Date of Issue: February 21, 1995

Y/ER/SUE/91-ALV96/6, Rev. 2

**POST-CLOSURE PERMIT APPLICATION
FOR THE UPPER EAST FORK POPLAR CREEK HYDROGEOLOGIC REGIME
AT THE Y-12 PLANT: NEW HOPE POND AND
EASTERN S-3 PONDS PLUME**

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Prepared 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
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the U.S. DEPARTMENT OF ENERGY
Under Contract No. DE-AC05-84OR21400**

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PREFACE

This Post-Closure Permit Application for the New Hope Pond and the eastern S-3 Ponds plume within the Upper East Fork Poplar Creek Hydrogeologic Regime at the Y-12 Plant (Y/ER/SUB/91-ALV96/6) was prepared in accordance with requirements under the Resource Conservation and Recovery Act for obtaining a post-closure permit. This report was performed under Work Breakdown Structure 1.4.12.1.1.06 (Activity Data Sheet 2306). This document provides the Tennessee Department of Environment and Conservation and the Environmental Restoration Program with information about the history of New Hope Pond and the S-3 Ponds, results of previous groundwater monitoring programs, and proposed groundwater monitoring programs. This report also describes post-closure care activity for New Hope Pond and the S-3 Ponds.

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LIST OF ACRONYMS

ARAR	applicable and relevant or appropriate requirements
ASTM	American Society for Testing and Materials
Bear Creek Regime	Bear Creek Hydrogeologic Regime
BCV	Bear Creek Valley
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
Chestnut Ridge Regime	Chestnut Ridge Hydrogeologic Regime
COCs	constituents of concern
CY	calendar year
DCA	dichloroethane
DCE	dichloroethene
DOE	Department of Energy
EFPC	East Fork Poplar Creek
East Fork Regime	Upper East Fork Poplar Creek Hydrogeologic Regime
Energy Systems	Martin Marietta Energy Systems, Inc.
EPA	Environmental Protection Agency
EP	extraction procedure
FFA	Federal Facility Agreement
ft	feet
ft/day	feet per day
gpd	gallons per day
gpm	gallons per minute
GWPP	Groundwater Protection Program
GWPPM	Groundwater Protection Program Manager
GWQAR	Groundwater Quality Assessment Report
GWQR	Groundwater Quality Report
HWDU	Hazardous Waste Disposal Unit

in.	inches
MCL	maximum contaminant level
meq/L	milliequivalent per liter
mgd	million gallons per day
mg/L	milligrams per liter
MSL	mean sea level
NHP	New Hope Pond
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
OU	Operable Unit
pCi/L	picoCuries per liter
PCE	tetrachloroethene
PCPA	Post-Closure Permit Application
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
RPD	relative percent difference
SWMU	Solid Waste Management Unit
TCA	trichloroethane
TCE	trichloroethene
TDEC	Tennessee Department of Environment and Conservation
TDHE	Tennessee Department of Health and Environment
TDS	total dissolved solids
TSD	treatment, storage and disposal
TSS	total suspended solids
UEFPC	Upper East Fork Poplar Creek
UST	underground storage tank
VOCs	volatile organic compounds
µg/g	micrograms per gram
µg/L	micrograms per liter

A. GENERAL INFORMATION

Ref: 1200-1-11-.07(5)(a)
1200-1-11-.06(2)(a)
1200-1-11-.06(7)(a)
1200-1-11-.06(8)(a)

A.1 INTRODUCTION

The intent of this Post-Closure Permit Application (PCPA) is to satisfy the post-closure permitting requirements of the Tennessee Department of Environment and Conservation (TDEC) Rule 1200-1-11 (Tennessee Department of Environment and Conservation 1994). This application is for the entire Upper East Fork Poplar Creek Hydrogeologic Regime (East Fork Regime), which is within the Bear Creek Valley (BCV). This PCPA has been prepared to include the entire East Fork Regime because, although there are numerous contaminant sources within the regime, the contaminant plumes throughout the East Fork Regime have coalesced and can no longer be distinguished as separate plumes. This PCPA focuses on two recognized Resource Conservation and Recovery Act (RCRA) interim status units: New Hope Pond (NHP) and the eastern S-3 Ponds plume.

This PCPA presents data from groundwater assessment monitoring throughout the regime, performed since 1986. Using this data, this PCPA demonstrates that NHP is not a statistically discernible source of groundwater contaminants and that sites upgradient of NHP are the likely sources of groundwater contamination seen in the NHP vicinity. As such, this PCPA proposes a detection monitoring program to replace the current assessment monitoring program for NHP.

A PCPA was prepared for the S-3 Ponds (Geraghty & Miller, Inc. 1993), located in the Bear Creek Hydrogeologic Regime (Bear Creek Regime), which addressed site maintenance and corrective action monitoring. The S-3 Ponds lie just west of a topographic and shallow groundwater divide. During operation of the S-3 Ponds, groundwater mounding occurred, which resulted in a contaminant plume that migrated

eastward into the East Fork Regime (eastern S-3 Ponds plume). As such, this PCPA addresses the eastern S-3 Ponds plume and proposes a corrective action monitoring program focusing on contaminant transport through exit pathways.

A.2 FACILITY DESCRIPTION

Ref: 1200-1-11-.07(5)(a)
1200-1-11-.06(2)(a)

New Hope Pond and the S-3 Ponds are located on U.S. Department of Energy (DOE) property at the Y-12 Plant, Oak Ridge, Tennessee (EPA ID #TN3-89-009-0001) (Plate A-1). The location of the Y-12 Plant is presented in Figure A-1. The Oak Ridge Y-12 Plant was built by the U.S. Army Corps of Engineers in 1943 as part of the Manhattan Project. Until 1992, the primary mission of the Y-12 Plant was the production and fabrication of nuclear weapons components. Activities associated with these functions included production of lithium compounds, recovery of enriched uranium from scrap material, and fabrication of uranium and other materials into finished parts for assemblies. Fabrication operations included vacuum casting, arc melting, powder compaction, rolling, forming, heat treating, machining, inspection, and testing.

Currently, the Y-12 Plant is refocusing its technical capabilities and expertise to serve DOE and other DOE-approved customers. The Y-12 Plant continues to serve as a key manufacturing technology center for the development and demonstration of unique materials, components, and services of importance to DOE and the nation. Specific focus areas for the Y-12 Plant in coming years include: (1) weapons dismantlement and storage; (2) enriched uranium materials warehousing and management; (3) nuclear weapons process technology and development support; (4) Y-12 Plant management/landlord activities including taking standby or shutdown facilities into a safe, legally compliant condition; (5) identifying and managing the decontamination and decommissioning of facilities;

(6) providing unique capabilities and technologies not found in the private sector on DOE-approved tasks; (7) transferring technology developed at DOE facilities to enhance the United States' industrial competitive edge in worldwide markets; and (8) maintain and support the National Security Program Office for DOE.

As a result of previous activities within the Y-12 Plant, areas containing waste products have been under investigation as possible sources of contamination. This PCPA addresses two potential sources: the NHP and the eastern S-3 Ponds plume. A complete summary of the S-3 Ponds waste characteristics, Post-Closure Care Plan, and interim status monitoring was provided in the S-3 Ponds PCPA (Geraghty & Miller, Inc. 1993) and will not be reiterated herein.

A.2.1 New Hope Pond

New Hope Pond is located in the eastern portion of the Oak Ridge Y-12 Plant (Figure A-2) and the eastern portion of the East Fork Regime within BCV (Figure A-3). New Hope Pond was an unlined, man-made settling basin. It was constructed in 1962 to remove suspended solids and to regulate pH fluctuations from Upper East Fork Poplar Creek (UEFPC) which receives Y-12 Plant discharges prior to entering the East Fork Poplar Creek (EFPC). The surface area of NHP was 5.2 acres, with a volume of approximately 46,500 cubic yards, about 24,000 of which were typically filled with sediment.

Flow from UEFPC entered NHP by way of 12 discharge inlets located in a diversion-distribution channel. Operation of NHP ceased on November 8, 1988. Since closure of the pond in 1990, the channel has been re-routed around to the south and east of NHP to deliver flow into Lake Reality.

In November 1988, DOE began the process of draining NHP for closure as described in the February 29, 1988 Closure Plan (Appendix A.1), which was approved by the TDEC [formerly Tennessee Department of Health and Environment (TDHE)]. Closure included discharging water in NHP through the National Pollutant Discharge Elimination System (NPDES) monitoring point, dredging sediments from the diversion-distribution channel and placing them in NHP, and upgrading the diversion-distribution channel. Also, an oil skimmer basin was removed which was located at the inlet to NHP and was used to collect any residual oil from the inflow. Closure of NHP was officially completed on April 30, 1990 with the installation of a multi-layer cap. Sediments that accumulated in the pond during operation were left in place during the closure process.

A.2.2 S-3 Ponds

The S-3 Ponds are located adjacent to the west end of the Oak Ridge Y-12 Plant (Figure A-2). Although the S-3 Ponds lie west of the natural groundwater divide that separates the Bear Creek Regime and the East Fork Regime (Figure A-3), operation of the site and associated groundwater mounding, when coupled with preferred along-strike groundwater flow in the Oak Ridge Reservation (ORR) Aquitards, enabled contaminants from the S-3 Ponds to migrate eastward into the East Fork Regime. Since termination of waste disposal at the S-3 Ponds in calendar year (CY) 1984, the mound in the water table has abated and is no longer present.

In 1988, the S-3 Ponds were closed in accordance with the requirements of TDEC Rule 1200-1-11-.05. Final closure of the site was certified by the TDEC on November 15, 1990. A PCPA was prepared for the S-3 Ponds (Geraghty & Miller, Inc. 1993) and a permit issued (Tennessee Department of Environment and Conservation 1993). Additional information regarding the S-3 Ponds is contained in the S-3 Ponds PCPA (Geraghty & Miller, Inc. 1993) and the S-3 Ponds Post-Closure Permit (Tennessee Department of Environment and Conservation 1993).

A.3 WASTE CHARACTERIZATION

Ref: 1200-1-11-.07(5)(a)
1200-1-11-.06(2)(a)

A.3.1 New Hope Pond

In May 1983, core samples were taken from NHP by Union Carbide Corporation and analyzed for various contaminants. In addition, samples were subjected to the extraction procedure (EP) toxicity test method. A total of seven core samples were taken using procedures outlined in the American Society for Testing and Materials (ASTM) (1452-80 Standard Practice for Soil Investigation and Sampling by Auger Borings) and U.S. Environmental Protection Agency (EPA) standards (EPA-600/2-80-018, January 1980, Samplers and Sampling Procedures for Hazardous Waste Streams) (Union Carbide Corporation 1983a). Results of these analyses are presented in Tables A-1 and A-2. These results showed that the materials were not hazardous wastes based on EP toxicity testing criteria (Roy F. Weston 1988a).

After the May 1983 analytical results were reviewed, it was decided that further sampling and analyses would be necessary to determine if the pond sediments were hazardous as defined by the RCRA. In September 1983, ten additional samples of NHP sediment were collected by Union Carbide Corporation. At each of the ten sample locations, three 2-inch (in.) diameter cores were collected and composited into a single sample which were analyzed for the constituents listed on Table A-3 (Union Carbide Corporation 1983b). These analytical results demonstrated that the NHP sediments were not a RCRA characteristic hazardous waste.

In the Fall of 1987, a sediment and surface-water sampling program which was designed to confirm results of previous sampling and analytical programs was conducted at NHP (Roy F. Weston, Inc. 1988a). A total of 25 locations were sampled and analyzed

for the Appendix IX constituents. Seventeen locations in the pond were chosen by random selection procedures as described in EPA publication SW-846. An additional eight locations were sampled from the inlet and diversion-distribution channels for adequate characterization. Vibra-core sampling and manual coring techniques were used to collect the samples. Analytical results for sediment and surface water are presented on Tables A-4 and A-5, respectively (Roy F. Weston, Inc. 1988b). These results were in concurrence with the 1983 sampling results.

A.3.2 S-3 Ponds

Information pertaining to the waste characteristics of S-3 Ponds is provided in the S-3 Ponds PCPA (Geraghty & Miller, Inc. 1993) and the Post-Closure Permit for the S-3 Ponds (Tennessee Department of Environment and Conservation 1993).

A.4 LOCATION

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

The Y-12 Plant is located in BCV which is flanked on the north by Pine Ridge and on the south by Chestnut Ridge. Based on surface-water drainage characteristics and groundwater flow patterns, three hydrogeologic regimes have been established (Figure A-3) for the purpose of groundwater quality assessment and reporting: the Bear Creek Regime, the East Fork Regime, and the Chestnut Ridge Hydrogeologic Regime (Chestnut Ridge Regime). The East Fork Regime encompasses the Y-12 Plant, extending west from NHP to the divide located near the west end of the Plant that separates the East Fork Regime from the Bear Creek Regime.

A.4.1 New Hope Pond

New Hope Pond is located in the eastern portion of the Y-12 Plant (Plate A-1 and Figure A-2). The site occupies approximately 5.2 acres situated within plant grid

coordinates E 63,292 to E 64,132 and N 28,700 to N 29,153 (King and Haase 1987). The elevation of the outer boundary of the facility is approximately 905 feet (ft) above mean sea level (MSL), and the post-closure surface covering NHP has an elevation ranging from approximately 910 to 915 ft MSL. The average water elevation of NHP prior to closure was 901.6 ft MSL with seasonal fluctuations of less than 0.75 ft in 1986 (CH₂M Hill et al. 1989). New Hope Pond is within the 100-year floodplain of UEFPC (Plate A-2).

A.4.2 S-3 Ponds

The S-3 Ponds are located just west of a topographic divide separating the headwaters of Bear Creek to the southwest from the headwaters of UEFPC to the northeast (Figure A-3). Additional information pertaining to the location of the S-3 Ponds is provided in the S-3 Ponds PCPA (Geraghty & Miller, Inc. 1993) and the S-3 Ponds Post-Closure Permit (Tennessee Department of Environment and Conservation 1993).

A.5 TRAFFIC PATTERNS

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

The Y-12 Plant is served by three major interstate highways. The rural 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, the principal access to the site, 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).

Vehicle access to NHP is via Scarboro Road to 2nd Street. Vehicle access to the S-3 Ponds is via Bear Creek Road (Figure A-4). Vehicle traffic along 2nd Street and Bear Creek Road is restricted to authorized personnel and official use only.

A.6 SECURITY PROCEDURES AND EQUIPMENT

Ref: 1200-1-11-.07(5)(a)
1200-1-11-.06(2)(a)

The Oak Ridge Y-12 Plant is a DOE facility which produces and handles nuclear materials. There are security procedures and equipment that prevent unauthorized entry into the facility. The Y-12 Plant has 24-hour surveillance and security. New Hope Pond is located in a controlled-access area that is patrolled regularly by security personnel. Off-shift hours access to NHP is possible only through security check points. The locations of gates and portals in the vicinity of NHP are illustrated on Figure A-4. Posted at regular intervals along the perimeter of the site are warning signs stating the following, or similar, message:

"Danger — Unauthorized Personnel Keep Out"

No languages other than English are necessary for the signs in the area and all signs are legible from a distance of at least 25 ft.

Information pertaining to the security procedures and equipment for the S-3 Ponds is provided in the S-3 Ponds Post-Closure Permit (Tennessee Department of Environment and Conservation 1993).

A.7 INSPECTION SCHEDULE

Ref: 1200-1-11-.07(5)(a)
1200-1-11-.06(2)(a)
1200-1-11-.06(11)(a)

Inspections of NHP will be conducted to ensure that the integrity of the closure and post-closure activities is maintained.

The inspections will identify any breach to the cap as well as any malfunctions of monitoring equipment, safety equipment, or security devices associated with post-closure care of the properties. Throughout the post-closure care period all components of the cap will be inspected quarterly. Groundwater monitoring wells will be inspected annually. Detailed inspection activities are discussed in the Post-Closure Plan (Appendix A.2). Notification of damage or need of maintenance of NHP monitoring wells will be made to the Y-12 Plant Groundwater Protection Program Manager (GWPPM). All inspection records and other RCRA documentation for NHP will be maintained at the Y-12 Plant.

A discussion of the inspection schedule for the S-3 Ponds is provided in the S-3 Ponds Post-Closure Permit (Tennessee Department of Environment and Conservation 1993).

A.8 TRAINING

Ref: 1200-1-11-.07(5)(a)
1200-1-11.06(2)(a)

Training will be provided to employees conducting inspections to satisfy the requirements of the post-closure permit. The Y-12 Plant GWPPM or authorized designee will train the field personnel who will be performing the well inspections to familiarize them with: 1) the purpose for, and objectives of, well inspection and maintenance; 2) the well inspection items; 3) the well inspection procedure; 4) the well-depth measurement procedure; 5) the proper completion of the well inspection and maintenance documentation; and 6) what conditions must be brought to the attention of the Y-12 Plant GWPPM. Training will be provided prior to program implementation and updated annually.

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

- identifying soil erosion;
- evaluating impervious and vegetative cover;

- identifying cover settlement or subsidence;
- evaluating run-on and run-off drainage systems;
- examining monitoring wells and benchmarks;
- rodent control; and
- identifying unauthorized deliveries/dumpings.

A checklist will be used during the inspection and maintained for inspection records. Figures 1 and 2 of the Post-Closure Plan for NHP (Appendix A.2) show examples of checklists to be used during post-closure inspections. The Post-Closure Plan for the S-3 Ponds is presented in the S-3 Ponds PCPA (Geraghty & Miller, Inc. 1993) and the S-3 Ponds Post-Closure Permit (Tennessee Department of Environment and Conservation 1993).

A.9 CLOSURE AND POST-CLOSURE PLAN

Ref: 1200-1-11-.07(5)(a)
1200-1-11-.06(7)(a)

The Closure and Post-Closure plans for NHP are provided in Appendix A.1 and Appendix A.2, respectively. The purpose of the Post-Closure Plan is to describe activities that will be performed during the post-closure care period. Appendix A.3 contains the Closure Certification letter from TDEC stating that the closure has been performed in accordance with the approved Closure Plan.

The S-3 Ponds Closure Plan is provided in the S-3 Ponds PCPA (Geraghty & Miller, Inc. 1993). The Post-Closure Plan is found in the S-3 Ponds Post-Closure Permit (Tennessee Department of Environment and Conservation 1993).

A.10 CONTINGENCY PLAN

Ref: 1200-1-11-.07(5)(a)
1200-1-11-.06(7)(a)

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

A.11 NOTICES REQUIRED FOR DISPOSAL FACILITIES

Ref: 1200-1-11-.07(5)(a)
1200-1-11-.06(7)(a)

Following closure of NHP, DOE submitted to TDEC and the Anderson County Zoning Authority a survey plat for NHP, that was prepared and certified by a professional land surveyor licensed in the State of Tennessee (Plate A-3). The survey plat accurately represents the location and dimensions of NHP with reference to permanently surveyed benchmarks. A survey plat of the S-3 Ponds is presented in the S-3 Ponds PCPA (Geraghty & Miller, Inc. 1993).

A record describing the types, location, and quantity of hazardous wastes disposed at NHP based upon the best available knowledge was also submitted. The DOE ORR property does not have a deed; therefore, if any Y-12 Plant property on which hazardous wastes have 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.

A.12 CLOSURE AND POST-CLOSURE COST ESTIMATES

Ref: 1200-1-11-.07(5)(a)
1200-1-11-.06(8)(a)

As stated in part 264.140(c) of the U.S. Code of Federal Regulations (CFR), federal facilities are exempt from the requirements for closure and post-closure cost estimates mandated by the above-referenced regulations.

A.13 TOPOGRAPHIC MAP

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

A topographic map of NHP which fulfills all the requirements of the above-referenced regulation is provided on Plate A-2. A topographic map of the S-3 Ponds is provided in the S-3 Ponds PCPA (Geraghty & Miller, Inc. 1993).

A.14 LIABILITY INSURANCE
Ref: 1200-1-11-.07(5)(a)

As stated in CFR 264.140(c), federal facilities are exempt from the liability insurance requirements of the above referenced regulation.

A.15 POST-CLOSURE CONTACT
Ref: 1200-1-11-.07(5)(a)

The address and phone number of the office to contact regarding NHP 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

Ref: 1200-1-11-.07(5)

1200-1-11-.06(6)

1200-1-11-.05(6)

B.1 SUMMARY OF INTERIM STATUS DATA

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

1200-1-11-.05(6)(a)

In 1984, EPA and the TDEC determined that several of the waste-management sites at the Y-12 Plant were hazardous waste TSD units subject to regulation under RCRA. One of these TSD units, NHP, was granted RCRA interim status in 1986. Between 1987 and 1989, several other waste-management sites in the East Fork Regime were identified as solid waste management units (SWMUs) (Figure B-1 and Table B-1) subject to regulation under section 3004(u) of RCRA (Welch 1987; Welch et al. 1987; Wiggins and Welch 1988a and b; and Murphy 1989). A RCRA Facility Investigation was planned for each of these sites to determine if contaminant releases to the environment had occurred.

In November 1989, the ORR was added to the National Priorities List (NPL) and in January 1992, the DOE, EPA, and TDEC negotiated a Federal Facility Agreement (FFA) regarding environmental restoration at the ORR under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). This agreement changed the regulatory status of several of the RCRA-regulated SWMUs in the East Fork Regime to CERCLA Operable Units (OUs). As such, the DOE appealed the applicability of RCRA permitting, post-closure care, corrective action, and groundwater monitoring requirements to CERCLA OUs. This appeal was formally resolved in April 1993 when DOE, Martin Marietta Energy Systems, Inc. (Energy Systems), and TDEC signed an Agreed Order for the S-3 Ponds Hazardous Waste Disposal Unit (HWDU) to proceed with CERCLA as the lead regulatory requirement and RCRA as an applicable, relevant, and appropriate requirement (ARAR).

Under this agreement, RCRA will be applied as an ARAR to the extent that post-closure maintenance and care of former TSD facilities will be conducted in compliance with the terms of RCRA post-closure permits. Groundwater monitoring is to be integrated with the CERCLA Remedial Investigation/Feasibility Study (RI/FS) programs with RCRA corrective action deferred to CERCLA. Groundwater monitoring data reporting will comply with RCRA post-closure permit conditions as well as RI/FS requirements.

Two types of OUs were established under the FFA: source control OUs and integrator OUs. Source control OUs are individual or groups of waste sites for which a RI/FS is required, including any interim actions and/or remedial actions. Integrator OUs encompass groundwater and surface water, and are considered separate from source control OUs that contribute to the contamination of these media. Integrator OUs were established because available data showed that contaminants from multiple sources had intermingled in the groundwater system and migrated through a common exit-pathway (U.S. Department of Energy 1994).

The UEFPC OU1 is the integrator OU established by the FFA for the East Fork Regime and includes groundwater in the regime and areas within the Y-12 Plant where elemental mercury was routinely handled during the extraction process for lithium isotopes at the Y-12 Plant between 1955 and 1962 (U.S. Department of Energy 1994). The integrator OU was established because monitoring results obtained since the mid-1980s indicated that groundwater contamination in the regime resulted from releases from several separate sources, possibly including the mercury process spill areas.

A complete summary of interim status of the S-3 Ponds was provided in the S-3 Ponds PCPA (Geraghty & Miller, Inc. 1993) and will not be reiterated here.

B.1.1 Monitoring-Well Network

B.1.1.1 New Hope Pond

Numerous monitoring wells, in addition to the assessment monitoring wells associated with NHP, are sampled quarterly to monitor the nature and extent of groundwater contamination in the East Fork Regime. The following paragraphs discuss the installation of monitoring wells at or near NHP.

During the summer and fall of 1985, 11 monitoring wells were installed at NHP by Geotek Engineering Company under the supervision of Energy Systems (Geraghty & Miller, Inc. 1987a). Well clusters comprised of three wells each were installed to the east (GW-150, GW-151, and GW-220), southeast (GW-152, GW-153, and GW-240), and west (GW-154, GW-222, and GW-223) of NHP to monitor groundwater in the unconsolidated zone, and bedrock beneath NHP. A two-well cluster was installed north of NHP which included wells GW-148 and GW-149 screened in the unconsolidated zone and the upper shallow bedrock, respectively (Figure B-2 and Table B-2).

In the spring and summer of 1988, six additional wells were installed for assessment monitoring purposes (Geraghty & Miller, Inc. 1989a). These wells comprise two three-well clusters located to the west (GW-380, GW-381, and GW-382) and northwest (GW-383, GW-384, and GW-385) of NHP (Figure B-2 and Table B-2).

Two additional two-well clusters (GW-603/GW-604 and GW-605/GW-606), critical to evaluation of groundwater quality in the vicinity of NHP, were installed in 1989 and 1991, respectively. These wells were installed under the supervision of the Y-12 Plant Groundwater Protection Program (GWPP) as part of exit pathway monitoring. Monitoring wells GW-603 and GW-604 were installed in the Maynardville Limestone east of NHP, and monitoring wells GW-605 and GW-606 were installed in the Maynardville Limestone

west of NHP (Figure B-2). Wells GW-603 and GW-604 were installed to collect additional downgradient hydraulic head and chemical data, while wells GW-605 and GW-606 were installed to determine the extent of volatile organic compounds (VOCs) present upgradient of the site within the Y-12 Plant area. Other pertinent exit pathway wells downgradient of NHP include: GW-167, GW-168, and GW-239 (installed during the spring of 1986); the easternmost exit pathway transect including wells GW-733, GW-735, GW-750 (installed during the fall of 1991 and the winter of 1992); GW-722 a multiport monitoring well (installed in the spring of 1991); and grid wells GW-744 through GW-749, GW-751 and GW-752, GW-762 and GW-763, and GW-817, which were constructed between mid-1992 and July 1994 (Figure B-2).

B.1.1.2 S-3 Ponds

Groundwater monitoring for the S-3 Ponds is addressed in the PCPA for the site (Geraghty & Miller, Inc. 1993). The S-3 Ponds fall within the Bear Creek Regime and, therefore, have not had a specific assessment monitoring well network installed within the East Fork Regime. However, the eastern plume from the S-3 Ponds can be traced by wells installed in the western portions of the Y-12 Plant under a variety of regulatory and best management practice drivers. Table B-2 provides a list of the wells in the vicinity of the S-3 Ponds within the East Fork Regime and Figure B-2 shows the location of each of these wells. Detailed descriptions of the monitoring well network over time can be found in the annual Groundwater Quality Assessment Reports (GWQARs).

B.1.2 Groundwater Sampling and Analysis

The majority of historical groundwater sampling activities within the East Fork Regime have addressed the purposes of four monitoring programs: (1) RCRA assessment monitoring, (2) underground storage tank (UST) monitoring, (3) exit-pathway monitoring,

and (4) grid-well monitoring. Each of these monitoring programs is implemented within the context of the technical approach contained in the Comprehensive Monitoring Plan (Geraghty & Miller, Inc. 1990c). However, in light of the increase in regulatory requirements, such as those imposed by the listing of the ORR on the NPL, an increasing number of wells are sampled to meet multiple programmatic goals (HSW Environmental Consultants, Inc. 1994a). Additionally, exit-pathway and grid-well monitoring is implemented by the Y-12 Plant GWPP to comply with the requirements contained in DOE Order 5400.1.

Groundwater monitoring within the East Fork Regime during 1993 involved the collection of groundwater samples from 93 monitoring wells, 12 of which specifically monitored NHP (HSW Environmental Consultants, Inc. 1994b). A detailed discussion regarding the monitoring program is provided in the Annual Groundwater Quality Report (GWQR) for the 1993 comprehensive groundwater monitoring program (HSW Environmental Consultants, Inc. 1994a). A discussion of the historical progression of monitoring at NHP and the S-3 Ponds is contained in the following sections.

B.1.2.1 New Hope Pond

Interim status detection monitoring was begun at NHP in February 1986 in conjunction with the Y-12 Plant base program developed by Energy Systems (Geraghty & Miller, Inc. 1987b). Quarterly sampling in 1986 of the 11 wells installed in 1985 at NHP established background concentrations for drinking water parameters, water quality parameters and contamination indicator parameters (Table B-3). Groundwater samples were also analyzed for VOCs, uranium, and total and dissolved metals. Concentrations of contamination indicator parameters from second quarter 1987 samples were statistically compared with background values in accordance with the procedures outlined in the Appendix .05/C of the former Tennessee's Hazardous Waste Management Regulations (Rule Chapter 1200-1-11) (Tennessee Department of Health and

Environment 1986). The statistical results showed a significant change in pH and specific conductance in wells downgradient of the site compared to background measurements. Confirmatory samples were not collected because low concentrations of VOCs had been consistently detected during the previous four quarters suggesting that groundwater beneath NHP was contaminated.

An assessment program, which was approved by TDEC, was initiated to further investigate groundwater quality in the vicinity of NHP. In the fall of 1987, Energy Systems began a one-time, plant-wide Appendix IX sampling and analyses program which incorporated over 100 monitoring wells, including ten wells located at NHP (Table B-4) (Roy F. Weston 1988a).

A groundwater quality assessment plan was prepared as required by Rule 1200-1-11-.05(6)(a)4 (Geraghty & Miller, Inc. 1987b); and, beginning in the first quarter of 1988, groundwater quality assessment monitoring was initiated at the 11 existing wells at NHP (Geraghty & Miller, Inc. 1989a). Groundwater samples were collected from these wells in March, June, August, and October 1988 and analyzed for the constituents listed in Table B-5. Also, monitoring wells GW-383, GW-384, and GW-385 were sampled in August and October 1988, and wells GW-380, GW-381 and GW-382 were sampled in December 1988 (Geraghty & Miller, Inc. 1989a). Results of the assessment monitoring program are detailed in the GWQARs submitted to TDEC annually and are summarized in Section B.4.

Starting in 1989, with the implementation of the comprehensive groundwater monitoring program for all regulated units at the Y-12 Plant, the 1988 list of assessment monitoring parameters was amended. This list of constituents was refined during subsequent monitoring periods to reflect results obtained from previous events. Tin and several VOCs were added in CY 1989 while several other VOCs, not previously detected, were removed from the list (Table B-6). Tin and acrylonitrile were deleted from the 1990 list of assessment parameters because they were not detected during 1989 sampling;

however, 15 metals, 10 radionuclides, and several field and miscellaneous parameters were added to the 1990 list (Table B-7). Assessment parameters for 1991 remained the same as those for 1990 except for the deletion of six radionuclides which were not detected during the 1990 sampling (Table B-8). Assessment parameters for 1992 and 1993 are presented on Tables B-9 and B-10, respectively. Wells associated with 1993 RCRA assessment monitoring for NHP are presented on Table B-11. Table B-2 provides general construction data for all wells included in the RCRA assessment monitoring program.

B.1.2.2 S-3 Ponds

Information on the groundwater sampling and analysis activities for the S-3 Ponds is provided in the S-3 Ponds PCPA (Geraghty & Miller, Inc. 1993) and the Post-Closure Permit for the S-3 Ponds (Tennessee Department of Environment and Conservation 1993).

B.2 HYDROGEOLOGIC FRAMEWORK

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

The following sections of this chapter have been prepared, as required under the above-referenced rule, to identify the uppermost aquifers that are hydraulically connected beneath the areas within the East Fork Regime. The information provided below was obtained from the 1993 GWQAR (HSW Environmental Consultants, Inc. 1994b).

B.2.1 Regional Geology

The Y-12 Plant is located in the Valley and Ridge Physiographic Province which extends roughly 500 miles from Alabama northeast to Virginia (Figure B-3). The province is approximately 50 miles wide and is characterized by long, narrow ridges of resistant Paleozoic sandstones, siltstones, and siliceous limestones with intermediate valleys of less resistant shales and soluble carbonates (Rodgers 1953).

Bedrock geology in the Valley and Ridge province is predominantly represented by four units: the Rome Formation and the Conasauga, Knox, and Chickamauga groups. These units occur in repeating northeast-southwest oriented bands and are Cambrian to Ordovician in age. Lesser areas of exposed alternating outcrops of Late Ordovician to Pennsylvanian sandstone, shale, and limestone exist throughout the province (Rodgers 1953).

The structural framework of the province is characterized by thrust faults and subsidiary faults that are part of a major decollement of the Southern Appalachian thin-skinned orogenic thrust belt (Roeder et al. 1978). Movement along thrust faults in the region toward the northwest has placed older stratigraphic sequences on top of younger sequences. Horizontal displacement along major thrust faults is as great as 30 to 60 miles. Regional strike of the strata and thrust faults is to the northeast with a regional dip to the southeast. The dip generally decreases with depth as thrust faults become nearly horizontal and form bedding-plane parallel faults. Other structural features common to the region are unconformities, high angle cross faults oriented normal to the regional strike, joint sets, and small amplitude folds.

B.2.2 Stratigraphic Units

B.2.2.1 Unconsolidated Deposits

Bedrock is overlain by unconsolidated deposits of varying thickness consisting of man-made fill, alluvium, colluvium, and weathered bedrock. The depths to unweathered bedrock differ throughout the valley owing to the different thicknesses of fill and alluvium and the particular weathering characteristics of the bedrock (Geraghty & Miller, Inc. 1985); however, Hoos and Bailey (1986) report a total composite thickness of unconsolidated

materials in BCV that ranges from 10 to 50 ft. Man-made fill material covers most of the industrial portions of the Y-12 Plant and consists of asphalt, cement blocks, wire, wood, plastic, and excavated shale, limestone, and chert intermixed with clay. Residuum weathered from the Maynardville Limestone produces an orange-red, chert-free material; whereas, the Nolichucky Shale develops a clay-rich residuum with abundant shale chips (Rothschild et al. 1984).

B.2.2.2 Bedrock Units

Bedrock units in BCV range from Ordovician to Cambrian in age and include limestones, dolostones, shales, and sandstones. These strata have been classified into groups and formations based on age, lithology, and fossil content. From youngest to oldest, the bedrock units are the Knox Group, the Conasauga Group, and the Rome Formation. Figure B-4 includes a geologic column which illustrates the stratigraphic relationship of these units.

Rocks of the Knox Group have an aggregate thickness of 3,000 to 3,500 ft and consist of gray to blue-gray, thinly- to thickly-bedded dolostone with interbeds of limestone; however, only the lowermost formation of the Knox Group, the Copper Ridge Dolomite, occurs within the study area. The Copper Ridge Dolomite is a tan to medium gray, massive to thinly-bedded, locally chert-rich dolostone containing abundant stylolites.

The Conasauga Group is composed of alternating layers and laminations of shale, siltstone, and limestone that have been divided, based on lithology, into six formations. These formations are, from youngest to oldest, the Maynardville Limestone, Nolichucky Shale, Maryville Limestone, Rogersville Shale, Rutledge Limestone, and Pumpkin Valley Shale. The uppermost bedrock units underlying NHP are the Maynardville Limestone and Nolichucky Shale. The Knox Group crops out to the south of NHP.

The Maynardville Limestone is a light-gray and blue-gray to tan, fine- to coarse-grained, thinly-bedded to massive limestone and dolostone with interbedded dark-red shales. Dolostones are more common in the upper third of the formation whereas the lower two-thirds consist of wavy to even, thinly-bedded to massive micrite, microsparite, and biosparite limestones with oolitic zones and numerous calcareous shale laminae. The thickness of the Maynardville Limestone near NHP is approximately 440 ft (King and Haase 1987). In some areas, extensive solution cavities have been documented in the Maynardville Limestone (Geraghty & Miller, Inc. 1986).

The contact between the Maynardville Limestone and the underlying Nolichucky Shale is gradational over a 15-ft interval characterized by an increase in shale with depth (Haase et al. 1987). The Nolichucky Shale is a maroon-brown to green-gray, massive to very-thinly-bedded, locally calcareous mudstone and shale interstratified with thinly-bedded, medium-gray limestones and calcareous siltstones. The interbedded limestones typically contain limestone-pebble conglomerates and oolite-rich beds. Limestone interbeds commonly are only inches thick, although beds 2 to 3 ft thick have been observed. The total thickness of the Nolichucky Shale near NHP is approximately 490 ft (King and Haase 1987).

The Maryville Limestone is composed of thin to medium-bedded biosparites and calcarenites interbedded with calcareous mudstones and siltstones. Intraformational conglomerates are common in the upper part of the formation. The contact with the overlying Nolichucky Shale is gradational over a 50-ft interval. Commonly jointed and fractured, the Maryville Limestone is approximately 346 to 445 ft thick. Weathering of the Maryville Limestone produces a dark red to reddish-brown clayey soil (Rothschild et al. 1984).

Underlying the Maryville Limestone is the Rogersville Shale. The contact between the two units is characterized by calcareous mudstones grading downward into the massive mudstones of the Rogersville Shale. The Rogersville Shale is a reddish-brown to dark gray shale that weathers to a thin clayey soil containing shale chips. In BCV, the Rogersville Shale is approximately 90 to 120 ft thick (Law Engineering Testing Company 1975).

The Rutledge Limestone, which underlies the Rogersville Shale, is composed of interbedded gray limestones and shales with calcareous siltstones. Increased amounts of limestone distinguish the Rutledge Limestone from the overlying and underlying formations. Shale locally represents up to 75 percent of the Rutledge Limestone, which is approximately 90 to 120 ft thick and which weathers to form a yellow-brown to yellow-orange soil (Law Engineering Testing Company 1975).

The oldest of the Conasauga Group formations, the Pumpkin Valley Shale, crops out along the southeastern edges of ridges formed on the Rome Formation. Predominantly an olive and maroon, massive clayey shale with thin beds of siltstone and sandstone, the Pumpkin Valley Shale is gradational with the Rome Formation but lacks the sandstone that is characteristic of the Rome Formation. The Pumpkin Valley Shale has a low overall hydraulic conductivity and is considered one of the poorest aquifers in East Tennessee (DeBucharanne and Richardson 1956). The formation is approximately 260 to 320 ft thick and weathers to form a clay-rich soil with an abundance of shale chips (Law Engineering Testing Company 1975).

The Rome Formation is a sequence of interbedded sandstones, siltstones, and shales of variegated olive, maroon, and drab colors that conformably underlies the Conasauga Group. Erosion-resistant buff-colored sandstones of the upper Rome Formation form Pine Ridge. The lower part of the formation has been truncated by

faulting, and the total thickness of the unit is unknown (DeBuchananne and Richardson 1956).

B.2.3 Structural Relationships

The dominant structural features in BCV area are the Copper Creek and White Oak Mountain thrust faults. Both faults strike to the northeast and were formed during the Alleghenian Orogeny. Radiometric studies indicated that mylonite from the Copper Creek Fault is 270 to 300 million years old, thereby establishing the latest movements to be Late Pennsylvanian or Early Permian in age (Law Engineering Testing Company 1975).

The Copper Creek Fault is southeast of BCV in Bethel Valley and merges with the White Oak Mountain Fault near Cleveland, Tennessee. Movement along the fault, which generally dips 25° to 30° SE at the ground surface, has thrust the Rome Formation on top of the Chickamauga Group. Stratigraphic displacement is about 7,000 ft (Law Engineering Testing Company 1975).

The White Oak Mountain Fault in the Oak Ridge area is a zone of faulting in which a number of individual thrust faults have juxtaposed various stratigraphic units. This fault zone is exposed northwest of Pine Ridge.

Bedrock strike and dip are generally N 55° E and 45° SE, respectively. At any given location, the strike may range from N 35° to 65° E and the dip may vary from 30° SE to nearly vertical. Strata at NHP dip 40 to 50° to the southeast (King and Haase 1987). Small-scale folds, associated with thrust faulting, are common in the Conasauga Group and contribute to the various bedding orientations observed in the area (Rothschild et al. 1984).

Joint sets are a common structural feature of the strata. Several studies of the joints have indicated that their orientations and spacings are quite variable (Rothschild et al. 1984;

Ketelle and Huff 1984; Lutz, pers. comm. 1988). Each of these studies identified at least one major joint set that roughly parallels geologic strike and dips approximately 40° NW (Geraghty & Miller, Inc. 1985; Lutz, pers. comm. 1988). A second steeply-dipping joint set strikes approximately N 12° W (Rothschild et al. 1984). The presence of this joint set probably accounts for the pattern of parallel tributaries flowing south from Pine Ridge into Bear Creek. Other documented joint set orientations are 35° W with a dip of 35° NE, N 46° W with a dip of 57° NE, and N 50° W with a dip of 72° SW. The orientation of the major joint sets suggests that they were the result of compressional stresses due to thrust faulting during the Appalachian Orogeny. Joint spacings may vary from fractions of an inch to several feet. The greatest concentrations of joints were observed in siltstones and sandstones. Joint density was found to be inversely proportional to the bed thickness in both shales and siltstones.

The development of solution cavities is prevalent in the Knox Group and in the carbonate units of the Conasauga Group. Solution features tend to develop along structural features such as joints, bedding planes, and other zones of weakness which provide avenues along which dissolution can occur. Solution cavities in Bear Creek Valley and on Chestnut Ridge are commonly in the upper part of the saturated zone and may be partly to completely filled with water and/or clay and secondary mineralization (i.e., calcite). The geologic unit at NHP most susceptible to dissolution is the Maynardville Limestone. Documented solution cavities in this formation range from a fraction of an inch to several tens of feet in size (Geraghty & Miller, Inc. 1986).

B.2.4 Surface-Water Systems

B.2.4.1 East Fork Poplar Creek Watershed

UEFPC originates near the western edge of the Y-12 Plant as a surface water drainage system. The headwaters are contained in a network of underground collection

pipes that extend to near the central area of the Y-12 Plant, where the above-ground portion of the creek emerges. The creek then flows along the southern boundary of the Y-12 Plant and enters Lake Reality. From the outfall at Lake Reality, UEFPC passes north through a gap in Pine Ridge and enters the City of Oak Ridge (HSW Environmental Consultants, Inc. 1994b).

During construction of the Y-12 Plant, all the north-south tributaries to UEFPC were backfilled or replaced with storm drains. Additionally, UEFPC was altered by construction of the storm sewer system at its headwaters and straightening of the original channel along the southeastern portion of the Plant complex (PEER Consultants 1989).

Discharge in UEFPC is measured daily at Station 17 located at the outfall of Lake Reality. Current discharge at Station 17 is approximately 3 to 4 million gallons per day (mgd) (Vaughn 1994). Daily streamflow measurements collected at the outfall of NHP during 1986 and 1987 averaged 6.084 and 5.194 mgd, respectively. Precipitation runoff delivered rapidly to the stream by the storm drain system typically results in high but short-lived flow peaks after rainfall events.

B.2.4.2 Surface-Water Use

The nearest surface-water supply within the vicinity of the Y-12 Plant and NHP is obtained from the Clinch River. Several pumping stations are located within 5 miles of NHP. Two of the pumping stations are owned by the DOE and provide water for both domestic and industrial use at the Y-12 Plant (upstream) and ORNL (downstream). Two pumping stations are operated by the West Knox Utility District with a total usage of 4 to 5.5 mgd. This utility supplies 16,000 meters (more than 50,000 customers) with water for domestic use (Heidel, pers. comm. 1994).

B.2.4.3 Precipitation Data

The precipitation data for 1993, shown in Figure B-5, were collected from a site located approximately 1 mile north of the Y-12 Plant. These measurements were made on a daily basis by the National Oceanic and Atmospheric Administration (NOAA) staff (National Oceanic and Atmospheric Administration 1994).

The mean annual precipitation between 1954 and 1983 was 52.2 in. From 1986 to 1988, unusually low readings were recorded in the ORNL area (34.5 in. in 1986 and 41.7 in. in 1987) (National Oceanic and Atmospheric Administration 1994). The driest months usually occur between August and October, which typically have average monthly rainfall ranging from 2.9 to 3.8 in. The wettest months are January through March with typical average monthly rainfall ranging from 5.3 to 6.2 in. (Moore 1988). According to the Oak Ridge Station of the NOAA, the monthly extremes are currently 13.3 in. in January 1954, and 0.5 in. in August 1953.

On the ORR, evapotranspiration consumes, on an average, 30 in. of annual precipitation. Approximately 75 percent (22.5 in.) of evapotranspiration occurs April through September. This information is based on pan evaporation measurements at Norris, Tennessee (Moore 1988).

B.2.5 Groundwater System

According to Solomon et al. (1992), groundwater at the Y-12 Plant occurs in two broad hydrologic units with fundamentally different hydrologic characteristics: the Knox Aquifer and the ORR Aquitards. The Knox Aquifer is comprised of the Knox Group and the underlying Maynardville Limestone Formation of the Conasauga Group. Groundwater flow in the Knox Aquifer is controlled by solution conduits and the bulk permeability is ten times greater than that of the ORR Aquitards. The ORR Aquitards include the remaining Conasauga Group formations, the Rome Formation, and the strata of the Chickamauga

Group. Groundwater flow in the ORR Aquitards is controlled by short, intersecting fractures in a relatively impermeable matrix, and the bulk of the groundwater flows in a shallow zone near the water table.

Solomon et al. (1992) divided the groundwater flow system in both the Knox Aquifer and the ORR Aquitards into four subsystems: (1) the stormflow zone, (2) the vadose zone, (3) the groundwater zone (subdivided into water-table, intermediate, and deep intervals), and (4) the aquiclude (Figure B-6). The divisions are based on the amount of water transmitted by each subsystem (i.e., flux), which decreases with depth; the largest water flux occurs in the stormflow zone and the smallest in the aquiclude.

The groundwater flow system is vertically gradational with no discrete boundaries separating the subsystems. The stormflow zone occurs in regolith as does much of the vadose zone, although in some areas the vadose zone includes weathered and fresh rock. About 90 percent of subsurface flow occurs in the stormflow zone. In the groundwater zone, flow volumes decrease and solute residence times increase sharply with depth. The bulk (98 percent) of groundwater flow occurs at shallow depths (<100 ft below ground surface), and most (80 percent) of this flow occurs in the water-table interval. Below the water-table interval, groundwater flow occurs along permeable fractures (or possibly fractured regions) within a relatively impermeable matrix. Variations in the number and aperture of the fractures within these regions occur along flow paths, and these differences determine lateral and vertical flow directions. Additionally, the vertical spacing between the permeable regions increases with depth, and permeable regions at depth 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 ground surface to a depth of about 6 ft (Moore 1989). Construction of the Y-12 Plant probably destroyed the stormflow zone in developed areas of the East Fork Regime. 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).

Water is present in the stormflow zone during, and for short periods after, significant rainfall events; some of the water is lost to evapotranspiration and recharge to the water table, and the remaining water discharges at nearby seeps, springs, and streams. Analysis of infiltrometer test results from Bethel Valley and Melton Valley suggest that the hydraulic conductivity of the stormflow zone averages about 29 ft per day (ft/day) near the top and 0.1 ft/day near the base (Moore 1989). Lateral flow in the stormflow zone is intermittent, lasting a few days to a few weeks after precipitation. Flow is fairly rapid when the zone is full of water but 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 ORR Aquitards is about 13 ft (Moore 1989). The vadose zone in undeveloped areas is primarily composed of regolith, but in much of the East Fork Regime the vadose zone consists of man-made fill material. Moore (1989)

estimates effective porosity (the porosity through which significant advective transport can occur) for regolith of 0.01 to 0.15, but porosity may be higher in the man-made fill.

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). A geometric mean hydraulic conductivity of about 0.006 ft/day was determined from analysis of infiltrometer tests in the vadose zone in Bethel Valley and Melton Valley (Moore 1989).

B.2.5.3 Groundwater Zone

Solomon et al. (1992) divided the saturated zone in the Knox Aquifer and ORR Aquitards into water-table, intermediate, and deep intervals (Figure B-6) based on observed changes in hydrologic characteristics and groundwater geochemistry with depth. For the purposes of this report, the above subdivisions have been modified for the East Fork Regime to include a shallow interval between the water-table and intermediate intervals. The boundary between the shallow and intermediate intervals is set at 100 ft below ground surface (bgs), which generally corresponds with an aquifer subdivision noted by Moore (1989) in an evaluation of groundwater flow parameters, and is the depth at which a fairly abrupt change from calcium-magnesium-bicarbonate groundwater to sodium-biocarbonate groundwater typically occurs in the ORR Aquitards. Additionally, solution cavities in the Maynardville Limestone occur most frequently at depths less than 100 ft below the ground surface, suggesting that the active karst flow system in the Maynardville Limestone is relatively shallow (Shevenell et al. 1993).

B.2.5.3.1 Water-Table Interval

A permeable interval 3 to 15 ft thick usually occurs in the transitional horizon between regolith and unweathered bedrock, and 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. It is postulated that in the ORR Aquitards, the water-table interval transmits more than 80 percent of the flow that occurs below the stormflow zone. Estimates of the permeability of the water-table zone are provided by results of hydraulic conductivity tests performed in wells completed in regolith below the water table. Analysis of these test results indicated a range of hydraulic conductivity of 0.03 to 3.25 ft/day (Connell and Bailey 1989).

Results of geochemical dating studies of groundwater in 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 ft 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 ft bgs) suggest much greater residence times (Poreda et al. 1988).

In conjunction with assessment monitoring, static water levels within the East Fork Regime were measured in 98 monitoring wells during January (the seasonally high water table) and August/September (the seasonally low water table) 1993 (HSW Environmental Consultants Inc. 1994b). The configuration of the water table is a subdued image of surface topography, with steep gradients along the flanks of Pine Ridge and Chestnut Ridge, and more gentle gradients along the axis of BCV. The general direction of groundwater flow in the ORR Aquitards is toward the Maynardville Limestone, suggesting

that this formation is a discharge point for the hydrogeologic system in the regime. Groundwater flow in the Maynardville limestone is generally to the east, along geologic strike. At the east end of the regime, groundwater flow directions diverge, with one component flowing to the north through a gap in Pine Ridge, and the other component flowing east within the Maynardville Limestone along geologic strike. The horizontal gradient across BCV (normal to strike) is 0.046 and 0.012 along the axis of BCV (parallel to strike) (HSW Environmental Consultants Inc. 1994b).

Groundwater elevation data show that the water table declined on average about 3 ft between the high and low seasons; however, no significant changes occurred in flow directions or horizontal gradients (HSW Environmental Consultants Inc. 1994b). The configuration of the water table within the shallow and intermediate intervals during seasonally high and seasonally low conditions are illustrated in Figures B-7 and B-8, respectively.

B.2.5.3.2 Shallow Interval

The shallow interval of the groundwater zone extends from the bottom of the water-table interval to depths of about 100 ft in the ORR Aquitards, and from 160 to 325 ft in the Knox Aquifer (Moore 1989). Groundwater in this zone is typically encountered under unconfined conditions in fractures and solution cavities. 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. Fractures outnumber the cavities, are interconnected, and provide the continuity for groundwater flow paths (Moore 1989).

Analysis of hydraulic conductivity test results for wells completed at shallow depths in the ORR Aquitards and the Knox Aquifer generally shows two populations: an upper

population with a geometric mean hydraulic conductivity of about 0.15 ft/day and a lower population with a geometric mean hydraulic conductivity of about 0.0008 ft/day (Moore 1989). The upper population represents more permeable, water-producing intervals and the lower population represents less permeable matrix intervals.

The hydraulic conductivity of the water-producing intervals at shallow depths in the Knox Aquifer is much greater owing to an interconnected network of solution cavities and solution-enlarged fractures. For instance, results of hydraulic conductivity tests for wells less than 100 ft deep in the Maynardville Limestone, as summarized in Geraghty & Miller, Inc. (1989a), range from 0.13 to 99 ft/day and average about 22 ft/day. Additionally, Shevenell et al. (1993) report that fractures and solution cavities in the Maynardville Limestone encountered during installation of several exit-pathway wells yield as much as 200 to 300 gallons per minute (gpm), which is several orders-of-magnitude greater than the typical yield (0.25 gpm; Solomon et al. 1992) of wells completed in the ORR Aquitards. Results of a dye tracer test in the Maynardville Limestone in the Bear Creek Regime suggested (qualitatively) a conduit flow rate of about 25 ft/day (Geraghty & Miller, Inc. 1989b).

Results of tracer tests performed in the Bear Creek Regime and calculations of the fracture porosity in bedrock provide estimates of the effective porosity of the ORR Aquitards and the Maynardville Limestone. Tracer tests have yielded effective porosity values ranging from 0.002 to 0.004 (Law Engineering Testing Company 1983; Lozier et al. 1987). Moore (1989) calculated a fracture porosity ranging from 0.001 to 0.002, based on estimates of fracture density and average fracture aperture for water-producing intervals at shallow depths in the Conasauga Group.

B.2.5.3.3 Intermediate Interval

Groundwater in the intermediate bedrock interval occurs in relatively permeable fractures (or possibly fractured intervals) within a relatively impermeable matrix. Review of data obtained with an electromagnetic borehole flowmeter suggest that the permeable regions commonly develop within a single layer of rock, and the average thickness of a permeable region (assuming an average dip of 35°) is less than 2 ft. The vertical spacing between permeable regions in the intermediate interval is believed to be more than 100 ft (Solomon et al. 1992); a vertical spacing of 150 ft is supported by results of matrix diffusion modeling of measured ^{14}C and ^3H activities (Toran et al. 1991). Results of straddle packer tests in wells completed in the intermediate interval of the ORR Aquitards at several locations in BCV and Melton Valley show a range of mean hydraulic conductivity of 0.006 to 0.016 ft/day (Solomon et al. 1992).

B.2.5.3.4 Deep Interval

Identification of the deep bedrock interval is based on hydraulic and geochemical data for several deep (greater than 500 ft) monitoring wells and coreholes. Solomon et al. (1992) reported that the boundary between the intermediate interval and the deep interval in BCV occurs at depths of about 325 ft in the ORR Aquitards and 650 ft in the Knox Aquifer. The boundary is based on lower hydraulic conductivity and unusually high hydraulic heads (estimated from packer tests), although use of hydraulic conductivity may not always be a reliable indicator (Solomon et al. 1992).

The transition from the intermediate interval to the deep interval in the ORR Aquitards is often indicated by a change from sodium-bicarbonate groundwater to sodium-chloride 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 more than 400 ft below the ground surface (Solomon et al. 1992). However, no such change in groundwater geochemistry has been observed in the Knox Aquifer, calcium-magnesium-bicarbonate or calcium-sulfate groundwater occurs to depths of 1,000 ft below the ground surface (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 in BCV is about 0.001 ft/day (Solomon et al. 1992). Although the mean hydraulic conductivity is comparable to that of the intermediate interval, measured conductivities in the deep interval are as low as 2.83×10^{-6} ft/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 solids concentrations of 40,000 to 300,000 milligrams per liter (mg/L). The water in the aquiclude is a sodium-, calcium-, and chloride-rich brine that is chemically similar to brines associated with major sedimentary basins. In Melton Valley, saline water typically occurs at depths of about 600 to 700 ft below the ground surface (Solomon et al. 1992).

Saline groundwater has not been encountered at depth in the East Fork Regime. However, several wells in BCV completed at depths of about 500 to 1,000 ft below the ground surface monitor groundwater with total dissolved solids concentrations of several thousand mg/L to several tens of thousand mg/L. The presence of water with relatively high total dissolved solids (as well as increased sodium and chloride concentrations) in the

deep groundwater interval in BCV may represent a mixing zone or diffusion zone between the fresh and saline groundwater suggesting that the aquiclude is most likely present at greater depth in the BCV than in Melton Valley (Solomon et al. 1992).

B.2.5.5 Geochemistry

Groundwater geochemistry in the East Fork 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 each groundwater sample collected from each monitoring well. Dissolved cation concentrations exclude digested cations that do not contribute charge to the groundwater (HSW Environmental Consultants, Inc. 1994b).

The accuracy of the data was checked by computing a relative percent difference (RPD) in the summed milliequivalent concentrations of the principal cations and anions using the following formula:

$$RPD = \left(\frac{\sum \text{Cations} - \sum \text{Anions}}{\sum \text{Cations} + \sum \text{Anions}} \right) * 100$$

The annual mean concentration of each ion [in milliequivalents per liter (meq/L)] was used to determine the groundwater composition at each sampling location. Samples for which the RPD exceeded 10 percent were not used to determine mean concentrations. Based on this criterion, principal ion data reported for about 6 percent of the groundwater samples collected during CY 1993 were not evaluated. Unusually low alkalinity or unusually high calcium and sodium concentrations typically caused positive RPDs greater than 10 percent. High nitrate concentrations (probably reflecting contamination) typically caused negative RPDs greater than 10 percent (HSW Environmental Consultants, Inc. 1994b).

A calcium-magnesium-bicarbonate groundwater usually occurs in the water-table and shallow bedrock interval in the ORR Aquitards and the Knox Aquifer. The calcium to magnesium molar ratio from approximately 12:1 to 0.3:1, and was typically about 3:1 (HSW Environmental Consultants, Inc. 1994b).

The geochemistry of the groundwater in the ORR Aquitards changes with depth. Although there are exceptions, data for most wells in BCV show that the calcium-magnesium-bicarbonate groundwater in the shallow bedrock interval changes (fairly abruptly) to a sodium-bicarbonate water at a depth of approximately 100 ft bgs. This type of groundwater is monitored by well GW-385 (Figure B-9), which is completed in the Nolichucky Shale with an open interval between 123 and 178 ft below the ground surface (HSW Environmental Consultants, Inc. 1994b).

Exceptions to this change in groundwater geochemistry with depth is the calcium-magnesium-bicarbonate type groundwater in intermediate depth bedrock wells GW-168 and GW-207, and deep bedrock well GW-208 (Figure B-9). The monitored interval for ORR Aquitard well GW-168, located at the east end of the East Fork Regime near NHP, lies near the contact between the Maynardville Limestone and the Nolichucky Shale at a depth of 104 to 135 ft bgs. The geochemistry of the groundwater monitored by the well may reflect the influence of limestone strata in the Nolichucky Shale near the contact with the Maynardville. Wells GW-207 and GW-208 are completed in the Rome Formation and the geochemistry of the samples from these wells probably indicate that the change to sodium-dominated groundwater does not occur in this formation, or occurs at much greater depth than in the shale formations of the ORR Aquitards (HSW Environmental Consultants, Inc. 1994b).

Data obtained from deep bedrock monitoring wells completed in the ORR Aquitards throughout BCV (mostly in the Bear Creek Regime) indicates that the sodium-bicarbonate

groundwater grades to a sodium-chloride groundwater at depths greater than 400 ft bgs. This geochemical trend is accompanied by an increase in total dissolved solids (TDS) with depth. In the East Fork Regime, well GW-239, which is completed in the Nolichucky Shale at a depth of 430 ft bgs, monitors sodium-chloride-bicarbonate groundwater (Figure B-9) with relatively high TDS ($>1,100$ mg/L) (HSW Environmental Consultants, Inc. 1994b).

Groundwater samples collected from several of the water-table and shallow bedrock wells in the ORR Aquitards contain high proportions of sodium (GW-204, GW-744, GW-755, GW-754, and GW-768), chloride (GW-284, GW-205, GW-631, and GW-760), or both (GW-508, GW-634, GW-656, GW-659, GW-746, GW-752, and GW-767). The elevated concentrations of these constituents is unusual for groundwater at shallow depths, and probably reflects impacts from a variety of industrial activities and processes within the Y-12 Plant. For example, the source of the high levels of sodium (>25 mg/L) and chloride (>100 mg/L) in groundwater monitored by wells GW-508 at the Rust Garage Area and GW-659 at the Building 9754-2 Fuel Facility is probably salt used to de-ice paved surfaces at these fuel stations. Surface runoff containing dissolved salt may infiltrate through cracks in the pavement or leak from subsurface storm drains near these wells (HSW Environmental Consultants, Inc. 1994b).

The distinct changes in groundwater geochemistry that occur with depth in the ORR Aquitards generally are not observed in the Knox Aquifer. Most of the wells screened in the Maynardville Limestone monitor calcium-magnesium-bicarbonate groundwater (Figure B-10). Exceptions include elevated concentrations of sodium, chloride, or sulfate in Maynardville Limestone wells GW-240, GW-380, GW-617, and GW-232 (HSW Environmental Consultants, Inc. 1994b).

Groundwater with high proportions of sodium and chloride (>40 percent) is monitored by water-table wells GW-240 and GW-380 near NHP. The geochemistry of the groundwater in these wells may reflect impacts on groundwater quality by industrial sources in the Y-12 Plant. Sulfate-enriched groundwater monitored by well GW-617, completed in the water-table interval upgradient of NHP, may indicate a hydraulic connection with groundwater in the Copper Ridge Dolomite of the Knox Group, which locally contains sulfate-rich groundwater resulting from solution of gypsum and disseminated sulfides (HSW Environmental Consultants, Inc. 1994b).

Well GW-232, completed at 412 ft bgs in the Maynardville Limestone about 2,800 ft east of New Hope Pond, monitors a sodium-bicarbonate type groundwater not usually encountered at this depth in the Maynardville. However, the monitored interval for well GW-232 does not intercept notably productive fractures or solution cavities (Jones et al. 1994), and the atypical groundwater geochemistry probably indicates that the well is completed in a less permeable zone in the Knox Aquifer where groundwater is relatively stagnant.

Unusual groundwater geochemistry has consistently been observed in samples from wells GW-619 and GW-620 located near the Fire Training Facility. The charge balance RPD exceeded ± 10 percent in 10 of the 12 samples collected from these wells since 1991. The pH of these samples has been consistently high (average 10.5), and potassium to sodium ratios (about 3:1) are higher than typically observed in samples from other wells. This chemical composition suggests possible contamination by cement grout used to construct the wells (HSW Environmental Consultants, Inc. 1994b).

B.2.5.6 Groundwater Use

Most industrial and drinking-water supplies in the Oak Ridge area are provided by surface-water sources. However, in rural areas not served by municipal water-supply systems, residential wells are the common source of potable water. Numerous wells and

springs used for domestic supplies are located within a 10-mile radius of the East Fork Regime. Most of these wells are located south of the Clinch River and none are located in BCV (Union Carbide Corporation, Nuclear Division 1982; King 1994). Water supplies for facilities in BCV are provided by the Oak Ridge municipal water-supply system.

There are eight public and industrial groundwater users within approximately 10 miles of the East Fork Regime (Table B-12). The closest public supply is the spring supplying Oliver Springs, which is about 6.5 miles north-northeast of the East Fork Regime, serves approximately 4,000 people, and produces an average of about 250,000 gallons per day (gpd).

Currently, groundwater is not used for "household" purposes within the DOE property boundaries around the East Fork Regime.

B.3 POST-CLOSURE HAZARDOUS WASTE MANAGEMENT UNIT

Ref: 1200-1-11-.07(5)(c)
1200-1-11-.06(6)(a)

A topographic map fulfilling the requirements of the above-referenced regulations is provided on 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)
1200-1-11-.05(6)(a)

The following summary from the 1993 GWQR (HSW Environmental Consultants Inc. 1994b) describes the current understanding of the nature and extent of groundwater contamination within the East Fork Regime. Evaluation of groundwater quality was based primarily on data collected during CY 1993; however, historical data (CY 1986 through CY 1992) were used to corroborate CY 1993 results, identify trends in the data, and define concentration distributions within contaminant plumes. Additional information may be obtained from groundwater quality assessment reports for NHP (Geraghty & Miller, Inc.

1989a) and the East Fork Regime (Geraghty & Miller, Inc. 1990a and b and HSW Environmental Consultants, Inc. 1991a and b, and 1992a and b, 1993a and b, and 1994a and b).

Previous groundwater monitoring results for the East Fork Regime have demonstrated that the principal constituents of concern (COCs) are VOCs, trace metals, nitrate, and radionuclides. However, the data obtained as of CY 1993 provide a somewhat limited characterization of the maximum concentrations and distribution of these constituents because few data are available for a large portion of the central part of the regime (the majority of monitoring wells are located in the western and eastern portions of the regime). In the eastern part of the regime, the Knox Aquifer has been more thoroughly characterized than the ORR Aquitards because of activities associated with the exit-pathway monitoring program. In the western portion of the regime, monitoring programs have historically focused on individual site characterizations. These sites have been predominantly located within the ORR Aquitards. Overall, the extent of contamination within the Knox Aquifer throughout the East Fork Regime is generally known and fairly well represented by recent data. Contamination within the ORR Aquitards in the western part of the regime is generally well characterized by older data that provide adequate general plume configurations, but may or may not exactly reflect current conditions (HSW Environmental Consultants, Inc. 1994b).

B.4.1 Distribution of Contaminants

There are numerous potential contaminant source areas within the East Fork Regime; however, as with much of the BCV area, groundwater plumes have coalesced and cannot be distinguished from one another nor traced back to a specific source term. However, a unique constituent of the eastern portion of the S-3 Ponds plume is nitrate, which can be monitored to define the leading edge of the plume because it is,

geochemically, relatively conservative in the groundwater system and; therefore, is transported more rapidly than other constituents. New Hope Pond has not been shown to be a statistically significant source of groundwater contamination because concentrations of constituents, known to be contained within the NHP sediments, found downgradient of the site are not statistically different from those upgradient (Appendix E).

Volatile organic compounds, nitrate, trace metals, and radioactivity are the primary contaminants in the East Fork Regime. Contaminated groundwater typically occurs in the water-table and shallow bedrock intervals of the ORR Aquitards and extends well into the intermediate bedrock interval in the Maynardville Limestone. The horizontal extent of contaminant plumes generally shows a limited migration in the water table and more extensive migration in the intermediate zone within the Maynardville Limestone. The primary VOCs in the groundwater are dissolved chlorinated solvents and petroleum hydrocarbons. The summed concentrations of dissolved chlorinated solvents and petroleum hydrocarbons are highest at the western end of the East Fork Regime. Volatile organic compounds observed in the eastern portions of the regime are from multiple upgradient sources within the Y-12 Plant rather than from NHP (Figures B-11 and B-12).

Nitrate concentrations have generally decreased in groundwater at shallow depths over time. During CY 1993, nitrate concentrations exceeded the maximum contaminant level (MCL) only from wells in the western portion of the East Fork Regime near the S-3 Ponds, S-2 Site, and Abandoned Nitric Acid Pipeline (HSW Environmental Consultants, Inc. 1994b).

Elevated concentrations of barium, cadmium, cobalt, copper, lead, mercury, strontium, and uranium reflect impacts on groundwater quality in the East Fork Regime. Most wells with consistently elevated concentrations of these metals are located in the western portion of the East Fork Regime, downgradient of the S-3 Ponds, S-2 Site, and

the Abandoned Nitric Acid Pipeline. Lead was detected from wells at NHP but generally correlate with total suspended solids (TSS) levels (for example: higher TSS levels correspond to higher lead concentration). Uranium concentrations in the groundwater at NHP are due to an upgradient source because statistically significant changes in concentration between upgradient and downgradient wells are not observed. Alpha and beta activity in samples from wells GW-222 and GW-154 in the vicinity of NHP (both upgradient and downgradient) have decreased significantly between CY 1990 and CY 1991 (HSW Environmental Consultants, Inc. 1994b).

B.4.1.1 Volatile Organic Compounds

Volatile organic compounds, primarily chlorinated solvents and petroleum hydrocarbons, are the most pervasive groundwater contaminants within the East Fork Regime. Confirmed sources of chlorinated solvents include the S-3 Ponds, several areas in the Y-12 Salvage Yard (e.g. the Salvage Yard Drum Deheader), the S-2 Site, the Fire Training Facility, and the Waste Coolant Processing Area (Figure B-11). Calendar years 1993 and 1994 preliminary data indicate other major source areas within the central portion of the plant in former processing areas (Figure B-11). An unidentified chlorinated VOC source area lies near Tank 0134-U. An aboveground storage tank existed just northwest of the Tank 2331-U site, which was removed in the mid-1950s and is a likely historical source of chlorinated organic compounds detected in soils and shallow groundwater in this area. Chlorinated solvents are present in the groundwater throughout the regime, and the sources of these compounds lie elsewhere within the Y-12 Plant upgradient of NHP. Sources of petroleum hydrocarbons include petroleum fuel USTs formerly located at the Rust Garage Area, the Building 9754-2 Fuel Facility, and Tank 2331-U.

The horizontal extent of the VOCs in groundwater in the East Fork Regime is not completely delineated by the existing monitoring well network (HSW Environmental Consultants, Inc. 1994b). In the water-table interval, an apparently continuous VOC plume extends from the western end of the regime to the vicinity of Lake Reality (Figure B-12).

Based on the available data, the horizontal distribution of VOCs in bedrock is similar to that in the water-table interval; a continuous plume extends from the western end of the regime to about 1,500 ft off the ORR to the east (Figure B-12). As is typical in BCV, horizontal migration is greatest in the Maynardville Limestone. In the East Fork Regime, general lateral plume boundaries are essentially defined, but the eastern extent of the plume in the Maynardville Limestone off the ORR has not been completely determined (HSW Environmental Consultants, Inc. 1994b).

Dissolved chlorinated solvents most frequently detected in groundwater in the East Fork Regime are tetrachloroethene (PCE), trichloroethene (TCE), 1,2-dichloroethene (1,2-DCE), carbon tetrachloride, and chloroform. In general, PCE, TCE, and 1,2-DCE occur in groundwater throughout the regime, but carbon tetrachloride and chloroform have been observed in wells only in the eastern half of the regime (Figure B-11). Samples containing PCE also usually contain TCE and 1,2-DCE. Likewise, samples containing carbon tetrachloride often contain chloroform. These apparent associations suggest that some of these compounds may be present in the groundwater as degradation products; both TCE and 1,2-DCE are degradation products of PCE, and chloroform is a degradation product of carbon tetrachloride. Other compounds detected in CY 1993 groundwater samples were 1,1-DCE, 1,1-dichloroethane (1,1-DCA), vinyl chloride, 1,1,1-trichloroethane (TCA), 1,2-dichloroethane (1,2-DCA), vinyl acetate, styrene, bromoform, carbon disulfide, and chloromethane.

In CY 1993, summed average concentrations of PCE, TCE, and 1,2-DCE were highest [10,475 micrograms per liter ($\mu\text{g/L}$)] in samples collected from well GW-656 at the Tank 0134-U site (Figure B-12). Summed average concentrations of PCE, TCE, and 1,2-DCE also were very high (10,310 $\mu\text{g/L}$) in the groundwater samples collected during CY 1993 from well GW-337 at the Waste Coolant Processing Area (Figure B-12). In addition to these compounds, average concentrations of other VOCs such as 1,1-DCE, vinyl chloride and 1,1,1-TCA exceed 100 $\mu\text{g/L}$ in the groundwater monitored by this particular well. These monitoring results are consistent with historical results for well GW-337, which show that PCE, TCE, and 1,2-DCE concentrations in the groundwater at the Waste Coolant Processing Area have remained relatively unchanged since the first quarter of 1990 (Figure B-13).

The Fire Training Facility has historically been a primary VOC source area (Figure B-12); however, the CY 1993 VOC data reported for wells GW-619 and GW-620 show that PCE, TCE, and 1,2-DCE concentrations continue to decrease in the groundwater at this site. As summarized on Table B-13, concentrations of these compounds at the site have steadily decreased since the wells at the site were first sampled in the second quarter of CY 1990. The data from Table B-13 also shows that the concentrations of each compound have decreased more rapidly in the groundwater monitored by well GW-619 than in the groundwater monitored by GW-620. Well GW-619 is completed in the water-table interval at a depth of about 41 ft bgs and well GW-620 is completed in the shallow bedrock interval at a depth of 75 ft bgs.

Historical monitoring data show that PCE, TCE, and 1,2-DCE also are present in the groundwater near NHP (Figure B-11). A potential source of these compounds was originally believed to be a 25 x 40 ft basin located just north of the inlet to NHP. This basin was part of a system that received oils and floating debris diverted by a boom across the pond inlet. A skimmer weir at the basin outlet retained the oil and debris for

subsequent removal and disposal. Direct hydraulic connection with the basin was observed during installation of wells GW-222 and GW-223 about 100 ft northeast of the basin (Geraghty & Miller, Inc. 1989a), and groundwater samples collected from these wells contained summed PCE, TCE, and 1,2-DCE concentrations that exceeded 500 µg/L. However, VOC concentrations in the samples from these wells decreased substantially after closure of NHP and the oil skimmer system in November 1988. For example, respective PCE concentrations of 390 and 510 µg/L were reported for the samples collected from wells GW-222 and GW-223 in the first quarter of CY 1988. By the second quarter of CY 1991 (the last time samples were collected from the wells), PCE concentrations had decreased to 15 µg/L in well GW-222 and 160 µg/L in well GW-223. With the addition of wells GW-762 and GW-763 to the monitoring well network, the extent of PCE, TCE, and 1,2-DCE was found to be farther north and west than previously indicated. These new data suggest that at least one source area other than the oil skimmer basin may be present within machining and storage facilities located in the southeast quadrant of the Y-12 Plant.

Carbon tetrachloride and chloroform generally occur in groundwater throughout the eastern half of the plant (Figure B-11). Summed average concentrations of these compounds exceeded 1,000 µg/L in samples collected during CY 1993 from wells GW-381 (6,302 µg/L), GW-382 (5,595 µg/L), and GW-606 (1,002 µg/L) upgradient of NHP. Concentrations of carbon tetrachloride are highest in the Maynardville Limestone at depths from 100 to 500 ft bgs. Concentrations of these VOCs are lower at shallower depths likely due to high recharge and dilution effects in the shallow karst and fill zones (Figure B-14). Because the highest concentrations of carbon tetrachloride and chloroform occur in upgradient wells, NHP is not the source of these compounds. The most current spatial data for the composition of the VOC plume suggest that the major source area of carbon tetrachloride and chloroform lies within the central part of the Y-12 Plant within former process areas.

Historical data for well GW-381 show fairly consistent carbon tetrachloride and chloroform concentrations in the groundwater upgradient from NHP, but the data for well GW-220 (downgradient of NHP) show that concentrations of these compounds have steadily increased since CY 1990 (Figure B-13) in the groundwater downgradient of the site although concentrations in GW-381 are higher than those in GW-220 (Figure B-14). This increase likely reflects contaminant migration eastward and northeast. Migration in these directions is to be expected due to the shallow and intermediate groundwater flow patterns in the East Fork Regime. In addition, shallow flow to the northeast may have been enhanced by the Lake Reality Sump (Figure B-14) that pumped groundwater from a depth of about 20 ft into Lake Reality. An upward hydraulic gradient caused the liner of Lake Reality to rise, and the sump was installed and intermittently pumped to keep the liner from floating until sediment weighted it down.

The extent of dissolved petroleum hydrocarbon plumes in the groundwater in the regime is much less than that of dissolved chlorinated solvents; plumes typically occur only within 100 ft of the USTs (Figure B-11). Moreover, petroleum hydrocarbons were not detected in any of the exit-pathway wells. The more limited extent of petroleum hydrocarbons may reflect short-term releases, greater attenuation in the aquifer, the results of free-product recovery and other remedial actions performed at the UST sites, natural biodegradation, or a combination of these factors.

Groundwater samples collected from 18 wells during CY 1993 contained dissolved petroleum hydrocarbon compounds (Figure B-11). Dissolved concentrations of benzene, toluene, ethylbenzene, and xylenes (BTEX) exceeded 1,000 µg/L in samples from wells GW-508 (57,700 µg/L), GW-632 (14,270 µg/L), and GW-634 (3,972 µg/L) at the Rust Garage Area; wells GW-708 (4,012 µg/L) and GW-193 (3,306 µg/L) at Tank 2331-U; and well GW-658 (24,515 µg/L) at the Building 9754-2 Fuel Facility (Figure B-11).

Results reported for these wells, as well as lower BTEX concentrations reported for samples from well GW-633 at the Rust Garage Area, well GW-659 at the Building 9754-2 Fuel Facility, and well GW-708 at Tank 2331-U exceeded respective MCLs established for these compounds.

B.4.1.2 Nitrate

Nitrate is pervasive in groundwater in the western portion of the East Fork Regime. Source areas include the S-3 Ponds, the Abandoned Nitric Acid Pipeline, and the S-2 Site. Although the S-3 Ponds lie west of the shallow groundwater flow divide that separates the Bear Creek Regime and the East Fork Regime, operation of the site resulted in constant positive hydraulic head and contaminant flow to the water table. When coupled with a preferred strike-parallel flow direction in the BCV, these conditions enabled contaminants from the S-3 Ponds (chiefly nitrate, metals, and radionuclides) to migrate into the East Fork Regime. Since termination of waste disposal at the S-3 Ponds in 1984, the mound in the water table has abated and shifted eastward in alignment with the topographic divide.

Many of the wells that monitor contaminated groundwater in the western portion of the regime were not sampled during CY 1993. Historical data for a number of wells, summarized in Table B-14, show that nitrate concentrations have exceeded 10,000 mg/L in the groundwater in the ORR Aquitards underlying the Y-12 Salvage Yard. In CY 1993, the highest average nitrate concentration (3,629 mg/L) was determined for samples from water-table interval well GW-633 located at the Rust Garage Area about 700 ft east of the S-3 Ponds.

Comparison of the maximum nitrate concentrations reported for samples collected from these wells during CYs 1986 and 1990 shows concentration decreases, particularly in the groundwater monitored by water-table wells GW-105, GW-107, GW-270, and

GW-276 (Table B-14). Shevenell et al. (1994) interpret the decreasing nitrate concentrations to indicate that the primary source of the nitrate essentially lies within the unfractured rock matrix near the S-3 Ponds; the large mass of nitrate introduced into the groundwater system during site operations produced a significant concentration gradient between contaminated water in the fractures and the water in the less permeable but more porous rock matrix. The concentration gradient induced molecular diffusion of nitrate (and probably other contaminants) from the fractures into the rock matrix. The concentration gradient between groundwater in the fractures and the rock matrix subsequently reversed after waste disposal was discontinued in CY 1984, and nitrate (and other contaminants) now diffuses from the matrix into the fractures and is subsequently flushed out of the shallow groundwater flow system by natural recharge and discharge cycles (Shevenell et al. 1994). In contrast to other shallow wells in this area, the nitrate concentrations in the groundwater samples collected from well GW-633 have remained fairly stable since CY 1991 (Figure B-15).

Based on historical and CY 1993 data, the nitrate plume in groundwater in the water-table interval extends eastward from the S-3 Ponds to a prominent topographic high located east of the S-2 Site (Figure B-16). Additionally, the data for water-table wells GW-270 and GW-274 indicate that nitrate concentrations in the groundwater monitored by these wells are higher than in the groundwater monitored by several water-table wells (e.g., GW-105, GW-107, and GW-505) located closer to the S-3 Ponds. The higher nitrate concentrations reported for wells GW-270 and GW-274 strongly suggest that a leak in the Abandoned Nitric Acid Pipeline has contributed nitrate to the groundwater in the northeastern part of the Y-12 Salvage Yard (HSW Environmental Consultants, Inc. 1994b).

The shape of the nitrate plume in the water-table interval indicates that buried stream channels that were formerly part of the headwaters of UEFPC before construction of the Y-12 Plant and subsurface pipe traces significantly influence the movement of nitrate in the shallow groundwater east of the S-3 Ponds (Figure B-16). For example, the groundwater sample collected from water-table well GW-105 during the first quarter of CY 1990 contained 921 mg/L of nitrate; however, nitrate concentrations reported for samples from well GW-505, which is located about 200 ft immediately downgradient of well GW-105, did not exceed 2 mg/L. The abrupt decrease in the nitrate concentration over this short distance is probably caused by a buried stream channel believed to be located between the wells. This filled drainage feature apparently forms a highly permeable flow path that channels the shallow groundwater to the southeast toward well GW-633 (HSW Environmental Consultants, Inc. 1991b).

A similarly abrupt nitrate concentration decrease is apparent between wells located on either side of a subsurface drain that forms part of a network installed to replace the headwaters of UEFPC (Figure B-16). Samples collected during CY 1993 from well GW-632, located immediately west of a northwest-southeast trending section of a subsurface drain, had an average nitrate concentration of 12.05 mg/L. However, nitrate concentrations in samples from wells GW-508 and GW-634, which are located immediately east of the drain, were below the 0.2 mg/L analytical quantitation limit (Figure B-16).

In the shallow bedrock interval, the nitrate plume extends for a similar distance east of the S-3 Ponds (Figure B-16), and may extend beneath the topographic high that apparently restricts further eastward nitrate migration in the water-table interval. Although none of the bedrock wells within the nitrate plume were sampled during CY 1993, the most recent data available for wells GW-109 and GW-275 indicate that nitrate concentrations

exceed 5,000 mg/L in the bedrock in this part of the regime. The high nitrate concentrations reported for well GW-275, which is paired with water-table well GW-274, further indicate a separate source of nitrate in this area, probably a leak in the Abandoned Nitric Acid Pipeline (HSW Environmental Consultants, Inc. 1991b).

B.4.1.3 Trace Metals

Results of a detailed review of CY 1990 through CY 1993 data for Knox Aquifer and ORR Aquitard wells indicate that elevated total concentrations of barium, cadmium, cobalt, lead, mercury, strontium, and uranium most likely reflect potential impacts on groundwater quality in the regime. Most of the wells that consistently yield groundwater samples with elevated concentrations of these metals are located in the western part of the East Fork Regime. The locations of the wells in the following discussions are illustrated on Figure B-2 .

B.4.1.3.1 Barium

Groundwater with total barium concentrations in excess of the 2.0 mg/L MCL occurs only in the ORR Aquitards underlying the Y-12 Salvage Yard and the Rust Garage Area in the western part of the East Fork Regime. In CY 1993, total barium concentrations exceeded the MCL only in groundwater samples collected from ORR Aquitard well GW-633 located near the Rust Garage Area; total barium concentrations have exceeded 20 mg/L in 11 of the 12 samples collected from GW-633 since CY 1990. The anomalously low barium concentration (0.87 mg/L) reported for the sample collected from this well during the fourth quarter of 1993 was considered an analytical error (HSW Environmental Consultants, Inc. 1994b).

As shown in Table B-15, the most recent data for water-table interval wells GW-105, GW-274, and GW-276, shallow bedrock interval wells GW-108, GW-275, and

GW-277, and intermediate interval well GW-109 show that total barium concentrations are highest in the groundwater near the Y-12 Salvage Yard.

Comparison with the maximum total barium concentrations reported for samples collected from these wells during CY 1987 (the first year samples from each well were analyzed for barium) shows significant concentration decreases in the groundwater at shallow depths (e.g., GW-105, GW-106, and GW-276), but only a slight decrease in the barium concentrations in the groundwater at greater depth (GW-109). This pattern would be expected based on the conceptual model of the groundwater flow system in the ORR Aquitards; flushing by natural recharge and discharge cycles in the more permeable and hydrologically active water table and shallow bedrock intervals would tend to reduce contaminant concentrations more rapidly in the shallow groundwater system (Shevenell et al. 1994).

Elevated barium concentrations in the groundwater monitored by wells GW-105, GW-108, GW-109, GW-276, and GW-277 probably reflect the impact of acidic effluents released from the S-3 Ponds. However, a leak in the Abandoned Nitric Acid Pipeline is the most likely source of the elevated barium concentrations in the groundwater monitored by wells GW-274 and GW-275. Barium concentrations reported for the samples from these wells are higher than those reported for the samples from wells located much closer to the S-3 Ponds.

B.4.1.3.2 Cadmium

Total cadmium concentrations have consistently exceeded the 0.005 mg/L MCL in unfiltered samples collected from Knox Aquifer wells GW-251 and GW-253 at the S-2 Site, and exit-pathway well GW-618. Of these, only wells GW-251 and GW-618

were sampled during CY 1993 (Table B-16). The S-2 Site is a known source area of cadmium and other metals (Gianfrancesco et al. 1988).

Data reported for several wells not sampled during CY 1993 indicate that elevated cadmium concentrations also occur in groundwater monitored by five ORR Aquitard wells located near the Y-12 Plant Salvage Yard (GW-108, GW-109, GW-274, and GW-276) and the Building 9754-2 Fuel Facility (GW-282). The S-3 Ponds and the Abandoned Nitric Acid Pipeline are the most likely sources of the cadmium in this area.

B.4.1.3.3 Cobalt

Elevated total cobalt concentrations have consistently been reported for samples collected from ORR Aquitard wells GW-508, GW-631, GW-632, and GW-634 at the Rust Garage Area, and Knox Aquifer wells GW-251 and GW-253 at the S-2 Site. Cobalt concentrations reported for selected wells contaminated with cobalt that were sampled during CY 1993 are summarized on Table B-17. Wells GW-167 and GW-253 were not sampled during CY 1993. These results are consistent with historical data for these wells; every unfiltered groundwater sample collected from the wells except one sample from well GW-631 have contained cobalt concentrations that exceed the 0.025 mg/L screening level. Elevated cobalt concentrations in the groundwater monitored by these wells are probably related to, or caused by, past releases of acidic effluent from the S-3 Ponds.

Total cobalt concentrations reported for well GW-251 at the S-2 Site generally decreased after the second quarter of CY 1993, although all 15 samples collected from the well since CY 1990 have contained elevated cobalt concentrations. Results for groundwater and soil samples collected at the S-2 Site (Gianfrancesco et al. 1988) show that the S-2 Site is a potential source of cobalt in groundwater in the Knox Aquifer.

Total cobalt concentrations exceeded the 0.011 mg/L Knox Aquifer screening level in four of the six groundwater samples collected since CY 1990 from well GW-167 at NHP. Except for a less-than-detection limit (0.005 mg/L) result reported for the sample collected in the first quarter of CY 1991, total cobalt concentrations generally increased from 0.017 mg/L in the first quarter of CY 1990 to 0.26 mg/L in the second quarter of CY 1991. However, the total cobalt concentrations reported for the most recent sample collected from well GW-167 (0.01 mg/L in third quarter of CY 1991) was slightly below the screening level.

B.4.1.3.4 Copper

Only Knox Aquifer wells GW-251 and GW-253 at the S-2 Site consistently yield groundwater samples with total copper concentrations in excess of the 0.1 mg/L screening level, but only well GW-251 was sampled during CY 1993. Total copper concentrations in the samples from well GW-251 generally increased from 0.58 mg/L in the first quarter of CY 1993 to 0.95 mg/L in the third quarter, then decreased to 0.091 mg/L in the fourth quarter of CY 1993 and elevated copper concentrations have been reported for all unfiltered groundwater samples collected from the well since CY 1990. Analytical results reported by Gianfrancesco et al. (1988) showed copper concentrations ranging from 40,000 to 60,000 micrograms per gram ($\mu\text{g/g}$) in the soil samples collected from 6 to 14 ft bgs. The lack of elevated copper concentrations in Knox Aquifer wells located downgradient of the S-2 Site suggests that copper is easily attenuated and is not readily transported in the groundwater.

B.4.1.3.5 Lead

Total lead concentrations that consistently exceed the 0.05 mg/L standard have been reported only for Knox Aquifer wells GW-167 at NHP, well GW-169 located beyond the

ORR boundary east of NHP, and well GW-253 at the S-2 Site. Of these, only well GW-169 was sampled during CY 1993.

Total lead concentrations have exceeded the lead standard in eight of the 12 unfiltered samples collected from well GW-169, including three of the samples collected during CY 1993. The concentrations fluctuated through CY 1993 with higher concentrations in the first (0.15 mg/L) and third (0.18 mg/L) quarters, and lower concentrations in the second (0.042 mg/L) and fourth (0.091 mg/L) quarters. Such fluctuations are characteristic of the total lead concentrations reported for this well. In contrast, dissolved lead concentrations in all 12 filtered groundwater samples from the well have not exceeded the 0.004 mg/L analytical detection limit. Moreover, the fluctuating total lead concentrations generally correlate with TSS levels reported for the unfiltered samples; lead concentrations are typically highest in the more turbid samples (Figure B-17). This apparent relationship between lead concentrations and TSS levels, coupled with the consistently non-detected dissolved lead concentrations, suggests that lead ions sorbed onto the suspended material are mobilized into solution when acid preservative is added to the unfiltered samples. The relationship between TSS levels in the samples from GW-169 and water levels in the well suggests that the TSS levels are not sampling artifacts but may reflect naturally turbid groundwater in the karst flow system monitored by the well. It may therefore be possible that the total lead concentrations in the groundwater monitored by well GW-169 represent facilitated transport of lead ions sorbed to organic or inorganic materials (possibly colloids) (HSW Environmental Consultants, Inc. 1994b).

Since CY 1990, total lead concentrations exceeded 0.05 mg/L in four of the six samples collected from well GW-167 at NHP, and in two of the five samples collected from well GW-253 at the S-2 Site. However, the concentrations reported for well GW-167 generally decreased from 0.3 mg/L in the fourth quarter of CY 1990 to less than

the analytical detection limit in the third quarter of CY 1991. More stable total lead concentrations were reported for the samples from well GW-253; concentrations ranged between 0.045 and 0.055 mg/L from the second quarter of CY 1990 to the second quarter of CY 1991.

B.4.1.3.6 Mercury

Although substantial volumes of elemental mercury were handled at several locations within the Y-12 Plant, there are few wells that consistently yield groundwater samples with total mercury concentrations that exceed the 0.002 mg/L MCL. Each elevated mercury concentration reported for the ORR Aquitard wells sampled since CY 1990 was screened as anomalous. However, data for wells sampled chiefly before CY 1990 indicate that elevated mercury concentrations occur in the groundwater monitored by wells GW-109, GW-274, and GW-276 near the Y-12 Salvage Yard. Data for each of these wells are fairly sporadic, but comparison of the maximum mercury concentrations reported during CY 1987 (the first year all three wells were sampled) and CY 1990 (the last year all three wells were sampled) show concentration decreases in wells GW-109 (from 0.16 to 0.087 mg/L) and GW-276 (from 0.002 to 0.0009 mg/L), but a concentration increase in well GW-274 (from 0.0016 to 0.024 mg/L).

Only the elevated mercury concentrations reported for Knox Aquifer wells GW-222 at NHP and GW-253 at the S-2 Site were not screened as anomalous. Results for these wells, summarized in Table B-18, show that mercury concentrations are highest in the samples from well GW-253 and that concentrations generally decreased to less than the analytical detection limit in samples from well GW-222.

B.4.1.3.7 Strontium

Total strontium concentrations reported for samples from well GW-633 at the Rust Garage Area and well GW-744 at Comprehensive Monitoring Plan (Geraghty &

Miller, Inc. 1990c) grid location K1 have consistently exceeded the 0.83 mg/L screening level. In CY 1993, concentrations were highest in the samples collected from well GW-633, ranging from 15 mg/L in the first quarter to 11 mg/L in the third quarter of the year. The anomalously low strontium concentration (0.68 mg/L) reported for the fourth quarter sample was discounted as a probable analytical error. Past releases of acidic effluent from the S-3 Ponds is the probable source (or cause) of the strontium in the groundwater monitored by this well.

Strontium concentrations in the samples from well GW-744 increased from 0.084 mg/L in the first quarter to 1.1 mg/L in the fourth quarter of CY 1993. This well is not located near any known strontium source area, and total strontium concentrations reported for samples collected from shallower wells clustered with well GW-744 (wells GW-745 and GW-746) have not exceeded the ORR Aquitard screening level.

B.4.1.3.8 Uranium

Elevated total uranium concentrations were reported for only three wells in the East Fork Regime that were sampled during CY 1993: ORR Aquitard well GW-204, and Knox Aquifer wells GW-193 and GW-605. The CY 1993 results for these wells are summarized in Table B-19.

As shown in Table B-19, total uranium concentrations have exceeded the ORR Aquitard screening level in 14 of the 15 samples collected from well GW-204 since CY 1990. Additionally, annual average gross alpha activities determined for well GW-204 have exceeded the 15 picoCuries per liter (pCi/L) screening level for the last 4 years and showed a distinct increase in CY 1993. Like Tank 2331-U, Tank 0134-U was reportedly used only for petroleum hydrocarbons and therefore may not be the source of the elevated uranium concentrations in the groundwater monitored by well GW-204.

The total uranium concentrations reported for well GW-193 have exceeded the Knox Aquifer screening level in 10 of the 14 samples collected from the well since CY 1990. Concentrations in the samples collected during CY 1993 ranged from 0.009 mg/L (second quarter) to 0.086 mg/L (third quarter). Additionally, the annual average gross alpha activity for the well (21 ± 2 pCi/L) exceeded 15 pCi/L. Tank 2331-U was reportedly used only for petroleum hydrocarbons and, therefore, another source area may be responsible for the elevated uranium concentrations in the samples collected from well GW-193.

The total uranium concentrations reported for Knox Aquifer well GW-605 ranged from <0.001 to 0.19 mg/L in CY 1993. Uranium concentrations have exceeded 0.007 mg/L in nine of the ten samples collected from well GW-605 since CY 1990 (only the result for the third quarter of CY 1993 was below the screening level). Additionally, the mean gross alpha activity in samples from well GW-605 have exceeded 15 pCi/L. The source of the uranium in the groundwater monitored by well GW-605 has not been determined but most likely is located within the Y-12 Plant complex upgradient (west) of the well (HSW Environmental Consultants, Inc. 1994b).

Available data for Knox Aquifer wells that were last sampled during CY 1991 show that consistently elevated total uranium concentrations also have been reported for samples collected from well GW-253 at the S-2 Site, and wells GW-154 and GW-222 at NHP. As summarized on Table B-20, uranium concentrations in the wells at NHP, particularly GW-154, generally show decreasing trends. Concentrations reported for well GW-253 at the S-2 Site show a similar general decrease. Additionally, the much lower total uranium concentrations reported for well GW-253, in comparison to those reported for downgradient wells GW-605, GW-222, and GW-154, do not support the S-2 Site as a significant source of uranium in the Knox Aquifer. Thus, the source of the elevated

uranium concentrations in the groundwater at NHP lies upgradient of well GW-605 and downgradient of the S-2 Site.

B.4.1.4 Radioactivity

Available data indicate that the principal sources of alpha and beta emitting radioisotopes in the East Fork Regime are the S-3 Ponds, the S-2 Site, and possibly the Abandoned Nitric Acid Pipeline (HSW Environmental Consultants, Inc. 1994b). The gross alpha and gross beta activities in samples from monitoring wells upgradient of NHP suggest one or more upgradient sources somewhere within the Y-12 Plant complex.

The primary alpha-emitting radionuclides in the groundwater in the East Fork Regime are isotopes of uranium (^{234}U , ^{235}U , and ^{238}U). Data obtained during CY 1989 show that isotopes of radium (^{223}Ra , ^{224}Ra , ^{226}Ra), neptunium (^{237}Np), and americium (^{241}Am) also contribute to the gross alpha activity in groundwater in the western part of the regime (Geraghty & Miller, Inc. 1990b). Technecium (^{99}Tc) has been identified as the primary beta-emitting radionuclide in the groundwater in the East Fork Regime, although strontium (^{90}Sr) and tritium (^3H) also contribute to gross beta activity in groundwater in the western end of the regime (Geraghty & Miller, Inc. 1990b).

Average annual gross alpha activity determined from three wells in the ORR Aquitards (GW-204, GW-206, and GW-505) and three wells in the Knox Aquifer (GW-169, GW-193, and GW-605) exceeded 15 pCi/L during CY 1993 (HSW Environmental Consultants, Inc. 1994b). In general, the samples from well GW-169 with gross alpha activity greater than 15 pCi/L also exhibited high TSS levels (Figure B-17). Inaccurate gross alpha activities caused by analytical interferences from the excessive amounts of particulates may therefore have been reported for these samples. Also, uranium concentrations reported for the samples from well GW-169 have not exceeded

the 0.007 mg/L Knox Aquifer screening level. In contrast, every sample collected from well GW-605 with gross alpha activity above 15 pCi/L exhibited low TSS levels (<10 mg/L) and uranium concentrations that exceeded the screening level. Elevated gross alpha activity in the samples from GW-605 suggest that the source of the alpha-emitting radionuclides in the groundwater at NHP lies upgradient of this site.

Historical data (CYs 1990 and 1991) for Knox Aquifer wells GW-154 and GW-222 show that gross alpha activity has exceeded 15 pCi/L in groundwater near NHP (Figure B-18). Annual average gross alpha activity exceeded 500 pCi/L in samples from water-table interval well GW-154, and 60 pCi/L in samples from shallow bedrock well GW-222. The alpha activity reported for samples from both of these wells decreased from CY 1990 to CY 1991, and may have continued to decrease since the most recent sampling event (second quarter of CY 1991). These data indicate that because NHP is located downgradient of these two wells, the elevated gross alpha activity in the groundwater in the vicinity of the site cannot be correlated to contaminant releases from the pond.

Average annual gross beta activity determined for two ORR Aquitard wells exceeded 50 pCi/L during CY 1993 (GW-206 and GW-633). The data for well GW-633, and historical results for nearby monitoring wells not sampled during CY 1993, show that gross beta activity above 50 pCi/L occurs primarily in groundwater in the western end of the East Fork Regime (Figure B-19). Data obtained during CY 1990 indicated gross beta activity as high as 4,000 pCi/L (GW-276) in the water-table interval, and 10,000 pCi/L in the bedrock interval (GW-109). Historical data for wells GW-154 and GW-222 located upgradient of NHP have shown gross beta activity above 50 pCi/L. As described for gross alpha activity, gross beta activity decreased significantly from CY 1990 to CY 1991. Because of major source areas upgradient of the well, these elevated gross beta activities are not thought to be a result of releases from NHP.

B.4.2 Contaminant Transport

The calculation of rates of contaminant migration provided in this section is mandated under the reporting requirements specified in 1200-1-11-.05(6)(a). Quantitative and qualitative methods were used to estimate contaminant migration rates (HSW Environmental Consultants, Inc. 1994a). Quantitative rates were estimated only for the water-table and shallow bedrock intervals in the groundwater zone. Migration rates in the stormflow zone were not estimated because this zone has probably been destroyed or substantially altered throughout most of the East Fork Regime. Estimates of migration rates in the intermediate and deep bedrock intervals also were not performed, but representative rates, are probably as low as a few centimeters per year in the ORR Aquitards (Solomon et al. 1992). Qualitative transport rates were determined based on the extent of nitrate in the Bear Creek Regime assuming a constant input rate from a single source area. These qualitative rates were assumed to be applicable to the East Fork Regime because of similar geologic and hydrologic conditions (HSW Environmental Consultants, Inc. 1994a).

The wide range of potential contaminant migration rates reported in the following sections demonstrate the uncertainty in determining a representative rate of solute transport for this groundwater flow system. Long term transport of solutes in dual porosity and/or highly heterogeneous media is a complex physical and chemical process that is not fully explained by calculations using the modified Darcy equation or qualitative estimates based on distances from source areas to plume boundaries. It is probable that at various times and under various conditions, migration rates throughout the given range occur; some contaminants such as nitrate move relatively rapidly through the flow system, while other more highly attenuated constituents move much more slowly. Moreover, even the highly mobile compounds will diffuse into smaller pores from the large conduits and later, under a

reverse concentration gradient, will slowly diffuse back out. Thus, although the actual transport rates may vary over several orders of magnitude, the relatively limited extent of the contaminant plumes in the East Fork Regime suggests that slower transport rates may dominate and that attenuation processes such as matrix diffusion are an important controlling factor (HSW Environmental Consultants, Inc. 1994a).

B.4.2.1 Quantitative Contaminant Migration Rates

Quantitative estimates of contaminant transport were based on the assumption that contaminants move with the groundwater unimpeded by various retardations processes. Factors which would reduce transport rates, such as matrix diffusion, degradation, sorption, and chemical precipitation, or factors which may increase transport, such as dispersion, were not explicitly considered. Free product migration, which may occur independent of groundwater flow rates and directions, also was not considered (HSW Environmental Consultants, Inc. 1994a).

Assuming that saturated regolith and fractured bedrock can be treated as an equivalent porous medium, average groundwater flow rates can be estimated using the modified Darcy equation;

$$v = Ki/n$$

where v is the average linear velocity of the groundwater, K is the hydraulic conductivity of the medium, i is the hydraulic gradient, and n is the effective porosity. Although the modified Darcy equation can be used to calculate average flow velocities in fractured rock, the velocities in individual fractures may vary over orders of magnitude, depending on the fracture aperture and wall roughness (Freeze and Cherry 1979).

Using the range of hydraulic conductivities for regolith (0.03 and 3.25 ft/day), effective porosities ranging from 0.001 to 0.15, an average strike-parallel (down-valley) gradient of 0.011, and an average strike-normal (cross-valley) gradient of 0.045, calculated rates of solute transport in the water-table range from 0.002 to 146.2 ft/day. However, the bulk of the water mass in the water-table interval resides within the porous matrix zone between fractures, and diffusive exchange between matrix and fractures would reduce contaminant migration rates relative to calculated flow rates (Solomon et al. 1992).

Contaminant transport rates for the shallow interval in the ORR Aquitards were calculated using a geometric mean hydraulic conductivity of 0.0008 ft/day for matrix intervals and 0.15 ft/day for water-producing intervals, effective porosity values ranging from 0.001 to 0.004, and an average strike normal hydraulic gradient of 0.046. Using these values, the rate of contaminant migration in the ORR Aquitards ranges from 0.009 to 6.7 ft/day (HSW Environmental Consultants, Inc. 1994a).

Contaminant transport rates for the shallow interval in the Maynardville Limestone were calculated using the average hydraulic conductivity (22 ft/day) obtained from well tests, effective porosity values ranging from 0.001 to 0.004, and an average strike-parallel hydraulic gradient of 0.012. Using these values, the rate of contaminant migration in the Maynardville Limestone ranges from about 66 to 264 ft/day. Relatively high transport rates in the Maynardville Limestone also are indicated by results of a dye-tracer study performed in the Bear Creek Regime which yielded a transport rate of about 200 ft/day (Geraghty & Miller, Inc. 1989c).

B.4.2.2 Qualitative Contaminant Migration Rates

Qualitative estimates of contaminant migration rates in the East Fork Regime were based on the extent of the nitrate plume originating from the S-3 Ponds observed in the

Bear Creek Regime during CY 1990 (HSW Environmental Consultants, Inc. 1991a). Unlike most of the other groundwater contaminants in the Bear Creek Regime, many of which have multiple source areas, the S-3 Ponds is the only significant nitrate source in the regime. Moreover, nitrate salts are highly soluble and generally move with no significant sorption or decay during transport (Geraghty & Miller, Inc. 1989c).

The nitrate plume originating from the S-3 Ponds extends westward (along strike) about 3,650 ft in the water-table interval, approximately 2,000 ft at shallow depths in the ORR Aquitards, and about 9,500 ft at shallow depths in the Maynardville Limestone (HSW Environmental Consultants, 1991a). Given the 39 years between initial waste disposal at the S-3 Ponds in 1951 and the horizontal extent of the nitrate plume observed in 1990, the rate of nitrate transport, ($v = \text{distance/time}$) is about 0.3 ft/day in the water-table interval, about 0.1 ft/day in the ORR Aquitards, and about 0.7 ft/day in the Maynardville Limestone.

B.4.3 Resumption of Detection Monitoring at NHP

To determine whether contaminants from NHP were significantly contributing to contaminant plumes emanating from upgradient sources, a series of statistical analyses was performed on analytical data from wells in the vicinity of NHP (Paradigm Data Services, Inc. 1994). This statistical analysis was conducted to investigate whether NHP was a source of groundwater contamination for indicator parameters for which analyses were performed between CY 1988 through CY 1994. The indicator parameters used for this statistical test were chosen on the basis of their presence in NHP sediments. The parameters include barium, cadmium, chromium, lead, mercury, nickel, silver, uranium, gross alpha, and gross beta. The analysis was aimed at determining if concentrations of the target parameters were significantly higher in a set of wells downgradient of the site as

compared to concentrations in paired wells upgradient of the site. A summary of the statistical tests are presented in Appendix E.

The evaluated data consisted of sampling results collected from 1988 through the second quarter of 1994 on unfiltered samples at ten wells around NHP. Well pairs consisted of five upgradient and five downgradient wells of similar depths in the same geologic formation. Wells were paired to minimize the effects of time, well depth, and geochemical variations. The data were also paired by sampling event to control for seasonal variations. The locations of these wells are shown in Figure B-20. Table B-21 presents the well pairs used in the statistical evaluation. In all cases, wells monitored groundwater within the Maynardville Formation. For example, GW-733 is downgradient of NHP, and monitors groundwater within the Maynardville Limestone (the intermediate bedrock interval) at elevations between 715.6 and 699.2 ft MSL. The well paired with GW-733 is GW-606, which is upgradient of NHP, is in the Maynardville Limestone, and also monitors the intermediate bedrock interval between 762.0 and 745.3 ft MSL.

The statistical analysis indicated that, of all the target parameters, only barium and lead were statistically significantly greater in some downgradient wells versus their paired upgradient wells. However, it appears that the concentrations of both lead and barium correlate with the varying concentrations of TSS. That is, as TSS increases, the lead and barium concentrations increase. Therefore, the apparent higher concentrations of lead and barium in a downgradient position appear to be a result of a sampling artifact in the downgradient wells as colloidal particles have been entrained into the groundwater which was sampled. The summary of the statistical tests on the target parameters is presented below.

B.4.3.1 Barium

There is statistical evidence that the concentration of barium in downgradient wells exceeds that in upgradient wells in pairs 1, 2, and 3 (Table B-21). A regression analysis was run to determine if there was a statistical relationship between the concentration of barium and the level of TSS in the downgradient groundwater samples. The analysis concluded that there was a statistically significant relationship between barium and total suspended solids for GW-220 (pair 2, downgradient well); thus, barium concentrations increase with increasing total suspended solids. High concentrations of barium within groundwater in the Knox Aquifer have been associated with the occurrence of disseminated sulfide mineralization (per. comm., H.L. King 1995). These wells, therefore may be influenced by high recharge from the Knox Aquifer. Furthermore, the median barium concentrations in the downgradient wells for all three well pairs are four times less than the MCL for barium.

B.4.3.2 Lead

There is statistical evidence that the concentration of lead in the pair 2 downgradient well (GW-220) exceeds that in the paired upgradient well (GW-605). A regression analysis was run to determine if there was a statistical relationship between the concentration of lead and the level of TSS in the downgradient groundwater samples. The analysis concluded that there was a statistically significant relationship between lead and TSS for GW-220. Also, south of NHP is a pistol range (Figure B-20) that is currently being considered for SWMU status. The pistol range is hydraulically upgradient from GW-220 (Figure B-8) and could be contributing to lead in groundwater.

B.4.3.3 Non-Significant Indicator Parameters

There is no statistical evidence that the concentration of cadmium, chromium, mercury, silver, uranium, gross alpha, and gross beta in downgradient wells exceeds that

in the paired upgradient wells in five of five well pairs. Additionally, for nickel, there is no statistical evidence that the concentration of nickel in downgradient wells exceeds that in the paired upgradient wells in four of the five well pairs. No comparisons were possible for pair 1 because no data was available in wells GW-154 and GW-148 for nickel.

Tolerance limits were generated from the concentrations found in upgradient wells for future comparisons. These tolerance limits were generated based on nine wells upgradient of NHP. These wells were GW-152, GW-153, GW-154, GW-223, GW-380, GW-381, GW-605, GW-762, and GW-763. Table B-22 summarizes the tolerance limit for each indicator parameter. These tolerance limits are significant in that, as they are high, they represent sources upgradient to NHP. As presented in Appendix E, high concentrations in well GW-154 elevated the tolerance limits for gross beta, gross alpha, uranium, and mercury. Well GW-380 was the dominant well for cadmium, chromium, and nickel, while GW-152 and GW-762 were the dominant wells for lead and barium, respectively.

The tolerance limits will be used in comparison with the detection monitoring results to determine if corrective action monitoring is needed at the NHP. A detailed discussion of the derivation of the tolerance limits and associated statistical test data are presented in Appendix E.

Because it has been demonstrated that contaminants are not found at statistically significantly greater concentrations downgradient than upgradient (other than barium in two well pairs) and that NHP is not a significant source of contamination, assessment monitoring will no longer be performed for NHP. Rather, detection monitoring will be performed on selected wells at NHP.

The tolerance limits for the constituents of concern (Table B-22), based on the concentrations in upgradient wells, will be used to evaluate future sampling data associated with detection monitoring. The values are high, particularly for gross alpha and gross beta; however, they are based on actual upgradient water-quality data. Elimination of the outlier concentrations (i.e., in well GW-154) from tolerance limit calculations would result in artificially reduced limits and a greater frequency of false positives in downgradient detection monitoring wells. As the plume moves downgradient of NHP, and higher concentrations are detected downgradient, these tolerance limits will demonstrate that the concentrations found are not associated with NHP.

Statistical analysis will be performed on alternative indicator parameters collected for the NHP detection monitoring well network. Since it has been demonstrated that NHP is not a statistically discernible contaminant source, statistical analysis will not be performed on the standard indicator parameters dictated by Rule 1200-1-11-.05 (Tennessee Department of Environment and Conservation 1994). Rather, an alternative statistical analysis will be performed only on the target parameters with the results compared to the established tolerance limits.

B.5 GROUNDWATER PROTECTION

Ref: 1200-1-11-.06(6)(a)

Based on the past groundwater monitoring and statistical analysis (Appendix E), it is apparent that contaminants observed in the vicinity of NHP (particularly VOCs) are from other upgradient sources within the Y-12 Plant. Results of statistical evaluations of metals and gross radiological parameters, suggest that NHP is not a statistically identifiable source of contamination. Because of this, groundwater assessment monitoring specific to NHP will no longer be performed. Rather, a detection monitoring program will be initiated. If NHP 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. Corrective action groundwater monitoring in the vicinity of the eastern S-3 Ponds plume will be conducted as part of the East Fork Regime-wide monitoring. Corrective action monitoring of the S-3 Ponds in the Bear Creek Regime will also be conducted as described in the Post-Closure Permit (Tennessee Department of Environment and Conservation 1993). Remedial actions will be performed in accordance with remedial action work plans developed under CERCLA utilizing RCRA as an ARAR. In order to ensure protection of human health and the environment, the wells comprising the monitoring networks in the East Fork Regime (Table B-23 and Figure B-21) will be sampled on a semiannual basis. The groundwater samples collected from the monitoring wells will be analyzed for the target parameter list found on Table B-24.

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 according to the following: after the work called for in the FFA has been completed, the need for any further corrective action, under this permit, shall be evaluated. Such 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 selection under the FFA and that render the FFA remedy no longer protective of human health and the environment.

B.5.1 Monitoring Requirements

The groundwater monitoring activities to be required for NHP and the eastern S-3 Ponds plume are included in the following sections. Collection and analysis of

groundwater samples will be performed semiannually by qualified personnel identified by the Y-12 Plant GWPP. All groundwater assessment and remediation activities within the East Fork Regime will be conducted pursuant to the FFA. Statistical evaluations will be performed for NHP groundwater samples and the results will be compared to tolerance limits computed from upgradient wells as presented in Appendix E.

B.5.2 Groundwater Monitoring System

Four downgradient wells (GW-148, GW-149, GW-151, and GW-220) adjacent to NHP will be monitored for alternative indicator parameters of concern (eight metals, gross alpha and gross beta) (Table B-24). A unique constituent of the S-3 Ponds groundwater plume is nitrate, which is very mobile and moves relatively unimpeded through the groundwater system and more rapidly than other constituents of the plume. Thus, the leading edge of the eastern portion of the S-3 Ponds groundwater plume will be monitored for the presence of nitrate. Therefore, wells GW-193, GW-605, GW-606, and GW-733 (Figure B-21), which are downgradient of the S-3 Ponds, will be analyzed for COCs. Nitrate will be used to monitor the advance of the S-3 Ponds plume. In addition, at least one of five wells from the eastern side of the S-3 Ponds (GW-108, GW-109, GW-253, GW-274, or GW-275) will also be monitored for COCs to evaluate long-term contaminant levels within the plume.

Additional information regarding the Bear Creek Regime groundwater monitoring system at the S-3 Ponds is provided in the S-3 Ponds Post-Closure Permit (Tennessee Department of Environment and Conservation 1993).

All wells were constructed in accordance with the standards outlined in Part 1200-1-11-.06(6)(a) of the TDEC rules for hazardous waste management (Tennessee Department of Environment and Conservation 1994). Well-construction diagrams for the

proposed monitoring well network for NHP and the S-3 Ponds are presented in Appendix B. Complete well-construction details for the proposed monitoring well network are provided on Table B-23. Additional wells may be installed in the area as part of future groundwater investigations under CERCLA or other non-RCRA activities. Construction in the East Fork Regime may require that some wells be abandoned and plugged at some point in the future. Prior approval for plugging and abandoning any corrective action or 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 sampling and analysis procedures for groundwater monitoring at the East Fork Regime are designed to provide representative results of the groundwater quality within the hydrogeologic regime. The water level elevation in each well will be measured as required in Rule 1200-1-11-.06(6)(a), and in accordance with the most current approved version of the procedures presented in Appendix D. Well depths will be verified annually in accordance with the most current approved version of the Y-12 Plant GWPP well inspection procedures (Appendix C.3). Additional information regarding the sampling and analysis plan for the S-3 Ponds is provided in the S-3 Ponds Post-Closure Permit.

B.5.3.1 Sample Collection

Groundwater samples from monitoring wells in the East Fork Regime will be collected in accordance with the most current approved version of the procedures 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 pump, and bailers. Groundwater sample collection will

be conducted from the least contaminated to the most contaminated well within each set of wells sampled.

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

B.5.3.2 Sample Containers, Preservation, and Transportation

The types of sample containers, preservation, and transportation methods will be specified in the most current approved version of the groundwater sampling and analysis plan (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 are presented in Burnett and Dill (1990).

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 of 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

2/27/95

Date Signed

Martin Marietta Energy Systems, Inc.
Co-Operator

Feb 20 1995

Date Signed

The DOE and its operating contractor, Energy Systems, 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 Energy Systems', 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 Energy Systems with respect to the permitted facility and it shall not be construed as altering or limiting the certification.

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TABLES

Table A-1. New Hope Pond Sediment Analysis, May 1983
Energy Systems, Inc. Y-12 Plant Oak Ridge, Tennessee

Constituent	Concentration (µg/g)						
	Sample Location						
	1	2	3	4	5	6	7
Barium	280	440	470	430	510	380	530.00
Cadmium	9	20	26	21	28	14	33.00
Chromium	450	420	760	800	430	600	820
Lead	130	100	230	240	250	230	290
Mercury	57	110	160	150	120	160	94
Silver	55	130	130	140	190	89	160
Polychlorinated biphenyls	30	34	34	43	14	48	21
Beryllium	6.2	8	9.50	10	9.2	11	11
Uranium	370	535	550	700	560	970	755
Uranium-235 (%)	0.63	1	0.79	0.88	1.2	0.59	0.91
Thorium	130	100	160	130	72	130	94
Technetium (nCi/g)	<0.22	<0.22	<0.22	<0.22	<0.22	<0.22	<0.22
Neptunium (nCi/g)	0.05	0.036	0.06	<0.01	0	0.01	<0.01
Plutonium-238 (nCi/g) ^(a)	0.00003	0.00007	0.00007	0.00010	0.00009	0.00007	0.00009
Plutonium-239 (nCi/g) ^(b, c, d)	0.00008	0.00016	0.00016	0.00023	0.00021	0.00016	0.00022
Plutonium-240 (nCi/g) ^(e)	0.00004	0.00006	0.00006	0.00009	0.00008	0.00006	0.00008
Alpha (nCi/g)	0.625	0.685	0.99	0.99	0.84	1.12	1
Beta (nCi/g)	0.45	0.935	1.125	0.8	0.715	0.865	0.89

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SOURCE: Union Carbide 1983a.

(a) Ratio of 0.00031 nCi ²³⁸Pu, ²³⁹, ²⁴⁰Pu used to calculate ²³⁸Pu.

(b) Nanograms of ²³⁹Pu obtained from ²⁴²Pu spike isotope dilution mass spectrometry.

(c) Extraction and analysis of ²³⁹Pu/²⁴⁰Pu ratio resulted in an average of 10:1 (average of 5 of the 7 samples).

(d) Specific activity of ²³⁹Pu = 1.38 x 10⁵ dpm/µg.

(e) Specific activity of ²⁴⁰Pu = 5.08 x 10⁵ dpm/µg.

µg/g - micrograms per gram

dpm/µg - disintegration per minute per microgram

nCi/g - nano curies per gram

Table A-2. Extraction Procedure (EP) Leach Test Data for Samples Taken from New Hope Pond, May 1983

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

Constituent	Concentration (µg/L)						
	Sample Location						
	1	2	3	4	5	6	7
Required for the EP Leach Test							
Arsenic	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Barium	<10	<10	<10	<10	<10	<10	<10
Cadmium	<0.1	0.1	<0.1	0.1	0.1	0.1	0.2
Chromium	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Lead	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5
Mercury	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Selenium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Silver	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Not required by the EP Leach Test but were obtained for information purposes							
Beryllium	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Fluoride	0.6	0.7	0.9	1	1	0.9	1
NO ³ -N	0.6	0.8	1	0.7	1.9	1.1	0.8
Thorium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Uranium	0.08	0.04	0.12	0.16	0.04	0.59	0.07
Uranium-235 (%)	0.85	1.62	0.82	1.2	1.3	0.83	1.17

Table A-3. New Hope Pond Sediment Analysis, September 1983

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

Constituent	Concentration ($\mu\text{g/g}$)		
	Average	Minimum	Maximum
Antimony	<9	<9	<9
Arsenic	25.6	15	38
Beryllium	3.6	1.4	10.9
Cadmium	7.8	3.4	13
Chromium	210	54	324
Copper	205	96	278
Lead	87	38	116
Mercury	126	47	320
Nickel	141	90	280
Selenium	<2	<2	<2
Silver	29.7	7	51
Thallium	<3	<3	<3
Zinc	578	333	788
Cyanide (mg/L)	0.5	<0.5	0.61
Phenol (mg/L)	0.65	0.34	1.13

16JAN95 SB

SOURCE: Union Carbide 1983b.

$\mu\text{g/g}$ - micrograms per gram
 mg/L - milligrams per liter

Table A-4. New Hope Pond Appendix IX Sediment Analysis, September 30, 1988

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

	Minimum Value	Maximum Value	Mean
Elemental Analyses (mg/kg)			
Silver	8.6	126	59
Aluminum	6170	15,200	10,765
Arsenic	5.7	36.4	21.9
Barium	169	325	232
Beryllium	0.7	11.7	3.4
Calcium	16,600	62,100	33,210
Cadmium	3.7	20.2	11.3
Cobalt	5.7	19.5	10.8
Chromium	38.4	571	249
Copper	112	485	303
Iron	14,100	37,700	28,000
Mercury	20.6	134	70
Potassium	570	1475	1050
Magnesium	3890	13,500	7148
Manganese	241	731	523
Sodium	570	1475	1050
Nickel	42.2	211	130
Lead	10.7	214	109
Antimony	6.85	17.7	12.6
Selenium	0.7	3.4	1.4
Tin	11.4	69.4	22.7
Thallium	1.5	13.3	2.5
Vanadium	6.9	22.5	12.8
Zinc	336	1390	932
Inorganics (mg/kg)			
Cyanide	0.465	2.9	1.1
Corrosivity (pH units)	5.7	8.2	7.0
Fluoride	17.3	75.3	42.2
Sulfide	0.195	0.41	0.30
Volatile Organics (µg/kg)^(a)			
Vinyl chloride	0.0	33	2
Methylene chloride	22	890	231
Acetone	48	1800	651
Carbon disulfide	0.0	31	3
Chloroform	.	30	8
2-Butanone	.	590	59
1,1,1-Trichloroethane	.	22	2
Carbon tetrachloride	.	130	4
Trichloroethene	.	96	4
Benzene	.	7	0.2
Tetrachloroethene	.	510	18
Toluene	.	620	155
Ethylbenzene	.	2700	97
Styrene	.	1400	48
Xylenes	.	200	24
Acrolein	.	27	0.9
Acrylonitrile	.	500	17
Fluorotrichloromethane	.	650	75

29JAN95 SB

SOURCE: Roy F. Weston 1988b.

^(a) Dry weight basis.

mg/kg - milligrams per kilogram

µg/kg - micrograms per kilogram

Table A-4. New Hope Pond Appendix IX Sediment Analysis, September 30, 1988

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

	Minimum Value	Maximum Value	Mean
Semivolatile Organics (µg/kg)			
1,2,4-Trichlorobenzene	.	1900	66
Naphthalene	.	3000	279
2-Methylnaphthalene	.	5500	445
Acenaphthene	.	5700	238
Dibenzofuran	.	3600	124
Diethylphthalate	.	88,000	3034
Fluorene	.	6300	217
Phenanthrene	.	26,000	4631
Anthracene	.	8400	713
Di-n-butylphthalate	.	6400	271
Fluoranthene	.	44,000	9755
Pyrene	.	30,000	6034
Butyl benzyl phthalate	.	3700	276
Benzo(a)anthracene	.	22,000	1931
bis(2-Ethylhexyl)phthalate	.	40,000	16,914
Chrysene	.	26,000	2828
Di-n-octylphthalate	.	510	18
Benzo(b)fluoranthene	.	22,000	1721
Benzo(k)fluoranthene	.	1100	89
Benzo(a)pyrene	.	1100	38
Indeno(1,2,3-cd)pyrene	.	9800	540
Dibenzo(a,h)anthracene	.	1300	49
Benzo(g,h,i)perylene	.	9400	536
Pesticides and Polychlorinated Biphenyls (PCBs) (µg/kg)			
Beta-endosulfan	.	600	31
4,4-DDT	.	170	6
Chlordane	.	60	10
PCB-(Aroclor)-1242	.	39,000	8289
PCB-(Aroclor)-1254	.	23,000	7570
Organophosphorus Pesticides (µg/kg)			
Methyl parathion	.	28	2
Malathion	.	120	4
Ethyl parathion	.	110	4
Azinphos-methyl	.	780	120

29JAN95 SB

SOURCE: Roy F. Weston 1988b.

(a) Dry weight basis.

mg/kg - milligrams per kilogram

µg/kg - micrograms per kilogram

**Table A-5. New Hope Pond Appendix IX Surface Water Analyses,
September 30, 1988**

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

	Minimum Value	Maximum Value	Mean
Elemental Analyses (mg/L)			
Silver	0.005	0.005	0.005
Aluminum	0.1	0.216	0.2
Arsenic	0.005	0.005	0.005
Barium	0.1	0.1	0.1
Beryllium	0.0025	0.0025	0.0025
Calcium	42.	45.5	44
Cadmium	0.0025	0.0025	0.0025
Cobalt	0.025	0.025	0.025
Chromium	0.005	0.005	0.005
Copper	0.0125	0.0286	0.0206
Iron	0.106	0.17	0.14
Mercury	0.0001	0.0001	0.0001
Potassium	2.5	2.5	2.5
Magnesium	11.2	12.1	11.7
Manganese	0.0484	0.0651	0.056
Sodium	14.1	19.9	17.0
Nickel	0.02	0.02	0.02
Lead	0.0025	0.0025	0.0025
Antimony	0.03	0.03	0.03
Selenium	0.0025	0.0025	0.0025
Tin	0.05	0.05	0.05
Thallium	0.005	0.005	0.005
Vanadium	0.25	0.25	0.25
Zinc	0.0965	0.0972	0.0969
Field Measurements and Inorganics (mg/L)			
Water temperature (degrees centigrade)	12	16	14
Dissolved oxygen (parts per million)	8	8.9	8
Field conductivity, Rep. 1 (µmhos/cm)	160	250	205
Field conductivity, Rep. 2	165	255	210
Field conductivity, Rep. 3	168	255	212
Field pH, Rep. 1 (pH units)	7.7	7.8	7.8
Field pH, Rep. 2	7.7	7.8	7.8
Field pH, Rep. 3	7.8	7.8	7.8
Field redox, Rep. 1 (MV)	99	110	105
Field redox, Rep. 2	98	110	104
Field redox, Rep. 3	100	110	105
Cyanide	0.005	0.005	0.005
Fluoride	0.89	0.92	0.91
Sulfide	0.05	0.05	0.05
Volatile Organics (mg/L)			
Methylene chloride	2	4	3
Acetone	5	8	7
Chloroform	1	5	3
Carbon tetrachloride		1	0.5
Tetrachloroethene		2	1
Toluene		1	0.5
Fluorotrichloromethane		3	1.5

30JAN95 SB

SOURCE: Roy F. Weston 1988b.
mg/L - milligrams per liter

Table B-1. Waste-Management Sites, CERCLA Operable Units, and Underground Storage Tanks Included in the 1993 Groundwater Protection Program

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

Site Name	Regulatory Classification	
	Historical ^a	Current ^b
New Hope Pond	TSD Unit	TSD Unit
Mercury Process Spill Areas	SWMU	EFPC OU 01
Abandoned Nitric Acid Pipeline	SWMU	EFPC OU 02
Salvage Yard Scrap Metal Storage Area	SWMU	EFPC OU 03
Salvage Yard Oil/Solvent Drum Storage Area	SWMU	EFPC OU 03
Salvage Yard Oil Storage	SWMU	EFPC OU 03
Salvage Yard Drum Deheader	SWMU	EFPC OU 03
Tank 2063-U	SWMU	EFPC OU 03
S-2 Site	SWMU	EFPC OU 03
Waste Coolant Processing Area	SWMU	EFPC OU 03
Tank 2328-U	SWMU	Y-12 SA
Tank 2329-U	SWMU	Y-12 SA
Interim Drum Yard	SWMU	Y-12 SA
Beta-4 Security Pits	SWMU	Y-12 SA
Tank 2331-U	UST	UST
Tank 0134-U	UST	UST
Building 9754-2 Fuel Facility	UST	UST
Garage Underground Tanks	SWMU/UST	Y-12 SA/UST
Rust Garage Area	SMWU/UST	Y-12 SA/UST

7FEB95 SB SOURCE: HSW Environmental Consultants 1994a.

NOTES:

^a Regulatory status before 1992 Federal Facility Agreement.

TSD Unit	-	RCRA regulated land-based treatment, storage, or disposal unit
SWMU	-	RCRA regulated Solid Waste Management Unit
UST	-	Non-RCRA Underground Storage Tank

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

EFPC OU 01	-	East Fork Poplar Creek Operable Unit 01 (Integrator)
EFPC OU 02	-	East Fork Poplar Creek Operable Unit 02 (Source Control)
EFPC OU 03	-	East Fork Poplar Creek Operable Unit 03 (Source Control)
Y-12 SA	-	Y-12 Plant Study Area

Table B-2. Construction Details of Monitoring Wells in the Upper East Fork Poplar Creek Hydrogeologic Regime

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

Well	Installation Date	Measuring Point Elevation (TOC) (ft, msl)	Open/Screen	Open/Screened Interval (depth, ft)	Aquifer Zone Monitored	Formation Monitored
New Hope Pond Assessment Wells						
GW-148	July 1985	907.36	Screen	5.6 - 11.1	UNC	--
GW-149	August 1985	907.72	Screen	37.0 - 47.0	BDR	€mn
GW-150	August 1985	915.56	Screen	6.2 - 11.2	UNC	—
GW-151	August 1985	915.97	Screen	86.0 - 96.0	BDR	-C mn
GW-152	August 1985	921.18	Screen	11.8 - 16.8	UNC	—
GW-153	October 1985	921.44	Screen	49.5 - 59.5	BDR	-C mn
GW-154	July 1985	911.50	Screen	5.7 - 10.7	UNC	—
GW-220	August 1985	915.64	Screen	34.7 - 44.7	BDR	-C mn
GW-222	August 1985	911.82	Screen	19.5 - 24.5	BDR	-C mn
GW-223	August 1985	911.62	Screen	80.0 - 90.0	BDR	-C mn
GW-240	October 1985	922.90	Screen	24.0 - 29.0	BDR	-C mn
GW-380	August 1988	913.55	Screen	9.8 - 15.2	UNC	—
GW-381	April 1988	913.36	Open	49.3 - 60.4	BDR	-C mn
GW-382	April 1988	913.17	Open	125.0 - 173.0	BDR	-C mn
GW-383	April 1988	908.50	Screen	18.1 - 23.1	BDR	-C n
GW-384	March 1988	908.38	Open	35.5 - 55.7	BDR	-C n
GW-385	March 1988	908.87	Open	123.7 - 178.7	BDR	-C n
Regime-Wide Assessment						
GW-105	September 1984	1017.40	Screen	12.1 - 16.1	UNC	—
GW-106	September 1984	1016.00	Screen	61.9 - 70.9	BDR	-C n
GW-107	September 1984	998.19	Screen	8.5 - 12.5	UNC	—
GW-108	September 1984	998.18	Screen	46.7 - 55.7	BDR	-C n
GW-109	September 1984	996.99	Screen	102.9 - 121.9	BDR	-C n
GW-167	April 1986	931.38	Screen	26.0 - 30.1	UNC	—
GW-168	April 1986	932.21	Open	104.0 - 135.4	BDR	-C n
GW-169	September 1986	931.87	Screen	29.7 - 34.7	UNC	—
GW-170	April 1986	932.44	Open	104.0 - 156.9	BDR	-C mn
GW-190	August 1989	1033.70	Screen	9.8 - 25.9	BDR	-C mn
GW-191	October 1985	1011.10	Screen	49.5 - 59.5	BDR	-C mn
GW-192	September 1985	1008.60	Screen	7.5 - 17.5	BDR	-C mn
GW-193	August 1989	934.00	Screen	8.2 - 18.4	BDR	-C mn
GW-194	September 1985	995.36	Screen	7.5 - 12.5	UNC	—
GW-195	September 1985	1002.90	Screen	17.0 - 23.0	UNC	—
GW-199	September 1985	961.08	Screen	17.5 - 22.5	BDR	-C rg
GW-204	August 1989	958.57	Screen	7.3 - 17.3	BDR	-C mn
GW-205	October 1985	1104.00	Screen	154.0 - 164.0	BDR	Ock
GW-206	September 1985	894.50	Screen	11.8 - 16.9	UNC	—
GW-207	September 1985	898.36	Open	100.0 - 109.6	BDR	-C r
GW-208	May 1986	897.72	Open	404.0 - 412.8	BDR	-C r
GW-232	March 1986	931.22	Open	401.0 - 411.7	BDR	-C mn
GW-239	April 1986	931.50	Open	404.0 - 433.3	BDR	-C n

17FEB95 SB

TOC - Top of Casing
ft - feet
msl - mean sea level
P&A'd - Plugged and Abandoned
BDR - Bedrock
UNC - Unconsolidated Zone

-C rg - Rogersville Shale
-C rt - Rutledge Limestone
-C r - Rome Foundation
Ock - Knox Group

-C mn - Maynardville Limestone
-C n - Nolichucky Shale
-C m - Maryville Limestone

Table B-2. Construction Details of Monitoring Wells in the Upper East Fork Poplar Creek Hydrogeologic Regime

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

Well	Installation Date	Measuring Point Elevation (TOC) (ft, msl)	Open/Screen	Open/Screened Interval (depth, ft)	Aquifer Zone Monitored	Formation Monitored
GW-251	April 1986	1003.60	Screen	37.5 - 47.1	UNC	—
GW-252	April 1986	1024.20	Screen	43.8 - 48.8	UNC	—
GW-253	April 1986	1004.00	Screen	37.0 - 46.6	UNC	—
GW-255	April 1986	1027.10	Screen	71.3 - 81.3	BDR	-C mn
GW-256	P&A'd September 1987	996.12	Screen	12.7 - 17.4	UNC	—
GW-261	May 1986	1050.00	Screen	18.3 - 23.7	BDR	-C m
GW-262	May 1986	1049.70	Screen	60.2 - 70.6	BDR	-C m
GW-263	May 1986	1057.70	Screen	25.5 - 30.8	BDR	-C m
GW-264	May 1986	1058.30	Screen	60.5 - 70.7	BDR	-C m
GW-268	June 1986	1026.50	Screen	28.1 - 33.7	BDR	-C m
GW-269	June 1988	1027.80	Screen	23.7 - 29.4	BDR	-C m
GW-270	June 1986	1009.00	Screen	13.0 - 18.4	BDR	-C n
GW-271	June 1986	1009.00	Screen	45.9 - 56.3	BDR	-C n
GW-272	June 1986	1009.20	Screen	10.9 - 16.2	BDR	-C n
GW-274	June 1986	995.43	Screen	28.5 - 33.9	BDR	-C n
GW-275	May 1986	995.36	Screen	54.8 - 65.2	BDR	-C n
GW-276	July 1986	1001.30	Screen	13.0 - 18.3	BDR	-C n
GW-277	July 1986	1001.80	Screen	67.0 - 77.4	BDR	-C n
GW-278	P&A'd September 1987	997.13	Screen	15.8 - 21.0	BDR	-C mn
GW-279	P&A'd September 1987	998.15	Screen	66.0 - 76.4	BDR	-C mn
GW-284	August 1986	941.61	Screen	3.0 - 18.0	UNC	—
GW-315	September 1987	1047.30	Screen	93.3 - 103.3	BDR	-C mn
GW-317	September 1987	1063.00	Screen	119.5 - 130.5	BDR	-C mn
GW-337	August 1987	987.31	Screen	16.7 - 22.1	UNC	—
GW-338	August 1987	987.27	Screen	12.1 - 17.6	BDR	-C n
GW-349	May 1988	993.50	Screen	9.0 - 24.0	UNC	—
GW-350	May 1988	993.51	Screen	33.4 - 43.4	BDR	-C mn
GW-505	April 1988	1014.65	Screen	1.9 - 12.3	UNC	—
GW-508	April 1988	1012.50	Screen	2.2 - 12.5	UNC	—
GW-603	December 1989	961.32	Screen	64.9 - 75.2	BDR	-C mn
GW-604	December 1989	960.86	Screen	102.5 - 112.4	BDR	-C mn
GW-605	March 1991	918.88	Screen	29.7 - 39.9	BDR	-C mn
GW-606	March 1991	919.39	Screen	161.0 - 171.7	BDR	-C mn
GW-617	March 1990	985.11	Screen	7.3 - 17.6	UNC	—
GW-618	March 1990	984.94	Screen	26.7 - 37.0	BDR	-C mn
GW-619	March 1990	1015.20	Screen	30.0 - 40.8	UNC	—
GW-620	March 1990	1015.30	Screen	64.2 - 75.0	BDR	-C mn
GW-631	May 1990	1004.00	Screen	5.0 - 15.0	UNC	—
GW-632	May 1990	1005.70	Screen	4.5 - 14.5	UNC	—
GW-633	May 1990	996.30	Screen	4.5 - 14.5	UNC	—
GW-634	May 1990	1007.20	Screen	4.8 - 14.8	BDR	-C n

17FEB95 SB

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-C r - Rome Foundation
Ock - Knox Group

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-C n - Nolichucky Shale
-C m - Maryville Limestone

Table B-2. Construction Details of Monitoring Wells in the Upper East Fork Poplar Creek Hydrogeologic Regime

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

Well	Installation Date	Measuring Point Elevation (TOC) (ft, msl)	Open/Screen	Open/Screened Interval (depth, ft)	Aquifer Zone Monitored	Formation Monitored
GW-656	July 1990	954.79	Screen	10.7 - 20.7	BDR	-C n
GW-658	August 1990	944.81	Screen	8.8 - 18.8	BDR	-C n
GW-659	September 1990	941.16	Screen	5.7 - 16.7	BDR	-C n
GW-708	October 1990	930.87	Screen	3.4 - 13.4	UNC	-C mn
GW-722	June 1991	953.71	Multiport	75.0 - 644.3	BDR	Ock, -C mn, -C n
GW-733	October 1991	959.04	Open	240.1 - 256.5	BDR	-C mn, Ock
GW-735	October 1991	924.28	Screen	67.9 - 78.1	BDR	-C n, -C mn
GW-744	January 1992	907.43	Screen	57.0 - 67.0	BDR	-C pv
GW-745	January 1992	907.06	Screen	22.5 - 32.5	BDR	-C pv
GW-746	January 1992	906.88	Screen	4.5 - 14.75	BDR	-C pv
GW-747	January 1992	920.96	Screen	69.2 - 79.1	BDR	-C m
GW-748	January 1992	921.17	Screen	17.0 - 27.0	BDR	-C m
GW-749	February 1992	921.19	Screen	6.0 - 16.0	BDR	-C m
GW-750	February 1992	918.86	Screen	62.4 - 72.4	BDR	-C n, -C m
GW-751	February 1992	912.05	Screen	50.1 - 60.1	BDR	-C n
GW-752	February 1992	912.78	Screen	5.5 - 15.5	BDR	-C n
GW-753	March 1992	927.69	Screen	60.4 - 70.4	BDR	-C m, -C n
GW-754	March 1992	928.59	Screen	14.0 - 24.0	BDR	-C n
GW-755	March 1992	930.36	Screen	50.0 - 60.0	BDR	-C m, -C rg
GW-756	March 1992	927.92	Screen	6.0 - 16.0	UNC/BDR	-C m
GW-758	April 1992	992.70	Screen	40.2 - 50.2	BDR	-C rg
GW-759	April 1992	994.01	Screen	18.9 - 29.6	BDR	-C rt
GW-760	May 1992	970.02	Screen	49.7 - 59.7	BDR	-C m
GW-761	May 1992	968.23	Screen	5.3 - 15.0	BDR	-C m
GW-762	May 1992	915.34	Screen	48.2 - 58.2	BDR	-C n
GW-763	May 1992	914.85	Screen	5.15 - 15.4	UNC	—
GW-764	May 1992	1009.90	Screen	54.9 - 64.9	BDR	C rg
GW-765	May 1992	1008.50	Screen	21.2 - 31.5	BDR	C rg
GW-766	May 1992	948.37	Screen	34.9 - 44.9	BDR	-C n, -C m
GW-767	May 1992	948.54	Screen	7.8 - 17.8	BDR	-C m
GW-768	May 1992	959.73	Screen	54.6 - 64.5	BDR	-C rg
GW-769	June 1992	944.26	Screen	49.4 - 59.4	BDR	-C n
GW-770	June 1992	944.55	Screen	8.5 - 18.5	UNC/BDR	-C n
GW-771	June 1992	1011.20	Screen	44.0 - 54.0	BDR	-C rg
GW-772	June 1992	1012.70	Screen	5.1 - 15.2	UNC	—
GW-773	June 1992	963.76	Screen	48.6 - 58.7	BDR	-C m
GW-774	June 1992	963.16	Screen	16.0 - 25.8	BDR	-C m
GW-775	July 1992	931.35	Screen	46.3 - 56.3	BDR	-C n
GW-776	July 1992	931.25	Screen	12.3 - 22.3	UNC/BDR	-C n
GW-816	June 1994	898.21	Screen	4.2 - 14.2	UNC	-C r
GW-817	June 1994	918.12	Screen	1.0 - 22.3	UNC/BDR	-C n

17FEB95 SB

TOC - Top of Casing

ft - feet

msl - mean sea level

P&A'd - Plugged and Abandoned

BDR - Bedrock

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-C r - Rome Foundation

Ock - Knox Group

-C mn - Maynardville Limestone

-C n - Nolichucky Shale

-C m - Maryville Limestone

-C pv - Pumpkin Valley Shale

**Table B-3. Groundwater Monitoring Parameters from Quarterly Sampling
of Monitoring Wells at New Hope Pond, 1986 and 1987**

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

Metals

Aluminum	Nickel
Antimony	Niobium
Arsenic	Phosphorous
Barium	Potassium
Beryllium	Radium
Boron	Selenium
Cadmium	Silicon
Calcium	Silver
Chromium	Sodium
Cobalt	Strontium
Copper	Thallium
Iron	Thorium
Lead	Titanium
Lithium	Uranium
Magnesium	Vanadium
Manganese	Zinc
Mercury	Zirconium
Molybdenum	

Volatile Organic Compounds (VOCs)

Acetone	1,2-Dichloropropane
Benzene	trans-1,3-Dichloropropene
Bromodichloromethane	cis-1,3-Dichloropropene
Bromoform	Ethylbenzene
Bromomethane	2-Hexanone
2-Butanone	4-Methyl-2-Pentanone
Carbon disulfide	Methylene chloride
Carbon tetrachloride	Styrene
Chlorobenzene	1,1,2,2-Tetrachloroethane
Chlorodibromomethane	Tetrachloroethene
Chloroethane	Toluene
2-Chloroethylvinyl ether	1,1,1-Trichloroethane
Chloroform	1,1,2-Trichloroethane
Chloromethane	Trichloroethene
1,1-Dichloroethane	Vinyl acetate
1,2-Dichloroethane	Vinyl chloride
1,1-Dichloroethene	Xylenes
trans-1,2-Dichloroethene	

Pesticides/Herbicides

2,4-D	Methoxychlor
Endrin	Silvex
Lindane	Toxaphene

Miscellaneous Parameters

Water level	Phenols
Temperature	Chloride
Dissolved oxygen	Nitrate (as N)
Specific Conductance	Sulfate
pH	Total organic carbon
Redox	Total organic halogen (as Cl)
Turbidity	Gross alpha
Coliform	Gross beta
Fluoride	

**Table B-4. Monitoring Wells Used in the Appendix IX Sampling Program
at New Hope Pond**

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

GW-148	GW-154
GW-149	GW-220
GW-151	GW-222
GW-152	GW-223
GW-153	GW-240

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Table B-5. List of Groundwater Quality Assessment Parameters at New Hope Pond, 1988

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

Metals

Arsenic	Mercury
Barium	Selenium
Cadmium	Silver
Chromium	Uranium
Lead	

Major Cations and Anions

Alkalinity, bicarbonate	Nitrate (as N)
Calcium	Potassium
Chloride	Sodium
Fluoride	Sulfate
Magnesium	

Volatile Organic Compounds (VOCs)

Acrolein	1,1-Dichloroethene
Acrylonitrile	trans-1,2-Dichloroethene
Benzene	1,2-Dichloropropane
Bromodichloromethane	cis-1,3-Dichloropropene
Bromoform	trans-1,3-Dichloropropane
Bromomethane	Ethylbenzene
Carbon tetrachloride	Fluorotrichloromethane
Chlorobenzene	Methylene chloride
Chlorodibromomethane	1,1,2,2-Tetrachloroethane
Chloroethane	Tetrachloroethene
2-Chloroethyl vinyl ether	Toluene
Chloroform	1,1,1-Trichloroethene
Chloromethane	1,1,2-Trichloroethane
Dichlorodifluoromethane	Trichloroethene
1,1-Dichloroethane	Vinyl chloride
1,2-Dichloroethane	

Radiochemical Parameters

Gross Alpha Activity
Gross Beta Activity

Miscellaneous Parameters

pH	Total Dissolved Solids
Specific Conductance	Total Suspended Solids

Table B-6. List of Groundwater Quality Assessment Parameters at New Hope Pond, 1989

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

Metals

Barium	Lead
Cadmium	Mercury
Chromium	Uranium

Major Cations and Anions

Alkalinity	Nitrate (as N)
Calcium	Potassium
Chloride	Sodium
Fluoride	Sulfate
Magnesium	

Volatile Organic Compounds (VOCs)

Acetone	Ethylbenzene
Benzene	Methylene chloride
Bromoform	1,1,2,2-Tetrachloroethane
Carbon tetrachloride	Tetrachloroethene
Chloroethane	Toluene
Chloroform	1,1,1-Trichloroethane
Chloromethane	1,1,2-Trichloroethane
1,1-Dichloroethane	Trichloroethene
1,2-Dichloroethane	Vinyl chloride
1,1-Dichloroethene	Xylenes
1,2-Dichloroethene	

Radiochemical Parameters

Gross Alpha Activity
Gross Beta Activity

Miscellaneous Parameters

pH	Total Organic Carbon
Specific Conductance	Total Organic Halides
Total Dissolved Solids	Turbidity
Total Suspended Solids	

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SOURCE: Geraghty & Miller, Inc., 1990a.

Table B-7. List of Groundwater Quality Assessment Parameters at New Hope Pond, 1990

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

Metals	ICP	AAS
	Aluminum	Cadmium
	Antimony	Chromium
	Arsenic	Lead
	Barium	
	Beryllium	CVAA
	Boron	Mercury
	Cadmium	
	Chromium	FLUOR
	Cobalt	Uranium
	Copper	
	Iron	
	Molybdenum	
	Nickel	
	Selenium	
	Silicon	
	Silver	
	Strontium	
	Thorium	
	Vanadium	
	Zinc	
Major Cations and Anions		
	Alkalinity, bicarbonate	Manganese
	Alkalinity, carbonate	Nitrate (as N)
	Calcium	Potassium
	Chloride	Sodium
	Fluoride	Sulfate
	Magnesium	
Volatile Organic Compounds (VOCs)		
	Acetone	1,2-Dichloropropane
	Benzene	cis-1,3-Dichloropropene
	Bromodichloromethane	trans-1,3-Dichloropropene
	Bromoform	Ethylbenzene
	Bromomethane	2-Hexanone
	2-Butanone	4-Methyl-2-pentanone
	Carbon disulfide	Methylene chloride
	Carbon tetrachloride	Styrene
	Chlorobenzene	1,1,2,2-Tetrachloroethane
	Chlorodibromomethane	Tetrachloroethene
	Chloroethane	Toluene
	Chloroform	1,1,1-Trichloroethane
	Chloromethane	1,1,2-Trichloroethane
	1,1-Dichloroethane	Trichloroethene
	1,2-Dichloroethane	Vinyl acetate
	1,1-Dichloroethene	Vinyl chloride
	1,2-Dichloroethene	Xylenes
Radiochemical Parameters		
	Gross Alpha Activity	
	Gross Beta Activity	
	Radionuclides: Cesium 137 (a)	Strontium
	Iodine 129 and 125	Technetium 99
	Protactinium (a)	Thorium - 231 + 234 (a)
	Radium (total)	Tritium
	Radium (228) (a)	Uranium - 234, 235, and 238
Field Parameters		
	pH	Depth to water
	Specific Conductance	Water Temperature
	Dissolved Oxygen	Redox
Miscellaneous Parameters		
	pH	Total Organic Carbons
	Specific Conductance	Total Organic Halogens
	Total Dissolved Solids	Total Petroleum Hydrocarbons
	Total Suspended Solids	Turbidity
	Phenols	

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SOURCE: HSW Environmental Consultants, Inc., 1991a.

(a) Radionuclides analyzed in first quarter 1990 samples from GW-108, GW-115, GW-274, and GW-275.

ICP - Inductively-Coupled Plasma (Spectroscopy)
AAS - Atomic Absorption Spectroscopy

CVAA - Cold Vapor Atomic Absorption
FLUOR - Fluorometric

Table B-8. List of Groundwater Quality Assessment Parameters at New Hope Pond, 1991

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

Metals

Aluminum	Mercury
Antimony	Molybdenum
Arsenic	Nickel
Barium	Selenium
Beryllium	Silicon
Boron	Silver
Cadmium	Strontium
Chromium	Thorium
Cobalt	Uranium
Copper	Vanadium
Iron	Zinc
Lead	

Major Cations and Anions

Alkalinity, bicarbonate	Manganese
Alkalinity, carbonate	Nitrate (as N)
Calcium	Potassium
Chloride	Sodium
Fluoride	Sulfate
Magnesium	

Volatile Organic Compounds (VOCs)

Acetone	1,2-Dichloropropane
Benzene	cis-1,3-Dichloropropene
Bromodichloromethane	trans-1,3-Dichloropropene
Bromoform	Ethylbenzene
Bromomethane	2-Hexanone
2-Butanone	4-Methyl-2-pentanone
Carbon disulfide	Methylene chloride
Carbon tetrachloride	Styrene
Chlorobenzene	1,1,2,2-Tetrachloroethane
Chlorodibromomethane	Tetrachloroethene
Chloroethane	Toluene
Chloroform	1,1,1-Trichloroethane
Chloromethane	1,1,2-Trichloroethane
1,1-Dichloroethane	Trichloroethene
1,2-Dichloroethane	Vinyl acetate
1,1-Dichloroethene	Vinyl chloride
1,2-Dichloroethene	Xylenes

Radiochemical Parameters

Gross Alpha Activity
Gross Beta Activity
(a) Radionuclides: Strontium
Technetium 99
Tritium
Uranium - 234, 235, and 238

Field Parameters

pH	Depth to water
Specific Conductance	Water Temperature
Dissolved Oxygen	Redox

Miscellaneous Parameters

pH	(b) Total Organic Carbons
Specific Conductance	(b) Total Organic Halogens
Total Dissolved Solids	(b) Total Petroleum Hydrocarbons
Total Suspended Solids	Turbidity
(b) Phenols	

Table B-9. List of Groundwater Quality Assessment Parameters at New Hope Pond, 1992

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

Trace Metals

Aluminum	Cobalt	Potassium
Antimony	Copper	Selenium
Arsenic	Iron	Silver
Barium	Lead	Sodium
Beryllium	Magnesium	Strontium
Boron	Manganese	Thorium
Cadmium	Mercury	Uranium
Calcium	Molybdenum	Vandium
Chromium	Nickel	Zinc

Volatile Organic Compounds

Acetone	1,2-Dichloropropane
Benzene	cis-1,3-Dichloropropene
Bromodichloromethane	trans-1,3-Dichloropropene
Bromoform	Ethylbenzene
Bromomethane	2-Hexanone
2-Butanone	4-Methyl-2-pentanone
Carbon disulfide	Methylene chloride
Carbon tetrachloride	Styrene
Chlorobenzene	1,1,2,2-Tetrachloroethane
Chlorodibromomethane	Tetrachloroethene
Chloroethane	Toluene
Chloromethane	1,1,1-Trichloroethane
Chloroform	1,1,2-Trichloroethane
1,1-Dichloroethane	Trichloroethene
1,2-Dichloroethane	Vinyl acetate
1,1-Dichloroethene	Vinyl chloride
1,2-Dichloroethene	Xylenes

Major Anions

Alkalinity - Carbonate	Fluoride
Alkalinity - Bicarbonate	Nitrate (as N)
Chloride	Sulfate

Radiological Parameters

Isotopic Uranium (²³⁴ U, ²³⁵ U, ²³⁸ U)	Neptunium 237
Gross Alpha Activity	Strontium
Gross Beta Activity	Tritium
Americium 241	Technetium 99

Miscellaneous Parameters

pH	Phenols
Specific Conductance	Total Organic Carbon (TOC)
Total Dissolved Solids (TDS)	Total Organic Halogen (TOX)
Total Suspended Solids (TSS)	Total Petroleum Hydrocarbons (TPH)
Turbidity	

Field Measurements

pH	Static Water Level
Specific Conductance	Dissolved Oxygen
Temperature	Reduction Oxidation Potential (REDOX)

30JAN95 Ba SOURCE: IISW Environmental Consultants, 1993a.

NOTE : Gross alpha activity and gross beta activity determined for all wells; selected radionuclide analyses performed for selected wells only.

Table B-10. List of Groundwater Quality Assessment Parameters at New Hope Pond, 1993
 Energy Systems, Inc. Y-12 Plant Oak Ridge, Tennessee

Trace Metals

Aluminum	Cobalt	Potassium
Antimony	Copper	Selenium
Arsenic	Iron	Silver
Barium	Lead	Sodium
Beryllium	Magnesium	Strontium
Boron	Manganese	Thorium
Cadmium	Mercury	Uranium
Calcium	Molybdenum	Vandium
Chromium	Nickel	Zinc

Volatile Organic Compounds

Acetone	1,2-Dichloropropane
Benzene	cis-1,3-Dichloropropene
Bromodichloromethane	trans-1,3-Dichloropropene
Bromoform	Ethylbenzene
Bromomethane	2-Hexanone
2-Butanone	4-Methyl-2-pentanone
Carbon disulfide	Methylene chloride
Carbon tetrachloride	Styrene
Chlorobenzene	1,1,2,2-Tetrachloroethane
Chlorodibromomethane	Tetrachloroethene
Chloroethane	Toluene
Chloroform	1,1,1-Trichloroethane
1,1-Dichloroethane	Trichloroethene
1,2-Dichloroethane	Vinyl acetate
1,1-Dichloroethene	Vinyl chloride
1,2-Dichloroethene	Xylenes

Anions

Alkalinity - Carbonate	Nitrate (as N)
Alkalinity - Bicarbonate	Fluoride
Chloride	Sulfate

Radiological Parameters

Gross Alpha Activity
 Gross Beta Activity

Miscellaneous Parameters

pH
 Specific Conductance
 Total Suspended Solids (TSS)
 Total Dissolved Solids (TDS)
 Turbidity

Field Measurements

Static Water Level
 pH
 Temperature
 Dissolved Oxygen
 Specific Conductance
 Oxidation - Reduction Potential (REDOX)

Table B-11. RCRA Assessment Monitoring Wells Sampled, 1993

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

Well No.	Location
GW-151	NHP
GW-168	NHP
GW-220	NHP
GW-239	NHP
GW-240	NHP
GW-380	NHP
GW-381	NHP
GW-382	NHP
GW-383	NHP
GW-384	NHP
GW-385	NHP
GW-735	NHP

30JAN95 Ba

SOURCE: HSW Environmental Consultants 1994a.

Table B-12. Public and Industrial Users of Groundwater within 10 Miles of New Hope Pond and the S-3 Ponds

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

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 (a)	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 (b)	Knox
Charles H. Bacon Co.		8.4×10^4	Well	Knox

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SOURCE: Union Carbide Corporation, Nuclear Division (1982) and Personal communication between H. King and D. Rosowitz (1994).

(a) Half supply.

(b) Primary source.

gpd - gallons per day

Table B-13. Annual Average PCE, TCE, 1,2-DCE Concentrations, 1990 through 1993
 Energy Systems, Inc. Y-12 Plant Oak Ridge, Tennessee

Well	Compound	Annual Average Concentrations (µg/L)			
		CY 1990	CY 1991	CY 1992	CY 1993
GW-619	PCE	1,000	459.8	350	25.8
	TCE	371	136.3	115	53.3
	1,2-DCE	1,033	375	227	101.3
	Summed Average:	2,404	971.1	692	180.4
GW-620	PCE	726.6	833.3	725	153.8
	TCE	246.6	296.7	295	185
	1,2-DCE	2,133.3	1,033.3	935	530
	Summed Average:	3,106.5	2,163.3	1,955	868.8

11FEB95 Ba SOURCE: HSW Environmental Consultants, Inc. 1994a.
 µg/L - micrograms per liter

Table B-14. Nitrate Concentrations, 1986 and 1990

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

Well	Nitrate (as N) (mg/L)		% Decrease
	CY 1986	CY 1990	
GW-105	2,619	921	65
GW-106	1,158	706	39
GW-107	43	21	51
GW-108	16,889	13,100	22
GW-109	11,700	9,960	15
GW-270	549	136	75
GW-274	15,800	10,900	31
GW-275	9,400	8,770	7
GW-276	1,580	454	71
GW-277	1,761	1,690	4

8feb95 SB

SOURCE: HSW Environmental Consultants, Inc., 1994a
mg/L - milligrams per liter

Table B-15. Barium Concentrations, 1987 and 1990

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

Well	Total Barium (mg/L)		% Decrease
	CY 1987	CY 1990	
GW-105	16	5	69
GW-106	4	0.78	80
GW-108	180	150	17
GW-109	59	54	8
GW-274	305	83	73
GW-275	294	120	59
GW-276	7.7	2.3	70
GW-277	11.9	8	33

8FEB95 SB

SOURCE: HSW Environmental Consultants, Inc., 1994a
mg/L - milligrams per liter

Table B-16. Cadmium Concentrations, GW-251 and GW-618

Energy Systems, inc. Y-12 Plant Oak Ridge, Tennessee

Well Number	MCL (mg/L)	1990-1993 Sampling History		1993 Total Cadmium (mg/L)			
		Total Samples	Elevated Results	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
GW-251	0.005	15	15	0.16	0.2	0.083	0.078
GW-618		15	15	0.014	0.02	0.03	0.02

8FEB95 SB

SOURCE: HSW Environmental Consultants, Inc., 1994a
mg/L - milligrams per liter

**Table B-17. Cobalt Concentrations in Selected Oak Ridge Reservation
Aquitard Wells and Knox Aquifer Wells**

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

Well Number	Screening Level	1990 - 1993 Sampling History		1993 Total Cobalt (mg/L)			
		Total Samples	Elevated Results	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
ORR Aquitard Wells							
GW-508	0.025	9	9	0.13	0.15	0.22	0.15
GW-631		12	11	0.035	0.028	0.034	0.025
GW-632		12	12	0.071	0.08	0.11	0.084
GW-634		12	12	0.046	0.052	0.051	0.051
Knox Aquifer Wells							
GW-167	0.011	6	4	NS	NS	NS	NS
GW-251		15	15	0.035	0.039	0.023	0.015
GW-253		5	5	NS	NS	NS	NS

11FEB95 Ba

SOURCE: IISW Environmental Consultants, Inc. 1994a.

mg/L - milligrams per liter

Table B-18. Mercury Concentrations, GW-222 and GW-253

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

Well	Total Mercury (mg/L)					
	CY 1990				CY 1991	
	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.
GW-222	0.00056	0.0032	0.0015	0.0036	<0.0002	<0.0002
GW-253	—	0.014	0.008	0.01	0.009	0.0064

8FEB95 SB

SOURCE: HSW Environmental Consultants, Inc., 1994a
mg/L - milligrams per liter

Table B-19. Uranium Concentrations, GW-204, GW-193, and GW-605

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

Well Number	Screening Level	1990-1993 Sampling History		Total Uranium (mg/L) CY 1993			
		Total Samples	Elevated Results	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
ORR Aquitard Wells							
GW-204	0.015	15	14	0.075	0.21	0.126	0.094
Knox Aquifer Wells							
GW-193	0.007	14	10	0.017	0.009	0.086	0.08
GW-605	—	10	9	0.149	0.189	<0.001	0.19

8FEB95 SB

SOURCE: HSW Environmental Consultants, Inc., 1994a
mg/L - milligrams per liter

Table B-20. Uranium Concentrations, GW-154, GW-222 and GW-253

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

Well	Total Uranium (mg/L)					
	CY 1990				CY 1991	
	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.
GW-154	2.35	1.1	0.751	1.02	0.81	0.36
GW-222	0.099	0.354	0.364	0.093	0.141	0.115
GW-253	—	0.01	0.008	0.007	0.01	0.001

8FEB95 SB

SOURCE: HSW Environmental Consultants, Inc., 1994b
mg/L - milligrams per liter

Table B-21. Well Pairing for Statistical Test

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

Well Pair Number	Downgradient Well	Upgradient Well	Reason for Well Pairing
1	GW-148	GW-154	Comparable Depth Monitored Same Formation Monitored
2	GW-220	GW-605	Comparable Depth Monitored Same Formation Monitored
3	GW-149	GW-153	Comparable Depth Monitored Same Formation Monitored
4	GW-151	GW-223	Comparable Depth Monitored Same Formation Monitored
5	GW-733	GW-606	Comparable Depth Monitored Same Formation Monitored

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Table B-22. Summary of Tolerance Limits

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

Indicator Parameter	Tolerance Limit
Barium	0.62 mg/L
Cadmium	0.016 mg/L
Chromium	2.9 mg/L
Lead	0.24 mg/L
Mercury	0.0014 mg/L
Nickel	0.39 mg/L
Silver	<0.006 mg/L
Uranium	2.24 mg/L
Gross Alpha Activity	796 pCi/L
Gross Beta Activity	728 pCi/L

8FEB95 SB

mg/L - milligrams per liter

pCi/L - picocuries per liter

Table B-23. Construction Details of Proposed Monitoring Well Network for the Upper East Fork Poplar Creek Hydrogeologic Regime

Well Number:	GW-148	GW-149	GW-151	GW-193	GW-220	GW-605	GW-606
Monitoring Program	NHP Detect. Mon.	NHP Detect. Mon.	NHP Detect. Mon.	Corr. Act. Mon.	NHP Detect. Mon.	Corr. Act. Mon.	Corr. Act. Mon.
North Coordinates	29202.00	29201.00	28958.00	29343.93	28949.00	28706.83	28708.32
East Coordinates	63817.00	63824.00	64232.00	59536.17	64225.00	62001.50	61951.42
Surface Elevation (ft)	904.53	904.76	913.06	931.11	912.74	916.97	916.98
Measuring Point Elevation (ft)	907.36	907.72	915.97	934.00	915.64	918.88	919.39
Zone Monitored	U	B	B	WB	WB	B	B
Formation Monitored	CON:Maynardville	CON:Maynardville	CON:Maynardville	CON:Maynardville	CON:Maynardville	CON:Maynardville	CON:Maynardville
Lithology	limestone	limestone	limestone	limestone	limestone	limestone	limestone
Top of Fresh Bedrock (ft bgs)	N/A	12.00	12.00	N/A	11.00	9.50	10.80
Total Drilled Depth (ft bgs)	11.10	50.50	96.50	18.45	45.20	40.50	175.00
Screen Or Open	Screened	Screened	Screened	Screened	Screened	Screened	Screened
Top of Monitoring Interval (ft bgs)	5.60	37.00	86.00	8.15	34.70	29.70	161.00
Bottom of Monitoring Interval (ft bgs)	10.60	47.00	96.00	18.45	44.70	39.70	171.00
Screen Material	PVC	PVC	PVC	SS	PVC	SS	SS
Screen Slot Size (inches)	sw/0.01	sw/0.01	sw/0.01	sw/0.01	sw/0.01	sw/0.01	sw/0.01
Screen Length (ft)	5	10	10	10.3	10	10	10
Top Filter Pack (ft bgs)	4.60	36.00	85.00	5.50	31.00	28.20	155.00
Bottom Filter Pack (ft bgs)	11.10	50.50	96.50	18.45	45.20	39.90	171.70
Top Filter Pack (ft, msl)	899.93	868.76	828.06	925.61	881.74	888.77	761.98
Bottom Filter Pack (ft, msl)	893.43	854.26	816.56	912.66	867.54	877.07	745.28
Cond. Borehole Depth (ft bgs)	-	-	12.00	-	13.00	9.5	66
Cond. Borehole Diameter (inches)	-	-	11.00	-	16.75	16	9.88
Conductor Casing Type	-	-	PVC	-	PVC	STEEL	STEEL
Conductor Casing O.D. (inches)	-	-	12.5	-	12.5	11.75	7
Conductor Casing I.D. (inches)	-	-	11.75	-	11.75	11	6.4
Conductor Casing Depth (ft bgs)	-	-	12.00	-	13.00	9.50	64.70
Pilot Borehole Depth (ft bgs)	11.10	50.50	96.50	18.45	45.20	40.50	175.00
Pilot Borehole Diameter (inches)	8.00	11.00	11.00	8.00	11.00	10.60	6.75
Inner Casing Type	PVC Sch#40	PVC Sch#40	PVC Sch#40	SS/#304	PVC Sch #40	SS/#304	SS/#304
Inner Casing O.D. (inches)	4.5	4.5	4.5	4.5	4.5	4.5	4.25
Inner Casing I.D. (inches)	4	4	4	4	4	4	4
Inner Casing Depth (ft bgs)	10.60	47	96	18.45	44.70	39.9	171.7
Date Completed	30Jul85	14Aug85	14Aug85	04Aug89	22Aug85	19Mar91	20Mar91
Reference	Y/TS-881/R2	Y/TS-881/R2	Y/TS-881/R2	Y/TS-881/R2	Y/TS-881/R2	Y/TS-881/R2	Y/TS-881/R2
Comments							

21FEB95 SB

Abbreviations:

B - Bedrock

bgs - Below Ground Surface

msl - mean sea level

**Corr. Act. Mon. - Corrective Action Monitoring
for the East Fork Regime**

NHP Dec. Mon. - New Hope Pond Detection Monitoring

CON - Conasauga Group

dia. - diameter

ft - Feet

I.D. - Inside Diameter

in. - inches

KNOX - Knox Group

N/A - Not available

- Not applicable

O.D. - Outside Diameter

PVC-polyvinyl chloride

SS - Stainless Steel

sw - spiral wound screen

U - Unconsolidated

WB - Weathered Bo

Table 1

- At least one of these wells will be monitored semiannually.

Table B-23. Construction Details of Proposed Monitoring Well Network for the Upper East Fork Poplar Creek Hydrogeologic Regime
Energy Systems, Inc. Y-12 Plant Oak Ridge, Tennessee

Well Number:	GW-733	GW-108*	GW-109*	GW-253*	GW-274*	GW-275*
Monitoring Program	Corr. Act. Mon.	Corr. Act. Mon.	Corr. Act. Mon.	Corr. Act. Mon.	Corr. Act. Mon.	Corr. Act. Mon.
North Coordinates	28447.00	30069.00	30055.00	29404.00	30152.00	30151.00
East Coordinates	65057.00	53207.00	53207.00	54057.00	53673.00	53688.00
Surface Elevation (ft)	955.69	995.61	994.54	1001.60	992.94	993.08
Measuring Point Elevation (ft)	959.04	998.18	996.99	1003.99	995.43	995.36
Zone Monitored	B	WB	B	U	WB	B
Formation Monitored	CON:Maynardville	CON:Nolichucky	CON:Nolichucky	CON:Maynardville	CON:Nolichucky	CON:Nolichucky
Lithology	limestone	shale	shale	limestone	shale	shale
Top of Fresh Bedrock (ft bgs)	47.10	N/A	16.00	N/A	35.00	35.00
Total Drilled Depth (ft bgs)	256.50	58.60	147.60	50.00	35.00	65.50
Screen Or Open	Open	Screened	Screened	Screened	Screened	Screened
Top of Monitoring Interval (ft bgs)	240.10	46.70	102.90	37.00	28.50	54.80
Bottom of Monitoring Interval (ft bgs)	256.50	55.70	121.90	46.60	33.90	65.20
Screen Material	-	PVC	PVC	PVC	SS	SS
Screen Slot Size (inches)	-	sl/0.01	sw/0.01	sw/0.01	sw/0.01	sw/0.01
Screen Length (ft)	-	9.0	19.0	9.6	5.4	10.4
Top Filter Pack (ft bgs)	-	41.00	96.60	36.20	25.80	53.30
Bottom Filter Pack (ft bgs)	-	58.60	128.50	50.00	35.00	65.50
Top Filter Pack (ft, msl)	-	954.61	897.94	965.40	967.14	939.78
Bottom Filter Pack (ft, msl)	-	937.01	866.04	951.60	957.94	927.58
Cond. Borehole Depth (ft bgs)	51.8	20.7	20.0	-	-	38.00
Cond. Borehole Diameter (inches)	15	16.0	16.0	-	-	15.00
Conductor Casing Type	STEEL	PVC #40	PVC #40	-	-	PVC
Conductor Casing O.D. (inches)	11.75	10.00	10.00	-	-	10.00
Conductor Casing I.D. (inches)	11	N/A	N/A	-	-	N/A
Conductor Casing Depth (ft bgs)	51.80	20.7	20.00	-	-	38.00
Pilot Borehole Depth (ft bgs)	240.10	58.60	147.60	50.00	35.00	65.50
Pilot Borehole Diameter (inches)	10.60	9.00	9.00	8.25	8.00	10.00
Inner Casing Type	STEEL	PVC #40	PVC #40	PVC #40	SS/#304	SS/#304
Inner Casing O.D. (inches)	7	4.5	4.5	4.5	4.5	4.5
Inner Casing I.D. (inches)	6.54	4	4	4	4	4
Inner Casing Depth (ft bgs)	256.5	55.70	121.90	46.70	33.90	65.20
Date Completed	02Oct91	26Sept84	27Sept84	11Apr86	09Jun86	30May86
Reference	Y/TS-881/R2	Y/TS-881/R2	Y/TS-881/R2	Y/TS-881/R2	Y/TS-881/R2	Y/TS-881/R2
Comments						

21FEB95 SB

Abbreviations:

B - Bedrock
bgs - Below Ground Surface
msl - mean sea level
Corr. Act. Mon. - Corrective Action Monitoring
for the East Fork Regime
NHP Dect. Mon. - New Hope Pond Detection
Monitoring
CON - Conasauga Group

dia. - diameter
ft - Feet
I.D. - Inside Diameter
in. - inches
KNOX - Knox Group
N/A - Not available
- Not applicable

O.D. - Outside Diameter
PVC-polyvinyl chloride
SS - Stainless Steel
sw - spiral wound screen
U - Unconsolidated
WB - Weathered Bedrock

* At least one of these wells will be monitored semiannually.

**Table B-24. Proposed Target Parameters List, Upper East
Fork Poplar Creek Hydrogeologic Regime**

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

New Hope Pond

Metals

Barium	Mercury
Cadmium	Nickel
Chromium	Silver
Lead	Uranium

Radionuclides

Gross Alpha
Gross Beta

**S-3 Ponds/East Fork Regime Corrective Action
Monitoring Network**

VOCs

Metals (same as above)

Radionuclides (same as above)

Nitrate

22FEB95 SB

FIGURES

DRAWING DATE: 21MAY92 Ba | PROJECT NO.: TN20501 | FILE NAME: NHP PCPA | DRAWING NO.: 90-1261 a | CHECKED: M. KELLEY | APPROVED: A. MOTLEY | DRAFTER: B. ALTM

Regional Location of the Y-12 Plant
Energy Systems, Inc. Y-12 Plant Oak Ridge, Tennessee

FIGURE
A-1

FIGURE

A-2

Location of the New Hope Pond and S-3 Ponds

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

SCALE 0 2,000 ft

0 4000 ft
SCALE

Hydrogeologic Regimes

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

FIGURE

A-3

MODIFIED FROM: HSW Environmental Consultants 1994b, Drawing DR171-HC.

FIGURE

Waste-Management Sites, CERCLA Operable Units, and Underground Storage Tanks Located in the Upper East Fork Poplar Creek Hydrogeologic Regime

B-1

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

DRAWING NO.: 0195-17537.DWG / DRAWING DATE: 12FEB95 BA / FILE NAME: NHP PCPA / PROJECT NO.: TN0205.001 / PROJECT MANAGER: S.MCINLEY / PROJECT OFFICER: BILGNER / DRAFTER: B.ALTOM /

Monitoring Well Network in the Upper East Fork Poplar Creek Hydrogeologic Regime

FIGURE

B-2

MODIFIED FROM: Union Carbide Corporation, Nuclear Division, 1982

NOT TO SCALE

Physiographic Map of Tennessee

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

FIGURE

B-3

/ DRAWING NO.: 0592-5318 / DRAWING DATE: 16JAN85 SB / FILE NAME: NHP PCPA / PROJECT NO.: TN0205.001 / PROJECT MANAGER: S. MCGINLEY / PROJECT OFFICER: B. ILGNER / DRAFTER: S. BAKER /

SOURCE: King and Haase, 1987
 REFERENCE: HSW Environmental Consultants, Inc. 1992

SYSTEM	GROUP	FORMATION	MAP SYMBOL	THICKNESS (ft)
CAMBRIAN	UPPER	KNOX		
		COPPER RIDGE DOLOMITE	Oek	NOT DETERMINED
	MIDDLE	CONASAUGA		
	LOWER	ROME	er	NOT DETERMINED

0 1000 ft
SCALE

Bedrock Geology in the Upper East Fork Poplar
Creek Hydrogeologic Regime
Energy Systems, Inc. Y-12 Plant Oak Ridge, Tennessee

FIGURE

B-4

1993

SOURCE: NOAA 1994.

FIGURE

B-5

1993 Precipitation Data at the Oak Ridge Station

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

DRAWING NO.: 0195-17485.DWG / DRAWING DATE: 7FEB95 SB / FILE NAME: NHP PCPA / PROJECT NO.: TH0205.001 / PROJECT MANAGER: S.MCGINLEY / PROJECT OFFICER: BILGNER / DRAFTER: B.ALTON /

- EXPLANATION**
- 1090 ■ — Water Table Monitoring Well and Water Level Elevation (ft. msl)
 - 1043.38 — Water-Level Isopleth (ft. msl)
 - Surface Drainage Feature

SOURCE: HSW Envir

Groundwater Elevations
in the Water-Table Interval

FIGURE
B-7

This topographic map depicts the S-2 site area, characterized by contour lines ranging from 940 to 1100 feet. Key features include:

- Security Pits:** Labeled as "BETA 4 SECURITY PITS" and "S-2 SITE", shown as rectangular structures.
- Groundwater Monitoring Wells (GW):** Numerous wells are marked with their IDs and elevations, such as GW-141 (1094.4), GW-175 (969.3), GW-217 (1070.96), GW-302 (1042.87), GW-339 (1058.19), GW-203 (1025.36), GW-205 (1027.07), GW-305 (1065.85), GW-177 (1040.85), GW-178 (1055.29), GW-176 (1008.87), GW-322 (983.15), GW-612 (1011.13), GW-186 (1006.57), GW-611 (949.78), GW-124 (997.88), GW-315 (997.28), GW-317 (996.18), GW-313 (989.12), GW-615 (1005.15), GW-271 (1005.11), GW-275 (992.16), GW-109 (993.49), GW-370 (1006.86), GW-262 (1032.27), GW-264 (1031.1), GW-251 (992.1), GW-56-1C (962.99), GW-56-2C (953.74), GW-56-4C (952.52), GW-754 (989.67), and GW-186 (1006.57).
- Other Features:** "SALVAGE YARD" is located in the upper left, and "TANK 0134-U" is situated near the center-right.
- Grid Lines:** The map includes a grid with Easting coordinates (56,000 to 58,000) and Northing coordinates (1000 to 1100).

→ 28,000

AUGUST 31 - SEPTEMBER 7, 1993

GW-205 ● — Bedrock Monitoring Well
 1027.07 — and Water Level Elevation (ft. msl)
 — Water-Level Isoleth (ft msl)
 - - - Surface Drainage Feature

SOURCE: HSW Envir

Groundwater Elevations in
the Shallow and Intermediate Intervals

FIGURE

B-8

- EXPLANATION
- GROUNDWATER COMPOSITIONS CLUSTER IN THESE AREAS
 - GW-767 ■ — WATER-TABLE MONITORING WELL
 - GW-755 ○ — BEDROCK MONITORING WELL, LESS THAN 100 FT DEEP
 - GW-207 ● — BEDROCK MONITORING WELL, 100 TO 300 FT DEEP
 - GW-208 ▲ — BEDROCK MONITORING WELL, GREATER THAN 300 FT DEEP

SOURCE: HSW Environmental Consultants 1994b.

Groundwater Geochemistry in the ORR Aquitards

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

FIGURE

B-9

EXPLANATION

— GROUNDWATER COMPOSITIONS CLUSTER IN THESE AREAS

GW-767 ■ — WATER-TABLE MONITORING WELL

GW-755 ○ — BEDROCK MONITORING WELL, LESS THAN 100 FT DEEP

GW-207 ● — BEDROCK MONITORING WELL, 100 TO 300 FT DEEP

GW-208 ▲ — BEDROCK MONITORING WELL, GREATER THAN 300 FT DEEP

SOURCE: HSW Environmental Consultants 1994b.

Groundwater Geochemistry in the Knox Aquifer

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

FIGURE

B-10

DRAWING NO.: 0195-17487.DWG / DRAWING DATE: 11FEB95 Ba / FILE NAME: NHP PCPA / PROJECT NO.: TN0205.001 / PROJECT MANAGER: S.MCINLEY / PROJECT OFFICER: B.JLGNR / DRAFTER: B.ALTON /

MODIFIED FROM: HSW Environmental Consultants 1994b, Drawing OR426-HC.

EXPLANATION

WELL LOCATION	
B4	Beta-4 Security Pits
FF	Building 9754-2 Fuel Facility
FTF	Fire Training Facility
NHP	New Hope Pond
RG	Rust Garage Area
S2	S-2 Site
S3	S-3 Site
SY	Y-12 Salvage Yard
T0134	Tank 0134-U
T2331	Tank 2331-U
WC	Waste Coolant Processing Area

- GW-767 ■ WATER-TABLE INTERVAL MONITORING WELL
 GW-755 ○ BEDROCK INTERVAL MONITORING WELL, <100 FT DEEP
 GW-207 ● BEDROCK INTERVAL MONITORING WELL, 100 TO 300 FT DEEP

- 50% OF VOCs (TOTAL VOCs 10 ug/L)**
 VOCs — SUMMED AVERAGE CONCENTRATION (1990-1993)
 OF THE SELECTED COMPOUNDS
- ◐ — SUMMED BTEX
 - ◑ — PCE + TCE + 1,2-DCE
 - — CARBON TETRACHLORIDE

Distribution of Dissolved VOCs in Groundwater, 1993

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

FIGURE

B-11

[illegible]

VOCs in Groundwater in the Upper East Fork Poplar Creek Hydrogeologic Regime

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

FIGURE
B-12

GW-337 Waste Coolant Processing Area

GW-220 New Hope Pond

GW-204 Tank T0134-U

SOURCE: HSW Environmental Consultants, 1994b, Drawing No. A-21

NOT TO SCALE

VOC Concentrations in Wells GW-337, GW-220,
and GW-204, 1990-1993

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

FIGURE

B-13

EXPLANATION	
GW-006 ●	BEDROCK MONITORING WELL, < 300 FT
GW-131 ▼	BEDROCK MONITORING WELL, > 300 FT
●	SAMPLED BEFORE 1993 (QUALITATIVE DATA)
	SCREENED WELL CONSTRUCTION
0	OPEN-HOLE WELL CONSTRUCTION
W.B.S.	WESTBAY SYSTEM SAMPLING PORTS SAMPLES COLLECTED IN MARCH 1994
ANNUAL AVERAGE CARBON TETRACHLORIDE CONCENTRATION (ug/L)	
ND	NOT DETECTED
-5	-5
-5-100	-5-100
-100-1,000	-100-1,000
> 1,000	> 1,000

SOURCE: HSW Environmental Consultants 1994b, Drawing OR421-HC.

Carbon Tetrachloride in Groundwater Near New Hope Pond

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

FIGURE

B-14

GW-633 Rust Garage Area

GW-204 Tank 0134-U

GW-193 Tank 2331-U

SOURCE: HSW Environmental Consultants, 1994b, Drawing No. A-24

NOT TO SCALE

**Nitrate Concentrations in Well GW-633 and Gross Alpha and
Gross Beta Activities in Wells GW-633, GW-204, and GW-193**

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

FIGURE

B-15

DRAWING NO.: 0195-17478.DWG / DRAWING DATE: 7FEB95 SB / FILE NAME: NHP PCPA / PROJECT NO.: TN0205.001 / PROJECT MANAGER: S.MCGINLEY / PROJECT OFFICER: BILGHER / DRAFTER: B.ALTON /

SOURCE: HSW Envir

Nitrate in Groundwater in the
Upper East Fork Poplar Creek Hydrogeologic Regime

FIGURE
B-16

GW-169 Lead

GW-169 Radioactivity

SOURCE: HSW Environmental Consultants, 1994b, Drawing No. A-23

NOT TO SCALE

**Relationship between TSS and Lead Concentrations and
Gross Alpha and Gross Beta Activities in Well GW-169**

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

FIGURE

B-17

DRAWING NO.: 0195-17491.DWG / DRAWING DATE: 8FEB95 SB / FILE NAME: NHP PCPA / PROJECT NO.: TN0205.001 / PROJECT MANAGER: S.MCGINLEY / PROJECT OFFICER: BILGNER / DRAFTER: BALTON /

Gross Alpha Activity in Groundwater in the
Upper East Fork Poplar Creek Hydrogeologic Regime

FIGURE
B-18

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

[illegible]

This map of the Savannah River Site includes the following features and labels:

- Monitoring Wells:** GW-264 (0.7), GW-282 (4.4), GW-271x (9), GW-275x (256), GW-277x (2,900), GW-109x (10,100), GW-251 (11.9), GW-771 (-2.4), and GW-784 (0.1).
- Salvage Yard:** Located in the upper left quadrant.
- BETA 4 SECURITY PITS:** Located near the center of the map.
- ABANDONED NITRIC ACID PIPELINE:** Indicated by a dashed line running horizontally across the middle.
- WASTE COOLANT PROCESSING AREA:** Located below the abandoned pipeline.
- TANK 0134-U:** Located on the right side of the map.
- Interim Drum Yard:** Located at the bottom center.
- Sites:** S-3 (shaded area on the left) and S-2 SITE (indicated by a dashed line at the bottom).
- Grid Lines:** Horizontal lines are labeled N 32,000 and N 30,000.
- Other Labels:** "Cn" and "Cm" are visible on the right edge of the map.

SOURCE: HSW Envir

**Gross Beta Activity in Groundwater in the
Upper East Fork Poplar Creek Hydrogeologic Regime**

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

**FIGURE
B-19**

0 400 ft

SCALE

Location of Well Pairs for Statistical Test

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

FIGURE
B-20

DRAWING NO.: 0195-17540.DWG / DRAWING DATE: 17FEB95 SB / FILE NAME: NHP PCPA / PROJECT NO.: TN0205.001 / PROJECT MANAGER: S.MCINLEY / PROJECT OFFICER: B.ILGNER / DRAFTER: B.ALTON /

**Proposed Detection and Corrective Action Monitoring Well Networks
for the Upper East Fork Poplar Creek Hydrogeologic Regime**

FIGURE

B-21

APPENDIX A

RCRA CLOSURE/POST-CLOSURE PLANS FOR THE NEW HOPE POND SITE

- A.1 RCRA Closure Plan
- A.2 RCRA Post-Closure Plan
- A.3 Closure Certification Letter

A.1 RCRA Closure Plan

February 29, 1988

Y/TS-389

REVISED CLOSURE PLAN

for

NEW HOPE POND

Environmental Management Department
Health, Safety, Environment
and Accountability Division

Prepared by the
Oak Ridge Y-12 Plant
P.O. Box Y, Oak Ridge, Tennessee 37831
operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under Contract DE-AC05-84OR21400

FOREWORD

In December, 1987, the Closure Plan for New Hope Pond was submitted to the Tennessee Department of Health and Environment (TDHE) for review and approval. This closure is submitted for approval with revisions in the following sections:

- 1) Design Element of Closure
- 2) Installation Procedure
- 3) Closure Schedule

CLOSURE PLAN FOR NEW HOPE POND
Y-12 PLANT, OAK RIDGE, TENNESSEE

INTRODUCTION

New Hope Pond (NHP) is an unlined, man-made settling basin which was constructed at the Y-12 Plant in 1962. The location of NHP is illustrated in Figure 1. The surface area of the pond is 5.2 acres and the volume is 46,500 cu yd. The configuration of the pond is shown in Figure 2. NHP is located near the eastern boundary of the Y-12 Plant and receives flow from Upper East Fork Poplar Creek (UEFPC); the flow is composed primarily of surface runoff. UEFPC flow enters the pond through a distribution ditch from which it is directed through any of nine discharge drains into the pond. The upper portion of the incoming flow is also routed through an oil-skimming basin located adjacent to NHP. Oil is collected in the basin and water is discharged into NHP. The north end of NHP discharges to East Fork Poplar Creek.

The purpose of NHP is to remove suspended sediments from the creek prior to discharge from the Y-12 Plant. The pond, originally, also served to modify fluctuations in pH levels.

In 1984, a continuation of the distribution ditch was constructed around the east side of NHP to act as a bypass ditch, allowing flow to be diverted around the pond if necessary.

Accumulated sediments were dredged from NHP in 1973 and placed in the Chestnut Ridge Sediment Disposal Basin (CRSDB) located south of NHP on Chestnut Ridge. Since 1973, sediments have been removed several times from the pond inlet distribution ditch and placed in the disposal basin.

Numerous sampling and analysis efforts were conducted from 1982 to 1987 to determine the levels of contamination present in NHP sediments. Results of the analyses of sediment core samples from New Hope Pond at different depths are given in Table 1. In addition, the RCRA Extraction Procedure (EP) Toxicity test and other tests were conducted on sediment samples; results of the analyses are shown in Table 2. These analytical results indicate that the NHP sediments are not a RCRA waste as defined by EP Toxicity test. Additional analytical data from tests performed on NHP sediments which were dredged and disposed in CRSDB also indicate that the sediments do not exhibit the characteristics of a RCRA waste (Saunders, 1983).

FIGURE 2. NEW HOPE POND AND LOCATION OF REPLACEMENT BASIN

TABLE 1. ANALYSES OF SEDIMENT CORE SAMPLES FROM NEW HOPE POND^(a)

Sample Depth, cm	Concentration, ppm		
	PCB	U	Hg
0-5	1.7	420	107
5-10	2.2	250	108
10-15	2.4	295	116
15-20	3.5	460	110
20-25	3.2	495	122
25-30	4.4	430	174
30-35	5.8	650	240
35-40	7.0	585	220
40-45	9.3	475	278
45-50	43.0	640/525	170/166
50-55	71.0	1190	153
60-65	41.0	1280	220
70-75	96.0	800	302
80-85	130.0	1080	299

(a) Samples collected by R.R. Turner (1982)

Source: Martin Marietta Energy Systems, Inc., Letter, Fee to Spence, November 9, 1987.

TABLE 2. RESULTS OF EXTRACTION PROCEDURE TOXICITY TESTS AND OTHER ANALYSES OF SEDIMENT SAMPLES FROM NEW HOPE POND, REPORTED IN JUNE, 1983

	Concentration. ug/L (a)		
	Minimum	Maximum	Average
Arsenic	<0.5	<0.5	<0.5
Barium	<10.0	<10.0	<10.0
Cadmium	<0.1	0.2	0.114
Chromium	<0.5	<0.5	<0.5
Lead	<0.5	0.5	0.5
Mercury	<0.01	<0.01	<0.01
Selenium	<0.1	<0.1	<0.1
Silver	<0.5	<0.5	<0.5
Beryllium (ug/g)	<0.02	<0.02	<0.02
Fluoride (ug/g)	0.6	1.0	0.87
NO ₃ as N (ug/g)	0.6	1.9	0.99
Thorium (ug/g)	<0.1	<0.1	<0.1
Uranium (ug/g)	0.04	0.59	0.16

(a) The Extraction Procedure (EP) Toxicity Test was run at a pH of 5.0 using acetic acid to adjust the pH per RCRA requirements.

Source: Union Carbide, June 15, 1983.

APPROACH TO CLOSURE

The closure of New Hope Pond is part of a larger program which also involves dredging Upper East Fork Poplar Creek (UEFPC), cleaning, upgrading and extending the existing diversion channel, rerouting of UEFPC, and the construction of a replacement pond. Analyses of the pond sediments have shown elevated levels of uranium, PCBs and mercury. Results of the USEPA Extraction Procedure for Toxicity tests (40 CFR Part 261, Appendix II) indicate that the sediments do not exhibit the characteristics of a RCRA waste (Table 2). However, because of (1) the levels of PCBs, mercury, and uranium present in the sediments and (2) the potential presence of residuals from the plant effluent discharges prior to 1984, NHP will be closed in a manner equivalent to a RCRA closure to protect the water quality in UEFPC.

NHP will be closed with the wastes in place, in the same manner as a landfill. Removal of the waste sediments is neither advisable nor feasible for the following reasons. First, since the DOE accepted standard for shipment of materials to offsite commercial disposal facilities is 30 pCi/g (which is equivalent to 50 ppm of depleted uranium), the NHP sediments, with 250-1,280 ppm of uranium (i.e., 150-768 pCi/g of radioactivity), cannot be recommended for offsite disposal in a PCB landfill. Second, incineration of NHP sediments in the Oak Ridge Gaseous Diffusion Plant (ORGDP) incinerator is not a viable option because of the mercury contamination levels (102-302 ppm) in the sediments. In order to not exceed the permitted discharge limits of 200 lb/yr from the ORGDP incinerator stack, the mercury levels for incoming wastes should not exceed 28 ppm. The maximum level of mercury in the NHP sediments is more than 10 times this limit. Moreover, at the normal operating temperature of the incinerator (1000°C), mercury will be vaporized and could damage the internal parts of the off-gas treatment system.

This closure plan addresses primarily the initial steps in the closure process for NHP, up to and including the design and installation of an appropriate secure cap for the facility. The results of the preliminary hydro-geological assessment of NHP indicate that there is an upward groundwater gradient beneath the pond. The groundwater elevations measured in the monitoring wells in the vicinity of NHP are reported to be approximately equal

to the elevation of water surface in the pond [Martin Marietta Energy Systems, Inc. (Energy Systems), letter, Fee to Spence, November 9, 1987].

The sources, extent, and impacts of this upward gradient are presently under study. Therefore, an initial step in the closure process for NHP is to conduct a more detailed study of this condition and its impacts, including an attempt to calculate a mass water balance for the pond. Proposed engineering solutions to prevent groundwater inflow under the cap might include actions such as installation of physical barriers to groundwater movement underneath the sediments, or installation of deep drains to allow removal of groundwater below and around the pond. The results of the detailed study of the groundwater conditions and the selected engineering solution or solutions will be submitted to TDHE for approval prior to implementation of the closure program for NHP.

NPDES AREA SOURCE CONTROL PROGRAM

The Y-12 Plant Area Source Pollution Assessment and Control Plan for the East Fork Poplar Creek (EFPC) is currently proceeding under an aggressive, multi-phased program (Energy Systems letter, Fee to Spence, November 9, 1987). The initial phase of work is approximately complete, the final product being the development of a comprehensive sampling and analysis plan to identify and characterize area source pollution in EFPC. Initiation of this sampling program is scheduled for December 1987 and is expected to take approximately nine months to complete. Concurrent with the initiation of the sampling program, the second phase of the program is scheduled to begin. Scheduled work under this phase includes the development of a management program for the control of erosion, siltation and other pollutants from plant construction activities, the development of a Stream Management and Analysis Program for EFPC, and the initiation of preliminary conceptual design work for proposed control facilities. The second phase work is expected to be completed near the end of 1988.

Included in the design of the replacement facility is an oil-skimming device. The oil skimmer will be utilized to retain oil runoff from parking

lots, spills, and other releases that could be detrimental to the water quality of EFPC.

CLOSURE PERFORMANCE STANDARD

As described in the Approach to Closure, the preliminary closure steps involve upgrading of the existing diversion channel and diversion of the Upper East Fork Poplar Creek (UEFPC) into the upgraded channel. During the first step, contaminated soils and sediments in the diversion channel will be removed with conventional earth-moving equipment and placed in NHP. Contaminated sediments also will be removed from the channel of UEFPC from the point where it exits an underground culvert (approximately 50 feet upstream of the NHP inlet) to the NHP inlet and placed in NHP. The flow from UEFPC will then be permanently diverted into the diversion channel.

In a subsequent step during closure, NHP will be drained and the sediments will be structurally stabilized using coarse aggregate (24-inch limestone rock) so that the wastes (sediments) will have a bearing capacity sufficient to support the final cover. The structural stabilization, however, does not include any treatment, chemical fixation, or modification of the wastes to reduce the leachability of the waste or to alter its chemical or physical properties.

The water in the skimming basin will be sampled and discharged to the pond if of acceptable quality. The oils will be drummed and sampled to determine the appropriate method of treatment and/or disposal. The oil- and PCB-contaminated sediments from the oil-skimming basin (which are not believed to be contaminated with mercury) and contaminated soils, from the immediate surrounding area, will be excavated if the PCB concentrations are above 25 ppm. The excavated materials will be moved to the Disposal Area Remedial Action Storage Building or the Oil Land Farm Soils Storage Vault at the west end of the Y-12 Plant. These facilities are being designed to accept for storage PCB-contaminated soils and sludges, removed from other Y-12 closure projects, until the soils can be incinerated at the TSCA incinerator located at Oak Ridge. If these facilities are not completed in time to receive the oil-skimming basin soils and sediments, they will be taken to the Contaminated

Soils Storage Area (CSSA) on Chestnut Ridge. Contaminated soils with mercury levels above 28 ppm will be placed in NHP. The site will be sampled before and after the excavation to ensure complete removal of the contaminants. The site will be backfilled with clean soil and capped as a part of the NHP closure.

Following the stabilization of NHP sediments with coarse aggregate and backfilling of the oil-skimming basin after removal of contaminated soil, NHP will be covered with an integrated cap system. The cap will consist of the following components (Figure 3): a minimum of 2-ft clay layer, a flexible membrane liner, a geosynthetic drainage net overlain by a geotextile filter fabric and a 1.5-ft topsoil layer.

The HELP model (Schroeder et al., 1984) was used to estimate the surface runoff, subsurface drainage, and leachate that may be expected to result from the proposed cap design. The HELP model results, and supporting data, submitted separately, indicate that the cap design discussed in this plan will meet the requirements for secure capping of this facility. However, the model does not address the effects of an upward groundwater gradient underneath the proposed cap. Detailed engineering plans will incorporate those engineered elements that will reduce and minimize potential groundwater movement that could result in the degradation of groundwater quality. The groundwater monitoring system available in the vicinity of NHP will be used to evaluate the effectiveness of the cap during the post-closure period.

CONTINGENCY PLAN

Historically, the New Hope Pond area was dry before and during the excavation of soil in 1962 when the pond was originally constructed. However, because 1986 groundwater monitoring data indicate the presence of an upward groundwater gradient in the area of the New Hope Pond (Haase et al., 1987), the current contingency plan consists of four parts:

- (1) Mass water balance calculations for existing pond

TYPICAL CROSS-SECTION OF CAP

GEOTEXTILE FABRIC: MIRAFI 140N OR EQUAL
DRAINAGE NET: NATIONAL SEAL PN 3000 OR EQUAL
MEMBRANE LINER: 30 MIL PVC LINER

COMPONENTS OF ENGINEERED CAP
FIGURE 3.

- (2) Installation of additional groundwater monitoring wells
- (3) Determination of the effect of draining the pond on the hydrologic system and groundwater quality
- (4) Determination of the effect of the installed cap on the hydrologic system and groundwater quality.

The four parts of the contingency plan will allow a determination as to whether the buried sediments will be protected by installation of the cap. The results of the studies will indicate if additional drains or physical barriers are required to control the groundwater movement after the cap is installed.

Regardless of the need for additional engineering solutions, post-closure sampling and analyses of groundwater monitoring wells will be done to confirm that none of the contaminants in the buried sediments are leaching from underneath the cap. This is not expected to occur since many years of groundwater and surface water data are available which show that the contaminants of primary concern (i.e., PCB's, mercury, and uranium) have not migrated from the sediments despite the sediments being in contact with the pond water since 1962.

MAXIMUM WASTE INVENTORY

The surface area and the volume of New Hope Pond are 5.2 acres and 45,600 cu yd, respectively. The volume of sediment in the pond is estimated to be 24,000 cu yd. The volume of sediment that will be removed from Upper East Fork Poplar Creek and the existing diversion channel and placed in NHP, is about 1000 cu yd. The quantity of oil and oil-contaminated water in the oil-skimming basin that requires removal for storage and treatment cannot be estimated at this time. The volume of sediments and soils that will be removed from the oil-skimming basin and surrounding area is estimated to be 50 cu yd. These soils and sediments will be placed in the Disposal Area Remedial Action Storage Building, the Oil Land Farm Soils Storage Vault, or the Contaminated Soils Storage Area on Chestnut Ridge as described above.

DECONTAMINATION PROCEDURES

Contaminated soils and sediments in NHP will not be removed from the site during closure activities. However, the oil-contaminated sediments/soils in the oil-skimming basin and the immediately surrounding area with PCB levels exceeding 25 ppm will be excavated and moved to a proper storage area. If mercury contamination above 28 ppm is detected and the soils are not heavily contaminated with oils, these soils will be replaced in NHP. Excavated soils and sediments from the Upper East Fork Popular Creek and the existing diversion channel also will be replaced in NHP. Water from the skimming basin will be discharged to New Hope Pond provided the water meets the limits established by the NPDES permit. Oils and oil-contaminated water will be drummed and sampled to determine the appropriate method of treatment.

After soils are excavated and sediments are stabilized, construction equipment which might have contacted contaminated wastes will be decontaminated. This process primarily will involve scraping off any contaminated material retained on the equipment and triple steam cleaning or water blasting of the equipment. Soil residues and rinse waters will be placed in NHP. Verification sampling is not proposed for the equipment. The equipment will be visually inspected to ensure that no visible residues remain from the excavation activities. Health Physics personnel will conduct radioactivity measurements to ensure compliance with Y-12 standards for decontamination of equipment.

DESIGN ELEMENTS OF CLOSURE

The final cover will be installed following the stabilization, if required, of the waste. The principal purpose of stabilization is for structural support of the cap. The loads anticipated from the multilayer cap will be less than 1000 lb/ft². The bearing capacity of the stabilized waste will support a surface load of over 1,000 lb/ft².

The multi-layered cap proposed will include (from bottom to top): a minimum of 24 inches of compacted clay, a 30-mil flexible membrane liner, a geosynthetic drainage net overlain by a geotextile filter fabric, and 18 inches of topsoil with a vegetative cover. The manufacturer's detailed data sheet and the quality assurance/quality control information on installation of the liner and drainage net will be incorporated into a construction specification and will be submitted to the Tennessee Department of Health and Environment. Design details of each layer are given below, starting with the clay layer at the bottom of the cap:

1. Clay Barrier and Fill

Stabilized waste will be covered with native soils, which have been graded in, to create an even surface. The compacted clay barrier and fill layer will be a minimum of 24 inches and will be native subsoil, borrowed from the Chestnut Ridge area of the Oak Ridge Reservation. The soil is generally a medium-to-high plasticity clay. The cover clay material will be compacted to yield a permeability of equal to or less than 1×10^{-7} cm/sec.

2. Flexible Membrane Liner

A continuous 30-mil thick synthetic liner will be placed over the clay layer as an impermeable membrane.

3. Drainage Layer

The purpose of this layer is to laterally drain water, which may infiltrate the top vegetative layer, to the perimeter of the cap and then out of the cap. The drainage layer is a geosynthetic drainage net made of strands to form a mesh pattern, overlain by a permeable geotextile filter fabric. The net allows for the conveyance of relatively large quantities of infiltrated water along the plane of the net to the perimeter of the cap; the geotextile filter fabric provides tensile reinforcement and prevents transport of the fine soil particles and debris into the core.

4. Vegetative Layer

The final 18 inches of soil for the cap will be soil for the support of vegetation. This soil will be moderately-to-well drained and free of debris. The soil shall be lightly compacted, fertilized, seeded, and mulched. The grasses will be short-rooted types to avoid root intrusion into other layers of the cap. The final grade of the completed cap shall be between 2-7 percent and have side slopes of approximately 3 to 1.

INSTALLATION PROCEDURES

The construction of the cap will proceed in two steps: cover placement and toe-drain installation. The two construction steps are described below:

1. Cover Placement

a. Clay Barrier and Fill

The cap will be placed in a manner to maintain between a 2-7 percent cross slope along the top of the cap. Each of the two soil layers shall conform to the same gradient protocol and shall be constructed utilizing soil from the same borrow area.

The clay barrier shall consist of a minimum of 24 inches of clay compacted to a moisture content/dry density which correlates to a permeability of at least 10^{-7} cm/sec. The relationship between density and permeability has been developed with laboratory tests for the clay to be used to construct the barrier.

The Department of Energy shall demonstrate, with laboratory data, that the clay to be utilized for the bottom layer of the cover can be recompacted to achieve a permeability of 1×10^{-7} cm/sec or less. Additional laboratory data must be provided which establishes a correlation between the density and moisture content of the clay cover material when a permeability of 1×10^{-7} cm/sec or less is achieved. The Department of Energy will submit these data to the TDHE prior to the construction of the cover.

Field tests to determine the density and moisture content of the in-place clay cover material will be conducted at a rate of at least one test per each 5,000 ft² of surface area after each 6-inch lift has been placed. The density and moisture content must fall within the range of values which was established in laboratory testing to ensure that a permeability of 1×10^{-7} cm/sec or less is achieved. The sampling locations shall be randomly selected in accordance with Test Methods for Evaluating Solid Waste Physical/Chemical Methods

FIGURE 4. SCHEMATIC CROSS SECTION OF NEW HOPE POND WITH CAP

(SE-857), Third Edition. Field density testing will be in accordance with the Drive Cylinder Test Method (ASTM D2937), Sand Cone Density Test Method (ASTM D1556), or another appropriate ASTM method for testing the in-place density of soil.

After placement of loose soil for each lift, but before compaction, the soil shall be broken up and homogenized, if necessary, using disk harrows, rotary tillers, or other equipment capable of reducing the size of clods to facilitate moisture-control operations, compaction, and to reduce the heterogeneity of the compacted soil mass. The equipment used will extend through the loose soil into the previous (already compacted) lift a depth of 1 to 2 inches to scarify the surface of the previous lift in order to provide bonding between the lifts.

b) Flexible Membrane Liner

The installation of the flexible membrane liner (FML) is critical to the integrity of the cover system. Before the FML is shipped to the site, an installer will be chosen on the basis of verified qualifications and experience. As part of the installation the installer will:

- o Provide a diagram indicating the intended alignment of the membrane panels. The design will minimize seams and locate them at least 5 feet from toes of embankment slopes.
- o Illustrate on a diagram locations of penetrations, and embankment abutments, etc. A methodology will be employed to minimize water ponding on the liner surface during placement. Additionally, a 14-inch wide minimum seam will be used.
- o Determine the direction of installation, taking into account slope subgrade and prevailing winds. Specific techniques to protect against uplift (sand bags, tires) and rainwater intrusion (dikes) between the FML and subgrade will be provided.
- o Identify the seaming technique, nondestructive and destructive testing methods, and patching techniques.

In order to ensure consistent quality, the FML seams will be inspected using nondestructive and destructive techniques. Nondestructive testing shall be performed on all seamed edges of the liner.

Appropriate nondestructive test methods include: Ultrasonic Pulse-Echo, continuous wave resonant frequency, Air Lance, and vacuum chamber.

Destructive testing is accomplished by taking 18-inch square samples (centered on the seam) for laboratory testing. The destructive test methods appropriate for the present analysis are listed below:

Puncture: Federal Test Method Standard 101B, Method 2065

Tear: ASTM D624, D1004, and D751

Hydrostatic Pressure: ASTM D751 (Method A)

The following locations are proposed to be evaluated using destructive testing methods:

- o areas suspect from nondestructive testing;
- o one sample from different seaming conditions (e.g., flat slop, toe areas, and slopes, etc.);
- o one sample from varying working conditions (e.g., hot days, cold days, and days following rain, etc.);
- o no less than one sample for every 500 linear feet of seaming and no less than one sample per day.

c) Drainage Layer

The installation of the geosynthetic drainage net should be done so as to facilitate the flow of infiltrated water to the perimeter of the cap and to prevent any fine particles settling into the net. During the selection and installation of the drainage net the following issues will be taken into consideration.

Net: The material will satisfy mechanical requirements such as the quasi-static stress versus strain tests and the long-term creep test. Hydraulic characteristics of the drainage core will satisfy the requirements such as conveyance of liquid at the given hydraulic gradient and applied pressure.

Fiber Fabric: It will be permeable enough to convey the water draining from the soil; it will retain the overlying soil; it will be nonclogging over the lifetime of the system; it will have sufficient tensile strength so as not to deform or creep into the net; and will be resistant to rot, freeze/thaw and chemicals.

d) Vegetative Layer

Topsoil will be carefully placed onto the geosynthetic drainage net to minimize disturbance of the drainage layer and will be spread in the direction of the filter fabric overlay. Once a 6-inch continuous layer of topsoil has been applied, the entire area will be lightly compacted by wide-tracked, D-4 dozers or the equivalent. Upon completion of the base layer, the remainder of the topsoil will be applied by standard earth moving equipment. Earth scraper loads will be minimized, however, as a precautionary measure. Topsoil will be applied in 12-inch loose lifts and lightly compacted until the minimum 18 inches of thickness is reached.

The cap will be fertilized, seeded, and mulched to promote rapid vegetation growth in accordance with techniques used successfully in the past by Energy Systems in the Bear Creek Valley. The grass to be used will be Kentucky 31 fescue applied at 200 lb/acre. This grass variety is a rapid growing perennial with a short root structure, well adapted to the climate of Tennessee.

2. Toe Drain Installation

Natural waterways will be constructed along all four sides of the closed impoundments. Two drain slopes will commence 5 feet from the toe of the embankment and will be sloped to follow the existing grade. Suitable riprap will line the base and side slopes of the channels where necessary to mitigate erosion. Riprap will also be placed from 3 feet above the elevation where the drainage layer intersects the embankment to the toe of the embankment. A culvert will be installed beneath the accessway to promote drainage across the entire side of the waterway and provide access to the cap by roadway for cover maintenance. Surface components (i.e., toe drains, culverts and outlet works) will be sized based on predicted runoff volumes for a given storm event and antecedent soil-moisture conditions.

RUNON AND RUNOFF CONTROL STRUCTURES

Preliminary design studies indicate that the final grade of the capped New Hope Pond area will be at a higher elevation than the surrounding area. Therefore, runon control is unnecessary. Runoff will be controlled by paved or riprapped ditches tied into the existing area storm drainage system. An analysis of the existing storm-drainage system will be performed in association with the preparation of the final design construction drawings for the New Hope Pond closure. Any required upgrading of the storm-drainage system will be included in the design.

CONSTRUCTION DRAWINGS

Construction drawings will be prepared and submitted to the Commissioner before construction of the cap is initiated. These drawings will depict the proposed final contours after cap placement; cross sections showing each layer of the cap, including slopes; and runoff control structures, including calculations supporting the design.

CONSTRUCTION QUALITY ASSURANCE

The closure of the impoundment will be designed and constructed to protect human health and the environment. To assure that the closed impoundment meets or exceeds all projected design criteria, plans, and specifications, a construction quality assurance (CQA) program is necessary.

Design and Construction

- a) The owner/operator will prepare a written construction quality assurance plan to be used during construction of the cap. The plan will be used in monitoring and documenting the quality of materials used and the conditions and manner of their placement. The plan will be developed, administered, and documented by a registered professional civil or geotechnical engineer with experience in impoundment closure and construction-site inspections. In addition, the CQA plan will be provided during site inspection to any officer, employee, or representative of the Division who is duly designated by the TDHE Commissioner. While the specific content of the construction quality assurance

plan will depend on site-specific factors, the following specific components will be included, at a minimum:

- o Areas of responsibility and lines of authority in executing the CQA plan;
 - o Qualifications of CQA personnel;
 - o The frequency and scale of observations and tests;
 - o Documentation of CQA. This will include daily record-keeping (observation and test data sheets, problem-reporting and corrective-measures data sheets), design engineer acceptance reports (for errors, inconsistencies, and other problems), and final documentation. After completion of the installation of the liner and the leachate-collection system, a final documentation report will be prepared. This report will include summaries of all construction activities, observations, test data sheets, deviations from design and material specifications, and as-built drawings.
- b) The document for the CQA program will be kept onsite in the facility operating record.

CLOSURE SCHEDULE

A closure schedule is presented in Table 3.

TABLE 3. CLOSURE SCHEDULE

<u>Activity</u>	<u>Completion Time (Days)</u>
Closure Plan Approval (Approval by TDHE assumed to be 4/15/88)	0
Construction of New Pond	181
Submit detailed engineering drawings	363
Empty pond and place exhumed creek sediments in emptied pond	553
Stabilize sediments and sludges in pond	595
Install compacted clay layer of cap	931
Install synthetic membrane layer of cap	938
Install drainage layer of cap	945
Install vegetative layer of cap	959
Complete closure certification	969

MAINTENANCE OF SURVEY BENCHMARKS

The survey benchmarks installed at New Hope Pond will be protected and maintained. The benchmarks will be protected by guard posts or set in areas that are not to be disturbed.

CERTIFICATION OF CLOSURE

The Department of Energy will submit closure certifications from both DOE and an independent registered professional engineer that closure has been completed in accordance with the approved closure plan. The certifications shall be submitted to the Commissioner within 30 days after closure is completed.

NOTICE TO LOCAL LAND AUTHORITY

Within 90 days after final closure is completed, a survey plat indicating the location and dimensions of the capped impoundment with respect to permanent survey benchmarks will be submitted to the local land authority and to the TDHE Commissioner. 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 New Hope Pond, as shown on this plat, is obligated to restrict disturbance of the site in accordance with Rules Governing Hazardous Waste Management in Tennessee. Post closure use of the property on or in which hazardous wastes remain must never be allowed to disturb the integrity of the final cover, liner(s), or any other components of any containment system unless the owner or operator receives approval from the Commissioner of the Tennessee Department of Health and Environment under the previously referenced rules."

RECORD OF WASTES

A record showing the identification of the type, location, and quantity of hazardous waste disposed of within the closed areas of the facility will be submitted to the TDHE Commissioner and local land authority. The record showing the identification of the type, location, and quantity of waste will be based upon best available knowledge and records.

NOTICE IN DEED

The note presented in the section entitled, "Survey Plat and Certification by Professional Land Surveyor", 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 the Department of Energy will be submitted to the Commissioner stating that the required notices have been filed. A copy of the document in which the notation has been placed will be attached.

REFERENCES

Geotechnical Engineering. Geotechnical Investigation Proposed New Containment Pond for Closure of New Hope Pond, Y-12 Plant, Oak Ridge, Tennessee, Y/SUB/87-47970/1. Geotechnical Engineering, Nashville, TN; June 1987.

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Martin Marietta Energy Systems, Inc., Letter, G. G. Fee to R. J. Spence (DOE), Information for New Hope Pond. Nov. 5, 1987.

Martin Marietta Energy Systems, Inc., Letter, G. G. Fee to R. J. Spence (DOE). New Hope Pond Information. Nov. 9, 1987.

Saunders, M. B. Leachability of Samples from New Hope Pond Disposal Basin. USDOE Y-12 Plant, Oak Ridge, TN, Y/DZ-81, Rev. 1. July 29, 1983.

Union Carbide Corporation. Characterization of Sediments from New Hope Pond and the New Hope Pond Sediment Basin. USDOE Y-12 Plant, Oak Ridge, TN, Y/IA-164. December 12, 1983.

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A.2 RCRA Post-Closure Plan

NEW HOPE POND

POST-CLOSURE PLAN

Ref: 1200-1-11-.05(7)
1200-1-11-.05(8)

1.0 Post-Closure Care and Use of Property

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

This information is detailed in the following sections.

1.1 Length of Post-Closure Care Period

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

Post-closure care of NHP will continue for 30 years after date of final closure.

1.2 Increasing/Decreasing Length of Post-Closure Care Period

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

All activities described in this plan will continue throughout the post-closure care period unless a demonstration is made to and accepted by TDEC that a certain post-closure activity is no longer necessary to provide sufficient protection of human health and the environment.

1.3 Security Requirements

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

Security will be maintained at NHP for 30 years after closure is completed as described in Section A.5 of the Post-Closure Permit Application (PCPA) for NHP. If it is determined that security around the facility can be terminated or reduced, a petition with explanation and justification will be submitted to the Commissioner requesting reduction or

elimination of security requirements. Access to the site is restricted to authorized personnel only. Large signs prohibiting nonbusiness traffic are posted upon entry to the Y-12 Plant area. Access roads to the site have lockable gates.

1.4 Property Use Restrictions

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

Post-closure use of the property, including the capped portion of the facility, will be restricted to prevent disturbance of the final cover, containment system components, and the functioning of the monitoring system.

2.0 Submittal of Post-Closure Plan

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

The Post-Closure Plan is being submitted as part of the NHP and eastern S-3 Ponds plume PCPA.

3.0 Availability of Post-Closure Plan

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

The name, address, and phone number of the office to contact about NHP during the post-closure period are listed below. An updated post-closure plan for the facility will be maintained in this office during the post-closure 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 Post-Closure Plan

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

This information is detailed in the following sections.

4.1 Monitoring Activities Described

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

Groundwater monitoring activities to be performed before and after issuance of a post-closure permit for NHP are presented in Section B.5 of the PCPA for NHP and eastern S-3 Ponds plume.

4.2 Maintenance Activities Described

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

Post-closure performance of the facility is strongly dependent on adequate inspection and maintenance of the cover. All components of NHP will be inspected quarterly throughout the post-closure care period. Comprehensive monitoring well inspections will be performed annually. Also, because erosional damage is of great concern, the cover will be inspected following any rainfall event equivalent to a 25-year, 24-hour intensity.

The items to be inspected and any corrective actions needed are outlined in Table 1. The inspector will look for any evidence of erosion, such as rills or areas of bare soil. The inspector will also check the general condition of the vegetative cover looking for dead spots, areas of excessive weed-growth, and growth of deep-rooted vegetation. The inspector will look for areas of cover settlement or subsidence, particularly any differential settlement. The inspector will note the presence of any ponded water on the cover or evidence of damage due to rodents.

All detection monitoring wells will be inspected 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 make sure that the protective

Table 1. Inspection and Maintenance Plan for the New Hope Pond Site
 Energy Systems, Inc. Y-12 Plant Oak Ridge, Tennessee

Inspection	Corrective Action
Erosion Damage (Especially Gully Erosion)	
- Check for rills or areas of bare soil.	Restore site to its original grade and reseed.
Condition of Vegetative Cover	
- Check for dead spots, areas of excessive weed growth, and growth of deep-rooted vegetation.	Remove any competitive species and reseed area.
Cover Settlement	
- Check for subsidence, especially any differential settlement. - Check for cracks, potholes, etc. in pavement.	Restore site to grade and reseed. Fill cracks and potholes with appropriate material.
Monitoring Wells	
- Check for damage, make sure protective caps are locked.	If samples cannot be obtained, seal damaged well and construct replacement well at same location.
Run-On and Run-Off Drainage Control System	
- Check for signs of settlement, ponding, blockage, erosion, etc.	Repair settlement and erosion, remove blockages.
Benchmarks	
- Check for damage.	Replace if damaged.
Rodent Control	
- Check for damage/burrows.	Repair damage; fill burrows.

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caps are locked. The benchmarks at the boundaries of the disposal units will be inspected to determine if they have been damaged.

Run-on and run-off drainage control structures will be inspected as a part of the general facility inspection. Channels will be inspected for signs of settlement, ponding, blockage, excess vegetation, erosion, and other visible factors which could affect their performance.

Following each inspection, the inspector will complete a Post-Closure Inspection Checklist for the site. Figures 1 and 2 are examples of inspection checklists to be completed.

The primary maintenance activity at NHP will be the maintenance of the cover at the site. The cover will be maintained regularly throughout the year.

Routine maintenance of the drainage channels will include removal of visible blockages, and repair of unstable areas. Any additional channel maintenance requirements such as erosion repair will be promptly addressed as they are noted.

Site maintenance will include repair of any damages observed during the site inspection. Any erosion damage will be repaired by restoring the site to its original grade and replacing cover material. Differential settlement will be repaired by restoring the site to its original grade and reseeding. If monitoring wells are damaged such that representative samples of groundwater 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 most current approved version of the procedure described in Appendix C of the PCPA.

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
EROSION DAMAGE	gullies, rills or bare soil >25' sq.			ensure site is restored to original grade and reseed	
VEGETATIVE COVER	dead spots excessive weeds or deep-rooted vegetation			ensure competitive species are removed and/or reseed area	
COVER SETTLEMENT	settlement or subsidence >6" over 25' sq.			ensure site is restored to original grade and reseed	
RUN-ON AND RUN-OFF DRAINAGE SYSTEM	settlement, ponding, (>25"sq) blockage, erosion.			ensure settlement and erosion is repaired, remove any blockage	
MONITORING WELLS	signs of damage, wells protective caps locked			ensure wells are replaced if damaged and protective well caps are locked	
RODENT CONTROL	signs of damage and burrows			repair damage and fill burrows, implement animal control measures	
UNAUTHOR- IZED DELIVERIES	extraneous materials			ensure all unauthorized materials are removed	
"LANDFILL" SIGN	damaged or missing			ensure sign is replaced or repaired	

*(Photograph representative deteriorated conditions before repairs.)

DRG-3014
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Example of a Post-Closure Inspection Checklist

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

FIGURE

1

/ DRAWING NO.: 0185-17482 / DRAWING DATE: 13JAN95 SB / FILE NAME: NHP PCPA / PROJECT NO.: TN0205.001 / PROJECT MANAGER: S. McGINLEY / PROJECT OFFICER: B. ILGNER / DRAFTER: S. BAKER /

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		☐ Steel	☐ Stainless Steel	☐ PVC	NO	YES	N/A
1. Is the steel or stainless steel well casing corroded, bent, or broken?					☐	☐	☐
2. Is the PVC well casing cracked or broken?					☐	☐	☐
3. Is a protective surface casing installed (PVC well only)?					☐	☐	☐
4. Is the protective casing corroded, bent, or broken?					☐	☐	☐
5. Is a weep located at the base of the protective casing?					☐	☐	☐
6. Is the steel, stainless steel, or PVC casing loose?					☐	☐	☐
WELL SECURITY							
1. Does the well have a well cap or lid?					☐	☐	☐
2. Does the well have a waterproof steel/brass lock?					☐	☐	☐
3. Are the hasps firmly welded to well cap and/or metal casing?					☐	☐	☐
DOWNHOLE CONDITION							
1. Is a measurement reference point marked on the top of the well casing?					☐	☐	☐
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)?					☐	☐	☐
5. Do any obstructions occur within the well?					☐	☐	☐
SECONDARY INSPECTION ITEMS							
WELL ACCESS:							
1. Does the access road require regrading or additional gravel?					☐	☐	☐
2. Do any obstructions (locked gates, fallen trees, etc.) block access to well? Explain: _____					☐	☐	☐
WELL IDENTIFICATION:							
1. Is a stainless steel plate with engraved well number attached to the outermost casing?					☐	☐	☐
2. Is the well number legible?					☐	☐	☐
3. Is the well identification number correct?					☐	☐	☐
CONCRETE PAD:							
1. Is a concrete pad installed (active wells only)?					☐	☐	☐
2. Is the pad cracked or deteriorated?					☐	☐	☐
3. Is the pad sloped to prevent water from ponding around the casing?					☐	☐	☐
GUARD POSTS:							
1. Are the guard posts damaged?					☐	☐	☐
2. Are the guard posts positioned to prevent collision damage to well?					☐	☐	☐
3. Are the guard posts of adequate height?					☐	☐	☐
4. Is the high-traffic yellow paint degraded?					☐	☐	☐
WELL MAINTENANCE REQUEST							
Complete only if any of the above shaded yes/no boxes are checked.							
☐ Primary Item(s)		☐ Secondary Item(s)		Maintenance Request Number: _____			
COMMENTS							

Inspection Date: _____				Inspected By: _____			

FORM 95-17442

Example of a Well Inspection Checklist

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

FIGURE

2

4.3 Post-Closure Contact Identified

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

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

5.0 Amendment of Post-Closure Plans

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

An amended post-closure plan will be submitted to the Commissioner whenever: (1) changes in operating plans or facility design affect the post-closure plan; or (2) events which occur during the final closure affect the post-closure plan. 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 has affected the post-closure plan.

6.0 Post-Closure Notices

Ref: 1200-1-11.05(7)(a)

This information is detailed in the following sections.

6.1 Notice to Local Zoning Authority/Record of Wastes

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

Following certification of closure, a record and identification of the type, location, and quantity of hazardous wastes disposed of within NHP was submitted to the Commissioner and the local land authority. The record and identification of the type, location, and quantity of wastes was based upon best available knowledge presented in the closure-plan (Appendix A.1) and sections A.1 and A.2 of the PCPA concerning facility description and maximum waste inventory.

6.2 Notice in Deed/Survey Plat

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

Following certification of closure, a notation on the plant property deed or some instrument normally examined during a title search, was recorded. This notation contained the following or similarly worded note:

"The owner or operator of the property containing New Hope Pond as shown on this plat is obligated to restrict disturbance of the site in accordance with Rules Governing Hazardous Waste Management in Tennessee. Post closure use of the property on or in which hazardous wastes remain must never be allowed to disturb the integrity of the final cover, liner(s), or any other components of any containment system, or the function of the facility's monitoring systems unless the owner or operator receives approval from the Commissioner of Tennessee Department of Environment and Conservation under the previously referenced rules."

A survey plat indicating the locations and dimensions of the land treatment area with respect to permanently surveyed benchmarks was submitted to the local land authority and to the Commissioner of the TDEC. The plat was prepared and certified by a registered professional land surveyor.

6.3 Certification of Notice

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

A certification by the Department of Energy was submitted to the Commissioner stating that the required notations in the deed have been recorded.

6.4 Removal of Wastes From a Closed Surface Impoundment

Ref: 1200-1-11.05(7)(a)

NHP has been closed in place, therefore, removal of waste is not planned at this time.

7.0 Certification of Completion of Post-Closure Care

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

DOE will submit by registered mail a certification that the post-closure care period for the unit was conducted in accordance with the approved post-closure plan. This certification will be submitted no later than 60 days after completion of the established post-closure care period. It will be signed by the owner/operator and an independent certified registered professional engineer. Documentation supporting the engineer certification will be furnished upon request.

8.0 Post-Closure Care Cost Estimate

Ref: 1200-1-11-.05(8)(a)1 and 1200-1-11-.05(8)(e)1

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-.05(8)(a)1 and 1200-1-11-.05(8)(e)1

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-.05(8)(a)1 and 1200-1-11-.05(8)(e)1

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-.05(8)(a)1 and 1200-1-11-.05(8)(f)1

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

A.3 Closure Certification Letter

91 JAN -7 PH 1:15

STATE OF TENNESSEE
CUSTOMS HOUSE
DEPARTMENT OF HEALTH AND ENVIRONMENT
NASHVILLE, TENNESSEE 37247

December 11, 1990

Mr. Robert J. Spence
Y-12 Site Manager
Department of Energy
Oak Ridge Operations
P.O. Box 2001
Oak Ridge, TN 37831-8555

CERTIFIED MAIL P 574 524 874
RETURN RECEIPT REQUESTED

Mr. Gordon G. Fee
Plant Manager
Martin Marietta Energy Systems
P.O. Box 2009
Oak Ridge, TN 37831

CERTIFIED MAIL P 574 524 875
RETURN RECEIPT REQUESTED

RE: Closure Certification
New Hope Pond
Y-12 Plant

Dear Mr. Spence and Mr. Fee:

This letter is to inform you that the Division has completed its review of the certification of closure submitted May 5, 1990, by the Department of Energy, Y-12 Plant for the New Hope Pond. We concur that closure has been performed in accordance with the approved closure plan and in compliance with the closure performance standard of Tennessee Rule 1200-1-11-.05(7)(b).

Ms. Jacqueline Okoreeh-Baah is the primary contact should you have any questions regarding this matter.

Sincerely,

Tom Tiesler, Director
Division of Solid Waste Management

JTT/JOB/F2030319

cc: Jack Crabtree, DSWM, Knoxville Field Office
Ronnie Bowers, DSWM, Chief Corrective Action Unit
James Scarbrough, EPA, Region IV
Dave Hopkins, EPA, Region IV, Federal Facilities
Craig Brown, EPA, Region IV
Earl Leming, TDHE, Knoxville
Jimmy Stone, MMES, Y-12 Plant
Tom Perry, MMES
Tom Tison, DOE, Y-12 Plant
Kris Veltz, Lee Wan

APPENDIX B

WELL-CONSTRUCTION DIAGRAMS FOR NEW HOPE POND AND EASTERN S-3 PONDS PLUME MONITORING-WELL NETWORK

OBSERVATION WELL		PROJECT	WELL NO.
		BEAR CREEK WASTE DISPOSAL	GW-108
JOB NO.	SITE	COORDINATES	
16218	S-3 PONDS	N 30070 E 53207	
BEGUN	COMPLETED	PREPARED BY	REFERENCE POINT FOR MEASUREMENTS
9/26/84	9/26/84	R. KELLEHER	TOP OF RISER CASING

	DEPTH (FT)	ELEV. (FT)
ELEV. - TOP OF RISER CASING: 998.8 FT.		
GROUND SURFACE	0.0	995.8
20.7	975.1	
39.1	956.7	
41.0	954.8	
46.7	949.1	
55.7	940.1	
56.8	939.0	
58.6	937.2	

GENERALIZED GEOLOGIC LOG	WELL LOG
0.0 - 4.0 FT. OVERBURDEN: CLAY AND GRAVEL, BROWN TO GRAY, SOME ROAD FILL.	SURFACE CASING DIA: 10 INCHES TYPE: SCHEDULE 40 PVC
4.0 - 12.5 FT. WEATHERED SHALE: BROWN TO ORANGE, SOFT, HIGHLY WEATHERED TO DECOMPOSED.	BACKFILL MATERIAL TYPE: PORTLAND TYPE I CEMENT GROUT SLURRY
12.5 - 16.0 FT. LIMESTONE: GRAY, WEATHERED, FEW THIN SHALE STRINGERS.	RISER CASING DIA: 4 INCHES TYPE: SCHEDULE 40 PVC-FLUSH THREADED
16.0 - 18.0 FT. SHALE: BROWN TO BLACK, FISSILE, HIGHLY TO MODERATELY WEATHERED.	TOP OF SEAL ANNULAR SEAL TYPE: FINE-GRAINED SAND
18.0 - 23.0 FT. LIMESTONE: GRAY, HARD, MODERATELY WEATHERED.	TOP OF FILTER PACK FILTER PACK TYPE: SANDBLAST SAND
23.0 - 25.7 FT. SHALE: BROWN, SOFT, HIGHLY WEATHERED, FISSILE.	TOP OF SCREEN SCREEN: BRAINARD-KILMAN DIA: 4 INCHES TYPE: SCHEDULE 40 PVC-FLUSH THREADED OPENING WIDTH: 0.010 INCH TYPE: MACHINE SLOTTED
25.7 - 28.2 FT. LIMESTONE: MEDIUM GRAY, HARD, WEATHERED.	BOTTOM OF SCREEN
28.2 - 58.6 FT. SHALE: BROWN TO GRAY, MODERATELY TO HIGHLY WEATHERED, SOFT TO MODERATELY HARD, OCCASIONAL LIMESTONE LENSES AND BEDS UP TO 2 FEET THICK.	BOTTOM OF SUMP
	BOTTOM OF HOLE

HOLE ADVANCED WITH 16" TRICONE BIT TO 22.7 FT. AND 9" TRICONE BIT TO 58.6 FT. USING AIR. LOGGED FROM CUTTINGS.

HOLE DIA: 9 INCHES

CENTRALIZERS AT : 7.0' AND 37.0'

OBSERVATION WELL		PROJECT	WELL NO.
		BEAR CREEK WASTE DISPOSAL	GW-109
JOB NO.	SITE	COORDINATES	
16218	S-3 PONDS	N 30056 E 53207	
BEGUN	COMPLETED	PREPARED BY	REFERENCE POINT FOR MEASUREMENTS
9/27/84	9/27/84	R. KELLEHER	TOP OF RISER CASING

GENERALIZED GEOLOGIC LOG	DEPTH (FT)	ELEV. (FT)
0.0 - 0.5 FT. GRAVEL: MEDIUM GRAY.	0.0	995.3
0.5 - 5.0 FT. SILTY CLAY: BROWN, TRACE OF GRAVEL AND SAND.		
5.0 - 11.5 FT. WEATHERED SHALE: BROWN TO ORANGE, HIGHLY WEATHERED TO DECOMPOSED. PLASTIC IN PART. SOME GRAY LIMESTONE LENSES.	20.0	975.3
11.5 - 16.0 FT. LIMESTONE: GRAY, MODERATELY TO HIGHLY WEATHERED, MODERATELY HARD.		
12.0 - 13.0 FT. SHALE, BROWN, SOFT, HIGHLY WEATHERED.		
16.0 - 147.6 FT. SHALE AND LIMESTONE: SHALE IS MODERATE BROWN TO GRAY, HIGHLY TO MODERATELY WEATHERED, FISSILE, SOFT TO MODERATELY HARD. LIMESTONE IS MEDIUM GRAY, HIGHLY TO MODERATELY WEATHERED AND OCCURS AS STRINGERS OR LENSES UP TO 3 FEET THICK.		

WELL COMPONENTS	DEPTH (FT)	ELEV. (FT)
ELEV. - TOP OF RISER CASING: 997.6 FT.		
GROUND SURFACE	0.0	995.3
SURFACE CASING DIA: 10 INCHES TYPE: SCHEDULE 40 PVC		
BOTTOM OF SURFACE CASING	20.0	975.3
BACKFILL MATERIAL TYPE: PORTLAND TYPE I CEMENT GROUT SLURRY		
RISER CASING DIA: 4 INCHES TYPE: SCHEDULE 40 PVC-FLUSH THREADED		
TOP OF SEAL		
ANNULAR SEAL TYPE: FINE-GRAINED SAND	94.6	900.7
TOP OF FILTER PACK		
FILTER PACK TYPE: SANDBLAST SAND	96.6	898.7
TOP OF SCREEN	102.9	892.4
SCREEN: BRAINARD-KILMAN DIA: 4 INCHES TYPE: SCHEDULE 40 PVC-FLUSH THREADED OPENING WIDTH: 0.010 INCH TYPE: PVC WIRE-WOUND CONTINUOUS SLOT		
BOTTOM OF SCREEN	121.9	873.4
BOTTOM OF SUMP	123.0	872.3
BOTTOM OF HOLE	128.5	866.8
GROUT PLUG DRILLED	147.6	847.7
HOLE DIA: 9 INCHES		

HOLE ADVANCED WITH 16" TRICONE BIT TO 20.0 FT. AND 9" TRICONE BIT TO 147.6 FT. USING AIR. LOGGED FROM CUTTINGS.

CENTRALIZERS AT : 18.2', 58.2', AND 100.2'

Y-12 PLANT GROUNDWATER PROTECTION PROGRAM

WELL NO. GW-148

WELL INSTALLATION DIAGRAM

LOGGED BY: _____

DRILLING DATES:

DRILLING COMPANY: Geotek Engineering

STARTED: _____

DRILLER: Gossage HELPER: _____FINISHED: 7/30/85

NOT TO SCALE

REFERENCE:

Geraghty & Miller, 1989

King and Haase, et al., 1991

Lee Wan & Associates, 1989

Y-12 PLANT GROUNDWATER PROTECTION PROGRAM

WELL NO. GW-149

WELL INSTALLATION DIAGRAM

LOGGED BY: _____

DRILLING DATES:

DRILLING COMPANY: Geotek Engineering

STARTED: _____

DRILLER: R.H. Collins HELPER: _____FINISHED: 8/14/85

NOT TO SCALE

Y-12 PLANT GROUNDWATER PROTECTION PROGRAM

WELL NO. GW-151

WELL INSTALLATION DIAGRAM

LOGGED BY: _____

DRILLING DATES:

DRILLING COMPANY: Geotek Engineering

STARTED: _____

DRILLER: R. Collins HELPER: _____FINISHED: 8/14/85

NOT TO SCALE

REFERENCE:

Geraghty & Miller, 1989
King and Haase, et al., 1991
Lee Wan & Associates, 1989

EDGE**Engineering, Design & Geosciences Group, Inc.**

725 Pellissippi Parkway

P.O. Box 23010 Knoxville, Tn 37933-1010

(615)966-9788

WELL No. GW-193

WELL INSTALLATION DIAGRAM**Y-12 WELL INSTALLATION PROGRAM**

LOGGED

BY: Y-12, Near Building 9201-1DRILLING COMPANY: Charlie Young DrillingDRILLER: James C. Draper HELPER: Gregg Shilling

DRILLING DATES:

STARTED: 8/3/89FINISHED: 8/4/89

NOT TO SCALE

REFERENCE:

Geraghty & Miller, 1989
 King and Haase, et al., 1991
 Lee Wan & Associates, 1989

WELL CONSTRUCTION DIAGRAM

WELL NO. **GW-253**
PROJECT **S-2 Site Investigation**

LOCATION Y-12 Plant, S-2 Site	COORDINATES (PLANT GRID) N29,404 E54,057	GROUND ELEVATION 1,001.60 ft msl	MEASURING PT. ELEVATION 1,003.99 ft msl
GEOLOGIST C.A. Motley	DRILLING CONTRACTOR Geotek	DRILLING METHOD Hollow-Stem Auger	RIG TYPE Mobile B-53
WELL DEVELOPMENT METHOD B-K Hand Pump	WELL DEVELOPMENT DURATION 3 hours	WELL COMPLETED 04-11-86	MONITORED FORMATION Unconsolidated Zone

NOT TO SCALE

WELL CONSTRUCTION DIAGRAM

WELL NO. **GW-274**
PROJECT **Y-12 Plant**
Monitor Well Installation

LOCATION Salvage Yard	COORDINATES N 30151.84 (Plant Grid) E 53672.75	GROUND ELEVATION 992.94 ft. msl	MEASURING PT. ELEVATION 995.43 ft. msl
GEOLOGIST G. Weiss	DRILLING CONTRACTOR Geotek	DRILLING METHOD Air Rotary	RIG TYPE Ingersol Rand T-4
WELL DEVELOPMENT METHOD Submersible Pump	VOLUME EVACUATED 174.5 gal.	WELL COMPLETED 06/09/86	MONITORED FORMATION Unconsolidated Zone

NOT TO SCALE

WELL CONSTRUCTION DIAGRAM

WELL NO. **GW-275**
PROJECT **Y-12 Plant**
Monitor Well Installation

LOCATION Salvage Yard	COORDINATES N 30151.36 Plant Grid) E 53687.52	GROUND ELEVATION 993.08 ft. msl	MEASURING PT. ELEVATION 995.36 ft. msl
GEOLOGIST G. Weiss	DRILLING CONTRACTOR Geotek	DRILLING METHOD Air Rotary	RIG TYPE Ingersoll Rand T-5
WELL DEVELOPMENT METHOD Submersible Pump	VOLUME EVACUATED 406.5 gal.	WELL COMPLETED 05/30/86	MONITORED FORMATION Nolichucky Sahle

Y-12 PLANT GROUNDWATER PROTECTION PROGRAM

WELL NO. GW-605

WELL INSTALLATION DIAGRAM

LOGGED BY: W. Kevin Jago - SAIC

DRILLING DATES:

DRILLING COMPANY: Highland DrillingSTARTED: 3/8/91FINISHED: 3/19/91DRILLER: John Young HELPER: David Wright/Hubert Hall

NOT TO SCALE

Y-12 PLANT GROUNDWATER PROTECTION PROGRAM

WELL INSTALLATION DIAGRAM

WELL NO. GW-606

LOGGED BY: W. Kevin Jago - SAIC

DRILLING DATES:

DRILLING COMPANY: Highland Drilling

STARTED: 2/21/91

FINISHED: 3/20/91

DRILLERS: Steve Brown/Scott Gilbert

HELPERS: David Wright/Scott Gilbert

NOT TO SCALE

Y-12 PLANT GROUNDWATER PROTECTION PROGRAM

WELL NO. GW-733

WELL INSTALLATION DIAGRAM

LOGGED BY: W. Kevin Jago - SAIC

DRILLING DATES

DRILLING COMPANY: Highland DrillingSTARTED: 9/13/91DRILLER: John Young HELPER: Hubert Hall/Lecil JonesFINISHED: 10/2/91

NOT TO SCALE

APPENDIX C

APPLICABLE STANDARD PRACTICE PROCEDURES FOR THE GROUNDWATER PROTECTION PROGRAM

- C.1 Well Plugging and Abandonment Procedure
- C.2 Well Inspection Procedure
- C.3 Well Depth Measurement Procedure

C.1 Well Plugging and Abandonment Procedure

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

Well Plugging and Abandonment Procedure

G-003
Rev. 1., October 1994

Approved by: W. Kevin Jago Date: 02-08-95
Effective Date: 02-08-95

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: October 1997
Date

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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.

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 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.

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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.

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).

- 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.

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: $\text{Sediment Accumulation} = \text{Constructed Depth} - \text{Measured Depth}$. 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

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

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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.

TITLE: Monitor Well Depth Measurement Procedure

July 1994

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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).

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	

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- 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: $0.1632 \text{ gal/ft} \times (\text{height of water column}) = \text{gallons}$

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

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

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.

- 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
STATISTICAL ANALYSES

NEW HOPE POND POST-CLOSURE PERMIT APPLICATION STATISTICAL ANALYSIS

A statistical analysis was conducted to investigate whether the New Hope Pond site was a source of groundwater contamination. The analysis was aimed at determining if concentrations of indicator parameters were significantly higher in wells downgradient of the site as compared to those in wells upgradient of the site. The data consisted of sampling results collected from 1988 through the second quarter of 1994 at five upgradient and five downgradient wells around the New Hope Pond site. The indicator parameters used were barium, cadmium, chromium, lead, mercury, nickel, silver, uranium, gross alpha and gross beta.

Effects due to time, well depth, and geologic formation were controlled in the analysis by pairing the data. Data pairs were constructed of upgradient and downgradient wells of similar depths in the same geologic formation. The data were also paired by sampling event to control for seasonal variations. The statistical hypothesis for paired data states "The mean difference between paired upgradient and downgradient well results is less than or equal to zero". If the hypothesis is rejected, one would accept the alternative hypothesis, "The mean difference is greater than zero". In other words, the concentrations in the downgradient well are higher than the concentrations in the paired upgradient well. This would indicate that the site is a contributor to groundwater contamination. All tests were run at $\alpha=0.05$.

The well pairs determined by formation and depth were:

<u>Pair</u>	<u>Downgradient</u>	<u>Upgradient</u>	<u>Formation</u>	<u>Depth</u>
1	GW-148	GW-154	Maynardville	11-12'
2	GW-220	GW-605	Maynardville	30-49'
3	GW-149	GW-153	Maynardville	50-60'
4	GW-151	GW-223	Maynardville	90-100'
5	GW-733	GW-606	Maynardville	170-260'

The statistical test used depended on the assumptions of the test. If differences were normally distributed, a t-test was run. If differences were not normally distributed but the distribution was symmetric, a signed ranks test was run. If the distribution was neither normal nor symmetric, a sign test was run. Normality was assessed through the Shapiro-Wilk statistic output from the SAS[®] univariate procedure. Symmetry was visually determined by looking at the stem and leaf plot output from the same SAS[®] procedure. The t-test is a parametric test which frames the hypothesis in terms of mean differences. The signed ranks and sign tests are non-parametric tests which frame the hypothesis in terms of median differences.

The summary of the statistical tests run follows:

Barium

There is statistical evidence that the concentration of barium in downgradient wells exceeds that in upgradient wells in three of the five well pairs (Pairs 1, 2, and 3). A regression analysis was run to determine if there was a statistical relationship between the concentration of barium and the level of total suspended solids in the downgradient groundwater samples. The analysis concluded that there was a statistically significantly

relationship between barium and total suspended solids for GW-220 (Pair 2 downgradient well). Barium concentrations increase with increasing total suspended solids. The r^2 was equal to 0.72. The F value was 25.3. The Prob > F was 0.0005.

Lead

There is statistical evidence that the concentration of lead in the pair 2 downgradient well exceeds that in the paired upgradient well. A regression analysis was run to determine if there was a statistical relationship between the concentration of lead and the level of total suspended solids in the downgradient groundwater samples. The analysis concluded that there was a statistically significant relationship between lead and total suspended solids for GW-220 (Pair 2 downgradient well). Lead concentrations increase with increasing total suspended solids. The r^2 was equal to 0.75. The F value was 30.1. The Prob > F was 0.0003.

Cadmium

There is no statistical evidence that the concentration of cadmium in downgradient wells exceeds that in the paired upgradient wells in five of the five well pairs.

Chromium

There is no statistical evidence that the concentration of chromium in downgradient wells exceeds that in the paired upgradient wells in five of the five well pairs.

Mercury

There is no statistical evidence that the concentration of mercury in downgradient wells exceeds that in the paired upgradient wells in five of the five well pairs.

Nickel

There is no statistical evidence that the concentration of nickel in downgradient wells exceeds that in the paired upgradient wells in four of the five well pairs. No comparisons were possible for pair 1.

Silver

There is no statistical evidence that the concentration of silver in downgradient wells exceeds that in the paired upgradient wells in five of the five well pairs.

Uranium

There is no statistical evidence that the concentration of uranium in downgradient wells exceeds that in the paired upgradient wells in five of the five well pairs.

Gross Alpha

There is no statistical evidence that the alpha activity in downgradient wells exceeds that in the paired upgradient wells in five of the five well pairs.

Gross Beta

There is no statistical evidence that the beta activity in downgradient wells exceeds that in the paired upgradient wells in five of the five well pairs.

December 20, 1994

Ms. Suzanne McGinley
Geraghty & Miller, Inc.
97 Midway Lane
Oak Ridge, Tennessee 37830

Dear Suzanne:

I have enclosed the following documentation associated with the New Hope Pond Post-Closure Permit Application:

- A. Task 1
 - 1. Summary of statistical test results from comparison of paired downgradient vs upgradient wells
 - 2. Plots of barium vs total suspended solids
lead vs total suspended solids
for well pairs where downgradient results > upgradient results
 - 3. Print out of data used in Task 1
- B. Task 2
 - 1. Summary of the tolerance limits calculations
 - 2. Frequency distributions for analytes showing differences between wells
 - 3. Print out of data used in Task 2

If you have any questions, please feel free to call me.

Sincerely,
PARADIGM DATA SERVICES, INC.

Terre Mercier

PARADIGM DATA SERVICES, INC.
12029 Ridgeland Drive Knoxville, TN 37932
Phone: 966-1553 Fax: 966-2098

TASK 1

SUMMARY OF STATISTICAL TEST RESULTS
IS THE DOWNGRADIENT RESULT > UPGRADIENT RESULT ?
(IS DOWNGRADIENT RESULT $\neq$ UPGRADIENT RESULT ?)

Data used:

1988 - 2nd quarter 1994 (no field duplicates, unfiltered metals, screened for charge balance (must be between -20 and +20%))

Pair	Downgradient	Upgradient
1	GW-148	GW-154 (known to be contaminated)
2	GW-220	GW-605 (known to be contaminated)
3	GW-149	GW-153
4	GW-151	GW-223
5	GW-733	GW-606

If result reported as <#, # used in calculation (NA for rad analytes reported as -#,0,+#)

Paired by sampling event (pair/year/quarter)

Test used was dependent on satisfying test assumptions, the most limiting assumption being:

t-test:	Differences between down and up gradient results must be normally distributed
Signed ranks test:	Distribution of differences must be symmetric
Sign test:	

Question asked by each test:

t-test:	Is the mean	difference (down-up) > 0 ?	1-tailed
	Is the mean	difference (down-up) $\neq$ 0 ?	2-tailed
Signed ranks test:	Is the median	difference (down-up) > 0 ?	1-tailed
	Is the median	difference (down-up) $\neq$ 0 ?	2-tailed
Sign test:	Is the median	difference (down-up) > 0 ?	1-tailed
	Is the median	difference (down-up) $\neq$ 0 ?	2-tailed

TABLE EXPLANATION

Line 1: If test statistic was significant, the statistical test conducted

TT: t-test
 SR: Signed ranks test
 ST: Sign test

Line 2: If test statistic was significant,

TT: mean difference (down-up)
 SR: median difference (down-up)
 ST: median difference (down-up)

Line 3: Sample size

Line 5: If test statistic was significant,
 The mean (down) - mean (up)

1-tailed test unless otherwise noted

* = no comparisons possible

**DOWNGRADIENT STATISTICALLY SIGNIFICANTLY GREATER THAN
(DIFFERENT FROM, for 2-tailed test) UPGRADIENT**

ANALYTE	PAIR				
	1	2	3	4	5
Alkalinity- HCO ₃ 2-tailed	TT 147 mg/L n=9 362-215	TT -20 mg/L n=12 234-254	TT 105 mg/L n=13 246-141	ST -73 mg/L n=13 219-267	TT -75 mg/L n=9 145-220
Aluminum	*	SR 1.36 mg/L n=12 2.33-0.17	n=5	n=5	n=9
Barium ICAP	*	TT 0.04 mg/L n=12 0.11-0.07	TT 0.39 n=5 0.44-0.05	n=5	n=9
Barium AAS	TT 0.33 mg/L n=5 0.46-0.12	*	TT 0.38 mg/L n=5 0.48-0.10	n=5	*
Boron	*	n=12	TT 0.39 mg/L n=5 0.41-0.02	TT 0.04 mg/L n=5 0.08-0.04	n=9
Calcium	TT 75 mg/L n=9 183-109	n=12	n=13	n=13	n=9
Conductivity (Lab)	n=9	n=12	n=13	n=13	n=9

**DOWNGRADIENT STATISTICALLY SIGNIFICANTLY GREATER THAN
(DIFFERENT FROM, for 2-tailed test) UPGRADIENT**

ANALYTE	PAIR				
	1	2	3	4	5
Conductivity (Field)	n=8	n=12	TT 61 mg/L n=13 524-463	n=13	n=9
Dissolved Oxygen 2-tailed	n=8	TT 1.27 ppm n=12 2.19-0.93	n=13	TT 0.54 ppm n=13 1.77-1.23	ST 0.5 ppm n=9 1.88-1.81
Fluoride	n=9	n=12	ST 0.2 mg/L n=13 0.34-0.18	n=13	TT 0.08 mg/L n=9 0.23-0.14
Iron	*	ST 1.13 mg/L n=12 2.41-0.24	n=5	n=5	TT 5.83 mg/L n=9 5.86-0.02
Lead AAS	n=9	ST 0.00075 mg/L n=12 0.00865-0.004	n=13	n=13	n=9
Magnesium	n=9	TT 7.42 mg/L n=12 23.67-16.25	n=13	TT 9.38 mg/L n=13 24.15-14.77	n=9
Manganese	*	n=12	TT 0.06 mg/L n=5 0.089-0.034	n=5	TT 0.13 mg/L n=9 0.15-0.018

**DOWNGRADIENT STATISTICALLY SIGNIFICANTLY GREATER THAN
(DIFFERENT FROM, for 2-tailed test) UPGRAIDENT**

ANALYTE	PAIR				
	1	2	3	4	5
Nitrate-N	n=9	TT 0.39 mg/L n=12 0.68-0.29	n=13	n=13	n=9
pH (Lab) 2-tailed	n=9	TT 0.27 n=12 7.65-7.38	n=13	n=13	n=9
pH (Field) 2-tailed	TT -0.56 n=9 6.72-7.28	ST 0.35 n=12 7.36-7.06	TT -0.44 n=13 7.55-7.98	TT 0.52 n=13 7.41-6.88	TT 0.47 n=9 7.90-7.43
Potassium	n=9	n=12	TT 3.05 mg/L n=13 7.58-4.54	n=13	n=9
Redox (Field) 2-tailed	n=9	n=12	TT -149 mV n=12 93-242	TT 54 mV n=13 272-218	TT -115 mV n=9 7-122
Silicon	*	*	n=5	TT 0.48 mg/L n=5 5.68-5.2	*
Sodium	n=9	n=12	TT 29 mg/L n=13 62-33	n=13	n=9

**DOWNGRADIENT STATISTICALLY SIGNIFICANTLY GREATER THAN
(DIFFERENT FROM, for 2-tailed test) UPGRADIENT**

ANALYTE	PAIR				
	1	2	3	4	5
Strontium	*	TT 0.24 mg/L n=12 0.41-0.17	TT 0.78 mg/L n=5 0.96-0.19	SR 0.24 mg/L n=5 0.55-0.30	n=9
Total Suspended Solids	TT 92 mg/L n=9 106-13	ST 9.5 mg/L n=12 102-3	n=13	n=13	TT 17 mg/L n=9 18-2
Turbidity	n=4	ST 32.4 NTU n=12 81.4-3.3	n=8	n=8	TT 15.5 NTU n=9 16.6-1.1
Water Temp. 2-tailed	n=9	TT -1.7 n=12 16.0-17.7	ST 2.1 n=13 17.9-15.0	TT -1.0 n=13 16.3-17.4	n=9

**DOWNGRAIENT NOT STATISTICALLY SIGNIFICANTLY GREATER
THAN (DIFFERENT FROM, 2-tailed test) UPGRADIENT**

ANALYTE	PAIR				
	1	2	3	4	5
Alkalinity- CO ₃ 2-tailed	n=9	n=12	n=13	n=13	n=9
Antimony	*	n=12	n=5	n=5	n=9
Arsenic ICAP	*	n=12	n=5	n=5	n=9
Arsenic AAS	n=5	*	n=5	n=5	*
Beryllium	*	n=12	n=5	n=5	n=9
Cadmium ICAP	*	n=12	n=5	n=5	n=9
Cadmium AAS	n=5	n=12	n=10	n=10	n=9
Chloride	n=9	n=12	n=13	n=13	n=9
Chromium ICAP	*	n=12	n=5	n=5	n=9
Chromium AAS	n=9	n=12	n=13	n=13	n=9
Cobalt	*	n=12	n=5	n=5	n=9
Copper	*	n=12	n=5	n=5	n=9
Dissolved Solids	n=9	n=12	n=13	n=13	n=9
Gross Alpha	n=9	n=12	n=13	n=13	n=9
Gross Beta	n=9	n=12	n=13	n=13	n=9
Mercury	n=9	n=12	n=13	n=13	n=9
Molybdenum	*	n=12	n=5	n=5	n=9
Nickel	*	n=12	n=5	n=5	n=9
Radium	n=4	*	n=4	n=4	*

**DOWNGRADIENT NOT STATISTICALLY SIGNIFICANTLY GREATER
THAN (DIFFERENT FROM, 2-tailed test) UPGRADIENT**

ANALYTE	PAIR				
	1	2	3	4	5
Selenium ICAP	*	n=12	n=5	n=5	n=9
Selenium AAS	n=5	*	n=5	n=5	*
Silver ICAP	*	n=12	n=5	n=5	n=9
Silver AAS	n=5	*	n=5	n=5	*
Sulfate	n=9	n=12	n=13	n=13	n=9
Thorium	*	n=12	n=5	n=5	n=9
Tin AAS	n=4	*	n=3	n=3	*
Uranium Fluorometric	n=9	n=12	n=13	n=13	n=9
Vanadium	*	n=11	n=5	n=5	n=9
Zinc	*	n=12	n=5	n=5	n=9

BARIUM AAS (MG/L)
 GW-148

Legend: A = 1 obs, B = 2 obs, etc.

NOTE: 4 obs had missing values.

BARIUM

ICAP (MG/L)

GW-220

Legend: A = 1 obs, B = 2 obs, etc.

BARIUM

AAS (MG/L)

GW-149

Legend: A = 1 obs, B = 2 obs, etc.

NOTE: 8 obs had missing values.

LEAD

AAS (MG/L)

GW-220

Legend: A = 1 obs, B = 2 obs, etc.

				CONDUCTIVITY		(UMHOS/CM)				
OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	1130	940	-190
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	974	965	-9
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	819	1020	201
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	868	854	-14
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	655	891	236
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	744	1025	281
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	50	1170	1120
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	668	947	279
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	1362	889	-473
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	596	515	-81
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	519	371	-148
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	609	531	-78
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	629	479	-150
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	598	482	-116
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	590	467	-123
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	613	482	-131
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	603	516	-87
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	571	478	-93
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	591	524	-67
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	625	553	-72
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	625	454	-171
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	703	517	-186
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	442	542	100
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	630	500	-130
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	520	529	9
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	493	503	10
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	445	531	86
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	387	511	124
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	366	485	119
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	362	497	135
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	538	546	8
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	531	482	-49
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	440	493	53
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	390	505	115
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	562	456	-106
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	612	468	-144
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	565	452	-113
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	576	450	-126
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	575	468	-107
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	555	473	-82
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	649	442	-207
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	740	400	-340
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	708	431	-277
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	749	465	-284
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	699	423	-276
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	689	437	-252
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	663	455	-208
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	584	311	-273
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	588	350	-238
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	568	299	-269
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	594	367	-227
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	600	357	-243
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	608	355	-253
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	617	383	-234
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	623	353	-270
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	601	349	-252

CONDUCTIVITY, REP. 2 (UMHOS/CM)

OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	1110	935	-175
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	969	966	-3
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	802	1020	218
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	862	854	-8
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	673	858	185
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	744	1022	278
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	50	1006	956
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	665	917	252
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	1378	885	-493
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	.	.	.
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	.	.	.
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	.	.	.
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	.	.	.
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	.	.	.
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	.	.	.
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	.	.	.
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	.	.	.
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	.	.	.
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	.	.	.
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	.	.	.
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	.	.	.
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	700	518	-182
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	432	537	105
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	615	495	-120
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	527	532	5
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	499	518	19
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	448	531	83
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	393	518	125
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	369	497	128
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	.	.	.
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	.	.	.
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	.	.	.
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	.	.	.
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	.	.	.
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	450	455	5
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	613	468	-145
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	568	458	-110
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	576	451	-125
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	578	465	-113
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	552	473	-79
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	659	449	-210
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	671	403	-268
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	.	.	.
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	.	.	.
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	.	.	.
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	.	.	.
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	.	.	.
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	.	.	.
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	.	.	.
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	.	.	.
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	.	.	.
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	.	.	.
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	.	.	.
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	.	.	.
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	.	.	.
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	.	.	.

CONDUCTIVITY, REP. 3 (UMHOS/CM)

OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	1120	937	-183
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	953	963	10
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	803	1020	217
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	880	855	-25
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	658	873	215
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	753	1025	272
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	50	1006	956
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	662	957	295
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	1429	919	-510
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	.	.	.
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	.	.	.
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	.	.	.
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	.	.	.
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	.	.	.
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	.	.	.
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	.	.	.
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	.	.	.
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	.	.	.
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	.	.	.
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	.	.	.
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	.	.	.
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	701	515	-186
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	454	540	86
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	603	498	-105
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	531	525	-6
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	493	524	31
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	445	534	89
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	393	521	128
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	369	500	131
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	.	.	.
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	.	.	.
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	.	.	.
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	.	.	.
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	.	.	.
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	560	452	-108
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	614	471	-143
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	554	456	-98
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	572	448	-124
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	575	465	-110
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	555	470	-85
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	659	449	-210
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	658	403	-255
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	.	.	.
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	.	.	.
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	.	.	.
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	.	.	.
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	.	.	.
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	.	.	.
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	.	.	.
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	.	.	.
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	.	.	.
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	.	.	.
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	.	.	.
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	.	.	.
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	.	.	.
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	.	.	.

CONDUCTIVITY, REP. 4 (UMHOS/CM)

OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	1130	938	-192
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	957	967	10
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	812	1020	208
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	869	846	-23
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	670	882	212
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	744	1025	281
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	50	1009	959
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	665	934	269
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	1368	919	-449
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	.	.	.
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	.	.	.
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	.	.	.
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	.	.	.
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	.	.	.
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	.	.	.
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	.	.	.
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	.	.	.
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	.	.	.
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	.	.	.
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	.	.	.
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	.	.	.
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	708	518	-190
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	433	540	107
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	610	507	-103
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	529	527	-2
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	493	521	28
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	448	534	86
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	400	524	124
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	369	508	139
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	.	.	.
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	.	.	.
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	.	.	.
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	.	.	.
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	.	.	.
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	498	459	-39
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	614	471	-143
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	552	452	-100
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	583	452	-131
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	578	465	-113
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	555	470	-85
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	649	449	-200
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	743	396	-347
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	.	.	.
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	.	.	.
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	.	.	.
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	.	.	.
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	.	.	.
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	.	.	.
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	.	.	.
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	.	.	.
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	.	.	.
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	.	.	.
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	.	.	.
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	.	.	.
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	.	.	.
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	.	.	.

OBS	Pair	Year	Quarter	CYANIDE		(MG/L)		Upgradient Result	Downgradient Result	Down-Up Gradient
				Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date			
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	.	.	.
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	.	.	.
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	.	.	.
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	.	.	.
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	.	.	.
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	.	.	.
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	.	.	.
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	.	.	.
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	.	.	.
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	.	.	.
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	.	.	.
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	.	.	.
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	.	.	.
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	.	.	.
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	.	.	.
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	.	.	.
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	.	.	.
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	.	.	.
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	.	.	.
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	.	.	.
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	.	.	.
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	.	.	.
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	.	.	.
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	.	.	.
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	.	.	.
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	.	.	.
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	.	.	.
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	.	.	.
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	.	.	.
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	.	.	.
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	.	.	.

DISSOLVED OXYGEN, FIELD MMT. (PPM)

OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	9.5	4	-5.50
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	3.4	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	3.9	4.8	0.90
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	2.3	2.7	0.40
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	12	4.8	-7.20
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	4.9	11.2	6.30
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	2.2	3.3	1.10
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	8.8	3.9	-4.90
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	3.2	3.3	0.10
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	1.2	1	-0.20
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	0.1	0.4	0.30
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	0.7	5	4.30
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	0.6	0.9	0.30
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	0.6	3.8	3.20
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	0.6	1	0.40
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	0.9	1.6	0.70
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	1.1	2.9	1.80
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	3	1.4	-1.60
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	1	0.9	-0.10
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	0.9	6.1	5.20
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	0.4	1.3	0.90
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	1.8	4.1	2.30
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	2.8	10.4	7.60
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	1.2	2.4	1.20
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	1.6	3.8	2.20
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	3.8	3.5	-0.30
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	5	9.2	4.20
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	3	1.6	-1.40
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	4.2	1.5	-2.70
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	3.4	2.7	-0.70
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	2.5	0.4	-2.10
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	2.5	1.5	-1.00
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	4.7	4.1	-0.60
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	3.2	0.9	-2.30
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	2.4	2.6	0.20
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	4.6	4.2	-0.40
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	1.2	2.5	1.30
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	1.2	2.4	1.20
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	1	1.3	0.30
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	0.6	1.6	1.00
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	1.2	1	-0.20
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	1.2	3	1.80
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	0.3	1.2	0.90
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	0.2	0.5	0.30
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	0.4	0.9	0.50
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	1.2	1	-0.20
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	0.5	0.8	0.30
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	0.7	2.2	1.50
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	0.5	1	0.50
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	0.6	1.7	1.10
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	1.1	1.4	0.30
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	1.4	1.5	0.10
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	2.4	3.1	0.70
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	0.9	1.4	0.50
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	8.3	3.6	-4.70
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	0.4	1.06	0.66

				MERCURY		CVAA (MG/L)				
OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	<0.0002	0.0002	0.00000
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	0.0014	<0.0002	-.00120
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	0.0003	<0.0002	-.00010
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	0.0006	<0.0002	-.00040
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	<0.0002	0.0007	0.00050
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	0.0011	<0.0002	-.00090
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	0.00046	<0.0002	-.00026
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	0.0013	<0.0002	-.00110
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	<0.0002	<0.0002	0.00000
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	<0.0002	<0.0002	0.00000
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	<0.0002	<0.0002	0.00000
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	<0.0002	<0.0002	0.00000
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	<0.0002	<0.0002	0.00000
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	<0.0002	<0.0002	0.00000
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	<0.0002	<0.0002	0.00000
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	<0.0002	<0.0002	0.00000
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	<0.0002	<0.0002	0.00000
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	<0.0002	<0.0002	0.00000
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	<0.0002	<0.0002	0.00000
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	<0.0002	<0.0002	0.00000
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	<0.0002	<0.0002	0.00000
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	<0.0002	0.0004	0.00020
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	<0.0002	<0.0002	0.00000
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	<0.0002	<0.0002	0.00000
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	<0.0002	<0.0002	0.00000
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	<0.0002	<0.0002	0.00000
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	<0.0002	<0.0002	0.00000
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	<0.0002	<0.0002	0.00000
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	<0.0002	<0.0002	0.00000
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	<0.0002	<0.0002	0.00000
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	<0.0002	<0.0002	0.00000
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	<0.0002	<0.0002	0.00000
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	<0.0002	<0.0002	0.00000
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	<0.0002	<0.0002	0.00000
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	<0.0002	<0.0002	0.00000
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	<0.0002	<0.0002	0.00000
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	<0.0002	<0.0002	0.00000
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	<0.0002	<0.0002	0.00000
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	<0.0002	<0.0002	0.00000
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	<0.0002	<0.0002	0.00000
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	<0.0002	<0.0002	0.00000
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	<0.0002	<0.0002	0.00000
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	<0.0002	<0.0002	0.00000
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	<0.0002	<0.0002	0.00000
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	<0.0002	<0.0002	0.00000
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	<0.0002	<0.0002	0.00000
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	<0.0002	<0.0002	0.00000
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	<0.0002	<0.0002	0.00000
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	<0.0002	<0.0002	0.00000
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	<0.0002	<0.0002	0.00000
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	<0.0002	<0.0002	0.00000
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	<0.0002	<0.0002	0.00000
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	<0.0002	<0.0002	0.00000
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	<0.0002	<0.0002	0.00000
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	<0.0002	<0.0002	0.00000
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	<0.0002	<0.0002	0.00000

OBS	Pair	Year	Quarter	ALUMINUM		ICAP (MG/L)		Upgradient Result	Downgradient Result	Down-Up Gradient
				Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date			
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	0.91	0.46	-0.450
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	0.081	5.3	5.219
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	0.092	0.27	0.178
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	0.026	3.2	3.174
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	0.3	3.6	3.300
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	0.053	0.27	0.217
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	0.034	0.23	0.196
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	0.027	8.6	8.573
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	0.044	2.4	2.356
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	0.026	0.39	0.364
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	0.045	2.9	2.855
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	0.37	0.34	-0.030
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	0.4	0.04	-0.360
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	0.59	0.088	-0.502
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	0.49	0.027	-0.463
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	0.58	0.23	-0.350
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	0.41	0.81	0.400
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	0.05	0.033	-0.017
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	0.031	0.18	0.149
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	0.089	0.069	-0.020
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	0.083	0.064	-0.019
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	0.028	<0.02	-0.008
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	0.023	<0.02	-0.003
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	0.17	0.026	-0.144
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	0.04	0.027	-0.013
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	<0.02	<0.02	0.000
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	<0.02	0.082	0.062
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	0.055	0.02	-0.035
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	<0.02	0.044	0.024
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	<0.02	0.084	0.064
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	0.07	0.073	0.003

				ANTIMONY		ICAP (MG/L)				
OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	<0.05	<0.05	0.0
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	<0.05	<0.05	0.0
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	<0.05	<0.05	0.0
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	<0.05	<0.05	0.0
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	<0.05	<0.25	0.2
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	<0.05	<0.05	0.0
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	<0.05	<0.05	0.0
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	<0.05	<0.05	0.0
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	<0.05	<0.05	0.0
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	<0.05	<0.05	0.0
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	<0.05	<0.05	0.0
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	<0.05	<0.05	0.0
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	<0.05	<0.05	0.0
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	<0.05	<0.05	0.0
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	<0.05	<0.05	0.0
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	<0.05	<0.05	0.0
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	<0.05	<0.05	0.0
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	<0.05	<0.05	0.0
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	<0.05	<0.05	0.0
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	<0.05	<0.05	0.0
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	<0.05	<0.05	0.0
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	<0.05	<0.05	0.0
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	<0.05	<0.05	0.0
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	<0.05	<0.05	0.0
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	<0.05	<0.05	0.0
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	<0.05	<0.05	0.0
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	<0.05	<0.05	0.0
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	<0.05	<0.05	0.0
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	<0.05	<0.05	0.0
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	<0.05	<0.05	0.0
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	<0.05	<0.05	0.0

OBS	Pair	Year	Quarter	ARSENIC		ICAP (MG/L)		Upgradient Result	Downgradient Result	Down-Up Gradient
				Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date			
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	<0.05	<0.05	0.000
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	<0.05	<0.05	0.000
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	<0.05	<0.05	0.000
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	<0.05	<0.05	0.000
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	<0.05	<0.25	0.200
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	<0.05	<0.05	0.000
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	<0.05	<0.05	0.000
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	<0.05	<0.05	0.000
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	<0.05	<0.05	0.000
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	<0.05	<0.05	0.000
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	<0.05	<0.05	0.000
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	<0.05	<0.05	0.000
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	<0.05	<0.05	0.000
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	<0.05	<0.05	0.000
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	<0.05	<0.05	0.000
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	<0.05	<0.05	0.000
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	<0.05	<0.05	0.000
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	<0.05	0.071	0.021
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	<0.05	<0.05	0.000
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	<0.05	<0.05	0.000
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	<0.05	<0.05	0.000
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	<0.05	<0.05	0.000
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	<0.05	<0.05	0.000
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	<0.05	<0.05	0.000
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	<0.05	<0.05	0.000
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	<0.05	<0.05	0.000
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	<0.05	<0.05	0.000
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	<0.05	<0.05	0.000
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	<0.05	<0.05	0.000
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	<0.05	<0.05	0.000
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	<0.05	<0.05	0.000

OBS	Pair	Year	Quarter	BARIUM		ICAP (MG/L)		Upgradient Result	Downgradient Result	Down-Up Gradient
				Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date			
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	0.065	0.085	0.0200
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	0.068	0.13	0.0620
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	0.11	0.1	-0.0100
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	0.065	0.12	0.0550
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	0.071	0.12	0.0490
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	0.071	0.088	0.0170
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	0.065	0.095	0.0300
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	0.068	0.18	0.1120
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	0.063	0.11	0.0470
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	0.075	0.1	0.0250
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	0.072	0.13	0.0580
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	0.068	0.1	0.0320
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	0.045	0.44	0.3950
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	0.052	0.35	0.2980
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	0.052	0.51	0.4580
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	0.053	0.44	0.3870
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	0.046	0.47	0.4240
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	0.33	0.18	-0.1500
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	0.33	0.17	-0.1600
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	0.32	0.17	-0.1500
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	0.32	0.19	-0.1300
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	0.3	0.19	-0.1100
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	0.082	0.01	-0.0720
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	0.19	0.0071	-0.1829
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	0.083	0.0049	-0.0781
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	0.085	0.022	-0.0630
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	0.08	0.022	-0.0580
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	0.095	0.023	-0.0720
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	0.11	0.026	-0.0840
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	0.1	0.023	-0.0770
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	0.091	0.023	-0.0680

BERYLLIUM

ICAP (MG/L)

OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	<0.0003	<0.0003	0.00000
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	<0.0003	0.0008	0.00050
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	<0.0003	<0.0003	0.00000
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	<0.0003	<0.0003	0.00000
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	<0.0003	<0.0015	0.00120
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	<0.0003	<0.0003	0.00000
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	<0.0003	<0.0003	0.00000
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	<0.0003	0.00087	0.00057
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	<0.0003	<0.0003	0.00000
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	<0.0003	<0.0003	0.00000
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	<0.0003	0.00048	0.00018
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	<0.0003	<0.0003	0.00000
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	<0.0003	<0.0003	0.00000
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	<0.0003	<0.0003	0.00000
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	<0.0003	<0.0003	0.00000
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	<0.0003	<0.0003	0.00000
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	<0.0003	<0.0003	0.00000
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	<0.0003	<0.0003	0.00000
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	<0.0003	<0.0003	0.00000
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	<0.0003	<0.0003	0.00000
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	0.0016	<0.0003	- .00130
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	<0.0003	<0.0003	0.00000
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	<0.0003	<0.0003	0.00000
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	<0.0003	<0.0003	0.00000
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	<0.0003	<0.0003	0.00000
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	<0.0003	<0.0003	0.00000
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	<0.0003	<0.0003	0.00000
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	<0.0003	<0.0003	0.00000
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	<0.0003	<0.0003	0.00000
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	<0.0003	<0.0003	0.00000
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	<0.0003	<0.0003	0.00000

				BORON		ICAP (MG/L)				
OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	0.24	0.037	-0.203
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	0.24	0.039	-0.201
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	0.1	0.26	0.160
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	0.19	0.048	-0.142
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	0.21	0.039	-0.171
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	0.21	0.049	-0.161
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	0.16	0.04	-0.120
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	0.17	0.045	-0.125
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	0.063	0.061	-0.002
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	0.18	0.042	-0.138
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	0.2	0.044	-0.156
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	0.16	0.071	-0.089
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	0.018	0.45	0.432
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	0.021	0.35	0.329
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	0.022	0.36	0.338
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	0.036	0.46	0.424
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	0.012	0.45	0.438
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	0.03	0.083	0.053
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	0.041	0.087	0.046
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	0.047	0.099	0.052
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	0.052	0.075	0.023
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	0.039	0.067	0.028
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	0.037	0.056	0.019
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	1.1	0.023	-1.077
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	0.049	0.038	-0.011
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	0.026	0.025	-0.001
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	0.048	0.024	-0.024
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	0.034	0.021	-0.013
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	0.031	0.017	-0.014
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	0.059	0.015	-0.044
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	0.039	0.054	0.015

OBS	Pair	Year	Quarter	CADMIUM		ICAP (MG/L)		Upgradient Result	Downgradient Result	Down-Up Gradient
				Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date			
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	<0.003	<0.003	0.0000
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	<0.003	<0.003	0.0000
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	<0.003	<0.003	0.0000
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	<0.003	<0.003	0.0000
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	<0.003	<0.015	0.0120
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	<0.003	<0.003	0.0000
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	<0.003	<0.003	0.0000
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	<0.003	<0.003	0.0000
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	<0.003	<0.003	0.0000
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	<0.003	<0.003	0.0000
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	<0.003	<0.003	0.0000
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	<0.003	<0.003	0.0000
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	<0.003	<0.003	0.0000
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	<0.003	<0.003	0.0000
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	<0.003	<0.003	0.0000
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	<0.003	<0.003	0.0000
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	<0.003	<0.003	0.0000
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	<0.003	<0.003	0.0000
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	<0.003	<0.003	0.0000
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	<0.003	<0.003	0.0000
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	<0.003	0.0033	0.0003
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	<0.003	<0.003	0.0000
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	<0.003	<0.003	0.0000
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	<0.003	<0.003	0.0000
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	<0.003	<0.003	0.0000
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	<0.003	0.0034	0.0004
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	<0.003	<0.003	0.0000
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	<0.003	<0.003	0.0000
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	<0.003	<0.003	0.0000
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	<0.003	<0.003	0.0000
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	<0.003	<0.003	0.0000

OBS	Pair	Year	Quarter	CALCIUM		ICAP (MG/L)		Upgradient Result	Downgradient Result	Down-Up Gradient
				Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date			
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	120	180	60
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	120	190	70
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	110	180	70
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	95	180	85
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	90	190	100
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	94	190	96
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	100	200	100
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	100	170	70
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	150	170	20
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	76	65	-11
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	86	77	-9
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	87	72	-15
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	83	76	-7
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	86	74	-12
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	87	61	-26
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	82	59	-23
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	85	99	14
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	100	63	-37
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	87	64	-23
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	92	81	-11
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	85	64	-21
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	43	54	11
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	37	37	0
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	40	33	-7
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	37	32	-5
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	38	55	17
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	54	44	-10
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	32	55	23
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	38	31	-7
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	35	34	-1
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	39	27	-12
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	39	38	-1
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	38	29	-9
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	35	39	4
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	64	52	-12
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	100	57	-43
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	91	51	-40
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	96	48	-48
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	94	54	-40
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	86	56	-30
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	120	54	-66
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	140	55	-85
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	120	53	-67
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	120	54	-66
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	120	53	-67
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	110	57	-53
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	110	60	-50
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	57	18	-39
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	56	31	-25
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	62	24	-38
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	60	39	-21
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	63	40	-23
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	74	49	-25
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	69	40	-29
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	76	43	-33
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	67	36	-31

OBS	Pair	Year	Quarter	CHROMIUM		ICAP (MG/L)		Upgradient Result	Downgradient Result	Down-Up Gradient
				Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date			
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	<0.01	<0.01	0.000
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	<0.01	<0.01	0.000
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	<0.01	<0.01	0.000
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	<0.01	<0.01	0.000
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	<0.01	<0.05	0.040
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	<0.01	<0.01	0.000
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	<0.01	<0.01	0.000
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	<0.01	0.01	0.000
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	0.01	<0.01	0.000
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	<0.01	<0.01	0.000
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	<0.01	<0.01	0.000
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	<0.01	<0.01	0.000
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	<0.01	<0.01	0.000
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	<0.01	0.037	0.027
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	<0.01	<0.01	0.000
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	0.032	<0.01	-0.022
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	<0.01	<0.01	0.000
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	<0.01	<0.01	0.000
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	<0.01	<0.01	0.000
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	0.022	<0.01	-0.012
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	<0.01	0.082	0.072
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	<0.01	<0.01	0.000
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	<0.01	<0.01	0.000
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	<0.01	<0.01	0.000
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	<0.01	<0.01	0.000
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	<0.01	<0.01	0.000
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	<0.01	<0.01	0.000
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	<0.01	<0.01	0.000
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	<0.01	<0.01	0.000
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	<0.01	<0.01	0.000
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	<0.01	<0.01	0.000

OBS	Pair	Year	Quarter	COBALT		ICAP (MG/L)		Upgradient Result	Downgradient Result	Down-Up Gradient
				Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date			
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	<0.005	<0.005	0.0000
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	<0.005	0.0055	0.0005
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	<0.005	<0.005	0.0000
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	<0.005	<0.005	0.0000
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	<0.005	<0.025	0.0200
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	<0.005	<0.005	0.0000
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	<0.005	<0.005	0.0000
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	<0.005	<0.005	0.0000
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	<0.005	0.0052	0.0002
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	<0.005	<0.005	0.0000
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	<0.005	<0.005	0.0000
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	<0.005	<0.005	0.0000
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	<0.005	<0.005	0.0000
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	<0.005	<0.005	0.0000
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	<0.005	<0.005	0.0000
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	<0.005	<0.005	0.0000
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	<0.005	<0.005	0.0000
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	<0.005	<0.005	0.0000
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	<0.005	<0.005	0.0000
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	<0.005	<0.005	0.0000
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	<0.005	<0.005	0.0000
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	<0.005	<0.005	0.0000
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	<0.005	<0.005	0.0000
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	<0.005	<0.005	0.0000
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	<0.005	<0.005	0.0000
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	<0.005	<0.005	0.0000
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	<0.005	<0.005	0.0000
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	<0.005	<0.005	0.0000
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	<0.005	<0.005	0.0000
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	<0.005	<0.005	0.0000
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	<0.005	<0.005	0.0000

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OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	0.0042	<0.004	-0.0002
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	<0.004	0.0046	0.0006
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	0.0059	<0.004	-0.0019
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	<0.004	<0.004	0.0000
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	<0.004	<0.02	0.0160
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	<0.004	<0.004	0.0000
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	0.0068	0.0086	0.0018
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	<0.004	0.0094	0.0054
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	0.01	0.0073	-0.0027
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	<0.004	<0.004	0.0000
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	<0.004	0.0079	0.0039
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	<0.004	<0.004	0.0000
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	<0.004	0.0081	0.0041
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	0.0059	0.0044	-0.0015
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	0.012	<0.004	-0.0080
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	<0.004	<0.004	0.0000
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	<0.004	<0.004	0.0000
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	<0.004	<0.004	0.0000
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	0.0063	0.005	-0.0013
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	0.012	0.0042	-0.0078
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	0.0079	<0.004	-0.0039
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	<0.004	<0.004	0.0000
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	<0.004	<0.004	0.0000
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	<0.004	0.0048	0.0008
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	<0.004	<0.004	0.0000
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	<0.004	<0.004	0.0000
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	<0.004	<0.004	0.0000
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	<0.004	0.0088	0.0048
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	<0.004	0.0051	0.0011
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	<0.004	<0.004	0.0000
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	<0.004	<0.004	0.0000

				IRON		ICAP (MG/L)				
OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	1	0.46	-0.5400
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	0.073	7.7	7.6270
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	0.077	0.23	0.1530
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	0.023	3.1	3.0770
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	0.12	2	1.8800
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	0.056	0.2	0.1440
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	0.03	0.2	0.1700
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	0.08	8.5	8.4200
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	0.97	2.8	1.8300
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	0.033	0.47	0.4370
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	0.058	2.9	2.8420
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	0.38	0.32	-0.0600
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	0.32	0.2	-0.1200
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	0.59	0.38	-0.2100
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	0.6	0.25	-0.3500
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	0.76	0.29	-0.4700
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	0.49	1	0.5100
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	0.34	0.0053	-0.3347
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	0.48	0.016	-0.4640
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	0.42	0.01	-0.4100
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	0.33	0.012	-0.3180
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	0.49	0.024	-0.4660
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	0.019	3.4	3.3810
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	0.027	8.7	8.6730
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	<0.005	4.5	4.4950
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	0.028	4.7	4.6720
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	0.049	2	1.9510
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	0.017	16	15.9830
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	0.018	1.6	1.5820
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	0.013	1.8	1.7870
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	0.027	10	9.9730

OBS	Pair	Year	Quarter	MAGNESIUM		ICAP (MG/L)		Upgradient Result	Downgradient Result	Down-Up Gradient
				Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date			
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	22	11	-11.0
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	20	13	-7.0
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	17	11	-6.0
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	17	11	-6.0
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	12	16	4.0
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	15	13	-2.0
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	19	12	-7.0
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	20	12	-8.0
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	23	11	-12.0
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	14	23	9.0
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	16	25	9.0
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	17	24	7.0
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	16	23	7.0
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	16	21	5.0
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	16	22	6.0
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	15	24	9.0
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	15	26	11.0
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	17	23	6.0
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	17	22	5.0
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	18	25	7.0
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	18	26	8.0
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	19	14	-5.0
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	18	12	-6.0
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	18	9.7	-8.3
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	17	8.9	-8.1
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	17	13	-4.0
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	25	12	-13.0
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	15	13	-2.0
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	17	8.6	-8.4
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	16	9.5	-6.5
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	18	7.8	-10.2
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	18	10	-8.0
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	18	8.4	-9.6
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	16	10	-6.0
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	10	26	16.0
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	15	27	12.0
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	14	23	9.0
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	13	23	10.0
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	14	24	10.0
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	14	25	11.0
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	17	23	6.0
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	18	24	6.0
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	16	23	7.0
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	16	24	8.0
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	15	23	8.0
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	15	25	10.0
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	15	24	9.0
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	28	17	-11.0
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	25	17	-8.0
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	31	20	-11.0
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	31	15	-16.0
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	31	16	-15.0
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	36	18	-18.0
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	35	16	-19.0
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	38	17	-21.0
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	35	16	-19.0

				MANGANESE		ICAP (MG/L)				
OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	0.54	0.022	-0.518
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	0.54	0.2	-0.340
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	0.55	0.014	-0.536
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	0.54	0.11	-0.430
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	0.55	0.11	-0.440
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	0.55	0.013	-0.537
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	0.42	0.014	-0.406
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	0.49	0.24	-0.250
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	0.45	0.077	-0.373
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	0.54	0.019	-0.521
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	0.52	0.097	-0.423
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	0.65	0.02	-0.630
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	0.031	0.082	0.051
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	0.03	0.068	0.038
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	0.034	0.09	0.056
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	0.047	0.11	0.063
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	0.027	0.095	0.068
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	0.64	<0.001	-0.639
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	0.67	<0.001	-0.669
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	0.65	<0.001	-0.649
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	0.65	<0.001	-0.649
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	0.63	<0.001	-0.629
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	0.022	0.21	0.188
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	<0.001	0.4	0.399
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	0.019	0.37	0.351
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	0.021	0.053	0.032
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	0.018	0.021	0.003
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	0.02	0.15	0.130
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	0.022	0.016	-0.006
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	0.02	0.068	0.048
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	0.016	0.061	0.045

OBS	Pair	Year	Quarter	MOLYBDENUM		ICAP (MG/L)		Upgradient Result	Downgradient Result	Down-Up Gradient
				Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date			
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	<0.01	<0.01	0.000
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	<0.01	<0.01	0.000
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	<0.01	<0.01	0.000
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	<0.01	<0.01	0.000
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	<0.01	<0.05	0.040
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	<0.01	<0.01	0.000
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	<0.01	<0.01	0.000
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	<0.01	<0.01	0.000
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	<0.01	<0.01	0.000
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	<0.01	<0.01	0.000
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	<0.01	<0.01	0.000
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	<0.01	<0.01	0.000
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	<0.01	<0.01	0.000
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	<0.01	<0.01	0.000
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	<0.01	<0.01	0.000
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	0.012	<0.01	-0.002
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	<0.01	<0.01	0.000
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	<0.01	<0.01	0.000
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	<0.01	<0.01	0.000
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	<0.01	<0.01	0.000
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	<0.01	<0.01	0.000
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	<0.01	<0.01	0.000
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	<0.01	0.014	0.004
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	<0.01	<0.01	0.000
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	0.011	<0.01	-0.001
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	<0.01	<0.01	0.000
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	<0.01	<0.01	0.000
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	<0.01	<0.01	0.000
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	<0.01	<0.01	0.000
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	<0.01	<0.01	0.000
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	<0.01	<0.01	0.000

				NICKEL		ICAP (MG/L)				
OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	<0.01	<0.01	0.000
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	<0.01	<0.01	0.000
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	<0.01	<0.01	0.000
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	<0.01	<0.01	0.000
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	<0.01	<0.05	0.040
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	0.017	<0.01	-0.007
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	<0.01	<0.01	0.000
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	<0.01	<0.01	0.000
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	<0.01	<0.01	0.000
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	<0.01	<0.01	0.000
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	<0.01	<0.01	0.000
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	<0.01	<0.01	0.000
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	<0.01	<0.01	0.000
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	<0.01	0.024	0.014
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	<0.01	<0.01	0.000
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	<0.01	<0.01	0.000
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	<0.01	<0.01	0.000
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	<0.01	<0.01	0.000
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	<0.01	<0.01	0.000
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	0.022	<0.01	-0.012
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	0.015	0.012	-0.003
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	<0.01	<0.01	0.000
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	<0.01	<0.01	0.000
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	<0.01	<0.01	0.000
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	<0.01	<0.01	0.000
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	<0.01	<0.01	0.000
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	<0.01	<0.01	0.000
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	<0.01	0.012	0.002
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	<0.01	<0.01	0.000
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	<0.01	<0.01	0.000
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	<0.01	<0.01	0.000

SELENIUM

ICAP (MG/L)

OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	<0.05	<0.05	0.000
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	<0.05	<0.05	0.000
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	<0.05	<0.05	0.000
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	<0.05	<0.05	0.000
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	<0.05	<0.25	0.200
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	<0.05	<0.05	0.000
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	<0.05	<0.05	0.000
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	<0.05	<0.05	0.000
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	<0.05	<0.05	0.000
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	<0.05	<0.05	0.000
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	<0.05	<0.05	0.000
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	<0.05	<0.05	0.000
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	<0.05	<0.05	0.000
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	<0.05	<0.05	0.000
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	<0.05	<0.05	0.000
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	<0.05	<0.05	0.000
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	<0.05	<0.05	0.000
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	<0.05	<0.05	0.000
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	<0.05	<0.05	0.000
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	<0.05	<0.05	0.000
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	<0.05	<0.05	0.000
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	<0.05	<0.05	0.000
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	<0.05	<0.05	0.000
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	<0.05	<0.05	0.000
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	<0.05	<0.05	0.000
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	0.056	<0.05	-0.006
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	<0.05	<0.05	0.000
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	<0.05	<0.05	0.000
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	<0.05	<0.05	0.000
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	<0.05	<0.05	0.000
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	<0.05	<0.05	0.000

				SILICON		ICAP (MG/L)				
OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	.	.	.
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	.	.	.
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	.	.	.
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	.	.	.
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	.	.	.
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	.	.	.
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	.	.	.
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	.	.	.
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	.	.	.
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	.	.	.
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	.	.	.
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	.	.	.
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	4.6	7.8	3.2
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	4.1	5.9	1.8
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	4.9	3.9	-1.0
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	4.6	5.2	0.6
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	4.8	9.2	4.4
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	5	5.6	0.6
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	5.1	5.5	0.4
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	6.2	6.2	0.0
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	4.9	5.6	0.7
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	4.8	5.5	0.7
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	.	.	.
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	.	.	.
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	.	.	.
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	.	.	.
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	.	.	.
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	.	.	.
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	.	.	.
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	.	.	.
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	.	.	.

SILVER

ICAP (MG/L)

OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	<0.006	<0.006	0.000
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	<0.006	<0.006	0.000
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	<0.006	<0.006	0.000
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	<0.006	<0.006	0.000
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	<0.006	<0.03	0.024
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	<0.006	<0.006	0.000
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	<0.006	<0.006	0.000
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	<0.006	<0.006	0.000
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	<0.006	<0.006	0.000
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	<0.006	<0.006	0.000
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	<0.006	<0.006	0.000
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	<0.006	<0.006	0.000
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	<0.006	<0.006	0.000
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	<0.006	<0.006	0.000
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	<0.006	<0.006	0.000
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	<0.006	<0.006	0.000
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	<0.006	<0.006	0.000
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	<0.006	<0.006	0.000
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	<0.006	<0.006	0.000
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	<0.006	<0.006	0.000
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	<0.006	<0.006	0.000
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	<0.006	<0.006	0.000
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	<0.006	<0.006	0.000
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	<0.006	<0.006	0.000
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	<0.006	<0.006	0.000
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	<0.006	<0.006	0.000
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	<0.006	<0.006	0.000
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	<0.006	<0.006	0.000
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	<0.006	<0.006	0.000
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	<0.006	<0.006	0.000
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	<0.006	<0.006	0.000

OBS	Pair	Year	Quarter	SODIUM		ICAP (MG/L)		Upgradient Result	Downgradient Result	Down-Up Gradient
				Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date			
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	89	7.1	-81.9
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	66	6.8	-59.2
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	39	7	-32.0
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	55	8.8	-46.2
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	11	7.5	-3.5
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	36	7.9	-28.1
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	18	9.1	-8.9
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	12	8.7	-3.3
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	79	9.2	-69.8
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	15	3.3	-11.7
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	16	3.2	-12.8
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	16	4.1	-11.9
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	16	3.8	-12.2
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	14	2.9	-11.1
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	14	3.6	-10.4
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	12	3.9	-8.1
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	13	3.7	-9.3
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	8.8	4.6	-4.2
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	15	4.3	-10.7
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	15	3.4	-11.6
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	14	3.9	-10.1
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	67	60	-7.0
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	44	61	17.0
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	58	55	-3.0
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	44	80	36.0
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	27	43	16.0
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	22	48	26.0
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	20	38	18.0
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	15	86	71.0
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	19	73	54.0
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	34	53	19.0
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	41	65	24.0
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	27	79	52.0
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	16	67	51.0
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	14	4.9	-9.1
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	8.5	5.5	-3.0
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	8.7	4.7	-4.0
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	8.8	5.4	-3.4
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	7.8	4.8	-3.0
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	8	5.5	-2.5
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	8.8	5.6	-3.2
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	8.8	6.6	-2.2
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	9.8	6.1	-3.7
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	12	6.3	-5.7
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	9.8	6.3	-3.5
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	10	5.2	-4.8
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	10	5.3	-4.7
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	5.2	8.4	3.2
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	8.6	5.4	-3.2
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	4.8	6	1.2
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	4.7	4.5	-0.2
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	4.5	4	-0.5
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	5	5.3	0.3
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	4.9	5.8	0.9
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	5.2	4.1	-1.1
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	5	3.7	-1.3

STRONTIUM

ICAP (MG/L)

OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	0.16	0.4	0.240
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	0.16	0.41	0.250
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	0.17	0.43	0.260
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	0.17	0.39	0.220
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	0.17	0.35	0.180
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	0.17	0.4	0.230
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	0.15	0.41	0.260
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	0.17	0.47	0.300
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	0.16	0.37	0.210
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	0.17	0.41	0.240
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	0.18	0.43	0.250
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	0.18	0.43	0.250
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	0.2	1	0.800
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	0.19	0.81	0.620
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	0.18	1.1	0.920
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	0.17	0.93	0.760
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	0.19	0.98	0.790
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	0.31	0.54	0.230
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	0.31	0.55	0.240
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	0.3	0.53	0.230
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	0.31	0.55	0.240
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	0.28	0.6	0.320
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	0.42	0.045	-0.375
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	0.58	0.092	-0.488
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	0.46	0.056	-0.404
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	0.43	0.11	-0.320
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	0.45	0.098	-0.352
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	0.5	0.13	-0.370
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	0.5	0.12	-0.380
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	0.52	0.11	-0.410
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	0.46	0.094	-0.366

				VANADIUM		ICAP (MG/L)				
OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	<0.005	<0.005	0.0000
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	<0.005	0.01	0.0050
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	<0.005	<0.005	0.0000
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	<0.005	<0.005	0.0000
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	<0.005	<0.025	0.0200
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	<0.005	<0.005	0.0000
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	<0.005	<0.005	0.0000
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	<0.005	0.011	0.0060
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	<0.005	0.0067	0.0017
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	<0.005	<0.005	0.0000
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	<0.005	0.0095	0.0045
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	<0.005	<0.005	0.0000
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	<0.005	<0.005	0.0000
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	<0.005	<0.005	0.0000
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	<0.005	<0.005	0.0000
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	<0.005	<0.005	0.0000
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	<0.005	<0.005	0.0000
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	<0.005	<0.005	0.0000
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	<0.005	<0.005	0.0000
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	<0.005	<0.005	0.0000
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	<0.005	<0.005	0.0000
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	<0.005	<0.005	0.0000
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	<0.005	<0.005	0.0000
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	<0.005	<0.005	0.0000
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	<0.005	<0.005	0.0000
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	<0.005	<0.005	0.0000
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	<0.005	<0.005	0.0000
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	<0.005	<0.005	0.0000
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	<0.005	<0.005	0.0000
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	<0.005	<0.005	0.0000
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	<0.005	<0.005	0.0000

ZINC

ICAP (MG/L)

OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	0.034	0.0061	-0.0279
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	0.0088	0.018	0.0092
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	0.0057	0.01	0.0043
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	0.008	0.015	0.0070
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	<0.002	0.024	0.0220
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	0.033	0.0074	-0.0256
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	0.01	0.016	0.0060
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	0.0089	0.023	0.0141
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	0.03	0.02	-0.0100
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	0.014	0.0029	-0.0111
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	0.0069	0.023	0.0161
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	0.014	0.019	0.0050
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	0.0076	0.0047	-0.0029
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	<0.001	<0.001	0.0000
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	0.015	<0.001	-0.0140
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	0.0053	0.0062	0.0009
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	0.0071	0.0082	0.0011
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	0.0031	0.0051	0.0020
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	0.0017	<0.001	-0.0007
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	0.0089	0.0067	-0.0022
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	0.0024	0.0034	0.0010
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	<0.002	<0.002	0.0000
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	0.0072	0.013	0.0058
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	<0.002	0.0047	0.0027
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	0.015	0.006	-0.0090
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	0.0076	<0.002	-0.0056
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	0.013	0.0059	-0.0071
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	0.0049	0.027	0.0221
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	0.0087	0.012	0.0033
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	0.0044	0.0029	-0.0015
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	0.012	0.011	-0.0010

				POTASSIUM		ICAP (MG/L)				
OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	5.3	4.2	-1.1
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	5.3	7.1	1.8
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	5.7	5.6	-0.1
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	4.9	6.4	1.5
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	3.8	14	10.2
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	4.1	11	6.9
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	8.9	2.7	-6.2
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	10	5.3	-4.7
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	7.1	2.2	-4.9
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	2.9	2.4	-0.5
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	3.5	3.5	0.0
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	6.8	2.9	-3.9
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	2.7	3.2	0.5
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	2.8	<3	0.2
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	3	2.5	-0.5
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	2.5	2.1	-0.4
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	2.6	4.4	1.8
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	5.6	3.1	-2.5
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	3.4	3	-0.4
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	3.2	4.2	1.0
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	3.7	2.4	-1.3
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	6.1	12	5.9
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	4.4	8.8	4.4
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	4.7	8.4	3.7
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	5.9	7.4	1.5
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	5.8	7.6	1.8
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	5.9	10	4.1
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	4.5	7	2.5
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	4	6.2	2.2
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	4	6.5	2.5
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	3.3	5.2	1.9
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	3.4	6.9	3.5
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	3.4	6.3	2.9
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	3.6	6.3	2.7
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	1.9	2	0.1
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	3.5	3.4	-0.1
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	3.2	3.3	0.1
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	3.7	2.4	-1.3
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	2	3	1.0
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	7.4	2.8	-4.6
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	1.9	1.9	0.0
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	1.9	2.2	0.3
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	1.9	1.8	-0.1
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	2.4	2.2	-0.2
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	2.1	2.1	0.0
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	1.9	2	0.1
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	1.8	2.1	0.3
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	4.3	7.2	2.9
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	2.1	2	-0.1
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	3.5	3.1	-0.4
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	4.1	1.5	-2.6
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	3.2	1.8	-1.4
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	3.3	1.7	-1.6
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	3.8	2	-1.8
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	3.6	1.9	-1.7
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	3.7	2	-1.7

LEAD

AAS (MG/L)

OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	<0.004	0.004	0.0000
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	0.0083	0.03	0.0217
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	0.016	0.011	-0.0050
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	0.058	0.0082	-0.0498
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	<0.004	0.039	0.0350
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	0.022	0.0062	-0.0158
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	<0.004	0.0064	0.0024
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	0.014	0.0061	-0.0079
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	<0.004	<0.004	0.0000
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	<0.004	<0.004	0.0000
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	<0.004	0.012	0.0080
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	<0.004	<0.004	0.0000
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	<0.004	0.014	0.0100
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	<0.004	0.019	0.0150
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	<0.004	<0.004	0.0000
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	<0.004	<0.004	0.0000
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	<0.004	0.023	0.0190
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	<0.004	0.0055	0.0015
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	<0.004	<0.004	0.0000
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	<0.004	0.0063	0.0023
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	<0.004	<0.004	0.0000
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	0.005	0.045	0.0400
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	0.0072	0.0046	-0.0026
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	0.0041	<0.004	-0.0001
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	0.0055	<0.004	-0.0015
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	0.0041	<0.004	-0.0001
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	0.0086	<0.004	-0.0046
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	<0.004	0.0048	0.0008
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	0.0043	0.0044	0.0001
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	<0.004	<0.004	0.0000
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	<0.004	<0.004	0.0000
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	<0.004	<0.004	0.0000
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	<0.004	<0.004	0.0000
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	0.0049	0.004	-0.0009
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	<0.004	0.007	0.0030
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	0.0051	<0.004	-0.0011
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	<0.004	<0.004	0.0000
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	0.0047	<0.004	-0.0007
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	0.005	<0.004	-0.0010
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	<0.004	<0.004	0.0000
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	0.012	<0.004	-0.0080
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	<0.004	<0.004	0.0000
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	<0.004	<0.004	0.0000
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	<0.004	<0.004	0.0000
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	<0.004	<0.004	0.0000
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	<0.004	<0.004	0.0000
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	<0.004	<0.004	0.0000
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	<0.004	0.015	0.0110
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	<0.004	<0.004	0.0000
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	<0.004	<0.004	0.0000
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	<0.004	<0.004	0.0000
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	<0.004	<0.004	0.0000
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	<0.004	<0.004	0.0000
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	<0.004	<0.004	0.0000
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	<0.004	<0.004	0.0000
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	<0.004	<0.004	0.0000

				SELENIUM		AAS (MG/L)				
OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	<0.005	<0.005	0
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	<0.005	<0.005	0
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	<0.005	<0.005	0
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	<0.005	<0.005	0
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	<0.005	<0.005	0
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	.	.	.
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	.	.	.
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	.	.	.
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	.	.	.
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	.	.	.
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	.	.	.
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	.	.	.
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	.	.	.
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	.	.	.
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	.	.	.
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	.	.	.
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	.	.	.
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	<0.005	<0.005	0
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	<0.005	<0.005	0
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	<0.005	<0.005	0
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	<0.005	<0.005	0
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	<0.005	<0.005	0
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	.	.	.
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	.	.	.
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	.	.	.
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	.	.	.
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	.	.	.
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	<0.005	<0.005	0
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	<0.005	<0.005	0
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	<0.005	<0.005	0
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	<0.005	<0.005	0
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	<0.005	<0.005	0
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	.	.	.
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	.	.	.
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	.	.	.
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	.	.	.
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	.	.	.
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	.	.	.
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	.	.	.
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	.	.	.
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	.	.	.
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	.	.	.
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	.	.	.
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	.	.	.
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	.	.	.
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	.	.	.

OBS	Pair	Year	Quarter	SILVER		AAS (MG/L)		Upgradient Result	Downgradient Result	Down-Up Gradient
				Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date			
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	<0.01	<0.01	0
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	<0.01	<0.01	0
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	<0.01	<0.01	0
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	<0.01	<0.01	0
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	<0.01	<0.01	0
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	.	.	.
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	.	.	.
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	.	.	.
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	.	.	.
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	.	.	.
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	.	.	.
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	.	.	.
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	.	.	.
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	.	.	.
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	.	.	.
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	.	.	.
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	.	.	.
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	<0.01	<0.01	0
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	<0.01	<0.01	0
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	<0.01	<0.01	0
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	<0.01	<0.01	0
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	<0.01	<0.01	0
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	.	.	.
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	.	.	.
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	.	.	.
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	.	.	.
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	.	.	.
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	<0.01	<0.01	0
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	<0.01	<0.01	0
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	<0.01	<0.01	0
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	<0.01	<0.01	0
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	<0.01	<0.01	0
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	.	.	.
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	.	.	.
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	.	.	.
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	.	.	.
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	.	.	.
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	.	.	.
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	.	.	.
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	.	.	.
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	.	.	.
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	.	.	.
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	.	.	.
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	.	.	.
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	.	.	.
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	.	.	.

OBS	Pair	Year	Quarter	TIN		AAS (MG/L)		Upgradient Result	Downgradient Result	Down-Up Gradient
				Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date			
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	<0.01	<0.01	0
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	<0.01	<0.01	0
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	<0.01	<0.01	0
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	<0.01	<0.01	0
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	.	.	.
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	.	.	.
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	.	.	.
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	.	.	.
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	.	.	.
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	.	.	.
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	.	.	.
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	.	.	.
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	.	.	.
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	.	.	.
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	.	.	.
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	.	.	.
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	<0.01	<0.01	0
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	<0.01	<0.01	0
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	<0.01	<0.01	0
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	.	.	.
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	.	.	.
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	.	.	.
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	.	.	.
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	.	.	.
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	<0.01	<0.01	0
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	<0.01	<0.01	0
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	<0.01	<0.01	0
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	.	.	.
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	.	.	.
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	.	.	.
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	.	.	.
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	.	.	.
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	.	.	.
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	.	.	.
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	.	.	.
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	.	.	.
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	.	.	.
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	.	.	.
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	.	.	.
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	.	.	.
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	.	.	.

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AAS (MG/L)

OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	<0.005	<0.005	0
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	0.005	<0.005	0
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	<0.005	<0.005	0
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	<0.005	<0.005	0
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	<0.005	<0.005	0
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	.	.	.
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	.	.	.
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	.	.	.
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	.	.	.
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	.	.	.
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	.	.	.
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	.	.	.
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	.	.	.
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	.	.	.
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	.	.	.
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	.	.	.
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	.	.	.
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	<0.005	<0.005	0
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	<0.005	<0.005	0
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	<0.005	<0.005	0
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	<0.005	<0.005	0
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	<0.005	<0.005	0
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	.	.	.
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	.	.	.
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	.	.	.
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	.	.	.
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	.	.	.
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	<0.005	<0.005	0
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	<0.005	<0.005	0
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	<0.005	<0.005	0
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	<0.005	<0.005	0
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	<0.005	<0.005	0
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	.	.	.
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	.	.	.
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	.	.	.
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	.	.	.
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	.	.	.
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	.	.	.
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	.	.	.
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	.	.	.
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	.	.	.
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	.	.	.
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	.	.	.
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	.	.	.
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	.	.	.
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	.	.	.

OBS	Pair	Year	Quarter	BARIUM		AAS (MG/L)		Upgradient Result	Downgradient Result	Down-Up Gradient
				Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date			
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	0.1	0.3	0.20
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	0.16	0.54	0.38
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	0.16	0.39	0.23
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	<0.1	0.42	0.32
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	<0.1	0.63	0.53
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	.	.	.
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	.	.	.
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	.	.	.
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	.	.	.
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	.	.	.
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	.	.	.
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	.	.	.
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	.	.	.
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	.	.	.
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	.	.	.
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	.	.	.
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	.	.	.
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	<0.1	0.51	0.41
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	<0.1	0.4	0.30
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	<0.1	0.45	0.35
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	<0.1	0.45	0.35
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	<0.1	0.61	0.51
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	.	.	.
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	.	.	.
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	.	.	.
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	.	.	.
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	.	.	.
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	0.13	0.13	0.00
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	0.27	0.17	-0.10
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	0.24	0.14	-0.10
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	0.29	0.2	-0.09
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	0.32	0.17	-0.15
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	.	.	.
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	.	.	.
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	.	.	.
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	.	.	.
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	.	.	.
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	.	.	.
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	.	.	.
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	.	.	.
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	.	.	.
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	.	.	.
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	.	.	.
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	.	.	.
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	.	.	.
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	.	.	.

CADMIUM

AAS (MG/L)

OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	<0.002	<0.002	0.0000
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	<0.002	<0.002	0.0000
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	0.0052	0.0035	- .0017
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	<0.002	<0.002	0.0000
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	<0.002	<0.002	0.0000
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	<0.002	<0.002	0.0000
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	<0.002	<0.002	0.0000
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	<0.002	<0.002	0.0000
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	<0.002	<0.002	0.0000
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	<0.002	<0.002	0.0000
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	<0.002	<0.002	0.0000
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	<0.002	<0.002	0.0000
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	<0.002	<0.002	0.0000
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	<0.002	<0.002	0.0000
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	<0.002	<0.002	0.0000
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	<0.002	<0.002	0.0000
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	<0.002	<0.002	0.0000
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	<0.002	<0.002	0.0000
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	<0.002	<0.002	0.0000
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	<0.002	<0.002	0.0000
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	<0.002	<0.002	0.0000
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	<0.002	<0.002	0.0000
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	<0.002	<0.002	0.0000
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	<0.002	<0.002	0.0000
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	<0.002	<0.002	0.0000
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	<0.002	<0.002	0.0000
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	<0.002	<0.002	0.0000
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	0.003	<0.002	- .0010
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	0.0037	<0.002	- .0017
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	<0.002	0.0041	0.0021
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	<0.002	<0.002	0.0000
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	<0.002	<0.002	0.0000
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	<0.002	<0.002	0.0000
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	<0.002	<0.002	0.0000
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	<0.002	<0.002	0.0000
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	<0.002	<0.002	0.0000
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	<0.002	<0.002	0.0000
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	<0.002	<0.002	0.0000
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	<0.002	<0.002	0.0000
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	<0.002	<0.002	0.0000
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	<0.002	<0.002	0.0000
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	<0.002	<0.002	0.0000
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	<0.002	<0.002	0.0000
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	<0.002	<0.002	0.0000
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	<0.002	<0.002	0.0000
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	<0.002	<0.002	0.0000

OBS	Pair	Year	Quarter	CHROMIUM		AAS (MG/L)		Upgradient Result	Downgradient Result	Down-Up Gradient
				Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date			
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	<0.01	<0.01	0.000
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	<0.01	0.04	0.030
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	<0.01	0.012	0.002
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	<0.01	<0.01	0.000
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	<0.01	0.05	0.040
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	<0.01	<0.01	0.000
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	<0.01	<0.01	0.000
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	<0.01	<0.01	0.000
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	<0.01	<0.01	0.000
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	<0.01	<0.01	0.000
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	<0.01	0.016	0.006
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	<0.01	<0.01	0.000
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	<0.01	0.025	0.015
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	<0.01	0.029	0.019
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	<0.01	<0.01	0.000
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	<0.01	<0.01	0.000
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	<0.01	0.021	0.011
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	<0.01	<0.01	0.000
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	<0.01	<0.01	0.000
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	<0.01	<0.01	0.000
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	<0.01	<0.01	0.000
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	<0.01	0.017	0.007
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	<0.01	<0.01	0.000
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	<0.01	<0.01	0.000
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	<0.01	0.013	0.003
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	<0.01	<0.01	0.000
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	<0.01	<0.01	0.000
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	<0.01	<0.01	0.000
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	<0.01	<0.01	0.000
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	<0.01	<0.01	0.000
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	<0.01	<0.01	0.000
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	<0.01	<0.01	0.000
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	<0.01	<0.01	0.000
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	<0.01	<0.01	0.000
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	<0.01	<0.01	0.000
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	<0.01	<0.01	0.000
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	<0.01	0.042	0.032
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	<0.01	<0.01	0.000
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	<0.01	<0.01	0.000
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	<0.01	<0.01	0.000
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	<0.01	<0.01	0.000
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	<0.01	<0.01	0.000
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	<0.01	<0.01	0.000
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	<0.01	<0.01	0.000
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	<0.01	<0.01	0.000
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	<0.01	<0.01	0.000
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	<0.01	<0.01	0.000
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	<0.01	<0.01	0.000
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	<0.01	<0.01	0.000
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	<0.01	<0.01	0.000
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	<0.01	<0.01	0.000
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	<0.01	<0.01	0.000
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	<0.01	<0.01	0.000
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	<0.01	<0.01	0.000
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	<0.01	<0.01	0.000
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	<0.01	<0.01	0.000

TOTAL SUSPENDED SOLIDS (MG/L).

OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	2	243	241.0
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	11	54	43.0
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	32	127	95.0
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	10	53	43.0
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	5	40	35.0
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	57	27	-30.0
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	<1	29	28.0
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	<1	262	261.0
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	1	117	116.0
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	8	15	7.0
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	2	226	224.0
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	3	7	4.0
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	<1	10	9.0
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	3	312	309.0
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	<1	5	4.0
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	<1	7	6.0
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	1	414	413.0
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	7	107	100.0
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	<1	11	10.0
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	<1	99	98.0
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	9	10	1.0
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	16	6	-10.0
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	26	2	-24.0
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	25	3	-22.0
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	16	1.5	-14.5
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	10	2	-8.0
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	61	3	-58.0
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	19	15	-4.0
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	10	43	33.0
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	7	<1	-6.0
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	17	<1	-16.0
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	8	11	3.0
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	10	23	13.0
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	9	18	9.0
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	1	1	0.0
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	2	1	-1.0
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	2	3	1.0
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	<1	<1	0.0
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	<1	<1	0.0
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	<1	2	1.0
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	<1	<1	0.0
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	<1	<1	0.0
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	1	<1	0.0
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	<1	<1	0.0
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	6	<1	-5.0
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	1	<1	0.0
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	2	2	0.0
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	2	20	18.0
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	4	21	17.0
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	<1	14	13.0
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	2	9	7.0
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	<1	37	36.0
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	<1	20	19.0
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	2	2	0.0
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	<1	10	9.0
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	<1	33	32.0

				DISSOLVED SOLIDS		(MG/L)				
OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	768	662	-106
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	642	818	176
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	664	782	118
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	564	556	-8
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	422	564	142
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	462	700	238
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	596	678	82
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	520	646	126
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	1034	612	-422
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	334	258	-76
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	366	277	-89
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	374	306	-68
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	368	274	-94
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	342	312	-30
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	376	288	-88
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	354	256	-98
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	354	332	-22
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	370	292	-78
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	394	310	-84
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	370	304	-66
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	346	284	-62
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	442	296	-146
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	436	422	-14
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	416	390	-26
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	294	366	72
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	238	304	66
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	228	300	72
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	242	310	68
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	208	338	130
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	238	322	84
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	290	336	46
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	366	296	-70
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	270	322	52
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	238	308	70
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	350	320	-30
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	428	308	-120
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	400	282	-118
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	358	266	-92
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	336	256	-80
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	308	246	-62
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	416	262	-154
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	462	268	-194
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	460	294	-166
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	474	274	-200
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	510	292	-218
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	442	262	-180
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	454	320	-134
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	349	156	-193
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	332	176	-156
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	348	174	-174
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	366	194	-172
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	360	186	-174
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	358	228	-130
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	382	222	-160
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	366	198	-168
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	372	250	-122

CONDUCTIVITY, FIELD MMT (UMHOS/CM)

OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	1400	954	-446
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	985	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	897	1015	118
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	830	883	53
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	616	788	172
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	673	937	264
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	725	905	180
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	709	874	165
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	911	793	-118
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	449	419	-30
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	689	421	-268
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	596	491	-105
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	549	477	-72
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	625	442	-183
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	589	423	-166
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	501	395	-106
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	488	423	-65
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	678	410	-268
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	555	453	-102
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	520	505	-15
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	578	452	-126
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	360	603	243
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	557	595	38
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	670	524	-146
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	485	466	-19
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	448	465	17
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	477	475	-2
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	419	523	104
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	293	488	195
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	374	528	154
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	506	569	63
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	543	479	-64
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	501	581	80
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	385	511	126
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	510	450	-60
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	628	496	-132
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	586	514	-72
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	575	425	-150
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	514	452	-62
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	486	479	-7
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	687	501	-186
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	658	464	-194
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	687	449	-238
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	640	459	-181
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	709	450	-259
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	647	496	-151
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	703	448	-255
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	527	264	-263
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	608	340	-268
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	583	311	-272
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	582	330	-252
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	501	314	-187
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	593	356	-237
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	577	348	-229
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	558	354	-204
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	620	384	-236

OBS	Pair	Year	Quarter	SULFATE		(MG/L)		Upgradient Result	Downgradient Result	Down-Up Gradient
				Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date			
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	123	19	-104.0
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	102	16	-86.0
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	129	23	-106.0
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	110	16	-94.0
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	82	16	-66.0
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	115	20	-95.0
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	223	32	-191.0
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	184	30	-154.0
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	174	32	-142.0
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	26	14	-12.0
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	27	12	-15.0
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	27.8	15.9	-11.9
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	29	15	-14.0
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	23.5	12.2	-11.3
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	22	9.8	-12.2
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	24	10.2	-13.8
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	26	17	-9.0
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	16	19	3.0
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	25.3	12.5	-12.8
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	27	11.8	-15.2
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	26	10	-16.0
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	15.8	7.9	-7.9
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	17	6	-11.0
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	16	6	-10.0
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	14	8	-6.0
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	12	6	-6.0
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	13	6	-7.0
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	12	4	-8.0
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	10	7.5	-2.5
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	11	6	-5.0
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	15	6	-9.0
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	21	5	-16.0
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	18	6	-12.0
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	13	6	-7.0
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	38	5.8	-32.2
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	30	5	-25.0
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	32	6	-26.0
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	29	117	88.0
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	30	6	-24.0
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	29	7	-22.0
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	36	11	-25.0
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	26	13	-13.0
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	27	15	-12.0
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	38	14	-24.0
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	30	15	-15.0
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	34	16	-18.0
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	34	17	-17.0
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	31	13	-18.0
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	30.1	10	-20.1
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	28	9.6	-18.4
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	34	12	-22.0
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	31	12	-19.0
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	28	11	-17.0
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	33.8	10	-23.8
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	31	14	-17.0
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	31	10	-21.0

				CHLORIDE		(MG/L)				
OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	140	82	-58.0
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	86	79	-7.0
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	50	101	51.0
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	59	40	-19.0
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	13	51	38.0
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	17	100	83.0
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	14	99	85.0
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	6	62	56.0
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	272	62	-210.0
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	23	7	-16.0
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	24	7	-17.0
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	27.4	6.2	-21.2
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	33	9	-24.0
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	25.1	8.8	-16.3
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	24	8	-16.0
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	22	8.3	-13.7
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	26	6.9	-19.1
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	23	8.4	-14.6
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	26.6	9.2	-17.4
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	22	8.7	-13.3
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	20	9	-11.0
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	140	15	-125.0
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	84	15	-69.0
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	128	16	-112.0
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	76	13	-63.0
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	48	14	-34.0
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	34	11	-23.0
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	37	16	-21.0
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	19	15	-4.0
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	31	14	-17.0
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	70	14	-56.0
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	77	13	-64.0
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	46	12	-34.0
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	29	12	-17.0
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	15.5	4.3	-11.2
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	18	4	-14.0
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	16	5	-11.0
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	15	4	-11.0
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	15	4	-11.0
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	14	6	-8.0
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	29	9	-20.0
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	32	12	-20.0
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	43	12	-31.0
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	46	11	-35.0
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	43	12	-31.0
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	41	13	-28.0
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	36	12	-24.0
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	52	18	-34.0
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	46.8	14	-32.8
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	47	15	-32.0
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	45	17	-28.0
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	43	13	-30.0
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	46	39	-7.0
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	51	13	-38.0
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	45	5.5	-39.5
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	39	11	-28.0

OBS	Pair	Year	Quarter	FLUORIDE		(MG/L)		Upgradient Result	Downgradient Result	Down-Up Gradient
				Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date			
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	0.1	1	0.90
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	0.18	0.11	-0.07
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	0.2	0.1	-0.10
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	0.2	<0.1	-0.10
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	0.3	<0.1	-0.20
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	0.2	<0.1	-0.10
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	<0.1	<0.1	0.00
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	0.5	0.1	-0.40
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	0.3	<0.1	-0.20
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	<0.1	<0.1	0.00
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	<0.1	<0.1	0.00
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	<0.1	<0.1	0.00
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	<0.1	0.2	0.10
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	<0.1	<0.1	0.00
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	<0.1	<0.1	0.00
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	<0.1	<0.1	0.00
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	<0.1	<0.1	0.00
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	<0.1	<0.1	0.00
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	0.1	0.2	0.10
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	<0.1	<0.1	0.00
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	<0.1	0.1	0.00
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	0.1	0.3	0.20
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	0.2	0.43	0.23
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	0.2	0.3	0.10
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	0.2	0.4	0.20
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	0.17	0.3	0.13
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	0.2	0.4	0.20
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	0.2	0.2	0.00
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	0.2	0.3	0.10
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	0.2	0.4	0.20
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	0.2	0.4	0.20
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	0.1	0.3	0.20
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	0.2	0.4	0.20
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	0.18	0.3	0.12
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	0.2	0.1	-0.10
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	0.19	0.11	-0.08
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	0.3	0.1	-0.20
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	0.3	<0.1	-0.20
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	0.2	<0.1	-0.10
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	0.2	0.1	-0.10
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	0.2	0.1	-0.10
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	0.2	<0.1	-0.10
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	0.1	0.1	0.00
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	0.1	<0.1	0.00
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	<0.1	<0.1	0.00
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	<0.1	<0.1	0.00
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	0.12	<0.1	-0.02
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	0.2	0.1	-0.10
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	0.2	0.2	0.00
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	0.1	0.2	0.10
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	0.1	0.3	0.20
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	0.1	0.2	0.10
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	0.1	0.2	0.10
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	0.2	0.3	0.10
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	0.1	0.3	0.20
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	0.2	0.25	0.05

CHEMICAL OXYGEN DEMAND (MG/L)

OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	.	.	.
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	.	.	.
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	.	.	.
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	.	.	.
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	.	.	.
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	.	.	.
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	.	.	.
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	.	.	.
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	.	.	.
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	.	.	.
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	.	.	.
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	.	.	.
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	.	.	.
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	.	.	.
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	.	.	.
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	.	.	.
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	.	.	.
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	.	.	.
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	.	.	.
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	.	.	.
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	.	.	.
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	.	.	.
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	.	.	.
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	.	.	.
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	.	.	.
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	.	.	.
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	.	.	.
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	.	.	.
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	.	.	.
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	.	.	.
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	.	.	.

				COLIFORM		(CC/100 ML)				
OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	.	.	.
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	.	.	.
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	.	.	.
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	.	.	.
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	.	.	.
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	.	.	.
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	.	.	.
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	.	.	.
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	.	.	.
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	.	.	.
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	.	.	.
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	.	.	.
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	.	.	.
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	.	.	.
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	.	.	.
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	.	.	.
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	.	.	.
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	.	.	.
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	.	.	.
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	.	.	.
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	.	.	.
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	.	.	.
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	.	.	.
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	.	.	.
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	.	.	.
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	.	.	.
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	.	.	.
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	.	.	.
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	.	.	.
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	.	.	.
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	.	.	.

				ALKALINITY-HCO ₃		(MG/L)				
OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	248	345	97
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	239	354	115
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	252	352	100
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	244	356	112
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	231	304	73
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	208	341	133
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	160	365	205
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	208	449	241
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	144	391	247
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	209	221	12
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	249	215	-34
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	258	256	-2
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	254	240	-14
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	258	229	-29
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	262	227	-35
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	256	222	-34
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	252	234	-18
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	255	220	-35
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	260	239	-21
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	268	267	-1
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	262	238	-24
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	136	234	98
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	130	229	99
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	126	228	102
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	124	224	100
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	139	221	82
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	133	221	88
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	134	267	133
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	157	258	101
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	149	268	119
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	146	268	122
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	148	250	102
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	157	270	113
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	150	260	110
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	179	217	38
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	242	215	-27
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	231	207	-24
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	233	204	-29
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	226	205	-21
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	208	211	3
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	327	250	-77
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	314	225	-89
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	310	223	-87
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	291	218	-73
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	309	220	-89
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	309	224	-85
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	297	223	-74
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	202	107	-95
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	209	145	-64
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	213	125	-88
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	207	149	-58
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	218	151	-67
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	224	158	-66
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	243	158	-85
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	232	157	-75
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	231	156	-75

				ALKALINITY-CO3		(MG/L)				
OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	<1	<1	0
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	<1	<1	0
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	<1	<1	0
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	<1	<1	0
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	<1	<1	0
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	<1	<1	0
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	<1	<1	0
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	<1	<1	0
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	<1	<1	0
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	<1	<1	0
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	<1	<1	0
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	<1	<1	0
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	<1	<1	0
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	<1	<1	0
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	<1	<1	0
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	<1	<1	0
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	<1	<1	0
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	<1	<1	0
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	<1	<1	0
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	<1	<1	0
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	<1	<1	0
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	6	<1	-5
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	4	<1	-3
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	3	<1	-2
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	4	<1	-3
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	<1	<1	0
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	<1	<1	0
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	<1	<1	0
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	<1	<1	0
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	<1	<1	0
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	<1	<1	0
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	<1	<1	0
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	<1	<1	0
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	<1	<1	0
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	<1	<1	0
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	<1	<1	0
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	<1	<1	0
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	<1	<1	0
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	<1	<1	0
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	<1	<1	0
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	<1	<1	0
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	<1	<1	0
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	<1	<1	0
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	<1	<1	0
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	<1	<1	0
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	<1	<1	0
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	<1	<1	0
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	<1	<1	0
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	<1	<1	0
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	<1	<1	0
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	<1	<1	0
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	<1	<1	0
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	<1	<1	0
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	<1	<1	0
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	<1	<1	0
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	<1	<1	0

OBS	Pair	Year	Quarter	TURBIDITY		(NTU)		Upgradient Result	Downgradient Result	Down-Up Gradient
				Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date			
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	28	16	-12.00
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	13	5	-8.00
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	3	16	13.00
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	1.4	16	14.60
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	14	9.5	-4.50
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	1.9	200	198.10
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	1.1	6.6	5.50
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	0.6	150	149.40
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	2.9	170	167.10
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	1.7	5.5	3.80
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	1.8	6	4.20
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	2.4	280	277.60
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	3.2	74	70.80
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	1.9	8.2	6.30
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	1.5	60	58.50
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	6.8	7.2	0.40
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	30	1.9	-28.10
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	23	13	-10.00
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	20	48	28.00
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	17	2.4	-14.60
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	20	2.6	-17.40
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	21	3.4	-17.60
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	12	6.5	-5.50
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	11	1.8	-9.20
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	0.7	0.6	-0.10
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	2	0.5	-1.50
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	2.8	0.45	-2.35
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	3.6	0.9	-2.70
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	4	0.65	-3.35
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	3	0.9	-2.10
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	4.1	0.3	-3.80
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	6	0.2	-5.80
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	0.7	16	15.30
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	1.4	14	12.60
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	0.5	15	14.50
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	1.4	15	13.60
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	1.5	38	36.50
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	0.7	20	19.30
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	2	4.8	2.80
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	0.8	4.5	3.70
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	1	22	21.00

				NITRATE NITROGEN		(MG/L)				
OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	<0.11	<0.11	0.00
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	<0.11	0.12	0.01
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	0.88	<0.11	-0.77
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	<0.11	<0.11	0.00
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	0.8	<0.11	-0.69
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	0.6	<0.2	-0.40
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	0.2	<0.2	0.00
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	0.3	<0.2	-0.10
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	<0.2	<0.2	0.00
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	0.69	0.7	0.01
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	<0.2	0.45	0.25
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	<0.2	0.8	0.60
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	0.28	0.78	0.50
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	<0.2	0.52	0.32
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	<0.2	0.5	0.30
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	<0.2	0.43	0.23
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	0.38	0.78	0.40
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	<0.2	0.85	0.65
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	0.25	0.72	0.47
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	0.39	0.99	0.60
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	0.3	0.6	0.30
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	1.95	<0.11	-1.84
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	1.4	<0.11	-1.29
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	1.4	<0.11	-1.29
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	1.2	<0.11	-1.09
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	0.94	<0.11	-0.83
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	1	<0.2	-0.80
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	0.9	<0.2	-0.70
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	0.7	<0.2	-0.50
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	0.8	<0.2	-0.60
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	1	<0.2	-0.80
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	1	<0.2	-0.80
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	1.2	<0.2	-1.00
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	1	<0.5	-0.50
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	0.2	<0.11	-0.09
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	<0.11	<0.11	0.00
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	0.39	0.2	-0.19
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	0.28	0.28	0.00
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	0.16	0.32	0.16
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	0.4	0.4	0.00
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	<0.2	0.6	0.40
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	<2	0.7	-1.30
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	<0.2	0.7	0.50
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	<0.2	0.7	0.50
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	<0.2	0.7	0.50
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	<0.2	0.6	0.40
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	<0.2	0.8	0.60
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	0.94	<0.2	-0.74
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	0.86	<0.2	-0.66
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	0.91	<0.2	-0.71
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	0.73	<0.2	-0.53
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	0.87	<0.2	-0.67
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	0.64	<0.2	-0.44
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	0.95	0.2	-0.75
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	0.7	<0.12	-0.58
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	1	0.3	-0.70

PH, FIELD MMT. (PH UNITS)

OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	8.2	7.2	-1.00
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	7.3	7.2	-0.10
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	6.9	6.8	-0.10
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	6.9	5.6	-1.30
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	6.4	6.5	0.10
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	8	6.5	-1.50
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	7.2	7	-0.20
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	7.1	6.9	-0.20
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	7.5	6.8	-0.70
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	6.9	7.7	0.80
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	7.1	7.5	0.40
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	7	7.3	0.30
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	7.07	7.3	0.23
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	6.9	7.5	0.60
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	7	7.4	0.40
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	7	7.6	0.60
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	7.1	7	-0.10
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	7.5	6.7	-0.80
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	6.8	7.4	0.60
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	7	7.2	0.20
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	7.4	7.7	0.30
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	7.2	8.2	1.00
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	8.3	8.3	0.00
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	7.7	7.3	-0.40
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	7.9	7.7	-0.20
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	8.1	7.1	-1.00
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	7.1	7.3	0.20
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	8.4	7.1	-1.30
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	8	7.6	-0.40
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	8.6	7.5	-1.10
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	8.2	7.5	-0.70
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	8.2	7.5	-0.70
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	8.2	7.6	-0.60
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	7.9	7.4	-0.50
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	7.4	7.8	0.40
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	7.1	7.2	0.10
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	6.6	7.2	0.60
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	6.8	7.3	0.50
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	6.6	7.3	0.70
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	7	7.3	0.30
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	6.8	7.3	0.50
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	6.7	7.7	1.00
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	7	7.6	0.60
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	6.8	7.4	0.60
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	6.9	7.4	0.50
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	6.9	7.4	0.50
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	6.9	7.4	0.50
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	7.4	8.8	1.40
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	7.5	8	0.50
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	7.4	7.2	-0.20
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	7.5	8	0.50
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	7.5	7.8	0.30
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	7.7	7.9	0.20
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	7.1	7.9	0.80
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	7.4	7.5	0.10
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	7.4	8	0.60

				PH		(PH UNITS)				
OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	7.7	6.8	-0.90
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	7.2	6.8	-0.40
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	7.3	6.7	-0.60
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	6.6	6.6	0.00
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	6.7	6.8	0.10
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	6.5	6.5	0.00
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	6.4	6.6	0.20
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	7.4	6.8	-0.60
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	6.8	7	0.20
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	7.3	7.8	0.50
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	7.2	7.6	0.40
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	7.07	7.29	0.22
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	7.4	7.8	0.40
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	7.1	7.8	0.70
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	7	7.6	0.60
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	7.3	7.6	0.30
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	7.9	7.8	-0.10
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	8	7.6	-0.40
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	7.3	7.6	0.30
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	7.2	7.5	0.30
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	7.8	7.8	0.00
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	8.2	7.5	-0.70
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	8.3	7.7	-0.60
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	8.3	8	-0.30
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	6.6	6.7	0.10
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	6.7	6.6	-0.10
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	6.3	6.6	0.30
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	6.4	6.7	0.30
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	8	7	-1.00
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	6.9	6.9	0.00
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	7.1	7.2	0.10
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	6.9	7.2	0.30
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	7.1	7	-0.10
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	6.3	7.1	0.80
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	7.1	7.3	0.20
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	7.1	7.5	0.40
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	7	7.5	0.50
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	6.5	6.7	0.20
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	6.7	6.8	0.10
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	6.7	6.2	-0.50
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	7.1	7.6	0.50
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	7.1	7	-0.10
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	6.9	6.9	0.00
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	7	7.1	0.10
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	6.9	7	0.10
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	6.8	7	0.20
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	6.5	6.5	0.00
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	7.8	8.3	0.50
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	7.5	8	0.50
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	7.5	8.2	0.70
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	7.6	8	0.40
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	8.3	7.7	-0.60
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	7.6	7.9	0.30
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	8	7.9	-0.10
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	7.6	7.9	0.30
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	7.8	8	0.20

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OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	7.5	6.8	-0.7
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	7.2	6.8	-0.4
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	7.5	6.7	-0.8
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	6.6	6.6	0.0
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	6.8	6.6	-0.2
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	6.5	6.5	0.0
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	6.5	6.6	0.1
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	7.4	6.9	-0.5
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	6.8	7	0.2
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	.	.	.
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	.	.	.
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	.	.	.
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	.	.	.
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	.	.	.
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	.	.	.
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	.	.	.
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	.	.	.
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	.	.	.
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	.	.	.
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	.	.	.
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	.	.	.
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	8.2	7.5	-0.7
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	8.3	7.7	-0.6
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	8.3	7.9	-0.4
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	6.8	6.7	-0.1
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	6.8	6.7	-0.1
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	6.1	6.7	0.6
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	6.4	6.7	0.3
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	8	7	-1.0
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	.	.	.
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	.	.	.
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	.	.	.
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	.	.	.
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	.	.	.
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	7.5	7.3	-0.2
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	7.1	7.5	0.4
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	7	7.4	0.4
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	6.6	6.7	0.1
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	6.7	6.8	0.1
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	6.5	6.2	-0.3
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	7.3	7.6	0.3
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	7	7	0.0
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	.	.	.
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	.	.	.
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	.	.	.
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	.	.	.
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	.	.	.
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	.	.	.
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	.	.	.
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	.	.	.
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	.	.	.
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	.	.	.
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	.	.	.
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	.	.	.
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	.	.	.
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	.	.	.

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(PH UNITS)

OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	7.5	6.7	-0.8
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	7.2	6.8	-0.4
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	7.4	6.7	-0.7
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	6.6	6.6	0.0
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	6.8	6.6	-0.2
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	6.5	6.5	0.0
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	6.4	6.6	0.2
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	7.5	7.3	-0.2
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	6.9	7	0.1
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	.	.	.
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	.	.	.
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	.	.	.
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	.	.	.
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	.	.	.
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	.	.	.
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	.	.	.
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	.	.	.
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	.	.	.
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	.	.	.
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	.	.	.
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	.	.	.
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	8.2	7.6	-0.6
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	8.3	7.6	-0.7
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	8.3	8	-0.3
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	6.8	6.7	-0.1
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	6.8	6.7	-0.1
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	6.3	6.6	0.3
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	6.4	6.7	0.3
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	8	7	-1.0
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	.	.	.
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	.	.	.
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	.	.	.
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	.	.	.
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	.	.	.
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	7.2	7.6	0.4
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	7.1	7.5	0.4
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	7	7.4	0.4
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	6.6	6.7	0.1
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	6.7	6.8	0.1
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	6.5	6.2	-0.3
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	7.1	7.6	0.5
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	7.2	7	-0.2
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	.	.	.
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	.	.	.
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	.	.	.
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	.	.	.
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	.	.	.
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	.	.	.
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	.	.	.
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	.	.	.
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	.	.	.
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	.	.	.
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	.	.	.
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	.	.	.
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	.	.	.
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	.	.	.

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(PH UNITS)

OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	7.6	6.8	-0.8
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	7.2	6.9	-0.3
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	7.4	6.7	-0.7
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	6.6	6.6	0.0
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	6.8	6.7	-0.1
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	6.5	6.5	0.0
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	6.4	6.7	0.3
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	7.4	6.9	-0.5
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	6.8	7	0.2
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	.	.	.
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	.	.	.
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	.	.	.
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	.	.	.
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	.	.	.
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	.	.	.
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	.	.	.
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	.	.	.
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	.	.	.
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	.	.	.
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	.	.	.
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	.	.	.
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	8.2	7.6	-0.6
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	8.3	7.8	-0.5
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	8.3	8	-0.3
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	6.9	6.7	-0.2
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	6.8	6.7	-0.1
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	6.4	6.8	0.4
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	6.4	6.7	0.3
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	8	7	-1.0
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	.	.	.
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	.	.	.
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	.	.	.
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	.	.	.
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	.	.	.
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	7.3	7.4	0.1
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	7.1	7.5	0.4
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	7	7.4	0.4
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	6.6	6.7	0.1
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	6.7	6.8	0.1
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	6.6	6.2	-0.4
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	7.1	7.6	0.5
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	7	7	0.0
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	.	.	.
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	.	.	.
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	.	.	.
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	.	.	.
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	.	.	.
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	.	.	.
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	.	.	.
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	.	.	.
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	.	.	.
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	.	.	.
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	.	.	.
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	.	.	.
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	.	.	.
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	.	.	.

				RADIUM		(BQ/L)				
OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	<0.1	<0.1	0.00
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	<0.1	<0.1	0.00
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	0.21	<0.1	-0.11
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	<0.1	<0.1	0.00
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	.	.	.
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	.	.	.
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	.	.	.
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	.	.	.
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	.	.	.
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	.	.	.
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	.	.	.
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	.	.	.
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	.	.	.
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	.	.	.
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	.	.	.
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	.	.	.
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	<0.1	<0.1	0.00
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	<0.1	<0.1	0.00
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	<0.1	<0.1	0.00
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	<0.1	<0.1	0.00
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	.	.	.
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	.	.	.
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	.	.	.
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	.	.	.
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	.	.	.
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	<0.1	<0.1	0.00
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	<0.1	<0.1	0.00
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	<0.1	<0.1	0.00
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	<0.1	<0.1	0.00
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	.	.	.
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	.	.	.
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	.	.	.
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	.	.	.
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	.	.	.
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	.	.	.
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	.	.	.
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	.	.	.
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	.	.	.
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	.	.	.
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	.	.	.
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	.	.	.
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	.	.	.
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	.	.	.

WATER TEMP, FIELD MMT (DEG. CENT.)

OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	21.2	12	-9.2
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	17.5	16.5	-1.0
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	23	20.6	-2.4
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	19.6	18.8	-0.8
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	7.7	12.1	4.4
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	15	16.1	1.1
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	23.2	21	-2.2
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	16.2	9.7	-6.5
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	14.6	13.5	-1.1
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	18.1	19.2	1.1
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	18.6	16.6	-2.0
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	14.7	14.4	-0.3
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	17.6	16.3	-1.3
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	20.3	18.2	-2.1
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	19.2	14.8	-4.4
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	13.6	14.8	1.2
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	17.6	14.5	-3.1
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	22	17.1	-4.9
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	16	14.7	-1.3
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	15.8	14.9	-0.9
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	19.1	16.5	-2.6
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	14.3	15.4	1.1
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	16	25.6	9.6
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	16.5	19.7	3.2
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	14.2	15.4	1.2
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	13.5	14.1	0.6
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	14.9	19.7	4.8
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	15.7	18.3	2.6
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	13.7	14.2	0.5
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	14.9	16.1	1.2
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	16.5	23	6.5
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	15.3	17.8	2.5
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	14.1	16.2	2.1
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	16	17.8	1.8
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	19.2	17.9	-1.3
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	17.8	18	0.2
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	18.9	18.2	-0.7
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	17	15.7	-1.3
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	15.2	16.9	1.7
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	14	15.9	1.9
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	16.3	15.7	-0.6
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	17	14.5	-2.5
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	18.6	16	-2.6
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	18.7	18	-0.7
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	17.8	15.3	-2.5
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	16.5	13.7	-2.8
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	18.7	16.6	-2.1
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	17.3	13.8	-3.5
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	17.4	17.8	0.4
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	16.2	14.8	-1.4
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	13.3	14	0.7
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	17.5	15.9	-1.6
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	19.5	16.5	-3.0
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	13.6	13.8	0.2
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	14.2	12.5	-1.7
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	17.2	18.1	0.9

				THORIUM		ICAP (MG/L)				
OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	<0.2	<0.2	0.0
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	<0.2	<0.2	0.0
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	<0.2	<0.2	0.0
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	<0.2	<0.2	0.0
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	<0.2	<1	0.8
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	<0.2	<0.2	0.0
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	<0.2	<0.2	0.0
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	<0.2	<0.2	0.0
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	<0.2	<0.2	0.0
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	<0.2	<0.2	0.0
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	<0.2	<0.2	0.0
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	<0.2	<0.2	0.0
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	<0.2	<0.2	0.0
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	<0.2	<0.2	0.0
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	<0.2	<0.2	0.0
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	<0.2	<0.2	0.0
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	<0.2	<0.2	0.0
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	<0.2	<0.2	0.0
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	<0.2	<0.2	0.0
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	<0.2	<0.2	0.0
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	<0.2	<0.2	0.0
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	<0.2	<0.2	0.0
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	<0.2	<0.2	0.0
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	<0.2	<0.2	0.0
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	<0.2	<0.2	0.0
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	<0.2	<0.2	0.0
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	<0.2	<0.2	0.0
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	<0.2	<0.2	0.0
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	<0.2	<0.2	0.0
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	<0.2	<0.2	0.0
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	<0.2	<0.2	0.0

TOT. PETROLEUM HYDROCARBONS (MG/L)

OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	.	.	.
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	.	.	.
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	.	.	.
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	.	.	.
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	.	.	.
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	.	.	.
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	.	.	.
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	.	.	.
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	.	.	.
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	.	.	.
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	.	.	.
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	.	.	.
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	.	.	.
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	.	.	.
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	.	.	.
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	.	.	.
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	.	.	.
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	.	.	.
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	.	.	.
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	.	.	.
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	.	.	.
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	.	.	.
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	.	.	.
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	.	.	.
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	.	.	.
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	.	.	.
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	.	.	.
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	.	.	.
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	.	.	.
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	.	.	.
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	.	.	.

				URANIUM		FLUORIMETRIC (MG/L)				
OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	0.023	<0.001	-0.022
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	0.029	0.002	-0.027
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	0.05	<0.001	-0.049
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	0.025	<0.001	-0.024
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	0.11	0.001	-0.109
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	0.027	0.001	-0.026
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	2.24	<0.001	-2.239
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	2.68	0.002	-2.678
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	2.35	<0.001	-2.349
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	0.12	<0.001	-0.119
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	0.152	<0.001	-0.151
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	0.17	<0.001	-0.169
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	0.181	<0.001	-0.180
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	0.159	<0.001	-0.158
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	0.165	<0.001	-0.164
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	0.149	<0.001	-0.148
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	0.189	0.001	-0.188
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	<0.001	<0.001	0.000
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	0.19	0.001	-0.189
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	0.234	<0.001	-0.233
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	0.165	0.001	-0.164
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	<0.001	<0.001	0.000
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	0.002	0.001	-0.001
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	0.003	<0.001	-0.002
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	<0.001	<0.001	0.000
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	0.001	<0.001	0.000
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	0.001	<0.001	0.000
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	<0.001	<0.001	0.000
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	0.002	<0.001	-0.001
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	0.001	<0.001	0.000
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	0.001	<0.001	0.000
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	0.007	<0.001	-0.006
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	0.002	<0.001	-0.001
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	0.002	<0.001	-0.001
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	0.008	<0.001	-0.007
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	0.009	0.006	-0.003
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	0.006	<0.001	-0.005
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	0.008	<0.001	-0.007
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	0.003	0.002	-0.001
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	<0.001	<0.001	0.000
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	0.002	<0.001	-0.001
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	0.001	<0.001	0.000
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	0.004	<0.001	-0.003
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	0.004	<0.001	-0.003
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	0.004	<0.001	-0.003
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	0.005	<0.001	-0.004
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	0.008	<0.001	-0.007
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	0.005	<0.001	-0.004
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	0.007	<0.001	-0.006
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	0.008	<0.001	-0.007
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	0.006	0.001	-0.005
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	0.007	<0.001	-0.006
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	0.001	0.001	0.000
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	0.007	<0.001	-0.006
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	0.008	0.001	-0.007
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	0.007	<0.001	-0.006

REDOX, FIELD MMT.

(MV)

OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	399.0	132.0	-267.0
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	248.0	139.0	-109.0
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	28.9	260.0	231.1
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	310.0	375.0	65.0
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	360.0	289.0	-71.0
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	154.0	193.0	39.0
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	133.0	198.0	65.0
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	262.0	205.0	-57.0
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	320.0	318.0	-2.0
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	127.0	147.0	20.0
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	180.0	109.0	-71.0
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	188.0	184.0	-4.0
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	156.0	153.0	-3.0
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	187.0	164.0	-23.0
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	167.0	158.0	-9.0
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	139.0	99.0	-40.0
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	36.0	190.0	154.0
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	53.0	201.0	148.0
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	106.0	144.0	38.0
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	76.0	256.0	180.0
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	135.0	173.0	38.0
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	267.0	117.0	-150.0
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	192.0	196.0	4.0
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	258.0	-16.4	-274.4
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	305.0	332.0	27.0
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	313.0	198.0	-115.0
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	-	271.0	-
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	158.0	-100.0	-258.0
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	238.0	140.0	-98.0
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	240.0	80.0	-160.0
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	166.0	-72.0	-238.0
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	265.0	-42.0	-307.0
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	248.0	147.0	-101.0
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	248.0	132.0	-116.0
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	399.0	376.0	-23.0
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	40.0	213.0	173.0
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	183.0	295.0	112.0
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	300.0	264.0	-36.0
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	377.0	300.0	-77.0
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	242.0	277.0	35.0
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	166.0	181.0	15.0
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	288.0	321.0	33.0
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	130.0	265.0	135.0
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	-7.0	215.0	222.0
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	274.0	310.0	36.0
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	212.0	237.0	25.0
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	226.0	278.0	52.0
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	185.0	-103.0	-288.0
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	156.0	-78.0	-234.0
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	120.0	-110.0	-230.0
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	115.0	22.0	-93.0
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	133.0	65.0	-68.0
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	78.0	95.0	17.0
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	191.0	22.0	-129.0
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	110.0	-20.0	-130.0
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	7.6	128.0	120.4

				GROSS ALPHA		(PCI/L)				
OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	28.00	-34.000	-62.000
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	31.00	1.000	-30.000
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	56.00	0.840	-55.160
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	21.00	-0.100	-21.100
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	1.00	4.200	3.200
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	56.00	1.000	-55.000
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	481.00	17.000	-464.000
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	789.20	3.900	-785.300
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	796.07	0.720	-795.350
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	47.37	4.550	-42.820
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	73.10	2.880	-70.220
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	67.30	2.280	-65.020
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	61.00	1.760	-59.240
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	55.80	-17.300	-73.100
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	75.50	0.720	-74.780
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	53.40	0.000	-53.400
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	61.40	2.570	-58.830
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	29.00	1.510	-27.490
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	83.00	2.800	-80.200
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	112.00	1.100	-110.900
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	95.30	-0.190	-95.490
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	-3.00	-4.000	-1.000
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	4.00	1.000	-3.000
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	11.00	-2.000	-13.000
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	1.00	1.500	0.500
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	0.80	1.500	0.700
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	1.00	-1.000	-2.000
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	1.00	-0.400	-1.400
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	0.97	0.390	-0.580
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	0.21	0.100	-0.110
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	0.35	1.340	0.990
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	2.20	3.150	0.950
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	1.96	1.170	-0.790
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	1.64	0.510	-1.130
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	4.00	-4.000	-8.000
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	4.00	-0.140	-4.140
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	22.00	8.000	-14.000
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	3.00	1.000	-2.000
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	4.40	3.000	-1.400
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	1.00	0.000	-1.000
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	4.80	-0.400	-5.200
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	1.90	-0.810	-2.710
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	3.88	0.430	-3.450
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	1.06	-0.860	-1.920
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	3.72	0.040	-3.680
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	2.51	0.170	-2.340
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	4.79	1.080	-3.710
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	18.30	0.000	-18.300
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	1.67	3.570	1.900
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	9.78	0.456	-9.324
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	4.22	0.637	-3.583
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	4.93	-0.961	-5.891
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	1.13	1.220	0.090
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	6.31	1.060	-5.250
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	7.82	0.000	-7.820
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	5.84	0.507	-5.333

OBS	Pair	Year	Quarter	GROSS BETA		(PCI/L)		Upgradient Result	Downgradient Result	Down-Up Gradient
				Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date			
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	21.00	-31.000	-52.00
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	21.00	8.000	-13.00
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	25.00	-3.000	-28.00
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	11.00	7.000	-4.00
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	7.00	8.500	1.50
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	18.00	2.000	-16.00
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	716.00	19.000	-697.00
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	1111.10	3.500	-1107.60
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	727.94	1.120	-726.82
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	47.71	7.160	-40.55
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	69.20	5.080	-64.12
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	69.30	2.190	-67.11
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	58.40	4.600	-53.80
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	22.60	36.900	14.30
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	42.50	2.280	-40.22
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	43.40	-5.470	-48.87
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	51.40	18.800	-32.60
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	27.40	5.450	-21.95
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	58.10	4.150	-53.95
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	56.70	3.040	-53.66
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	66.40	2.840	-63.56
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	6.00	6.000	0.00
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	36.00	108.000	72.00
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	3.00	-2.000	-5.00
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	7.00	10.000	3.00
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	5.00	10.500	5.50
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	7.00	8.000	1.00
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	3.00	10.000	7.00
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	5.37	2.570	-2.80
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	2.68	5.940	3.26
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	1.28	6.980	5.70
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	8.95	5.330	-3.62
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	1.96	4.120	2.16
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	4.36	8.660	4.30
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	7.00	-0.210	-7.21
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	6.00	15.000	9.00
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	3.00	-3.000	-6.00
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	5.00	-0.300	-5.30
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	7.90	12.000	4.10
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	1.00	2.000	1.00
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	83.90	5.500	-78.40
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	9.50	-0.670	-10.17
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	0.47	1.630	1.16
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	0.47	-0.230	-0.70
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	9.74	5.820	-3.92
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	4.19	1.350	-2.84
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	1.96	4.910	2.95
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	26.60	6.110	-20.49
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	5.44	2.150	-3.29
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	7.43	-2.070	-9.50
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	6.37	4.490	-1.88
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	1.84	0.234	-1.61
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	5.09	4.960	-0.13
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	0.26	-0.686	-0.94
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	5.43	3.620	-1.81
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	3.66	2.460	-1.20

OBS	Pair	Year	Quarter	RADIUM		(BQ/L)		Upgradient Result	Downgradient Result	Down-Up Gradient
				Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date			
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	0.040	0.060	0.02
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	.	.	.
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	.	.	.
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	.	.	.
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	.	.	.
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	.	.	.
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	.	.	.
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	.	.	.
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	.	.	.
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	.	.	.
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	.	.	.
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	.	.	.
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	.	.	.
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	0.004	0.004	0.00
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	.	.	.
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	.	.	.
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	.	.	.
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	.	.	.
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	.	.	.
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	0.004	0.014	0.01
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	.	.	.
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	.	.	.
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	.	.	.
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	.	.	.
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	.	.	.
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	.	.	.
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	.	.	.
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	.	.	.
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	.	.	.
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	.	.	.
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	.	.	.
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	.	.	.
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	.	.	.
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	.	.	.

				STRONTIUM		(PCI/L)				
OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	.	.	.
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	.	.	.
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	.	.	.
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	.	.	.
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	.	.	.
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	.	.	.
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	.	.	.
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	.	.	.
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	.	.	.
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	.	.	.
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	.	.	.
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	.	.	.
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	.	.	.
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	.	.	.
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	.	.	.
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	.	.	.
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	.	.	.
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	.	.	.
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	.	.	.
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	.	.	.
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	.	.	.
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	.	.	.
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	.	.	.
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	.	.	.
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	.	.	.
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	.	.	.
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	.	.	.
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	.	.	.
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	.	.	.
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	.	.	.
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	.	.	.

				TRITIUM		(BQ/L)				
OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	.	.	.
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	.	.	.
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	.	.	.
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	.	.	.
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	.	.	.
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	.	.	.
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	.	.	.
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	.	.	.
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	.	.	.
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	.	.	.
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	.	.	.
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	.	.	.
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	.	.	.
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	.	.	.
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	.	.	.
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	.	.	.
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	.	.	.
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	.	.	.
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	.	.	.
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	.	.	.
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	.	.	.
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	.	.	.
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	.	.	.
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	.	.	.
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	.	.	.
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	.	.	.
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	.	.	.
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	.	.	.
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	.	.	.
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	.	.	.
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	.	.	.

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OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	.	.	.
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	.	.	.
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	.	.	.
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	.	.	.
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	.	.	.
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	.	.	.
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	.	.	.
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	.	.	.
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	.	.	.
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	.	.	.
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	.	.	.
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	.	.	.
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	.	.	.
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	.	.	.
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	.	.	.
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	.	.	.
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	.	.	.
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	203	.	.
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	-510	.	.
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	503	.	.
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	-2710	.	.
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	-4610	.	.
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	.	.	.
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	.	.	.
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	.	.	.
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	.	.	.
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	.	.	.
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	.	.	.
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	.	.	.
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	.	.	.
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	.	.	.

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OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	.	.	.
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	.	.	.
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	.	.	.
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	.	.	.
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	.	.	.
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	.	.	.
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	.	.	.
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	.	.	.
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	.	.	.
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	.	.	.
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	.	.	.
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	.	.	.
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	.	.	.
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	.	.	.
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	.	.	.
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	.	.	.
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	.	.	.
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	5.19	.	.
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	0.47	.	.
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	0.87	.	.
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	0.87	.	.
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	1.37	.	.
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	.	.	.
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	.	.	.
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	.	.	.
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	.	.	.
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	.	.	.
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	.	.	.
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	.	.	.
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	.	.	.
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	.	.	.

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OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	.	.	.
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	.	.	.
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	.	.	.
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	.	.	.
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	.	.	.
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	.	.	.
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	.	.	.
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	.	.	.
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	.	.	.
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	.	.	.
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	.	.	.
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	.	.	.
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	.	.	.
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	.	.	.
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	.	.	.
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	.	.	.
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	.	.	.
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	.	.	.
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	0	.	.
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	0	.	.
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	0	.	.
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	0	.	.
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	.	.	.
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	.	.	.
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	.	.	.
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	.	.	.
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	.	.	.
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	.	.	.
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	.	.	.
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	.	.	.
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	.	.	.

				238-URANIUM		(PCI/L)				
OBS	Pair	Year	Quarter	Upgradient Well	Upgradient Date	Downgradient Well	Downgradient Date	Upgradient Result	Downgradient Result	Down-Up Gradient
1	1	1988	1	GW-154	03/08/88	GW-148	03/08/88	.	.	.
2	1	1988	2	GW-154	06/09/88	GW-148	06/09/88	.	.	.
3	1	1988	3	GW-154	08/23/88	GW-148	08/22/88	.	.	.
4	1	1988	4	GW-154	10/27/88	GW-148	10/28/88	.	.	.
5	1	1989	1	GW-154	01/09/89	GW-148	01/12/89	.	.	.
6	1	1989	2	GW-154	04/20/89	GW-148	04/06/89	.	.	.
7	1	1989	3	GW-154	08/09/89	GW-148	08/08/89	.	.	.
8	1	1989	4	GW-154	10/13/89	GW-148	10/20/89	.	.	.
9	1	1990	1	GW-154	01/16/90	GW-148	01/04/90	.	.	.
10	2	1991	3	GW-605	08/26/91	GW-220	08/24/91	.	.	.
11	2	1991	4	GW-605	10/23/91	GW-220	10/22/91	.	.	.
12	2	1992	1	GW-605	01/26/92	GW-220	01/25/92	.	.	.
13	2	1992	2	GW-605	04/22/92	GW-220	04/21/92	.	.	.
14	2	1992	3	GW-605	08/02/92	GW-220	08/01/92	.	.	.
15	2	1992	4	GW-605	10/22/92	GW-220	10/18/92	.	.	.
16	2	1993	1	GW-605	02/02/93	GW-220	01/25/93	.	.	.
17	2	1993	2	GW-605	05/10/93	GW-220	04/22/93	.	.	.
18	2	1993	3	GW-605	08/19/93	GW-220	08/06/93	.	.	.
19	2	1993	4	GW-605	11/10/93	GW-220	11/01/93	.	.	.
20	2	1994	1	GW-605	02/02/94	GW-220	02/05/94	.	.	.
21	2	1994	2	GW-605	06/03/94	GW-220	05/12/94	.	.	.
22	3	1988	1	GW-153	03/08/88	GW-149	03/08/88	.	.	.
23	3	1988	2	GW-153	06/16/88	GW-149	06/08/88	.	.	.
24	3	1988	3	GW-153	08/17/88	GW-149	08/23/88	.	.	.
25	3	1988	4	GW-153	10/28/88	GW-149	10/27/88	.	.	.
26	3	1989	1	GW-153	01/18/89	GW-149	01/12/89	.	.	.
27	3	1989	2	GW-153	04/05/89	GW-149	04/06/89	.	.	.
28	3	1989	3	GW-153	08/09/89	GW-149	08/31/89	.	.	.
29	3	1990	1	GW-153	02/28/90	GW-149	01/04/90	.	.	.
30	3	1990	2	GW-153	05/23/90	GW-149	05/22/90	.	.	.
31	3	1990	3	GW-153	08/15/90	GW-149	08/09/90	.	.	.
32	3	1990	4	GW-153	10/29/90	GW-149	10/26/90	.	.	.
33	3	1991	1	GW-153	01/31/91	GW-149	01/28/91	.	.	.
34	3	1991	2	GW-153	05/02/91	GW-149	04/24/91	.	.	.
35	4	1988	1	GW-223	03/08/88	GW-151	03/08/88	.	.	.
36	4	1988	2	GW-223	06/09/88	GW-151	06/08/88	.	.	.
37	4	1988	3	GW-223	08/18/88	GW-151	08/19/88	.	.	.
38	4	1988	4	GW-223	10/26/88	GW-151	10/27/88	.	.	.
39	4	1989	1	GW-223	01/10/89	GW-151	01/06/89	.	.	.
40	4	1989	2	GW-223	04/08/89	GW-151	04/05/89	.	.	.
41	4	1989	4	GW-223	10/13/89	GW-151	10/18/89	.	.	.
42	4	1990	1	GW-223	01/23/90	GW-151	01/04/90	.	.	.
43	4	1990	2	GW-223	05/26/90	GW-151	05/23/90	51.89	.	.
44	4	1990	3	GW-223	08/17/90	GW-151	08/15/90	1.42	.	.
45	4	1990	4	GW-223	10/30/90	GW-151	10/29/90	0.43	.	.
46	4	1991	1	GW-223	02/01/91	GW-151	01/31/91	1.30	.	.
47	4	1991	2	GW-223	05/03/91	GW-151	05/01/91	1.37	.	.
48	5	1992	2	GW-606	04/22/92	GW-733	04/28/92	.	.	.
49	5	1992	3	GW-606	08/03/92	GW-733	08/11/92	.	.	.
50	5	1992	4	GW-606	10/23/92	GW-733	11/11/92	.	.	.
51	5	1993	1	GW-606	02/03/93	GW-733	02/02/93	.	.	.
52	5	1993	2	GW-606	05/10/93	GW-733	05/06/93	.	.	.
53	5	1993	3	GW-606	08/20/93	GW-733	08/18/93	.	.	.
54	5	1993	4	GW-606	11/11/93	GW-733	11/04/93	.	.	.
55	5	1994	1	GW-606	02/03/94	GW-733	01/30/94	.	.	.
56	5	1994	2	GW-606	06/06/94	GW-733	06/02/94	.	.	.

TASK 2

SUMMARY OF TOLERANCE LIMITS CALCULATIONS

Data used:

1988 - 2nd quarter 1994 (no field duplicates, unfiltered metals, screened for charge balance (must be between -20 and +20%))

Wells used were selected at a meeting with Helen King, Kevin Jago and Steve Haase 12/15/94 and met the following criteria:

upgradient to New Hope Pond
0-100 feet in total depth

They are:

GW-152
GW-153
GW-154
GW-223
GW-380
GW-381
GW-605
GW-762
GW-763

The resulting downgradient monitoring well network would consist of:

GW-148
GW-149
GW-151
GW-220

GW-733 was eliminated because it greater than 100 feet in total depth

Analytes considered were those chosen for Chestnut Ridge Sediment Disposal Basin:

Cd, Cr, Ni, Ag, Pb, Ba, U, Hg, plus Gross Alpha and Beta

None of the analytes was normally distributed, nor did log transformations normalize the data. Therefore non-parametric tolerance limits were calculated. It is evident that most of the tolerance limits were highly influenced by one well. Kruskal-Wallis tests (analysis of variance of ranks) for all analytes except Cd and Ag, indicated that there are differences in the location parameters across the different wells. Additional evidence of differences between wells may be seen in the frequency distributions. If all downgradient wells are hydraulically connected to all upgradient wells and likely to be influenced by each contaminant plume, I don't feel uncomfortable with the tolerance limits. If the prior statement is not true, I believe tolerance limits need to be established for each flow path.

TOLERANCE LIMITS
 Calculated from data from 9 upgradient wells
 GW-152, GW-153, GW-154, GW-223, GW-380, GW-381, GW-605, GW-762, GW-763

Element	Are the ranks of concentrations significantly different between wells?	Sample Size	% Not Detected	Detection Limit	Dominant Well	Percentiles	Tolerance Limit
Cd (AAS) mg/L	No	85	92	0.002	GW-380	95 0.0037 99 0.016 Max 0.016	0.016
Cr (AAS) mg/L	Yes	106	79	0.01	GW-380	95 0.4 99 1.5 Max 2.9	2.9
Ni (ICAP) mg/L	Yes	63	75	0.01	GW-380	95 0.31 99 0.39 Max 0.39	0.39
Ag (ICAP) mg/L	No	63	100	0.006			<0.006
Gross Beta pCi/L	Yes	106	NA	NA	GW-154	95 341 99 728 Max 1111	728
Gross Alpha pCi/L	Yes	106	NA	NA	GW-154	95 412 99 789 Max 796	796
Lead (AAS) mg/L	Yes	106	58	0.004	GW-152	95 0.044 99 0.096 Max 0.24	0.24
Barium (ICAP) mg/L	Yes	63	0	?	GW-762	95 0.59 99 0.64 Max 0.64	0.62
Uranium (Fluor) mg/L	Yes	106	40	0.001	GW-154	95 0.81 99 2.35 Max 2.68	2.24
Mercury (CVAA) mg/L	Yes	106	88	0.0002	GW-154	95 0.00046 99 0.0013 Max 0.0014	0.0014

LEAD	AAS (MG/L)		Cum.		Cum.
Midpoint		Freq	Freq	Percent	Percent
<0.004	'BBBBBBBBBBBBCCCCCCCCDDDDDDDDDDDEEEEEEEEEFFFFFFFFFFFGGGGGGGGGHHHHIIIIII	74	74	69.81	69.81
0.016	'BBCCCCCDEEEEEFFFFFH	22	96	20.75	90.57
0.036	'AAEEE	5	101	4.72	95.28
0.056	'C	1	102	0.94	96.23
0.076	'AA	2	104	1.89	98.11
0.096	'A	1	105	0.94	99.06
0.116		0	105	0.00	99.06
0.136		0	105	0.00	99.06
0.156		0	105	0.00	99.06
0.176		0	105	0.00	99.06
0.196		0	105	0.00	99.06
0.216		0	105	0.00	99.06
0.236	'A	1	106	0.94	100.00
XX 5 10 15 20 25 30 35 40 45 50 55 60 65 70					

Frequency

Symbol ID	Symbol ID	Symbol ID	Symbol ID	Symbol ID
A GW-152	B GW-153	C GW-154	D GW-223	E GW-380
F GW-381	G GW-605	H GW-762	I GW-763	

GROSS ALPHA	(PCI/L)		Cum.		Cum.
Midpoint			Freq	Freq	Percent
-14.3	'AAAAAABBBBBBBBBBBBCDDDDDDDDDDDEEEEEEEEEEEEEEEEEFFFFFFFFFFFHHHHHHIIIIII	82	82	77.36	77.36
40.7	'CCCCCGGGGGGGG	13	95	12.26	89.62
95.7	'GGG	3	98	2.83	92.45
150.7	'	0	98	0.00	92.45
205.7	'	0	98	0.00	92.45
260.7	'	0	98	0.00	92.45
315.7	'C	1	99	0.94	93.40
370.7	'	0	99	0.00	93.40
425.7	'CCC	3	102	2.83	96.23
480.7	'C	1	103	0.94	97.17
535.7	'C	1	104	0.94	98.11
590.7	'	0	104	0.00	98.11
645.7	'	0	104	0.00	98.11
700.7	'	0	104	0.00	98.11
755.7	'CC	2	106	1.89	100.00

AA
 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80

Frequency

Symbol ID	Symbol ID	Symbol ID	Symbol ID	Symbol ID
A GW-152	B GW-153	C GW-154	D GW-223	E GW-380
F GW-381	G GW-605	H GW-762	I GW-763	

GROSS BETA point	(PCI/L)	Freq	Cum. Freq	Percent	Cum. Percent
-6.25	AAAAAABBBBBBBBBBCCCCDDDDDDDDDEEEEEEEEEEEEEEEEEFFFFFFFFFFFGGHHHHHHIIIIII	88	88	83.02	83.02
68.75	BDGGGGGGGG	10	98	9.43	92.45
143.75	C	1	99	0.94	93.40
218.75	C	1	100	0.94	94.34
293.75		0	100	0.00	94.34
368.75	CCC	3	103	2.83	97.17
443.75		0	103	0.00	97.17
518.75		0	103	0.00	97.17
593.75		0	103	0.00	97.17
668.75		0	103	0.00	97.17
743.75	CC	2	105	1.89	99.06
818.75		0	105	0.00	99.06
893.75		0	105	0.00	99.06
968.75		0	105	0.00	99.06
1043.75	C	1	106	0.94	100.00
AA 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85					

Frequency

Symbol ID	Symbol ID	Symbol ID	Symbol ID	Symbol ID
A GW-152	B GW-153	C GW-154	D GW-223	E GW-380
F GW-381	G GW-605	H GW-762	I GW-763	

CADMIUM	AAS (MG/L)		Cum.		Cum.
Midpoint			Freq	Percent	Percent
<0.002	'AABBBBBBBBBBCCCCCCCCDDDDDDDEEEEEEEEEFFFFFFFFFFFGGGGGGGGGHHHHHHIIIIII		78	91.76	91.76
<0.0005			0	0.00	91.76
0.001			0	0.00	91.76
0.0025	'DE		2	2.35	94.12
0.004	'ADE		3	3.53	97.65
0.0055	'C		1	1.18	98.82
0.007			0	0.00	98.82
0.0085			0	0.00	98.82
0.01			0	0.00	98.82
0.0115			0	0.00	98.82
0.013			0	0.00	98.82
0.0145			0	0.00	98.82
0.016	'E		1	1.18	100.00
AA 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75					

Frequency

Symbol ID	Symbol ID	Symbol ID	Symbol ID	Symbol ID
A GW-152	B GW-153	C GW-154	D GW-223	E GW-380
F GW-381	G GW-605	H GW-762	I GW-763	

MERCURY	CVAA (MG/L)		Cum.		Cum.
Midpoint			Freq	Freq	Percent
	3				
<0.0002	3 AAABBBBBBBBCCDDDDDDDEEEEEEEEEFFFFFFFFFFGGGGGHHHII	93	93	87.74	87.74
	3				
<0.00005	3	0	93	0.00	87.74
	3				
0.0001	3	0	93	0.00	87.74
	3				
0.00025	3 CEF	6	99	5.66	93.40
	3				
0.0004	3 CE	2	101	1.89	95.28
	3				
0.00055	3 C	1	102	0.94	96.23
	3				
0.0007	3	0	102	0.00	96.23
	3				
0.00085	3 C	1	103	0.94	97.17
	3				
0.001	3	0	103	0.00	97.17
	3				
0.00115	3 C	1	104	0.94	98.11
	3				
0.0013	3 C	2	106	1.89	100.00
	3				

AA

10 20 30 40 50 60 70 80 90

Frequency

Symbol ID	Symbol ID	Symbol ID	Symbol ID	Symbol ID
A GW-152	B GW-153	C GW-154	D GW-223	E GW-380
F GW-381	G GW-605	H GW-762	I GW-763	

ANION point	FLUORIMETRIC (MG/L)		Freq	Cum. Freq	Percent	Cum. Percent
<0.001	'AAAAAABBBBBBBBBBBBCCCCDDDDDDDDDDDEEEEEEEEEEEEEEEFFFFFFFFFFFGHHHHHHIIIIII		88	88	83.02	83.02
0.179	'CGGGGGGGGG		10	98	9.43	92.45
0.359	'C		1	99	0.94	93.40
0.539	'		0	99	0.00	93.40
0.719	'C		1	100	0.94	94.34
0.899	'C		1	101	0.94	95.28
1.079	'CC		2	103	1.89	97.17
1.259	'		0	103	0.00	97.17
1.439	'		0	103	0.00	97.17
1.619	'		0	103	0.00	97.17
1.799	'		0	103	0.00	97.17
1.979	'		0	103	0.00	97.17
2.159	'C		1	104	0.94	98.11
2.339	'C		1	105	0.94	99.06
2.519	'C		1	106	0.94	100.00

AA
 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85

Frequency

Symbol ID	Symbol ID	Symbol ID	Symbol ID	Symbol ID
A GW-152	B GW-153	C GW-154	D GW-223	E GW-380
F GW-381	G GW-605	H GW-762	I GW-763	

CHROMIUM	AAS (MG/L)		Cum.		Cum.
Midpoint		Freq	Freq	Percent	Percent
<0.01	3 AAABBBBBBBCCCCCCCCDDDDDDDEEEFFFFFFFFFFFGGGGGHHHI	94	94	88.68	88.68
0.19	3 EEE	5	99	4.72	93.40
0.39	3 EE	3	102	2.83	96.23
0.59	3	0	102	0.00	96.23
0.79	3 E	1	103	0.94	97.17
0.99	3 E	1	104	0.94	98.11
1.19	3	0	104	0.00	98.11
1.39	3	0	104	0.00	98.11
1.59	3 E	1	105	0.94	99.06
1.79	3	0	105	0.00	99.06
1.99	3	0	105	0.00	99.06
2.19	3	0	105	0.00	99.06
2.39	3	0	105	0.00	99.06
2.59	3	0	105	0.00	99.06
2.79	3	0	105	0.00	99.06
2.99	3 E	1	106	0.94	100.00
AA 10 20 30 40 50 60 70 80 90					

Frequency

Symbol ID	Symbol ID	Symbol ID	Symbol ID	Symbol ID
A GW-152	B GW-153	C GW-154	D GW-223	E GW-380
F GW-381	G GW-605	H GW-762	I GW-763	

NICKEL	ICAP (MG/L)		Cum.		Cum.
Midpoint			Freq	Freq	Percent
<0.01	'BBBBBCCCCDDDDFFFFFFFFFFFFGGGGGGGGHHHHHHIIIIII		47	47	74.60
0.02	'DDFFG		5	52	7.94
0.05	'		0	52	0.00
0.08	'		0	52	0.00
0.11	'E		1	53	1.59
0.14	'		0	53	0.00
0.17	'E		1	54	1.59
0.2	'		0	54	0.00
0.23	'EEE		3	57	4.76
0.26	'E		1	58	1.59
0.29	'E		1	59	1.59
0.32	'E		1	60	1.59
0.35	'E		1	61	1.59
0.38	'EE		2	63	3.17
AA					
	5 10 15 20 25 30 35 40 45				

Frequency

Symbol ID	Symbol ID	Symbol ID	Symbol ID	Symbol ID
A GW-152	B GW-153	C GW-154	D GW-223	E GW-380
F GW-381	G GW-605	H GW-762	I GW-763	

SILVER Midpoint	ICAP (MG/L)	Freq	Cum. Freq	Percent	Cum. Percent
<0.006	BBBBBCCCCDDDDDEEEEEEEEEEEFFFFFFFFFFFGGGGGGGGGHHHHHHIIIIII	63	63	100.00	100.00
<0.005		0	63	0.00	100.00
<0.004		0	63	0.00	100.00
<0.003		0	63	0.00	100.00
<0.002		0	63	0.00	100.00
<0.001		0	63	0.00	100.00
0		0	63	0.00	100.00
0.001		0	63	0.00	100.00
0.002		0	63	0.00	100.00
0.003		0	63	0.00	100.00
0.004		0	63	0.00	100.00
0.005		0	63	0.00	100.00
0.006		0	63	0.00	100.00

AA

5 10 15 20 25 30 35 40 45 50 55 60

Frequency

Symbol ID	Symbol ID	Symbol ID	Symbol ID	Symbol ID
A GW-152	B GW-153	C GW-154	D GW-223	E GW-380
F GW-381	G GW-605	H GW-762	I GW-763	

WELL IDENTITY	DATE SAMPLED	GROSS ALPHA (PCI/L)	GROSS BETA (PCI/L)	URANIUM FLUORIMETRIC (MG/L)	MERCURY CVAA (MG/L)	SILVER ICAP (MG/L)
GW-152	03/08/88	-4.000	0.71	<0.001	<0.0002	.
	08/17/88	3.000	2.00	0.002	<0.0002	.
	01/18/89	0.130	4.00	<0.001	<0.0002	.
	04/11/89	-2.000	3.00	<0.001	<0.0002	.
	08/09/89	1.000	4.00	<0.001	<0.0002	.
	02/28/90	2.140	20.01	<0.001	<0.0002	.
GW-153	03/08/88	-3.000	6.00	<0.001	<0.0002	.
	06/16/88	4.000	36.00	0.002	<0.0002	.
	08/17/88	11.000	3.00	0.003	<0.0002	.
	10/28/88	1.000	7.00	<0.001	<0.0002	.
	01/18/89	0.800	5.00	0.001	<0.0002	.
	04/05/89	1.000	7.00	0.001	<0.0002	.
	08/09/89	1.000	3.00	<0.001	<0.0002	.
	02/28/90	0.970	5.37	0.002	<0.0002	.
	05/23/90	0.210	2.68	0.001	<0.0002	<0.006
	08/15/90	0.350	1.28	0.001	<0.0002	<0.006
	10/29/90	2.200	8.95	0.007	<0.0002	<0.006
	01/31/91	1.960	1.96	0.002	<0.0002	<0.006
	05/02/91	1.640	4.36	0.002	<0.0002	<0.006
GW-154	03/08/88	28.000	21.00	0.023	<0.0002	.
	06/09/88	31.000	21.00	0.029	0.0014	.
	08/23/88	56.000	25.00	0.05	0.0003	.
	10/27/88	21.000	11.00	0.025	0.0006	.
	01/09/89	1.000	7.00	0.11	<0.0002	.
	04/20/89	56.000	18.00	0.027	0.0011	.
	08/09/89	481.000	716.00	2.24	0.00046	.
	10/13/89	789.200	1111.10	2.68	0.0013	.
	01/16/90	796.070	727.94	2.35	<0.0002	.
	05/23/90	417.000	359.00	1.1	<0.0002	<0.006
	08/11/90	410.300	181.90	0.751	<0.0002	<0.006
	10/27/90	412.440	341.74	1.02	<0.0002	<0.006
	01/29/91	551.590	340.64	0.81	0.00028	<0.006
	04/26/91	332.420	155.83	0.386	0.00083	<0.006
GW-223	03/08/88	4.000	7.00	0.008	<0.0002	.
	06/09/88	4.000	6.00	0.009	<0.0002	.
	08/18/88	22.000	3.00	0.006	<0.0002	.
	10/26/88	3.000	5.00	0.008	<0.0002	.
	01/10/89	4.400	7.90	0.003	<0.0002	.
	04/08/89	1.000	1.00	<0.001	<0.0002	.
	10/13/89	4.800	83.90	0.002	<0.0002	.
	01/23/90	1.900	9.50	0.001	<0.0002	.
	05/26/90	3.880	0.47	0.004	<0.0002	<0.006
	08/17/90	1.060	0.47	0.004	<0.0002	<0.006
	10/30/90	3.720	9.74	0.004	<0.0002	<0.006
	02/01/91	2.510	4.19	0.005	<0.0002	<0.006
	05/03/91	4.790	1.96	0.008	<0.0002	<0.006
GW-380	12/22/88	1.100	9.00	0.002	0.0004	.
	01/11/89	4.400	9.60	0.004	0.0003	.
	04/08/89	3.000	7.00	<0.001	<0.0002	.
	08/09/89	3.000	5.00	<0.001	0.00025	.
	10/18/89	1.600	3.10	<0.001	<0.0002	.
	01/16/90	2.280	1.98	<0.001	<0.0002	.
	08/10/90	1.740	11.17	0.001	<0.0002	<0.006
	10/27/90	0.690	6.75	0.001	<0.0002	<0.006
	01/29/91	6.090	8.68	0.001	<0.0002	<0.006
	04/25/91	2.020	4.95	<0.001	<0.0002	<0.006
	10/22/91	5.680	10.40	0.001	<0.0002	<0.006
	01/25/92	0.595	1.79	0.001	<0.0002	<0.006

WELL IDENTITY	DATE SAMPLED	GROSS ALPHA (PCI/L)	GROSS BETA (PCI/L)	URANIUM FLUORIMETRIC (MG/L)	MERCURY CVAA (MG/L)	SILVER ICAP (MG/L)
GW-380	04/20/92	3.280	11.90	0.001	<0.0002	<0.006
	08/01/92	1.370	6.96	0.001	<0.0002	<0.006
	01/25/93	1.790	-6.25	0.001	<0.0002	<0.006
	04/21/93	-0.251	3.01	0.001	<0.0002	<0.006
	10/29/93	0.512	5.13	0.002	<0.0002	<0.006
GW-381	12/17/88	1.000	4.10	<0.001	<0.0002	.
	01/10/89	3.700	7.30	<0.001	<0.0002	.
	04/05/89	0.000	3.00	<0.001	0.0002	.
	08/09/89	2.000	-3.00	<0.001	<0.0002	.
	10/17/89	-0.100	4.50	<0.001	<0.0002	.
	01/16/90	2.290	3.03	<0.001	<0.0002	.
	05/30/90	0.480	2.35	<0.001	<0.0002	<0.006
	08/20/90	0.970	-0.70	<0.001	<0.0002	<0.006
	10/31/90	1.600	3.56	<0.001	<0.0002	<0.006
	02/04/91	2.330	2.32	<0.001	<0.0002	<0.006
	05/08/91	4.330	5.27	0.001	<0.0002	<0.006
	08/28/91	2.400	5.19	0.001	0.00026	<0.006
	10/27/91	3.260	5.89	<0.001	<0.0002	<0.006
	01/28/92	0.000	1.29	<0.001	<0.0002	<0.006
	04/25/92	2.950	5.48	<0.001	<0.0002	<0.006
	07/30/92	-14.300	13.90	0.001	<0.0002	<0.006
	10/16/92	-1.660	2.89	0.001	<0.0002	<0.006
	01/27/93	1.320	3.56	<0.001	<0.0002	<0.006
	04/26/93	1.170	4.00	0.001	<0.0002	<0.006
	08/08/93	1.520	3.47	0.001	<0.0002	<0.006
	11/08/93	1.800	0.00	<0.001	<0.0002	<0.006
GW-605	08/26/91	47.370	47.71	0.12	<0.0002	<0.006
	10/23/91	73.100	69.20	0.152	<0.0002	<0.006
	01/26/92	67.300	69.30	0.17	<0.0002	<0.006
	04/22/92	61.000	58.40	0.181	<0.0002	<0.006
	08/02/92	55.800	22.60	0.159	<0.0002	<0.006
	10/22/92	75.500	42.50	0.165	<0.0002	<0.006
	02/02/93	53.400	43.40	0.149	<0.0002	<0.006
	05/10/93	61.400	51.40	0.189	<0.0002	<0.006
	08/19/93	29.000	27.40	<0.001	<0.0002	<0.006
	11/10/93	83.000	58.10	0.19	<0.0002	<0.006
GW-762	08/11/92	2.800	5.99	<0.001	<0.0002	<0.006
	10/16/92	-0.868	4.16	<0.001	<0.0002	<0.006
	01/23/93	-0.603	6.09	<0.001	<0.0002	<0.006
	04/20/93	-0.482	4.68	<0.001	<0.0002	<0.006
	08/04/93	-3.280	1.54	<0.001	<0.0002	<0.006
	10/28/93	-1.130	2.42	<0.001	<0.0002	<0.006
GW-763	08/11/92	2.860	1.93	<0.001	<0.0002	<0.006
	10/17/92	0.000	2.45	<0.001	<0.0002	<0.006
	01/25/93	1.510	-4.15	<0.001	<0.0002	<0.006
	04/21/93	-3.420	1.40	<0.001	<0.0002	<0.006
	08/05/93	2.810	3.32	<0.001	<0.0002	<0.006
	10/29/93	3.940	4.10	<0.001	<0.0002	<0.006

WELL IDENTITY	DATE SAMPLED	BARIUM ICAP (MG/L)	LEAD AAS (MG/L)	CADMIUM AAS (MG/L)	CHROMIUM AAS (MG/L)	NICKEL ICAP (MG/L)
GW-152	03/08/88	.	0.044	<0.002	0.011	.
	08/17/88	.	0.082	0.0039	<0.01	.
	01/18/89	.	0.067	<0.002	<0.01	.
	04/11/89	.	0.026	.	<0.01	.
	08/09/89	.	0.24	.	<0.01	.
	02/28/90	.	0.096	.	<0.01	.
GW-153	03/08/88	.	0.005	<0.002	<0.01	.
	06/16/88	.	0.0072	<0.002	<0.01	.
	08/17/88	.	0.0041	<0.002	<0.01	.
	10/28/88	.	0.0055	<0.002	<0.01	.
	01/18/89	.	0.0041	<0.002	<0.01	.
	04/05/89	.	0.0086	.	<0.01	.
	08/09/89	.	<0.004	.	<0.01	.
	02/28/90	.	0.0043	.	<0.01	.
	05/23/90	0.045	<0.004	<0.002	<0.01	<0.01
	08/15/90	0.052	<0.004	<0.002	<0.01	<0.01
	10/29/90	0.052	<0.004	<0.002	<0.01	<0.01
	01/31/91	0.053	<0.004	<0.002	<0.01	<0.01
	05/02/91	0.046	0.0049	<0.002	<0.01	<0.01
GW-154	03/08/88	.	<0.004	<0.002	<0.01	.
	06/09/88	.	0.0083	<0.002	<0.01	.
	08/23/88	.	0.016	0.0052	<0.01	.
	10/27/88	.	0.058	<0.002	<0.01	.
	01/09/89	.	<0.004	<0.002	<0.01	.
	04/20/89	.	0.022	.	<0.01	.
	08/09/89	.	<0.004	.	<0.01	.
	10/13/89	.	0.014	.	<0.01	.
	01/16/90	.	<0.004	.	<0.01	.
	05/23/90	0.062	0.018	<0.002	<0.01	<0.01
	08/11/90	0.057	<0.004	<0.002	<0.01	<0.01
	10/27/90	0.057	0.0081	<0.002	<0.01	<0.01
	01/29/91	0.068	<0.004	<0.002	<0.01	<0.01
	04/26/91	0.086	<0.004	<0.002	<0.01	<0.01
GW-223	03/08/88	.	<0.004	0.003	<0.01	.
	06/09/88	.	0.0051	0.0037	<0.01	.
	08/18/88	.	<0.004	<0.002	<0.01	.
	10/26/88	.	0.0047	<0.002	<0.01	.
	01/10/89	.	0.005	<0.002	<0.01	.
	04/08/89	.	<0.004	.	<0.01	.
	10/13/89	.	0.012	.	<0.01	.
	01/23/90	.	<0.004	.	<0.01	.
	05/26/90	0.33	<0.004	<0.002	<0.01	<0.01
	08/17/90	0.33	<0.004	<0.002	<0.01	<0.01
	10/30/90	0.32	<0.004	<0.002	<0.01	0.022
	02/01/91	0.32	<0.004	<0.002	<0.01	0.015
	05/03/91	0.3	<0.004	<0.002	<0.01	<0.01
GW-380	12/22/88	.	0.03	<0.002	0.014	.
	01/11/89	.	0.026	<0.002	0.018	.
	04/08/89	.	0.0048	.	0.039	.
	08/09/89	.	0.0086	.	0.13	.
	10/18/89	.	0.016	.	0.18	.
	01/16/90	.	0.006	.	0.085	.
	08/10/90	0.05	0.0092	<0.002	2.9	0.28
	10/27/90	0.039	0.0083	0.0022	0.29	0.22
	01/29/91	0.066	0.005	<0.002	0.065	0.36
	04/25/91	0.028	<0.004	<0.002	0.14	0.23
	10/22/91	0.045	0.03	<0.002	0.4	0.22
	01/25/92	0.043	<0.004	0.016	0.41	0.26
	04/20/92	0.056	<0.004	<0.002	0.27	0.31
	08/01/92	0.055	0.006	<0.002	1.5	0.39

WELL IDENTITY	DATE SAMPLED	BARIUM ICAP (MG/L)	LEAD AAS (MG/L)	CADMIUM AAS (MG/L)	CHROMIUM AAS (MG/L)	NICKEL ICAP (MG/L)
GW-380	01/25/93	0.054	<0.004	<0.002	0.99	0.16
	04/21/93	0.029	<0.004	0.0037	0.27	0.12
	10/29/93	0.04	<0.004	<0.002	0.82	0.39
GW-381	12/17/88	.	<0.004	<0.002	0.054	.
	01/10/89	.	0.01	<0.002	<0.01	.
	04/05/89	.	0.0095	.	<0.01	.
	08/09/89	.	0.0085	.	<0.01	.
	10/17/89	.	<0.004	.	<0.01	.
	01/16/90	.	<0.004	.	<0.01	.
	05/30/90	0.17	<0.004	<0.002	<0.01	<0.01
	08/20/90	0.2	<0.004	<0.002	<0.01	<0.01
	10/31/90	0.23	<0.004	<0.002	0.017	<0.01
	02/04/91	0.21	<0.004	<0.002	<0.01	<0.01
	05/08/91	0.3	0.023	<0.002	0.025	<0.01
	08/28/91	0.38	0.02	<0.002	0.022	0.027
	10/27/91	0.22	<0.004	<0.002	<0.01	<0.01
	01/28/92	0.21	<0.004	<0.002	<0.01	<0.01
	04/25/92	0.2	<0.004	<0.002	<0.01	<0.01
	07/30/92	0.27	<0.004	<0.002	<0.01	0.012
	10/16/92	0.21	<0.004	<0.002	<0.01	<0.01
	01/27/93	0.2	<0.004	<0.002	<0.01	<0.01
	04/26/93	0.2	<0.004	<0.002	<0.01	<0.01
	08/08/93	0.22	<0.004	<0.002	<0.01	<0.01
	11/08/93	0.24	<0.004	<0.002	<0.01	<0.01
GW-605	08/26/91	0.065	<0.004	<0.002	<0.01	<0.01
	10/23/91	0.068	<0.004	<0.002	<0.01	<0.01
	01/26/92	0.11	<0.004	<0.002	<0.01	<0.01
	04/22/92	0.065	<0.004	<0.002	<0.01	<0.01
	08/02/92	0.071	<0.004	<0.002	<0.01	<0.01
	10/22/92	0.071	<0.004	<0.002	<0.01	0.017
	02/02/93	0.065	<0.004	<0.002	<0.01	<0.01
	05/10/93	0.068	<0.004	<0.002	<0.01	<0.01
	08/19/93	0.063	<0.004	<0.002	<0.01	<0.01
GW-762	11/10/93	0.075	<0.004	<0.002	<0.01	<0.01
	08/11/92	0.57	0.01	<0.002	<0.01	<0.01
	10/16/92	0.62	0.0075	<0.002	<0.01	<0.01
	01/23/93	0.61	0.004	<0.002	<0.01	<0.01
	04/20/93	0.58	<0.004	<0.002	<0.01	<0.01
	08/04/93	0.59	0.0043	<0.002	<0.01	<0.01
GW-763	10/28/93	0.64	<0.004	<0.002	<0.01	<0.01
	08/11/92	0.12	<0.004	<0.002	<0.01	<0.01
	10/17/92	0.098	<0.004	<0.002	<0.01	<0.01
	01/25/93	0.081	<0.004	<0.002	<0.01	<0.01
	04/21/93	0.065	<0.004	<0.002	<0.01	<0.01
	08/05/93	0.095	<0.004	<0.002	<0.01	<0.01
GW-763	10/29/93	0.11	<0.004	<0.002	<0.01	<0.01

PLATES

OAK RIDGE AREA

OAK RIDGE, TENNESSEE

5-33

Off Eastman

Small Grounds

MINIMUM GEORAPHIC AREA

Lake Realty

New Hope Pond
(Closed and Capped)

Chestnut Ridge
Sediment Disposal Basin

TENN
RIDGE AREA
COMMISSION
RICTED)

UNION

CHESTNUT

RIDGE

UNIVERSITY OF
TENNESSEE
EXPERIMENT STATION

BETHEL

VALLEY

RIDGE

HILL
ELEV 795

LAKE
ANDERSON CO
KNOX CO

MELTON

GUIN

ROAD

Fairway Bridge

510

ROAD

ROAD

ROAD

ROAD

ROAD

ROAD

PREPARED BY MAPS AND SURVEYS BRANCH TENNESSEE VALLEY AUTHORITY FOR THE OAK RIDGE OPERATIONS OFFICE, ATOMIC ENERGY COMMISSION. BASE MAP WAS ASSEMBLED FROM TVA-USGS, 1:24,000, TOPOGRAPHIC MAPS REVISED IN PART IN JUNE 1974 BY TVA FROM DATA FURNISHED BY AEC-ORO.

OAK RIDGE AREA

OAK RIDGE, TENNESSEE

POLYCONIC
1987 NORTH A

DECLINATION OF GR 3

POLYCONIC PROJECTION
1927 NORTH AMERICAN DATUM

DECLINATION OF GRID 34° 18' W OF TRUE NORTH

S-16A
JUNE, 1974

5000 YARDS
3 MILES

17

18

19

S-16A
JUNE, 1974

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

**Department of Energy
Oak Ridge Reservation**

PLATE A-1

1" = 2000'

Date	June, 1974
Revised	31AUG92 SB
Checked by	A. Motley

N 30,000

N 31,000

N 32,000

EXPLANATION

	Unpaved Road		Building		100 Year Flood Plain
	Paved Road		Electric Power Line		Approximate Extent of Post-Closure Waste Management Area
	Stream or Creek		Electrical Tower		
	Fence Line		Power Pole		
	Tree Line		Spot Elevation		
	Railroad		Intermediate Contour		
	Monument		Index Contour

E 63,000

SCALE

PHOTO DATE:

CONTOUR INTE

E 64,000

WIND ROSE FOR THE Y-12 PLANT, 1966

SCALE

PHOTO DATE: 03-29-79

CONTOUR INTERVAL 5'

N 28,000

N 27,000

E 65,000

E 66,000

Prepared for:		
Energy Systems, Inc. Y-12 Plant Oak Ridge, Tennessee		
Title		
New Hope Pond		
Compiled by:	PLATE A-2	Date:
G. Weiss		31AUG92 SB
Drawn by:	Scale: 1" = 200'	Revised:
B. Altom, S. Baker		
Checked by:		Checked by: M. Kelley

"THE OWNER OR OPERATOR OF THE PROPERTY CONTAINING THE NEW HOPE POND SITE AS SHOWN ON THIS PLAT IS OBLIGATED TO RESTRICT DISTURBANCE OF THE SITE IN ACCORDANCE WITH RULES GOVERNING HAZARDOUS WASTE MANAGEMENT IN TENNESSEE. POST CLOSURE USE OF THE PROPERTY ON OR IN WHICH HAZARDOUS WASTES REMAIN MUST NEVER BE ALLOWED TO DISTURB THE INTEGRITY OF THE FINAL COVER, LINER(S), OR ANY OTHER COMPONENTS OF ANY CONTAINMENT SYSTEM, OR THE FUNCTION OF THE FACILITY'S MONITORING SYSTEMS UNLESS THE OWNER OR OPERATOR RECEIVES APPROVAL FROM THE COMMISSIONER OF THE TENNESSEE DEPARTMENT OF HEALTH AND ENVIRONMENT UNDER THE PREVIOUSLY REFERENCED RULES."

D.O.E. Y-12 PLANT

LOCATION MAP

C-1 DATA:
R=150'
L=67.72'

Prepared for	Energy Systems, Inc.	Y-12 Plant	Oak Ridge, Tennessee
Title	Final Plat of New Hope Pond

Scale 1" = 100'

NOTES:

1. BOUNDARY COORDINATES DERIVED FROM DRAWINGS PROVIDED BY LOCKWOOD GREENE.
2. LINER COORDINATES DERIVED FROM LOCKWOOD GREENE DRAWING NO. C2E800490A002 AND C2E800490A003.
3. ELEVATIONS DERIVED BY RADIAL TRIG METHOD FROM PERMANENT REFERENCE MONUMENTS SHOWN HEREON.
4. IRON PIN SET AT ALL BOUNDARY CORNERS.
5. CONTOURS PLOTTED AT 2' INTERVALS.
6. TOTAL AREA FOR NEW HOPE POND SITE = 6.75 ACRES.
7. ALL COORDINATES BASED ON Y-12 GRID SYSTEM.

PR
THE
725
KN
PH

N 28773.95
E 63929.74

PERMANENT LOCATION MONUMENT

N 28805.71
E 64198.40
EL. 921.36

C-1 DATA:
R=150'
L= 97.72
T= 50.67
DELTA= 37°19'39"

PREPARED BY:

THE EDGE GROUP
725 PELLISSIPPI PARKWAY
KNOXVILLE, TENNESSEE 37933
PHONE: (615) 966-9788

Prepared for: Energy Systems, Inc. Y-12 Plant Oak Ridge, Tennessee		
Title Final Plat of New Hope Pond		
Compiled by	PLATE A-3	Date January 24, 1990
Drawn by		Revised 31AUG92 SB
Checked by:	Scale: 1" = 100'	Checked by:

Certification of Class and Accuracy of Survey.

I hereby certify that this is a class A survey and the ratio of precision of the unadjusted survey is not less than 1:10,000 as shown hereon.

Surveyor

Tennessee Certificate No. 1332

DATE		REVISION		BY
NEW HOPE POND Y-12				
DISTRICT 2, ANDERSON COUNTY, TENNESSEE				
SCALE: 1" = 100'		DR	TLK	CHK BRO REV
PREPARED FOR: DEPARTMENT OF ENERGY
ERC/EDGE		
		CIVIL ENGINEERING DIVISION		
NASHVILLE KNOXVILLE HUNTSVILLE LOUISVILLE CHARLOTTE				
PROJ. 0567-095		DATE: 01-24-90		SHEET 1 OF 1