who shot the containers floating in the quarry or the gas cylinders on the bank of the quarry, were positioned in the metal building on the southern bluff to protect them when the water-reactive or other materials exploded in the quarry.

Water-reactive metals such as lithium, potassium, calcium, sodium, or sodium-potassium alloy were normally packaged in 5-, 30-, or 55-gal containers and transported to the quarry, where they were placed in the chute and dropped to the water surface. These containers were punctured with rifle fire allowing water to contact the reactive metal or alloy. Water reacted with the metals, releasing hydrogen gas and forming oxides and hydroxides with the alkaline metal. Complete reaction of the metals is ensured because of the violent nature of the reactions; an explosion or violent burning was witnessed shortly after the container was punctured as the container sank below the surface of the water. A limited number of 500-gal

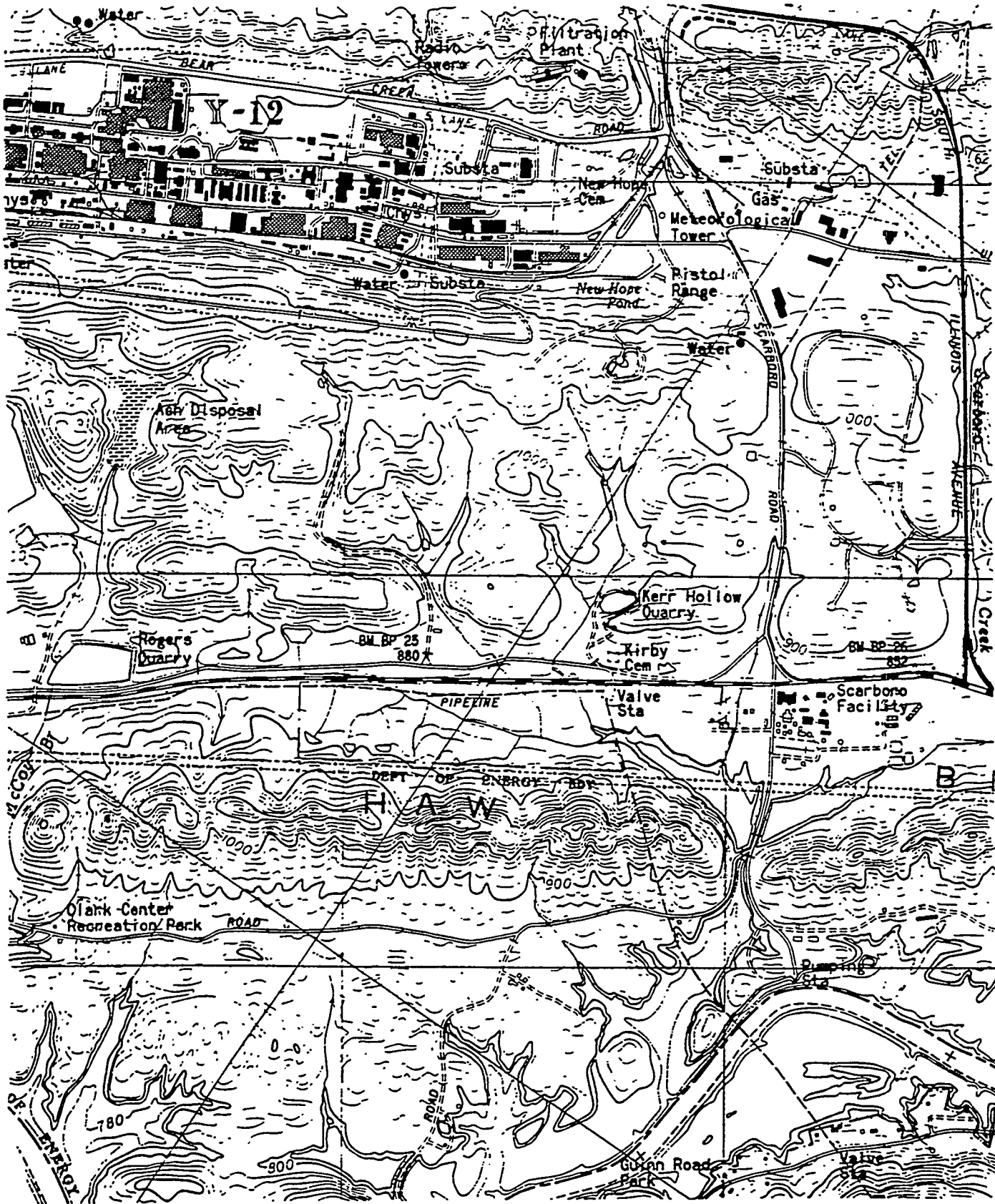


Fig. 1. Topographic map showing the Oak Ridge Y-12 Plant, pertinent facilities, and surrounding area.

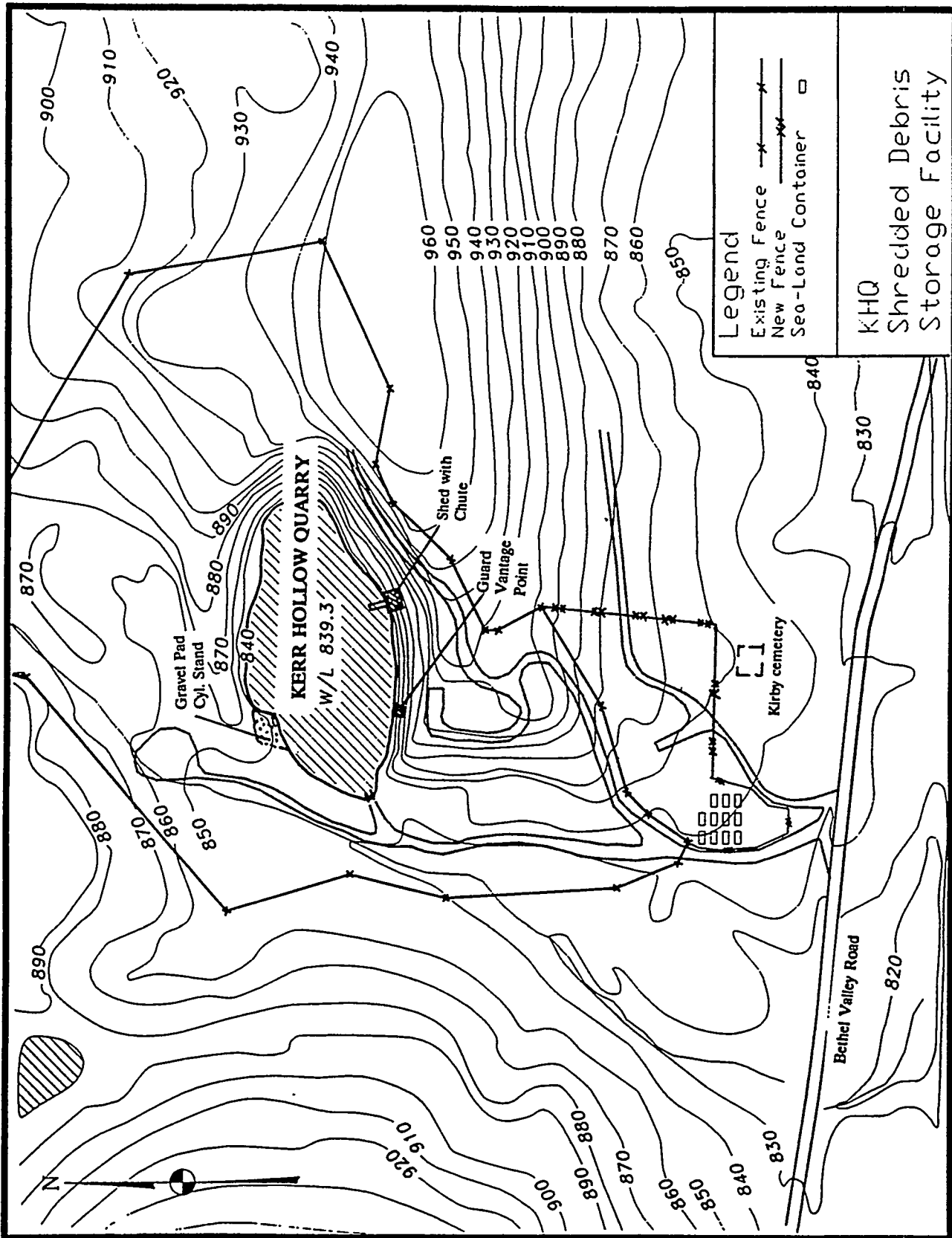


Fig. 2. Kerr Hollow Quarry sketch.

pressure vessels containing sodium were placed in the quarry. Those large containers, which were too heavy to float, were dropped from the upper rim of the quarry and allowed to vent as they entered the water by positioning valves and vent pipes in the open position.

Potentially explosive chemicals such as picric acid were transported to the quarry in specially packed containers to minimize shock and possible detonation in transit. The containers were suspended on a cable above the water surface and punctured with rifle fire prior to being released into the water.

Gas cylinders with frozen valves were vented on the northwest bank of the quarry by puncturing the cylinder wall with rifle fire. Once vented, the empty cylinders were removed from the area and returned to the Y-12 Plant for disposal; prior to the early 1970s, however, cylinders were discarded in the quarry. A typical listing of the materials that have been reacted or vented in the quarry is included in Table 1. A detailed inventory of the volumes and types of materials to KHQ in past years is on file and available for review at the Y-12 Plant.

Table 1. Description of typical wastes treated in Kerr Hollow Quarry

Waste type	Examples
Alkali metals and metal hydrides (water reactive)	Lithium and lithium hydride Sodium and sodium hydride Potassium and potassium hydride Calcium and calcium hydride Zirconium hydride Titanium hydride Lithium hydride Lithium aluminum hydride Sodium-potassium (NaK) metal
Unstable organics (explosive)	Picric acid and related compounds Ethers Peroxides Hydrazine
Metals (reactive)	Phosphorous Magnesium
Mechanical hazard (explosive)	Stressed steel parts (shrapnel danger) Vacuum tubes (implosive) Blasting caps Gas cylinders (with frozen/broken valves)
Miscellaneous hazards	Ammonia (irritant) Inorganic acids (corrosive)
Estimated total amount ^a	50 tons

^aThe estimated total amount includes hazardous and nonhazardous materials that have been sent to KHQ since 1962, when records were first kept. This estimated amount generally includes the weight of the containers and the materials that were sent to the quarry for treatment.

PAST CLOSURE PRACTICES

In March 1989, a remote-operated underwater vehicle (ROV) equipped with a camera was used to survey the bottom of the quarry. A review of the videotapes showed that most of the drums accessible to the camera appeared to be empty of any residual reactive or explosive materials. Since records of past disposals show that in addition to the containers observed in the videotapes, numerous large steel vessels of reactive metals were treated and left in KHQ, additional video surveys were made of KHQ to locate the large vessels. These large-vessel surveys were conducted during the spring and early summer months of 1991.

Also, because of the need at Y-12 for a Safety Assessment when dealing with potentially unsafe operations, a Safety Assessment was conducted by Y-12 during late 1988 and early 1989. The Safety Assessment and subsequent safety reviews evaluated whether all or part of the containers in KHQ could be moved and breached safely while ensuring the protection of human health and the environment. The planned closure activities were assessed as safe, and they are discussed in the following paragraphs.

To ensure that the large vessels on the quarry's bottom are empty, a remote method of breaching suspect containers will be used to confirm that no reactive or explosive wastes remain. The remote method of breaching will consist of placing explosive charge(s) on the drums or steel vessels, detonating the charge(s), and viewing the ruptured vessels by a remote-controlled camera attached to an ROV. After the breached containers are inspected and appear empty, the containers will be removed.

Gas cylinders will be breached underwater using hydraulically powered equipment and then removed from the quarry.

Other containers (5-gal buckets, 30- and 55-gal barrels, and other miscellaneous items) will be shredded underwater. This process will provide the greatest assurance that all reactive materials have been exposed to water. The shredded material will be removed from the quarry.

Obviously empty items will be inspected and then removed from the quarry as nonhazardous waste. All visible items/material removed from the quarry will be inspected as necessary to ensure proper disposal.

In accordance with a state of Tennessee (TDEC) request under the Tennessee Water Quality Control Act (letter dated October 11, 1987), disposal operations at KHQ were terminated on November 7, 1988, and steps were initiated to close the quarry in a manner adequate to meet closure requirements of a surface impoundment as specified in 40 CFR 265.

CLOSURE CRITERIA

As outlined in the previous sections, substantial progress has been made in eliminating the residual hazardous material present in the quarry, thereby minimizing to the extent necessary to protect human health and the environment the postclosure escape of hazardous waste or hazardous constituents to the groundwater or surface water or to the atmosphere. Visible containers or structures will be removed from the quarry after they are inspected. Closed containers, possibly containing reactive/hazardous material, will undergo shredding or breaching underwater to promote deactivation of reactive material.

The shredded debris is a residue of a primary treatment process designed to deactivate the reactive constituents. This treatment residue will be transported as nonhazardous waste to the Y-12 Plant and dispositioned to the Walk-In Pits at Bear Creek Burial Ground.

During closure activities at KHQ, visible containers will be breached to ensure that no waste material remains in the quarry. The material in the containers is water-reactive waste and is rendered nonhazardous after the chemical reaction has been concluded. If the final inspection of a breached container reveals that the entire contents have not been reacted, subsequent breaching efforts will be performed to ensure that no waste remains. If an unidentified material is found, a field evaluation will be performed to ensure that the treatment method protects human health and the environment.

Final inspection videotapes will be made of the quarry bottom to document that all visible containers have been removed. The videotapes will serve as verification that the closure requirements have been met.

Y-12 will continue to sample the groundwater wells around the quarry until closure activities are complete and closure has been certified as complete. This action is intended to confirm that if any containers are left in the quarry, they are not causing the groundwater at KHQ to exceed the TDEC groundwater quality standards.

The sediment in the quarry and any items/containers that may be concealed beneath the sediment will remain in the quarry. Should further investigation or remediation of the quarry be required, those activities will be conducted under the authority of the existing ORR Federal Facility Agreement between DOE, EPA, and TDEC. Subsequent investigations or other pertinent environmental monitoring activities will be conducted by the ER Program as part of the ongoing CERCLA activities at the Y-12 Plant. These actions will be conducted (if required) in lieu of the requirements found in 40 *CFR* 265.228b and Tennessee Rule 1200-1-11-05-112. Actions necessary under CERCLA will most likely include posting the KHQ site, maintaining a security fence, conducting regular security inspections, monitoring groundwater, and monitoring under the NPDES permit.

WATER AND MONITORING WELL SAMPLING AND RESULTS

Kerr Hollow Quarry has an NPDES permit, which requires monitoring at the KHQ outfall within 24 hours after a treatment operation in the quarry and submittal of quarterly reports to TDEC if there has been a treatment operation during the previous month. Table 2 lists the parameters that must be analyzed to satisfy the NPDES permit, along with standards for those parameters, required monitoring frequency, and sample type. The results of previous years of sampling are available in numerous Y-12 documents (Geraghty and Miller 1985, Oakes et al. 1987) or in the quarterly monitoring reports that have been submitted to TDEC. In summary, the only times the NPDES permit conditions were exceeded were once in 1983 involving the upper pH limit and once in 1984 involving the lower pH limit. The discharge limits for other parameters, total suspended solids, potassium, lithium, sodium, heavy metals, etc., have not been exceeded at the KHQ outfall.

Table 2. NPDES effluent limitations and monitoring requirements
for discharges at Kerr Hollow Quarry

Effluent parameters	Effluent limitations		Monitoring requirements	
	Daily average	Daily maximum	Measurement frequency	Sample type
Flow, m ³ /d			Continuous	
Total suspended solids, mg/L	30.0	50.0	<i>a</i>	Grab
Zirconium, mg/L		3.0	<i>a</i>	Grab
Potassium, mg/L			<i>a</i>	Grab
Lithium, mg/L		5.0	<i>a</i>	Grab
Sodium, mg/L			<i>a</i>	Grab
Heavy metals, mg/L			<i>a,b</i>	Grab
Temperature, °F/°C		86.9/30.5	<i>a</i>	Grab
pH		6.5-8.5	After disposal	Grab

^aThe NPDES permit specifies that "monitoring for this parameter shall be conducted following each disposal operation involving this material at a time which provides a sample representative of the discharge from this point."

^bThe NPDES permit specifies that "monitoring for heavy metals following disposal operations shall include total arsenic, cadmium, chromium, copper, iron, nickel, selenium, zinc, lead, and mercury. If significant quantities of heavy metals are recorded, the permit will be modified to reflect appropriate effluent limitations. The sampling procedure and frequency of monitoring shall be consistent with that of the other parameters at this location."

Seven groundwater wells were installed around the KHQ site, and an eighth boring is an exploratory core hole for subsurface characterization. The well locations are shown in Fig. 3. The seven wells at the KHQ site were all sampled during each of the four quarters of CY 1986. The sampling and analysis program being followed is consistent with state regulation TN 1200-1-11-.05, "Interim Status Groundwater Monitoring Requirements." The program is outlined as follows:

1986

<i>Indicator Parameters</i>	<i>Parameters Establishing Groundwater Quality</i>	
pH	Chloride	Phenols
Specific conductance	Iron	Sodium
Total organic carbon	Manganese	Sulfate
Total organic halogen		

1987-1989

Semiannually for indicator parameters

Annually for groundwater quality parameters and total uranium

CLOSURE SCHEDULE

A closure schedule is presented in Table 3.

Table 3. Kerr Hollow Quarry closure schedule

Activity	Closure plan dates	Actual dates
Review survey(s) information and map location of containers in KHQ	09/28/88	09/28/88
Perform survey/final removal operations	12/31/93	
Submit final closure certification to TDEC	03/01/94	

MAINTENANCE OF SITE

The KHQ site will remain under DOE management for the perceivable future. The fence network, gates and locks, and posted signs will be inspected quarterly. If any damage is found, the missing fence, signs, etc., will be replaced.

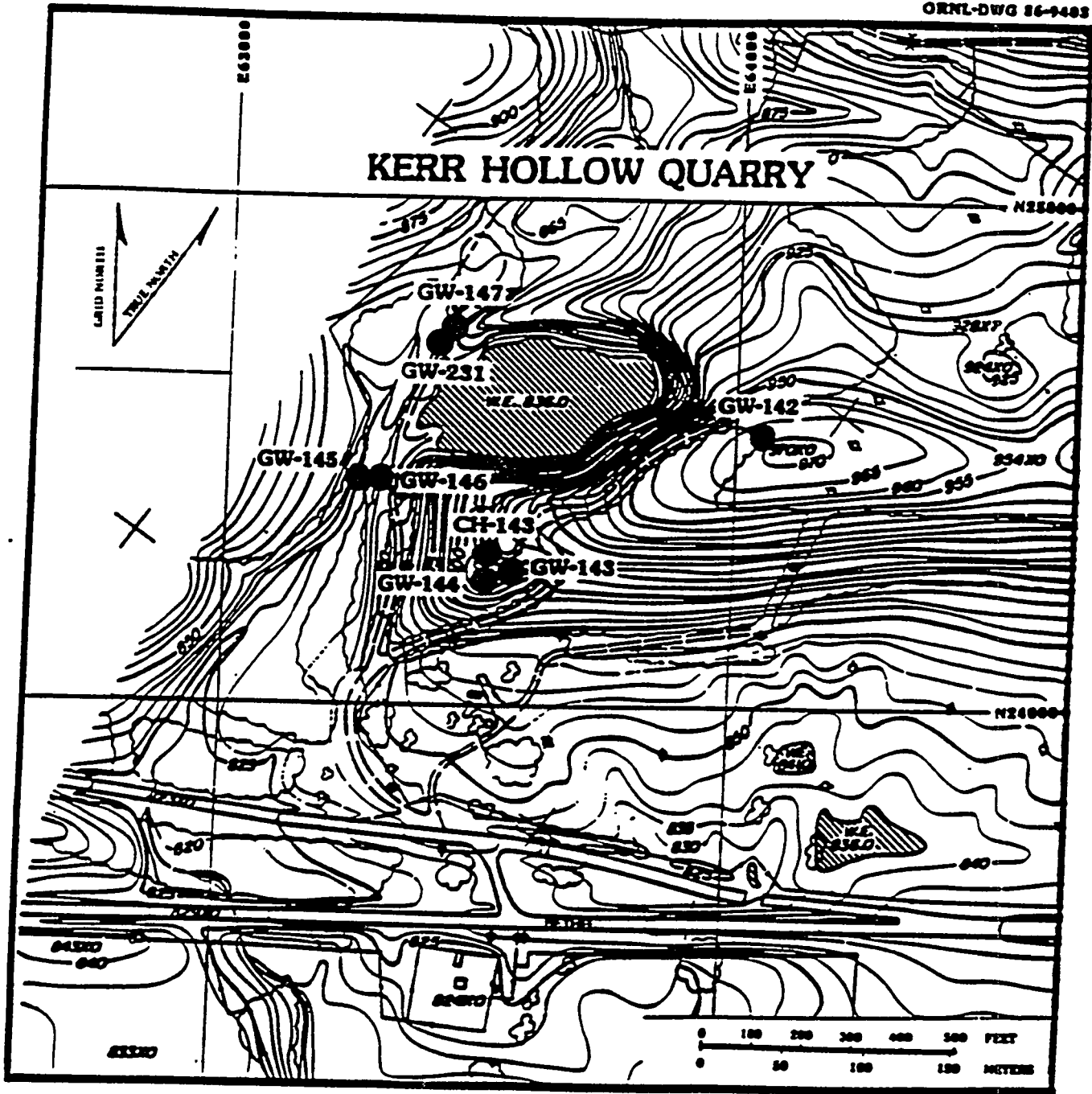


Fig. 3. Location of monitoring wells.

CERTIFICATION OF CLOSURE

DOE will submit a closure certification from both DOE and an independent registered professional engineer that closures have been completed in accordance with the approved closure plan. The certification shall be submitted to the Commissioner of TDEC within 60 days after completion of the last closure activity.

NOTICE OF LOCAL LAND AUTHORITY

Within 90 days after closure is completed, a survey plat indicating the location and dimensions of the KHQ will be submitted to the local land authority and to the Commissioner of TDEC. The plat will be prepared and certified by a professional land surveyor. The survey plat will contain the following prominently displayed note, or a similarly worded note:

The owner or operator of the property containing the Kerr Hollow Quarry, as shown on this plat, is obligated to restrict disturbance of the site in accordance with *Rules Governing Hazardous Waste Management in Tennessee*. Postclosure use of the property is limited to authorized personnel only, unless the owner or operator receives approval from the Commissioner of the Tennessee Department of Environment and Conservation under the previously referenced rules.

RECORD OF WASTES

A record of waste disposed of in KHQ and a record of removed waste will be submitted to the Commissioner of TDEC and the local land authority.

NOTICE OF DEED

The note presented in the section entitled Notice of Local Land Authority or a similarly worded note will be recorded on the facility property deed or on some instrument normally examined during a title search.

CERTIFICATION OF NOTICE

A certification by DOE will be submitted to the Commissioner of TDEC stating that the required notices have been filed. A copy of the document in which the notation has been placed will be attached.

REFERENCES

- Geraghty and Miller, Inc. 1985. *Proposed Groundwater Monitoring Plans for the Kerr Hollow and the Rogers Quarries*, Y/SUB-85-00206C/4R1, Martin Marietta Energy Systems, Inc., Oak Ridge Y-12 Plant, Oak Ridge, Tennessee, revised April 1986.
- Oakes, T. W., C. W. Kimbrough, P. M. Pritz, S. T. Goodpasture, S. F. Huang, C. S. Gist, C. W. Weber, and F. M. O'Hara. 1987. *Environmental Surveillance of the U.S. DOE Oak Ridge Reservation and Surrounding Environs During 1986, Volume 2: Data Presentation*, ES/ESH-1/V2, Martin Marietta Energy Systems, Inc., Oak Ridge, Tennessee, April.

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- 65-66. Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831

A.2 KERR HOLLOW QUARRY POST-CLOSURE PLAN

KERR HOLLOW QUARRY POST-CLOSURE PLAN

1.0 Post-Closure Care and Use of Property

Ref: 1200-1-11-.06(7)
40 CFR 264.117

This plan outlines the post-closure care activities to be conducted at the Kerr Hollow Quarry (KHQ). The property will be maintained in accordance with the post-closure plan upon approval by the Tennessee Department of Environment and Conservation (TDEC).

1.1 Length of Post-Closure Care Period

Ref: 1200-1-11-.06(7)
40 CFR 264.117(a)(1)

Post-closure care activities at the KHQ will continue for 30 years after the date of closure.

1.2 Increasing/Decreasing Length of Post-Closure Care Period

Ref: 1200-1-11-.06(7)
40 CFR 264.117(a)(2)

All activities described in this post-closure plan will be conducted for the duration of the post-closure care period unless a demonstration is made to and approved by TDEC that certain post-closure activities are no longer required to protect human health and the environment.

1.3 Security Requirements

Ref: 1200-1-11-.06(7)
40 CFR 264.117(b)

Security at the KHQ will be maintained for 30 years after closure. Access to the facility is limited to authorized personnel and is controlled by a chain-link fence with a lockable gate at the single access road. Signs have been posted around KHQ prohibiting unauthorized entry.

1.4 Property Use Requirements

Ref: 1200-1-11-.06(7)
40 CFR 264.117(c)

Land use at and near KHQ shall be restricted to ensure the unit is maintained and to prevent the disturbance of the monitoring system and security fence.

2.0 Submittal of Post-Closure Plan

Ref: 1200-1-11-.06(7)
40 CFR 264.118(a) and 270.14(b)(13)

This Post-Closure Plan is being submitted as a part of the KHQ Post-Closure Permit Application.

3.0 Availability of the Post-Closure Plan

Ref: 1200-1-11-.06(7)
40 CFR 264.118(b)(3)

The name, address, and phone number of the contact for the KHQ during the post-closure care period are listed below. A copy of the updated post-closure plan for the KHQ will be maintained in this office during the post-closure care period.

U.S. Department of Energy, Environmental Restoration Division
P.O. Box 2001
Oak Ridge, Tennessee 37831-8012
(615) 576-0715

4.0 Content of the Post-Closure Plan

Ref: 1200-1-11-.06(7)
40 CFR 264.118(b)

The activities discussed in this section are intended to meet the content requirements found in TN Rule 1200-1-11-.06(7) and 40 CFR 264.118 as incorporated by reference by the Tennessee Hazardous Waste Management Regulations.

4.1 Monitoring Activities

Ref: 1200-1-11-.06(7)
40 CFR 264.118(b)(1)

Groundwater monitoring activities to be performed upon issuance of a Post-Closure Permit for the KHQ are presented in Section B.5 of the "Post-Closure Permit Application for the Kerr Hollow Quarry at the Y-12 Plant."

4.2 Maintenance Activities

Ref: 1200-1-11-.05(7)

40 CFR 264.118(b)(2)

Closure activities at the KHQ, as required by the approved closure plan, included the removal of visible items and materials on the bottom of the quarry in order to remove potentially untreated hazardous wastes. A standard cap was impractical due to the quantity of water flowing into the quarry from the surrounding aquifer and was not included in the approved closure activities. Therefore, maintenance at the KHQ will be limited to inspection of the security fence, gate, signs, benchmarks, and groundwater monitoring system. Inspections will be conducted on a quarterly basis for all components of the KHQ. The monitoring wells associated with the KHQ will be subject to a comprehensive inspection on an annual basis. Table 1 identifies the items to be inspected and corrective actions to be taken.

All detection monitoring wells will be inspected annually by sounding the well. Rehabilitation or redevelopment will be conducted on those wells in which the sounding results indicate a well depth change of 20 percent or greater of the total screen length or of the open interval. In addition, as a part of the inspection program, all monitoring wells will be inspected to check for proper identification, damage, and to ensure that the protective caps are locked.

Following each inspection, the inspector will complete a Post-Closure Inspection Checklist for the site. Examples of inspection checklists are included in this Post-Closure Plan as Figures 1 and 2. These checklists will be maintained as required during the post-closure care period at the KHQ.

Table 1. Quarterly Inspection and Maintenance Plan for the Kerr Hollow Quarry

Inspection	Corrective Action
Monitoring Wells	
- Check for damage, make sure protective caps are locked. ID tags or numbers in place and legible.	Notify GWPPM if repairs cannot be made, P&A damaged well and construct replacement well with TDEC concurrence. Lock any unlocked caps.
Unauthorized Deliveries	
- Check for any extraneous materials at site.	Ensure all unauthorized materials are removed.
Signs	
- Check for any damaged or missing signs.	Ensure damaged or missing signs are repaired or replaced.
Benchmarks	
- Check for damage.	Ensure damaged benchmarks are replaced.

Source: Energy Systems, Inc., Y-12 Plant, Oak Ridge, Tennessee

Inspector's Name and Title: _____

Date of Inspection: _____

Time of Inspection: _____

Supervisor's Signature: _____

Inspection	Type of Problem	Acceptable Unacceptable*	Observations	Corrective Action	Date Action Requested
Monitoring Wells	Signs of damage, protective caps unlocked			Notify GWPPM. If repairs cannot be made, P&A damaged wells and replace with TDEC concurrence. Lock any unlocked caps.	
Unauthorized Deliveries	Extraneous materials at site			Ensure all unauthorized materials are removed.	
Signs	Damaged or missing signs			Ensure damaged or missing signs are repaired or replaced.	
Benchmarks	Check for damage			Ensure damaged benchmarks are replaced.	

* Photograph representing deteriorated conditions required before repairs.

Source: Energy Systems, Inc., Y-12 Plant, Oak Ridge, Tennessee

Figure 1. Example of a Post-Closure Inspection Checklist.

**Y-12 PLANT GROUNDWATER PROTECTION PROGRAM
WELL INSPECTION CHECKLIST
INSPECTION NO.:** _____

WELL INFORMATION						
Well Number: _____	Screen or Open Interval Length: _____		ft.			
Site: _____	Constructed Depth: _____		ft.			
PRIMARY INSPECTION ITEMS:						
WELL CASINGS:	<input type="checkbox"/> Steel	<input type="checkbox"/> Stainless Steel	<input type="checkbox"/> PVC	NO	YES	N/A
1. Is the steel or stainless steel well casing corroded, bent, or broken?				<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2. Is the PVC well casing cracked or broken?				<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
3. Is a protective surface casing installed (PVC well only)?				<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Is the protective casing corroded, bent, or broken?				<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
5. Is a weep located at the base of the protective casing?				<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
6. Is the steel, stainless steel, or PVC well casing loose?				<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
WELL SECURITY:						
1. Does the well have a cap or lid?				<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Does the well have a waterproof steel/brass lock?				<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Are the hasps firmly welded to well cap and/or metal casing?				<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
DOWNHOLE CONDITION:						
1. Is a measurement reference point marked on the top of the well casing?				<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Measured depth of well from top of well casing: _____					ft.	
3. Calculate: (Constructed Depth - Measured Depth)/Screen or Open Interval Length					%	
4. Is this value > 0.2 (represents % of screen or open - hole interval)?				<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
5. Do any obstructions occur within the well?				<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
SECONDARY INSPECTION ITEMS						
WELL ACCESS:				NO	YES	N/A
1. Does the access road require grading or additional gravel?				<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2. Do any obstructions (locked gates, fallen trees, etc.) block access to well? Explain: _____				<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
WELL IDENTIFICATION:						
1. Is a stainless steel plate with engraved well number attached to the outermost casing?				<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Is the well number legible?				<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Is the well identification number correct?				<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
CONCRETE PAD:						
1. Is a concrete pad installed (active wells only)?				<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Is the pad cracked or deteriorated?				<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
3. Is the pad sloped to prevent water from ponding around the casing?				<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
GUARD POSTS:						
1. Are the guard posts damaged?				<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
2. Are the guardposts positioned to prevent collision damage to well?				<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Are the guardposts of adequate height?				<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Is the high-traffic yellow paint degraded?				<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
WELL MAINTENANCE REQUEST						
Complete only if any of the above shaded yes/no boxes are checked.						
<input type="checkbox"/> Primary Item(s)	<input type="checkbox"/> Secondary Item(s)	Maintenance Request No. _____				
COMMENTS						
<hr/> <hr/>						
Inspection Date: _____			Inspected By: _____			

Figure 2. Example of a well inspection checklist.
A.2-6

Site maintenance will be conducted to repair any damage or correct site conditions at KHQ. If monitoring wells are damaged such that samples cannot be obtained, the wells will be plugged and replaced upon receiving written concurrence from the Commissioner. The damaged well will be plugged and abandoned in accordance with the current version of the procedure found in Appendix C.1 of the Post-Closure Permit Application for the KHQ.

4.3 Post-Closure Contact

Ref: 1200-1-11-.06(7)
40 CFR 164.118(b)(3)

The post-closure contact is identified in Section 3.0 of this plan.

5.0 Amendment of the Post-Closure Plan

Ref: 1200-1-11-.06(7)
40 CFR 264.118(d)

In the event that operating plans or facility design changes affect post-closure activities at the KHQ, an amended post-closure plan will be submitted to the Commissioner. The post-closure plan will be amended at least 60 days prior to the proposed change in facility design or operation, or not later than 60 days after an unexpected event has occurred which affects the post-closure plan.

6.0 Post-Closure Notices

Ref: 1200-1-11-.06(7)
40 CFR 264.119

Closure of the KHQ has been completed and notices as discussed in Section A of this permit application have been submitted. A plat map and waste description have been provided to the Anderson County, Tennessee Zoning Authority and TDEC. No record of deed has been made since the U.S. Department of Energy (DOE) Oak Ridge Reservation property does not have a deed. If, in the future, any Y-12 Plant property on which hazardous waste has been managed is to be released from federal government ownership for private development, information regarding these activities will be placed in a legal document which would be examined during a title search.

7.0 Certification of Completion of Post-Closure Care

Ref: 1200-1-11-.06(7)
40 CFR 264.120

Upon completion of the post-closure care activities at the KHQ, DOE will submit a certification to the Commissioner. This certification will be submitted no later than 60 days after completion of the established post-closure care period. The certification will be made by the owner/operator and an independent professional registered engineer that post-closure activities were conducted in accordance with the approved post-closure plan and permit.

8.0 Post-Closure Cost Estimate

Ref: 1200-1-11-.06(8)
40 CFR 264.140(c)

In accordance with the above references, federal facilities are exempt from providing post-closure care cost estimates.

8.1 Adjustments to Post-Closure Care Cost Estimates

Ref: 1200-1-11-.06(8)
40 CFR 264.140(c)

In accordance with the above references, federal facilities are exempt from the requirements concerning the submittal of cost estimates.

8.2 Revisions to Post-Closure Care Cost Estimates

Ref: 1200-1-11-.06(8)
40 CFR 264.140(c)

In accordance with the above references, federal facilities are exempt from the requirements concerning the submittal of cost estimates.

9.0 Financial Assurance for Post-Closure Care

Ref: 1200-1-11-.06(8)
40 CFR 264.140(c)

In accordance with the above references, federal facilities are exempt from the requirements pertaining to financial assurance.

A.3 CLOSURE CERTIFICATION LETTER

CERTIFIED

P 198 160 759

MAIL



STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
Division of Solid Waste Management
Fifth Floor, L & C Tower
401 Church Street
Nashville, Tennessee 37243-1535

February 22, 1995

Certified Mail
No. P 198 160 759
Return Receipt Requested

Mr. Robert C. Sleeman
Environmental Restoration Division
U.S. Department of Energy
Oak Ridge Operations Office
Post Office Box 2001
Oak Ridge, Tennessee 37831-8541

Re: Closure Certification
Kerr Hollow Quarry
Y-12 Plant
EPA I.D. No.: TN3 89 009 0001

Dear Mr. Sleeman:

This letter is to inform you that the Tennessee Department of Environment and Conservation's Division of Solid Waste Management has completed its review of the Owner/Operator/Co-Operator and Independent Registered Professional Engineer Closure Certifications submitted for the above referenced site.

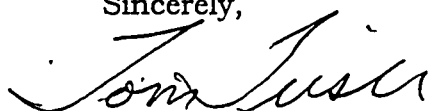
The Department concurs that closure has been performed in accordance with the approved closure plan and in compliance with the closure performance standards of 40 CFR 265.111 as incorporated by reference at Rule 1200-1-11-.05(7)(a).

Please recognize that closure of these units means that you are no longer authorized to operate these units under interim status. If, in the future, you wish to conduct operations that require a permit, you must first apply for and obtain that permit from this Department.

Mr. Robert C. Sleeman
February 22, 1995
Page 2

If you have any questions, please contact Mr. Edward Cox of my staff at (615)
532-0827.

Sincerely,



Tom Tiesler, Director
Division of Solid Waste Management

JTT/mec

cc: Ms. Jacqueline Okoreeh-Baah, Chief, Combustion Unit
Mr. Wayne Gregory, Chief, HW Permitting Unit
Mr. Bill Krispin, Chief, RCRA Land Unit
Mr. Earl Leming, Director, DOE Oversight Division
Mr. G. Alan Farmer, EPA, Region IV
Ms. Sherry Lankford, U. S. DOE
Mr. Tom Perry, Martin Marietta Energy Systems, Inc.
Mr. Mark Burris, MMES

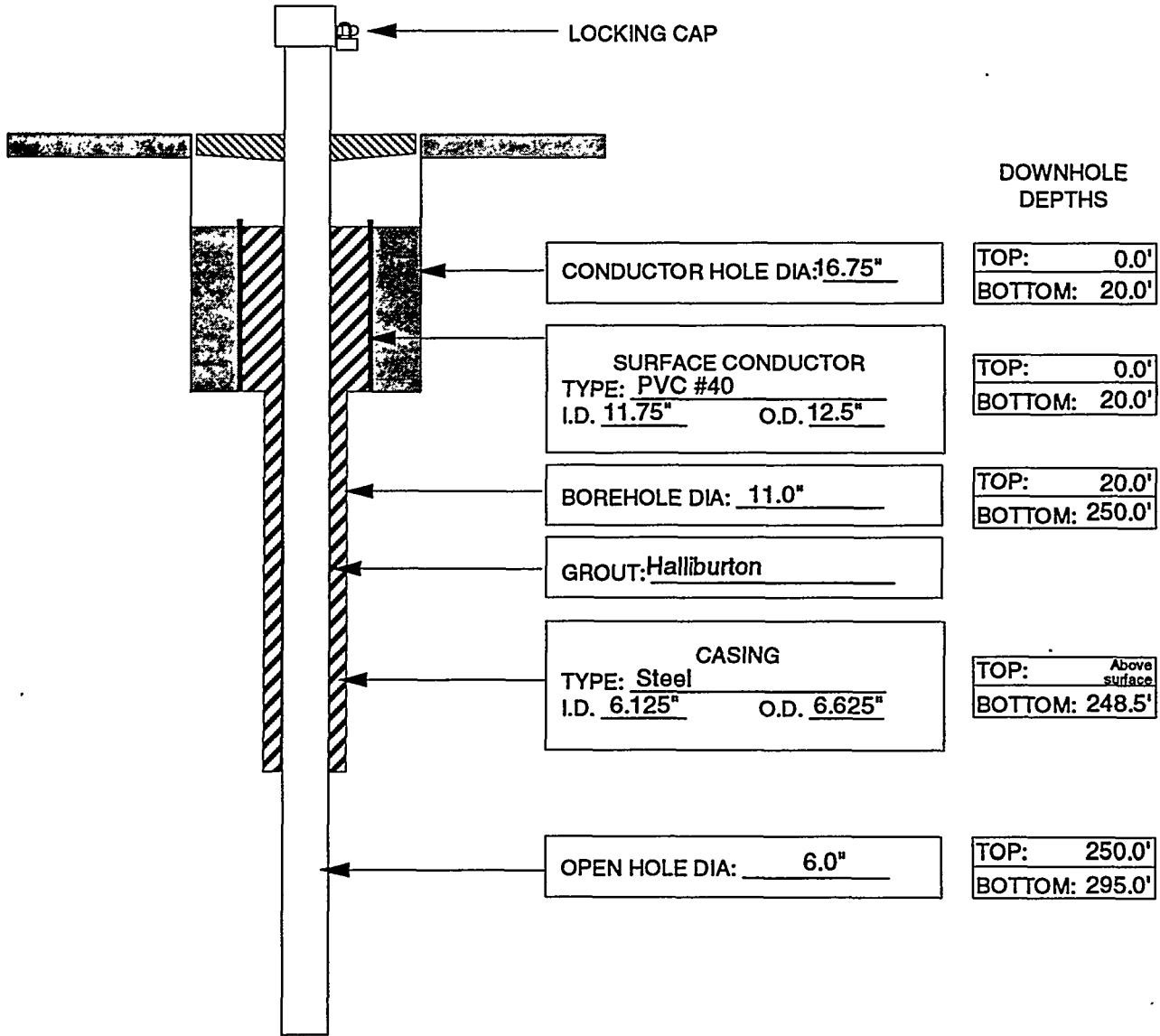
APPENDIX B
WELL CONSTRUCTION DIAGRAMS

WELL CONSTRUCTION SUMMARY

WELL NO. GW-142
 LOCATION Kerr Hollow
Quarry

DRILLING COMPANY: GEOTEK
 DRILLERS: R.M. Collins/Randy Collins

DATE COMPLETED:
3 Oct 1985
 TOTAL DEPTH: 295'



**DOWNHOLE
DEPTHS**

TOP: 0.0'
 BOTTOM: 20.0'

TOP: 0.0'
 BOTTOM: 20.0'

TOP: 20.0'
 BOTTOM: 250.0'

TOP: Above surface
 BOTTOM: 248.5'

TOP: 250.0'
 BOTTOM: 295.0'

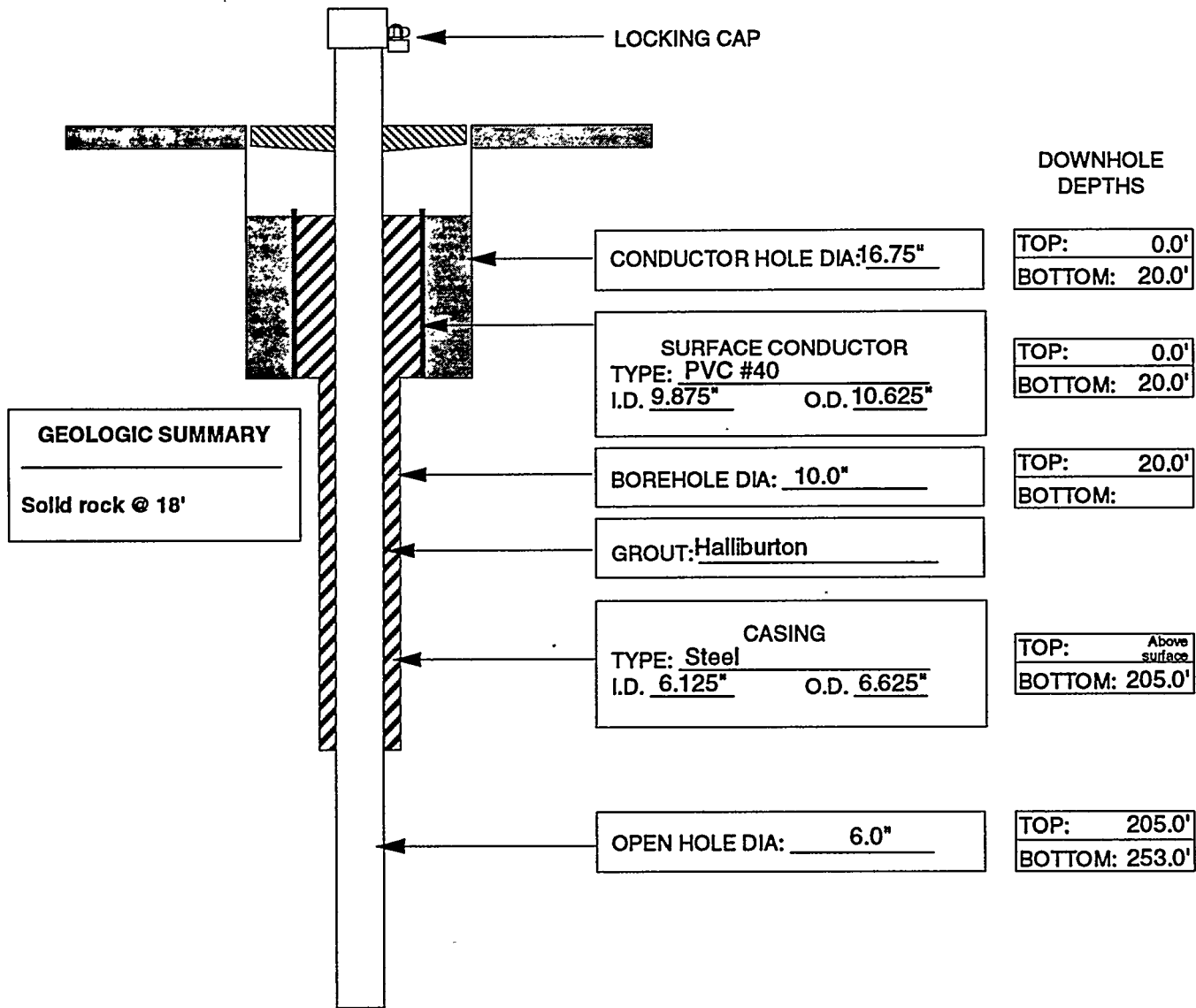
NOT TO SCALE

WELL CONSTRUCTION SUMMARY

WELL NO. GW-143
 LOCATION Kerr Hollow Quarry

DRILLING COMPANY: GEOTEK
 DRILLERS: R.M. Collins/Randy Collins

DATE COMPLETED:
24 Oct 1985
 TOTAL DEPTH: 253'



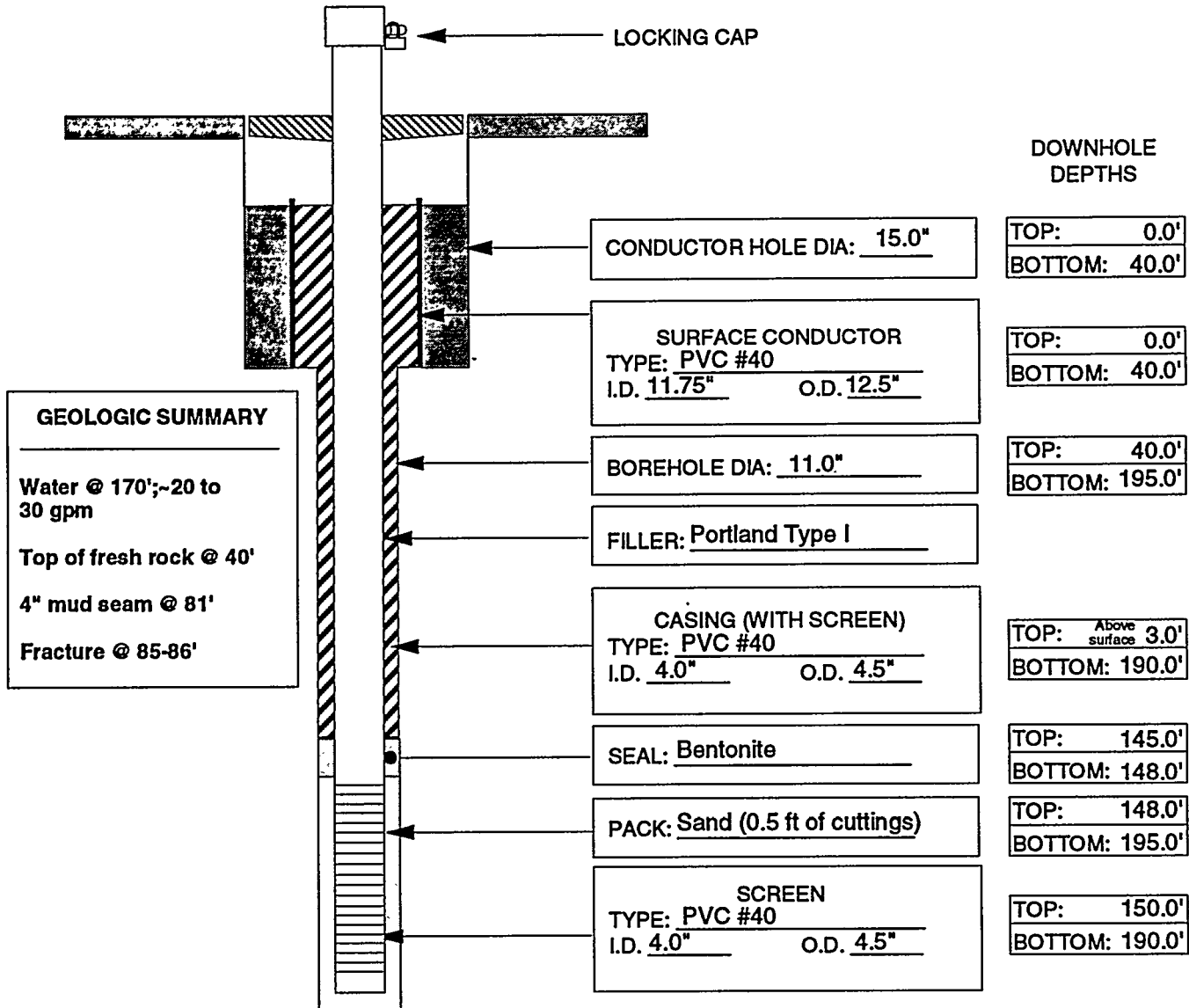
NOT TO SCALE

WELL CONSTRUCTION SUMMARY

WELL NO. GW-144
 LOCATION Kerr Hollow Quarry

DRILLING COMPANY: GEOTEK
 DRILLERS: R.M. Collins/Randy Collins

DATE COMPLETED:
24 Oct 1985
 TOTAL DEPTH: 195'



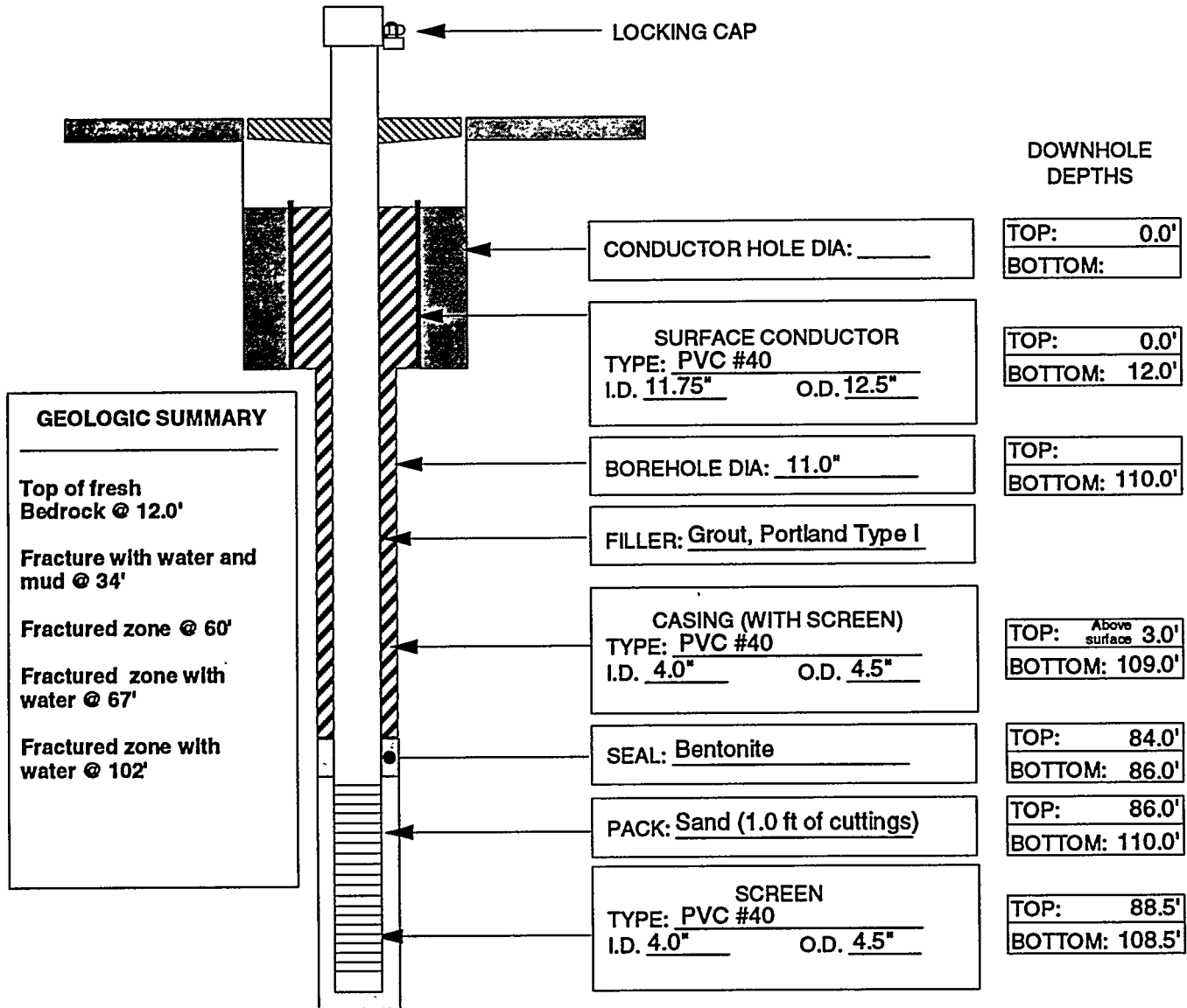
NOT TO SCALE

WELL CONSTRUCTION SUMMARY

WELL NO. GW-145
 LOCATION Kerr Hollow Quarry

DRILLING COMPANY: GEOTEK
 DRILLERS: R.M. Collins/Randy Collins

DATE COMPLETED:
14 Oct 1985
 TOTAL DEPTH: 110'



NOT TO SCALE

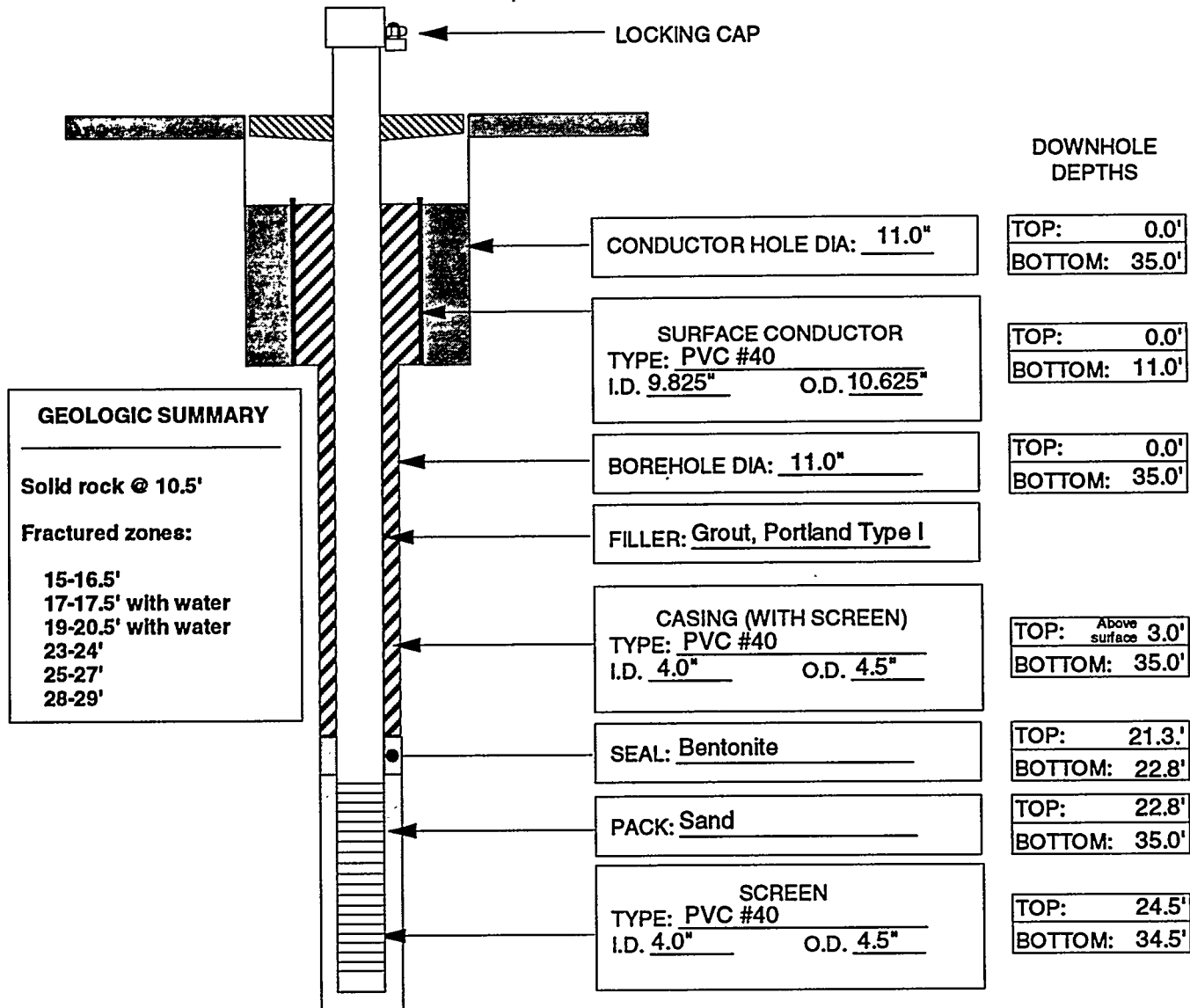
WELL CONSTRUCTION SUMMARY

WELL NO. GW-231
 LOCATION Kerr Hollow Quarry

DRILLING COMPANY: GEOTEK
 DRILLERS: Randy Collins

DATE COMPLETED:
02 Oct 1985
 TOTAL DEPTH: 35'

NOTE: Surface conductor temporary—not grouted.



GEOLOGIC SUMMARY

Sold rock @ 10.5'

Fractured zones:

- 15-16.5'
- 17-17.5' with water
- 19-20.5' with water
- 23-24'
- 25-27'
- 28-29'

NOT TO SCALE

APPENDIX C

APPLICABLE STANDARD PRACTICE PROCEDURES FOR THE GROUNDWATER PROTECTION PROGRAM

C.1 WELL PLUGGING AND ABANDONMENT

C.2 WELL INSPECTION PROCEDURE

C.3 WELL DEPTH MEASUREMENT PROCEDURE

C.1 WELL PLUGGING AND ABANDONMENT

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1.0 PURPOSE

This procedure contains guidelines and methods for well plugging and abandonment (P&A) at the Oak Ridge Y-12 Plant. Wells of similar construction materials and design are classified into one of four groups, and a specific P&A method is defined for each group. The methods are designed to remove all well materials, seal the borehole to prevent fluid migration into or between water-bearing zones, and to minimize the amount of waste-materials generated during P&A operations.

2.0 APPLICABILITY

This procedure applies to all wells at the Y-12 Plant which are designated for P&A by the Y-12 Plant Groundwater Protection Program Manager (GWPPM) or authorized designee.

3.0 DEFINITIONS

Annular Seal - material (grout or cement) which prevents fluid migration through the space between the well casing and borehole wall or outer casing.

Conductor Casing - an initial casing, typically steel or PVC, installed in the unconsolidated zone to support the borehole and provide drilling rig stability. This casing may be removed during completion of the well or grouted in place.

Containment System - excavated pit, drums, tanks or other containers used to collect and contain drill cuttings and fluids generated during P&A.

Diverter Assembly - apparatus used to direct drill cuttings and fluids to the containment system.

Groundwater Protection Program (GWPP) - program established to monitor groundwater quality and hydrologic conditions at the Y-12 Plant.

GWPP Manager (GWPPM) - person responsible for day-to-day management of the Y-12 Plant GWPP.

On-Site Geologist - a professional geologist, registered in the State of Tennessee, responsible for field supervision of P&A operations.

Open-Hole Interval - the bottom section of a well drilled in competent rock unsupported by well screen or casing.

Primary Inspection Item - those monitoring well components that are critical to the collection of representative groundwater samples and/or hydrologic data from the well. Includes the well casing and annular grout seal, well security, and the downhole condition of the well.

Protective Well Casing - a section of large diameter steel or polyvinyl chloride (PVC) pipe that is emplaced over the upper end of a smaller diameter monitoring well casing to provide structural protection to the well and restrict unauthorized access to the well.

Surface Casing - steel or PVC piping set from the ground surface into the top of bedrock to support the unconsolidated section of the borehole. The surface casing in a core hole extends into bedrock to the top of the open-hole interval.

Tremie Method - a method for placing cement in the borehole. Cement is pumped through a small diameter pipe (usually 2-in or less) extending to at least 1-ft above the bottom of the borehole or the top of a previously placed cement plug. The pipe is raised as the cement is emplaced. Use of this method reduces the potential for the cement to bridge and ensures placement of cement along the entire length of the borehole.

Washover Pipe - a drill pipe which fits around the well casing and is used to drill out the annular grout seal.

Well Casing - steel, stainless steel or PVC piping which provides unobstructed access to the monitored interval.

4.0 REFERENCES

- 4.1 Aller, Linda, Truman W. Bennett, Gene Hackett, Rebecca J. Petty, Jay H. Lehr, Helen Sedoris, and David M. Nielsen. Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells, National Water Well Association, Dublin, Ohio, 398 p.

-
- 4.2 Driscoll, Fletcher G. 1986. Groundwater and Wells, Johnson Division, St. Paul, Minnesota, 1089 p.
- 4.3 Martin Marietta Energy Systems, Inc. 1987. Environmental Surveillance Procedures Quality Control Program, ESH/SUB/87/21706/1.
- 4.4 Martin Marietta Energy Systems, Inc. 1987. Plugging and Abandonment Procedures for the Oak Ridge Y-12 Plant, Y/TS-531.
- 4.5 Martin Marietta Energy Systems, Inc. 1994. Monitoring Well Inspection and Maintenance Plan, Y-12 Plant, Oak Ridge, Tennessee (Revised), Y/TS-1215.
- 4.6 Halliburton Services, Inc., 1981, Halliburton Cementing Tables, Little's, Duncan, Oklahoma.
- 4.7 Jones, S.B., B. K. Thompson, and S. M. Field, 1994, 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, Y/TS-881/R2.

5.0 PRECAUTIONS AND LIMITATIONS

5.1 Cavities and Fractures

Cavities, fractures, joints, bedding planes, or other voids may be encountered during removal of the well casing and reaming of the borehole, resulting in a greater volume of cement to plug the borehole than calculated from the borehole depth and diameter. Additionally, lost-circulation additives may be required to minimize fluid loss during P&A operations.

5.2 Method Selection

Because of differences in well construction and conditions that may occur during drilling operations, not all of the monitoring wells at the Y-12 Plant can be classified into one of the four categories of well construction. A flexible policy is necessary to determine the most appropriate P&A method for each well and to allow some deviation from the specified method as conditions warrant.

5.3 Safety

Established safety standards and requirements of Martin Marietta Energy Systems, Inc., the Department of Energy (DOE), and the Occupational Safety and Health Administration (OSHA) will apply to all P&A field operations as outlined in *Health and Safety Plan for Well Installation and Plugging and Abandonment Activities, Y-12 Plant, Oak Ridge, Tennessee (Y/SUB/92-99928C(Y11)/1, July 1992.*

5.4 Cement Slurry Weights and Curing Schedules

The length of the column of cement emplaced at one time should not exceed 300 ft so that the weight of the cement is less than the fracture pressure of the monitored formation. This will also minimize infiltration of cement into the formation. Cement cure times shall be determined by the on-site geologist. Cure times will be specified depending on temperature and required compressive strength using guidelines established in Reference 4.6.

5.5 Casing Extraction

Certain monitoring wells have been constructed using substandard annular seals or no annular seal. Casings in these wells may be extracted without use of overwashing techniques. In cases where the construction of the well allows, an attempt to extract the well casing may be made using the drilling rig head and appropriate lifting device, such as lifting bell, clevis, wire rope, or chain. Casing extraction jacks may alternately be used. Drilling rig leveling jacks or winches shall not be used to attempt to extract casings prior to overwashing. The decision to attempt to extract a well casing shall be made by the on-site geologist, in conjunction with the GWPPM or authorized designee, and documented as specified in Section 7.0.

5.6 Well Construction Information

Data contained in Reference 4.7 is compiled from best available records. However, erroneous and missing well construction data exists, particularly for older wells that pre-date the GW Series. Where well construction data is unavailable, best technical judgment as to casing

set points or well depths will be employed by the on-site geologist in consultation with the GWPPM or authorized designee. As a result, deviations from the standard P&A likely will be required. All deviations shall be recorded as outlined in Section 9.0.

6.0 EQUIPMENT, TOOLS AND SUPPLIES

- 6.1 Fully Equipped Drilling Rig: includes but is not limited to drill bits, washover pipe, diverter assembly, etc.
- 6.2 Grouting Supplies and Equipment: cement, additives, potable water, mixer, pump, and tremie pipe.
- 6.3 Containment System (as required): excavated containment pit, drums, tanks, and/or other containers.
- 6.4 Safety Equipment (as required): includes but is not limited to safety shoes, tyvek coveralls, protective eye-wear, hard hat, and rubber gloves.
- 6.5 Decontamination Equipment (as required): includes but is not limited to steam cleaner, potable water, and mild detergent.

7.0 DOCUMENTATION

- 7.1 A Well Plugging and Abandonment Request Form is used to initiate P&A activities, and is completed by the Y-12 Plant GWPPM or authorized designee if: (1) a well impedes site operations, construction or closure, (2) inspection of a well has indicated significant damage to or deterioration of a Primary Inspection Item, or (3) the Y-12 Plant GWPPM or authorized designee determines that P&A of a well is warranted for other reasons. The completed form is transmitted to the on-site geologist when P&A operations are scheduled.
- 7.2 Before P&A operations begin, a Well Plugging and Abandonment Waste Management Plan is completed by the Y-12 Plant GWPPM or authorized designee. The plan includes: (1) the estimated volume of cuttings and fluids that will be generated during P&A, (2) the types and concentrations of contaminants (if any) known to be present in the well, (3) the appropriate waste containment method required during P&A operations (i.e.,

discharge to ground surface or containment system), (4) an estimate of the number and types of samples (e.g., cuttings) to be collected during P&A and the required analyses of the samples prior to disposal or treatment, and (5) the proposed disposition or treatment of any containerized materials.

- 7.3 Well Plugging and Abandonment Diagrams** are completed by the Y-12 Plant GWPP Manager or authorized designee, and the on-site geologist. Before P&A operations begin, the Y-12 Plant GWPP Manager or authorized designee completes the following sections of the diagram: (1) the well location (site), (2) the drilling subcontractor, (3) the rationale for P&A of the well, (4) the P&A method (including any proposed deviations from the specified method), and (5) applicable well construction details (e.g., borehole diameter). During P&A operations, the on-site geologist completes the diagram with specific P&A details for the well (e.g., depth to the top of the cement plug).
- 7.4 A Well Plugging and Abandonment Activity/Progress Report** is completed by the on-site geologist and includes descriptions of the daily activities performed during P&A operations.

8.0 PLUGGING AND ABANDONMENT

8.1 Site Preparation

- 8.1.1** Confirm well identification and site access, and mobilize drilling and grouting equipment to the well site.
- 8.1.2** Remove the surface features from the well (lock, well cap, guard posts, surficial concrete pad, protective well casing or manhole cover) as applicable.
- 8.1.3** If specified in the Well Plugging and Abandonment Waste Management Plan, set up the diverter assembly and the containment system.

8.2 Equipment Decontamination

If specified in the Well Plugging and Abandonment Waste Management Plan, decontaminate the drilling and associated equipment (e.g., drill bits, drill rods,

tremie pipe) when P&A operations at each well have been completed.

8.3 Method A

Method A is for wells constructed of 7 inch (in) outside diameter (OD) or smaller steel or stainless steel well casing, and typically completed with 5 to 20-ft well screens and sand filter packs. Wells completed in bedrock may also have 8- to 12-in-OD steel or PVC surface casing extending from ground surface to the top of bedrock. Some wells may also be completed with a conductor casing.

8.3.1 Remove the Well Casing

Drill out the annular grout seal using a washover pipe advanced to the bottom of the borehole. Retrieve the washover pipe and remove the well casing. Staged removal of the casing string may be necessary if it cannot be removed in one operation. In the event that a borehole is deviated, stainless steel casing may be drilled out with a tri-cone drill bit. If this approach is feasible, the bit size must be at least 0.25-in larger than the original borehole diameter to ensure that the casing and annular grout seal are completely removed.

8.3.2 Condition the Borehole

If the well was completed in bedrock, ream the borehole with a tri-cone drill bit that is at least 0.25-in larger in diameter than the original borehole. This will expose fresh bedrock and help ensure an effective bond between the cement plug and the borehole wall.

8.3.3 Set the Plug

Tremie API Class A neat cement, mixed with potable water to a slurry density of 12 to 15 pounds per gallon (lbs/gal), from the bottom of the borehole. If no surface/conductor casing is present, tremie the cement to within 4 ft of ground surface. If a surface/conductor casing is present, tremie the cement to within 4 ft of the bottom of the casing.

8.3.4 Remove the Surface/Conductor Casing

If the well was completed with surface/conductor casing, drill out the annular grout seal using a washover pipe advanced to the bottom of the casing. Retrieve the washover pipe and remove the casing. Using a tri-cone drill bit at least 0.25-in larger in diameter than that of the original borehole, ream the borehole to the top of the existing cement plug. Tremie cement, mixed to a density of 12 to 15 lbs/gal, from the top of the existing plug to within 4 ft of the ground surface (or bottom of conductor casing, if removing a surface casing).

It may be possible to remove PVC casing by drilling it out with a tri-cone drill bit. If this approach is feasible, the bit size must be at least 0.25-in larger than the original borehole diameter to ensure that the casing and annular grout seal are completely removed.

8.3.5 Verify Plug Depth

Measure the depth to the top of the cement plug to verify that it is within 4 ft of the ground surface. If not, add more cement until the specified depth is reached.

8.3.6 Cap the Plug

Fill the remainder of the borehole to ground surface with compacted non-contaminated soil.

8.4 Method B

Method B is for wells constructed of 7-in-OD or smaller steel or PVC well casing completed with open-hole intervals in competent bedrock. The well casing typically extends from the ground surface to the top of the open-hole interval, which typically extends from 5 to 100 ft below the bottom of the well casing. The wells may also be completed with 8- to 12-in-OD steel or PVC surface casing extending from ground surface to the top of bedrock. Some wells may also be completed with a conductor casing.

8.4.1 Condition the Open-Hole Interval

Lower a drill string and tri-cone drill bit into the well. Circulate air and potable water containing additives such as QUIK-GEL or QUICK-MUD to remove any old cuttings and debris that may have accumulated at the bottom of the well. After the initial circulation, drill approximately 1 ft below the bottom of the well to expose fresh rock, and repeat the well circulation procedure to remove the cuttings.

8.4.2 Set the Lower Plug

Tremie API Class A neat cement, mixed with potable water to a slurry density of 12 to 15 lbs/gal, from the extended bottom of the open-hole interval to within 4 ft of the bottom of the well casing.

8.4.3 Remove the Well Casing

Drill out the annular grout seal surrounding the well casing using a washover pipe advanced to the top of the open-hole interval. Retrieve the washover pipe and remove the casing. Staged removal of the casing string may be necessary if it cannot be removed in one operation.

It may be possible to remove PVC well casing by drilling it out with a tri-cone drill bit. If this approach is feasible, the bit size must be at least 0.25-in larger than the original borehole diameter to ensure that fresh bedrock is exposed and that the casing and annular grout seal are completely removed.

8.4.4 Condition the Borehole

Ream the borehole with a tri-cone drill bit that is at least 0.25-in larger in diameter than the original borehole. This will expose fresh bedrock and help ensure an effective bond between the cement plug and the borehole wall.

8.4.5 Set the Upper Plug

Tremie cement, mixed to a density of 12 to 15 lbs/gal, from the top of the lower plug. If no surface/conductor casing is present, tremie the

cement to within 4 ft of ground surface. If a surface/conductor casing is present, tremie the cement to within 4 ft of the bottom of the casing.

8.4.6 Remove the Surface/Conductor Casing

If the well was completed with surface/conductor casing, drill out the annular grout seal using a washover pipe advanced to the bottom of the casing. Retrieve the washover pipe and remove the casing. Using a tri-cone drill bit at least 0.25-in larger in diameter than the original borehole, ream the borehole to the top of the existing cement plug. Tremie cement, mixed to a density of 12 to 15 lbs/gal, from the top of the existing plug to within 4 ft of the ground surface (or bottom of the conductor casing, if removing a surface casing).

It may be possible to remove PVC casing by drilling it out with a tri-cone drill bit. If this approach is feasible, the bit size must be at least 0.25-in larger than the original borehole diameter to ensure that the casing and annular grout seal are completely removed.

8.4.7 Verify Plug Depth

Measure the depth to the top of the cement plug to verify that it is within 4 ft of the ground surface. If not, add more cement until the specified depth is reached.

8.4.8 Cap the Plug

Fill the remainder of the borehole to ground surface with compacted non-contaminated soil.

8.5 Method C

Method C is for wells constructed of 7-in-OD or smaller PVC well casing, and typically completed with 5 to 20-ft well screens and sand filter packs. Wells completed in bedrock may also have 8 to 12-in-OD steel or PVC surface casing extending from ground surface to the top of bedrock. Some wells may also be completed with a conductor casing.

8.5.1 Remove the Well Casing

Drill out the annular grout seal around the well casing using a washover pipe advanced to the bottom of the borehole. Retrieve the washover pipe and remove the well casing. Staged removal of the casing string may be necessary if it cannot be removed in one operation.

It may be possible to remove the PVC well casing by drilling it out with a tri-cone drill bit. If this approach is feasible, the bit size must be at least 0.25-in larger than the original borehole diameter to ensure that fresh bedrock is exposed (bedrock wells only) and that the casing and annular grout seal are completely removed.

8.5.2 Condition the Borehole

If the well was completed in bedrock, ream the borehole with a tri-cone drill bit that is at least 0.25-in larger in diameter than the original borehole. This will expose fresh bedrock and help ensure an effective bond between the cement plug and the borehole wall.

8.5.3 Set the Plug

Tremie API Class A neat cement, mixed with potable water to a slurry density of 12 to 15 lbs/gal, from the bottom of the borehole. If no surface/conductor casing is present, tremie the cement to within 4 ft of ground surface. If a surface/conductor casing is present, tremie the cement to within 4 ft of the bottom of the casing.

8.5.4 Remove the Surface/Conductor Casing

If the well was completed with surface/conductor casing, drill out the annular grout seal using a washover pipe advanced to the bottom of the casing. Retrieve the washover pipe and remove the casing. Using a tri-cone drill bit at least 0.25-in larger in diameter than the original borehole, ream the borehole to the top of the existing cement plug. Tremie cement, mixed to a density of 12 to 15 lbs/gal, from the top of the existing plug to within 4 ft of the ground

surface (or bottom of conductor casing if removing a surface casing).

It may be possible to remove PVC casing by drilling it out with a tri-cone drill bit. If this approach is feasible, the bit size must be at least 0.25-in larger than the original borehole diameter to ensure that the casing and annular grout seal are completely removed.

8.5.5 Verify Plug Depth

Measure the depth to the top of the cement plug to verify that it is within 4 ft of the ground surface. If not, add more cement until the specified depth is reached.

8.5.6 Cap the Plug

Fill the remainder of the borehole from the top of the cement plug to ground surface with compacted non-contaminated soil.

8.6 Method D

Method D is for exploratory core holes constructed of 4.5-in-OD or smaller steel surface casing, which typically extends from ground surface into competent bedrock, with an open-hole interval below the bottom of the casing. The core holes may also have 8 to 12-in-OD steel or PVC conductor casing extending through the unconsolidated material.

8.6.1 Condition the Open-Hole Interval

The open-hole interval of the core holes will not be conditioned (i.e., fluid circulation or reamed to expose fresh bedrock). This would require the prior removal of the 4.5-in-OD surface casing, which may risk collapse of the upper portion of the core hole before P&A operations are completed. In addition, core hole diameters are normally 3.5-in. or less, which are smaller than standard tri-cone bits.

8.6.2 Set the Lower Plug

Tremie API Class A neat cement, mixed with potable water to give a slurry density of 12 to 15 lbs/gal, from the bottom of the open-hole

portion of the core hole. Because of the long open hole intervals in the core holes, the cement must be installed in stages of approximately 300 ft or less. During placement, tremie the cement from the bottom to the top of the particular interval being plugged, and allow the cement to set for 24 hours. In the final stage, tremie the cement to within 4 ft of the bottom of the surface casing.

8.6.3 Remove the Surface Casing

Drill out the annular grout seal around the surface casing using a washover pipe advanced to the bottom of the casing. Retrieve the washover pipe and remove the casing. Staged removal of the casing may be necessary if it cannot be removed in one operation.

8.6.4 Condition the Borehole

Ream the borehole to the top of the existing cement plug using a tri-cone drill bit that is at least 0.25 larger than the original borehole diameter. This will expose fresh bedrock and help ensure an effective bond between the cement plug and the borehole well.

8.6.5 Set the Upper Plug

Tremie cement, mixed to a density of 12 to 15 lbs/gal, from the top of the lower plug. If no conductor casing is present, tremie the cement to within 4 ft of ground surface. If a conductor casing is present, tremie the cement to within 4 ft of the bottom of the conductor casing.

8.6.6 Remove the Conductor Casing

If the core hole was completed with conductor casing, drill out the annular grout seal using a washover pipe advanced to the bottom of the conductor casing. Retrieve the washover pipe and remove the conductor casing. Using a tri-cone drill bit at least 0.25-in larger in diameter than the original borehole, ream the upper portion of the borehole to the top of the existing cement plug. Tremie cement, mixed to a density of 12 to 15 lbs/gal, from the top of the

existing plug to within 4 ft of the ground surface.

It may be possible to remove PVC conductor casing by drilling it out with a tri-cone drill bit. If this approach is feasible, the bit size must be at least 0.25-in larger than the original borehole diameter to ensure that the casing and annular grout seal are completely removed.

8.6.7 Verify Plug Depth

Measure the depth to the top of the cement plug to verify that it is within 4 ft of the ground surface. If not, add more cement until the specified depth is reached.

8.6.8 Cap the Plug

Fill the remainder of the borehole to the ground surface with compacted non-contaminated soil.

9.0 ACCEPTANCE CRITERIA

The on-site geologist will verify that P&A operations were performed in accordance with the specified method. Any deviations from the specified P&A method must be pre-approved by the Y-12 Plant GWPPM or authorized designee. Requests for deviations may be verbal, but must be recorded immediately in the field log book and include date, time, and authorizing personnel. Deviations will also be noted on Activity/Progress Forms and P&A Diagrams as appropriate.

10.0 POST PERFORMANCE WORK ACTIVITIES

10.1 The on-site geologist will submit the Well Plugging and Abandonment documentation to the Y-12 Plant GWPPM or authorized designee.

10.2 Waste materials generated during P&A will be disposed of in accordance with the Well Plugging and Abandonment Waste Management Plan.

TITLE: Well Plugging and Abandonment Procedure

11.0 RECORDS

11.1 Well Plugging and Abandonment Request Form

11.2 Well Plugging and Abandonment Waste Management Plan

11.3 Well Plugging and Abandonment Diagram

11.4 Well Plugging and Abandonment Activity/Progress Report

C.2 WELL INSPECTION PROCEDURE

Oak Ridge Y-12 Plant
Groundwater Protection Program
Standard Practice Procedure

Well Inspection Procedure
G-001
Rev. 1., July 1994

Approved by: W. Kevin Jagg Date: 8-17-94

Effective Date: 8-18-94

Record of Changes

Change No.	Affected Pages	Approved Date	Expiration Date	Change No.	Affected Pages	Approved Date	Expiration Date

Next 3-year review required no later than: July 1997.

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1.0 PURPOSE

This is a procedure intended to establish a systematic method for inspecting the physical condition of a monitor well and to identify monitor-well maintenance needs that will extend the life of the well and ensure the collection of representative groundwater quality samples and hydrologic data from the well.

2.0 APPLICABILITY

This procedure is applicable to all monitor wells located at the Y-12 Plant.

3.0 DEFINITIONS

Annular Seal - a grout seal installed between the well casing and borehole wall or outer casing.

Christy Box - steel or plastic box installed below the ground surface that allows access to the top of casing in a flush-mounted well design.

Concrete Pad - typically a neat cement or concrete pad at ground surface that surrounds the well casing or protective surface casing.

Constructed Depth - the distance from the top of the innermost well casing to the bottom of the screened or open interval as reported in: 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, Y/TS-881(R2), August 1994 (or most recent version).

Flush-Mounted Well - well head completion where the top of casing is below the ground surface.

Groundwater Protection Program (GWPP) - a program developed per DOE Order 5400.1 to characterize the hydrogeology and monitor and protect groundwater quality at the Y-12 Plant.

GWPP Manager - person responsible for day-to-day management of the Y-12 Plant Groundwater Protection Program or authorized designee.

Guard Posts - posts placed around a well to prevent vehicular collision damage to the well.

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Hasp - a welded fastening that allows a well cap to be locked to the well casing, or a hinged steel lid to be locked to the protective casing.

Incrustation - deposition of mineral matter on the well screen and/or casing, typically through chemical or biological reactions.

Lock - a waterproof, steel or brass fastening device that secures the well cap or protective-casing lid and prevents unauthorized access to the well.

Measured Depth - the distance from the top of innermost well casing to the bottom of the well as measured in the field.

Monitor Well - a well installed to enable collection of groundwater samples and/or hydrologic data (i.e., staticwater level).

Open-Hole Interval - a portion of a monitor well that contains no well casing through which groundwater enters the well and samples are obtained.

Primary Inspection Items - those components of a monitor well that are critical to the collection of representative groundwater quality samples and hydrologic information. Primary inspection items include the well casing and screen, hasp, lock, cap, well identification, and condition of the screened or open-hole interval.

Protective Surface Casing - a section of large-diameter steel pipe that is emplaced over the surface extension of a smaller diameter well casing to provide structural protection to the well and restrict unauthorized access to the well. A weep (hole) is usually located near the base of the casing to serve as a drain and prevent water from collecting inside the protective surface casing.

Screened Interval - A portion of a monitor well that contains a slotted, perforated, or wire-wound section of casing (e.g., screen) through which groundwater enters the well and samples are obtained.

Secondary Inspection Items - those components of a monitor well which generally do not affect collection of representative groundwater quality samples or hydrologic information; these include well access, guard posts, and concrete pad.

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Sediment Accumulation - accumulation of sand, silt, precipitates, or other debris in the bottom of the well.

Well Access - the means by which a well is accessible (e.g., gravel road).

Well Cap - a removable cap or hinged steel lid used to cover a well casing.

Well Casing - steel, stainless steel or PVC pipe which provides unobstructed access to the monitored interval.

Well Identification - a stainless steel plate that is engraved with the well identification number and is attached to the outermost casing.

4.0 REFERENCES

4.1 Use References

- 4.1.1 "Comprehensive Groundwater Monitoring Plan for the Department of Energy Y-12 Plant Oak Ridge, Tennessee," Y/SUB/90-00206C/5, September 1990.
- 4.1.2 "Calendar Year 1993 Groundwater Quality Report for the Bear Creek Hydrogeologic Regime, Y-12 Plant, Oak Ridge, Tennessee," Y/SUB/94-EAQ10C/1, Parts 1 and 2.
- 4.1.3 "Calendar Year 1993 Groundwater Quality Report for the Chestnut Ridge Hydrogeologic Regime, Y-12 Plant, Oak Ridge, Tennessee," Y/SUB/94-EAQ10C/3, Parts 1 and 2.
- 4.1.4 "Calendar Year 1993 Groundwater Quality Report for the Upper East Fork Poplar Creek Hydrogeologic Regime, Y-12 Plant, Oak Ridge, Tennessee," Y/SUB/94-EAQ10C/2, Parts 1 and 2.
- 4.1.5 "Oak Ridge Y-12 Plant Groundwater Protection Program Management Plan (Revised)," Y/SUB/93-YP507C/4, June 1993 (or most recent revision).
- 4.1.6 "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," Y/TS-881(R2), August 1994 (or most recent revision).

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- 4.1.7 "Monitor Well Inspection and Maintenance Plan, Y-12 Plant, Oak Ridge, Tennessee (Revised)," Y/TS-1215, July 1994.

4.2 Source References

- 4.2.1 Aller, Linda, Truman W. Bennett, Gene Hackett, Rebecca J. Petty, Jay H. Lehr, Helen Sedoris, and David M. Nielsen "Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells", NWWA, Dublin, Ohio, 398 p.
- 4.2.2 Driscoll, Fletcher G., 1986, "Groundwater and Wells", Johnson Division, St. Paul, Minnesota, 1089 p.
- 4.2.3 "Environmental Surveillance Procedures Quality Control Program," ESH/Sub/87/21706/1, February 1987.
- 4.2.4 Gass, Tyler E., Truman W. Bennett, James Miller and Robin Miller, 1980, "Manual of Water Well Maintenance and Rehabilitation Technology", NWWA, Dublin, Ohio, 247 p.
- 4.2.5 Nielsen, David M., 1991, "Practical Handbook of Groundwater Monitoring", Lewis Publishers, Chelsea, Michigan, 717 p.
- 4.2.6 U.S. Department of Energy, "Procedures for the Collection and Preservation of Groundwater and Surface Water Samples and for the Installation of Monitoring Wells", GJ/TMC-08 (Second Edition) UC-70A, October 1985.
- 4.2.7 U.S. Environmental Protection Agency, "Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual", Region IV, Athens, Georgia, February 1991.
- 4.2.8 U.S. Environmental Protection Agency, "RCRA Comprehensive Groundwater Monitoring Evaluation Document" (RCRA Groundwater Monitoring Systems), RCRA Enforcement Division, March 1988.
- 4.2.9 U.S. Environmental Protection Agency, "RCRA Facility Investigation (RFI) Guidance, Volumes I-IV", OSWER Directive 9502.00-6C, July 1987.

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4.2.10 U.S. Environmental Protection Agency, "RCRA Groundwater Monitoring Technical Enforcement Guidance Document", OSWER-9950.1, September 1986.

5.0 PRECAUTIONS AND LIMITATIONS

5.1 Annular Seal

The downhole condition of the annular seal cannot be determined without geophysical techniques. Such evaluation is beyond the scope of this procedure.

5.2 Constructed Well Depth

The reported constructed depth of a well may require confirmation or may be inaccurate as recorded in original well construction records.

5.3 Incrustation

The downhole condition of a well screen cannot be determined without remote sensing. Such evaluation is beyond the scope of this procedure.

5.4 Limits of Tape Measure

Some wells are completed at depths (i.e., > 300 ft) that cannot be measured with a flat, weighted steel or fiberglass measuring tape. Additionally, the depth of wells which contain large water columns (i.e., greater than 100 ft) also may not be measurable with a flat, weighted measuring tape. A circular, stainless steel or coated steel measuring cable shall be used for all wells greater than a 300 ft depth and is preferable for all wells.

5.5 Measurement Accuracy

Increased depth and large water columns decrease the accuracy of the well depth measurements.

5.6 Safety

Established safety standards and requirements of Martin Marietta Corporation, DOE, and OSHA will apply to the inspection and maintenance of a monitor well. All field personnel will be provided with appropriate safety clothing, equipment, and training.

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5.7 Well Access

A well may be deemed inaccessible because of site conditions or operations.

6.0 PREREQUISITES

6.1 Initial Inspection

If a well is currently scheduled for Plugging and Abandonment (P/A), inspection and maintenance of the well is not performed.

6.2 Subsequent Inspections

If a well is currently included in the comprehensive groundwater monitoring program, the well is classified as active and a well inspection is performed annually. If not, the well is classified as inactive and a well inspection is performed every three years. Wells for which the status changes from inactive to active will be inspected prior to monitoring.

7.0 TEST EQUIPMENT, TOOLS AND SUPPLIES

7.1 Documentation: Updated Subsurface Data Base (Y/TS-881/R2 or most recent revision), Well Inspection Maintenance Summary, Well Construction Data Summary, Well Inspection Checklist, Well Maintenance Request Form, Well Depth Measurement Procedure (G-002), Active Well Status Checklist, and Daily Activity Log.

7.2 Field Equipment: Well locks, keys to unlock wells, weighted steel or fiberglass measuring tape and/or cable, pens, indelible markers, and clip-board.

7.3 Personal Protective Equipment:
Required: Rubber gloves
Optional: Safety shoes, tyvek coveralls, protective eye-wear, hard hat.

7.4 Decontamination Equipment: Plastic ground cover, distilled water, wash bottles, mild detergent, and collection vessels for wash and rinse water.

8.0 ACTION STEPS

8.1 Preparation

- 8.1.1 Identify wells to be inspected from the Well Inspection/Maintenance Summary.
- 8.1.2 Review Well Location Map(s) and Well Construction Data Summary to determine:
 - a. the well location;
 - b. the constructed depth of the well; and
 - c. length of the screen or open-hole interval for the well.

8.2 Inspection

- 8.2.1 On the Well Inspection Checklist, enter the inspection number for the well. The Y-12 Plant GWPP Manager or authorized designee will assign the inspection number using the following format: two-digit number denoting the year followed by a dash followed by a three-digit number (example: 91-001). Inspection numbers for each well should be assigned consecutively (i.e., 91-001, 91-002, 91-003,...).

Complete the Well Information section of checklist using information from the Updated Subsurface Data Base (for well number) and the Well Construction Data Summary (for site, screened or open-hole interval length, and constructed well depth).

- 8.2.2 Verify that the monitor well is accessible by vehicle (active wells only). If construction, fencing, fallen trees, or site operation or closure activities have isolated the well, note on Well Inspection Checklist and report the finding to the Y-12 GWPP Manager or authorized designee. Otherwise, note any maintenance needs for well access road on Well Inspection Checklist.
- 8.2.3 Inspect guard posts for damage, physical deterioration, paint degradation, and proper positioning (active wells only). Each post should be painted high-traffic yellow, and be a height above ground that is adequate to prevent vehicular collision damage. The guard posts should be situated between the well and each

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traffic approach to the well. Complete appropriate section of Well Inspection Checklist.

- 8.2.4 Confirm that a stainless steel plate engraved with a legible well identification number is attached to the outermost casing of the monitor well. Through a comparison with the Updated Subsurface Data Base, confirm that the well number is correct. Complete appropriate section of Well Inspection Checklist.
- 8.2.5 Inspect the concrete pad for cracks and deterioration (active wells only). The top of the pad should be level or slope away from the casing to prevent ponding of rain water around the well casing. Complete appropriate section of Well Inspection Checklist.
- 8.2.6 Inspect the lock for corrosion and operation of the locking mechanism. If a lock is corroded and difficult to open, replace it. Do not use any lubricant to improve lock performance. Complete appropriate section of Well Inspection Checklist.
- 8.2.7 Inspect the integrity of the hasps, making certain that they are firmly welded to the well cap and/or the metal casing. Complete appropriate section of Well Inspection Checklist.
- 8.2.8 Inspect the condition of the well cap or hinged steel lid. Complete appropriate section of Well Inspection Checklist.
- 8.2.9 Inspect all above-ground well casings and protective surface casings (if present) for cracks, corrosion, breaks, bends, or any other signs of deterioration that may effect structural integrity. Inspect base of protective surface casing to locate weep. Complete appropriate section of Well Inspection Checklist.
- 8.2.10 For flush-mounted wells, inspect traffic covers for presence of fasteners (bolts), excessive rust or deterioration, or any other notable damage. Covers should be securely bolted to the christy box.
- 8.2.11 For flush-mounted wells, inspect christy box for excessive rust or other damage. The concrete pad surrounding the christy box should be sloped as

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to minimize the potential for water accumulation inside of the box.

- 8.2.12 For flush-mounted wells, inspect the water-tight well cap for tightness and condition of the rubber seal. Caps should fit securely so that they cannot be turned by hand.
- 8.2.13 Inspect the annular seal for cracks, if visible, and by shaking the well casing. The casing should not easily move. Complete appropriate section of Well Inspection Checklist.
- 8.2.14 Put on rubber gloves.
- 8.2.15 Remove lock and well cap.
- 8.2.16 Verify that an established reference mark (measuring point) is on the top of the innermost well casing. If not, establish a mark with indelible marker on the well casing for future reference and notify the Y-12 Plant GWPP Manager or authorized designee.
- 8.2.17 Measure the well depth from the established reference mark to the bottom of the well and record on the checklist to the nearest 0.1 foot. Perform measurement in accordance with Y-12 Plant Well Depth Measurement Procedure (G-002).
- 8.2.18 Compare measured well depth to the constructed depth of the well by using the equation: Sediment Accumulation = Constructed Depth - Measured Depth. The sediment accumulation divided by the screen or open-hole interval length must be less than 0.2. Complete appropriate section of Well Inspection Checklist.
- 8.2.19 If any shaded yes/no answer box for each item on Well Inspection Checklist is checked, complete Well Maintenance Request section of checklist noting if maintenance is needed for Primary or Secondary Inspection Item(s), or both.

Enter the maintenance request number for the well on the Well Inspection Checklist and Maintenance Request Form. The Y-12 Plant GWPP Manager or authorized designee will assign maintenance request numbers using the following format: a two-digit number denoting the year followed by a

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dash followed by a three-digit number with a "P" (for Primary Inspection Item), or "S" (for Secondary Inspection Item), or "PS" (for both Primary and Secondary Inspection Items) suffix (examples: 91-001P, 91-001S, 91-001PS). Consecutive maintenance request numbers for each well should be assigned (example: 91-001P, 91-002S, 91-003S,...).

8.2.20 Sign and date Well Inspection Checklist.

9.0 ACCEPTANCE CRITERIA

If none of the inspection items require maintenance, inspection of the well is complete.

10.0 POST PERFORMANCE WORK ACTIVITIES

10.1 Documentation

Compile Well Inspection Checklists and Well Maintenance Request Forms. Transfer appropriate data from checklists and forms to the Well Inspection/Maintenance Summary. Submit all checklists, forms, and the completed Well Inspection/Maintenance Summary to the Y-12 Plant GWPP Manager or authorized designee.

10.2 Maintenance Work Inspection

The Y-12 Plant GWPP Manager or authorized designee will schedule and coordinate all well maintenance activities. When requested maintenance has been completed, obtain original Well Maintenance Request Form from Y-12 Plant GWPP Manager or authorized designee and inspect maintenance work performed.

10.3 Plugging and Abandonment Requests

If the Y-12 Plant GWPP Manager or authorized designee determines that, based upon consultations with field inspection personnel and a well site visit (if needed), a Primary Inspection Item is damaged or deteriorated beyond practical repair, the well may require plugging and abandonment. The Y-12 Plant GWPP Manager or authorized designee will prepare all Plugging and Abandonment Request Forms and schedule and coordinate all related activities.

C.3 WELL DEPTH MEASUREMENT PROCEDURE

Oak Ridge Y-12 Plant
Groundwater Protection Program
Standard Practice Procedure

Well Depth Measurement Procedure
G-002
Rev. 1., July 1994

Approved by: W. Kevin Jago Date: 8-17-94
Effective Date: 8-18-94

Record of Changes

Change No.	Affected Pages	Approved Date	Expiration Date	Change No.	Affected Pages	Approved Date	Expiration Date

Next 3-year review required no later than: July 1997

TITLE: Monitor Well Depth Measurement Procedure

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TITLE: Monitor Well Depth Measurement Procedure

1.0 PURPOSE

This procedure is a standardized method for determining the measured depth of a groundwater monitoring well. The measured depth of a well, when compared to the constructed depth of the well, provides an indication of sediment accumulation or obstructions within the well.

2.0 APPLICABILITY

Measuring well depth is applicable to all monitor wells located at the Y-12 Plant.

3.0 DEFINITIONS

Constructed Depth - the distance from the top of the innermost well casing to the bottom of the screened or open interval as reported in: 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, Y/TS-881(R2), August 1994 (or most recent revision).

Groundwater Protection Program (GWPP) - a program developed per DOE Order 5400.1 to characterize the hydrogeology and monitor and protect groundwater quality at the Y-12 Plant.

GWPP Manager - person responsible for day-to-day management of the Y-12 Plant Groundwater Protection Program or authorized designee.

Measured Depth - the distance from the top of the innermost well casing to the bottom of the well as measured in the field.

Sediment Accumulation - accumulation of sand, silt, precipitates, or other debris in the bottom of the well.

Well Cap - a removable cap used to cover a well casing.

Well Casing - steel, stainless steel, or PVC pipe which provides unobstructed access to the monitored interval.

Well Identification - a steel plate embossed with the well identification number that is attached to the outermost casing.

4.0 REFERENCES

4.1 Use References

- 4.1.1 "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", Y/TS-881(R2), August 1994 (or most revision).
- 4.1.2 "Monitor-Well Inspection and Maintenance Plan, Y-12 Plant, Oak Ridge, Tennessee (Revised)", Y/TS-1215, July 1994

4.2 Source References

- 4.2.1 Driscoll, Fletcher G., 1986, "Groundwater and Wells", Johnson Division, St. Paul, Minnesota, 1089 p.
- 4.2.2 "Environmental Surveillance Procedures Quality Control Program", ESH/Sub/87/21706/1, February 1987.
- 4.2.3 Gass, Tyler E., Truman W. Bennett, James Miller and Robin Miller, 1980, "Manual of Water Well Maintenance and Rehabilitation Technology", NWWA, Dublin, Ohio, 247 p.
- 4.2.4 U.S. Environmental Protection Agency, "A Compendium of Superfund Field Operations Methods", EPA/540/P-87/001, 1987.
- 4.2.5 U.S. Environmental Protection Agency, "RCRA Groundwater Monitoring Technical Enforcement Guidance Document", OSWER-9950.1, September 1986.

5.0 PRECAUTIONS AND LIMITATIONS

5.1 Constructed Well Depth

The reported constructed depth of the well may require confirmation or may be inaccurate as recorded in original well construction records.

5.2 Limits of Tape Measure

Some wells are completed at depths (i.e., > 300 ft) that cannot be measured with a flat, weighted steel or fiberglass measuring tape. Additionally, the depth of wells which contain large water columns (i.e., greater than 100 ft.) also may not be measurable with a flat, weighted measuring tape. A stainless steel or coated steel measuring cable shall be used for all wells greater than a 300-foot depth and is preferable for all wells.

5.3 Measurement Accuracy

Increased depth and large water columns decrease the accuracy of the well depth measurement.

5.4 Safety

Established safety standards and requirements of Martin Marietta Corporation, DOE, and OSHA will apply to the process of obtaining the measured depth of a monitor well. All field personnel will be provided with appropriate safety clothing, equipment, and training.

5.5 Well Access

A well may be deemed inaccessible because of site conditions or operations.

6.0 PREREQUISITES

All monitor wells will have the measured depth determined during a scheduled well inspection.

7.0 TEST EQUIPMENT, TOOLS AND SUPPLIES

7.1 Documentation: Well Construction Data Summary, Updated Subsurface Data Base, Y/TS-881(R2) (or most recent version), Daily Activity Logbook, and Monitor-Well Inspection Checklist.

7.2 Personnel Protection Equipment:

Required: rubber gloves

Optional: safety shoes, tyvek coveralls, hard hat, and protective eye-wear.

7.3 Field Equipment: Keys to unlock wells, indelible marker, pen, clipboard, and weighted fiberglass or steel measuring tape(s) and/or cable (the weight will be stainless steel or other approved inert material and have a blunt end facing down).

7.4 Decontamination Equipment: plastic ground cover, de-ionized water, mild detergent, and wash and rinse water collection vessels.

8.0 ACTION STEPS

8.1 Preparation: Review Well Construction Data Summary and Updated Subsurface Data Base to obtain the constructed depth of the well and determine the well location.

8.2 Record well number and date.

8.3 Put on rubber gloves.

8.4 Remove well lock and well cap.

8.5 Locate the reference mark at the top of the innermost well casing. If a reference mark is not present, make one with indelible marker, and notify Y-12 Plant GWPP Manager or authorized designee.

8.6 Select the appropriate length measuring tape and/or cable.

8.7 Slowly lower the weight into the well until the bottom of the well is encountered as indicated by slack in the tape measure or a solid impact.

8.8 When slack or impact occurs, slowly lift the tape until the tape becomes taut. Raise and lower the tape until the point of tension release becomes clearly defined.

8.9 Hold the tape to the reference mark on the casing.

8.10 Record the measurement to the nearest 0.1 ft as the measured well depth in the Daily Activity Logbook and/or Well Inspection Checklist.

8.11 Repeat steps 8.6 - 8.9 several times to ensure an accurate measurement. Readings should remain constant (i.e., within 0.1 ft).

TITLE: Monitor Well Depth Measurement Procedure

8.12 Remove the measuring tape from the well and decontaminate in accordance with ESP-900.

8.13 Close well cap and replace lock.

9.0 ACCEPTANCE CRITERIA

An acceptable measured depth of a well is achieved when the range of three or more consecutive measurements are within 0.1 ft.

10.0 POST-PERFORMANCE ACTIVITIES

Report to the Y-12 GWPP Manager or authorized designee those wells with significant (i.e., greater than 1 ft.) differences between the constructed well depth and the measured well depth.

11.0 RECORDS

11.1 Daily Activity Log

11.2 Well Inspection Checklist

APPENDIX D

**SAMPLING AND ENVIRONMENTAL SUPPORT DEPARTMENT
OPERATING PROCEDURE - GROUNDWATER SAMPLING**

Oak Ridge K-25 Site
 Analytical Services Organization, Sampling and Environmental Support Department
 Technical Procedure

GROUNDWATER SAMPLING
SESD-TP-8204
REV. 0

**CONTROL
 COPY NO.**

Written by: M. E. Cleveland Sponsor: C. B. Bryan

Subject Matter Expert: Fred P. Meyer Date: 7-22-94

Quality Staff Specialist: Clifford A. Cochran Date: 7-25-94

Approved by: [Signature] Date: 7-22-94

Effective Date: 7/25/94 Limits on Effectivity: None

Procedure Type	Yes	No	Category	Yes	No
In Hand		✓	Safety System		✓
Upgraded	✓		Quality-Related		✓

Record of Changes

Change No.	Affected Pages	Approval Signature	Approval Date	Expiration Date

Next review required no later than: 7/25/99

TITLE: Groundwater Sampling

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1.0 SCOPE

This procedure describes the methods used to sample groundwater wells at the K-25 and Y-12 sites.

2.0 REFERENCED DOCUMENTS

- 2.1 U.S. Environmental Protection Agency, 1987, A Compendium of Superfund Field Operations Methods, EPA/540/P-87/001, Washington, D.C.
- 2.2 U.S. Environmental Protection Agency, 1986. Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual, Region IV, Environmental Services Division, Atlanta, Ga.
- 2.3 U.S. Department of Energy, 1987, The Environmental Survey Manual, DOE/EH-0053.
- 2.4 U.S. Environmental Protection Agency, 1986, RCRA Groundwater Monitoring Technical Enforcement Document, OSWER-9950.1.
- 2.5 Martin Marietta Energy Systems, Inc., 1988, Environmental Surveillance Procedures Quality Control Program, Martin Marietta Energy Systems, ESH/Sub/87/21706/1, Oak Ridge, Tennessee.
- 2.6 U.S. Department of Transportation, Code FDR 49 Parts 100 - 177. Rev. 10-01-92.

3.0 RESPONSIBILITIES

3.1 Sampling Supervisor

- 3.1.1 Maintains communications with management and other groups for information that could affect the performance of this procedure.
- 3.1.2 Ensures that only trained field technicians are assigned to this procedure and that the training is documented.
- 3.1.3 Ensures that necessary materials and equipment are available and that maintenance is provided.
- 3.1.4 Schedules resources for sampling in conjunction with the ASO Project Manager.
- 3.1.5 Provides field sampling technicians with well data information, required sampling parameters, and sampling order as directed by customer.
- 3.1.6 Interfaces with the customer to obtain scheduling information, containment, access and information about unusual conditions.
- 3.1.7 Ensures quality in sampling through review of the technician's field sampling logbooks and field data sheets.

TITLE: Groundwater Sampling

- 3.1.8 Provides field quality assurance through planning and use of established and approved procedures.
- 3.1.9 Ensures complete chain-of-custody control through review of the chain-of-custody documents.
- 3.1.10 Implements corrective actions for field QA deficiencies.
- 3.1.11 Provides notification of unusual field conditions to ASO Project Manager and the Groundwater Protection Program Manager (GPPM) at each site.
- 3.1.12 Maintains control of this procedure and its controlled copies.

3.2 Sampling Technician

- 3.2.1 Performs groundwater sampling according to this procedure only after receiving appropriate training.
- 3.2.2 Decontaminates and maintains sampling equipment as required by this procedure.
- 3.2.3 Legibly documents all field measurements, field conditions, and samples as required by this procedure and ensures that all field documentation is complete.
- 3.2.4 Takes samples as required by approved methodology and maintains sample quality at all times.
- 3.2.5 Properly preserves all samples according to EPA protocol as defined in the current and approved S/A Plan.
- 3.2.6 Delivers all samples to the K-25 ACD Sample Management Group custodian or to the contract laboratory under documented chain-of-custody within the required holding times.
- 3.2.7 Ensures a complete chain-of-custody documentation on all samples.
- 3.2.8 Maintains a clean and orderly working area in the truck or lab.
- 3.2.9 Conducts sampling operations in a safe, efficient manner so as to not injure themselves or others.
- 3.2.10 Maintains field copies of the Environmental Surveillance Procedures, SOPs, and the following items from the current S/A Plan: all addendas, quarterly sampling schedules, bottle lists, site maps, and well depths.

4.0 TERMINOLOGY

Does not apply

5.0 SUMMARY OF TEST METHODS

- 5.1 Groundwater samples are collected after an appropriate well purge by using a bailer or pump. If required, the purge water from the wells is transferred into collection containers and is transported to the plant for appropriate water treatment. Field determinations which include pH, specific conductance, oxidation-reduction potential, dissolved oxygen, and temperature are obtained on an initial sample from the well. Additional measurements of the same type are taken for each well volume purged and after the final purge volume. All samples are preserved in the field according to EPA protocol as defined in the current and approved Sampling and Analysis (S/A) Plan.
- 5.2 All samples are then delivered to the K-25 Analytical Chemistry Department (ACD), Sample Management Group (SMG), or to a contract laboratory.

6.0 SIGNIFICANCE AND USE

- 6.1 This method is applicable to the sampling of groundwater wells at K-25 and Y-12 sites only.
- 6.2 This procedure does not replace manufacturer instrument operation manuals. The purpose of the procedure is to supplement that information and to provide field sampling technicians with additional sampling instructions.

7.0 INTERFERENCES

Does not apply

8.0 APPARATUS

- 8.1 Safety equipment: Company issued clothing (including cold weather apparel, rain suits), pagers and cellular phones, steel-toed safety shoes, safety glasses with side shields, rubber gloves, if required Tyvek coveralls or rubber aprons, rubber overshoes, hard hat, cotton gloves, respirators, fire extinguishers, insect repellent, and insulated water coolers.
- 8.2 Consumables: Ground cloth (polyethylene), pH paper, fluorocarbon resin-coated wire, nylon cord, single strand stainless wire, tape, gloves, plastic bags, paper towels, wash bottles, and blue or water ice.
- 8.3 Field data sheets, chain-of-custody forms, and equipment calibration record forms; chain-of-custody seals, labels, indelible black ink pens, indelible marking pens, and electronic calculator.

TITLE: Groundwater Sampling

- 8.4 Measuring tape and an electronic water level indicator (for measuring depth to water in the well).
- 8.5 Compressed gas cylinder or air compressor with associated regulators and high pressure air lines as necessary to operate the pump.
- 8.6 Bottom loading bailer of teflon or equivalent construction with a closed top, well sampling pump lines of sufficient length to reach the screened portion of the well, and if required controller boxes with associated air hoses and connections to operate the dedicated sampling pumps.
- 8.7 At the start of each day all field analytical equipment is calibrated in accordance with the procedures listed in Sections 8.7.1 through 8.7.5 of this procedure. Results are recorded in calibration log books with the sheet number recorded on the field data sheet. All temperature meters are calibrated and verified against a National Institute of Standards certified thermometer, which is calibrated annually by the K-25 Metrology, Testing and Equipment Laboratory (MT&E). If an instrument is thought to be out of calibration; while in the field, the technician must recalibrate the instrument. If the instrument is found to be out of calibration; the supervisor must be contacted; so the customer and program management can determine if the previous data is valid; of if a resample is required. If an instrument is no calibrated on the proper schedule (overdue), the instrument will be treated as out of calibration and then will be tagged with a " Do Not Operate" tag. Immediate action should be taken to ensure the instrument is recalibrated.
 - 8.7.1 Temperature Meter Operation and Verification, SESD-TP-8005.R0, 11-29-93
 - 8.7.2 Ph Meter Operation and Calibration, SESD-TP-8007.R0, 11-19-93
 - 8.7.3 Dissolved Oxygen Meter Operation & Calibration, SESD-TP-8008.R0, 11-29-93
 - 8.7.4 Redox Meter Operation and Calibration, SESD-TP-8201.R0, 11-29-93
 - 8.7.5 Conductivity Meter Operation and Calibration, SESD-TP-8202.R0, 11-29-93

NOTE: Do not use balance if certification is expired.

- 8.8 Laboratory Analytical Balance must be certified annually by the K-25 Site MT&E program and checked by technician each time of use to standard weight and recorded in reagent log book. Balance certification date must also be tracked in reagent log book.
- 8.9 Sample containers of assorted sizes and types as required by the analyses specified for each well as defined in the current and approved S/A Plan.
- 8.10 Filtration apparatus equipped with a 0.45 or 0.10 micron membrane filter for filtering the dissolved metals sample.

8.0 APPARATUS (Continued)

- 8.11 Insulated ice chest containing 8 lbs. of ice or 8 pint size packs of "Blue Ice" or an equivalent amount for sample preservation.
- 8.12 Hunter/Keck - Model KIR-89 portable product level and thickness measuring device for inorganic layers, and the thickness of each layer in groundwater monitoring wells.
- 8.13 Tools and Tool Box.
- 8.14 Required Procedure Books and Training Manuals.
- 8.15 DOT approved packaging, labels, and shipping papers.

9.0 REAGENTS AND MATERIALS

- 9.1 ASTM Type II distilled deionized water. A carboy of the water will be collected and stored in K-1004-A, Room 18, with a conductivity reading recorded each time the carboy is filled and recorded in a reagent log book.
- 9.2 A Chemical Inventory Sheet (HMIS) is required for the Groundwater Sampling Group and is to be located in K-1004-A, Room 18, K-1004-H Dock, and each of the sampling vehicles. An "*" indicates those materials maintained in the sampling vehicle. A "†" denotes a DOT shipping label required for transfer.

NOTE: Visually inspect preservatives for discoloration or degradation before use to ensure reagent quality. Replace dispensing bottles January 1 and July 1 of each year.

NOTE: Replace standard solutions in each instrument box at the beginning of each quarter.

9.2.1	H ₂ SO ₄ - Sulfuric Acid (96.4%)	UN 1830 PGII LID-QTY *†
9.2.2	HCl - Hydrochloric Acid (36.5 - 38.0%)	UN 1789 PGII LTD-QTY *†
9.2.3	NaOH - Sodium Hydroxide (50.0%)	UN 1824 PGII LTD-QTY *†
9.2.4	HNO ₃ - Nitric Acid (69.0 - 71.0%)	UN 2031 PGII Corrosive *†
9.2.5	Nitrogen, Compressed	UN 1066 Nonflammable Gas labels applied *†
9.2.6	Ascorbic Acid	

TITLE: Groundwater Sampling

- 9.2.7 Ascorbic Acid
- 9.2.8 Bolt Wasp & Hornet Killer II *
- 9.2.9 Buffer solutions 4,7, and 10 *
- 9.2.10 Formula 409
- 9.2.11 Hach Chlorine Equivalent Standard Solution
- 9.2.12 Isopropyl Alcohol
- 9.2.13 Lava Soap
- 9.2.14 Liqui-Nox Detergent
- 9.2.15 Micro Soap
- 9.2.16 Potassium chloride
- 9.2.17 Potassium ferricyanide
- 9.2.18 Potassium ferrocyanide
- 9.2.19 Sodium Calcium Hydrate (Soda Lime)
- 9.2.20 Sodium Sulfite *
- 9.2.21 Softcide Hand Wash
- 9.2.22 Zinc Acetate
- 9.2.23 0.01 N KCl standard solution. Each lot prepared and recorded in reagent log book.*
- 9.2.24 Zobell standard solution. Each lot prepared and recorded in reagent log book. *
- 9.2.25 Lead free gasoline *
- 9.2.26 10W-30W Motor Oil *

10.0 HAZARDS

- 10.1 Ensure that at least two persons are present during well sampling operations.
- 10.2 Conduct no sampling operations during thunderstorms.

10.0 HAZARDS (Continued)

- 10.3 Have some form of communication in the field for use during sampling operations.
- 10.4 Obtain permission to enter sampling areas located above the firing range and ensure that the firing range is clear before starting sampling operations.
- 10.5 On weekends or overtime hours, contact Plant Shift Superintendent at Y-12 and K-25 to give a record of sampling location.
- 10.6 Carry along an adequate supply of ASTM Type II distilled deionized reagent grade water for use in equipment rinses and cleaning.
- 10.7 Use adequate protective clothing during cold weather sampling operations. For hot weather sampling, carry an adequate supply of drinking water, insect repellent and wasp spray. For comfort, make sure air-conditioning in trucks is operational.
- 10.8 Recognize and be aware of hazardous flora and fauna.
- 10.9 Use the proper method for moving and lifting heavy equipment.

NOTE: Always remove the regulator and replace the cylinder cap before operating the vehicle.

- 10.10 Use proper technique for the safe operation of well pumps, portable gasoline-engine driven electric generators, portable air compressors, and high pressure compressed gas cylinders and regulators.

NOTE: Refer to Martin Marietta Energy Systems Safety and Health Plan (Y-12 procedure, 70 series for environmental health and safety applications).

- 10.11 Store, transport, and use hazardous and flammable reagents in the manner consistent with the guidance provided in each chemical's Material Safety Data Sheet (MSDS) and DOT regulations. This information can be found in Sections 8.14 and 9.0 of this procedure
- 10.12 Always wear steel-toed shoes, company issued clothing, gloves, and safety glasses while performing sampling operations.
- 10.13 As per the requirements of ESP-800, have all samples taken from K-25 and Y-12 groundwater wells, surveyed and green tagged by Health Physics before shipment to an off-site contract laboratory. Retain a copy of green tags for records.

TITLE: Groundwater Sampling

11.0 SAMPLING, SUBSAMPLING, AND TEST SAMPLES

Does not apply

12.0 PREPARATION OF APPARATUS

Does not apply

13.0 CALIBRATION AND STANDARDIZATION

Calibrated instruments are used to take field measurements at the well sites as per Section 8.7.

14.0 CONDITIONING

Does not apply

15.0 PROCEDURE

15.1 Preliminary Preparations

- 15.1.1 Don the necessary safety equipment.
- 15.1.2 Clean all pumps, bailers, water level indicators, and other down-hole equipment.
- 15.1.3 Identify the well(s) to be sampled.
- 15.1.4 Obtain the required information about the specific well(s) to be sampled.
 - 1. Well location
 - 2. Depth of the well
 - 3. Diameter of the well casing
 - 4. Method(s) to be used to sample the well
- 15.1.5 Check the field instrumentation as per the Steps of Sections 8.7 and 13.0. Record the required information on the equipment calibration data form.
- 15.1.6 Prepare the required trip blanks according to the Sampling and Analysis Plan requirements and SESD-TP-8203.R0.
- 15.1.7 Load the vehicle with the required equipment and supplies and secure it for transportation of supplies to the field.

15.2 Sampling

- 15.2.1 Record the well number, site, date, weather conditions, arrival time, and other well specific information on the field data sheet. Examples would include problems with site access, equipment malfunctions, well obstructions, strange odors, names of visitors, etc.

NOTE: When the sampling equipment must be removed from the tailgate area, use plastic trays or groundcover to prevent possible contamination. Discard the plastic sheeting after use along with any other disposable items.

- 15.2.2 Keep all equipment in the truck bed during sampling.

- 15.2.3 Unlock and open the well; note the condition of the well.

- 15.2.4 Don rubber gloves.

NOTE: Change rubber gloves between sampling wells.

- 15.2.5 Remove any dust or corrosion from around the well head using a non-metal bound brush.

- 15.2.6 Sample the air in the well head for organic vapors if required by the current and approved S/A Plan.

- 15.2.7 Note the diameter of the well bore and locate the reference mark at the top of the well casing.

- 15.2.8 Check the battery on the water level indicator.

- 15.2.9 Lower the electronic water level indicator probe into the well, making sure that the cord on the probe does not scrape the sides of the well casing.

NOTE: Accurate well depth data will be provided by site GWPP Manager's office annually.

- 15.2.10 Measure the depth to water from the established reference mark at the top of the innermost well casing.

- 15.2.11 Stop lowering the probe when the buzzer sounds.

- 15.2.12 Pull up on the probe until the buzzer no longer sounds.

- 15.2.13 Lower the probe again slowly.

TITLE: Groundwater Sampling

- 15.2.14 Stop at the instant the buzzer sounds.
- 15.2.15 Hold the cord to the side of the casing at the location of the reference mark.
- 15.2.16 Mark the cord with your thumb where it touches the reference mark.
- 15.2.17 Use a measuring tape to determine the total depth from the top of the casing to the water if the cord does not have measurement graduations.
- 15.2.18 Record the value in the field data logbook to the nearest 0.01 foot as per ESP 302-1.
- 15.2.19 Determine the depth to water two additional times to verify correct measurement.
- 15.2.20 Record the additional values as described in steps 15.2.9 through 15.2.18.
- 15.2.21 Average the three depth to water measurements and record the average value in the field data logbook.
- 15.2.22 Remove the water level indicator from the well.

NOTE: If required by the current and approved S/A Plan, collect the rinse water from this cleaning procedure in an appropriate containment vessel, and properly dispose of the water at the wastewater treatment system at the plant.

- 15.2.23 Rinse the probe and any portion of the cable that contacted the well water with ASTM Type II distilled deionized reagent water.
- 15.2.24 Wipe the probe and cabling with paper towels.
- 15.2.25 Place the indicator in a clean plastic bag to prevent contamination during transport.
- 15.2.26 Determine the height of the water column by subtracting the depth to the water from the total well depth.
- 15.2.27 Calculate the volume of water in the well casing using the appropriate formula given below.

15.0 PROCEDURE (Continued)

2" well: $0.1632 \text{ gallft} \times (\text{height of water column}) = \text{gallons}$

4" well: $0.6528 \text{ gallft} \times (\text{height of water column}) = \text{gallons}$

6" well: $1.4688 \text{ gallft} \times (\text{height of water column}) = \text{gallons}$

NOTE: Use a bailer that has a diameter of less than 2" on all 2" well casings.

15.2.28 Obtain an initial well water sample using either a bailer or a pump.

1. Attach the bailer to a fluorocarbon resin-coated wire, nylon cord, or single strand stainless steel wire.
2. Lower the bailer slowly to the mid-point of the screened or open portion of the well.

NOTE: The air can be connected prior to lowering the pump into well to insure that the pump head is working properly.

3. Lower the pump into the well casing to the air/water interface.
4. Attach an air line and source of compressed air to the pump.

NOTE: If required by the currently approved S/A Plan, collect the water from these analyses in an appropriate containment vessel, and properly dispose of the water at the plant wastewater treatment system.

5. Withdraw sufficient water from the well to perform the required "initial" determinations as specified in Step 15.2.30.4.

NOTE: If required by the currently approved S/A Plan, collect the well purging water in an appropriate containment vessel, and properly dispose of the water at the plant wastewater treatment system.

TITLE: Groundwater Sampling

15.2.29 Purge the well of the required number of volumes of water using a bailer (per ESP 302-3), or a gas driven Bennett Pump (per ESP 302-4), or using a Bladder pump (Well Wizard) (per ESP 302-5). Wells are required to be purged until at least three volumes of water are removed

NOTE: When evacuating low-yield wells(that are incapable of yielding three casing volumes), evacuate the well to dryness only once. A well is dry when the pump has been lowered to one foot from the bottom of the well and the water does not continue to evacuate.

1. Remove the required volumes of water or bail until the well goes dry if using a bailer.
2. Determine the pump flow rate in the field by timing the rate at which a one gallon container can be filled by the pump if using a pump.
3. Record the information on the field data sheet.
4. Calculate the required purge time based on this field determined pumping rate.
5. Purge the well a minimum of three well volumes of water or until the well goes dry.

NOTE: The purge rate of the Bennett Pump and Bladder pump is usually less than two gallons per minute.

6. Purge the well at a rate such that the recharge water does not become agitated or cascades back into the well.
7. Record the purge start time and the purge end time on the field data sheet.

15.2.30 Allow the water in the well to recover.

NOTE: Whenever full recovery exceeds two hours, extract the sample as soon as sufficient volume is available for a sample for each parameter.

15.0 PROCEDURE (Continued)

1. Recharge volume or time as directed by the current and approved S/A Plan.
2. Allow sufficient time for the well to recover and stabilize before obtaining samples if a well is bailed dry or pumped dry.

15.2.31 Sample the water in the well.

NOTE: Collect all samples at one time if sufficient water is present.

NOTE: Certain sites may require additional parameters (samples) at a site, such as COD, Cyanide, TPH, tritium, gamma spectrum, Ammonia, and Nitrite. See Bottle List for sampling sequence and additional parameters.

1. Obtain samples of the well water for the field determinations.
2. Obtain and analyze samples for pH as per ESP 307-2, specific conductance, temperature as per ESP 307-1, oxidation-reduction potential as per ESP 307-5, and dissolved oxygen as per ESP 307-3.
3. Obtain separate analyses for each parameter at evenly spaced intervals during the purge cycle.

NOTE: When sampling VOA, TOX, and TOC from a dedicated bladder pump, cut the purge rate down to approximately 100 ml/min. or as low as the pump will allow. When sampling VOA, TOX, and TOC with a bailer, lower the bailer slowly into the sample interval of the well to prevent loss of volatile components.

4. Collect the required samples for analysis in the laboratory.
 - Collect and obtain sample per ESP 302-3 when using a bailer, per ESP 302-4 when using a Bennett pump, and per ESP 302-5 when using a bladder pump.
 - Collect samples that may be affected by the loss of volatile components first, i.e., VOA, TOX, TOC.
 - Collect VOA, TOX, and TOC samples using a bailer or Bladder pump.
 - Transfer the samples slowly, with minimum agitation and aeration.
 - Collect these samples with zero headspace and check to ensure the absence of air bubbles.
 - Collect all VOAs, then all TOCs, then all the metals, etc. Do not pull one complete set of samples and then start to pull another set.

TITLE: Groundwater Sampling

- Collect samples for dissolved metals using an in-line filter while sampling with a Bennett pump or Bladder pump.
- If dissolved metal samples are being collected using a bailer, the unfiltered samples are returned to the laboratory for filtering and preservation.
- Collect the balance of the required samples for the particular site in the following order:

Base-Neutral-Acid Extractables

Herbicides

Pesticides

Phenols

Turbidity

Anions (Iodine, Carbonate-Bicarbonate, Nitrate-Nitrogen)

pH and conductivity

Total coliform bacteria

Total suspended solids

Total dissolved solids

Carbonate/Bicarbonate

Kjeldahl Nitrogen

Metals, total and dissolved

Gross alpha and beta

Total Radium

Uranium 235

- Exceptions to this sampling order include the following:
 - (A) The Bennett pump is used for purging and sampling groundwater wells located on the Y-12 and K-25 Plant sites. In these situations, the Bennett pump may be used to sample all non-volatile sample fractions first. Then remove the pump and collect the volatile fractions using a bailer. Note any exceptions to this order of collection in the field data sheets.
- Record the sample types taken on the field data sheet and the times when remaining samples are collected.

15.2.32 Obtain like samples one after another if duplicate samples are to be taken..

15.2.33 Add the required preservatives to the samples as they are obtained, if the preservatives have not already been added to the sample containers.

NOTE: Check the pH of all samples except the VOA samples in the 40 mL vials.

15.0 PROCEDURE (Continued)

NOTE: Do not insert the pH paper into the sample. To ensure the proper amount of preservative was added, check the pH of the preserved sample with narrow range pH paper by pouring a small amount of the sample over the pH paper.

- 15.2.34 Adjust the pH of a sample to < 2.0 by adding the appropriate acid for samples that require pH adjustment.
- 15.2.35 Document that the pH adjustment was made by checking the appropriate blank on the field data sheet.
- 15.2.36 Ensure that all samples are labeled properly with well number, date, time, sampler's name, any other pertinent information, and analysis.

NOTE: If required by the currently approved S/A Plan, collect the rinse water from this cleaning procedures in an appropriate containment vessel, and properly dispose of the water at the wastewater treatment system at the plant.

- 15.2.37 Wash the outside of the sample containers with distilled water.
- 15.2.38 Place the samples in a cooler containing blue or water ice.
- 15.2.39 Obtain any blank samples for the well as required by the Sampling and Analysis Plan.
- 15.2.40 Return the bailer to the lab for decontamination after each well's sampling is completed.

NOTE: If this is the last well for a given site, collect all equipment rinsate sample. Check the current S/A Plan for the analytical parameters required.

1. Rinse the interior and exterior with a non-phosphate detergent.
2. Rinse all detergent from the equipment with ASTM Type II distilled deionized reagent grade water.
3. Rinse the equipment a second time with ASTM Type II distilled deionized reagent grade water.
4. Rinse the bailers with a ten percent nitric acid solution, then with ASTM Type II distilled deionized reagent grade water.
5. Wipe down the equipment with paper toweling.
6. Wrap fully assembled bailer in aluminum foil for lab to field transport.

TITLE: Groundwater Sampling

15.2.41 Field clean the Bennett pumps after sampling each well in a given site as described below.

1. Rinse the entire length of the pump head with water, then pump one to two gallons of a non-phosphate detergent water through the system.
2. Rinse all detergent from the pump by flushing the entire length of the pump head with one to two gallons of ASTM Type II distilled deionized reagent grade water.
3. Rinse the equipment a second time with an additional one to two gallons of ASTM Type II distilled deionized reagent grade water.
4. Seal the pump head in a clean plastic bag and proceed to the next well site for sampling.

15.2.42 Decontaminate the Bennett pump after sampling the site (one to ten wells) by taking the pump to the lab area where a steam supply is available.

1. Steam clean the pump head and the entire length of tubing.
2. Bring pump into lab to perform rinse.

NOTE: To minimize waste, use approximately 0.7 gallons of solution for the 125 foot pump; approximately 1.4 gallons for the 250 foot pump; and approximately 2.8 gallons for the 500 foot pump.

3. Run a rinse solution consisting of 10% Nitric acid and water in lab ensuring that entire tubing bundle of the pump is fully filled with the solution.
4. Collect the Nitric acid waste in 55-gallon Acid Waste Drum.
5. Run a 30 minute tap water rinse to thoroughly remove the Nitric acid and any remaining residue.
6. Flush the tubing and pump with two tubing volumes of ASTM Type II deionized, distilled reagent grade water.
7. Wipe down pump head with paper towel and wrap in aluminum foil for lab to field transport.
8. Collect an equipment rinse blank at the frequency and for the parameters specified in the current and approved S/A Plan.

15.0 PROCEDURE (Continued)

- 15.2.43 Replace the cover on the well and secure the well with the lock.
- 15.2.44 Return the sampling equipment to the vehicle and secure the equipment for transport back to the plant or to the next well site.
- 15.2.45 Clean up the well sampling site.
- 15.2.46 Enter the departure time in the field data sheet.
- 15.2.47 Report any maintenance problems at the well site (such as replacing hasps, locks, concrete pads, protective posts, obstructions inside of the well casings, well access, etc.) to the appropriate GPPM by means of a Well Maintenance Request Form.
- 15.2.48 Sign the field data sheet.

16.0 CALCULATION OR INTERPRETATION OF RESULTS

The volume of water in a well casing is calculated using the formulas listed in step 15.2.26. The purge time and pump flow rate is calculated according to the step 15.2.28.2.

17.0 REPORT

All sampling data collected from a well site is recorded on the field data sheet and in the field data logbook.

18.0 PRECISION AND BIAS

Does not apply

19.0 QUALITY ASSURANCE/QUALITY CONTROL

- 19.1 Well sampling frequency and the required analyses are determined by the well location and the current Sampling and Analysis Plan.
- 19.2 This procedure will be performed in accordance with Martin Marietta Energy Systems regulations and state and federal laws.

20.0 SOFTWARE

Does not apply

APPENDIX E
FALSE-POSITIVE DEMONSTRATIONS

**FALSE-POSITIVE DEMONSTRATION FOR
CHESTNUT RIDGE SEDIMENT DISPOSAL BASIN
AND KERR HOLLOW QUARRY**

OAK RIDGE Y-12 PLANT

C. Stephen Haase¹
Helen L. King²
Terre M. Mercier³

September 10, 1991

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- ¹ Environmental Sciences Division, Oak Ridge National Laboratory,
P. O. Box 2008, Oak Ridge, Tennessee 37831-6352
- ² Environmental Management Department, Oak Ridge Y-12 Plant, P. O. Box 2009,
Oak Ridge, Tennessee 37831-8219
- ³ H & R Technical Associates, Oak Ridge, Tennessee 37830

Introduction

Groundwater quality data were collected for two sites in RCRA Interim Status - Detection Monitoring at the Oak Ridge Y-12 Plant during the first quarter of calendar year (CY) 1991. As required by Rule 1200-1-1-.05(6) of the Tennessee Department of Environment and Conservation, monitoring results for indicator parameters (pH, conductivity, total organic carbon (TOC), and total organic halides (TOX)) were reviewed to determine if a statistically significant change had occurred in the values of one or more indicator parameters. Analysis of the data obtained for the first quarter of 1991 indicated that statistically significant changes had occurred in pH for upgradient and downgradient wells at the Chestnut Ridge Sediment Disposal Basin and in pH and conductivity for upgradient and downgradient wells at Kerr Hollow Quarry.

The purpose of this document is to review pH and conductivity data in question to determine if the statistically significant changes in the indicator parameters noted for first-quarter 1991 data represent a release of contaminants into the groundwater from the facilities, or if the changes observed are due to other, naturally occurring factors.

Chestnut Ridge Sediment Disposal Basin

Data Summary

Data obtained during the first-quarter of 1991 indicate that statistically significant changes in pH occurred for both upgradient and downgradient monitoring wells at the Chestnut Ridge Sediment Disposal Basin. To evaluate these findings, all pH data from groundwater monitoring wells surrounding the facility (Fig. 1) have been reviewed to determine if the pH changes observed are truly indicative of contaminant releases from the Chestnut Ridge Sediment Disposal Basin.

Evaluation of pH Data

The mean, median, and variance of pH measurements obtained for all groundwater monitoring wells at the Chestnut Ridge Sediment Disposal Basin During are illustrated in Fig. 2. The data indicate that (1) the median pH values for all wells except well 1096 fall between 7.0 and 8.0 and (2) the degree of variance, as calculated by the distance between the 25th and 75th percentiles, is variable from well to well and ranges from approximately 0.5 pH units for wells GW-156 and GW-159 to approximately 2.0 pH units in well GW-158.

Skewness and kurtosis values for the data sets for each well were evaluated to determine if the pH values followed a normal distribution. Such an analysis suggests that pH values in four out of ten wells at the site may not be normally distributed. Of importance to detection monitoring requirements, the skewness and kurtosis values suggest that pH values for upgradient well GW-159, and downgradient wells GW-155 and GW-156 may not be normally distributed.

Trend plots for pH measurements from the upgradient and downgradient wells at the Chestnut Ridge Sediment Disposal Basin are illustrated in Figs. 3 through 6. Data for each of the wells will be summarized and interpreted in the following sections.

GW-159. Upgradient well GW-159 had pH values >8.0 for the base year of CY 1986 (Fig. 3). Subsequent to the base year, all pH values from well GW-159 were less than those observed during the base year, with values ranging from slightly above 8.0 to slightly less than 6.0. After the base year, pH values for well GW-159 exhibit a sawtooth cyclic variation. Values for pH gradually decline from approximately 8.0 to 6.0 during the period 1987 through mid-1989. During late CY 1989, pH values increase back to approximately 8.0 and mark the beginning of a second sawtooth cycle. Subsequent to this abrupt increase, pH values exhibit a gradual decline from approximately 8.0 to 7.0 during CY 1990. The pH value for first quarter 1991 is 7.6, which is below the median of 7.8, but within the interquartile range of 7.4 to 8.1 for the well (see Figs. 2 and 3), and within the maximum range of pH values observed in the well (see Fig. 3).

GW-155. Downgradient well GW-155 had pH values between slightly greater than 8.0 and approximately 7.5 during the base year of CY 1986 (Fig. 4). After the base year, pH values for well GW-155 exhibit a sawtooth cyclic variation similar to that observed in the upgradient well GW-159. Values for pH gradually decline from approximately 7.5 to slightly less than 6.0 during the period 1987 through mid-1989. During late CY 1989, pH values increase back to approximately 8.0, and mark the beginning of a second sawtooth cycle. Subsequent to this abrupt increase, pH values exhibit a gradual decline from approximately 8.0 to 7.0 during CY 1990. In general pattern of pH fluctuations in well GW-155 is similar to that observed in the upgradient well. The pH value for first quarter 1991 is 6.9, which is below the median of 7.5, but within the interquartile range of 6.9 to 7.7 for the well (see Figs. 2 and 4), and within the maximum range of pH values observed in the well (see Fig. 4).

GW-156. Downgradient well GW-156 had pH values between slightly less than 9.0 and approximately 8.0 during the base year of CY 1986 (Fig. 5). Subsequent to the base year, pH values for well GW-156 were typically less than those obtained during the base year, with values ranging between approximately 8.0 and slightly less than 7.0. Values for pH gradually decline from approximately 7.8 to slightly less than 7.0 during the period 1987 through mid-1989. During CY 1990, pH values have increased somewhat, and range between approximately 7.8 and 7.3. The general

pattern of pH fluctuations in well GW-156 is similar to that observed in the upgradient well (GW-159), although the sawtooth pattern is subdued due to the smaller range of pH fluctuation exhibited by well GW-156. The pH value for first quarter 1991 is 7.3, which is below the median of 7.5, but within the interquartile range of 7.3 to 7.7 for the well (see Figs. 2 and 5), and within the maximum range of pH values observed in the well (see Fig. 5).

GW-157. Downgradient well GW-157 had pH values between approximately 7.5 and approximately 8.5 during the base year of CY 1986 (Fig. 6). Subsequent to the base year, pH values for well GW-157 were typically less than those obtained during the base year, with values ranging between approximately 7.5 and slightly less than 7.0. Values for pH gradually declined from approximately 7.5 to slightly less than 7.0 during the period 1987 through mid-1989. During the last part of CY 1989, pH values have increased from approximately 7.0 to greater than approximately 7.5, and range between approximately 7.5 and 7.8. The general pattern of pH fluctuations in well GW-157 is similar to that observed in the upgradient well (GW-159), although the sawtooth pattern is subdued due to the smaller range of pH fluctuation exhibited by well GW-157. The pH value for first quarter 1991 is 7.4, which is at the median of 7.4, within the interquartile range of 7.2 to 7.5 for the well (see Figs. 2 and 6), and within the maximum range of pH values observed in the well (see Fig. 6).

Discussion and Summary

Temporal variations in downgradient wells at the Chestnut Ridge Sediment Disposal Basin are generally similar to those exhibited by the upgradient well. The temporal pH trend of the upgradient well is interpreted to represent naturally-occurring, secular pH fluctuations of the groundwater system surrounding the Chestnut Ridge Sediment Disposal Basin. All of the downgradient wells exhibit similar trends to that observed in the upgradient well. The temporal pH trend for well GW-155 is essentially identical to that observed in the upgradient well. The pH trends exhibited in downgradient wells GW-156 and GW-157 have similar form but differ in the magnitude of the the range of pH values observed. The similarity of trends suggests that variations in pH for groundwaters from all wells at the Chestnut Ridge Sediment Disposal Basin are due to secular variations in groundwater chemistry and not to contaminant releases from the site.

The pH values obtained during the base year of 1986 for the upgradient well and two of the three downgradient wells are always above 8.0, and typically above 9.0. Such values are significantly higher than those typical of uncontaminated groundwater from the Knox Group studied elsewhere on the Oak Ridge Reservation (HSW 1991a through e). Such values are interpreted to represent partial contamination of the groundwater samples by fluids remaining in the formation from well construction activities. All of the groundwater monitoring wells at the Chestnut Ridge Sediment Disposal Basin were developed after construction, and purged prior to sampling. However, the fractured and karstified nature of the Knox aquifer makes

development of wells potentially problematical. Because of such complications, and the fact that pH values for all wells during subsequent years were within ranges typical of Know Group groundwaters elsewhere in the Oak Ridge area, data obtained during the base period are suspect.

Based on the factors discussed above, the statistically significant changes in pH noted for wells at the Chestnut Ridge Sediment Disposal Basin are interpreted to be false positives, and to not represent a release of contaminants into groundwater from the site.

Kerr Hollow Quarry

Data Summary

Data obtained during the first-quarter of 1991 indicate that statistically significant changes in pH were noted for the upgradient well (GW-145) and all three downgradient monitoring wells (GW-142, GW-144, and GW-231) at Kerr Hollow Quarry (Fig. 7). Additionally, statistically significant increases in conductivity for one downgradient well (GW-142) were noted. To evaluate these findings, all pH and conductivity data from groundwater monitoring wells surrounding the facility have been reviewed to determine if the changes observed are truly indicative of contaminant releases from Kerr Hollow Quarry.

Evaluation of pH Data

The mean, median, and variance of pH measurements obtained for all groundwater monitoring wells at Kerr Hollow Quarry are illustrated in Fig. 8. The data indicate that (1) the median pH values for all wells fall between 7.5 and 8.0 and (2) the variability or spread of the middle 50 percent of the data for each well, as illustrated by the interquartile distance (distance between the 25th and 75th percentiles), is variable from well to well and ranges from approximately 0.5 pH units for well GW-231 to approximately 2.0 pH units in well GW-146.

Skewness and kurtosis values for the data sets for each well were evaluated to determine if the pH values followed a normal distribution. Such an analysis suggests that pH values in four out of seven wells at the site may not be normally distributed. Of importance to detection monitoring requirements, the skewness and kurtosis values suggest that pH values in downgradient wells GW-144 and GW-231 may not be normally distributed.

Trend plots for pH measurements from the upgradient and downgradient wells at Kerr Hollow Quarry are illustrated in Figs. 9 through 12. Data for each of the wells will be summarized and interpreted in the following sections

GW-145. Upgradient well GW-145 had pH values ranging between approximately 7.9 and 8.7 for the base year of CY 1986 (Fig. 9). Subsequent to the base year, all pH values from well GW-145 were typically less than 8.5, with values ranging from slightly above 8.3 to approximately 6.6. After the base year, pH values for well GW-145 exhibit a generalized decline through during the period 1987 through 1989, although the trend of this decline in values is complex and exhibits several reversals. This period of decreasing pH values concludes in late CY 1989, when pH values of approximately 6.6 are measured. Such values are the lowest values obtained during the period of observation. The pH value from the sample obtained in late in CY 1989 exhibits an abrupt increase back to approximately 8.0. Subsequent to this abrupt increase, pH values during CY 1990 exhibit a gradual decline that is again characterized by much variability and at least one reversal of trend. The pH value for first quarter 1991 is 7.1, which is below the median of 7.9, but within the interquartile range of 7.3 to 8.2 for the well (see Figs. 8 and 9), and within the maximum range of pH values observed in the well (see Fig. 9).

GW-142. Downgradient well GW-142 had pH values ranging between approximately 8.8 and 7.5 for the base year of CY 1986 (Fig. 10). Subsequent to the base year, all pH values from well GW-145 were typically less than 8.0, with values ranging from approximately 7.9 to 6.6. Values for pH from well GW-142 exhibit a generalized decline through 1989, although the trend of this decline in values is complex and exhibits several reversals. This period of decreasing pH values ends in late CY 1989, when pH values of approximately 6.6 are obtained. Such values are the lowest values obtained during the period of observation. The pH value from the sample obtained in late in CY 1989 exhibits an abrupt increase back to approximately 8.0. Subsequent to this abrupt increase, pH values during CY 1990 exhibit a gradual decline that is again characterized by much variability and at least one reversal of trend. The pH value for first quarter 1991 is 7.1, which is below the median of 7.5, but within the interquartile range of 7.1 to 7.8 for the well (see Figs. 8 and 10), and within the maximum range of pH values observed in the well (see Fig. 10). In general, the trend of pH values for well GW-142 resembles that observed in upgradient well GW-145.

GW-144. Downgradient well GW-144 had pH values between approximately 8.0 to 7.8 during the base year of CY 1986 (Fig. 11). Subsequent to the base year, all pH values from well GW-144 were typically less than 8.0, with values ranging from approximately 7.9 to 6.5. Values for pH from well GW-144 exhibit a generalized decline through 1989, although the trend of this decline in values is complex and exhibits several reversals. This period of decreasing pH values ends in late CY 1989, when pH values of approximately 6.5 are obtained. Such values are the lowest values obtained during the period of observation. The pH value from the sample obtained in late in CY 1989 exhibits an abrupt increase back to approximately 7.7. Subsequent to this abrupt increase, pH values during CY 1990 exhibit a gradual decline that is again characterized by much variability and at least one reversal of trend. The pH value for first quarter 1991 is 6.9, which is below the median of 7.6,

but within the interquartile range of 7.6 to 7.9 for the well (see Figs. 8 and 11), and within the maximum range of pH values observed in the well (see Fig. 11). In general, the trend of pH values for well GW-144 resembles that observed in upgradient well GW-145.

GW-231. Downgradient well GW-231 had pH values between approximately 8.1 and 7.6 during the base year of CY 1986 (Fig. 12). Subsequent to the base year, all pH values from well GW-231 were typically less than 7.5, with values ranging from approximately 7.5 to 6.3. Values for pH from well GW-231 exhibit a generalized decline through 1989, although the trend of this decline in values is complex and exhibits several reversals. This period of decreasing pH values ends in late CY 1989, when pH values of approximately 6.3 are obtained. Such values are the lowest values obtained during the period of observation. The pH value from the sample obtained in late in CY 1989 exhibits an abrupt increase back to approximately 7.7. Subsequent to this abrupt increase, pH values during CY 1990 exhibit a gradual decline that is again characterized by much variability and at least one reversal of trend. The pH value for first quarter 1991 is 6.9, which is below the median of 7.5, below the interquartile range of 7.0 to 7.6 for the well (see Figs. 8 and 12), but within the maximum range of pH values observed in the well (see Fig. 12). In general, the trend of pH values for well GW-231 resembles that observed in upgradient well GW-145.

Evaluation of Conductivity Data

The mean, median, and variance of conductivity measurements obtained for all groundwater monitoring wells at Kerr Hollow Quarry are illustrated in Fig. 13. The data indicate that (1) the median conductivity values for all wells fall between approximately 250 and 500 $\mu\text{mhos/cm}$ and (2) the variability or range of the middle 50 percent of the data for each well, as illustrated by the interquartile distance, is variable from well to well and ranges from approximately 75 $\mu\text{mhos/cm}$ in well GW-231 to approximately 200 $\mu\text{mhos/cm}$ in well GW-146.

Skewness and kurtosis values for the data sets for each well were evaluated to determine if the conductivity values followed a normal distribution. Such an analysis suggests that conductivity values in five out of seven wells at the site may not be normally distributed. Of importance to detection monitoring requirements, the skewness and kurtosis values suggest that conductivity values in upgradient well GW-145 and in downgradient wells GW-144 and GW-231 may not be normally distributed.

Trend plots for conductivity measurements from the upgradient well (GW-145) and the downgradient well (GW-142) of interest at Kerr Hollow Quarry are illustrated in Figs. 14 through 15. Data for each of the wells will be summarized and interpreted in the following sections

GW-145. Upgradient well GW-145 had conductivity values ranging between approximately 650 and 550 $\mu\text{mhos/cm}$ for the base year of CY 1986 (Fig. 14). Subsequent to the base year, all conductivity values from well GW-145 were less than 600 $\mu\text{mhos/cm}$, and ranged from approximately 560 to 375 $\mu\text{mhos/cm}$. Conductivity values gradually decline during the period 1987 through 1990, although the trend of this decline in values is complex and exhibits several reversals. The conductivity value for first quarter 1991 is 505 $\mu\text{mhos/cm}$, which is below the median of 567 $\mu\text{mhos/cm}$, below the interquartile range of 508 to 587 $\mu\text{mhos/cm}$ for the well (see Figs. 13 and 14), and among the lowest values obtained for groundwater from well GW-145 (Fig. 14).

GW-142. Downgradient well GW-142 had conductivity values between approximately 300 and 450 $\mu\text{mhos/cm}$ during the base year of CY 1986 (Fig. 15). After the base year, conductivity values for well GW-142 exhibit a generally constant trend with an average of approximately 400 $\mu\text{mhos/cm}$ during the period 1987 through 1989. The conductivity value for first quarter 1991 is 440 $\mu\text{mhos/cm}$, which is above the median of 406 $\mu\text{mhos/cm}$, above the interquartile range of 377 to 435 $\mu\text{mhos/cm}$ for the well (see Figs. 13 and 15), but within the maximum range of conductivity values observed in the well (see Fig. 15). Throughout the period of observation, the median conductivity values for downgradient well GW-142 has been less than that for upgradient well GW-145 (406 $\mu\text{mhos/cm}$ compared to 567 $\mu\text{mhos/cm}$, respectively; see Fig. 13).

Discussion and Summary

Temporal variations in downgradient wells at the Kerr Hollow Quarry are generally similar to those exhibited by the upgradient well. The temporal pH trend of the upgradient well is interpreted to represent naturally-occurring, secular pH fluctuations of the groundwater system surrounding the Kerr Hollow Quarry. All of the downgradient wells exhibit similar trends to that observed in the upgradient well. The temporal pH trend for downgradient wells are essentially identical to that observed in the upgradient well, although the magnitude of the the range of pH values observed differs from well to well. The similarity of trends suggests that variations in pH for groundwaters from all wells at the Kerr Hollow Quarry strongly suggests that observed pH variations are due to secular variations in groundwater chemistry and not to contaminant releases from the site.

The pH values obtained during the base year of 1986 for the upgradient well and one of the three downgradient wells (GW-142) are always above 7.5, and typically above 8.0. Such values are greater than those typical of uncontaminated groundwater from the Knox Group studied elsewhere on the Oak Ridge Reservation (HSW 1991a through e). Such values are interpreted to represent partial contamination of the groundwater samples by fluids remaining in the formation from well construction activities. All of the groundwater monitoring wells at the Kerr Hollow Quarry were developed after construction, and purged prior to sampling. However, the fractured

and karstified nature of the Knox aquifer makes development of wells potentially problematical. Because of such complications, and the fact that pH values for all wells during subsequent years were within ranges typical of Knox Group groundwaters elsewhere in the Oak Ridge area, data obtained during the base period are suspect.

The conductivity values for well GW-142 are less than those of the upgradient well (GW-145) at the site. Additionally, the temporal trends of conductivity values from both well GW-142 and the upgradient well (GW-145) exhibit much variability, with sample to sample changes of 50 $\mu\text{mhos/cm}$ not uncommon. Because the temporal conductivity trend in well GW-142 has a similar character to that of the upgradient well, and because conductivity values are less in well GW-142 than those from the upgradient well, the observed conductivity changes are interpreted to be due to secular groundwater variations and not due to a release of contaminants from the site.

Based on the factors discussed above, the statistically significant changes in pH and conductivity noted for wells at the Kerr Hollow Quarry are interpreted to be false positives, and to not represent a release of contaminants into groundwater from the site.

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- HSW, Inc. 1991b. Groundwater quality assessment for the Bear Creek hydrologic regime at the Y-12 Plant, 1990: Data interpretation and proposed program modifications. Y/SUB/91-YP507C/1 Part 2.
- HSW, Inc. 1991c. Groundwater quality assessment for the Upper East Fork Poplar Creek hydrologic regime at the Y-12 Plant, 1990: Groundwater quality data and calculated rate of contaminant migration. Y/SUB/91-YP507C/2 Part 1.
- HSW, Inc. 1991d. Groundwater quality assessment for the Upper East Fork Poplar Creek hydrologic regime at the Y-12 Plant, 1990: Data interpretation and proposed program modifications. Y/SUB/91-YP507C/2 Part 2.
- HSW, Inc. 1991e. Groundwater quality assessment for the Chestnut Ridge Security Pits Hazardous Waste Disposal Unit at the Y-12 Plant, 1990. Y/SUB/91-YP507C/3.

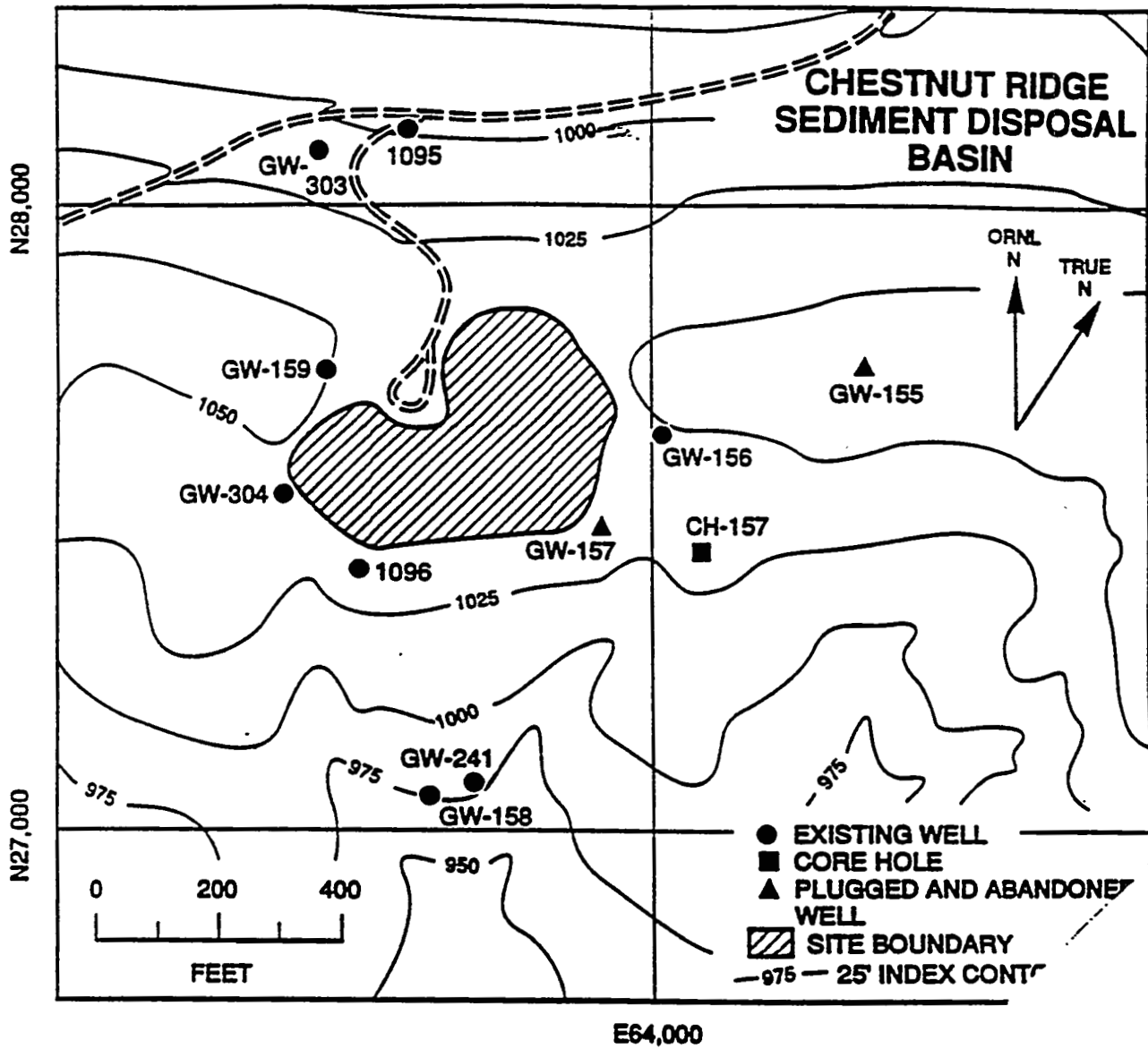


Figure 1. Location map for the Chestnut Ridge Sediment Disposal Basin. Upgradient monitoring well is GW-159. Downgradient monitoring wells are GW-155, GW-156, and GW-157.

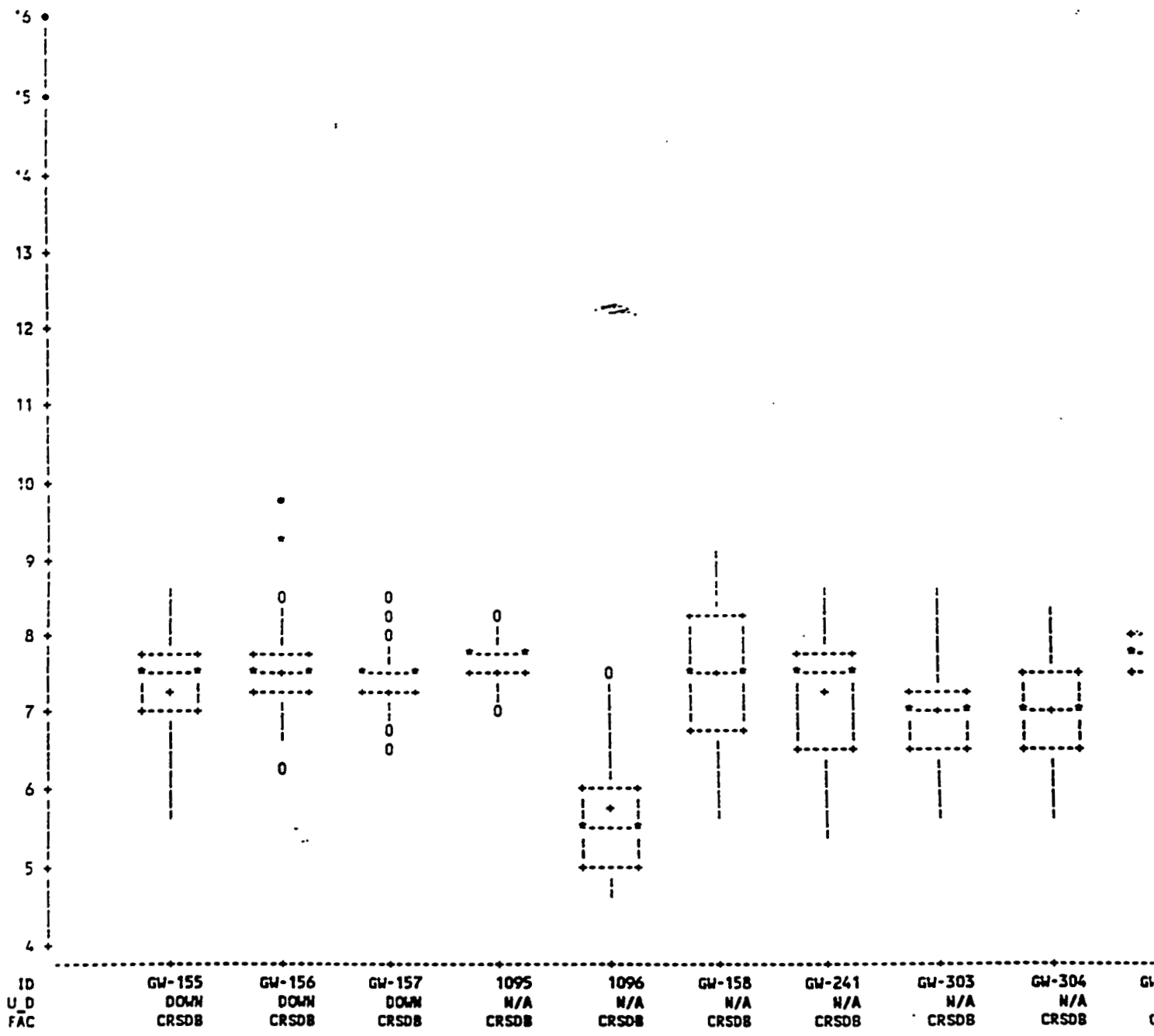


Figure 2. Statistical summary of pH data for groundwater monitoring wells at the Chestnut Ridge Sediment Disposal Basin. Box outlines represent the 25th percentile (bottom of box), median (middle line terminated with asterisks), and 75th percentile (top of box) of the data set for a individual well. Mean is indicated by central plus sign (+) within the box. Central lines or tails extending above and below the box indicate the range of outliers within 1.5 interquartile ranges below the 25th percentile and above the 75th percentile. Outliers beyond this range are illustrated by zero (0) if they are within 3 interquartile ranges. More extreme outliers are illustrated by an asterisk (*). Because of scale, some boxes appear incomplete.

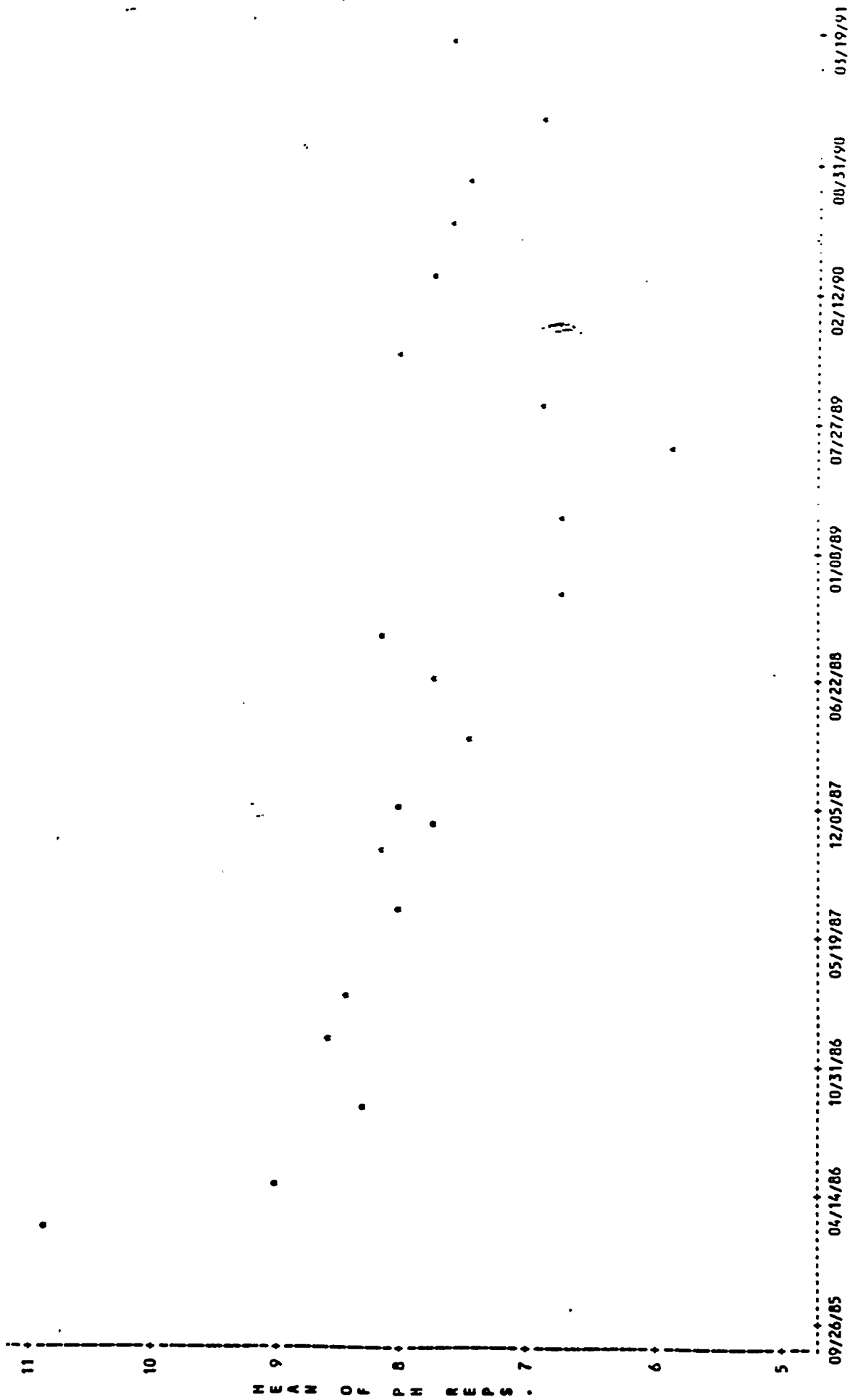


Figure 3. Plot of mean pH values for the upgradient well (GW-159) at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

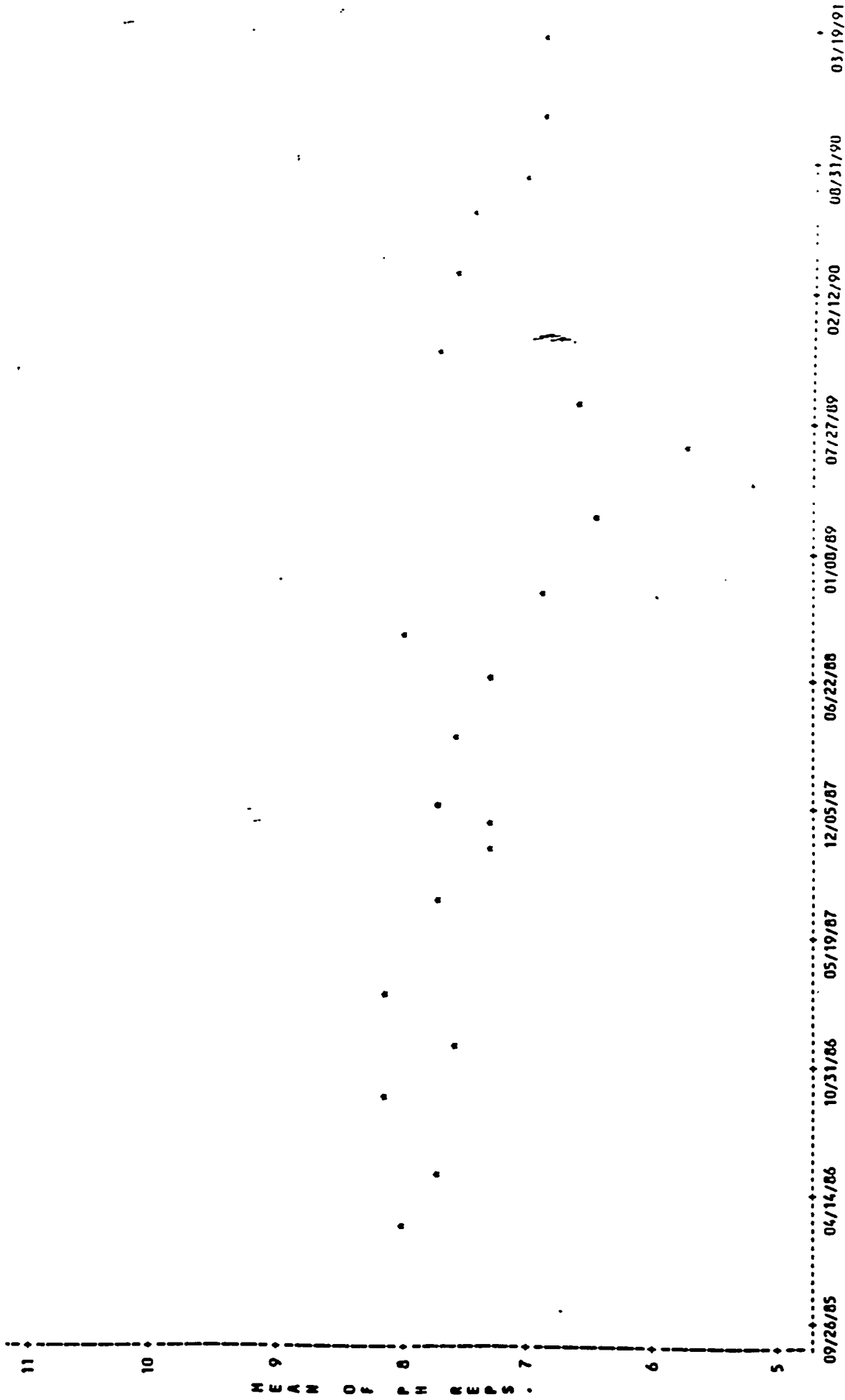


Figure 4. Plot of mean pH values for downgradient well GW-155 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

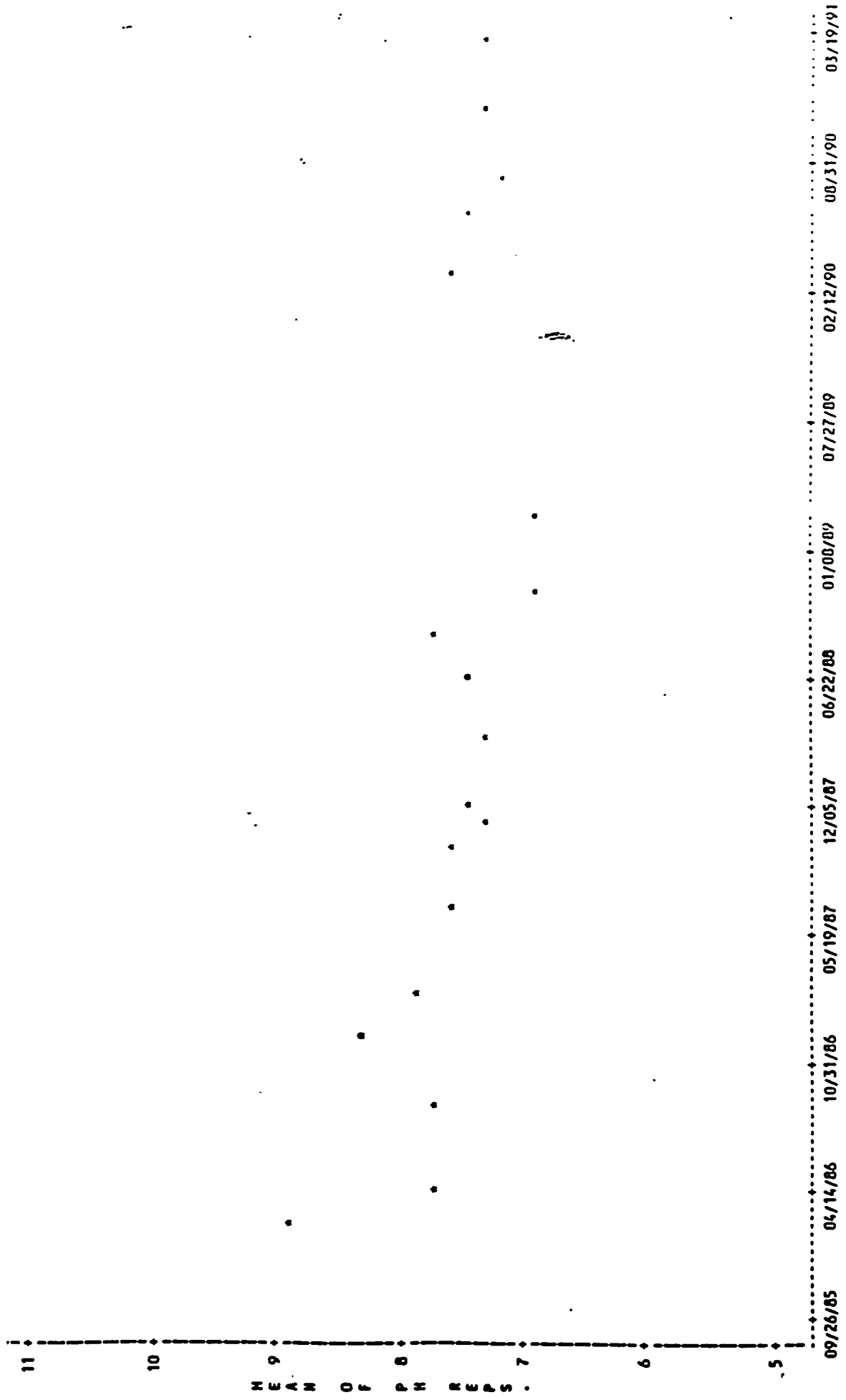


Figure 5. Plot of mean pH values for downgradient well GW-156 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

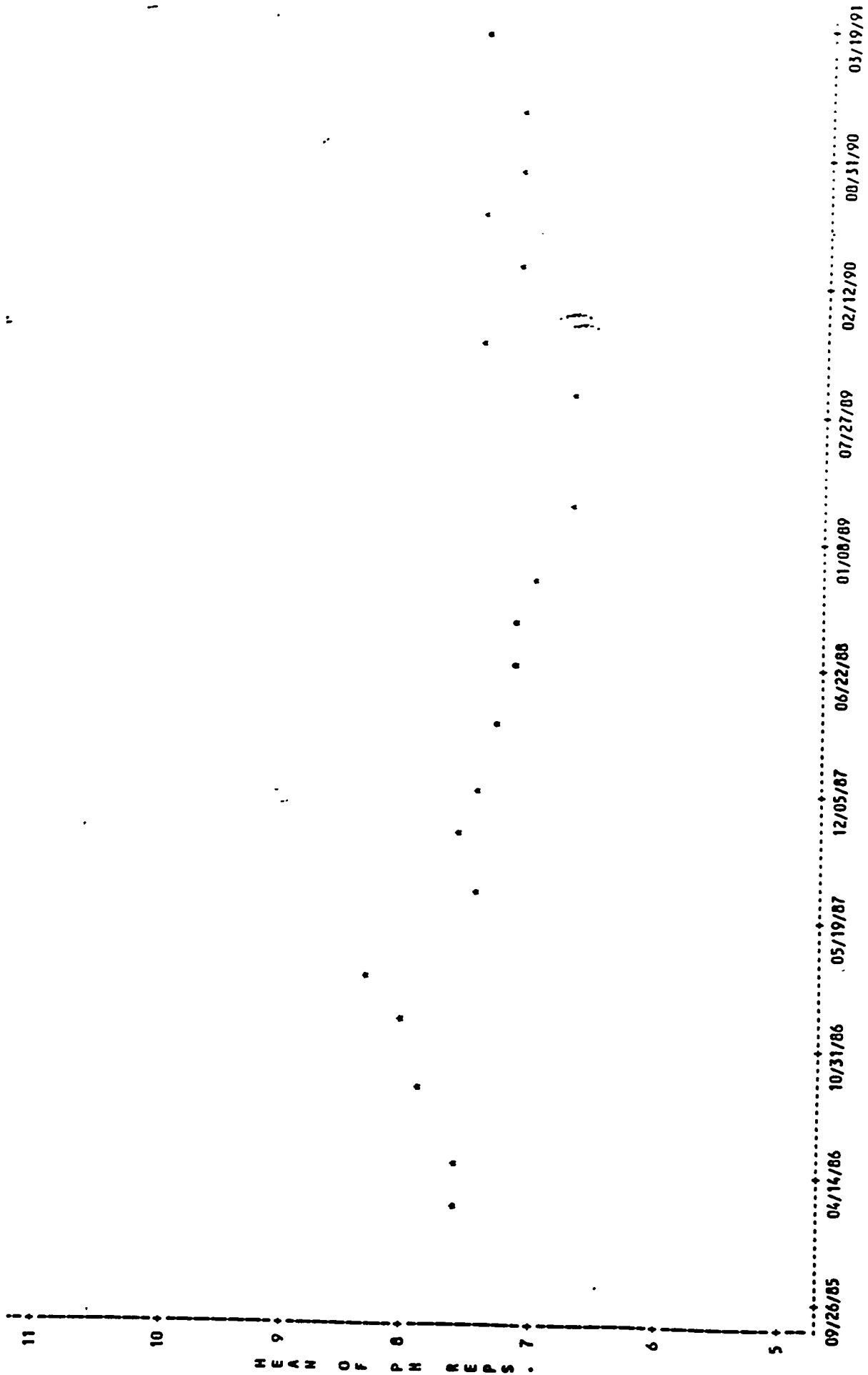


Figure 6. Plot of mean pH values for downgradient well GW-157 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

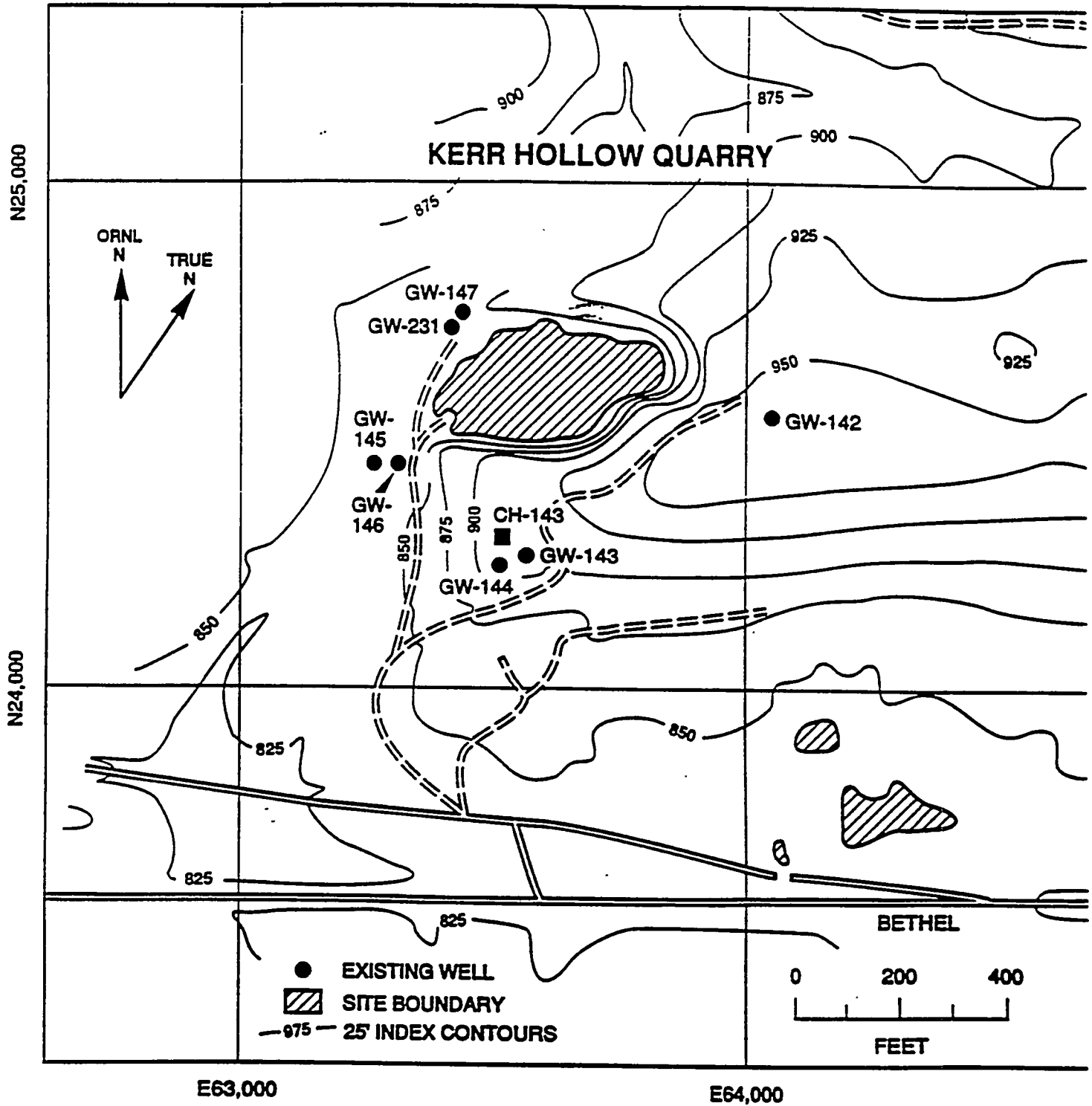


Figure 7. Location map for the Kerr Hollow Quarry. Upgradient monitoring well is GW-145. Downgradient monitoring wells are GW-142, GW-144, and GW-231.

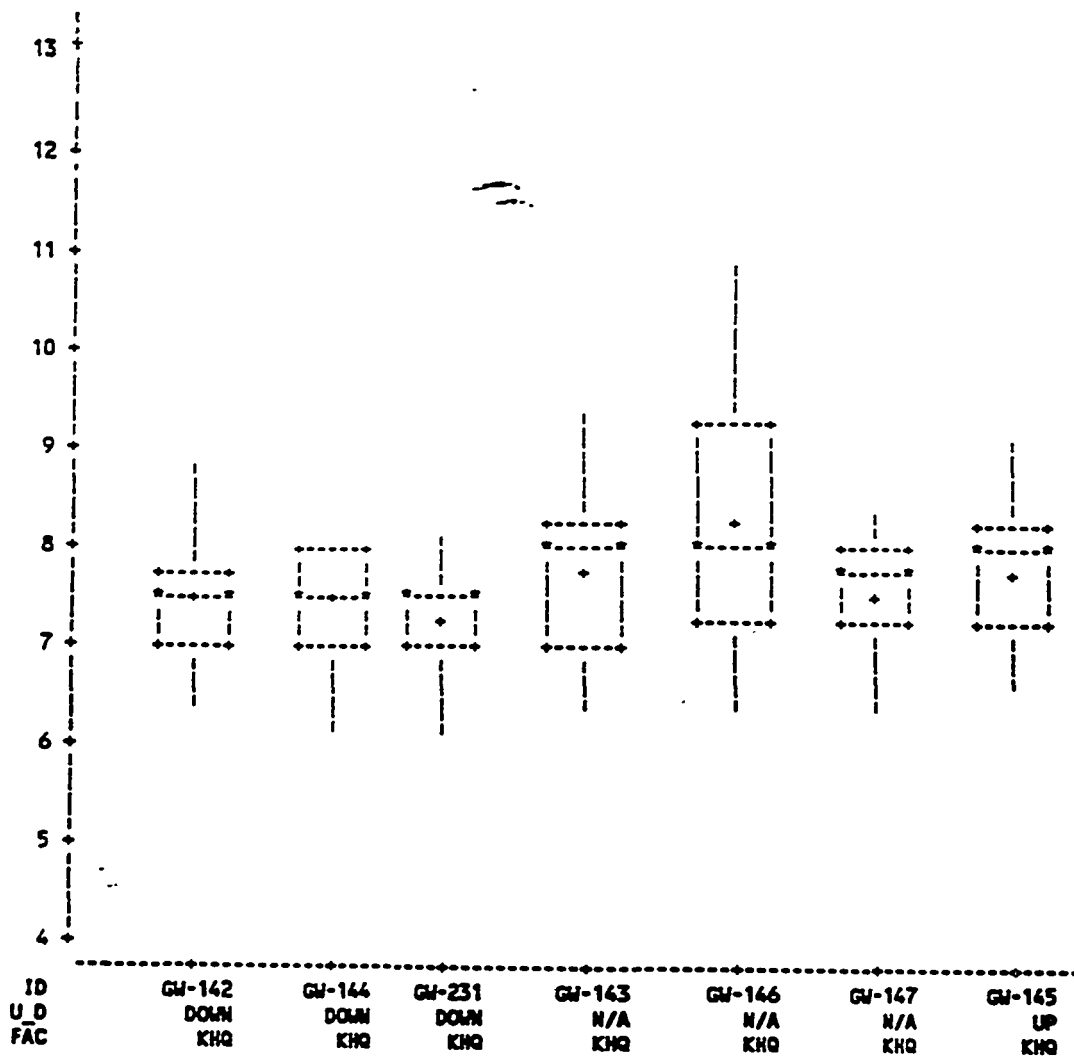


Figure 8. Statistical summary of pH data for groundwater monitoring wells at the Kerr Hollow Quarry. Box outlines represent the 25th percentile (bottom of box), median (middle line terminated with asterisks), and 75th percentile (top of box) of the data set for a individual well. Mean is indicated by central plus sign (+) within the box. Central lines or tails extending above and below the box indicate the range of outliers within 1.5 interquartile ranges below the 25th percentile and above the 75th percentile. Outliers beyond this range are illustrated by zero (0) if they are within 3 interquartile ranges. More extreme outliers are illustrated by an asterisk (*). Because of scale, some boxes appear incomplete.

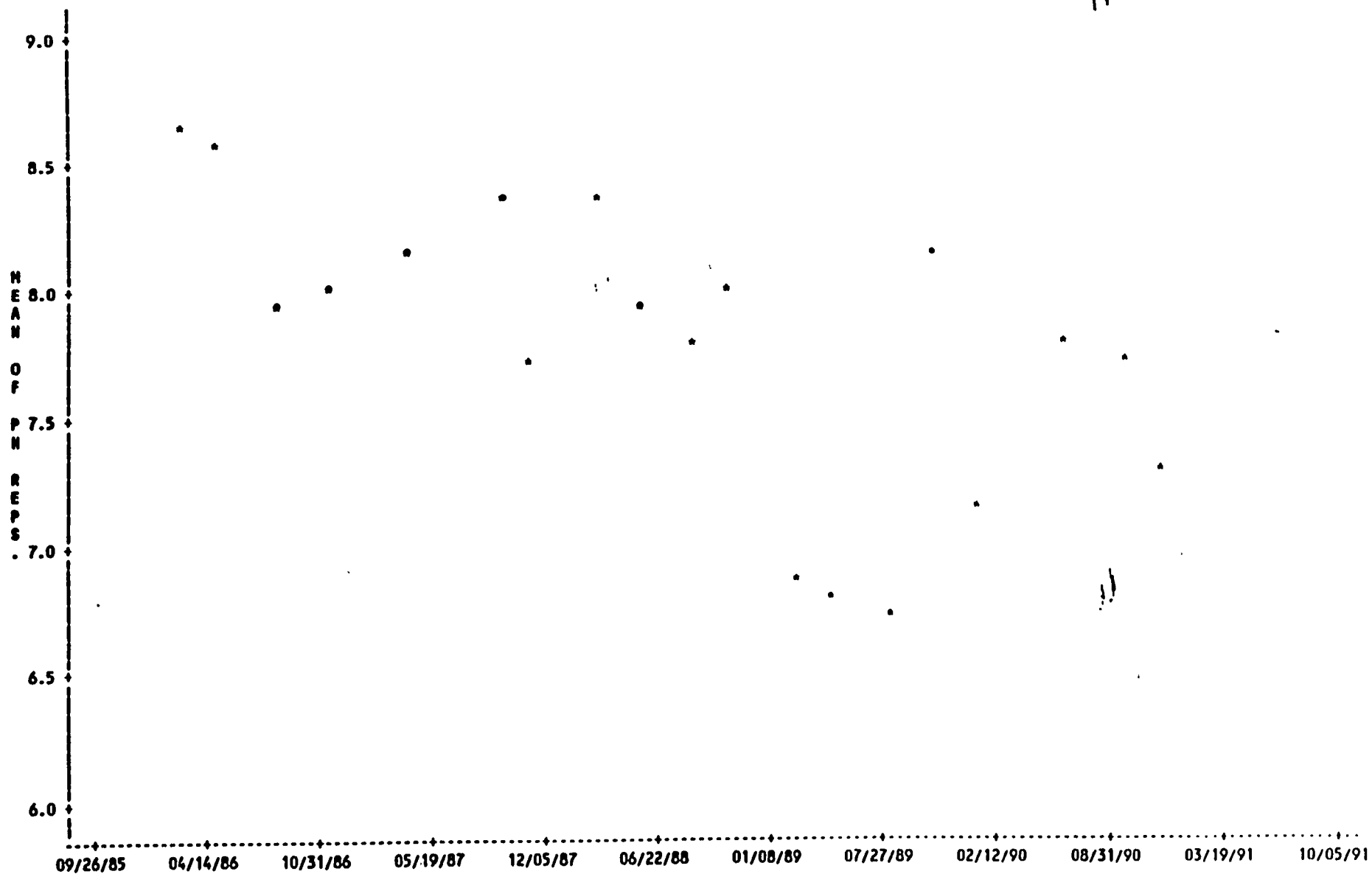


Figure 9. Plot of mean pH values for upgradient well GW-145 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

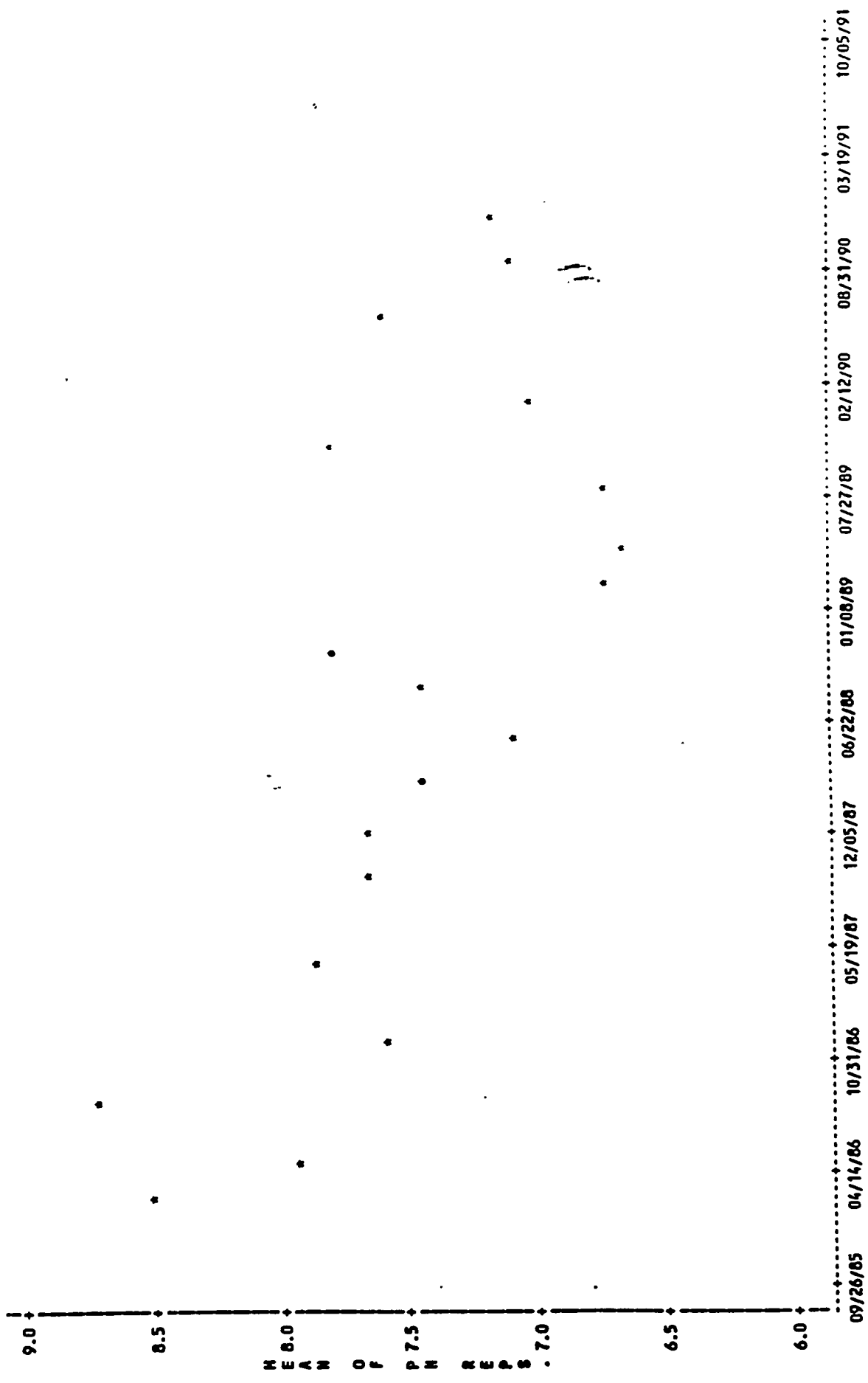


Figure 10. Plot of mean pH values for downgradient well GW-144 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

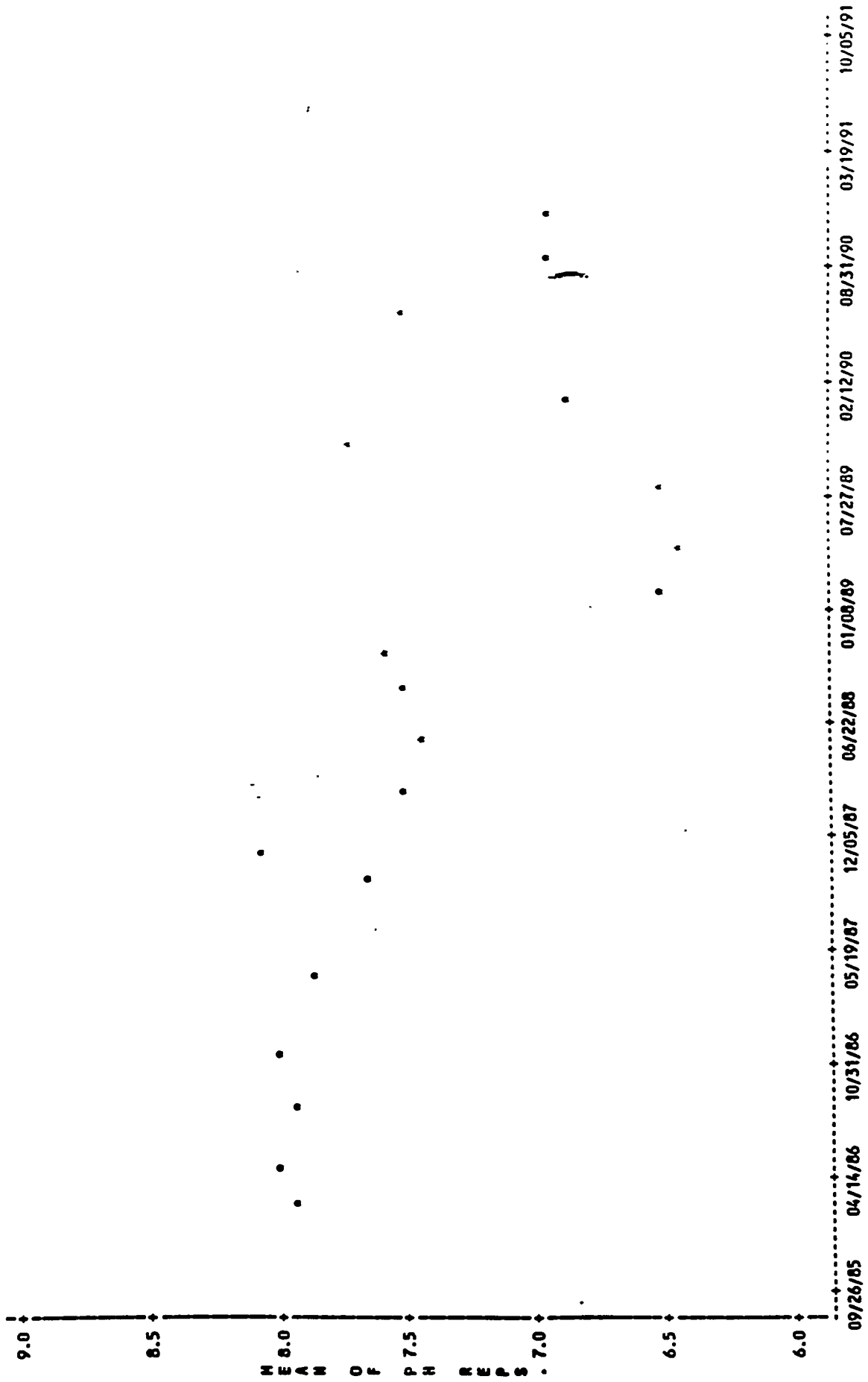


Figure 11. Plot of mean pH values for upgradient well GW-144 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

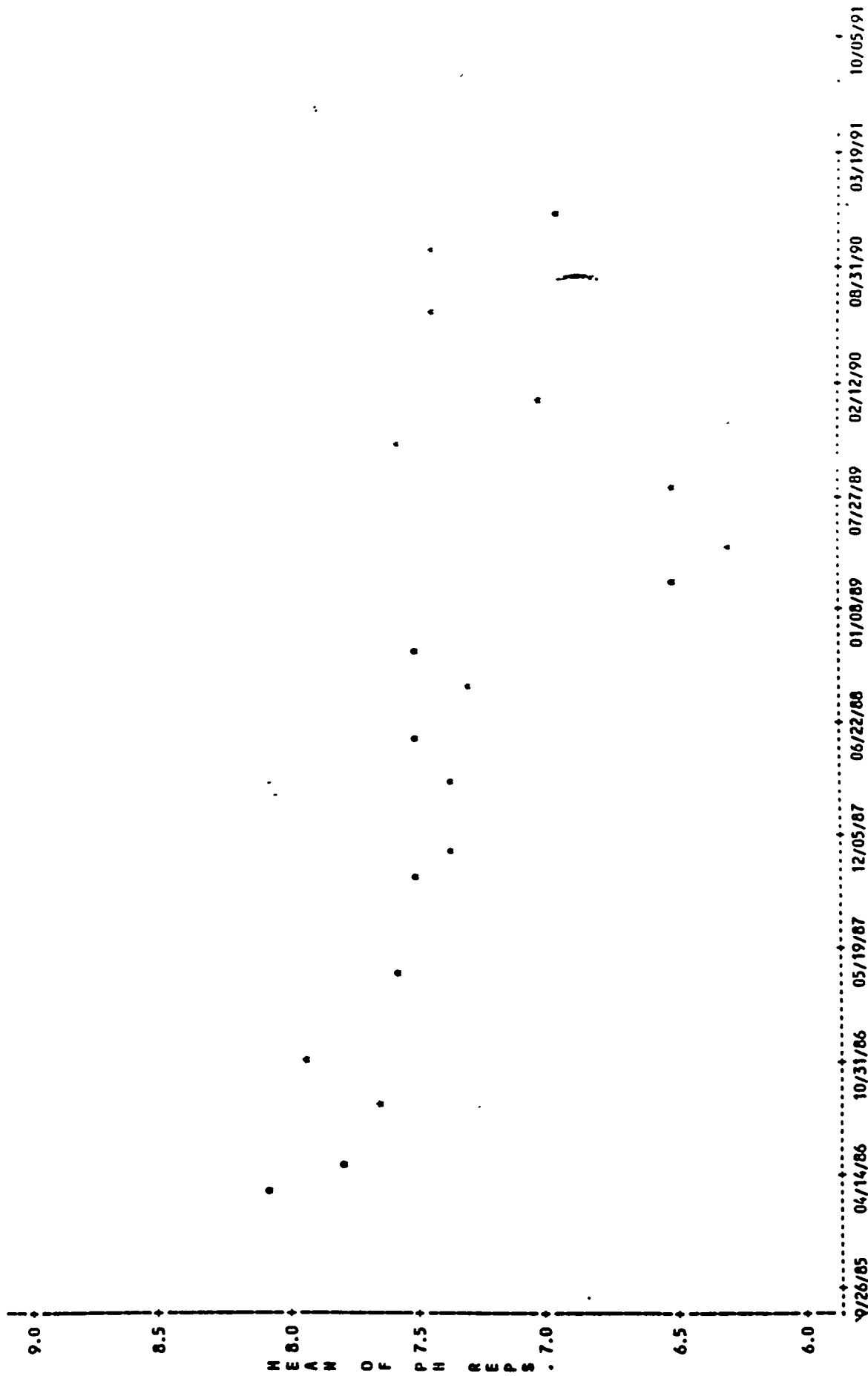


Figure 12. Plot of mean pH values for upgradient well GW-231 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

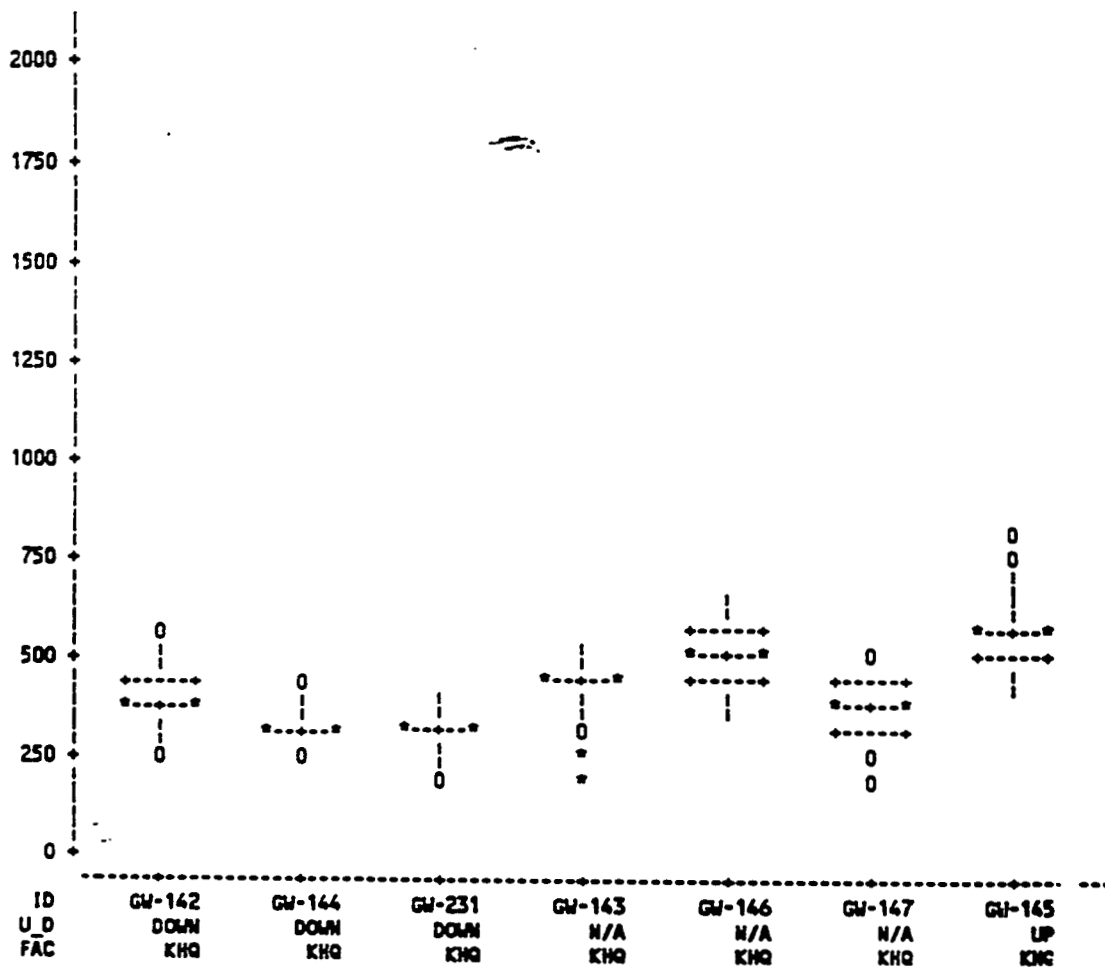


Figure 13. Statistical summary of conductivity data for groundwater monitoring wells at the Kerr Hollow Quarry. Box outlines represent the 25th percentile (bottom of box), median (middle line terminated with asterisks), and 75th percentile (top of box) of the data set for a individual well. Mean is indicated by central plus sign (+) within the box. Central lines or tails extending above and below the box indicate the range of outliers within 1.5 interquartile ranges below the 25th percentile and above the 75th percentile. Outliers beyond this range are illustrated by zero (0) if they are within 3 interquartile ranges. More extreme outliers are illustrated by an asterisk (*). Because of scale, some boxes appear incomplete.

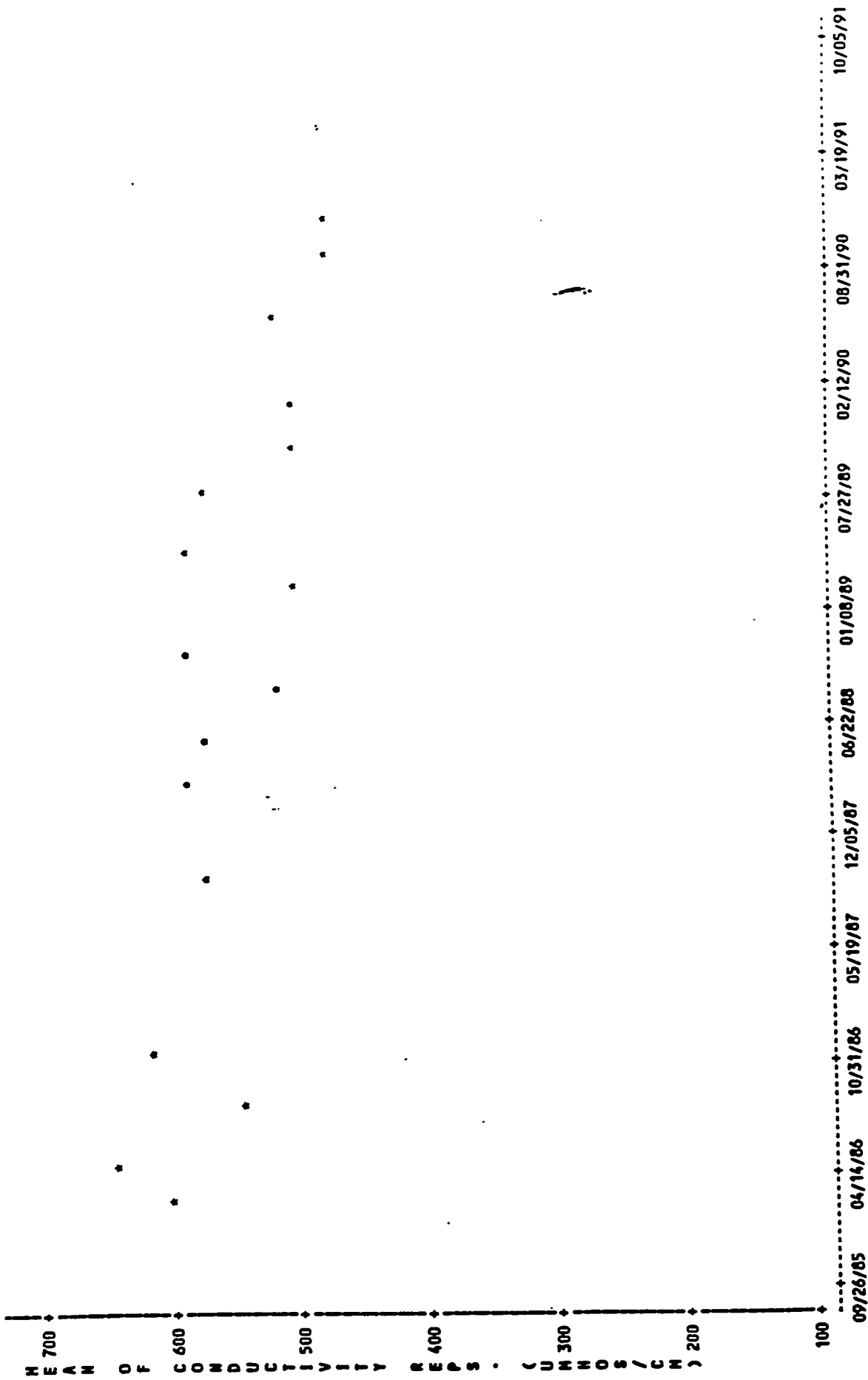


Figure 14. Plot of mean conductivity values for the upgradient well (GW-145) at Kerr Hollow Quarry. Each data point is the mean of four measurements.

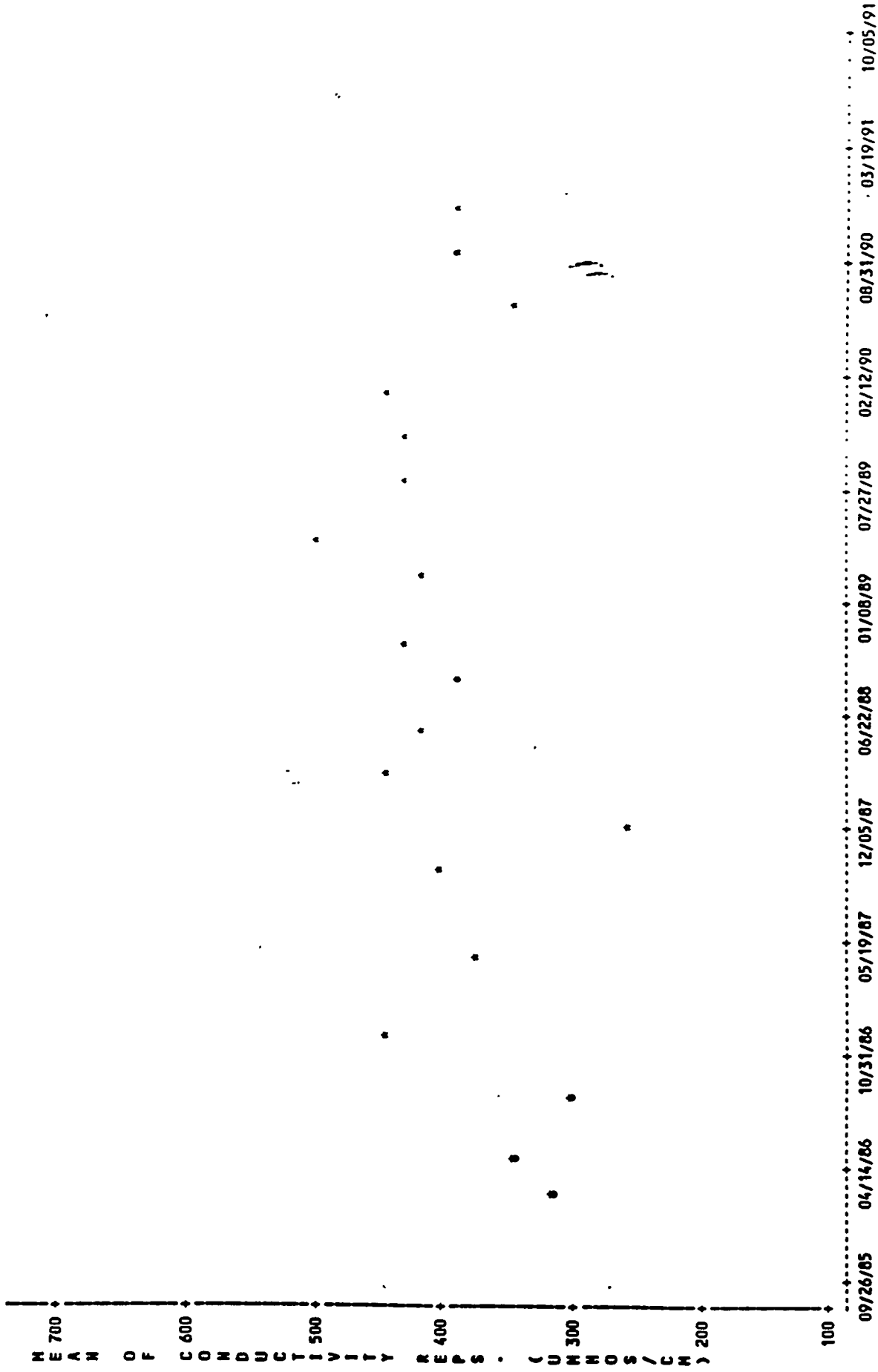


Figure 15. Plot of mean conductivity values for downgradient well GW-142 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

EVALUATION OF TOTAL ORGANIC CARBON AND TOTAL ORGANIC HALIDE
MEASUREMENTS FOR GROUNDWATER FROM THE CHESTNUT RIDGE
SEDIMENT DISPOSAL BASIN AND KERR HOLLOW QUARRY

OAK RIDGE Y-12 PLANT

C. Stephen Haase¹
Helen L. King²
Terre M. Mercier³

November 25, 1991

-
- ¹ Environmental Sciences Division, Oak Ridge National Laboratory,
P. O. Box 2008, Oak Ridge, Tennessee 37831-6352
- ² Environmental Management Department, Oak Ridge Y-12 Plant, P. O. Box 2009,
Oak Ridge, Tennessee 37831-8219
- ³ H & R Technical Associates, Oak Ridge, Tennessee 37830

Introduction

Groundwater quality data were collected for two sites in RCRA Interim Status - Detection Monitoring at the Oak Ridge Y-12 Plant during the first quarter of calendar year (CY) 1991. As required by Rule 1200-1-1-.05(6) of the Tennessee Department of Environment and Conservation, monitoring results for indicator parameters (pH, conductivity, total organic carbon (TOC), and total organic halides (TOX)) were reviewed to determine if a statistically significant change had occurred in the values of one or more indicator parameters. Analysis of the data obtained during the period 1987 through 1990 indicated that statistically significant changes had sporadically occurred in both TOC and TOX for groundwater samples obtained from upgradient and downgradient wells at both the Chestnut Ridge Sediment Disposal Basin and Kerr Hollow Quarry.

The purpose of this document is to review TOC and TOX data for groundwater monitoring wells at both facilities to determine if the statistically significant changes in the indicator parameters noted represent a release of contaminants into the groundwater from the facilities, or if the changes observed are due to other, naturally occurring factors.

Chestnut Ridge Sediment Disposal Basin

Evaluation of TOC Data

Total organic carbon measurements were obtained from groundwater monitoring wells at the Chestnut Ridge Sediment Disposal Basin (Fig. 1) beginning in CY 1987. The mean, median, and variance of TOC measurements are illustrated in Fig. 2. The data indicate that (1) in wells GW-155, GW-158, GW-241, GW-159, and No. 1096 the majority of TOC values obtained were below the detection limit of 1 mg/L, (2) for wells GW-156, GW-157, GW-303, GW-304, and No. 1095 the majority of TOC values are above the detection limit, and for these wells the median TOC values are less than 5 mg/L, (3) for wells GW-156, GW-157, GW-303, GW-304, and No. 1095 the degree of variance, as calculated by the distance between the 25th and 75th percentiles, is typically less than 1 mg/L, and (4) the greatest TOC values measured in any well during the period of observation was 7.1 mg/L from well GW-157.

Total organic carbon measurements reflect dissolved and suspended organic carbon within a groundwater sample. Naturally occurring humic and fulvic acids are major contributors to the dissolved component, and suspended organic material and soil debris are major contributors to the suspended component. In contaminated groundwaters, dissolved organic chemicals, such as petroleum products, chlorinated solvents, and chemically complex organic leachates are typically major contributors to TOC values.

Trend plots for TOC measurements from the upgradient and downgradient wells at the Chestnut Ridge Sediment Disposal Basin are illustrated in Figs. 3a through 6a. To evaluate whether the fluctuations observed in TOC values are naturally-occurring or are due to influxes of contaminant-related organic carbon, trend plots for summed chlorinated and aromatic volatile organic compounds (VOCs) are illustrated in Figs. 3b through 6b. Volatile organic compounds, such as carbon tetrachloride and trichloroethene, are the major potential organic contaminants at the Chestnut Ridge Sediment Disposal Basin and, therefore, are the only contaminant-related source of organic carbon that could impact TOC values in groundwater. Data for TOC and summed chlorinated and aromatic VOC measurements for the upgradient and downgradient monitoring wells is summarized and discussed in the following sections.

GW-159. The majority of TOC values for upgradient well GW-159 were below the detection limit of 1 mg/L (Fig. 3a). Three samples obtained during the period 1989 through 1990 were above detection limits and ranged between 2 and 3 mg/L. Summed chlorinated and aromatic VOCs for well GW-159 range between 0 and 10 µg/L (see Fig. 3b: note these concentrations are a factor of 1000 less than those of TOC values). None of the three TOC values above detection limits corresponds to elevated summed chlorinated and aromatic VOCs values, suggesting that the variations in TOC values noted are due to natural, secular fluctuations in the upgradient well.

GW-155. The majority of TOC values for downgradient well GW-155 were below the detection limit of 1 mg/L (Fig. 4a). Four samples obtained during the period 1989 through 1990 were above detection limits and ranged between 2 and 3 mg/L, which is within the range of TOC values noted for the upgradient well. Summed chlorinated and aromatic VOCs for well GW-155 range between 0 and 5 µg/L (see Fig. 4b: note these concentrations are a factor of 1000 less than those of TOC values). Only one of the four TOC values above detection limits corresponds to a nonzero summed chlorinated and aromatic VOCs value, but the smallness of the summed chlorinated and aromatic VOCs value (5 µg/L) compared to the TOC value (~1.5 mg/L) suggests that the TOC value represents natural-occurring fluctuations.

GW-156. The majority of TOC values for downgradient well GW-156 were above the detection limit of 1 mg/L (Fig. 5a). Samples obtained during the period 1987 through 1990 that were above the detection limit had a median of 2 mg/L and ranged from the detection limit of 1 to ~4.5 mg/L. This range of TOC values is greater than that noted for those samples from the upgradient well, but the median value of 2 mg/L is within the range noted for the upgradient well. Summed chlorinated and aromatic VOCs for well GW-156 range between 0 and ~12 µg/L (see Fig. 5b: note these concentrations are a factor of 1000 less than those of TOC values). During the period 1988 through 1990, however all summed chlorinated and aromatic VOCs values were 0. The fluctuations observed in TOC during that period, therefore, cannot be due to the introduction of contaminant-related organic carbon and must represent natural-occurring fluctuations.

GW-157. All TOC values for downgradient well GW-157 were above the detection limit of 1 mg/L (Fig. 6a). Samples obtained during the period 1987 through 1990 had a median of 3 mg/L and ranged from the detection limit of 1 to ~5.5 mg/L. This range of TOC values is greater than that noted for those samples from the upgradient well, but the median value of 2 mg/L is within the range noted for the upgradient well. Summed chlorinated and aromatic VOCs for well GW-157 range between 0 and ~45 µg/L (see Fig. 6b: note these concentrations are a factor of 1000 less than those of TOC values). Only three summed chlorinated and aromatic VOC values were above 10 µg/L, however, and the majority of values is within the range 0 to 5 µg/L. Examination of Figs. 6a and 6b indicates that there is no correlation between increases in TOC values and increases in summed chlorinated and aromatic VOCs values, suggesting that the TOC fluctuations represent natural-occurring variations.

Discussion and Summary. Temporal variations in TOC values for both the upgradient and downgradient wells at the Chestnut Ridge Sediment Disposal Basin exhibit no identifiable trend or relationship to each other. Many TOC values for all wells are below the 1 mg/L detection limit, and values above the detection limit typically range between 2 and 3 mg/L. Such a range is within what is expected for uncontaminated groundwaters (Hem 1986; Drever 1988). It is also typical of the range noted for uncontaminated groundwaters that occur elsewhere on the Oak Ridge Reservation (HSW 1991 a-e). Variations in TOC for a well are not correlated with variations in the summed chlorinated and aromatic VOC values in that well. In all cases variations in summed chlorinated and aromatic VOC values are small, with the values at or near 0 µg/L.

Based on the factors discussed above, the statistically significant changes in TOC noted for wells at the Chestnut Ridge Sediment Disposal Basin are interpreted to be false positives, and to not represent a release of contaminants into groundwater from the site.

Evaluation of TOX Data

Total organic halide measurements were obtained from groundwater monitoring wells at the Chestnut Ridge Sediment Disposal Basin (Fig. 1) beginning in CY 1986. The mean, median, and variance of TOX measurements are illustrated in Fig. 7. The data indicate that (1) much of the data for all wells is less than the 10 µg/L detection limit, and because of this the median values for all wells are at the detection limit, (2) six of the ten wells at the site have extreme outliers, (3) the extreme outliers for the upgradient well (GW-159) range up to ~900 µg/L, and (4) extreme outliers for the downgradient wells range up to ~400 µg/L (GW-156).

Trend plots for TOX measurements from the upgradient and downgradient wells at the Chestnut Ridge Sediment Disposal Basin are illustrated in Figs. 8a through 11a.

For comparison, trend plots of summed chlorinated VOCs are presented in Figs. 8b through 11b. Data for TOX and summed chlorinated VOC measurements for the upgradient and downgradient monitoring wells is summarized and discussed in the following sections.

GW-159. The majority of TOX values for upgradient well GW-159 were less than 25 $\mu\text{g/L}$ (Fig. 8a). Samples obtained during CY 1986 range from the detection limit of 10 $\mu\text{g/L}$ to ~ 900 $\mu\text{g/L}$. Subsequent to 1986 no TOX values greater than 25 $\mu\text{g/L}$ were obtained, which suggests that the results for CY 1986 represent spurious analytical data. Summed chlorinated VOCs for well GW-159 during the period 1986 through 1990 range between 0 and 8 $\mu\text{g/L}$ (Fig. 8b), with the results for the period 1987 through 1990 all being less than 5 $\mu\text{g/L}$. No consistent correlation or temporal pattern in TOX and summed chlorinated VOC values is noted, suggesting that the variability observed likely represents analytical uncertainties.

GW-155. With one exception, all TOX values for downgradient well GW-155 were less than 50 $\mu\text{g/L}$ (Fig. 9a), and the majority of values are below the detection limit of 10 $\mu\text{g/L}$. Samples obtained during CY 1986 range from the detection limit of 10 $\mu\text{g/L}$ to ~ 90 $\mu\text{g/L}$. Subsequent to 1986 no TOX values greater than 30 $\mu\text{g/L}$ were obtained, which suggests that the results for CY 1986 represent spurious analytical data. Summed chlorinated VOCs for well GW-155 during the period 1986 through 1990 range between 0 and 5 $\mu\text{g/L}$ (Fig. 9b). No consistent correlation or temporal pattern in TOX and summed chlorinated VOC values is noted, suggesting that the variability observed likely represents analytical uncertainties.

GW-156. With two exceptions, all TOX values for downgradient well GW-156 were less than ~ 30 $\mu\text{g/L}$ (Fig. 10a), and the majority of values are below the detection limit of 10 $\mu\text{g/L}$. Samples obtained during CY 1986 range from the detection limit of 10 $\mu\text{g/L}$ to ~ 350 $\mu\text{g/L}$. Subsequent to 1986 no TOX values greater than 30 $\mu\text{g/L}$ were obtained, which suggests that the results for CY 1986 represent spurious analytical data. Summed chlorinated VOCs for well GW-156 during the period 1987 through 1990 range from 0 to ~ 8 $\mu\text{g/L}$ (Fig. 10b), with the results for the period 1988 through 1990 all being 0 $\mu\text{g/L}$. No consistent correlation or temporal pattern in TOX and summed chlorinated VOC values is noted, suggesting that the variability observed likely represents analytical uncertainties.

GW-157. With one exception, all TOX values for downgradient well GW-157 were less than ~ 50 $\mu\text{g/L}$ (Fig. 11a), and the majority of values are below the detection limit of 10 $\mu\text{g/L}$. Samples obtained during CY 1986 range from the detection limit of 10 $\mu\text{g/L}$ to ~ 250 $\mu\text{g/L}$. Subsequent to 1986 no TOX values greater than 50 $\mu\text{g/L}$ were obtained, which suggests that the results for CY 1986 represent spurious analytical data. During the period 1989 through 1990, TOX values were less than ~ 20 $\mu\text{g/L}$. Summed chlorinated VOCs for well GW-157 during the period 1987 through 1990 range from 0 to ~ 45 $\mu\text{g/L}$ (Fig. 11b). With one exception, the results for the period 1988 through 1990 were all between 0 and 5 $\mu\text{g/L}$. No consistent correlation or

temporal pattern in TOX and summed chlorinated VOC values is noted, suggesting that the variability observed likely represents analytical uncertainties.

Discussion and Summary. Temporal variations in TOX values for both the upgradient and downgradient wells at the Chestnut Ridge Sediment Disposal Basin exhibit no identifiable trend or relationship to each other. Many TOX values for all wells are below the 10 µg/L detection limit, and values above the detection limit typically range between 10 and 50 µg/L. Variations in TOX for a well are not correlated with variations in the summed chlorinated and aromatic VOC values in that well. In all cases variations in summed chlorinated and aromatic VOC values are small, with the values at or near 0 µg/L.

Based on the factors discussed above, the statistically significant changes in TOX noted for wells at the Chestnut Ridge Sediment Disposal Basin are interpreted to be false positives, and to not represent a release of contaminants into groundwater from the site.

Kerr Hollow Quarry

Evaluation of TOC Data

Total organic carbon measurements were obtained from groundwater monitoring wells at Kerr Hollow Quarry (Fig. 12) beginning in CY 1987. The mean, median, and variance of TOC measurements are illustrated in Fig. 13. The data indicate that (1) in all wells the majority of TOC values obtained were below the detection limit of 1 mg/L, (2) although the median value for TOC in all wells is at or close to the detection limit of 1 mg/L, most wells have several outliers whose values can be as large as ~60 mg/L, and (3) because many of the data are less than the detection limit, the TOC data set is truncated, making statistical analysis difficult.

Total organic carbon measurements reflect dissolved and suspended organic carbon within a groundwater sample. Naturally occurring humic and fulvic acids are major contributors to the dissolved component, and suspended organic material and soil debris are major contributors to the suspended component. In contaminated groundwaters, dissolved organic chemicals, such as petroleum products, chlorinated solvents, and chemically complex organic leachates are typically major contributors to TOC values.

Trend plots for TOC measurements from the upgradient and downgradient wells at Kerr Hollow Quarry are illustrated in Figs. 14a through 17a. To evaluate whether the fluctuations observed in TOC values are naturally-occurring or are due to influxes of contaminant-related organic carbon, trend plots for summed chlorinated and aromatic volatile organic compounds (VOCs) are illustrated in Figs. 14b through 17b. Volatile organic compounds, such as carbon tetrachloride and trichloroethene, are the major potential organic contaminants at Kerr Hollow Quarry and, therefore,

are the only contaminant-related source of organic carbon that could impact TOC values in groundwater. Data for TOC and summed chlorinated and aromatic VOC measurements for the upgradient and downgradient monitoring wells is summarized and discussed in the following sections.

GW-145. The TOC values for upgradient well GW-145 range from the detection limit of 1 mg/L to ~3.3 mg/L (Fig. 14a), and, with the exception of one sample, all TOC values are less than 2 mg/L. Summed chlorinated and aromatic VOCs for well GW-145 are 0 µg/L throughout the period of interest (see Fig. 14b: note these concentrations are a factor of 1000 less than those of TOC values). These data suggest that the variations in TOC values noted are due to natural, secular fluctuations in the upgradient well, and not to contaminant-related organic carbon sources.

GW-142. The TOC values for downgradient well GW-142 range from the detection limit of 1 mg/L to ~6.3 mg/L (Fig. 15a). With the exception of two samples, all TOC values are less than 2 mg/L, which is within the range of values noted for the upgradient well. With one exception, summed chlorinated and aromatic VOCs for well GW-142 range from 0 to ~3 µg/L throughout the period of interest, with most values being 0 mg/L (see Fig. 15b: note these concentrations are a factor of 1000 less than those of TOC values). There is no correlation between TOC and summed chlorinated and aromatic VOCs variations, which suggests that the variations in TOC values noted are due to natural, secular fluctuations, and not to contaminant-related organic carbon sources.

GW-144. The TOC values for downgradient well GW-144 range from the detection limit of 1 mg/L to ~4 mg/L (Fig. 16a). With the exception of one sample, all TOC values are less than ~2 mg/L, which is within the range of values noted for the upgradient well. Summed chlorinated and aromatic VOCs for well GW-144 range from 0 to ~4 µg/L throughout the period of interest, with most values being 0 mg/L (see Fig. 16b: note these concentrations are a factor of 1000 less than those of TOC values). There is no correlation between TOC and summed chlorinated and aromatic VOCs variations, which suggests that the variations in TOC values noted are due to natural, secular fluctuations, and not to contaminant-related organic carbon sources.

GW-231. The TOC values for downgradient well GW-231 range from the detection limit of 1 mg/L to ~5.7 mg/L (Fig. 17a). With the exception of two samples, all TOC values are less than 2 mg/L, which is within the range of values noted for the upgradient well. Summed chlorinated and aromatic VOCs for well GW-231 range from 0 to ~3 µg/L throughout the period of interest, with most values being 0 mg/L (see Fig. 17b: note these concentrations are a factor of 1000 less than those of TOC values). There is no correlation between TOC and summed chlorinated and aromatic VOCs variations, which suggests that the variations in TOC values noted are due to natural, secular fluctuations, and not to contaminant-related organic carbon sources.

Discussion and Summary. Temporal variations in TOC values for both the upgradient and downgradient wells at the Kerr Hollow Quarry exhibit no identifiable trend or relationship to each other. Many TOC values for all wells are below the 1 mg/L detection limit, and values above the detection limit typically range between 2 and 3 mg/L. Such a range is within what is expected for uncontaminated groundwaters (Hem 1986; Drever 1988). It is also typical of the range noted for uncontaminated groundwaters that occur elsewhere on the Oak Ridge Reservation (HSW 1991 a-e). Variations in TOC for a well are not correlated with variations in the summed chlorinated and aromatic VOC values in that well. In all case variations in summed chlorinated and aromatic VOC values are small, with the values at or near 0 µg/L.

Based on the factors discussed above, the statistically significant changes in TOC noted for wells at the Kerr Hollow Quarry are interpreted to be false positives, and to not represent a release of contaminants into groundwater from the site.

Evaluation of TOX Data

Total organic halide measurements were obtained from groundwater monitoring wells at Kerr Hollow Quarry (Fig. 12) beginning in CY 1986. The mean, median, and variance of TOX measurements are illustrated in Fig. 18. The data indicate that (1) much of the data for all wells is less than the 10 µg/L detection limit, and because of this, the median values for all wells are at the detection limit, (2) three of the seven wells at the site have extreme outliers that range up to ~1900 µg/L, (3) two of the downgradient wells (GW-142 and GW-144) have extreme outliers that range up to ~400 µg/L, and (4) one of the downgradient wells (GW-231) has extreme outliers that range to ~1900 µg/L.

Trend plots for TOX measurements from the upgradient and downgradient wells at Kerr Hollow Quarry are illustrated in Figs. 19a through 22a. For comparison, trend plots of summed chlorinated VOCs are presented in Figs. 19b through 22b. Data for TOX and summed chlorinated VOC measurements for the upgradient and downgradient monitoring wells is summarized and discussed in the following sections.

GW-145. The majority of TOX values for upgradient well GW-159 were less than 25 µg/L (Fig. 19a). Samples obtained during CY 1986 range from ~25 µg/L to ~220 µg/L. Subsequent to 1986 TOX values greater than 25 µg/L were not obtained, which suggests that the results for CY 1986 represent spurious analytical data. Summed chlorinated VOCs for well GW-145 during the period 1987 through 1990 are 0 µg/L (Fig. 19b). No consistent correlation or temporal pattern in TOX and summed chlorinated VOC values is noted, suggesting that the variability observed likely represents analytical uncertainties.

GW-142. With one exception, all TOX values for downgradient well GW-142 were less than 50 µg/L (Fig. 20a), and the majority of values are below the detection limit of 10 µg/L. Samples obtained during CY 1986 range from the detection limit of 10 µg/L to ~380 µg/L. Subsequent to 1986 no TOX values greater than ~40 µg/L were obtained, which suggests that the results for CY 1986 represent spurious analytical data. Summed chlorinated VOCs for well GW-142 during the period 1987 through 1990 range between 0 and 1 µg/L (Fig. 20b). No consistent correlation or temporal pattern in TOX and summed chlorinated VOC values is noted, suggesting that the variability observed likely represents analytical uncertainties.

GW-144. With three exceptions, all TOX values for downgradient well GW-144 were less than ~20 µg/L (Fig. 21a). Samples obtained during CY 1986 range from the detection limit of 10 µg/L to ~80 µg/L. Subsequent to 1986 only one TOX value exceeded ~20 µg/L, suggesting that the results for CY 1986 represent spurious analytical data. Summed chlorinated VOCs for well GW-144 during the period 1987 through 1990 range from 0 to ~3 µg/L (Fig. 21b), with only two results being greater than 0 µg/L. No consistent correlation or temporal pattern in TOX and summed chlorinated VOC values is noted, suggesting that the variability observed likely represents analytical uncertainties.

GW-231. With one exception, all TOX values for downgradient well GW-231 were less than ~50 µg/L (Fig. 22a), and the majority of values are below the detection limit of 10 µg/L. Samples obtained during CY 1986 range from the detection limit of 10 µg/L to ~1750 µg/L. Subsequent to 1986 no TOX values greater than 50 µg/L were obtained, which suggests that the results for CY 1986 represent spurious analytical data. During the period 1989 through 1990, TOX values were less than ~20 µg/L. Summed chlorinated VOCs for well GW-231 during the period 1987 through 1990 range from 0 to 1 µg/L (Fig. 22b), with only one value above 0 µg/L. No consistent correlation or temporal pattern in TOX and summed chlorinated VOC values is noted, suggesting that the variability observed likely represents analytical uncertainties.

Discussion and Summary. Temporal variations in TOX values for both the upgradient and downgradient wells at the Kerr Hollow Quarry exhibit no identifiable trend or relationship to each other. Many TOX values for all wells are below the 10 µg/L detection limit, and values above the detection limit typically range between 10 and 50 µg/L. Variations in TOX for a well are not correlated with variations in the summed chlorinated and aromatic VOC values in that well. In all cases variations in summed chlorinated and aromatic VOC values are small, with the values at or near 0 µg/L.

Based on the factors discussed above, the statistically significant changes in TOX noted for wells at the Kerr Hollow Quarry are interpreted to be false positives, and to not represent a release of contaminants into groundwater from the site.

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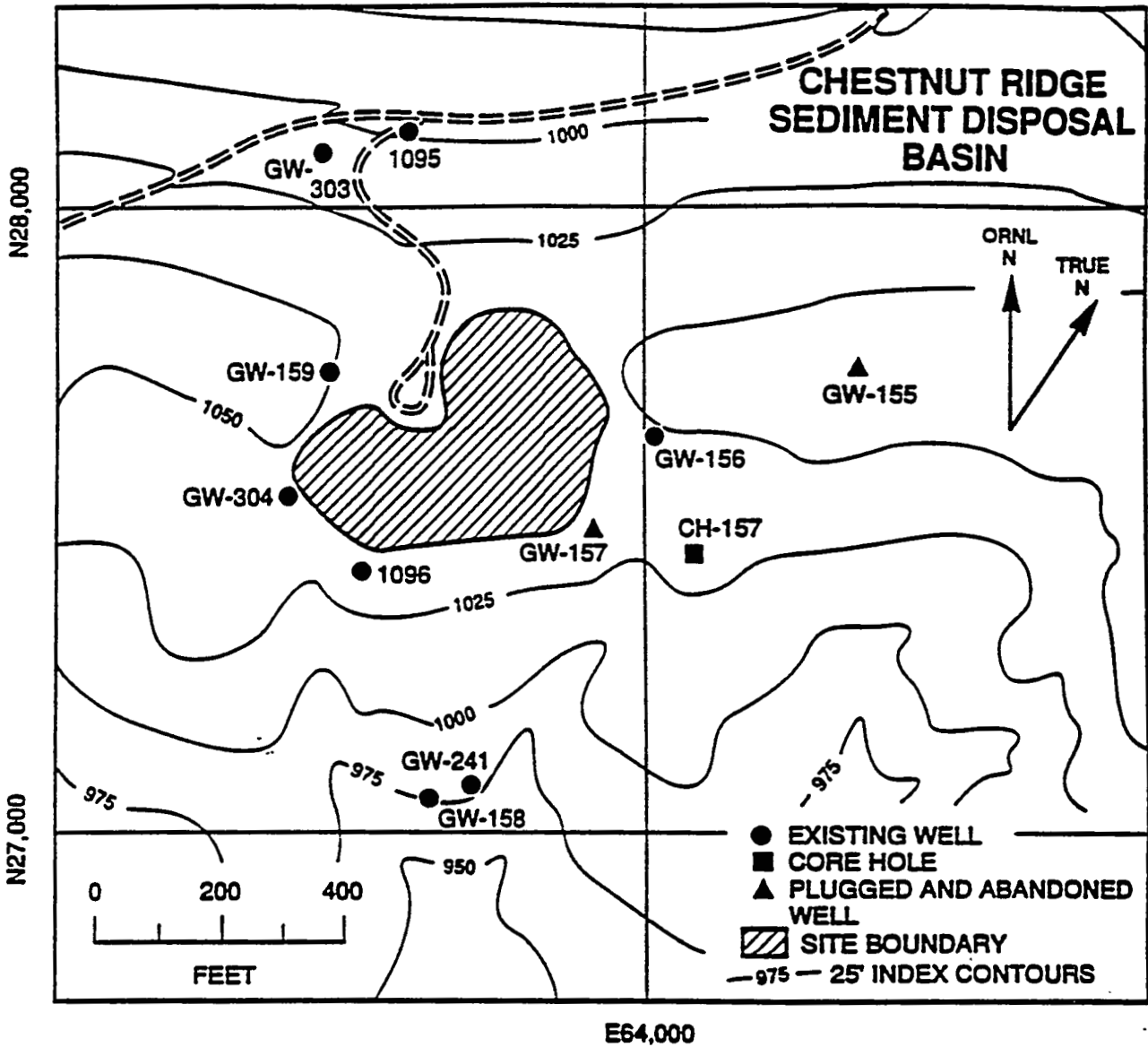


Figure 1. Location map for the Chestnut Ridge Sediment Disposal Basin. Upgradient monitoring well is GW-159. Downgradient monitoring wells are GW-155, GW-156, and GW-157.

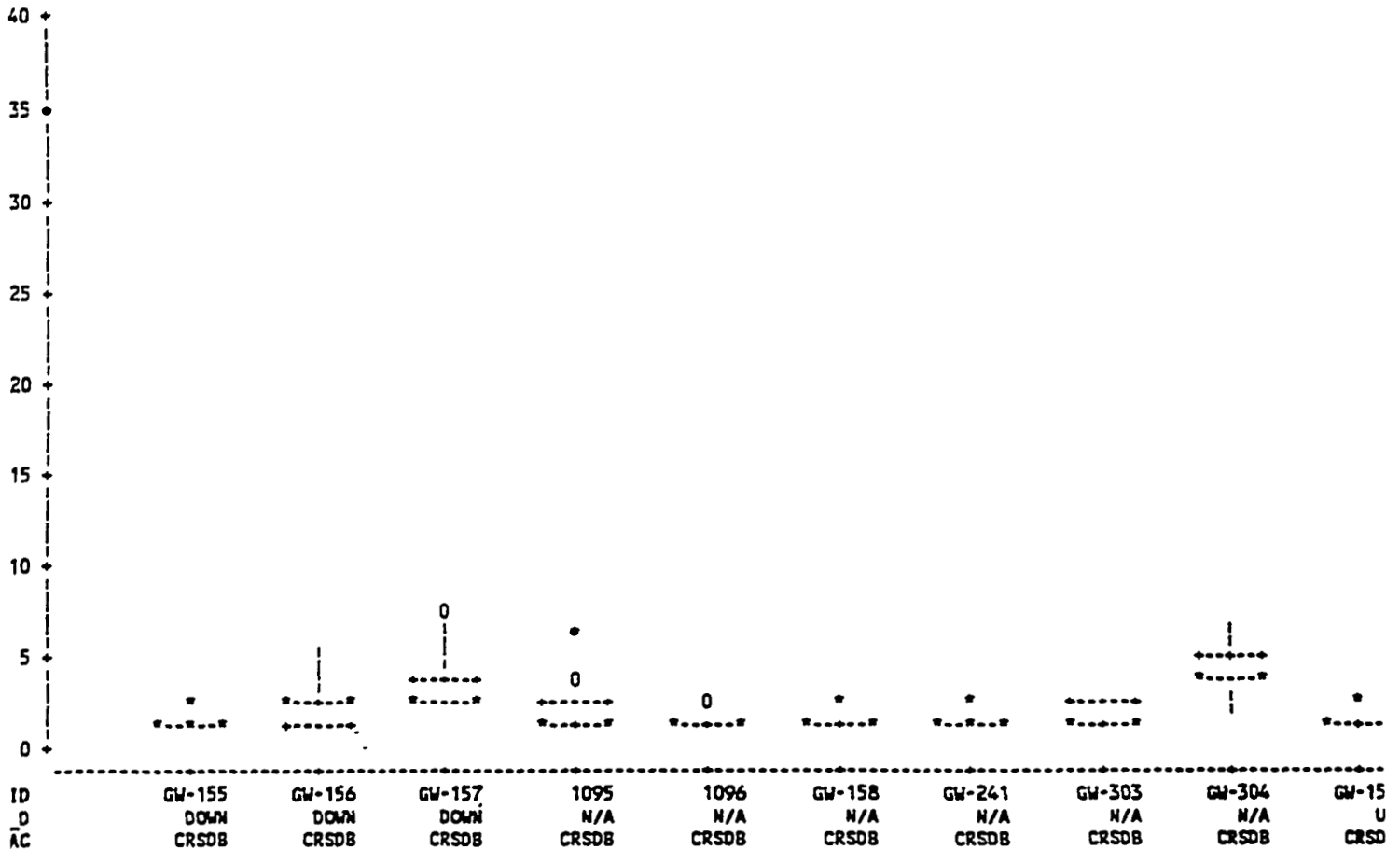


Figure 2. Statistical summary of TOC data for groundwater monitoring wells at the Chestnut Ridge Sediment Disposal Basin. Box outlines represent the 25th percentile (bottom of box), median (middle line terminated with asterisks), and 75th percentile (top of box) of the data set for a individual well. Mean is indicated by central plus sign (+) within the box. Central lines or tails extending above and below the box indicate the range of outliers within 1.5 interquartile ranges below the 25th percentile and above the 75th percentile. Outliers beyond this range are illustrated by zero (0) if they are within 3 interquartile ranges. More extreme outliers are illustrated by an asterisk (*). Because of scale, some boxes appear incomplete.

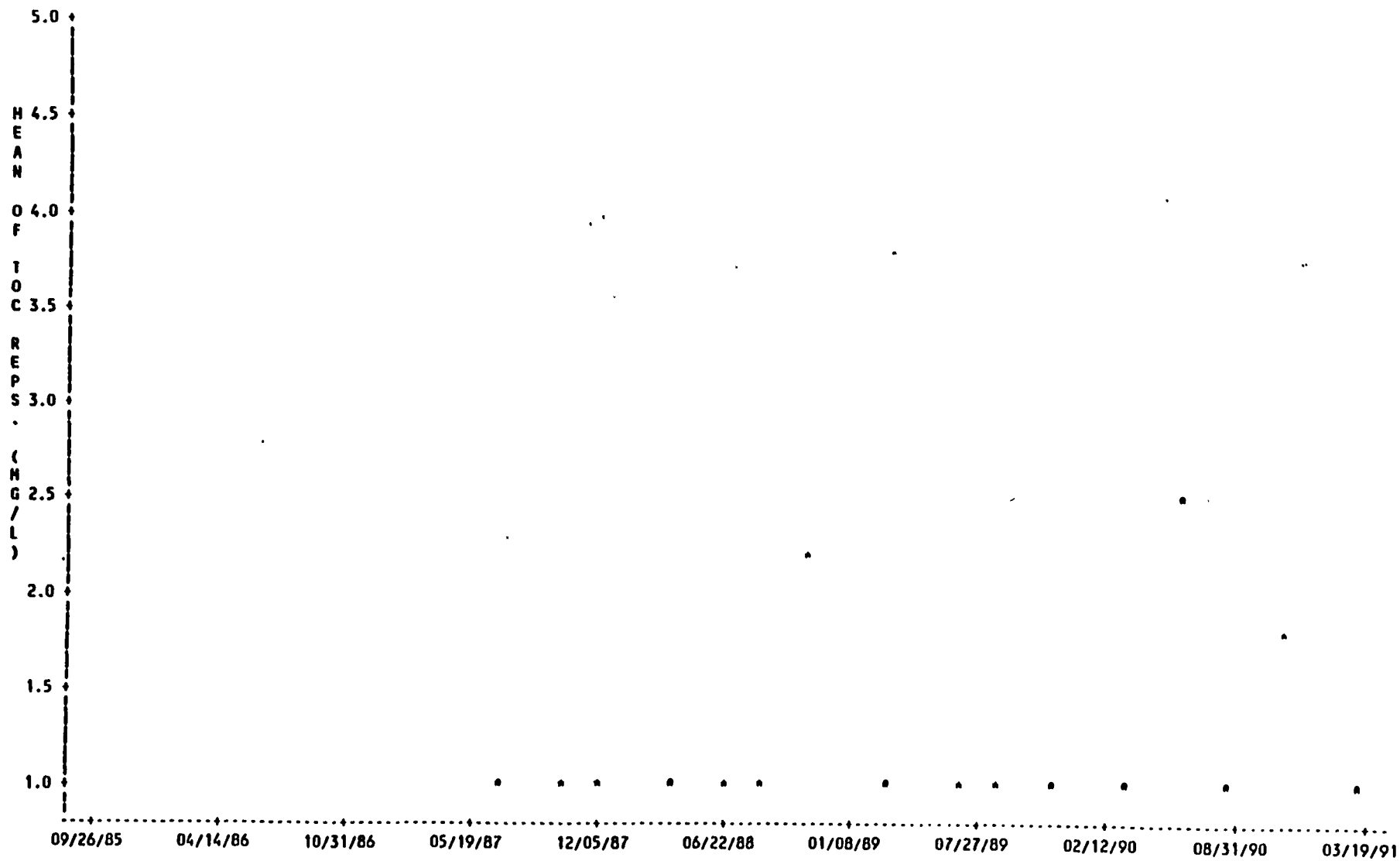


Figure 3a. Plot of TOC values for upgradient well GW-159 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

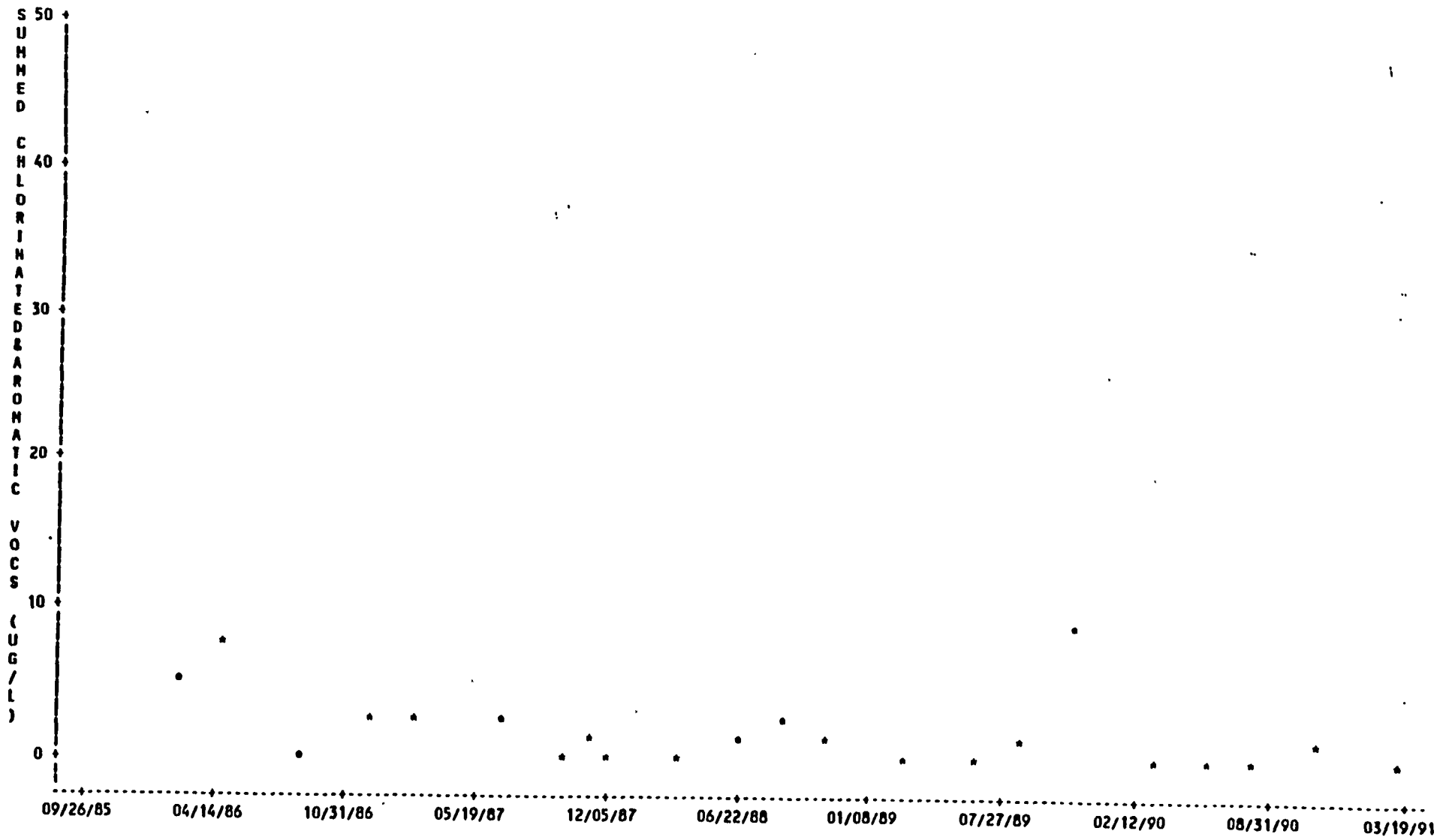


Figure 3b. Plot of summed chlorinated and aromatic VOCs for upgradient well GW-159 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

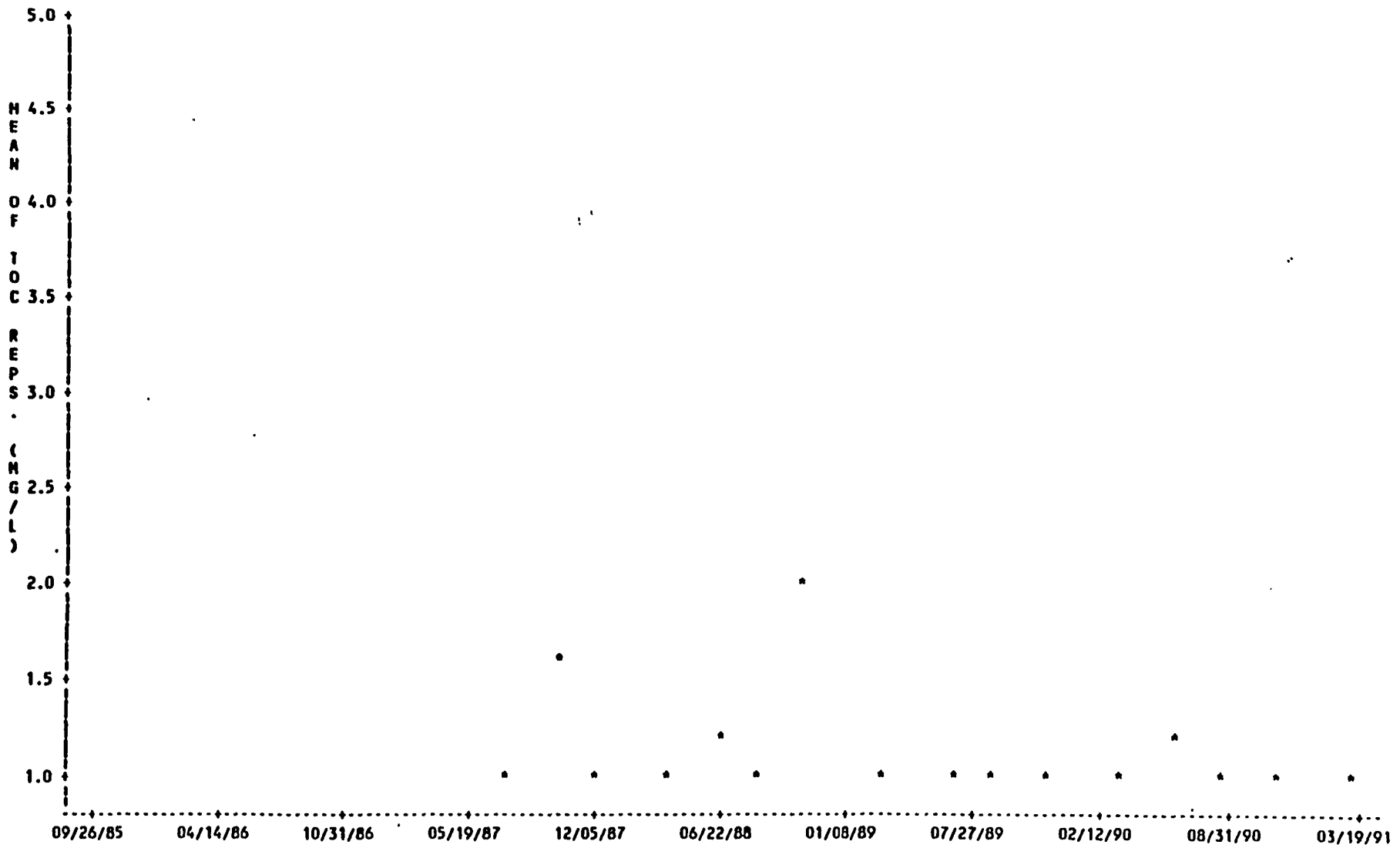


Figure 4a. Plot of TOC values for downgradient well GW-155 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

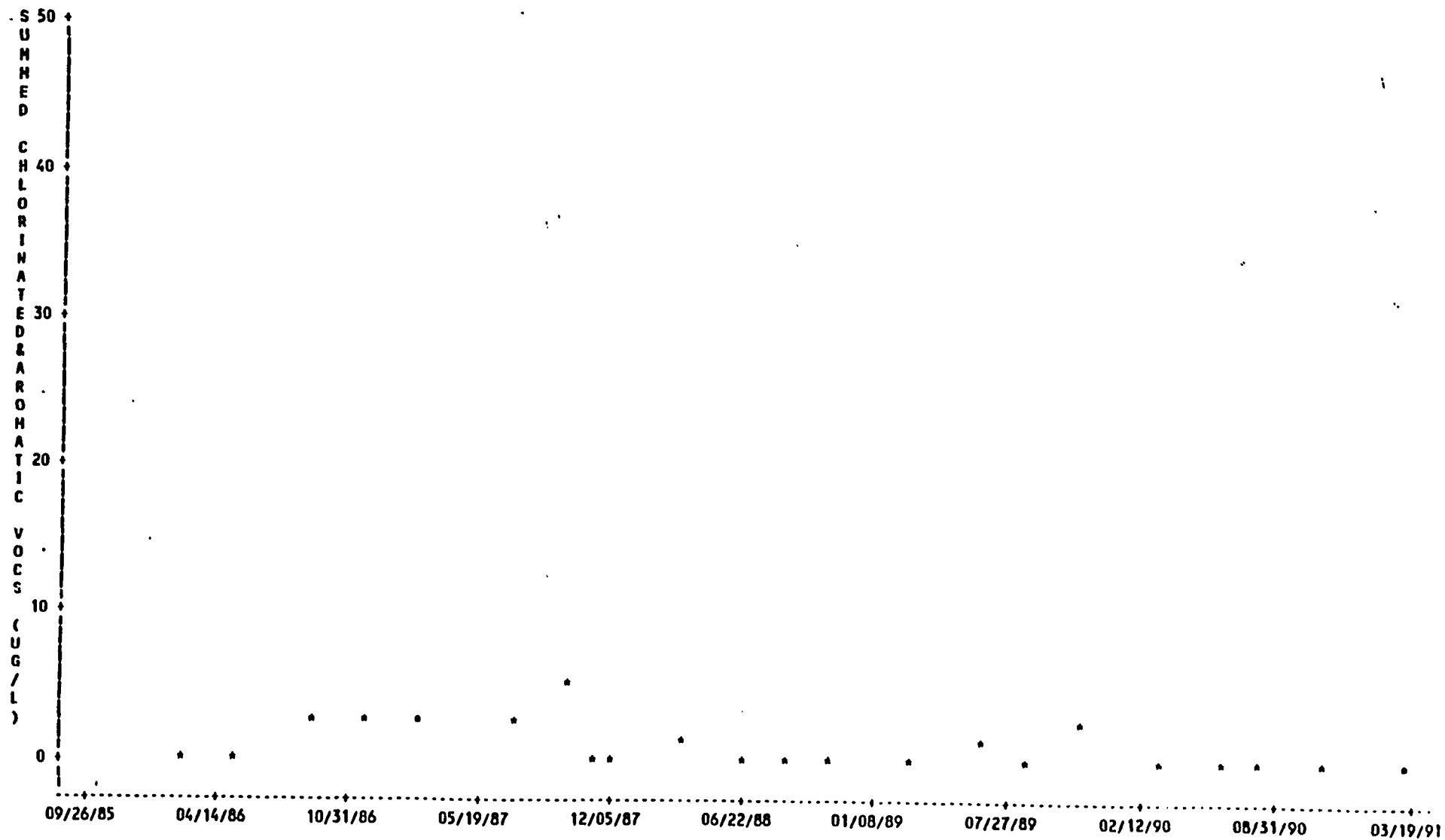


Figure 4b. Plot of summed chlorinated and aromatic VOCs for downgradient well GW-155 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

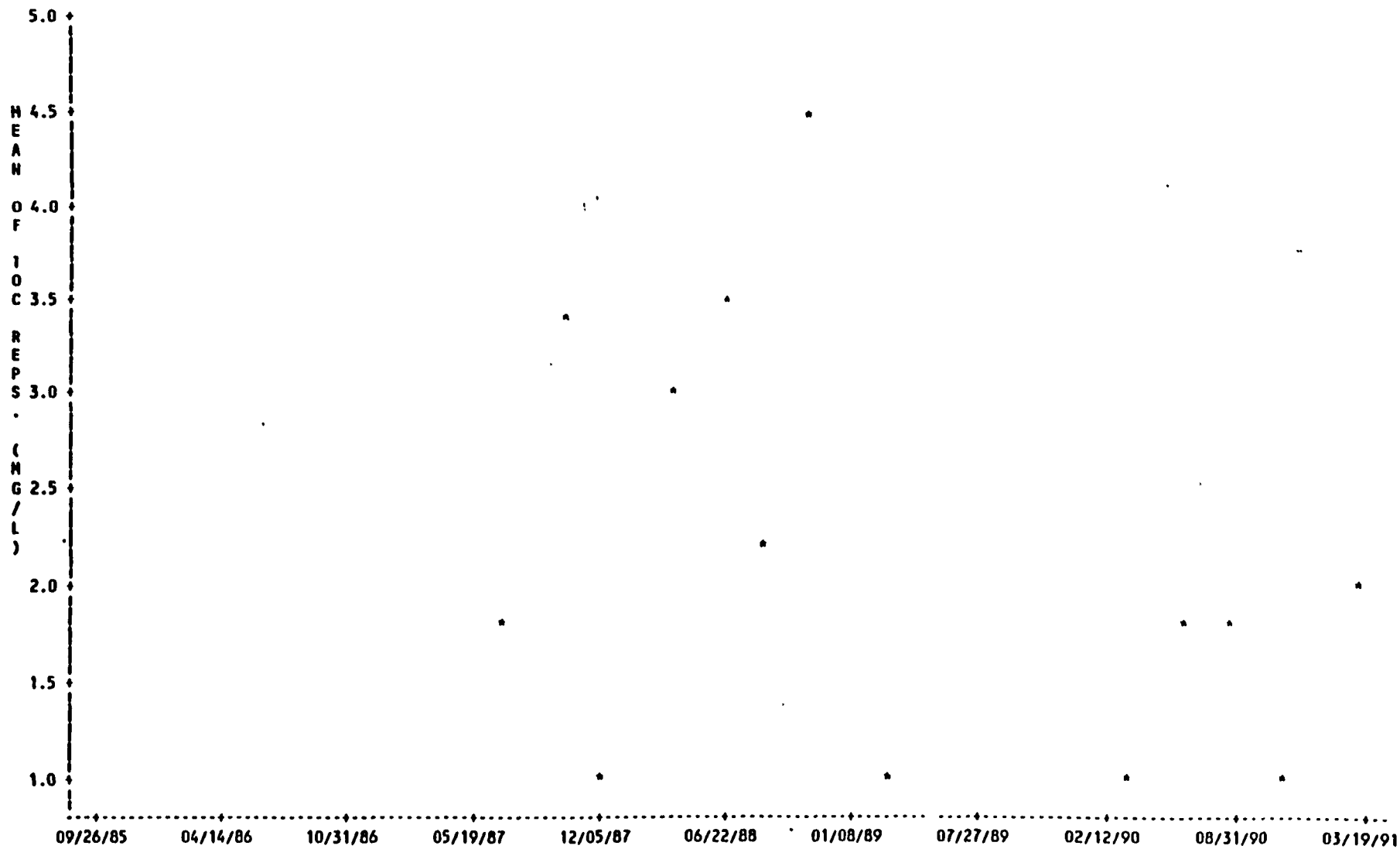


Figure 5a. Plot of TOC values for downgradient well GW-156 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

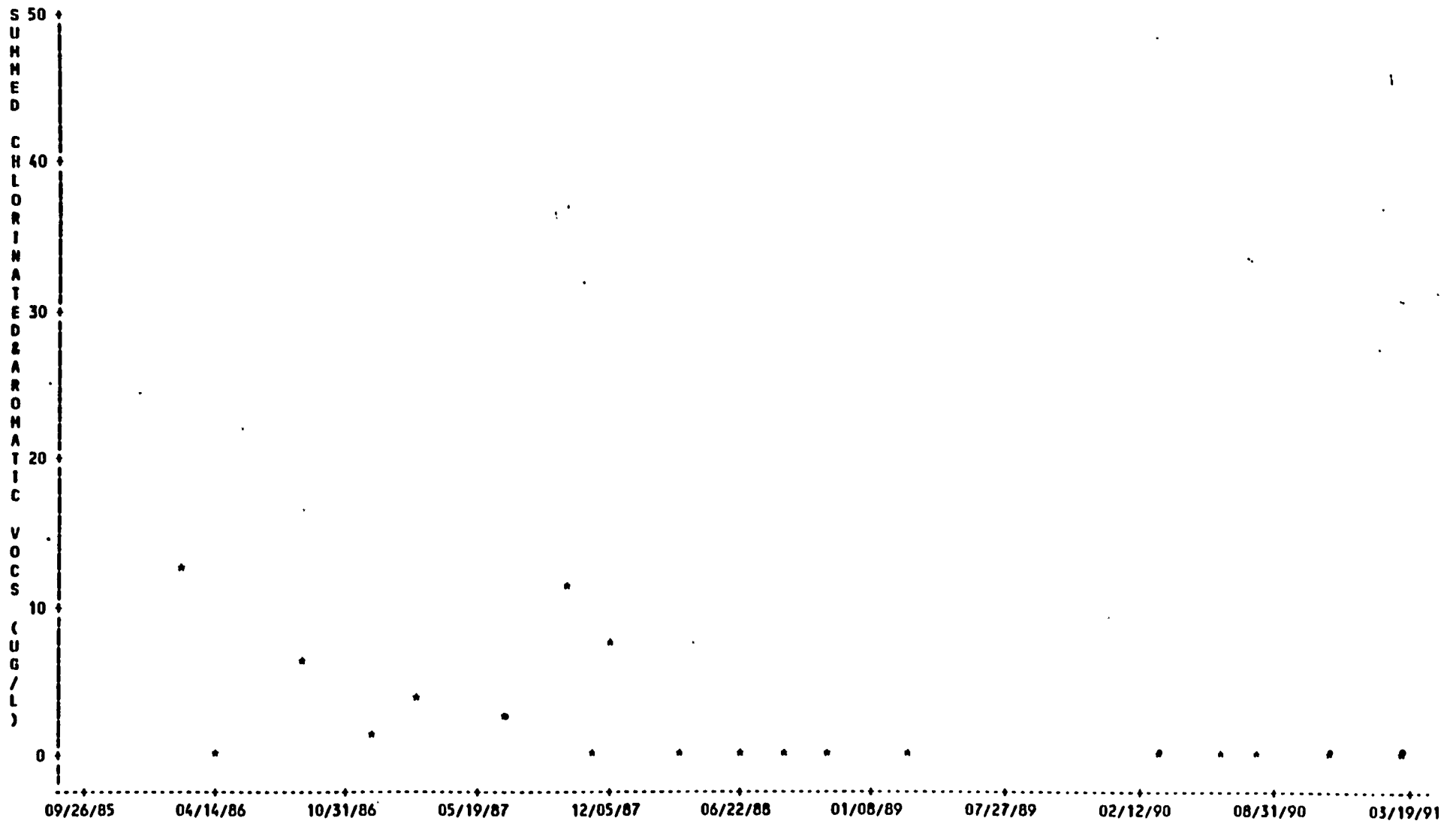


Figure 5b. Plot of summed chlorinated and aromatic VOCs for downgradient well GW-156 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

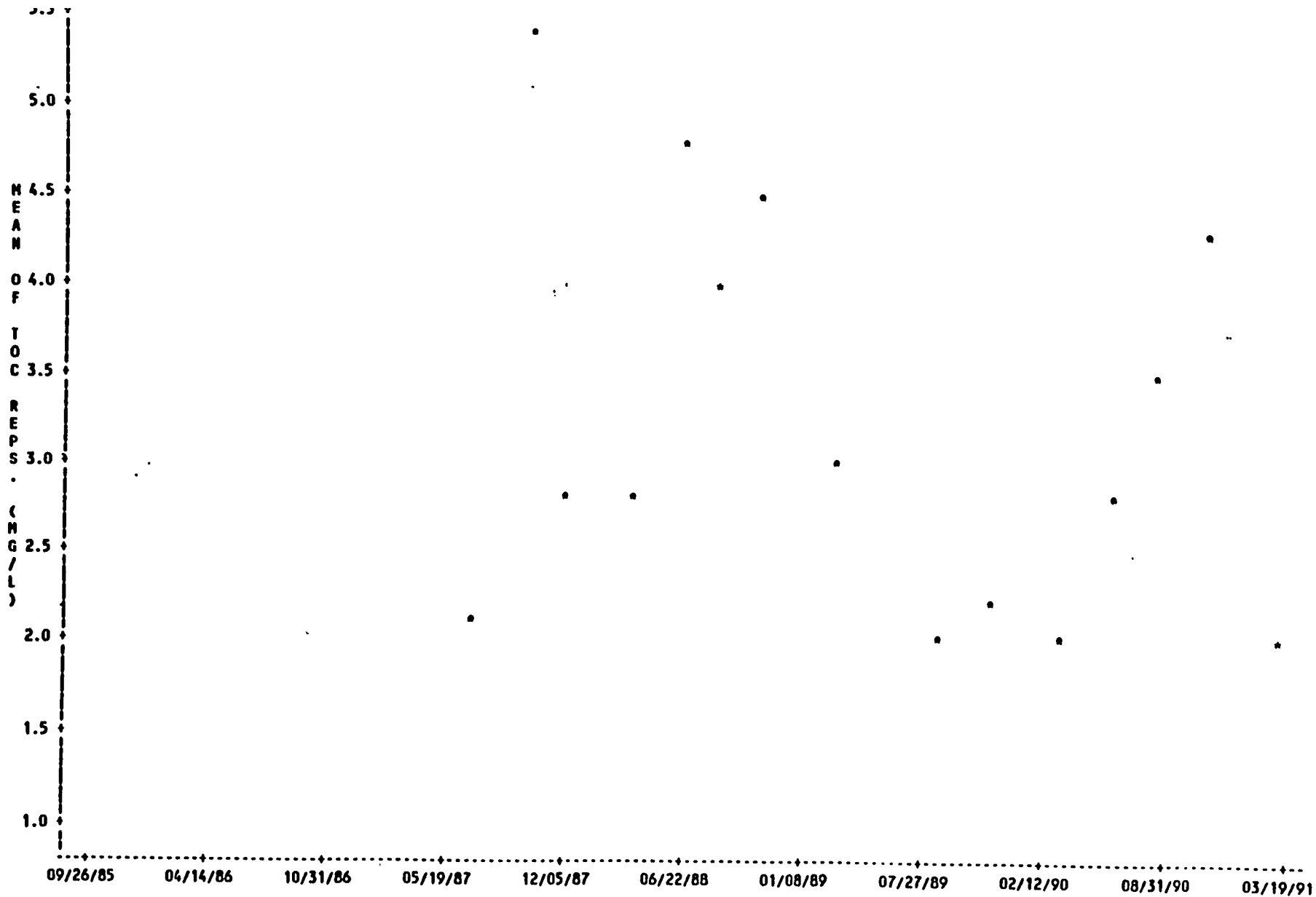


Figure 6a. Plot of TOC values for downgradient well GW-157 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

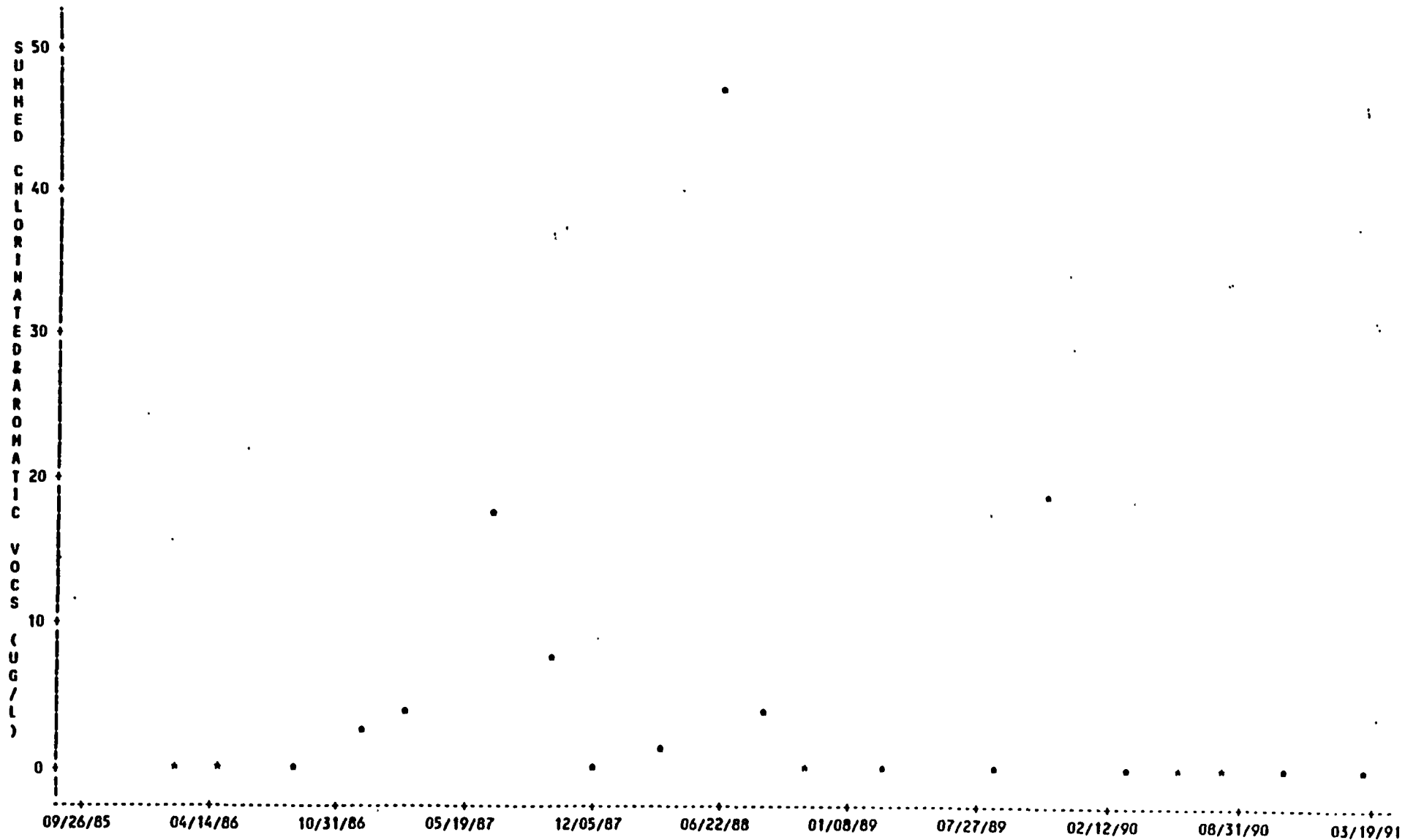


Figure 6b. Plot of summed chlorinated and aromatic VOCs for downgradient well GW-157 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

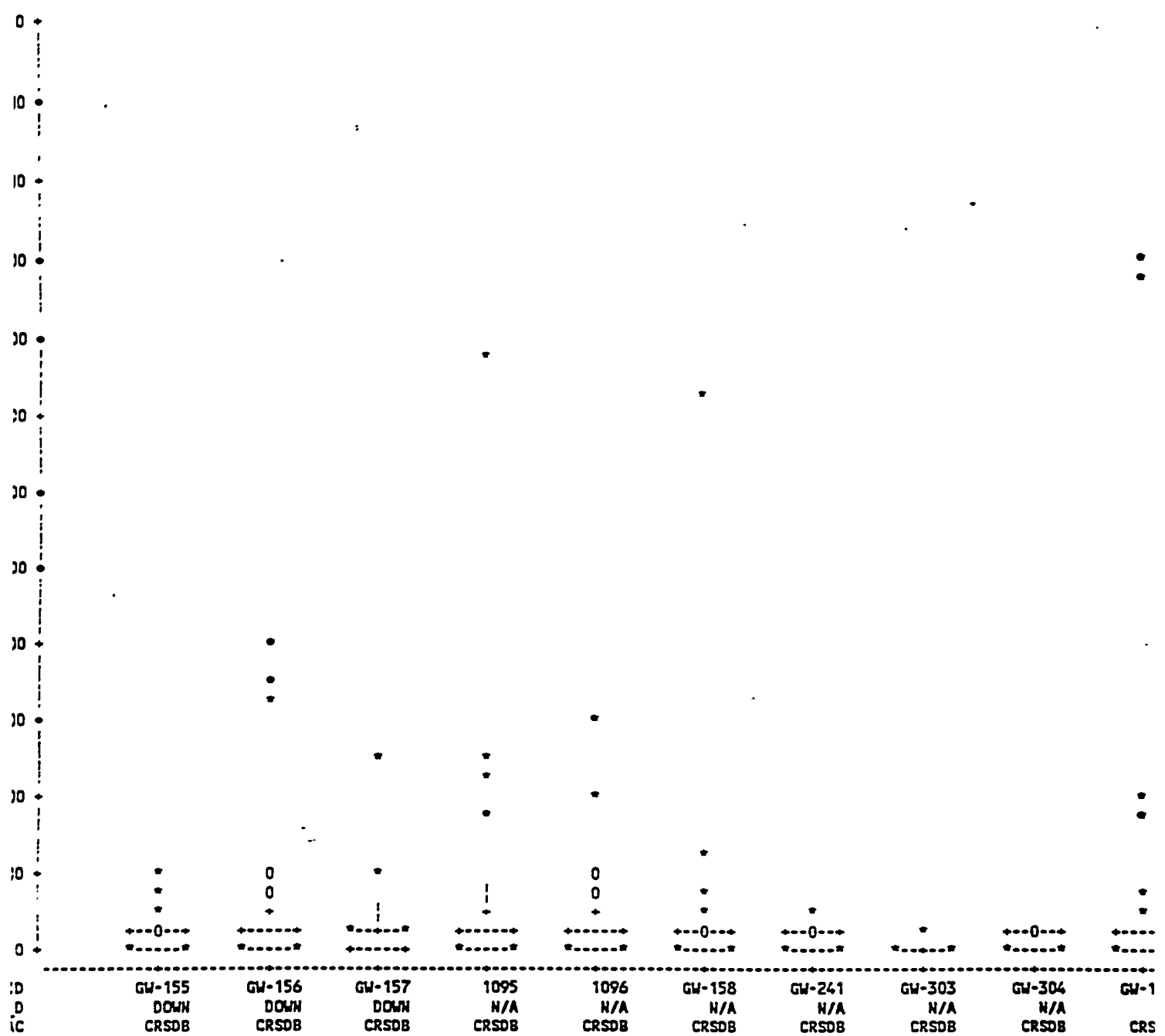


Figure 7. Statistical summary of TOX data for groundwater monitoring wells at the Chestnut Ridge Sediment Disposal Basin. Box outlines represent the 25th percentile (bottom of box), median (middle line terminated with asterisks), and 75th percentile (top of box) of the data set for a individual well. Mean is indicated by central plus sign (+) within the box. Central lines or tails extending above and below the box indicate the range of outliers within 1.5 interquartile ranges below the 25th percentile and above the 75th percentile. Outliers beyond this range are illustrated by zero (0) if they are within 3 interquartile ranges. More extreme outliers are illustrated by an asterisk (*). Because of scale, some boxes appear incomplete.

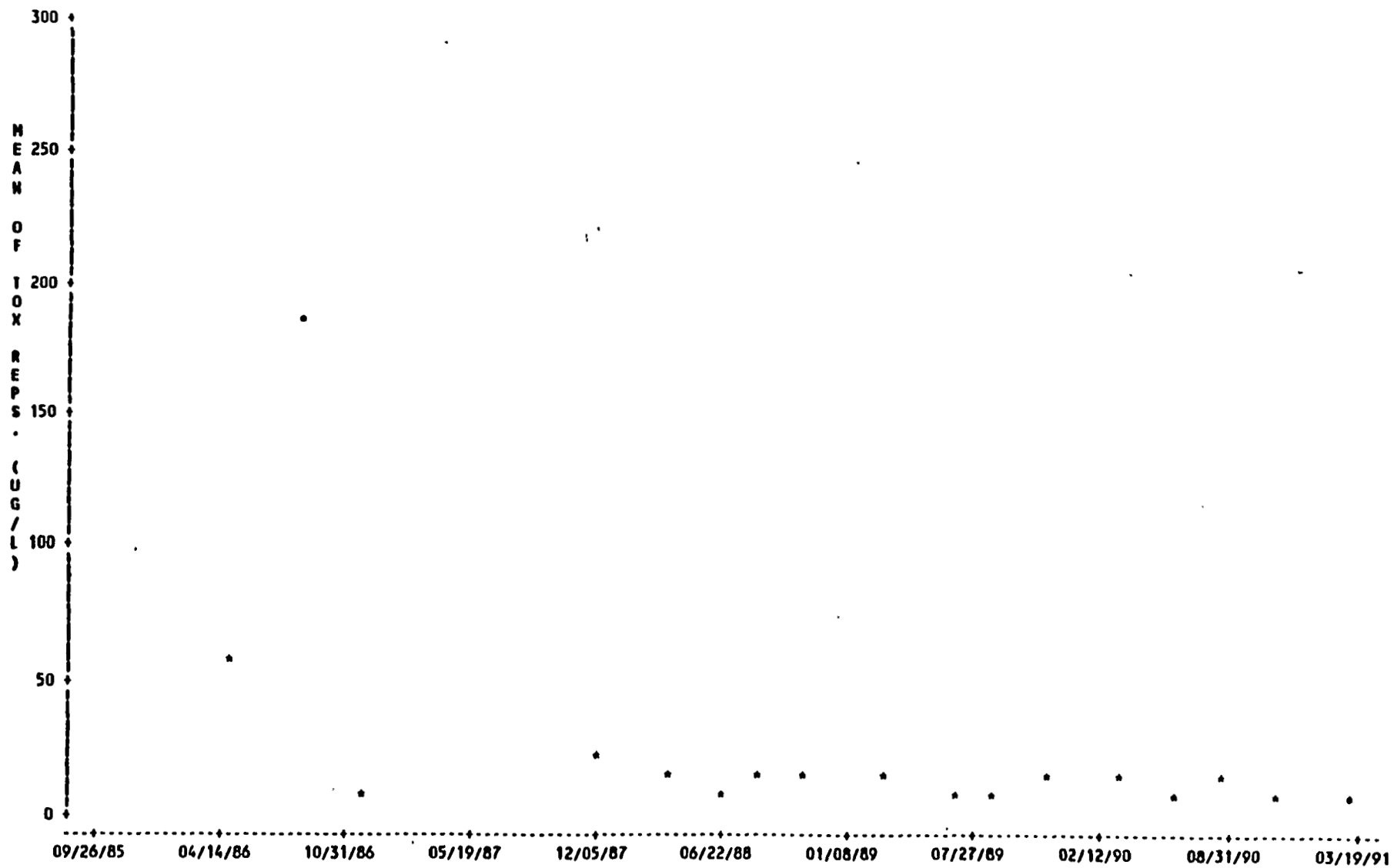


Figure 8a. Plot of TOX values for upgradient well GW-159 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

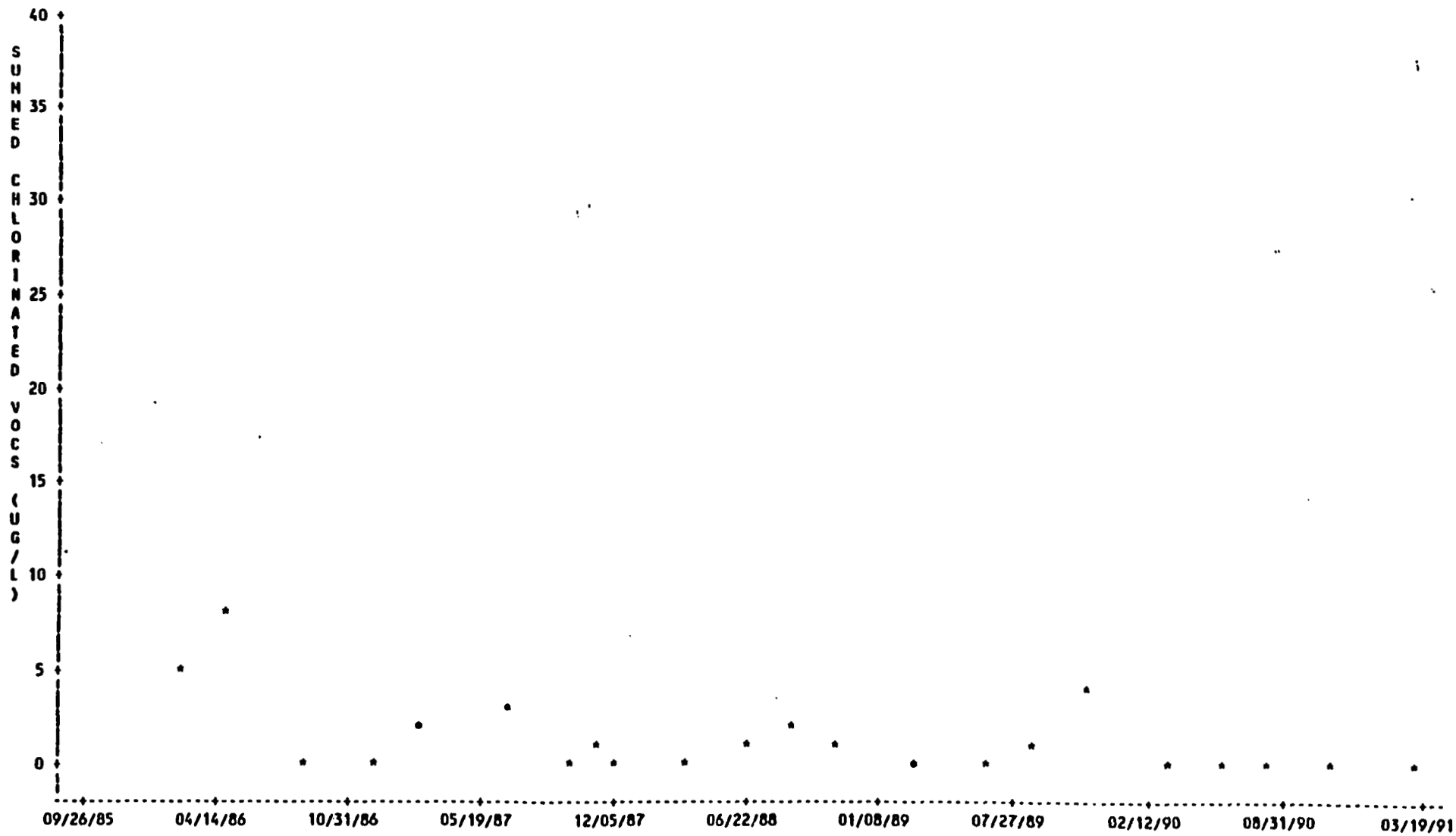


Figure 8b. Plot of summed chlorinated VOCs for upgradient well GW-159 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

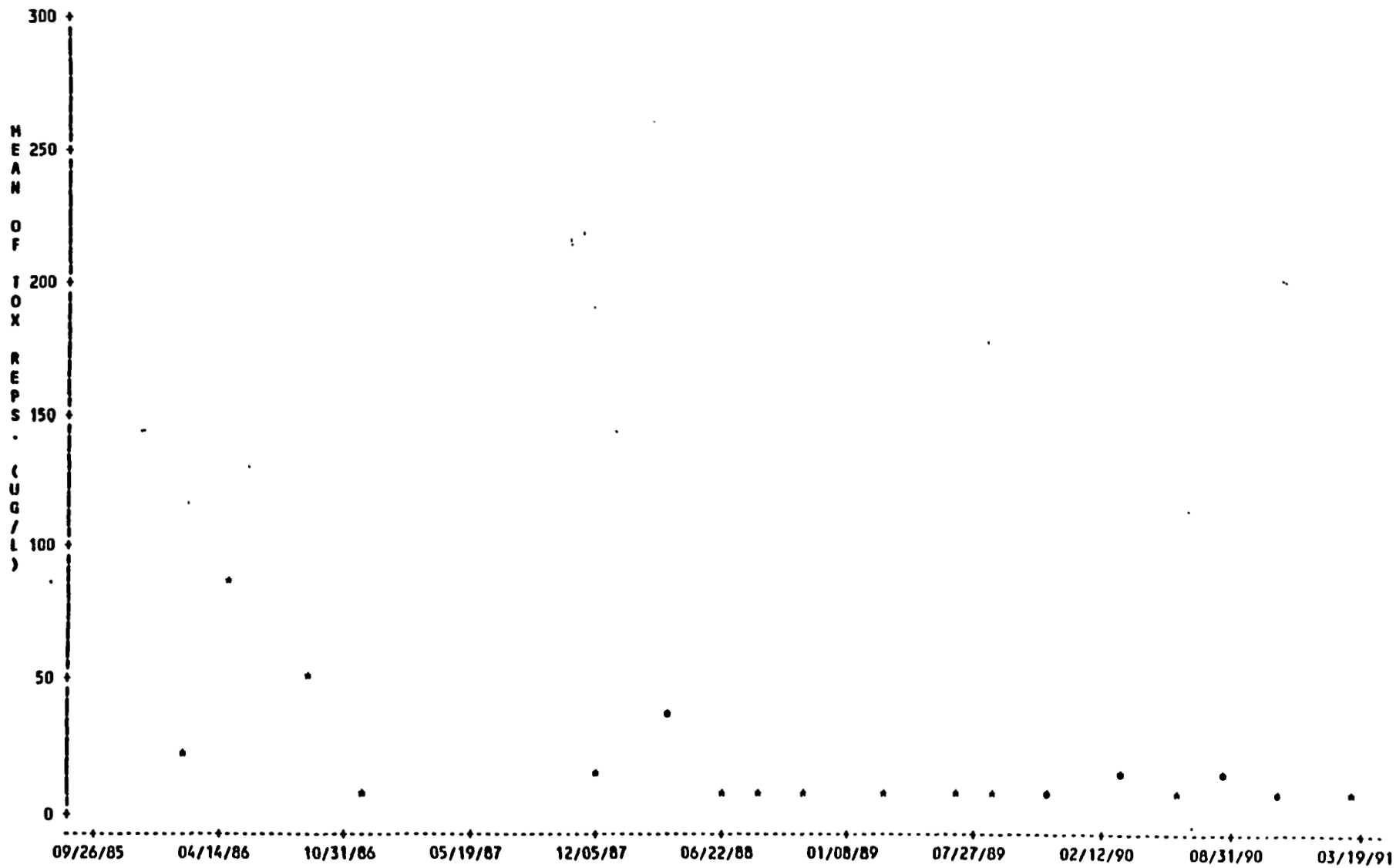


Figure 9a. Plot of TOX values for downgradient well GW-155 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

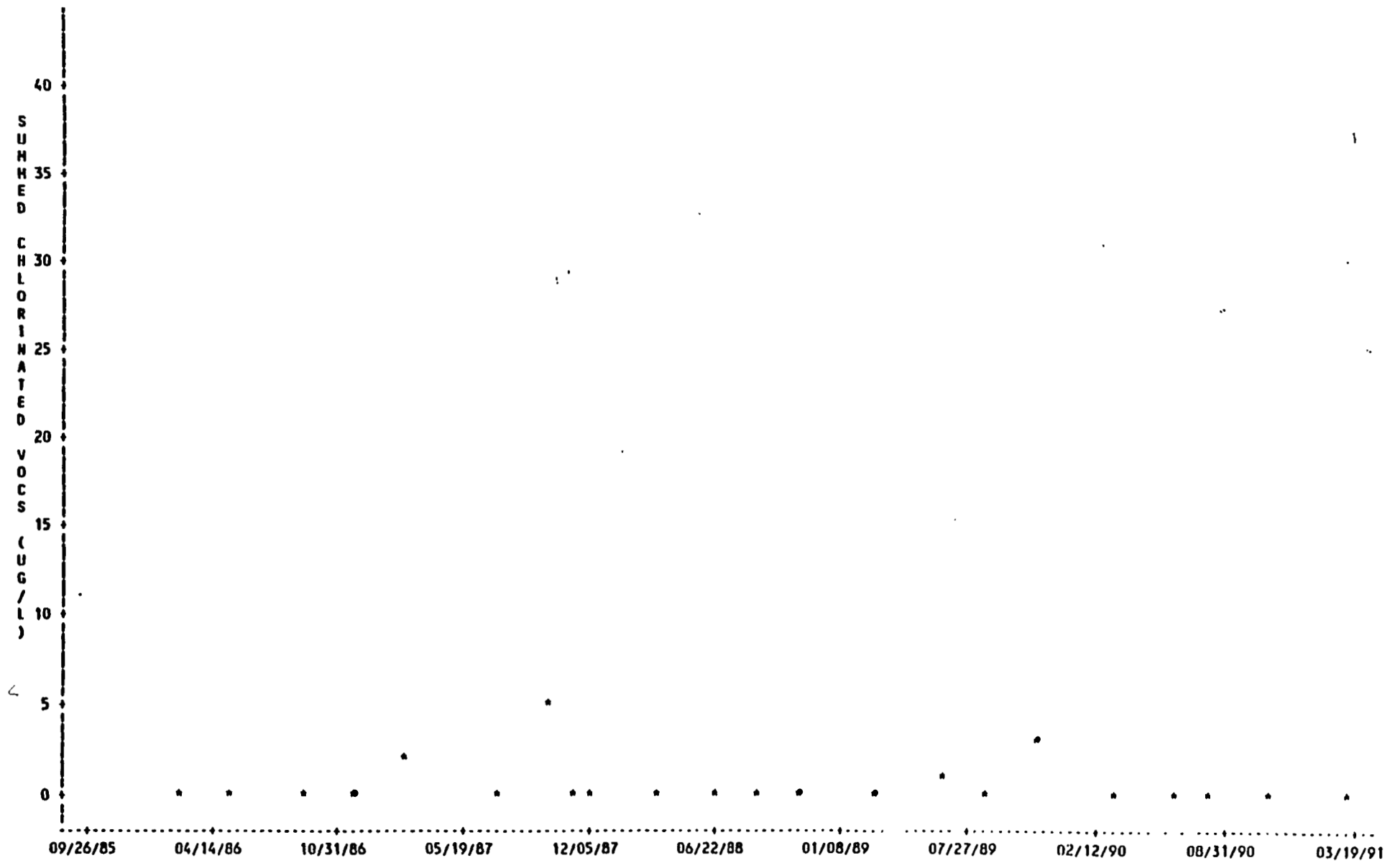


Figure 9b. Plot of summed chlorinated VOCs for downgradient well GW-155 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

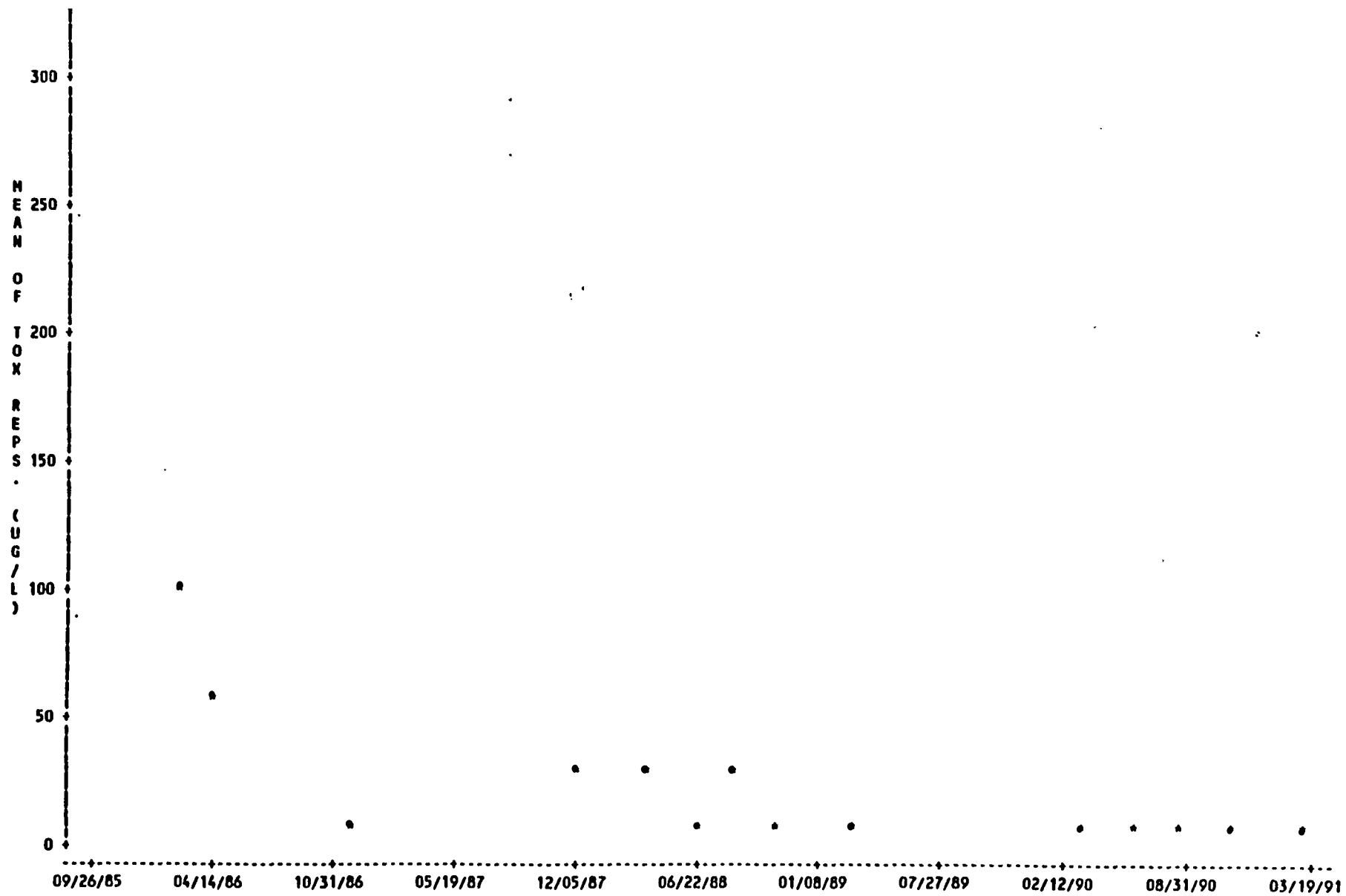


Figure 10a. Plot of TOX values for downgradient well GW-156 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

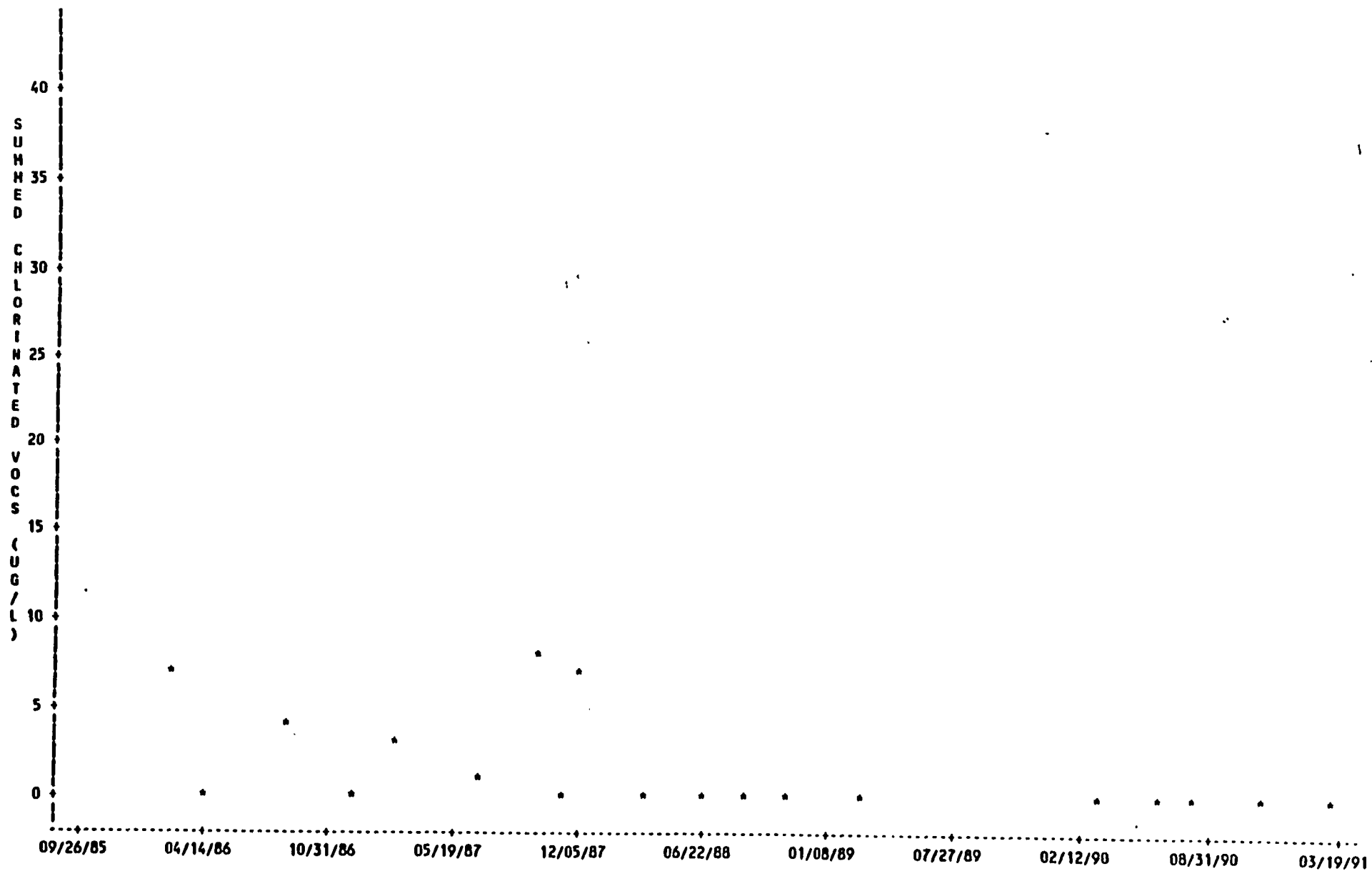


Figure 10b. Plot of summed chlorinated VOCs for downgradient well GW-156 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

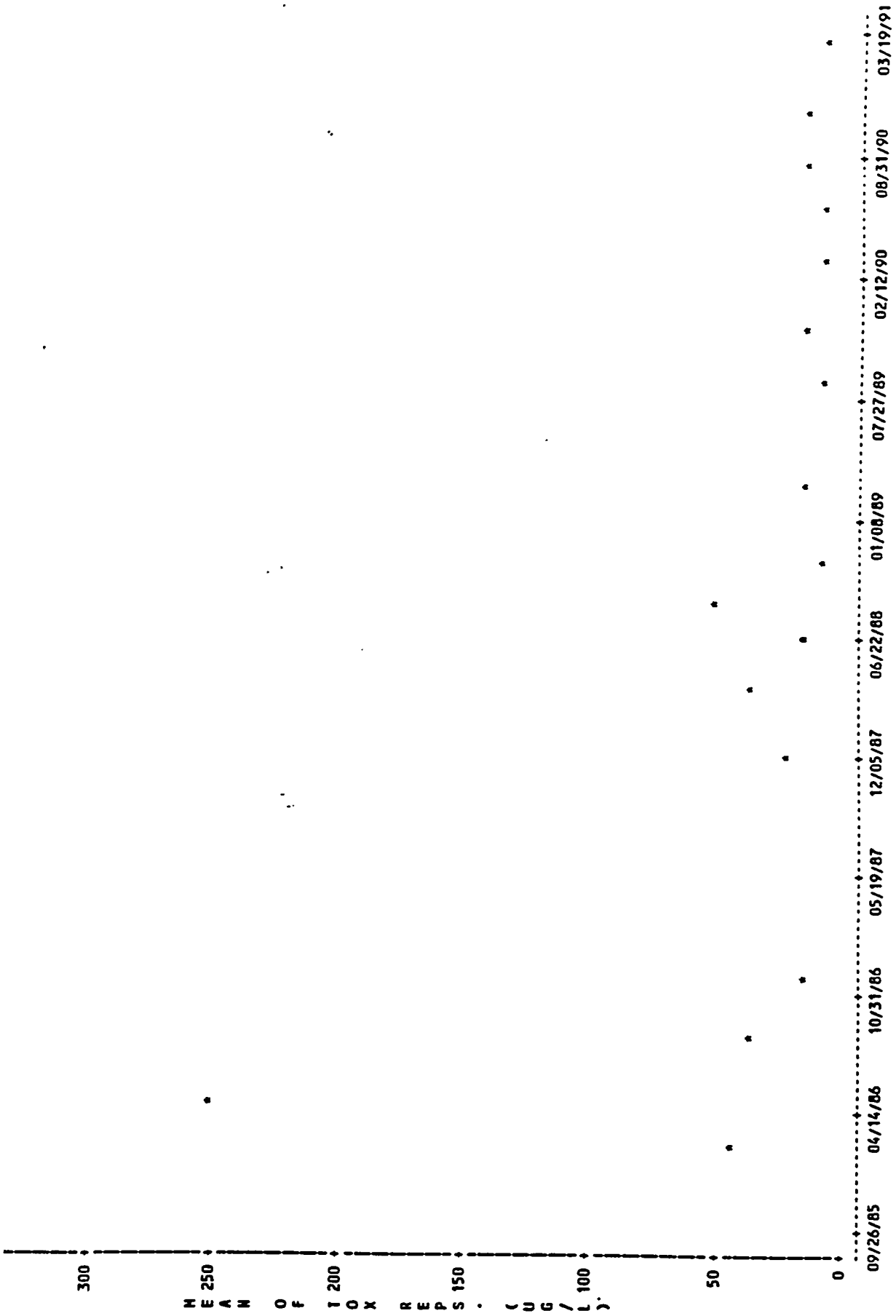


Figure 11a. Plot of TOX values for downgradient well GW-157 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

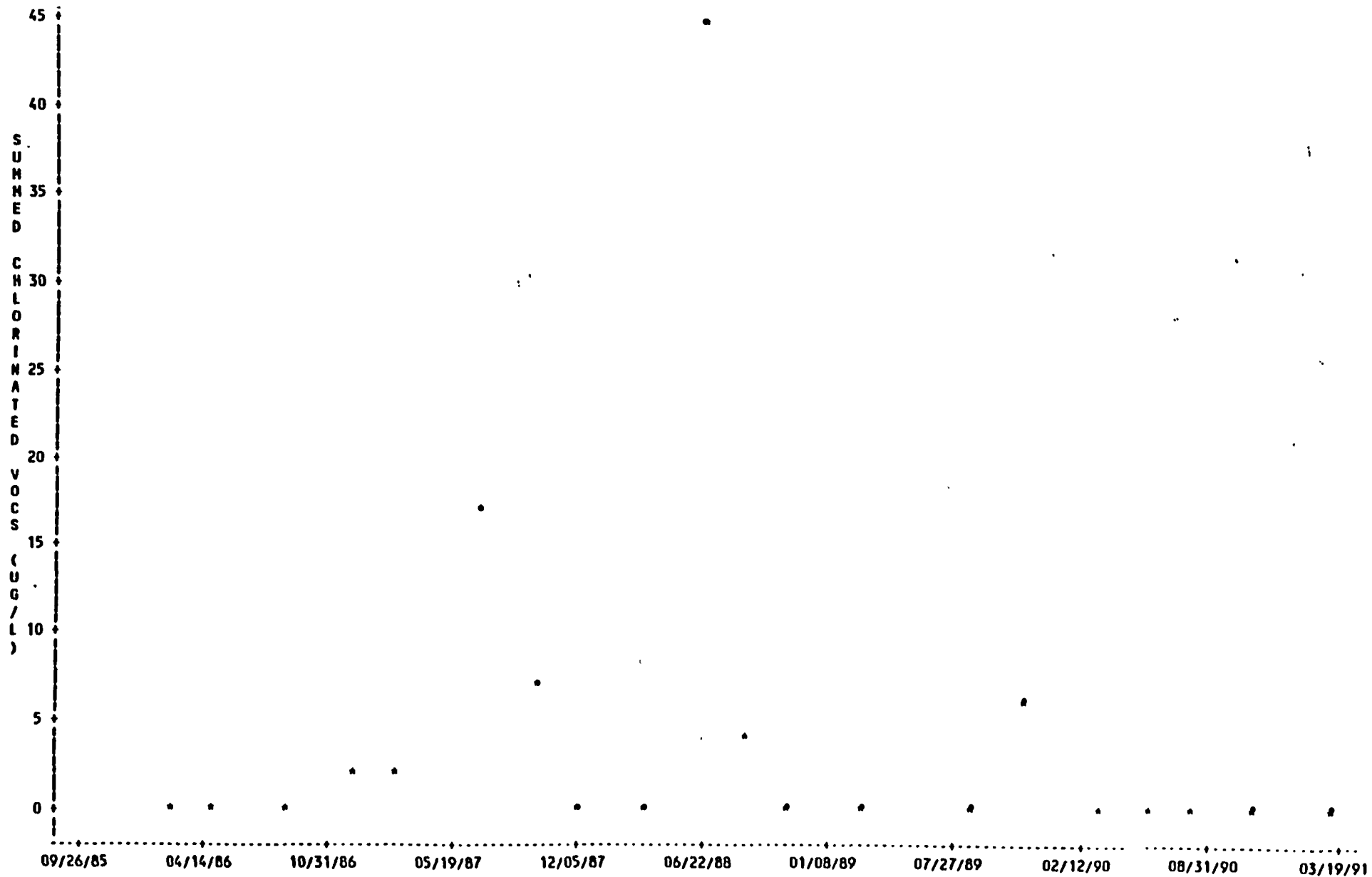


Figure 11b. Plot of summed chlorinated VOCs for downgradient well GW-157 at the Chestnut Ridge Sediment Disposal Basin. Each data point is the mean of four measurements.

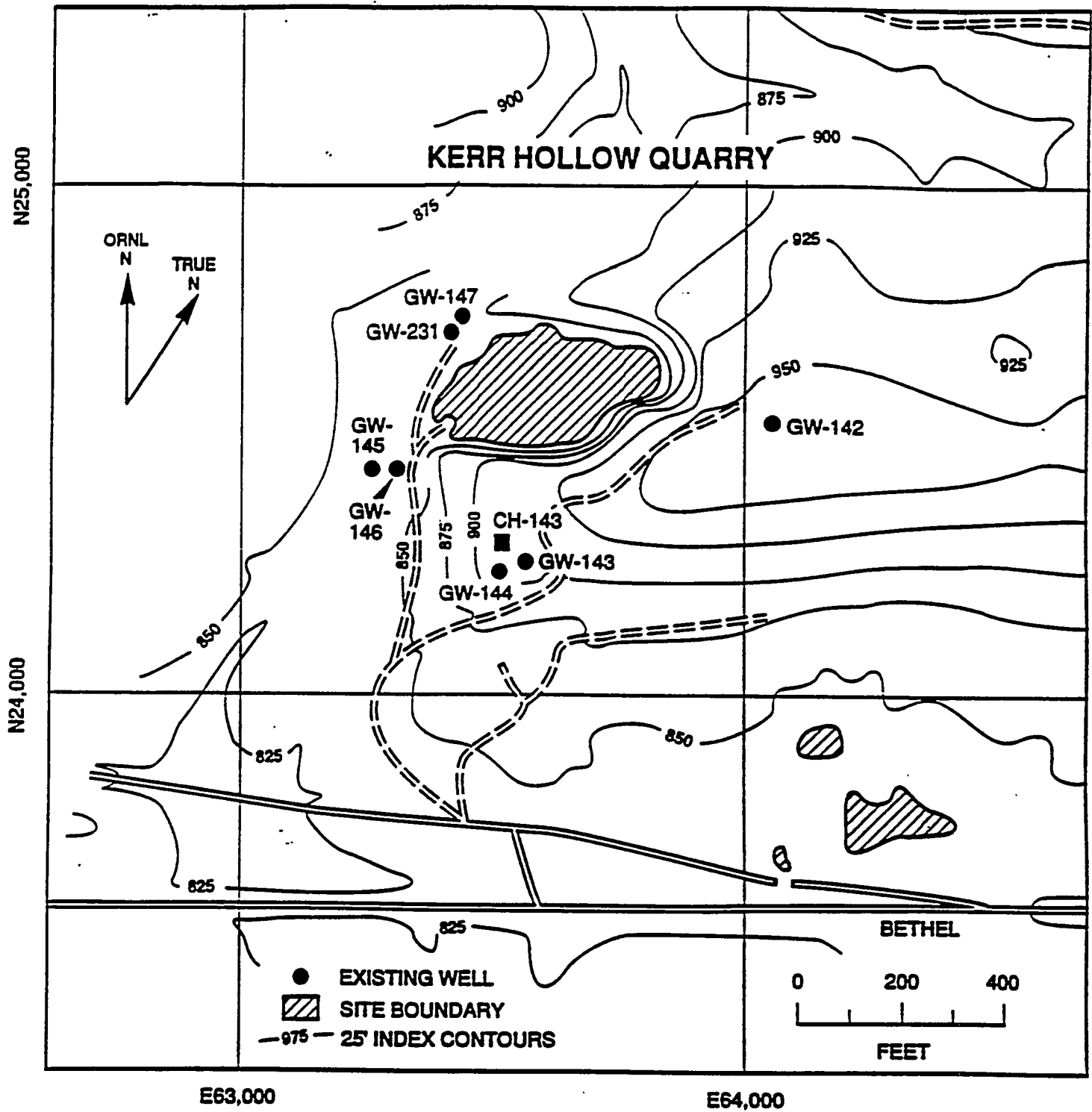


Figure 12. Location map for the Kerr Hollow Quarry. Upgradient monitoring well is GW-145. Downgradient monitoring wells are GW-142, GW-144, and GW-231.

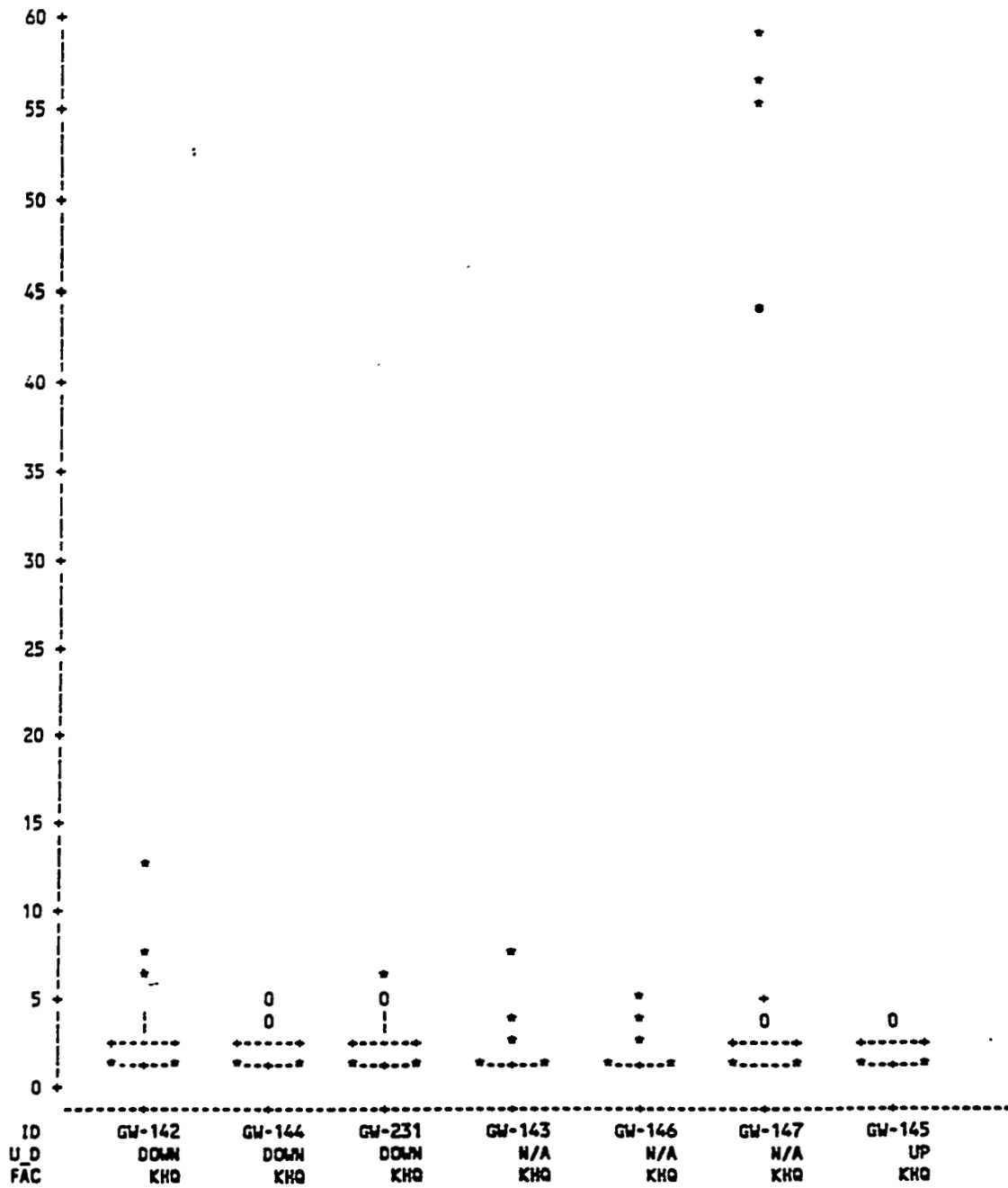


Figure 13. Statistical summary of TOC data for groundwater monitoring wells at the Kerr Hollow Quarry. Box outlines represent the 25th percentile (bottom of box), median (middle line terminated with asterisks), and 75th percentile (top of box) of the data set for a individual well. Mean is indicated by central plus sign (+) within the box. Central lines or tails extending above and below the box indicate the range of outliers within 1.5 interquartile ranges below the 25th percentile and above the 75th percentile. Outliers beyond this range are illustrated by zero (0) if they are within 3 interquartile ranges. More extreme outliers are illustrated by an asterisk (*). Because of scale, some boxes appear incomplete.

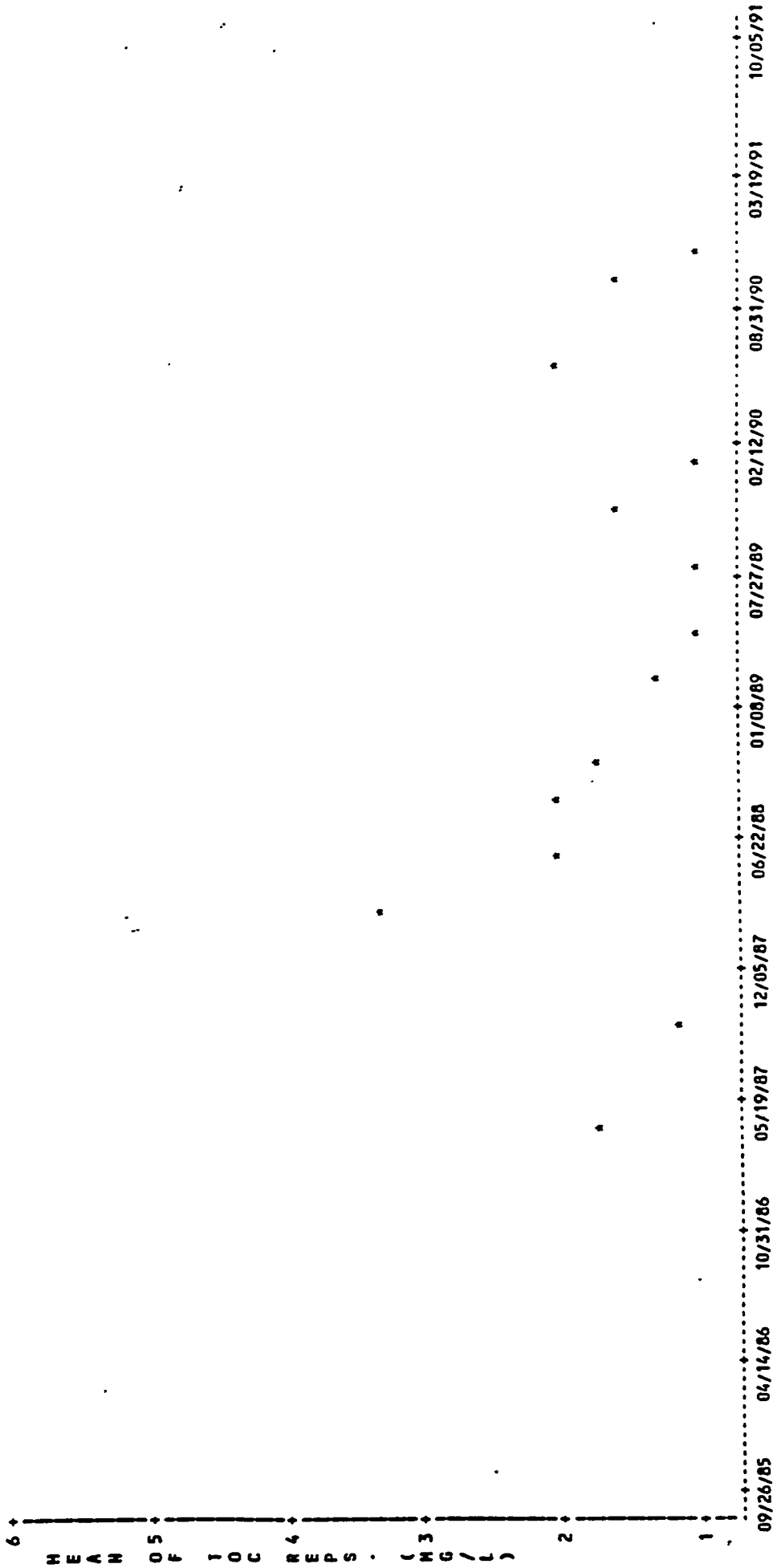


Figure 14a. Plot of TOC values for upgradient well GW-145 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

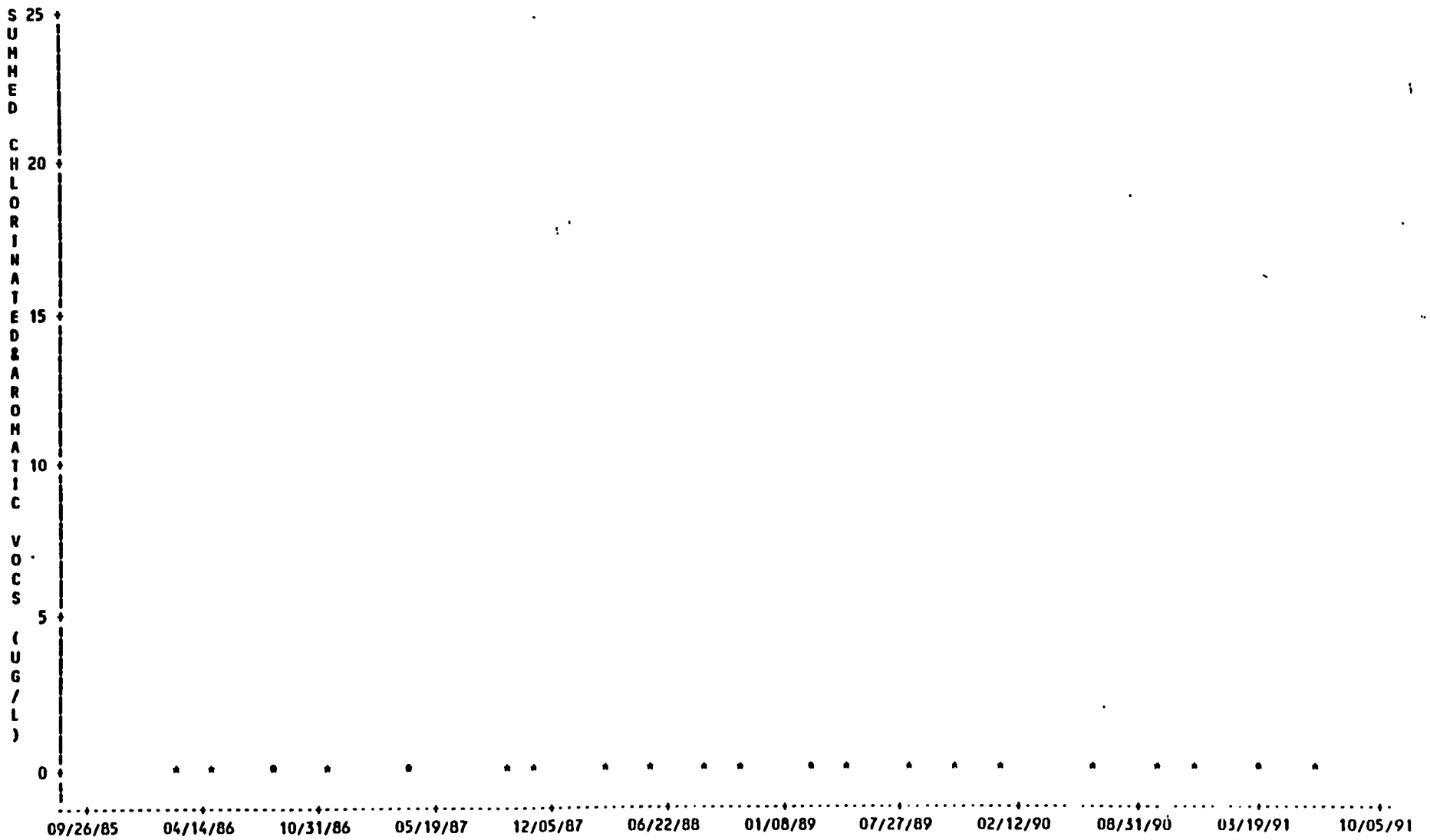


Figure 14b. Plot of summed chlorinated and aromatic VOCs for upgradient well GW-145 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

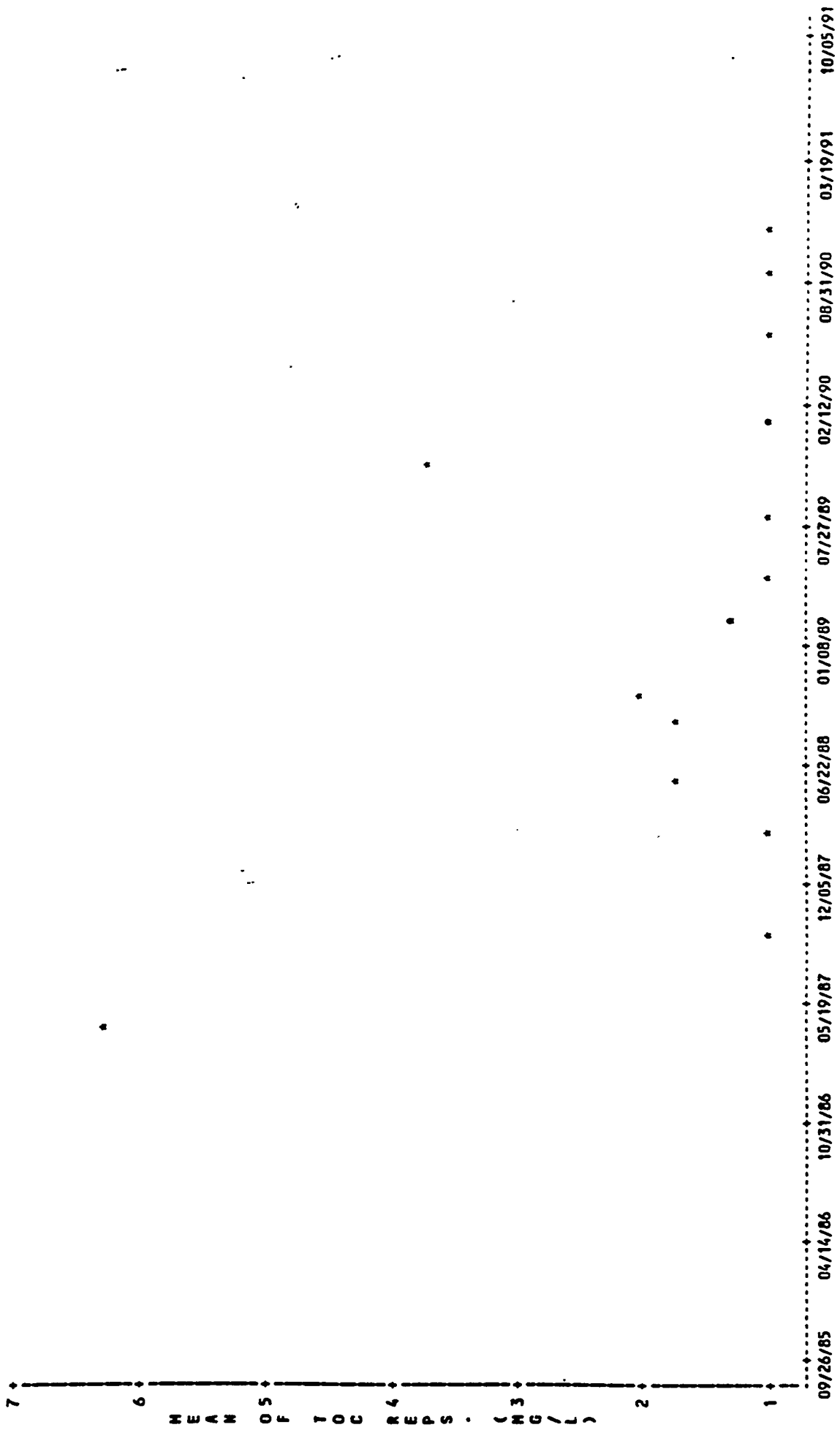


Figure 15a. Plot of TOC values for downgradient well GW-142 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

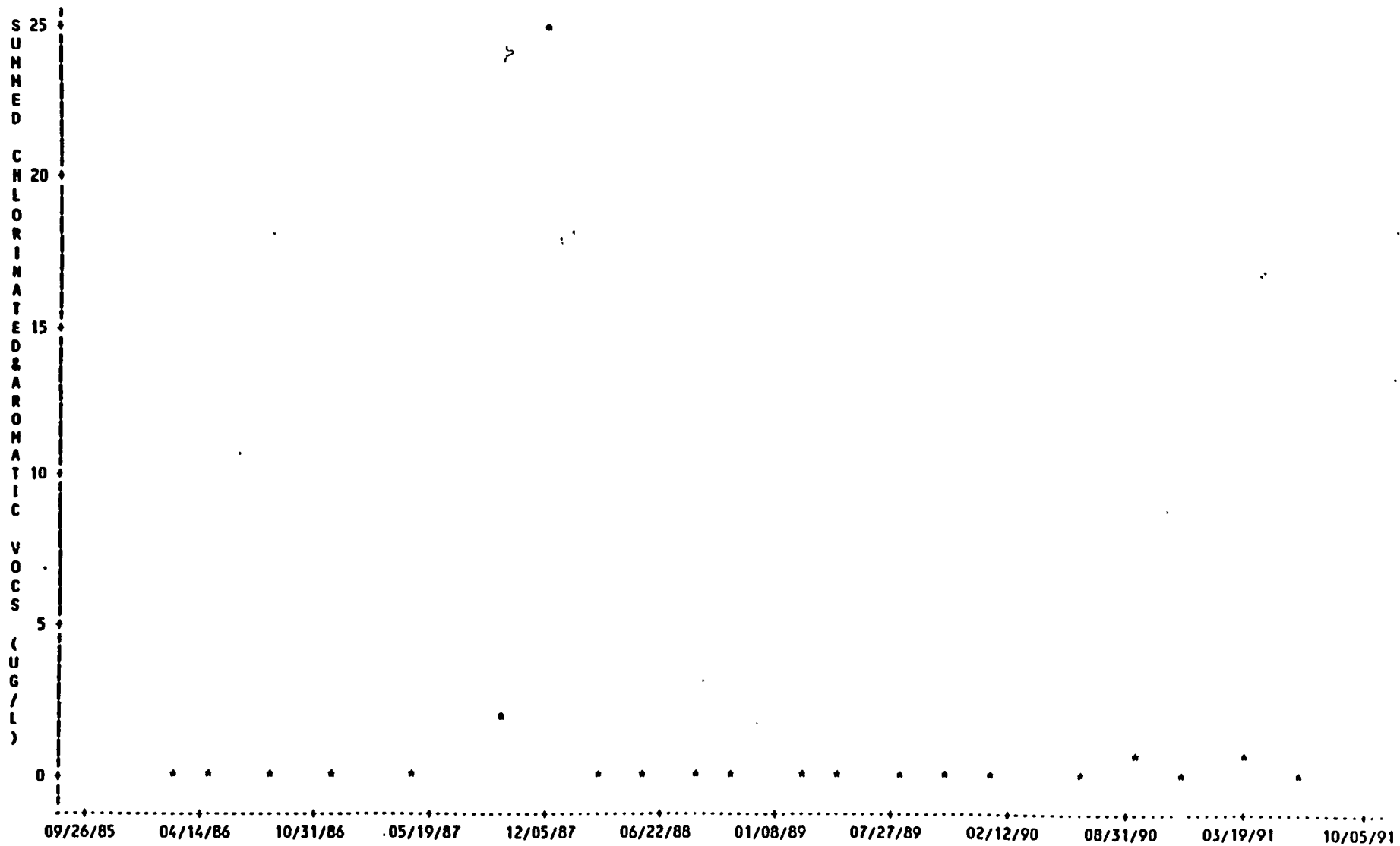


Figure 15b. Plot of summed chlorinated and aromatic VOCs for downgradient well GW-142 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

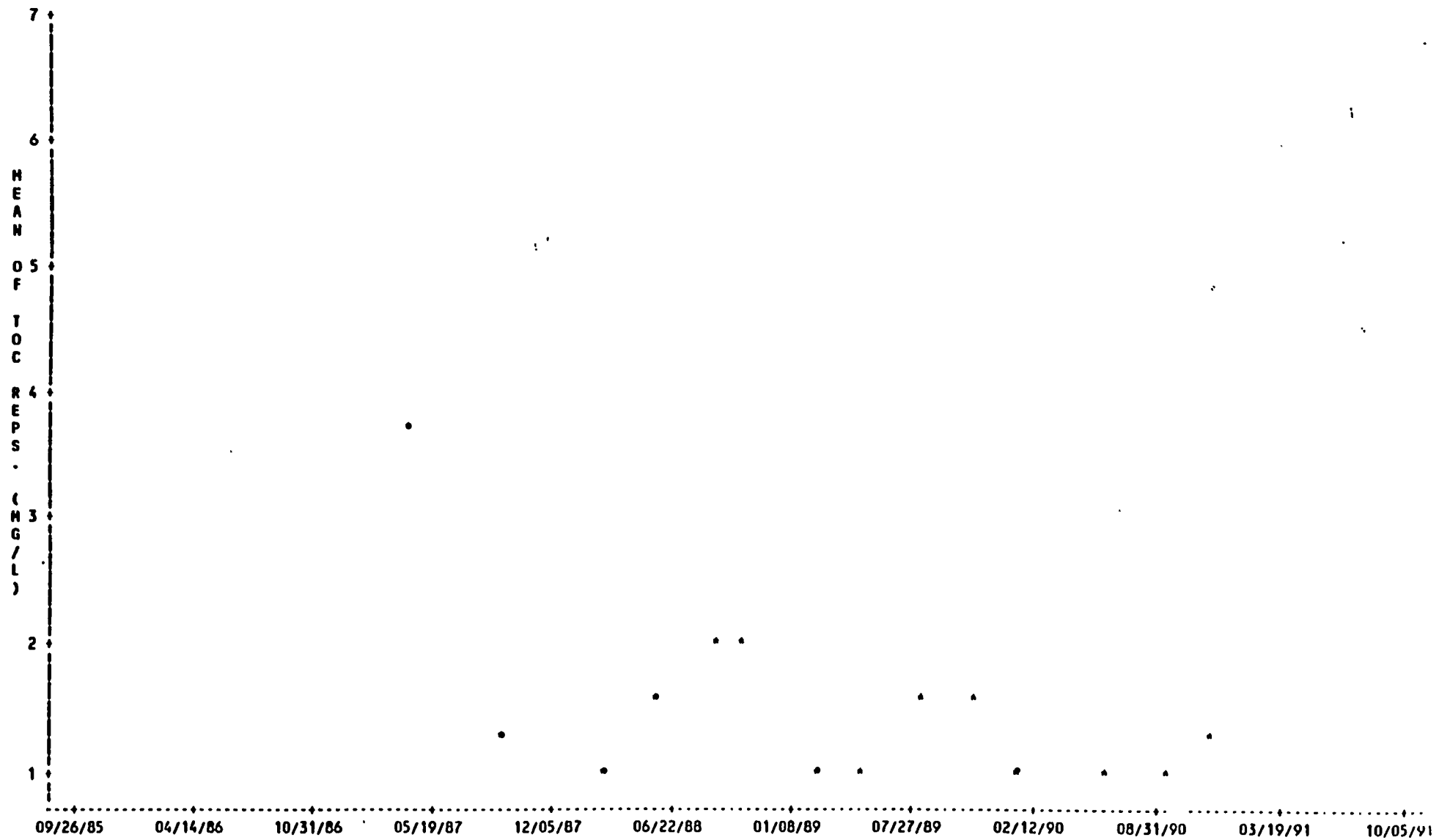


Figure 16a. Plot of TOC values for downgradient well GW-144 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

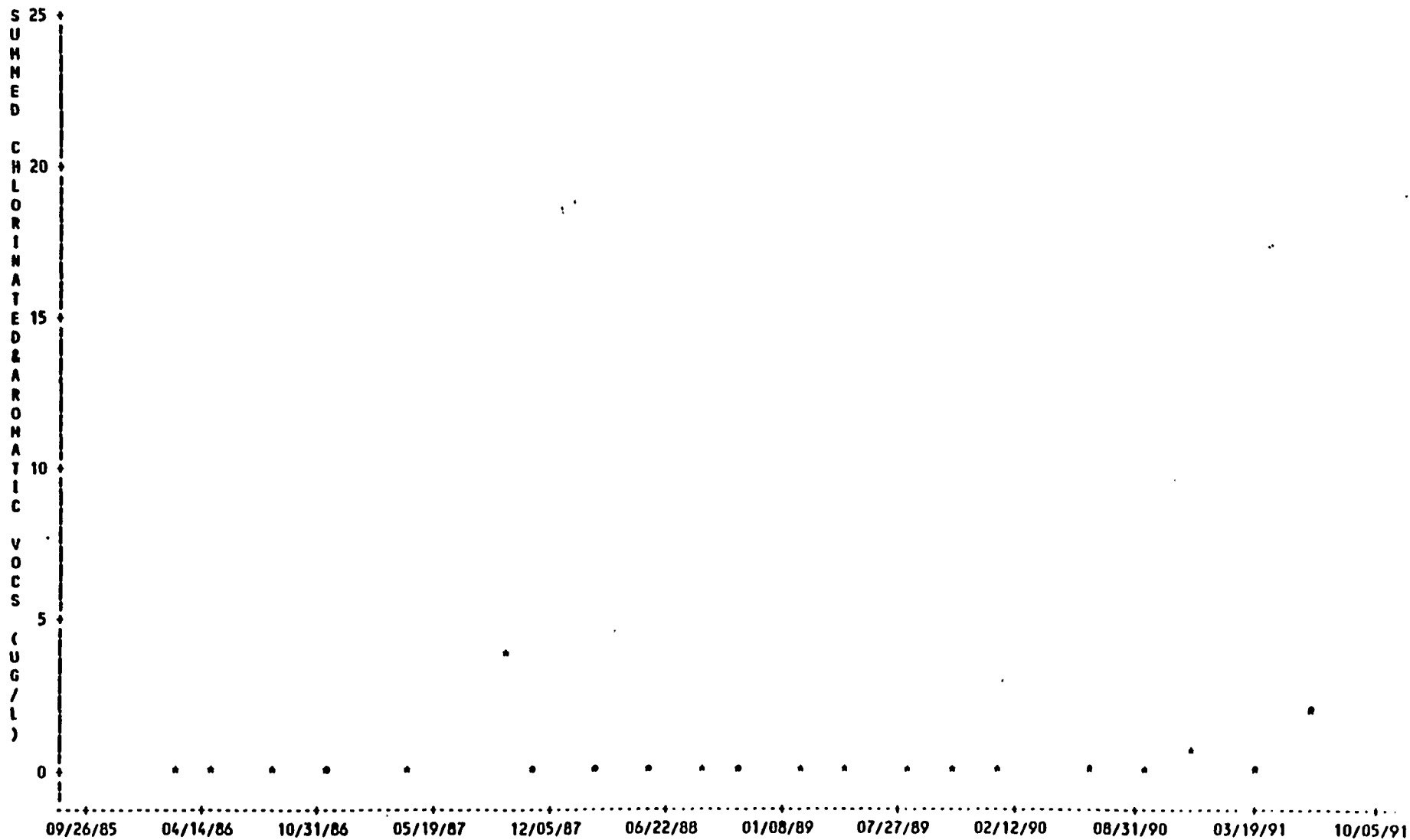


Figure 16b. Plot of summed chlorinated and aromatic VOCs for downgradient well GW-144 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

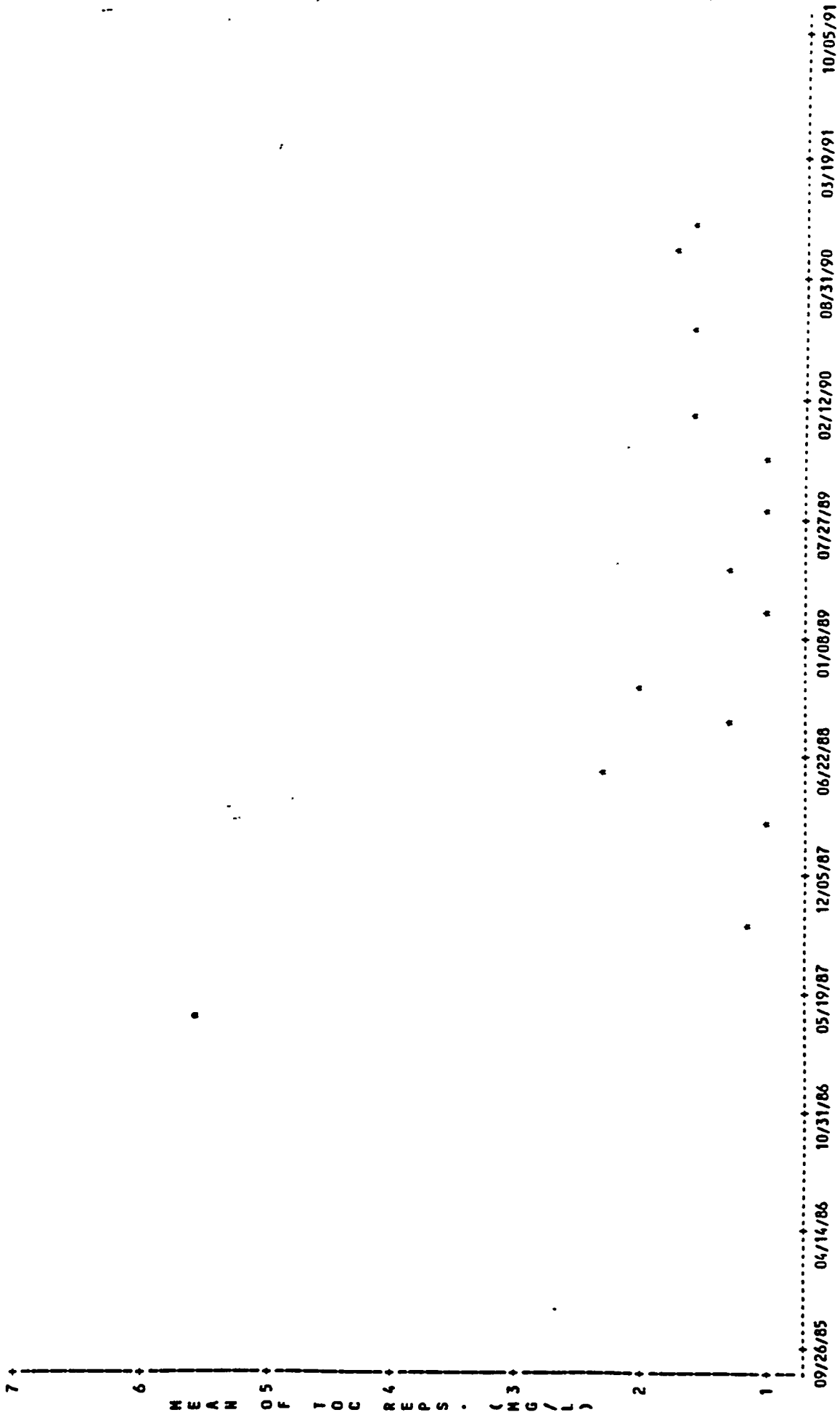


Figure 17a. Plot of TOC values for downgradient well GW-231 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

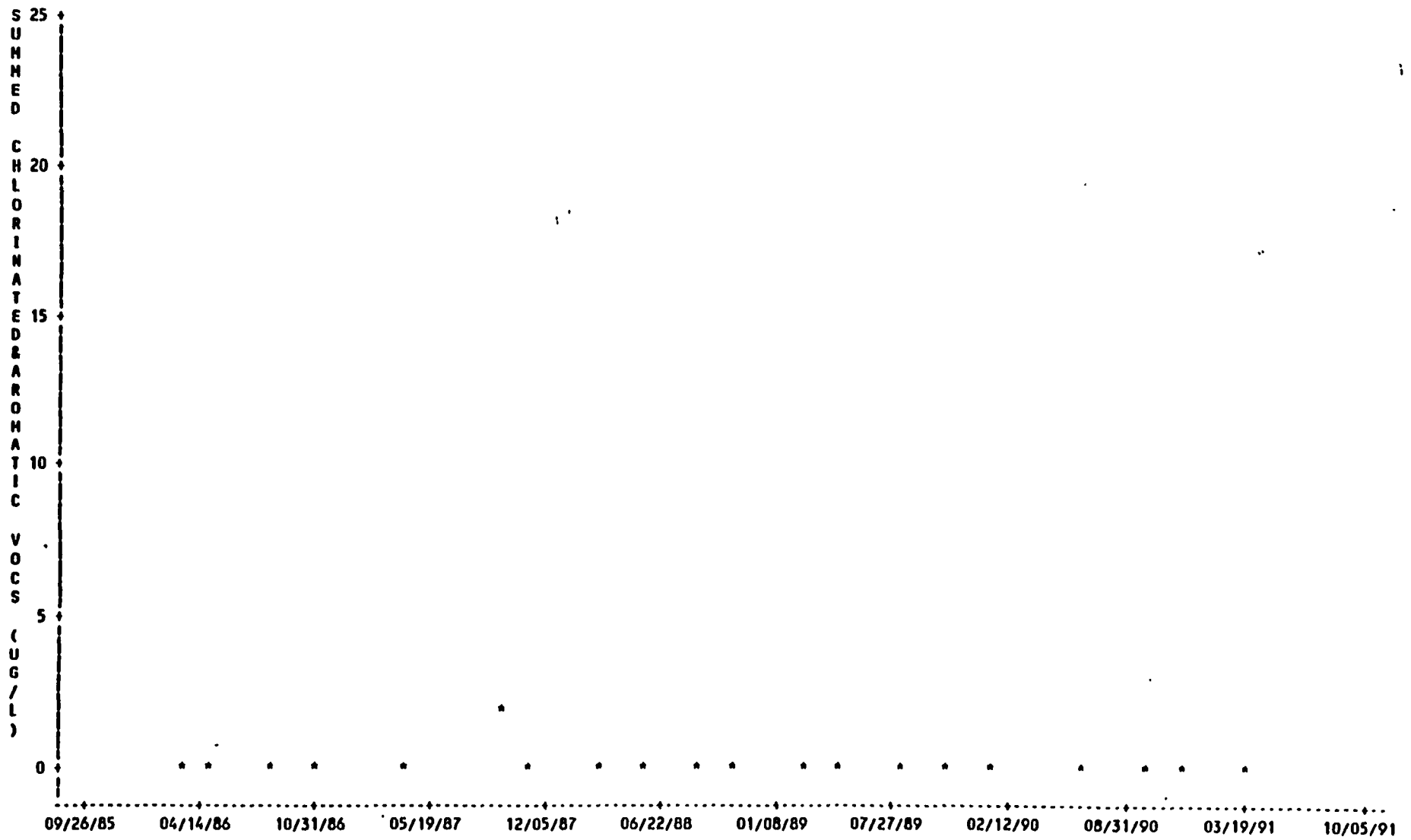


Figure 17b. Plot of summed chlorinated and aromatic VOCs for downgradient well GW-231 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

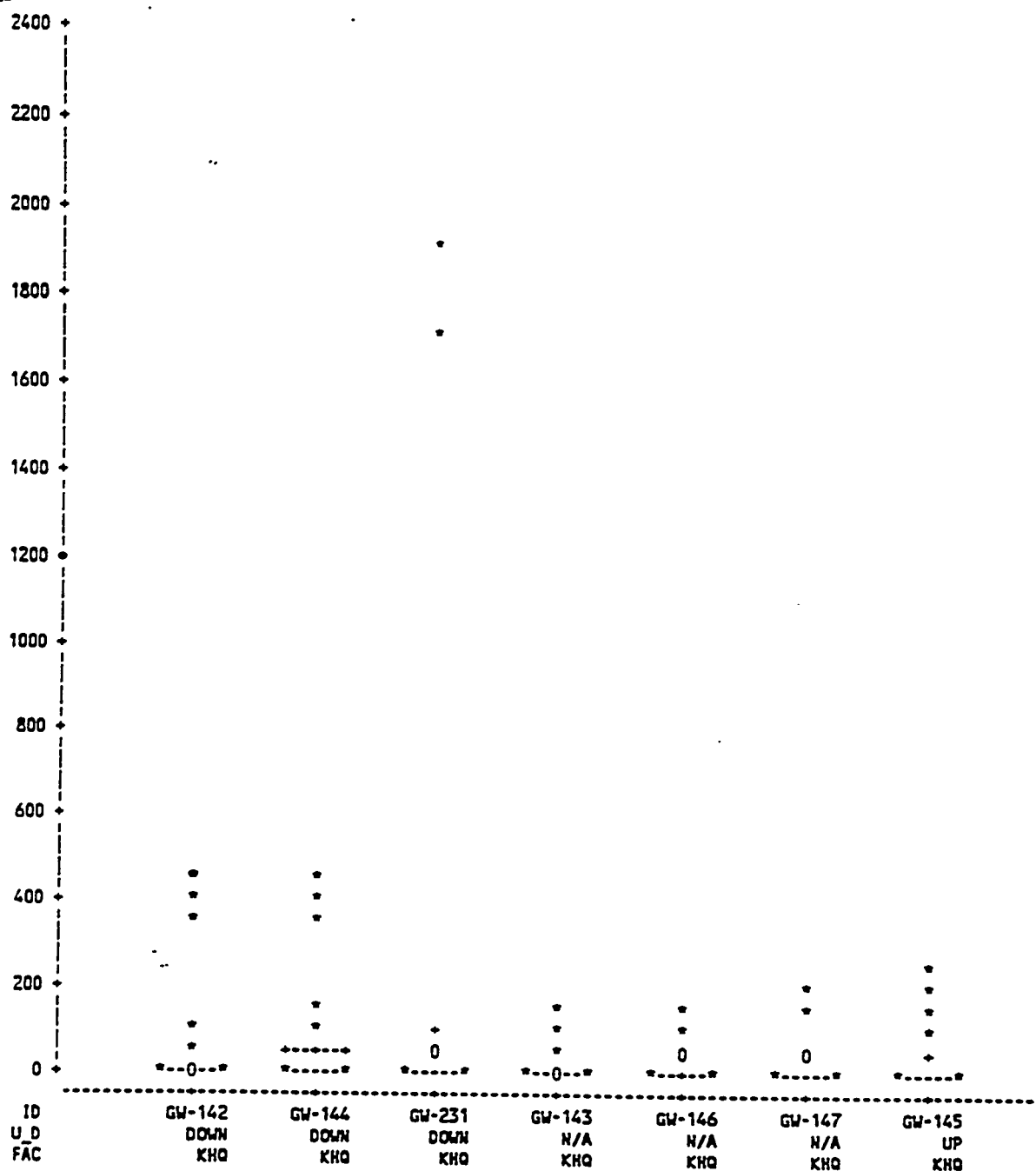


Figure 18. Statistical summary of TOX data for groundwater monitoring wells at the Kerr Hollow Quarry. Box outlines represent the 25th percentile (bottom of box), median (middle line terminated with asterisks), and 75th percentile (top of box) of the data set for a individual well. Mean is indicated by central plus sign (+) within the box. Central lines or tails extending above and below the box indicate the range of outliers within 1.5 interquartile ranges below the 25th percentile and above the 75th percentile. Outliers beyond this range are illustrated by zero (0) if they are within 3 interquartile ranges. More extreme outliers are illustrated by an asterisk (*). Because of scale, some boxes appear incomplete.

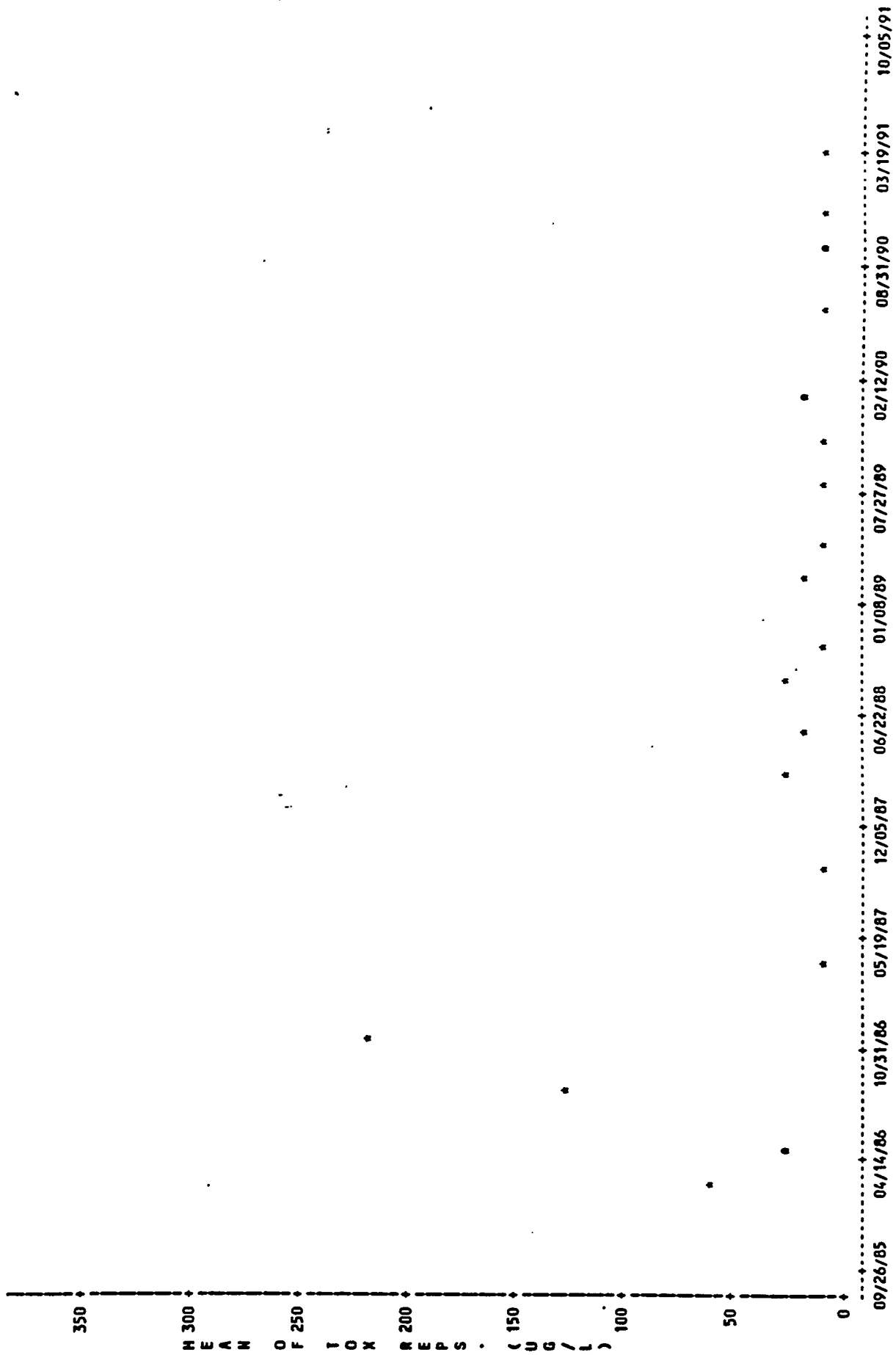


Figure 19a. Plot of TOX values for upgradient well GW-145 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

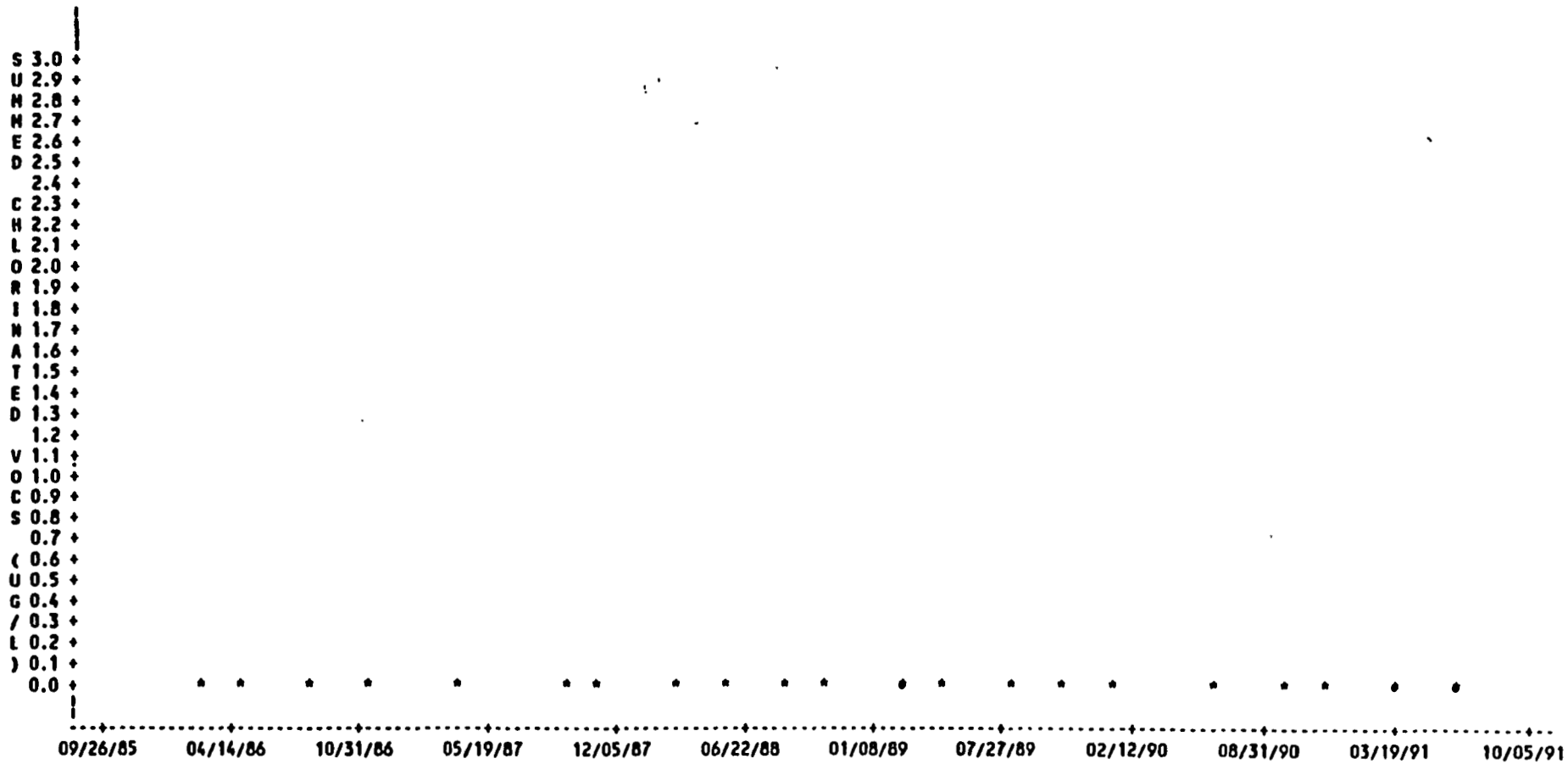


Figure 19b. Plot of summed chlorinated VOCs for upgradient well GW-145 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

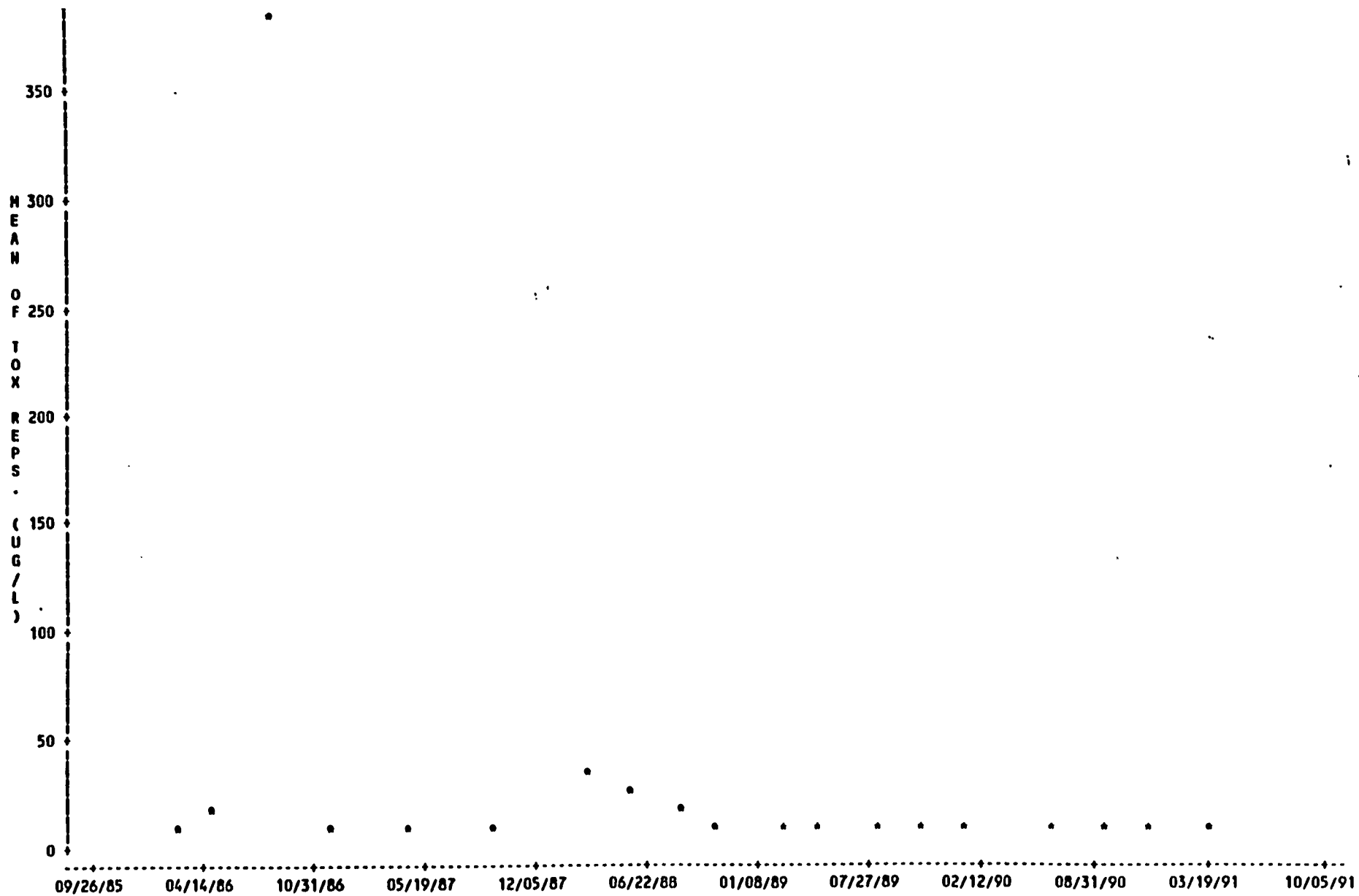


Figure 20a. Plot of TOX values for downgradient well GW-142 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

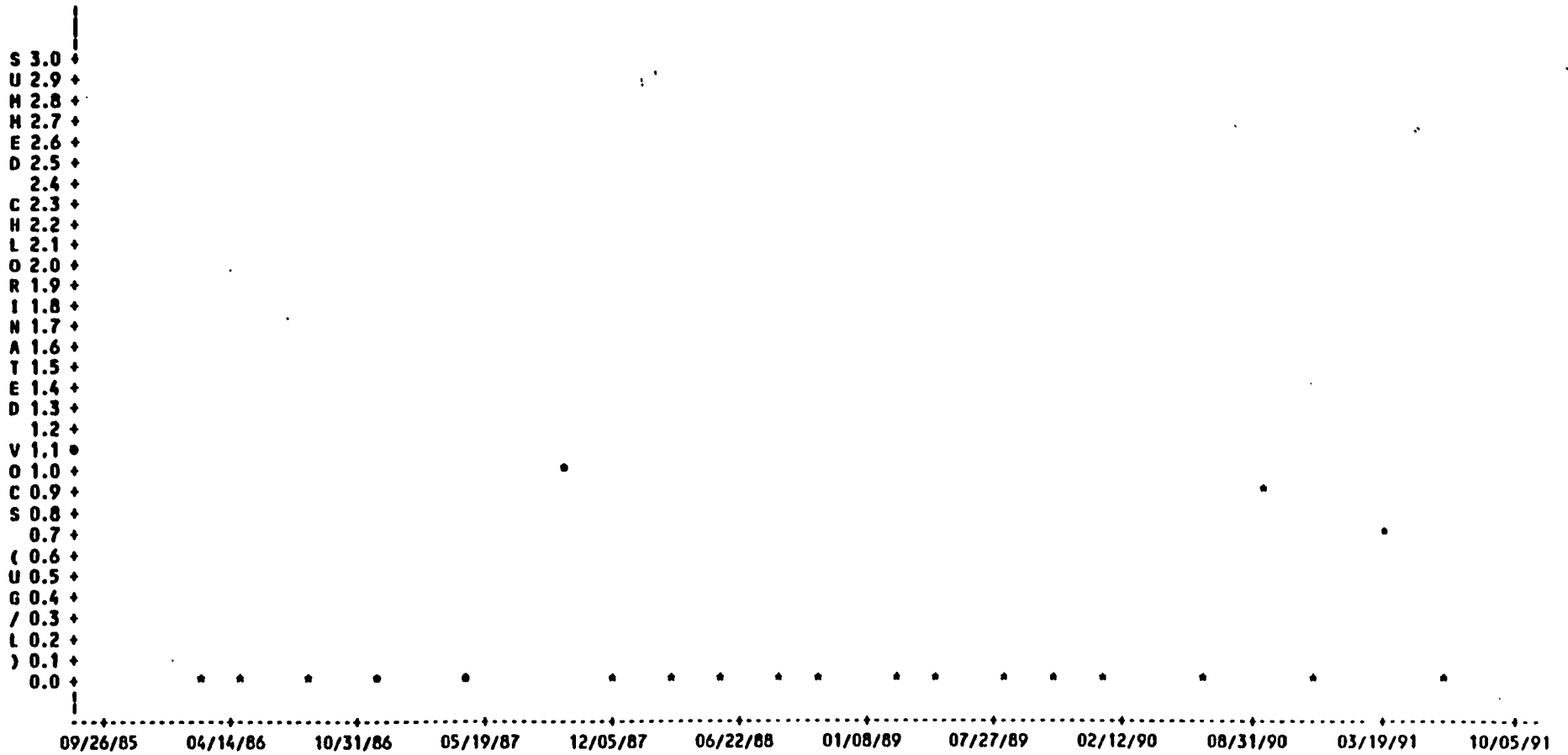


Figure 20b. Plot of summed chlorinated VOCs for downgradient well GW-142 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

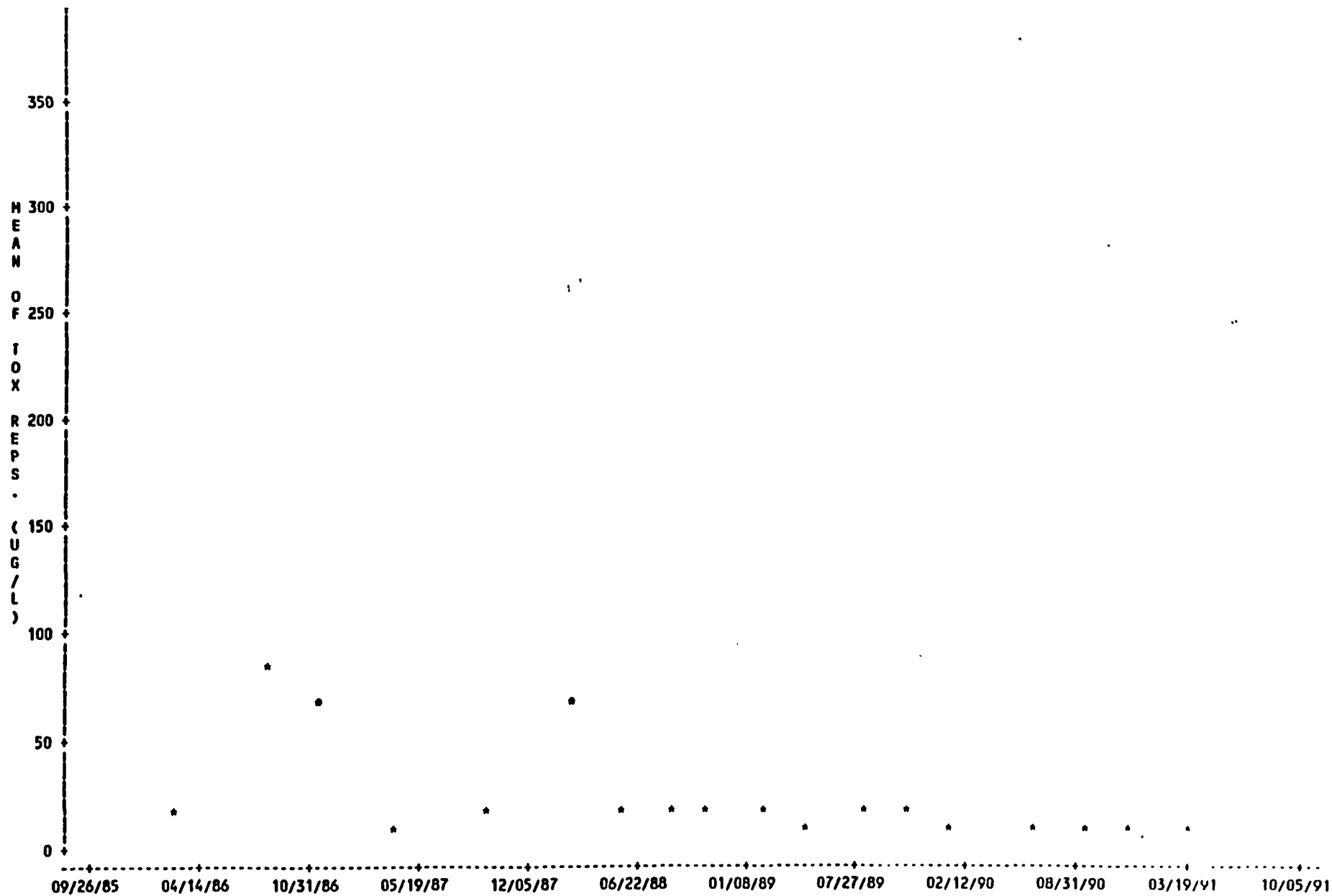
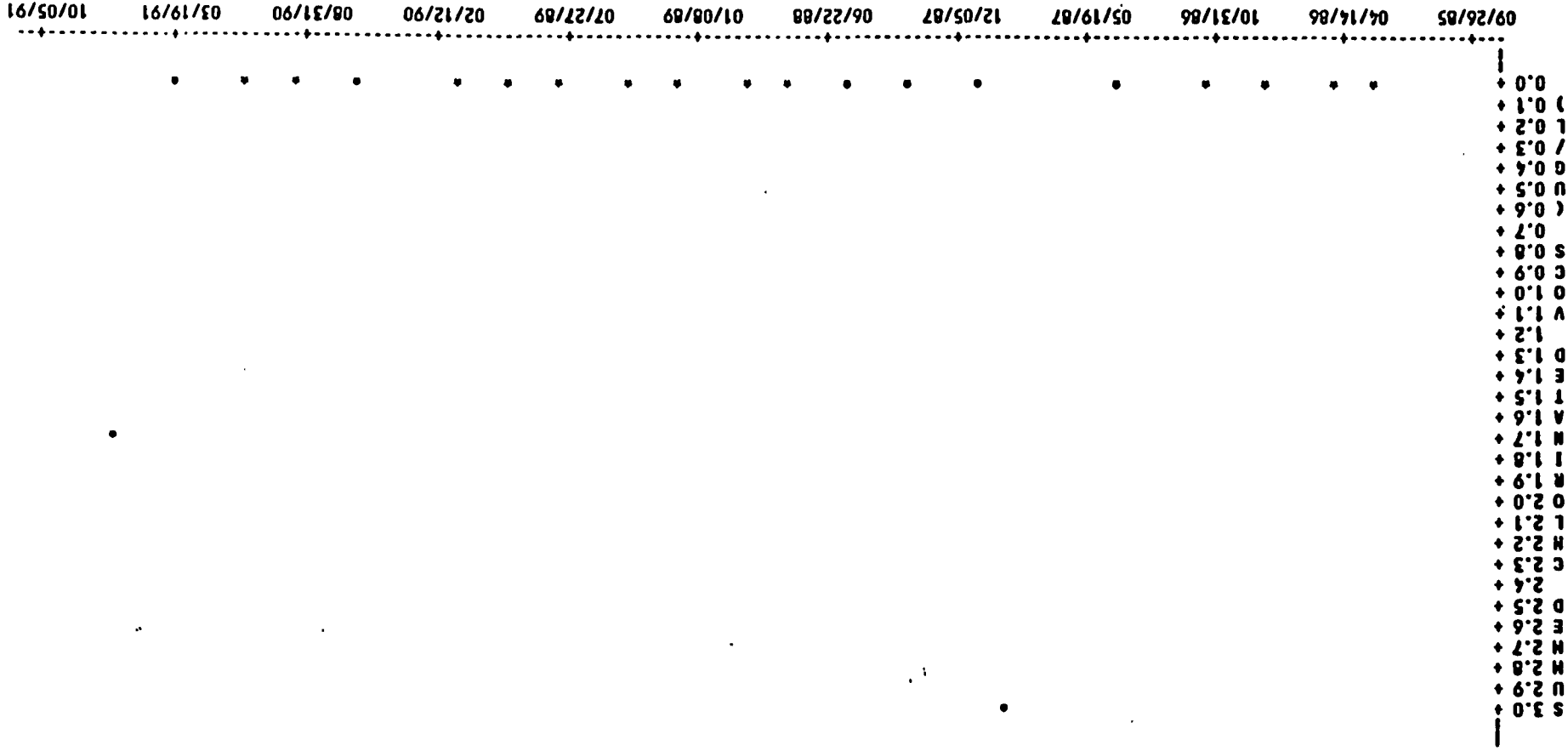


Figure 21a. Plot of TOX values for downgradient well GW-144 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

Figure 21b. Plot of summed chlorinated VOCs for downgradient well GW-144 at Kerr Hollow Quarry. Each data point is the mean of four measurements.



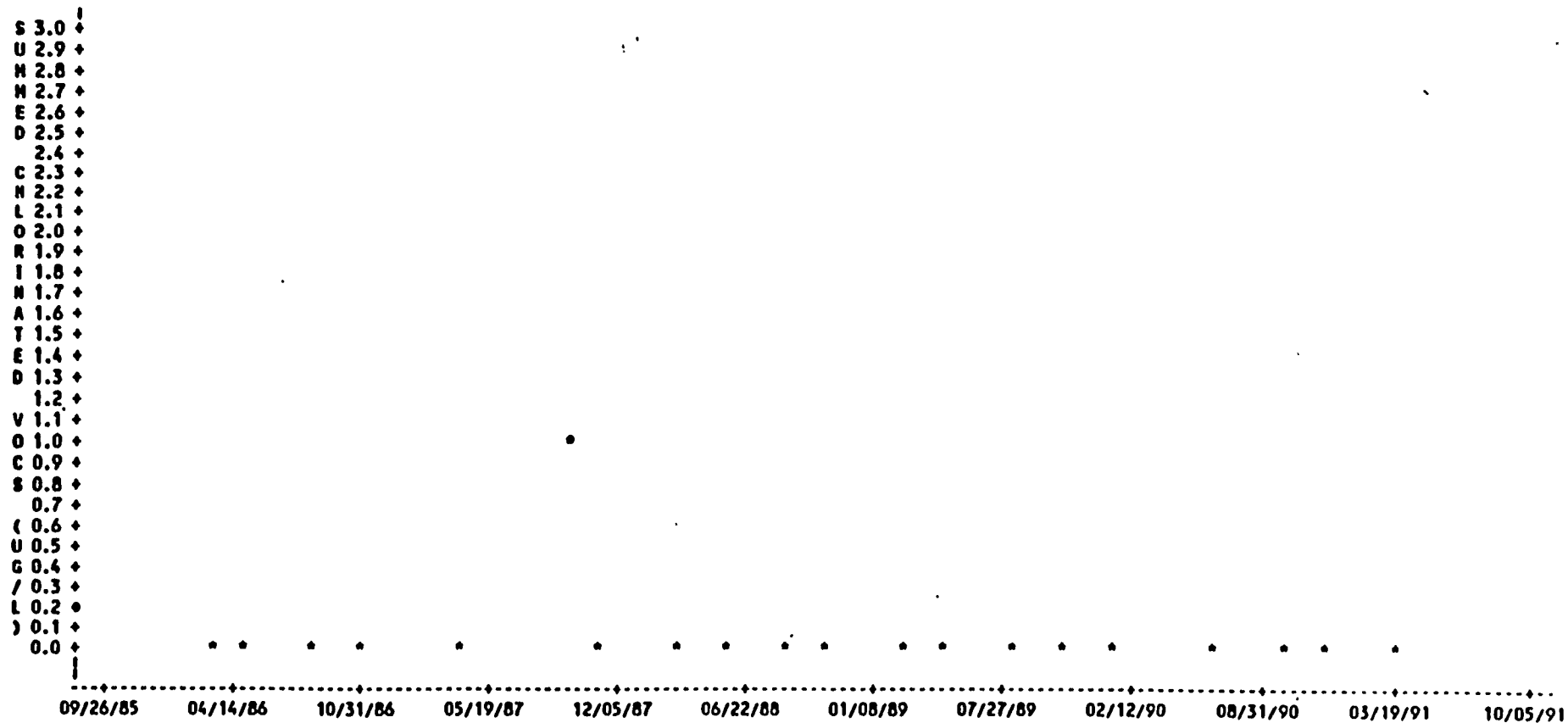


Figure 22b. Plot of summed chlorinated VOCs for downgradient well GW-231 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

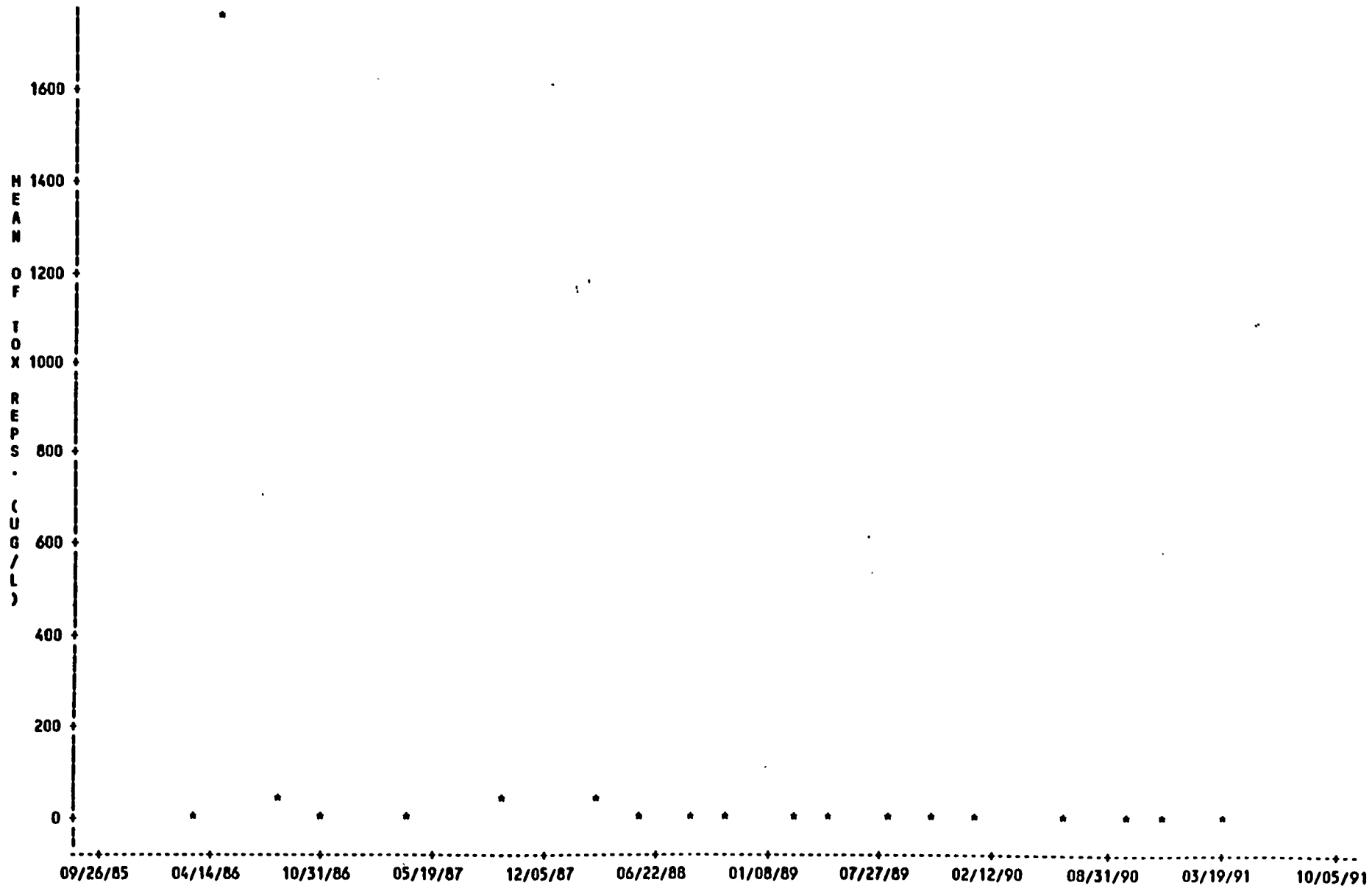


Figure 22a. Plot of TOX values for downgradient well GW-231 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

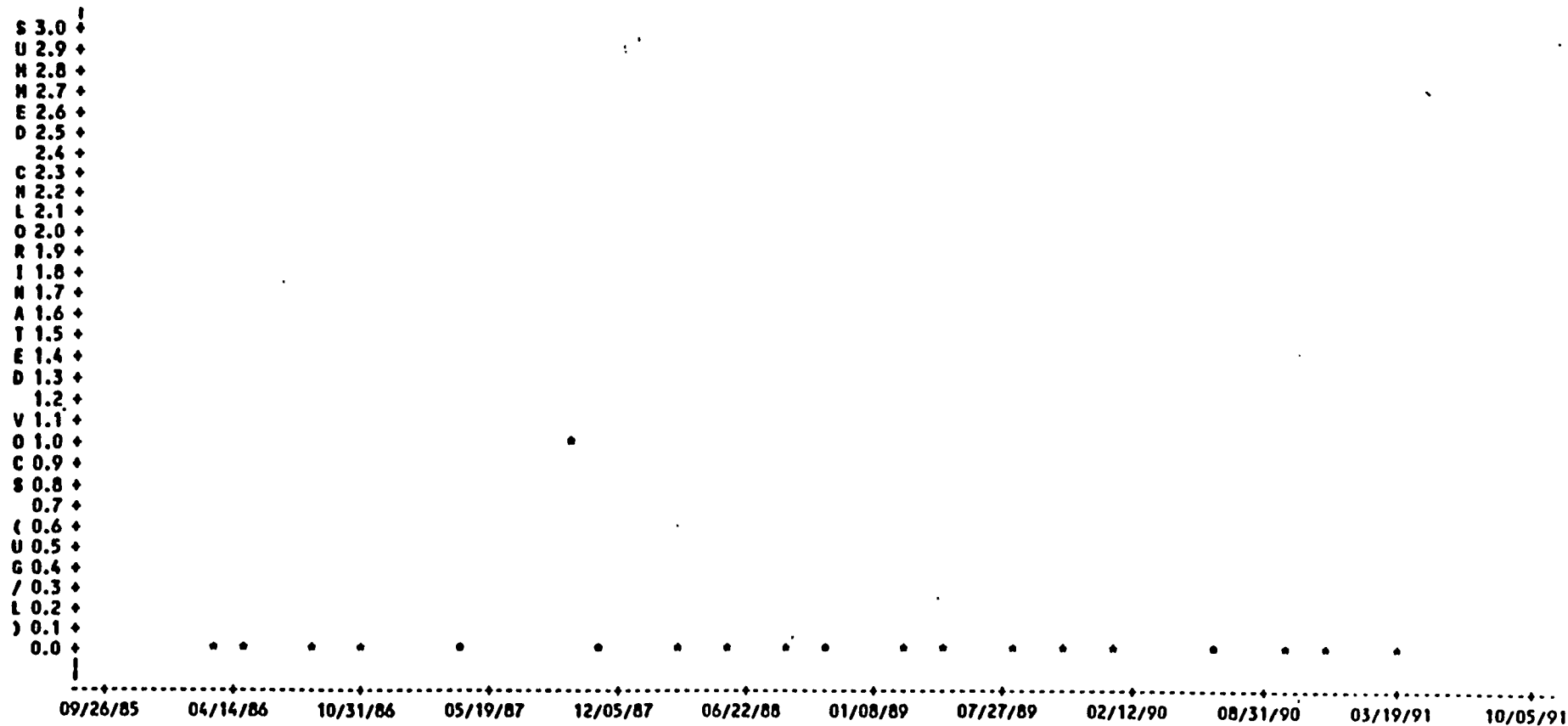


Figure 22b. Plot of summed chlorinated VOCs for downgradient well GW-231 at Kerr Hollow Quarry. Each data point is the mean of four measurements.

APPENDIX F

**TRACE METAL EVALUATIONS AND TOLERANCE LIMIT
DETERMINATIONS FOR GROUNDWATER AT
KERR HOLLOW QUARRY**

Trace Metal Evaluations and Tolerance Limit Determinations for Groundwater at Kerr Hollow Quarry

Metal concentrations in groundwater from seven wells near Kerr Hollow Quarry have been measured approximately quarterly since January 1986. Three of these wells (GW-142, GW-147, and GW-231) are considered upgradient of the quarry and four are downgradient (GW-143, GW-144, GW-145, and GW-146). Statistical analyses were performed to determine whether trace metal concentrations in the upgradient wells differed statistically from concentrations observed in the downgradient wells and to determine a tolerance limit concentration that could be used as an indicator of contamination in samples taken in the future. Based on the known wastes disposed in the quarry, nine metals were chosen for analysis: barium, boron, cadmium, chromium, lead, mercury, nickel, strontium, and uranium. Total metals (unfiltered samples) were analyzed by atomic adsorption or inductively coupled plasma methods except for total uranium which was determined by a fluorometric technique. Statistical methods followed U.S. Environmental Protection Agency (EPA) Resource Conservation and Recovery Act (RCRA) guidance documents (EPA 1989; EPA 1992).

Approach

Concentrations of each analyte were plotted versus time (Figures F-1 through F-9). These plots were evaluated to determine whether the variation in concentration was random over time or displayed a trend. The plots were also examined for data outliers and obvious differences between wells. Based on this evaluation, some data were excluded from subsequent statistical tests. Barium and strontium concentrations in upgradient well GW-142 in 1986 were excluded from the analysis. The concentrations of barium and strontium in GW-142 approximately doubled between 1986 and 1988 (Figures F-1 and F-8, respectively). The concentrations from 1988 through 1994, however, do not appear to have a trend over time. Excluding the 1986 data for barium and strontium for GW-142 removes the temporal trend and is more representative of the most recent conditions in the well. Uranium concentrations from the last quarter of 1994 were excluded for all wells because the detection limit for this sampling round was an order of magnitude higher than for the previous data. Lead results for all wells were excluded for the 1988 and 1989 sampling rounds again because the detection limit for these results was much higher than for the other data.

For cadmium, chromium, mercury, and nickel, which were detected in <10% of the samples, concentrations greater than the detection limits did not appear to occur randomly over the sampling period but were concentrated in the period between 1990 and 1992. This pattern of detected values suggests an unusual occurrence during that period of time. Trace metal contamination may have occurred in the groundwater during this period because of disturbances related to closure activities at the quarry. Because closure activities have ended and these trace metals were not detected during the most recent year of sampling, tolerance limits were not calculated. Further comparison between upgradient and downgradient wells was not conducted for these five analytes.

The upgradient and downgradient wells were statistically compared to determine if the concentrations of each of the remaining five analytes (barium, boron, lead, strontium, and uranium) were significantly different. A Shapiro-Wilk test was performed on the data from the upgradient and downgradient wells for each analyte to determine whether the distributions of the concentrations were normal or log-normal. In each case the distribution was significantly different (at the 0.05 probability level) from both normal and log-normal distributions indicating that comparisons should be made with nonparametric statistics (Table F-1). For analytes with >50% of the concentrations above the detection limit (barium, boron, strontium, and uranium) the Wilcoxon Rank Sum test was used to determine if the upgradient concentrations were significantly different from the downgradient concentrations (at the 0.05 probability level). For lead, which had <50% but >10% of the results above the detection limit, a test of proportions was used to compare the upgradient and downgradient concentrations. The data were also plotted as cumulative frequency plots to allow a visual comparison of the upgradient and downgradient distributions (Figures F-10 to F-14). For barium the concentrations in the upgradient wells were significantly higher than the concentrations in the downgradient wells. Therefore, only the upgradient wells were used for determining the tolerance limit. For strontium and boron, the concentrations in the upgradient wells were significantly lower than the concentrations in the downgradient wells. Therefore, only the upgradient wells were used for determining the tolerance limits. For lead and uranium, the concentrations in the upgradient wells were not significantly different from the downgradient wells and therefore all wells were used to determine the tolerance limit.

Because the distribution of the data was neither normal nor log-normal, a nonparametric 95% upper tolerance limit (UTL) was used for all the analytes. One is 95% confident that 95% of the concentrations should fall below the 95% UTL. For analytes with between 59 and 89 results, the 95% UTL is the maximum observed result. For cadmium, chromium, mercury, and nickel, which had a low frequency of non-random detected values, the maximum contaminant level (MCL) specified in the Safe Drinking Water Act was used as the tolerance limit. The tolerance limits for each analyte are provided in Table F-2 and discussed individually below.

Barium. The concentrations of barium in well GW-142 during 1986 were excluded from the statistical analysis because the concentrations in 1986 appeared to be significantly lower than the remaining period of record (Figure F-1). Using only the later data better represents current conditions. The mean concentration of the upgradient wells was significantly greater than the downgradient wells at the 0.05 probability level using the Wilcoxon Rank Sum test. Therefore only the upgradient wells were used to determine the tolerance limit. The nonparametric 95% UTL was 0.49 mg/L.

Boron. Other than the 1986 data, the boron concentrations appear fairly stable over time (Figure F-2). One result from GW-142 in the second quarter of 1986 was much higher than all subsequent results and was excluded from consideration. The concentration in the upgradient wells was significantly lower than the downgradient wells at the 0.05 probability level using the Wilcoxon Rank Sum test. However, pairwise tests indicated significant differences in concentration between all wells except GW-142 and GW-147. Therefore, no UTL was calculated. Boron is not an Appendix VIII constituent and does not have an established MCL. Therefore, annual trending will be conducted rather than using a comparative concentration.

Cadmium. Less than 10% of all cadmium results were above the detection limit (Table F-1). All of the detected values occurred between the second quarter of 1990 and the second quarter of 1992 (Figure F-3) although the detection limit was lowered in 1990 from 0.003 mg/L to 0.002 mg/L. Values presented in Figure F-3 for data prior to 1990 are detection limits rather than actual detections. Cadmium was not detected in any wells prior to 1990. These elevated levels detected in groundwater were coincident with closure activities at the site which involved the removal of materials from the sediments in the quarry. Therefore, those detected values were

not used to calculate a tolerance limit for future sampling. The MCL of 0.005 mg/L was chosen as the tolerance limit.

Chromium. Less than 10% of all chromium results were above the detection limit (Table F-1). All of the detected values occurred between the second quarter of 1990 and the second quarter of 1992 (Figure F-4). As noted for cadmium, the frequency of detected values does not appear to be random over time; therefore, the observed detected values were not used to calculate a tolerance limit for future sampling. The MCL of 0.1 mg/L was chosen as the tolerance limit.

Lead. Lead was detected in ~25% of the samples (Table F-1). Most of the detected values appeared in the 1986 samples but it has been detected sporadically since then (Figure F-5). Data from 1988 and 1989 were rejected because the detection limit was 0.05 mg/L, an order of magnitude above the detection limit for the other periods. A test of proportions was used to determine if the proportion of detected values was significantly larger for the downgradient than the upgradient samples. The test indicated that the proportion of detected values was not significantly different at the 0.05 probability level. The shape of the cumulative frequency plots of the sample groups was similar (Figure F-12). Results from both the upgradient and downgradient wells were therefore used to determine the tolerance limit. The non-parametric 95% UTL was 0.035 mg/L.

Mercury. Only three mercury results were above the detection limit and all of these were before 1992 (Table F-1 and Figure F-6). As noted for cadmium, the frequency of detected values does not appear to be random over time; therefore, the observed detected values were not be used to calculate a tolerance limit for future sampling. The MCL of 0.002 mg/L was chosen as the tolerance limit.

Nickel. About 10% of all nickel results were above the detection limit (Table F-1). Most of the detected values occurred between the second quarter of 1990 and the second quarter of 1992 (Figure F-7). As noted for cadmium, the frequency of detected values does not appear to be random over time; therefore, the observed detected values were not used to calculate a tolerance limit for future sampling. The MCL of 0.1 mg/L was chosen as the tolerance limit.

Strontium. The concentrations of strontium in well GW-142 during 1986 were excluded from the statistical analysis because the concentrations in 1986 appeared to be lower than the remaining period of record (Figure F-8). Using only the later data better represent current conditions. The concentration in the upgradient wells was significantly lower than the downgradient wells at the 0.05 probability level using the Wilcoxon Rank Sum test. However, pairwise tests (Kruskal Wallis) indicated significant differences in concentration between all wells. Therefore, no UTL was calculated. Due to statistical variance between wells and the fact that strontium is not an Appendix VIII constituent and does not have an established MCL, annual trending of the data will be conducted.

Uranium. Data from the fourth quarter of 1994 were rejected for the statistical analyses because the detection limit was an order of magnitude higher than during the other sampling periods (Figure F-9). The concentration of the remaining upgradient wells was not significantly different from the downgradient wells at the 0.05 probability level using the Wilcoxon Rank Sum test. Therefore, data from both the upgradient and downgradient wells were used to calculate the tolerance limit. The non-parametric 95% UTL was 0.019 mg/L.

References:

U.S. EPA, 1989. Statistical Analysis of Ground-water Monitoring Data at RCRA Facilities, Interim Final Guidance. Office of Solid Waste, Waste Management Division, U.S.EPA, Washington, D.C., February 1989. PB89-151047.

U.S. EPA, 1992. Addendum to the Interim Final Guidance on the Statistical Analysis of Ground-water Monitoring Data at RCRA Facilities. Office of Solid Waste, Waste Management Division, U.S.EPA, Washington, D.C., February.

Table F-1. Summary statistics for indicator parameters

Analyte	Group	Detects/ Samples	%Detects	Mean	Minimum Detect	Maximum Detect	MCL	Distribution
Barium	downgradient	104/104	100	0.0716	0.0024	0.54	2.	X
Barium	upgradient	73/73	100	0.195	0.031	0.49	2.	X
Boron	downgradient	104/104	100	0.396	0.016	1.10	NA	X
Boron	upgradient	73/76	96	0.0478	0.0062	0.17	NA	X
Cadmium	downgradient	1/104	0.962	0.00115	0.0023	0.0023	0.005	X
Cadmium	upgradient	3/78	3.85	0.0012	0.0023	0.003	0.005	X
Chromium	downgradient	5/104	4.81	0.00566	0.011	0.025	0.1	X
Chromium	upgradient	3/78	3.85	0.00565	0.011	0.011	0.1	D
Lead	downgradient	23/92	25	0.0065	0.004	0.128	NA	X
Lead	upgradient	16/68	23.5	0.00514	0.004	0.11	NA	X
Mercury	downgradient	2/92	2.17	0.000103	0.00024	0.00025	0.002	D
Mercury	upgradient	1/68	1.47	0.000102	0.0002	0.0002	0.002	D
Nickel	downgradient	11/104	10.6	0.00657	0.01	0.051	0.1	X
Nickel	upgradient	5/77	6.49	0.00838	0.01	0.19	0.1	X
Strontium	downgradient	104/104	100	4.12	0.078	18.0	NA	X
Strontium	upgradient	73/73	100	0.576	0.018	3.6	NA	X
Uranium	downgradient	88/103	85.4	0.00474	0.001	0.02	0.02	X
Uranium	upgradient	54/77	70.1	0.00397	0.001	0.032	0.02	X

Concentrations in mg/L.

NA - Not Applicable.

Results less than the detection limit were set to 1/2 the reported detection limit.

Dist. Codes: L - distribution most similar to lognormal.

N - distribution most similar to normal.

X - distribution significantly different from normal and lognormal.

D - distribution not determined because fewer than 5 detected values.

F-6

Table F-2. Tolerance limits for selected indicator parameters

Analyte	Up- vs. Downgradient Comparison		Tolerance Limit (mg/L)	Tolerance Limit Source
	Test	Result		
Barium	Wilcoxon	Up > Down	0.49	Non-Parametric 95% UTL
Cadmium	NA	NA	0.005	MCL
Chromium	NA	NA	0.1	MCL
Lead	Proportions	Not Different	0.035	Non-parametric 95% UTL
Mercury	NA	NA	0.002	MCL
Nickel	NA	NA	0.1	MCL
Uranium	Wilcoxon	Down > Up	0.019	Non-Parametric 95% UTL

NA - Not Applicable

F-7

Kerr Hollow Groundwater Data 1986-1994
 Concentrations Over Time
 Analyte (units)=BARIUM (MG/L)

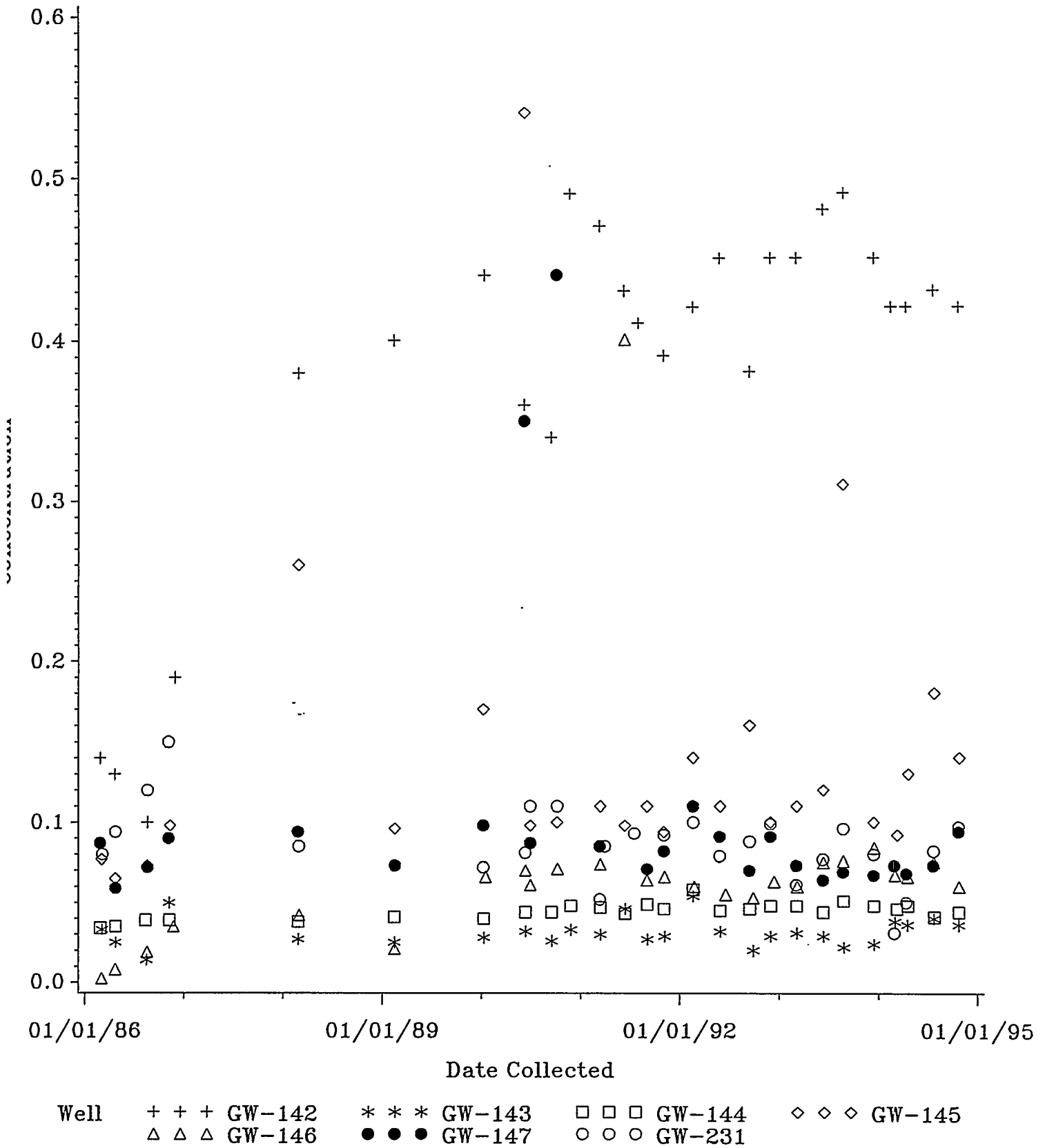


Figure F-1. Barium concentrations over time.

Kerr Hollow Groundwater Data 1986-1994
 Concentrations Over Time
 Analyte (units)=BORON (MG/L)

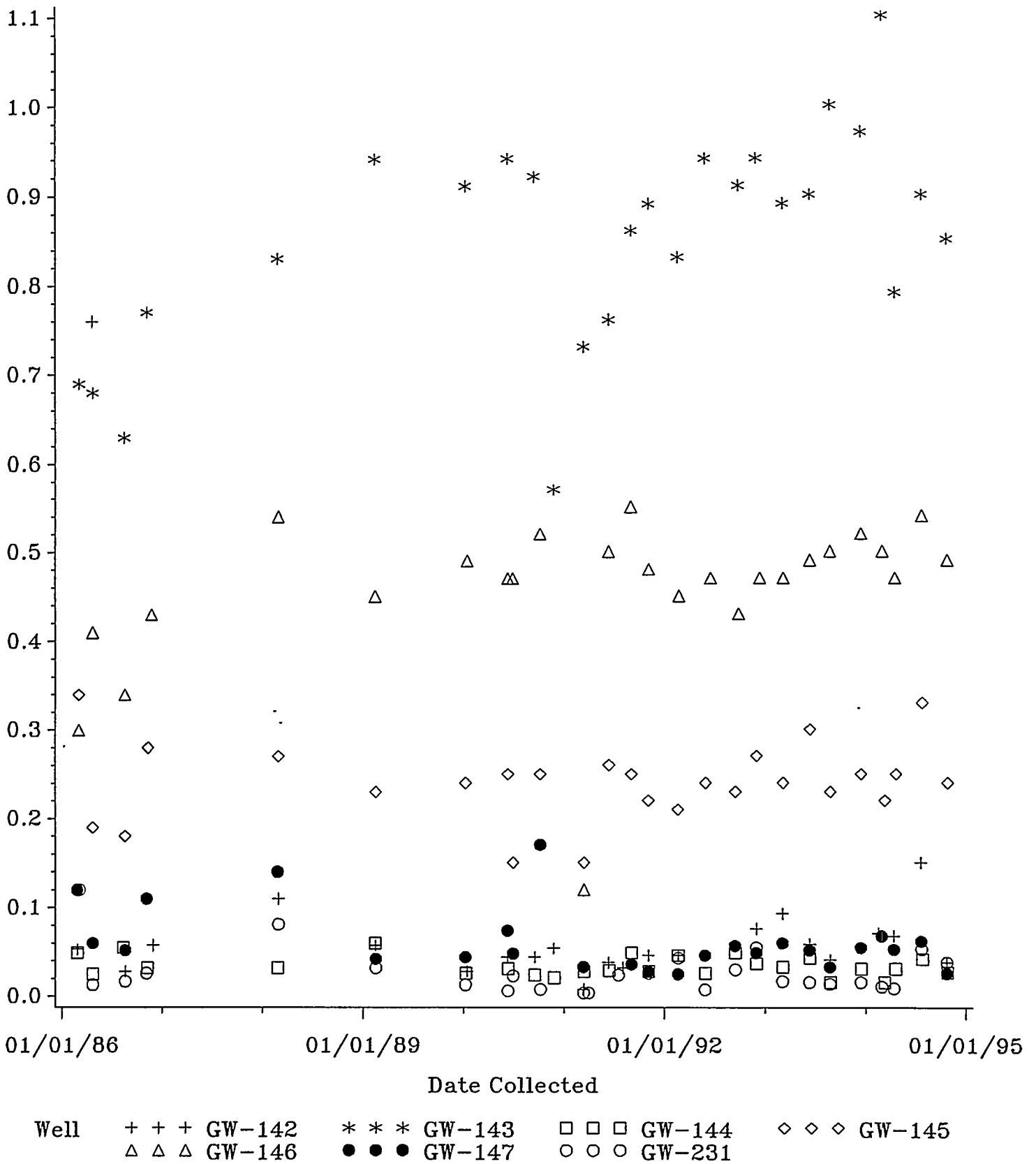


Figure F-2. Boron concentrations over time.

Kerr Hollow Groundwater Data 1986-1994
 Concentrations Over Time
 Analyte (units)=CADMIUM (MG/L)

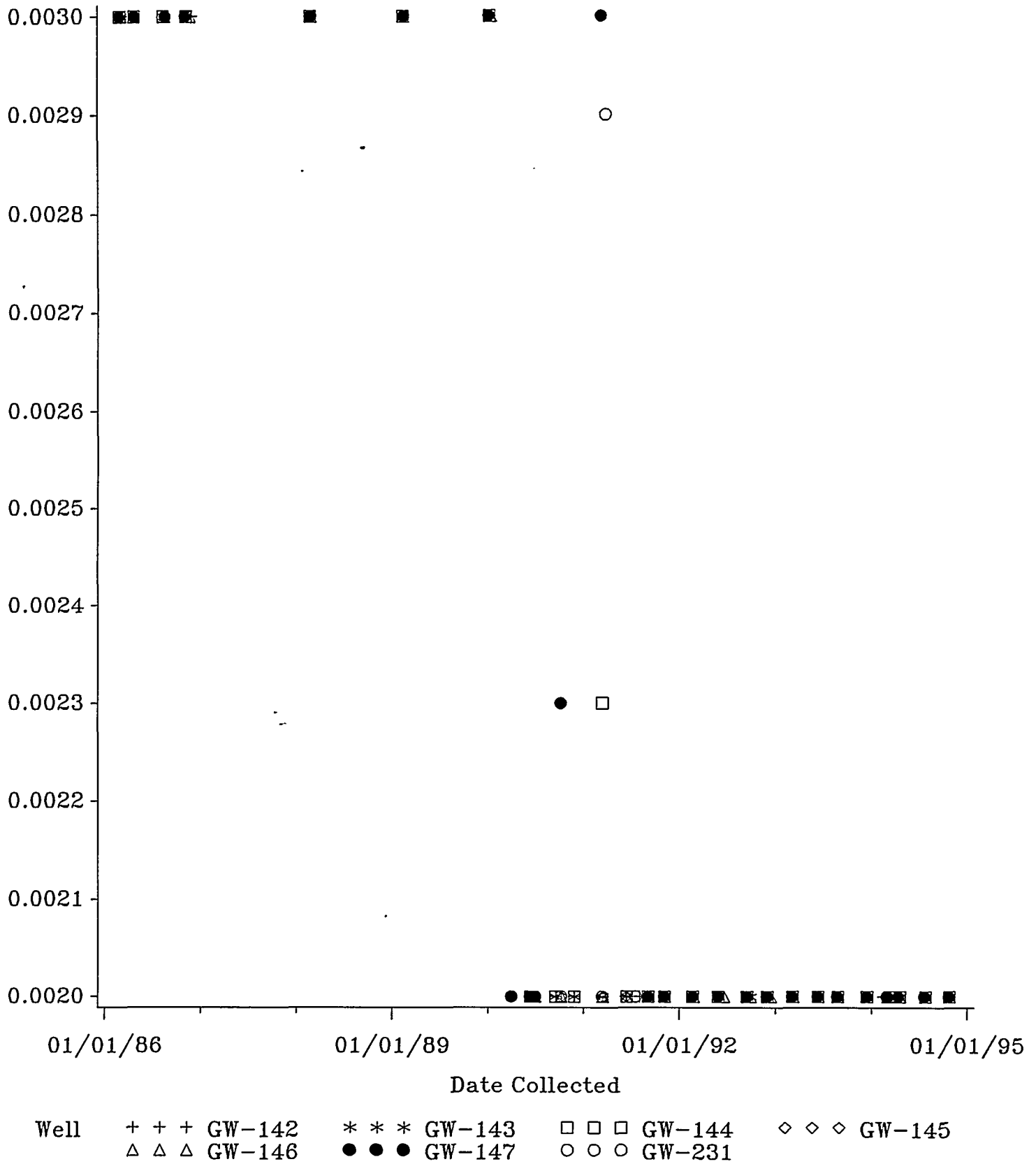


Figure F-3. Cadmium concentrations over time.

Kerr Hollow Groundwater Data 1986-1994
 Concentrations Over Time
 Analyte (units)=CHROMIUM (MG/L)

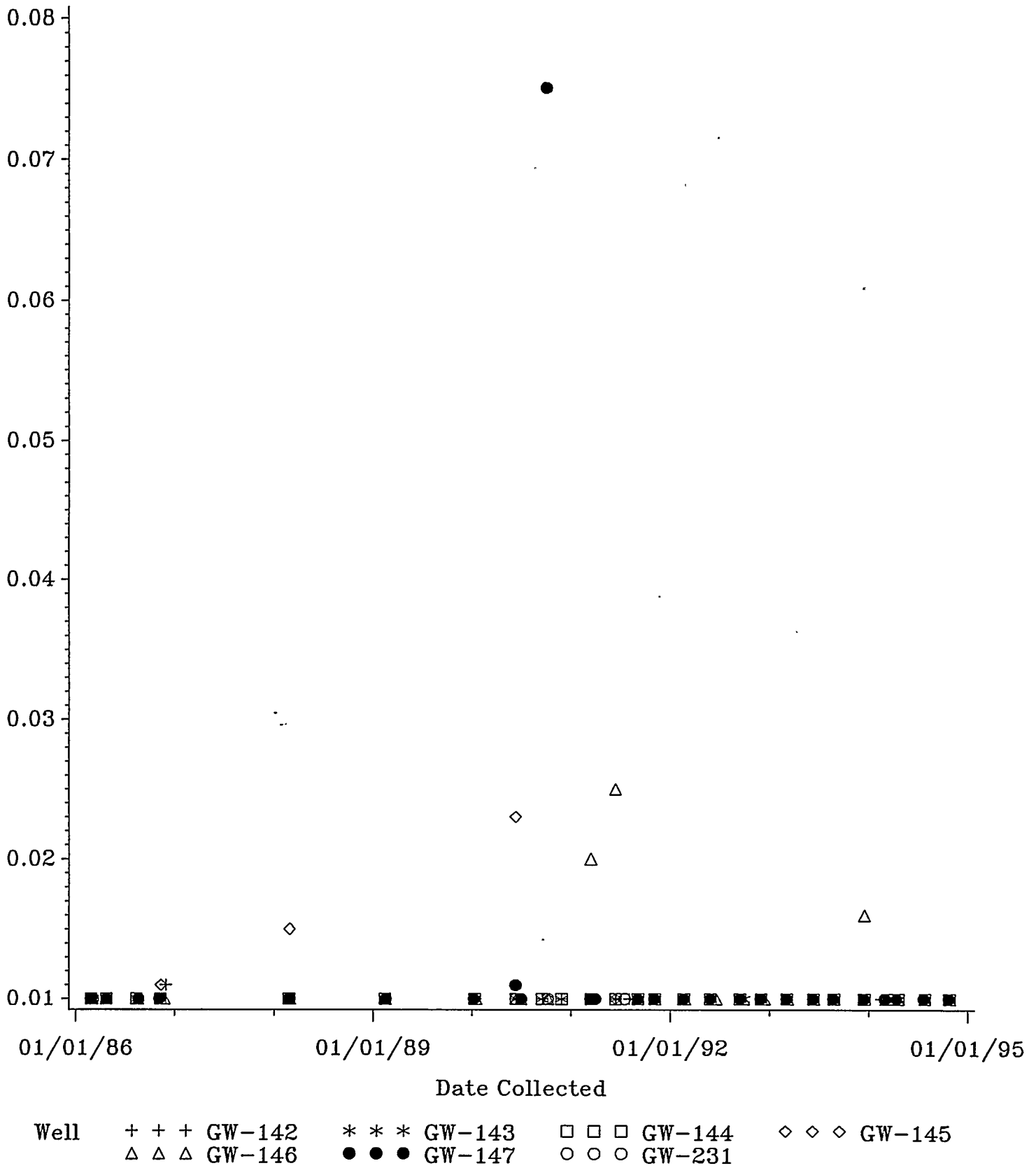


Figure F-4. Chromium concentrations over time.

Kerr Hollow Groundwater Data 1986-1994
 Concentrations Over Time
 Analyte (units)=MERCURY (MG/L)

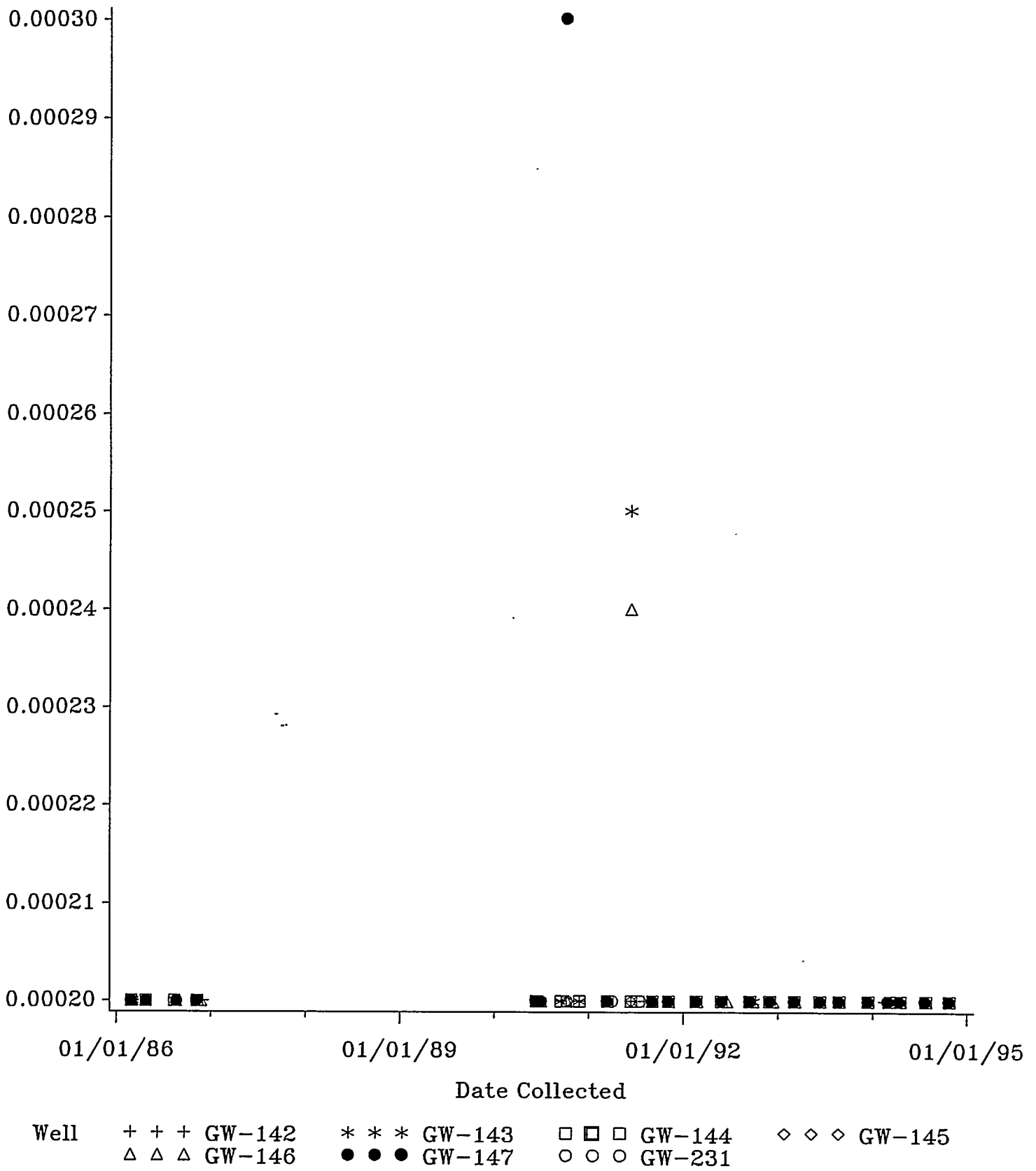


Figure F-6. Mercury concentrations over time.

Kerr Hollow Groundwater Data 1986-1994
 Concentrations Over Time
 Analyte (units)=NICKEL (MG/L)

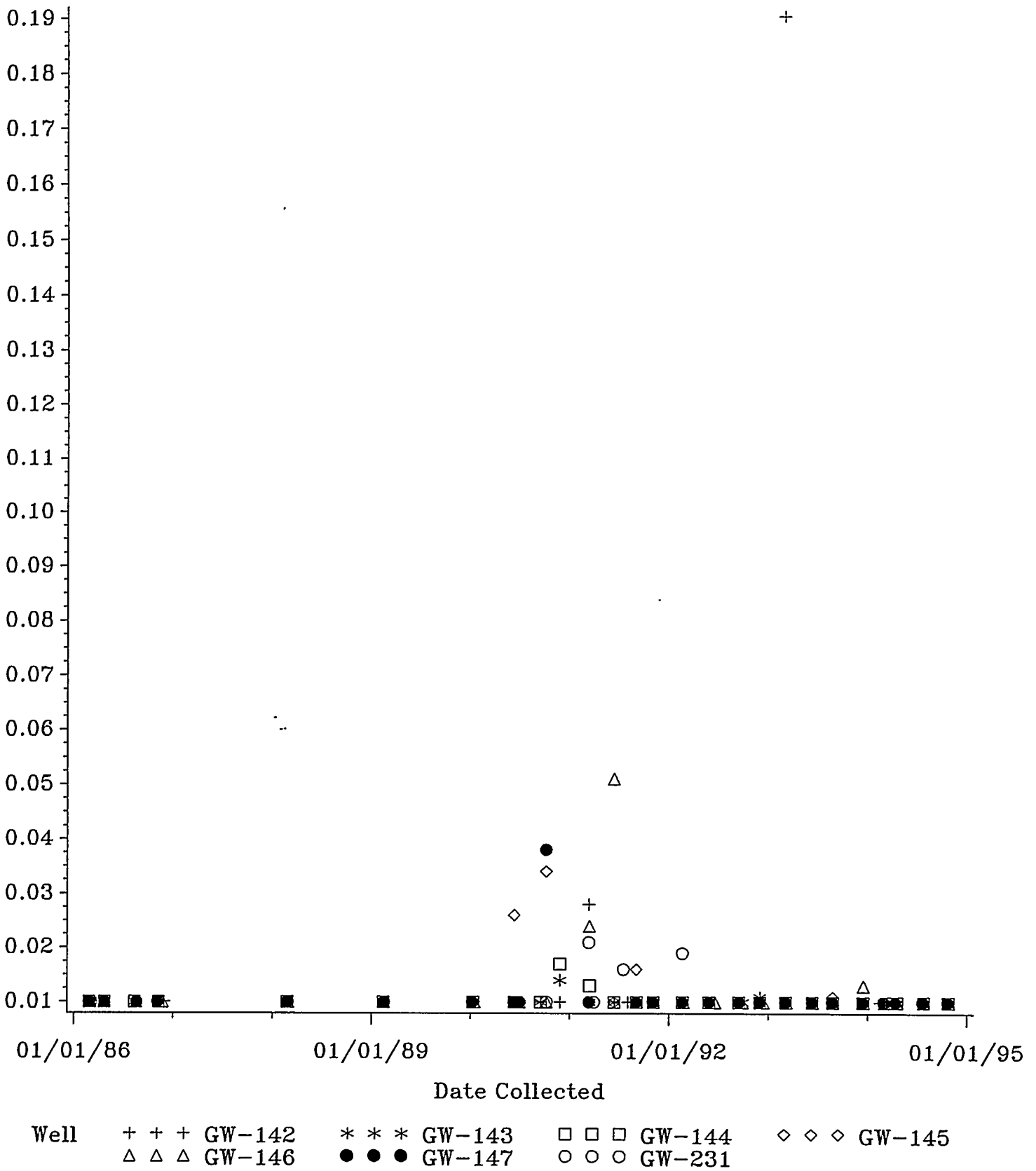


Figure F-7. Nickel concentrations over time.

Kerr Hollow Groundwater Data 1986-1994
 Concentrations Over Time

Analyte (units)=STRONTIUM (MG/L)

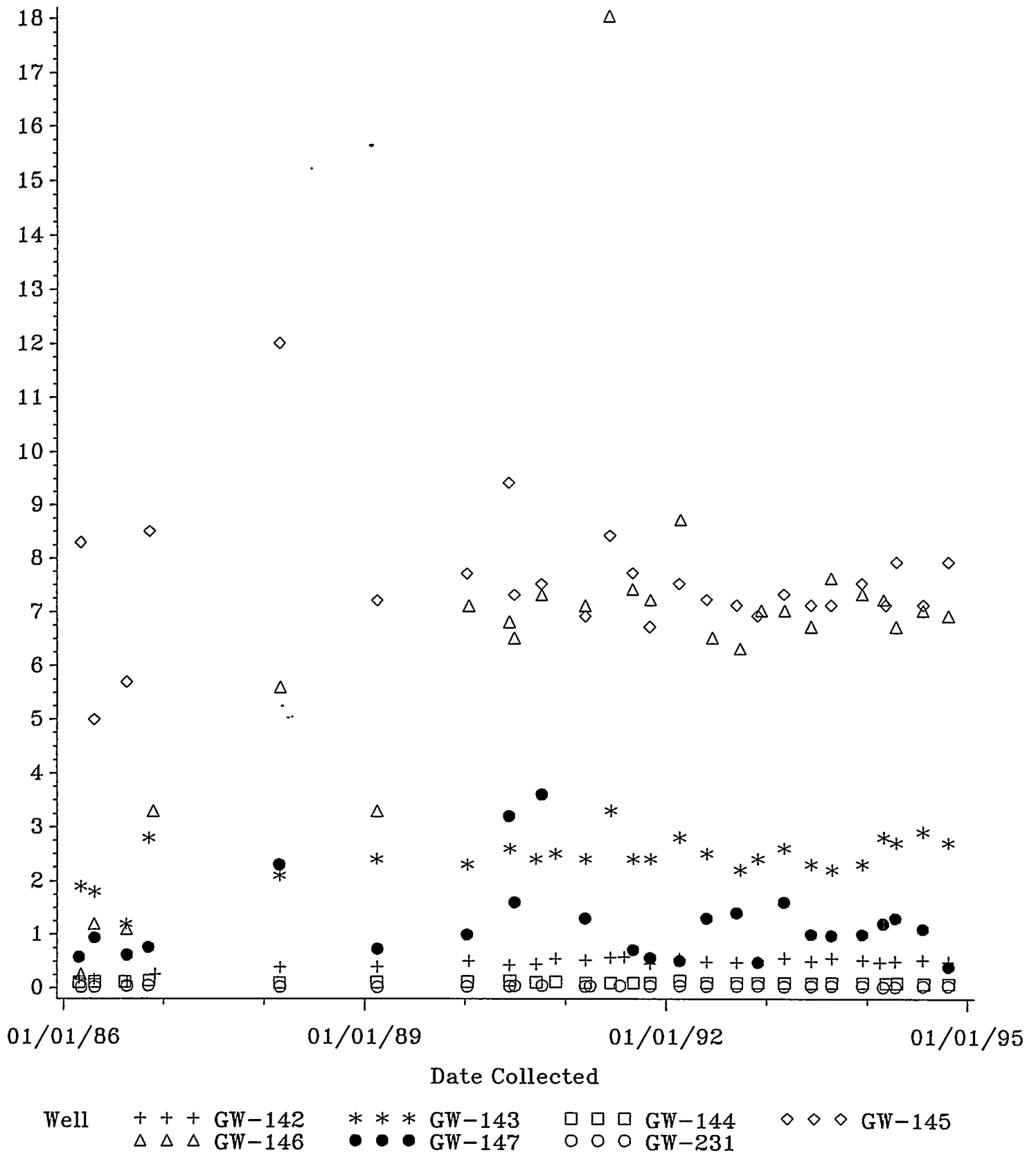


Figure F-8 Strontium concentrations over time.

Kerr Hollow Groundwater Data 1986-1994
 Concentrations Over Time
 Analyte (units)=TOTAL URANIUM (FLUOROMETRIC) (MG/L)

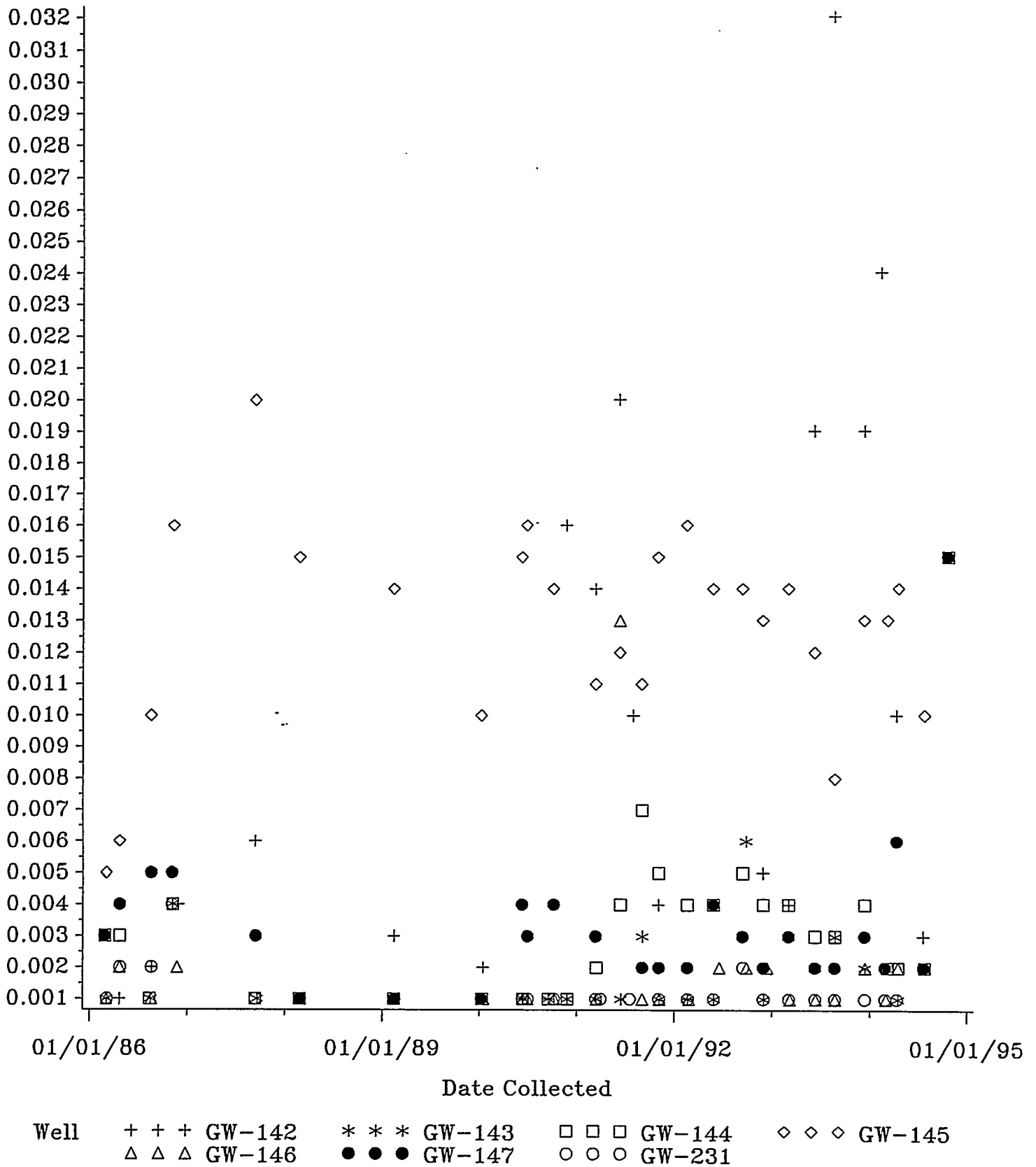
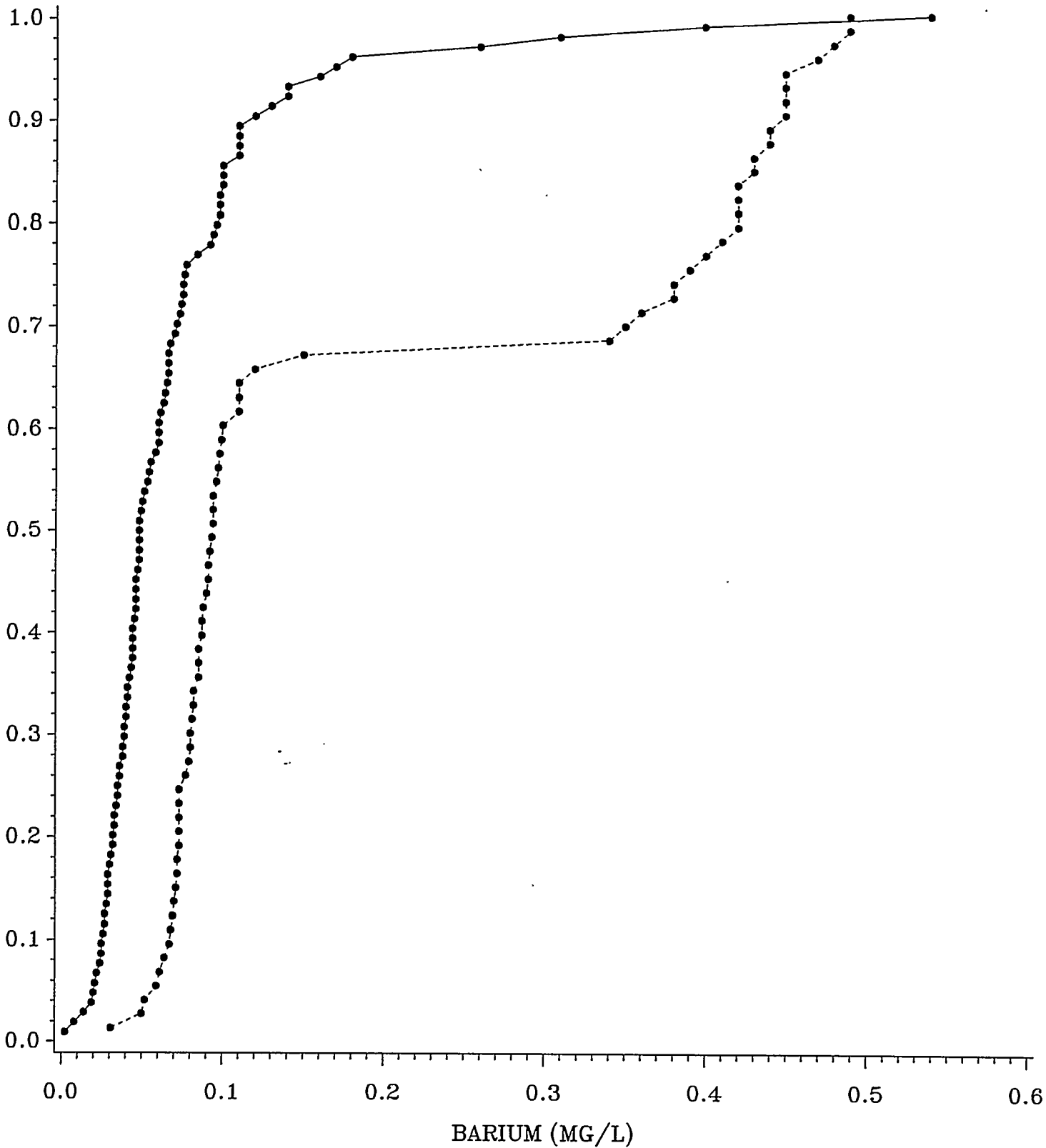


Figure F-9. Total Uranium concentrations over time.

Kerr Hollow Groundwater Data 1986-1994
 Cumulative Frequency Plots

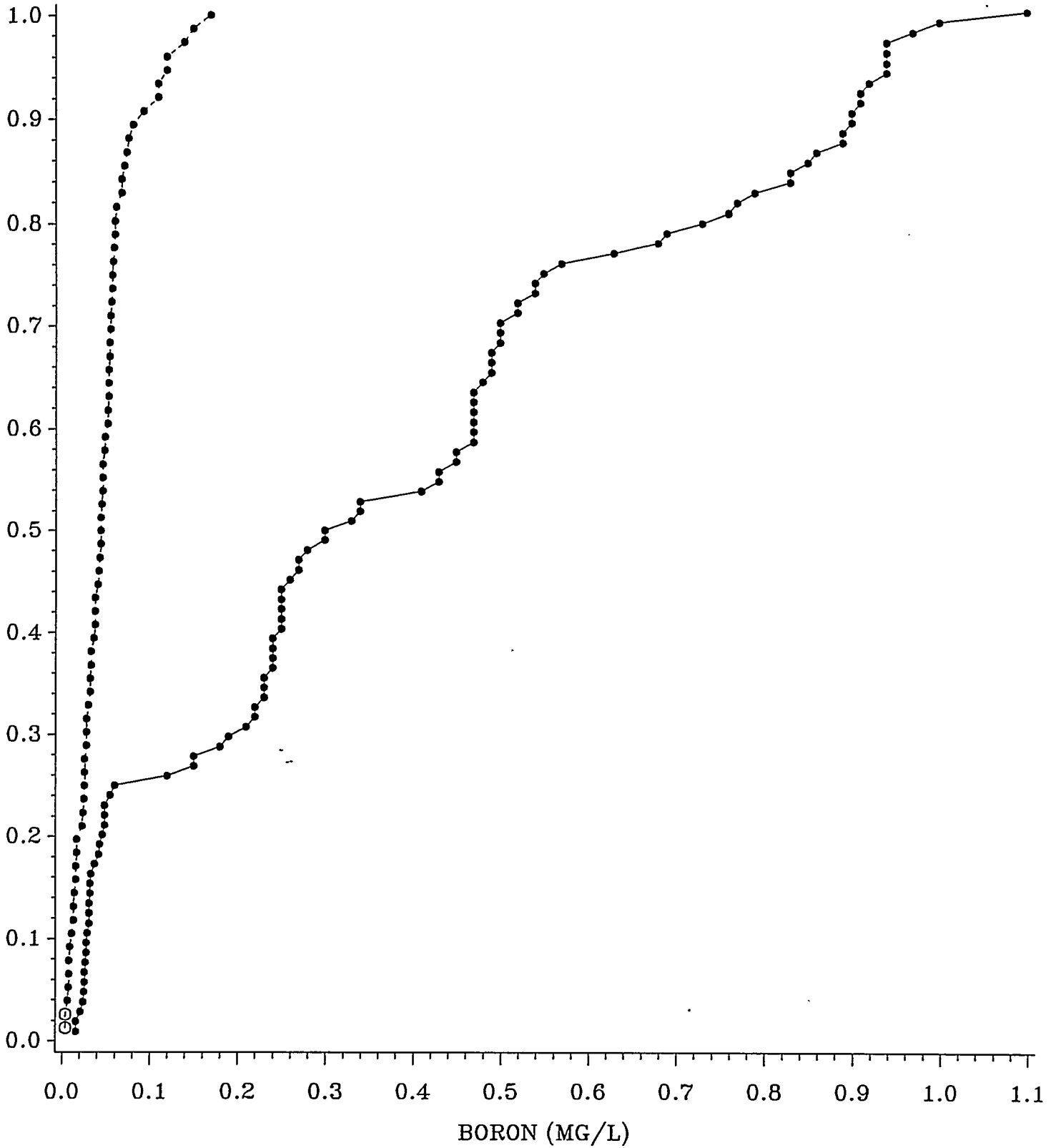


Area — Down-Gradient - - - - - Up-Gradient

Figure F-10. Barium cumulative frequency plots.

Small symbols indicate detects. Open symbols represent nondetects.

Kerr Hollow Groundwater Data 1986-1994
 Cumulative Frequency Plots



Area ——— Down-Gradient - - - - - Up-Gradient

Figure F-11. Boron cumulative frequency plots.

Open symbols indicate detects. Open symbols represent nondetects.

Kerr Hollow Groundwater Data 1986-1994
 Cumulative Frequency Plots

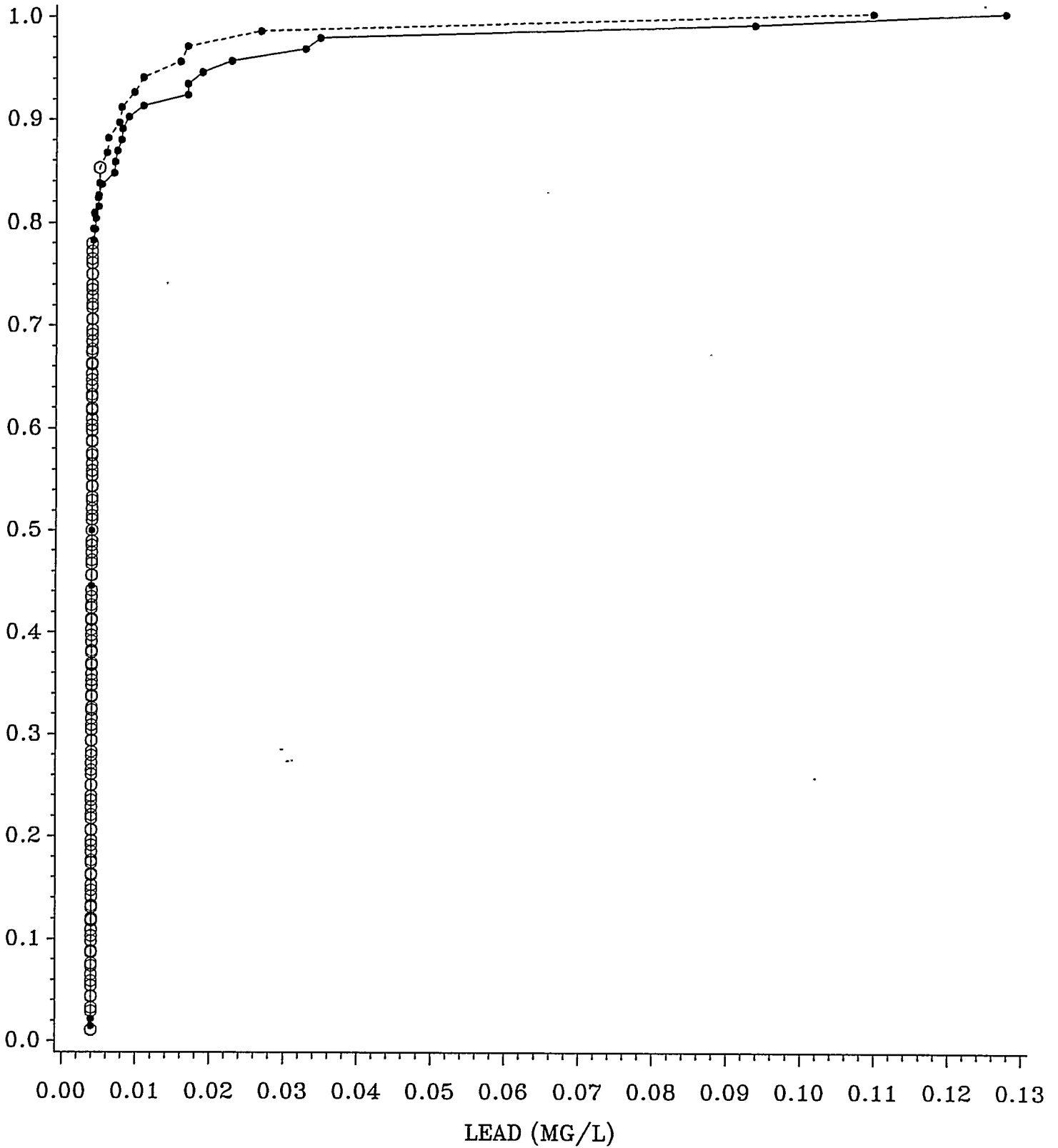
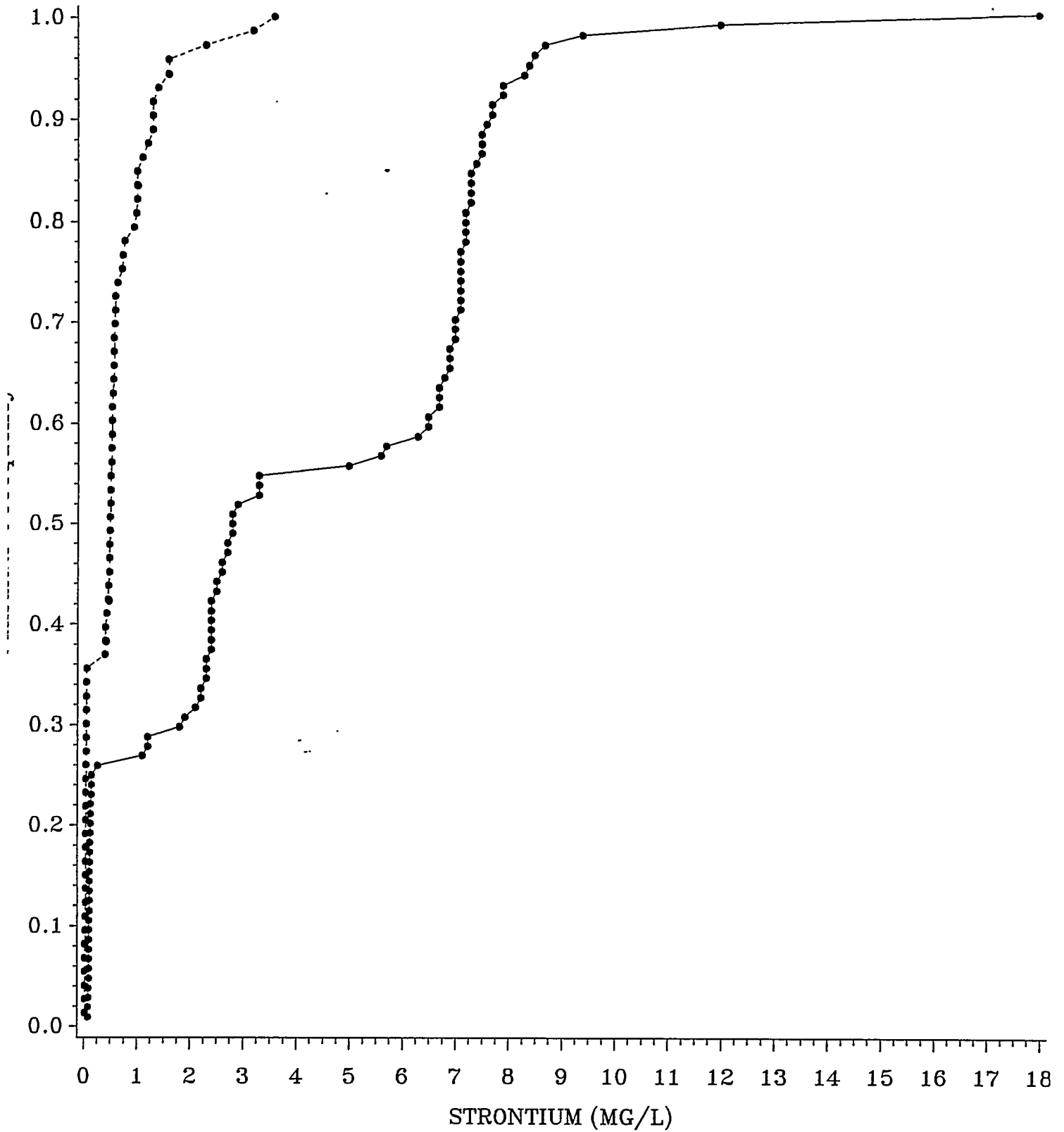


Figure F-12. Lead cumulative frequency plots.

filled symbols indicate detects. Open symbols represent nondetects.

Kerr Hollow Groundwater Data 1986-1994
 Cumulative Frequency Plots

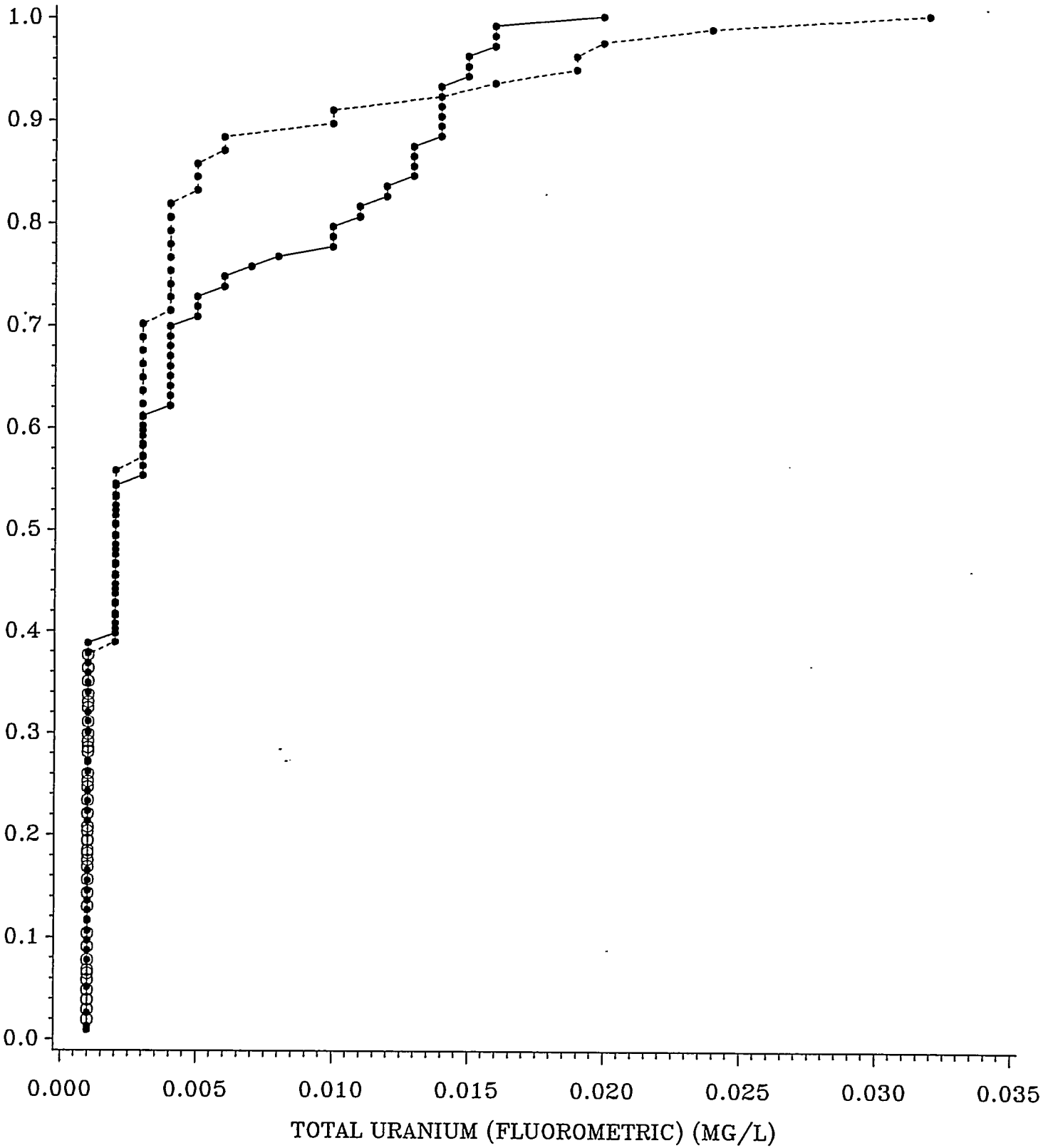


Area ——— Down-Gradient - - - - - Up-Gradient

Figure F-13. Strontium cumulative frequency plots.

lid symbols indicate detects. Open symbols represent nondetects.

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Area — Down-Gradient - - - - - Up-Gradient

Figure F-14. Total Uranium cumulative frequency plots.

id symbols indicate detects. Open symbols represent nondetects.