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TECHNICAL SUPPORT FOR ROCKY MOUNTAIN ARSENAL

Groundwater Monitoring Program
Draft Final Technical Plan

June 16, 1992
Contract DAAA15-88-D-0021
Delivery Order 0006

PREPARED BY

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PREPARED FOR

PROGRAM MANAGER FOR ROCKY MOUNTAIN ARSENAL

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THE OBJECTIVES OF THE GMP ARE: (1) MONITOR GROUNDWATER FLOW AND QUALITY TO ALLOW THE ARMY TO EVALUATE CHANGES IN THE AMOUNT AND EXTENT OF CONTAMINATION. (2) MAINTAIN A REGIONAL GROUNDWATER MONITORING PROGRAM FOR REGULATORY DATABASE MAINTENANCE AND VERIFICATION. (3) MAINTAIN A PROJECT AREA GROUNDWATER MONITORING PROGRAM FOR REGULATORY DATABASE MAINTENANCE AND VERIFICATION.

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1.0 INTRODUCTION

This Technical Plan (TP) has been prepared by Harding Lawson Associates (HLA) for the Program Manager for Rocky Mountain Arsenal (PMRMA) as Deliverable Requirement A005, a requirement under Delivery Order (DO) 0006, the implementation of the Groundwater Monitoring Program (GMP) at the Rocky Mountain Arsenal (RMA), for Contract No. DAAA15-88-D-0021 between HLA and the U.S. Department of the Army (Army).

This document presents a summary of the DO 0006 (GMP) scope of work and technical approach for the groundwater monitoring program proposed for the 1992 water monitoring year (October 1991 through September 1992). This document also describes the scope and approach to preparing the Annual Groundwater Monitoring Report for 1991, the technical report that will include the groundwater monitoring data collected during the 1991 water monitoring year (October 1990 through September 1991).

1.1 PURPOSE AND SCOPE OF THE GROUNDWATER MONITORING PROGRAM

Water monitoring programs are conducted at RMA to comply with substantive regulatory requirements and provide cleanup program technical and operations support. The general approach to water quality monitoring at RMA requires water sampling at three levels of detail, at varying frequencies, as outlined below:

- Regional monitoring: This includes a network of approximately 630 wells, sampled once every two years. The purpose of this network is to provide a comprehensive regional review of contaminant plumes and migration characteristics over time.

- Benchmark monitoring: This network is a subset of the regional monitoring network and includes approximately 220 wells located in the vicinity of specific project areas, such as the boundary containment systems and interim response action (IRA) areas, as well as the Offpost Operable Unit. This network is sampled once every year, either as a subset of the regional monitoring network or as a separate monitoring network during the years in which the regional monitoring network is not sampled. The purpose of this network is to provide site-specific information on a more frequent basis in areas where anthropogenic activities may be causing changes in contaminant distributions more rapidly than would be expected under normal groundwater flow conditions.

- Basin F IRA monitoring: This network includes 61 wells in the vicinity of Basin F. The network is a subset of the regional and benchmark networks, and is sampled to maintain compliance with substantive regulatory requirements. All 61 wells are sampled once each year and a subset, 20 wells, is sampled quarterly.

The scope of DO 0006 is to perform three quarters of monitoring for the 1992 water year, with three Basin F sampling rounds, and three regional water-level monitoring events, including field data collection, laboratory analyses of water samples, data evaluation, and report preparation. In addition, the DO 0006 scope includes providing sampling support and analyses of 100 tap samples at offpost residences designated by Tri-County Health Department (TCHD).

Specific objectives of the GMP are as follows:

1. Monitor groundwater flow and quality to allow the Army to evaluate changes in the amount and extent of contamination.
2. Maintain a regional groundwater monitoring program for regulatory database maintenance and verification.
3. Maintain a project area groundwater monitoring program for regulatory database maintenance and verification.

1.2 TASK ELEMENTS

The GMP will be undertaken to meet the objectives listed above, through the performance of seven work elements (WEs). These WEs form the framework of the task, from monitoring program planning, through implementation, and task management. The seven WEs are as follows:

.10 Planning

.20 Field Survey Program

.30 Disposal/Treatment Operations

.40 Health and Safety

.50 Data Management

.60 Technical Reporting

.70 Management/Administration

The activities that will be undertaken for each WE are described in the following subsections to illustrate the structure under which the GMP objectives will be achieved. Sections 2.0 through 7.0 provide specific details on various activities that will be performed for the GMP.

1.2.1 Planning (WE.10)

The planning WE includes preparation of all planning documents, including this TP, all supporting documents (Sampling Design Plan [SDP] [A004], Safety Plan [SP] [A009] [HLA, 1992a], Data Management Plan [DMP] [A000] [HLA, 1992b], and Quality Control Plan [QCP] [A006] [HLA, 1992c]), and the task Resource Utilization Plan (RUP) (A003) (HLA, 1991).

1.2.2 Field Survey Program (WE.20)

The scope of work for the field survey program consists of three distinct subelements under WE.20. These subelements consist of groundwater monitoring activities, chemical analyses of groundwater samples, and a quality assurance/quality control (QA/QC) program. Each is described separately in the following sections.

1.2.2.1 Groundwater Monitoring

Groundwater monitoring activities include both groundwater sampling and water-level measurements. The scope of the GMP provides for the collection of 150 groundwater samples as described in Section 2.3.1. The scope also provides for water-level measurements for 1050 monitoring wells (water-level measurements are actually being performed on 1209 wells) during three separate events, as described in Section 2.3.2.

1.2.2.2 Chemical Analyses

The scope of the GMP provides for the 150 groundwater samples collected under subelement .21 to be analyzed for the entire list of RMA target analytes, plus appropriate QA/QC analyses, as described in Section 3.0. In addition, 100 offpost tap samples collected for TCHD will be analyzed for the same list of chemicals.

1.2.2.3 Quality Assurance/Quality Control Program

The scope of the GMP provides for a QA/QC program that is consistent with the procedures described in the PMRMA Chemical Quality Assurance Plan (CQAP) (PMRMA, 1989). The GMP

QCP complies with these requirements and has been submitted under separate cover (HLA, 1992c) to support this GMP TP.

1.2.3 Disposal/Treatment Operations (WE.30)

The scope of this WE is confined to handling and disposing wastes generated during WE.20 activities. These wastes include purged groundwater and used personal protective equipment (PPE). PMRMA guidelines will be followed for all WE.30 activities. These guidelines require that all purged water be transferred to the PMRMA waste handling facility for temporary storage. Used PPE will be disposed in numbered and labeled barrels and transferred to the PMRMA waste handling facility.

1.2.4 Health and Safety (WE.40)

The health and safety program for the GMP will be performed to promote the health and safety of all GMP personnel and visitors to GMP work areas. As such, all work will be done in compliance with PMRMA and applicable regulatory guidance, as well as with HLA's specific SP (HLA, 1992a), as outlined in Section 7.0 of this TP.

1.2.5 Data Management (WE.50)

The data management WE for the GMP will be performed in compliance with PMRMA data management guidelines to ensure the smooth flow of analytical and water-level data from collection through receipt of preliminary analytical results and through data validation and transfer to PMRMA's environmental database manager. The specific procedures that will be followed during WE.50 activities are described in detail in the GMP DMP (A010) (HLA, 1992b). A brief overview of these procedures is provided in Section 5.0 of this TP.

1.2.6 Technical Reporting (WE.60)

Technical reporting for the GMP includes two distinct activities, as described more fully in Section 4.0. The first activity includes preparation of the 1991 Annual Groundwater Monitoring Report using data collected by the Army's CMP contractor during the period October 1990 to

October 1991. The second reporting activity includes preparation of a data collection letter and diskette of all the information collected during the GMP. As required by the GMP scope, all data will be transmitted on diskette, and QA/QC procedures will be used to review and assess data quality. The transmitted information will be listed, and the results of QA/QC reviews will be described. However, reporting on groundwater flow and contaminant migration for the 1992 water year will be undertaken by the Army subsequent to the completion of the GMP.

1.2.7 Management/Administration (WE.70)

The final WE in the GMP consists of all management activities and meetings necessary to ensure compliance with Army contracting, subcontracting, and reporting requirements, and to demonstrate compliance with contractual scope, schedule, and budget. These activities will allow PMRMA to adequately monitor and manage the progress of the GMP.

2.0 TECHNICAL APPROACH

The GMP was established to provide continued monitoring of hydrologic conditions and water quality throughout RMA and in offpost areas. The GMP includes comprehensive regional water-level monitoring and specific project area water quality monitoring (Basin F). The water quality monitoring network was designed using the CMP Basin F monitoring network as a starting point and then modifying that network. The wells to be included in the CMP groundwater monitoring network were selected, during a series of sessions attended by technical representatives of the Army, Shell Oil Company (Shell), and their contractors, through an evaluation of the well's location, historical water quality information, well construction, and well production capacity. The same wells continue to be included in the GMP to provide continuity to the water quality database and to provide historical trends of contaminant concentration and migration.

2.1 NETWORK DESIGN RATIONALE

The GMP groundwater monitoring network includes wells for water-level measurements and water quality monitoring in both onpost and offpost areas. The network was designed to provide the most efficient areal coverage that would meet PMRMA's groundwater monitoring objectives. The program was integrated to contain the most efficient monitoring well network, monitoring frequency, and analytical suite to achieve the program goals.

2.1.1 Water Quality Monitoring Network Design Rationale

Onpost groundwater quality sampling during the GMP will be limited to the Basin F IRA area, where more detailed information is needed to assess the effects of recent remedial efforts. Additional project area monitoring programs may also be specified by PMRMA for incorporation into the GMP as conditions warrant.

The wells in the Basin F IRA area were selected for water quality monitoring on the basis of the current evaluation of contamination distribution and source area location, and proximity to existing remedial structures. The Basin F IRA area consists of the following structures: a 92.7-acre area formerly occupied by Basin F that has been excavated and covered with a contoured low permeability clay cap; a 16-acre double-lined enclosed waste pile located within the historic perimeter of the basin; double-lined waste-pile leachate collection ponds (Ponds A and B) immediately north of the basin; and three carbon-steel holding tanks situated east of the basin.

Offpost groundwater samples will be collected at the request of TCHD, as approved by PMRMA, on the basis of need versus available PMRMA resources. TCHD offpost residential monitoring of tap water provides a continuing assessment of domestic water sources. Up to 100 samples will be collected by TCHD personnel (with support provided by HLA) and analyzed to assess water quality at specified offpost residential wells or domestic taps.

2.1.2 Water-level Monitoring Network Design Rationale

The water-level monitoring network for the GMP includes both onpost and offpost wells in both the unconfined and confined flow systems. The wells from the previous year's CMP water-level monitoring network and the Basin F IRA area water-level monitoring network will be used. Existing wells were selected during the CMP to provide an adequate distribution to assess the groundwater flow conditions, as well as seasonal or IRA-induced changes, in both the unconfined and the confined flow systems.

2.2 WELL SELECTION CRITERIA

This section details the specific criteria used for selecting wells included in the GMP groundwater quality monitoring network and the water-level monitoring network. For the GMP, there was essentially no change to the Basin F monitoring program/selected wells compared to the CMP (R. L. Stollas and others, 1990), except that a subset of the Basin F network, composed of 20 wells, was used during two GMP events. The full set of 61 Basin F wells was used for the other event, as described below.

2.2.1 Selection Criteria for Wells in the Groundwater Quality Monitoring Network

The GMP groundwater quality monitoring network is limited to wells in Sections 23, 26, and 27 to monitor the effects of recent remediation efforts in the Basin F IRA area. The wells in the

CMP Basin F IRA area network that met the criteria listed below were kept in the GMP Basin F IRA area water quality network. Wells that did not meet these criteria were omitted from the GMP water quality well network, as discussed in Section 2.2.1.3. Criteria common to both the alluvium and the Denver Formation that were used to select wells for the CMP and GMP monitoring networks included the following:

- Availability of historical water quality data for the well
- Current condition of the well
- Well location with respect to known areas of contamination
- Proximity of well to newly installed remedial structures
- The presence or absence of adjacent wells completed in different hydrologic zones (well clusters)
- The geologic and hydrologic conditions in the vicinity of the well

Wells previously included in the CMP monitoring network that had historical water quality data were given priority to be included in the GMP groundwater quality monitoring network. The historical water quality data for each of these wells were evaluated. The most recent water quality data (those derived from the CMP) were considered the most reliable and were given the highest consideration. Wells were selected that historically had elevated levels of contaminants or had helped to delineate and characterize contaminant migration pathways.

The current condition of each well was evaluated with respect to well performance during previous sampling. Wells that could not be sampled in the past were identified and eliminated from the GMP monitoring network. Factors preventing the sampling of wells included constrictions in well casings and insufficient production capacity of monitoring wells, resulting in wells dewatering without sufficient recharge to allow sampling in a 24-hour period. Abandoned or destroyed wells were also identified and eliminated from the monitoring network.

Wells were evaluated with respect to known areas of contamination. Wells upgradient of known areas of contamination were selected to provide background data. Wells downgradient of and lateral to known areas of contamination were selected to provide data on the extent of contaminant migration.

Wells located near or upgradient of newly installed remedial structures were selected to monitor the effects of remediation efforts on contamination migration.

Groups of adjacent wells, or well clusters, were evaluated with respect to their screened intervals. Well clusters screened in different aquifer zones were included in the network to provide information on vertical contaminant distribution. When well clusters contained wells that monitored the same aquifer zone and therefore provided essentially the same information, a single well was selected for sampling.

Geologic and hydrologic conditions (i.e., to assess continuity of water-bearing zones) in the vicinity of the well were evaluated with respect to possible hydraulic interaction between well locations. For example, wells downgradient of and in the same sand unit as a contaminated well were selected to track contaminant migration. Wells monitoring the next lower sand unit than a contaminated sand unit were selected to evaluate the vertical distribution of contaminants.

2.2.1.1 Unconfined Flow System Groundwater Quality Monitoring Network Selection Criteria

In addition to the factors described above, criteria specific to the unconfined flow system were considered in the design of the CMP groundwater quality monitoring network. The following criteria are specific to the unconfined flow system:

- Placement of the screened interval within the unconfined flow system
- Groundwater flow patterns in the unconfined flow system

To be included in the unconfined flow system monitoring network, the screened interval had to be within the saturated unconfined flow system with a sufficient recharge rate for sampling.

Unconfined flow system groundwater flow patterns were considered in the design of the monitoring network. Wells were selected both upgradient and downgradient of known areas of contamination and the Basin F IRA remedial structures.

2.2.1.2 Confined Flow System Groundwater Quality Monitoring Network Selection Criteria

The following additional criteria specific to the confined flow system were considered in the design of the CMP groundwater quality monitoring network:

- Placement of the screened interval entirely within the confined flow system
- Water-bearing zone within which each well was completed in the confined flow system
- Groundwater flow patterns in the confined flow system

Wells were selected to be in the confined flow system monitoring network only includes wells with their entire screened interval within the confined Denver Formation.

Water-bearing zones were identified within the confined flow system that appear to behave as different hydrostratigraphic units (Water Remedial Investigation Report [Ebasco Services, Inc., 1989]). Wells that were completed in various zones in the confined flow system were selected, where they were available, to provide as much information as possible about the groundwater flow and water quality in these zones and to assess the potential for vertical groundwater flow and contaminant migration.

Groundwater flow patterns within the confined flow system were taken into account in the design of the monitoring network. Wells were selected both upgradient and downgradient of known areas of contamination and the Basin F IRA structures.

2.2.1.3 Groundwater Quality Monitoring Network

The groundwater quality monitoring network for the 1991 water monitoring year consists of 60 wells that were in the Basin F IRA monitoring program during the CMP and monitors both the unconfined and the confined flow systems. One additional well, 26158, was added to the Basin F IRA area network during the 1992 water monitoring year. All 61 wells will be sampled once during the GMP to maintain the yearly sampling history in the Basin F IRA area. An 18-well subset of these wells, that monitor only the unconfined flow system, will be sampled during two additional events to provide compliance with the substantive regulatory requirements for groundwater monitoring in the IRA area.

Nine CMP Basin F IRA monitoring wells were deleted from the water quality monitoring network. Well 35506 was destroyed when the Basin A Neck System slurry wall was installed in 1990. A bailer is stuck in well 23108, making it unable to be sampled. Wells 23238, 26065, 26145, 26164, 26165, and 26167 have been dry since inception, rendering them unable to be sampled. Well 23530 dewaters with insufficient recharge for sampling. All of these wells, except 35506 and 23530 are still included in the water-level monitoring network.

2.2.2 Selection Criteria for Wells in the Water-level Monitoring Network

The water-level monitoring network includes onpost and offpost wells that monitor both the unconfined and confined flow systems. All of the wells in the CMP water-level monitoring network for the 1991 water monitoring year were included in the GMP water-level monitoring network for the 1992 water monitoring year with the exception of 13 wells that have been destroyed (wells 01047, 01074, 31513, 35506, 36065, 36066, 36067, 36104, 36163, 36164, 36592, 37309, and 37344). The wells in the Basin F IRA area water-level monitoring network were also included in the GMP water-level monitoring network with the exception of nine wells that have been destroyed (wells 23054, 26009, 26022, 26043, 26044, 26052, 26053, 26054, and 26126). No new wells were added to the GMP water-level monitoring network.

2.3 DESCRIPTION OF THE GROUNDWATER MONITORING PROGRAM MONITORING WELL NETWORK AND SAMPLING FREQUENCY

The GMP network includes wells for water quality sampling and water-level measurements. The sampling frequency and wells selected for each of these categories are discussed below.

2.3.1 Description of Groundwater Quality Monitoring Well Network

For the 1992 water monitoring year, the groundwater quality sampling network will be limited to the Basin F IRA area where more detailed hydrologic and chemical data are needed to assess the effects of recent remedial efforts. The network will be sampled three times during the GMP. The largest number of wells will be sampled during the first event. The second and third events are smaller water quality sampling events. If needed, additional groundwater samples may be specified by PMRMA to support project area monitoring programs.

A total of 61 wells, listed in Table 2.1 and shown in Figure 2.1, will be sampled for water quality during the first GMP water quality sampling event. This water quality sampling event is scheduled for January 1992. The network includes 38 unconfined flow system wells and 23 confined flow system wells.

A total of 20 wells, listed in Table 2.2, will be sampled for water quality during the second and third GMP sampling events. These wells are a subset of the larger Basin F groundwater-quality monitoring well network. These sampling events will be conducted during March and June 1992. All 20 water quality monitoring wells for the second and third events are completed in the unconfined flow system.

2.3.1.1 Tri-County Health Department Tap Sampling

Monitoring of residential tap water is being conducted by PMRMA in cooperation with TCHD to provide a continuing assessment of domestic water sources. In addition to the samples collected to assess groundwater quality in the Basin F IRA area, up to 100 water samples may be collected and analyzed under the direction of PMRMA for the TCHD tap sampling program.

2.3.2 Description of Water-level Monitoring Well Network

The GMP water-level monitoring network will consist of 1209 wells listed in Table 2.3. The wells will be monitored three times during the 1992 water monitoring year. Of the total wells, 840 are unconfined flow system wells and 369 are confined flow system wells. The water-level monitoring network includes both onpost and offpost wells. Newly installed wells may be added to the water-level monitoring well network as IRA actions are conducted. The water-level monitoring well network remains unchanged from the CMP monitoring network except for 22 wells that have been deleted because they were destroyed or abandoned.

Table 2.1: Groundwater Monitoring Program First Round Groundwater Quality Monitoring Network

Section	Total Number of Wells	Well Designations - Unconfined Flow System Wells
23	10	049, 095, 142, 179, 188, 191, 220, 237, 239, 241
26	27	015, 017, 019, 020, 041, 071, 073, 083, 085, 127, 133, 148, 157, 158, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 173
27	1	016

Total unconfined flow system wells = 38

Section	Total Number of Wells	Well Designations - Confined Flow System Wells
23	8	180, 181, 189, 190, 192, 193, 221, 222
26	15	066, 067, 072, 075, 084, 086, 129, 140, 142, 146, 149, 150, 153, 155, 156

Total confined flow system wells = 23

Table 2.2: Groundwater Monitoring Program Second and Third Sampling Events
Groundwater Quality Monitoring Network

Section	Total Number of Wells	Well Designations - Unconfined Flow System Wells
23	3	049, 095, 142, 220, 239
26	14	015, 017, 020, 041, 073, 085, 127, 160, 162, 163, 164, 168, 169, 170
27	1	016

Total unconfined flow system wells = 20

Table 2.3: Groundwater Monitoring Program Water-level Monitoring Network
(Page 1 of 5)

Section	Well Designations - Unconfined Flow System
1	001, 002, 004, 007, 008, 010, 011, 012, 014, 017, 018, 019, 020, 021, 024, 027, 030, 033, 038, 041, 044, 049, 051, 051A, 053, 054, 055, 061, 068, 069, 070, 073, 075, 078, 501, 510, 514, 516, 517, 518, 522, 524, 525, 528, 534, 537, 554, 568, 586, 588
2	001, 002, 003, 005, 006, 007, 008, 011, 014, 020, 023, 026, 034, 037, 040, 049, 050, 052, 053, 055, 056, 058, 059, 505, 509, 510, 512, 513, 520, 545, 578, 580, 583, 585
3	001, 002, 005, 008, 010, 011, 517, 519, 523
4	004, 007, 008, 010, 014, 016, 017, 019, 020, 021, 024, 026, 029, 030, 033, 036, 037, 038, 039, 040, 041, 042, 043, 044, 045, 046, 047, 048, 049, 050, 076, 077, 524, 525
5	005
6	002, 003, 006
7	001, 003
8	002, 003
9	001, 002, 005, 006, 007, 008, 010, 011, 012, 013, 014, 015
11	002, 005, 006, 007
12	001, 002, 005, 007, 008, 009
19	001, 003, 004, 008, 014
20	002
22	003, 004, 005, 006, 007, 008, 010, 011, 015, 016, 017, 018, 019, 020, 021, 025, 026, 029, 033, 034, 036, 040, 043, 044, 045, 049, 050, 051, 052, 053, 054, 056, 060, 065, 504, 505, 506, 508

Table 2.3: Groundwater Monitoring Program Water-level Monitoring Network
(Page 2 of 5)

Section	Well Designations - Unconfined Flow System
23	002, 004, 006, 007, 008, 009, 010, 011, 013, 016, 021, 025, 026, 028, 029, 030, 036, 039, 040, 043, 044, 045, 046, 047, 049, 050, 051, 052, 053, 057, 058, 059, 063, 064, 066, 067, 072, 079, 084, 085, 092, 094, 095, 096, 102, 106, 108, 110, 118, 119, 120, 121, 122, 123, 125, 134, 135, 139, 140, 141, 142, 143, 146, 150, 151, 157, 159, 160, 166, 178, 179, 182, 185, 188, 191, 196, 197, 198, 199, 202, 203, 204, 205, 206, 207, 208, 211, 212, 213, 214, 215, 216, 217, 220, 223, 226, 231, 232, 235, 237, 238, 239, 241
24	001, 003, 004, 007, 010, 011, 013, 017, 020, 023, 024, 027, 041, 043, 045, 048, 049, 051, 053, 055, 056, 057, 058, 062, 063, 064, 081, 085, 086, 088, 092, 093, 094, 095, 096, 097, 098, 101, 102, 103, 104, 105, 106, 107, 108, 111, 112, 113, 114, 117, 121, 122, 123, 124, 127, 128, 130, 135, 149, 150, 151, 152, 158, 161, 162, 163, 164, 165, 166, 169, 173, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 191, 192, 194, 195, 196, 199, 200, 201
25	001, 003, 008, 011, 015, 018, 022, 028, 030, 032, 035, 038, 041, 042, 043, 044, 046, 047, 048, 052, 054, 055, 056, 057
26	006, 010, 011, 015, 016, 017, 018, 019, 020, 040, 041, 046, 048, 049, 050, 062, 063, 065, 068, 071, 073, 076, 081, 083, 085, 088, 091, 093, 124, 127, 133, 143, 145, 148, 154, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 173, 501, 503
27	002, 003, 004, 005, 006, 007, 008, 009, 010, 011, 012, 013, 015, 016, 017, 018, 019, 024, 025, 026, 028, 030, 031, 034, 037, 040, 041, 042, 043, 044, 045, 049, 051, 053, 056, 057, 059, 062, 063, 064, 066, 068, 070, 071, 072, 073, 074, 075, 076, 077, 078, 079, 080, 081, 082, 083, 084, 085, 086
28	002, 003, 004, 005, 006, 007, 008, 009, 011, 012, 013, 014, 018, 020, 021, 022, 023, 024, 027, 503, 513
30	001, 002, 006, 009, 018, 019, 020, 021
31	002, 003, 005, 009, 012, 014, 015, 016, 509, 511, 516, 518
32	001, 004, 005

Table 2.3: Groundwater Monitoring Program Water-level Monitoring Network
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Section	Well Designations - Unconfined Flow System
33	001, 002, 014, 015, 017, 024, 025, 030, 033, 039, 048, 049, 050, 061, 063, 064, 066, 068, 070, 071, 072, 073, 074, 075, 076, 077, 078, 079, 500, 501, 502, 505, 507, 509, 510, 512, 514, 533, 534, 576, 577, 578, 579, 580, 581, 582, 583
34	002, 005, 008, 009, 504, 507, 508, 515
35	013, 014, 018, 020, 023, 025, 026, 030, 031, 034, 037, 040, 047, 048, 052, 053, 058, 061, 064, 065, 069, 077, 079, 087, 088, 090, 091, 092, 504, 505, 507
36	001, 013, 017, 050, 054, 056, 060, 062, 063, 068, 069, 073, 074, 075, 076, 077, 080, 081, 082, 084, 085, 086, 087, 089, 090, 093, 094, 108, 109, 112, 123, 128, 134, 135, 139, 141, 142, 145, 146, 165, 166, 167, 168, 169, 177, 180, 181, 184, 185, 186, 187, 188, 189, 190, 191, 192
Offpost	37058, 37082, 37304, 37306, 37307, 37308, 37310, 37312, 37313, 37320, 37323, 37327, 37330, 37331, 37332, 37333, 37334, 37335, 37336, 37337, 37338, 37339, 37340, 37341, 37342, 37343, 37345, 37346, 37347, 37348, 37349, 37350, 37351, 37352, 37353, 37354, 37355, 37356, 37357, 37358, 37359, 37360, 37361, 37362, 37363, 37364, 37366, 37367, 37368, 37369, 37370, 37371, 37373, 37374, 37377, 37378, 37381, 37382, 37383, 37385, 37386, 37389, 37391, 37392, 37395, 37396, 37397, 37398, 37399, 37402, 37403, 37404, 37405, 37406, 37407, 37408, 37409, 37410, 37411, 37412, 37413, 37414, 37415, 37416, 37417, 37418, 37419, 37420, 37421, 37422, 37423, 37424, 37425, 37426, 37427, 37428, 37429, 37430, 37432, 37433, 37434, 37435, 37436, 37437, 37438, 37439, 37440, 37441, 37442, 37443, 37444, 005, 198-606, 198-608, 198-609, 198-611, 198-614, DCGW01, DCGW03, SACMW03, SACMW08, SACMW11, SAC18

Total unconfined flow system wells = 840

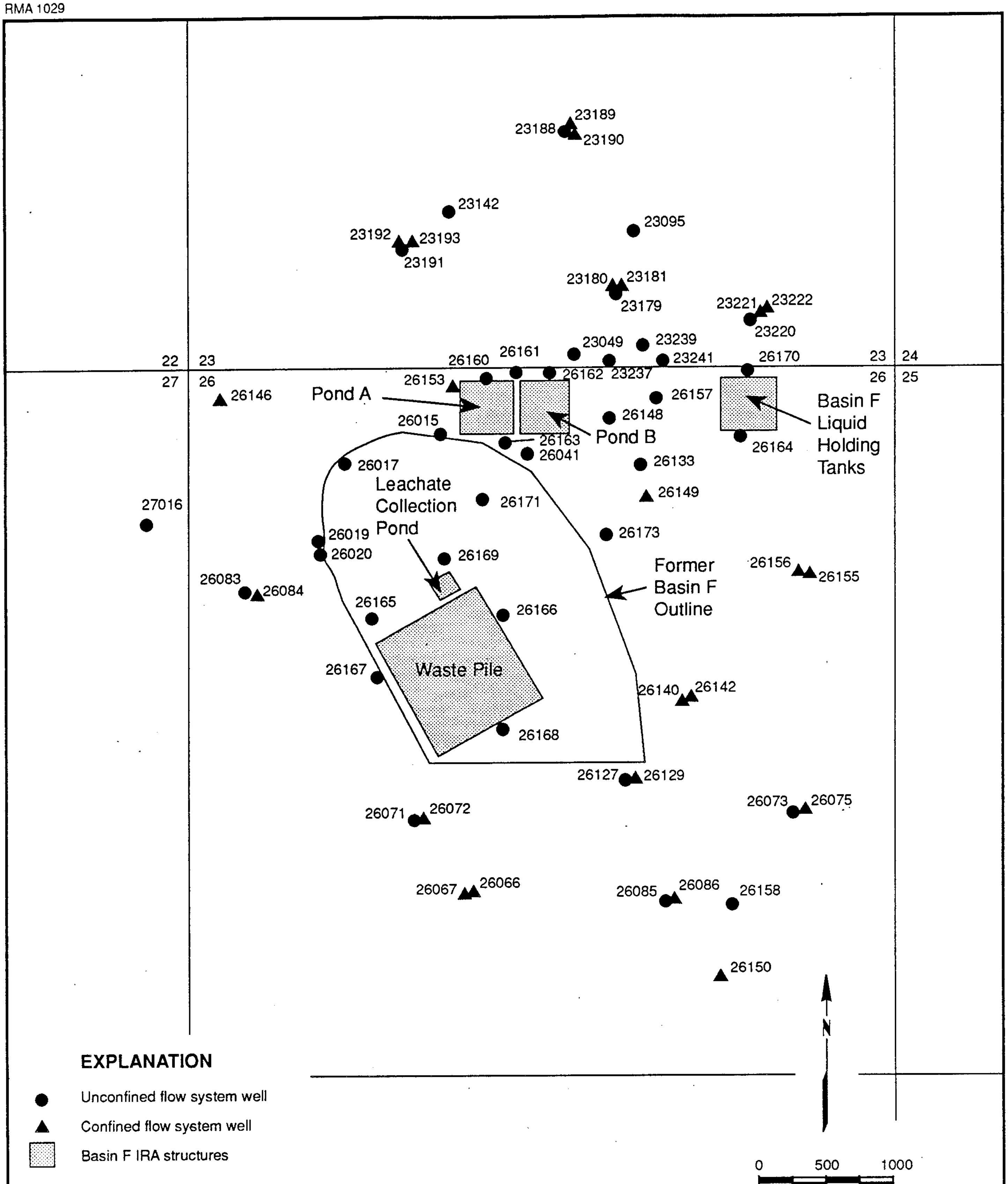
Table 2.3: Groundwater Monitoring Program Water-level Monitoring Network
(Page 4 of 5)

Section	Confined Flow System Wells
1	015, 022, 023, 025, 028, 029, 031, 032, 034, 035, 036, 037, 039, 040, 042, 043, 045, 046, 048, 050, 067, 071, 072, 076, 077, 079, 080, 081, 082
2	004, 009, 010, 012, 013, 015, 016, 018, 019, 021, 022, 024, 025, 027, 028, 030, 031, 032, 033, 035, 036, 038, 039, 041, 042, 043, 044, 045, 046, 047, 048, 057, 060
3	003, 004, 006, 007, 012
4	009, 011, 012
5	001, 002, 003
6	004, 005
7	004, 005
8	004, 005
9	003, 004
11	003, 004
12	003, 004
19	002, 005, 006, 007, 011, 015, 016, 017, 018, 019
22	012, 023, 024, 027, 028, 030, 031, 079, 080
23	055, 144, 161, 176, 177, 180, 181, 183, 184, 186, 187, 189, 190, 192, 193, 200, 201, 209, 218, 219, 221, 222, 224, 225, 227, 228, 229, 230, 233, 234, 236
24	080, 082, 083, 087, 089, 090, 109, 125, 126, 136, 137, 159, 167, 168, 171, 172, 174, 175, 197, 198, 202, 203, 204, 205, 206
25	004, 007, 009, 010, 012, 013, 014, 016, 017, 019, 020, 021, 023, 024, 025, 026, 029, 031, 033, 034, 037, 039, 040, 049, 050, 051, 058
26	023, 024, 025, 026, 027, 028, 029, 047, 051, 055, 056, 057, 058, 060, 061, 064, 066, 067, 069, 072, 074, 075, 077, 079, 080, 082, 084, 086, 089, 090, 092, 094, 096, 097, 123, 128, 129, 130, 134, 135, 136, 140, 141, 142, 144, 146, 147, 149, 150, 151, 152, 153, 155, 156
27	054, 055, 058
28	025, 026, 028, 029
29	002, 003

Table 2.3: Groundwater Monitoring Program Water-level Monitoring Network

Section	Confined Flow System Wells
30	004, 005, 007, 008, 010, 011
31	006, 007, 008, 010, 011
32	002, 003
33	026, 027, 028, 029, 031, 032, 034, 035
34	003, 004, 006, 007, 010, 011, 012, 013
35	008, 009, 012, 015, 016, 017, 021, 027, 028, 032, 033, 035, 036, 038, 039, 041, 050, 051, 054, 055, 056, 059, 060, 062, 063, 066, 067, 068, 070, 071, 073, 074, 078, 080, 081, 082, 083, 084, 089
36	010, 024, 029, 036, 057, 061, 072, 078, 079, 083, 092, 099, 105, 110, 113, 114, 116, 117, 118, 119, 121, 122, 138, 140, 147, 148, 149, 154, 158, 159, 160, 170, 171, 178, 179, 182, 183, 186
Offpost	37316, 37317, 37318, 37319, 37321, 37322, 37365, 37372, 37376, 37379, 37380, 37387, 37388, 37390

Total confined flow system wells = 369



Source: Modified from R.L.Stollar and Associates, Inc. and others, 1990

Prepared for:
Program Manager for
Rocky Mountain Arsenal

Commerce City, Colorado

Figure 2.1

GROUNDWATER QUALITY MONITORING WELL LOCATIONS FOR BASIN F INTERIM RESPONSE ACTION AREA

2.4 MAINTENANCE PROGRAM

In addition to groundwater monitoring field activities, the GMP includes necessary field work to maintain existing wells in the GMP monitoring network. This well maintenance is provided for under the GMP through a well maintenance program.

The need for maintenance activities will be identified during each water-level measurement and water quality sampling event. If deemed necessary, maintenance activities will be performed before the succeeding monitoring event. Monitoring well maintenance will be limited to the following maintenance activities:

- Repair casing stickup
- Install protector casing
- Install steel marker post
- Resurvey repaired well site
- Install permanent identification tag
- Replace damaged or missing well cap
- Redevelop monitoring well
- Remove accumulated sediment in well casing
- Clear vegetation from around well

3.0 LABORATORY ANALYSIS PROGRAM

The objective of the laboratory analysis program is to provide PMRMA with accurate, legally defensible groundwater quality data for RMA. The analytical program requires that groundwater samples be analyzed for a selected set of chemical parameters to achieve a quantitative assessment of water quality, as described in Section 3.1. The analytical program also includes a semiquantitative analysis of selected samples, as described in Section 3.2.

3.1 ANALYTICAL PARAMETERS

The groundwater samples collected during the water quality sampling events outlined in this TP will be analyzed for the parameters listed in Table 3.1. The same analytical parameters were used for the CMP. The analytical parameters were developed during previous Army water monitoring programs, specifically during Task 44 of the remedial investigation/feasibility study (RI/FS) contract that occurred from 1984 to 1988. Subsequent modifications have included the addition of benzothiazole, parathion, cyanide, and acid extractables. This list may be modified for future sampling events on the basis of interpretation of water quality data collected during the CMP and GMP and an evaluation of the results of gas chromatography/mass spectrometry (GC/MS) analysis of nontarget analytes. The methods and detection limits for analysis of the target analytes are as specified by PMRMA's Laboratory Support Division (LSD). Specific analytical methods are described in the GMP QCP (HLA, 1992c) and the CQAP (PMRMA, 1989).

All analytical procedures will be documented as specified in the CQAP (PMRMA, 1989) to assure accuracy and defensibility of technical data generated in the GMP. Sample collection and preparation, materials shipping and handling, and chain-of-custody (COC) procedures will follow the guidelines outlined in the GMP QCP (HLA, 1992c) and the CQAP (PMRMA, 1989).

3.2 GAS CHROMATOGRAPHY/MASS SPECTROMETRY ANALYSIS

Ten percent of the groundwater samples will be selected for GC/MS semiquantitative analysis. This technique will provide confirmation of the identification of the GC-detected target analytes listed in Table 3.1. The GC/MS analysis will also be used to detect the presence of

Table 3.1: Groundwater Monitoring Program Target Analyte List
(Page 1 of 2)

Agent Products by HPLC

Thiodiglycol

Agent Products by IONCHROM

Isopropylmethylphosphonic acid

Metals by ICP

Cadmium
Chromium
Copper
Lead
Zinc

Organophosphorus Compounds by GC/FPD

Diisopropylmethyl phosphonate (DIMP)
Dimethylmethyl phosphonate (DMMP)

Semivolatile Organic Compounds by GC/MS

1,4-oxathiane
2,2'-bis(Para-chorophenyl)-
1,1-dichloroethane
2,2'-bis(Para-chlorophenyl)-
1,1,1-trichloroethane
Aldrin
Atrazine
Chlordane
Chlorophenylmethyl sulfide
Chlorophenylmethyl sulfone
Chlorophenylmethyl sulfoxide
Dibromochloropropane
Dicyclopentadiene
Dieldrin
Diisopropylmethyl phosphonate
Dimethylmethyl phosphonate
Dithiane
Endrin
Hexachlorocyclopentadiene
Isodrin
Malathion
Parathion
Supona
Vapona

Organochlorine Pesticides by GC/ECD

2,2'-bis(Para-chlorophenyl)-
1,1-dichloroethane
2,2'-bis(Para-chlorophenyl)-
1,1,1-trichloroethane
Aldrin
Dieldrin
Endrin
Hexachlorocyclopentadiene
Isodrin

Organophosphorus Pesticides by GC/NPD

Atrazine
Malathion
Parathion
Supona
Vapona

Organosulphur Compounds by GC/FPD

1,4-Oxathiane
Benzothiazole
p-Chlorophenylmethyl sulfide
p-Chlorophenylmethyl sulfone
p-Chlorophenylmethyl sulfoxide
Dimethyldisulfide
Dithiane

Volatile Aromatic Organic
Compounds by GC/PID

Benzene
Ethylbenzene
Toluene
m-Xylene
o- and p-Xylene

Volatile Halogentated Organic
Compounds by GC/CON

1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethylene
trans-1,2-Dichloroethylene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Carbon tetrachloride

Table 3.1: Groundwater Monitoring Program Target Analyte List
(Page 2 of 2)

Volatile Halogentated Organic Compounds by GC/CON (continued)

- Chlorobenzene
- Chloroform
- Methylene chloride
- Tetrachloroethylene
- Trichloroethylene

Volatile Hydrocarbon Compounds by GC/FID

- Bicycloheptadiene
- Dicyclopentadiene (DCPD)
- Methylisobutyl ketone (MIBK)

Arsenic by AA

Dibromochloropropane by GC/ECD

Mercury by AA

Cyanide by Colorimetric

Anions by IONCHROM

- Chloride
- Fluoride
- Sulfate

Cations by ICP

- Calcium
- Magnesium
- Sodium
- Potassium

Volatile Organic Compounds by GC/MS

- 1,1-Dichloroethane
- 1,2-Dichloroethane
- trans-1,2-Dichloroethylene
- 1,1,1-Trichloroethane
- 1,1,2-Trichloroethane
- Benzene
- Bicycloheptadiene
- Carbon tetrachloride
- Chlorobenzene
- Chloroform
- Dibromochloropropane
- Dicyclopentadiene
- Dimethyldisulfide
- Ethylbenzene
- Methylene chloride
- Methylisobutyl ketone
- Tetrachloroethylene
- Toluene
- Trichloroethylene
- m-Xylene
- o- and p-Xylene

Alkalinity

Conductivity

pH

Nitrate/Nitrite by Colorimetric

AA = atomic absorption spectrometry
GC/CON = gas chromatography/conductivity detector
GC/ECD = gas chromatography/electron capture detector
GC/FID = gas chromatography/flame ionization detector
GC/FPD = gas chromatography/flame photometric detector
GC/MS = gas chromatography/mass spectrometry
GC/NPD = gas chromatography/nitrogen phosphorous detector
GC/PID = gas chromatography/photoionization detector
HPLC = high performance liquid chromatography
ICP = inductively coupled argon plasma screen
IONCHROM = ion chromatography

nontarget analytes. Nontarget analytes that are consistently detected at elevated levels will be identified and evaluated for inclusion as target analytes.

4.0 DATA ASSESSMENT AND REPORTING

Data assessment and reporting for the GMP will be undertaken with two objectives. First, the Annual Groundwater Monitoring Report for 1991 will be prepared using 1991 water monitoring data collected during the CMP and will also include interpretations of hydrologic and water quality conditions. The second reporting objective of the GMP is to prepare a data report and accompanying diskette, exclusive of interpretations, for information collected through GMP groundwater monitoring efforts.

4.1 TECHNICAL REPORTING AND DATA ASSESSMENT FOR 1991 WATER MONITORING

Hydrologic conditions and hydrochemical groundwater data collected by PMRMA contractors during the 1991 water monitoring year will be assessed and presented in the Annual Groundwater Monitoring Report for 1991. The focus of the 1991 water monitoring year was on specific project area monitoring. In keeping with the monitoring goals for the 1991 water monitoring year, the Annual Groundwater Monitoring Report for 1991 will focus on contaminant concentration and migration in the following specific project areas: the Basin F IRA area, the North Boundary Containment/Treatment System, the Northwest Boundary Containment/Treatment System, and the Basin A Neck System.

This report will include the following information:

- A summary of historical and background information
- The details of field activities performed during the previous year
- A compilation of all data collected or developed for the task
- Data interpretations
- The conclusions drawn from the data and interpretations
- Recommendations for any changes to the approach to monitoring groundwater for future monitoring programs

4.1.1 Presentation of Groundwater Data

Both tabular and graphical presentations of groundwater data will be provided. Tabular presentations (provided on diskette) will, at a minimum, include the following:

- A summary of water levels for all wells monitored by monitoring event
- A summary of groundwater chemistry by sampling event

Graphical presentations will, at a minimum, include the following:

- Water-level contour maps for each flow system (where sufficient data exist to allow mapping)
- Contaminant histograms or plume maps, where possible, for selected target analytes or for analyte groups for both the unconfined flow system and the confined flow system
- Maps indicating any changes to previously interpreted areas of unsaturated alluvium and the extent of inferred paleochannels, if necessary

4.1.2 Hydrologic Analysis

A section of the annual GMP report will address the hydrologic analysis or the occurrence and distribution of groundwater on RMA. This section will, at a minimum, include the following:

- The results of all groundwater-level monitoring conducted during the 1991 water monitoring year
- A comparison of water-level monitoring data obtained during the 1991 water monitoring year to monitoring data acquired during previous investigations; this analysis will include development of well and section hydrographs and identification of areas having significant groundwater fluctuations. Emphasis will be placed on specified project areas (i.e., Basin F IRA area, North Boundary Containment/Treatment System, Northwest Boundary Containment/Treatment System, and Basin A Neck System)
- A discussion of any recommended modifications to the water-level monitoring program
- Stratigraphic/hydrogeologic evaluation of the unconfined flow system and confined flow system to identify the extent and potential for hydraulic interaction between aquifers.

4.1.3 Contamination Assessment

The objective of the contamination assessment will be to assess the movement and extent of contamination in groundwater in the Basin F IRA area, the North Boundary Containment/ Treatment System area, the Northwest Boundary Containment/Treatment System area, the Offpost Operable Unit, and the Basin A Neck System to evaluate general relationships between groundwater quality and sources of contamination in these areas, and to assess changes in contaminant migration. The assessment will include, at a minimum, the following:

- Compilation and evaluation of all groundwater quality data obtained during the past year including a statistical evaluation where possible to identify significant trends
- Assessment of any changes in water quantity or quality compared to historical data
- An evaluation of contamination in both the unconfined flow system and confined flow system in the specified project areas
- A discussion of any recommended alterations in sampling locations, frequency, analytical parameters, equipment, methodology, and the need for other future out-of-scope activities

4.2 ASSESSMENT AND REPORTING FOR GROUNDWATER MONITORING PROGRAM-COLLECTED DATA

Groundwater monitoring data collected during the GMP period of performance includes water-level and analytical data for groundwater. After completion of the 1992 GMP water monitoring efforts, all the field and chemical data collected during the GMP will be compiled on diskette and reported to PMRMA through a brief data collection report that will simply report results without interpretation, so that they will be accessible to PMRMA and designated organizations.

5.0 DATA MANAGEMENT

All data collected during the GMP will be managed according to the procedures described in the DMP (HLA, 1992b) prepared for the GMP. The DMP describes the procedures that will be used for effective management of data generated during performance of the GMP, in compliance with the PMRMA Quality Assurance (QA) program and the Installation Restoration Data Management System (IRDMS). The DMP also establishes personnel responsibilities for management of data.

The DMP describes the types of data that will be generated, the flow of data from source to final repository, and the methods of controlling and managing the data. The DMP describes procedures for management and documentation of field and laboratory data. The DMP also describes QA/QC procedures and document control protocol.

The DMP provides a consistent framework for managing field and analytical data in support of the GMP conducted at RMA. It also establishes standards that permit HLA and PMRMA to exchange analytical results in a manner consistent with the task QA program. Finally, the DMP establishes procedures for verifying the accuracy, representativeness, comparability, and completeness of field and analytical results.

6.0 QUALITY ASSURANCE/QUALITY CONTROL

A QA/QC program has been implemented for the GMP to ensure the precision, accuracy, representativeness, completeness, and comparability of the results generated by GMP activities. QA includes the documentation related to the traceability, completeness, and security of field documents. QC includes the specific actions taken to demonstrate that the system performance is maintained at levels specified by PMRMA. A QCP (HLA, 1992c) was developed to provide guidance for data collection and chemical analyses to be performed in support of the GMP. The information in this section serves only as a brief overview of field and laboratory procedures specific to the GMP, and details are provided in the QCP (HLA, 1992c).

The GMP QCP (HLA, 1992c) for water-level measurements and groundwater sampling and analysis is consistent with the CQAP (PMRMA, 1989) developed to support the PMRMA contamination cleanup. As designed, the procedures outlined in the GMP QCP (HLA, 1992c) will ensure that valid and properly formatted data will be compiled and reported for each method used in the sampling and analysis efforts.

6.1 FIELD QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

Field QA audits of the groundwater monitoring and sampling procedures for the GMP will be performed by the HLA QA Coordinator (QAC) or a designated representative. Field operations that will be audited include sample collection, sample handling, use of sample containers for the specified analyses, field documentation, and COC use. The GMP QCP (HLA, 1992c) describes the field procedures to monitor adherence to approved QC sampling practices.

QA/QC procedures will be implemented during the collection, analysis, and validation of results for groundwater samples for water quality analysis to ensure consistent and reliable results. Field QA/QC procedures include the use of blank and duplicate samples. Field blanks will be used to ensure that no contamination is introduced during the collection of the sample. Field blanks will be filled with deionized water at the onsite support facility, sent to the field, and uncapped in the field during sampling to use as a control against contamination being introduced during the sampling process.

Trip blanks will be used as a control against contamination being introduced during transportation of the sample and will be used only when volatile organic compounds (VOCs) are specified as target compounds. Trip blanks will be filled with deionized water in the laboratory and carried, unopened, with the samples during transport and shipment. Rinse blanks will be collected in the field to assess the adequacy of field decontamination procedures. Rinse blanks will be obtained by running analyte-free deionized water through sample collection equipment after decontamination and collecting it in the appropriate sample containers for analysis.

Blank samples will be collected at the following percent of total investigative samples: trip blanks, 5 percent; field blanks, 2.5 percent; and rinse blanks, 2.5 percent. Duplicate samples, at a rate of 10 percent of total investigative samples, will be collected to monitor the consistency of sampling procedures and analytical results. GC/MS analysis will also be performed on 10 percent of total groundwater samples to confirm the presence of target analytes monitored in the investigative samples and to indicate the presence of nontarget analytes.

The HLA QAC or a designated representative will audit sample collection. A field sampling checklist will be prepared and a QA field audit report submitted to PMRMA. The HLA QAC will attempt to identify discrepancies with the GMP QCP and suggest corrective action. Specific QA/QC procedures are discussed in the GMP QCP (HLA, 1992c).

Field files and field logbooks will be maintained for each site sampled. These files and logbooks will document all information pertaining to the collection, custody, and shipment of the groundwater samples. Copies of the files, logbooks, and COC forms will be submitted to the HLA QAC. The GMP QCP (HLA, 1992c) discusses all field activity documentation requirements in detail.

6.2 LABORATORY QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

Specific laboratory procedures, as discussed in the GMP QCP (HLA, 1992c), have been developed to provide an adequate degree of QA/QC in the laboratory. The basic elements of these procedures include laboratory certification and standard operating procedures, sample analyses (including sample holding times and sample preparation), system controls, laboratory instrument maintenance, recordkeeping and audit procedures, laboratory corrective action, and laboratory QC reports.

The GMP QCP (HLA, 1992c) details the reviewing and reporting functions of the QAC. A formal review sheet will accompany the chemical analytical results for each completed lot of samples. It is the responsibility of the laboratory QA staff to check the review sheet and sign-off sheet to ensure that the review process is complete.

The laboratory QA staff will submit a QA Program Status Report to PMRMA upon completion of each analytical lot. A hardcopy of the lot QC charts will be included. Data that indicate an out-of-control situation will be evaluated and explained, and corrective action to prevent recurrence will be described.

Each laboratory will maintain a chemical data file for each lot of samples analyzed. The QCP contains details on laboratory analytical methods, laboratory analysis documentation, and the preparation and submission of laboratory analytical data packages.

Daily QC of the laboratory analytical systems ensures accurate and reproducible results. Accurate calibration of instruments and the use of control samples (control spikes and blanks) are required to obtain accurate and reliable results. The laboratory coordinator will monitor analytical controls. Calibration of instruments, sample lot controls, and analytical controls are described in the GMP QCP (HLA, 1992c).

7.0 HEALTH AND SAFETY

7.1 INTRODUCTION

The SP (HLA, 1992a) for the GMP outlines the necessary information to perform the groundwater monitoring tasks in a safe manner to minimize the potential for exposure to chemicals and injuries to site workers and visitors. The information in this section serves only as a brief overview of information specific to the GMP. The details are provided in the SP.

Activities associated with the GMP will be performed routinely in Sections 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 19, 20, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, and offpost. These sections contain varying degrees and types of contamination that will be considered for the PPE required and precautions to be taken. On the basis of historical chemical data, an evaluation will be made of each monitoring and sampling station and appropriate PPE will be worn accordingly, with the potential to upgrade, if necessary.

7.2 RESPONSIBILITIES

7.2.1 Site Safety Officer

Specific responsibilities of the Site Safety Officer (SSO) are listed in the SP. The SSO will advise all GMP personnel of potential health and safety issues in the areas in which they will be working and assign levels of protection for the associated hazards. The SSO will evaluate the necessity of using air monitoring equipment during the activities of this program. The SSO will be authorized to stop work activities if any operation threatens worker or public health or safety. The SSO will report to the Designated Health and Safety Officer (DHSO).

7.2.2 Groundwater Monitoring Personnel

The groundwater monitoring personnel will be responsible for coordinating their activities with the SSO. The SSO will be informed of their planned activities and location before the activities are performed.

A minimum of two people will be present during monitoring activities. Personnel will be responsible for reporting any unsafe or potentially hazardous conditions that are present during their activities. Personnel will be familiar with the safety procedures and emergency response contingency plan addressed in the SP for the GMP. It is the responsibility of each employee to conform to the rules and regulations contained in the SP for the GMP.

7.3 HAZARD ASSESSMENT

The potential for exposure to chemicals while performing tasks for the GMP will vary depending on the type of activity being performed, the weather conditions, and the location of the well being monitored. The sections that have the greatest risk of potential chemical exposure include Sections 1, 2, 26, and 36.

The South Plants area (Sections 1 and 2) has various chemicals present in the soil and groundwater that may become airborne on high wind or very hot days and pose a hazard by inhalation or skin absorption. These chemicals include chlorinated pesticides (aldrin and dieldrin), solvents (benzene), and heavy metals (lead, mercury, and arsenic). If weather conditions to create an inhalation hazard or air monitoring equipment indicate elevated levels of substance in the breathing zone, Level C PPE will be required as appropriate.

The Basin A area (Section 36) was used as a disposal basin for waste effluents from chemical agent and pesticide production in South Plants and North Plants. The basin is dry and barren over much of the area. Even though unvegetated areas have been covered with dust suppressing agents, the potential hazard from inhalation of airborne particulates remains on dry, high wind days. Airborne particulates may contain heavy metals (lead, mercury, and arsenic) and pesticides (aldrin and dieldrin). If weather conditions are present to create an inhalation hazard or air monitoring equipment indicates elevated levels of substance in the breathing zone, Level C or B PPE will be required as appropriate.

The Basin F (Section 26) area was used as an evaporation basin for wastewater generated from all of the production facilities in RMA. The actual basin was emptied of all remaining wastewater and sealed by a clay cap. All of the wells within the perimeter of the Basin F IRA cleanup area were destroyed. If air monitoring equipment indicates elevated levels of substance in the breathing zone of the wells remaining in Section 26, Level C PPE will be required as appropriate.

When activities are such that the possibility exists for skin contact with contaminated materials (notably water), then protective clothing must be worn that protects against the chemicals of concern. Descriptions of each level of PPE are contained in the SP. Hazardous property information for compounds that could potentially be encountered is contained in Appendix A of the SP. More in-depth toxicology information concerning the various compounds can be found in Appendix D of the SP.

7.4 PERSONAL PROTECTIVE EQUIPMENT

The minimum level of protection for personnel performing field activities for the GMP will be as follows:

- Sections 1 and 2 in the South Plants area, 26, and 36: Level C PPE with air monitoring equipment
- Other areas onpost: Modified Level D PPE with air monitoring equipment
- Offpost First Creek floodplain: Level D PPE with air monitoring equipment
- Other offpost area: Level D PPE

Levels of protection will be upgraded if air monitoring equipment indicates elevated levels of substance in the breathing zone or if the SSO deems upgrades are necessary.

Respiratory protection will be required in Sections 1, 2, 26, and 36 in the South Plants area. Full-face air-purifying respirators with combination organic vapor/high-efficiency particulate air (HEPA)/pesticide cartridges will be used for work requiring respiratory protection.

7.5 DECONTAMINATION

Decontamination will be required at the end of the work day by all personnel. Protective clothing will be decontaminated and disposed in the appropriately marked barrel. All field personnel will be required to wash their hands and face before eating, drinking, smoking, or leaving RMA. Showers will be mandatory for personnel working in areas where Level C or B PPE is required.

Equipment will be decontaminated before being stored or moved from one section to another. When driving in Section 36, vehicles must be decontaminated before to leaving the section. Vehicles driven in Section 36 must be driven on the service access roads on the perimeter of the section to the decontamination pad in the southeastern corner. The vehicle's exterior, undercarriage, and tires must be thoroughly steam cleaned at the decontamination pad before exiting Section 36.

7.6 EMERGENCY PROCEDURES

Personnel will be familiar with the emergency contingency plan in Appendix D of the SP. All injuries will be reported to the SSO immediately. Any condition that may create a health or safety hazard will be reported to the SSO as soon as it is observed. The SSO will evaluate the condition and make recommendations for corrective actions, if required.

8.0 LIST OF ABBREVIATIONS AND ACRONYMS

°C	degrees Celsius
≥	greater than or equal to
≤	less than or equal to
AA	atomic absorption spectroscopy
Army	U.S. Department of the Army
CMP	Comprehensive Monitoring Program
COC	chain of custody
COR	Contracting Officer's Representative
CQAP	Chemical Quality Assurance Plan
DBCP	dibromochloropropane
DCPD	dicyclopentadiene
DDT	dichlorodiphenyltrichloroethane
DHSO	Designated Health and Safety Officer
DIMP	diisopropylmethyl phosphonate
DMMP	dimethylmethyl phosphonate
DMP	Data Management Plan
DO	delivery order
FDS	field data sheet
FOC	Field Operations Coordinator
FTL	Field Team Leader
GC/CON	gas chromatography/conductivity detector
GC/ECD	gas chromatography/electron capture detector
GC/FID	gas chromatography/flame ionization detector
GC/FPD	gas chromatography/flame photometric detector
GC/MS	gas chromatography/mass spectrometry
GC/NPD	gas chromatography/nitrogen phosphorous detector

GC/PID	gas chromatography/photoionization detector
GMP	Groundwater Monitoring Program
H_2SO_4	sulfuric acid
HCl	hydrocloric acid
HEPA	high-efficiency particulate air
HLA	Harding Lawson Associates
HNO_3	nitric acid
HPLC	high performance liquid chromatography
ICP	inductively coupled plasma screen
IMPA	isopropylmethyl phosphonic acid
IONCHROM	ion chromatography
IRA	interim response action
IRDMS	Installation Restoration Data Management System
LSD	Laboratory Support Division
ml	milliliter
NaOH	sodium hydroxide
PMRMA	Program Manager for Rocky Mountain Arsenal
PPE	personal protective equipment
QA	quality assurance
QA/QC	quality assurance/quality control
QAC	Quality Assurance Coordinator
QC	quality control
QCP	Quality Control Plan
RI/FS	remedial investigation/feasibility study
RMA	Rocky Mountain Arsenal
RUP	Resource Utilization Plan
SDP	Sampling Design Plan

Shell	Shell Oil Company
SP	Safety Plan
SPDF	South Plant Decontamination Facility
SSO	Site Safety Officer
Stollar	R. L. Stollar and Associates, Inc.
TCHD	Tri-County Health Department
TOC	top of casing
TP	Technical Plan
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
VOA	volatile organic aromatic
VOC	volatile organic compound
VOH	volatile organohalogen
WE	work element

9.0 REFERENCES

D. P. Associates, Inc., 1991. Rocky Mountain Arsenal Section Plots and Well Summary Report, October.

Ebasco Services, Inc., 1989. Rocky Mountain Arsenal Water Remedial Investigation Report, July, RIC# 89186R01

Harding Lawson Associates, 1991. Groundwater Monitoring Program Resource Utilization Plan, prepared for the Program Manager for Rocky Mountain Arsenal.

Harding Lawson Associates, 1992a. Groundwater Monitoring Program Final Safety Plan, prepared for the Program Manager for Rocky Mountain Arsenal, April 7.

Harding Lawson Associates, 1992b. Groundwater Monitoring Program Final Data Management Plan, prepared for the Program Manager for Rocky Mountain Arsenal, April 15.

Harding Lawson Associates, 1992c. Groundwater Monitoring Program Final Quality Control Plan, prepared for the Program Manager for Rocky Mountain Arsenal, May 6.

Program Manager for Rocky Mountain Arsenal, 1989. Chemical Quality Assurance Plan, Version 1.0, July, RIC# 89233R01.

R.L. Stollar and Associates, Inc., and others, 1990. Comprehensive Monitoring Progam Draft Final Technical Plan Addendum, Version 3.3, prepared for the Program Manager for Rocky Mountain Arsenal, September.

Appendix A

GROUNDWATER MONITORING PROGRAM
GROUNDWATER MONITORING PROCEDURES

PREFACE

This appendix to the Groundwater Monitoring Program (GMP) Technical Plan has been prepared as the Sampling Design Plan, Deliverable Requirement A0004, for Delivery Order (DO) 0006 of Contract No. DAAA15-88-D-0021 between Harding Lawson Associates (HLA) and the U.S. Department of the Army (Army). This appendix presents specific and detailed groundwater monitoring procedures for the GMP at Rocky Mountain Arsenal (RMA), including procedures for monitoring water levels and obtaining groundwater samples for chemical analysis. This appendix will be used as a stand-alone document and will be distributed to and used by the HLA field personnel.

GROUNDWATER MONITORING PROCEDURES

This appendix presents groundwater monitoring procedures for the Groundwater Monitoring Program (GMP) at Rocky Mountain Arsenal (RMA), including procedures for measuring water levels and for sampling monitoring wells using various types of equipment. Additionally, procedures for containerizing groundwater samples and completing chain-of-custody (COC) forms and shipping forms are discussed.

Field Personnel

The activities of field personnel will be coordinated onsite by a Field Operations Coordinator (FOC). Most monitoring activities will be accomplished by two or three two-person field teams. One member of each field team will be designated as the Field Team Leader (FTL) and will be responsible for all of the tasks completed by his or her team. FTLs will be selected from personnel with onsite experience. Daily activities of field teams will be managed by the onsite FOC. In addition, the FOC will review all data collected to ensure the completeness of field data sheets (FDSs). The FOC will also be responsible for ensuring that COC forms are maintained and will supervise or expedite sample collection, handling, packaging, and shipment.

Field Equipment

At the beginning of each monitoring program, FTLs will be issued field sampling kits containing field instruments (with operators' manuals), sampling equipment, and laboratory certified calibration standards. The HLA field trailer will retain copies of the Safety Plan (HLA, 1992a) and the Quality Control Plan (HLA, 1992c). The field kits will contain copies of the RMA Section Plots and Well Summary Report (D. P. Associates, 1991). Depending on the well to be sampled, the sampling equipment may include an electric submersible pump, an air-driven piston pump, a stainless-steel bailer system, an air compressor, and/or an electrical generator.

The components of each field kit will be contained within a 4- x 2- x 2-foot all-weather metal storage locker. Each locker will be equipped with the following:

1. pH, conductivity, and dissolved oxygen meters; a complete set of spare probes, cables, and batteries for each instrument; and a flow-through cell in which to monitor purge-water parameters
2. Digital alkalinity titration kits
3. Calibration-standard solutions and detailed calibration procedure instructions for all instruments
4. Two 1-liter wash bottles and a set of two 500-milliliter (ml), two 250-ml, and two 100-ml beakers
5. A water-level measuring device
6. A roll of plastic sheeting
7. 100 pairs of gloves (nitrile and surgical)
8. 50 plastic bags
9. 1000 feet of 1/4-inch nylon rope (if the kit is for bailed wells)
10. A metals filtration kit (peristaltic pump, filter holder, replacement hoses, filters, 50 ml of dilute nitric acid [HNO_3] for metals preservation, and pH-indicator paper)
11. A complete set of spare sample fraction containers
12. A well casing volume calculation chart for 1-inch to 8-inch wells
13. Various equipment, such as marking pens, duct tape, clear tape, and tools for trouble-shooting equipment
14. A 1:1 solution of sulfuric acid (H_2SO_4) for nitrate sample preservation
15. A 1:1 solution of sodium hydroxide (NaOH) for adjusting to pH greater than or equal to ($\geq$) 12 for cyanide sample preservation
16. A 1:1 solution of hydrochloric acid (HCl) for adjusting to pH less than or equal to ($\leq$) 2 for volatile fraction preservation

Each field kit will be restocked as necessary by the FTL at the close of each day of sampling. Additional field equipment (e.g., deionized water and decontamination wash basins) will be stocked as necessary by each field team. A complete set of spare field instruments will be maintained at the onsite support facility.

Before startup of field work, the onsite FOC will be responsible for ensuring that all personnel are trained to operate all field equipment and that each team member understands the field procedures described in the main text of this GMP Technical Plan. If procedures are modified or additional equipment or instrumentation is incorporated into the ongoing program, the FOC will schedule training sessions to introduce these modifications or equipment changes to field personnel and provide them written instructions.

Data from samples collected in the field will be recorded on preprinted FDSs and in bound field logbooks. When not in use, field logbooks will be maintained by the FOC in a secured area at the site support facility. Logbooks will be checked in and out by the FOC to the FTLs on a daily basis.

Water-level Measurement Procedures

A water-level measurement program will be conducted before the initiation of each water-sampling event. A sufficient number of field teams will be mobilized to ensure that all water-level data are collected in a timely manner (i.e., within 21 days). The procedure for obtaining water-level measurements is summarized as follows:

1. Record the manufacturer and model of the water-level indicator used.
2. Record the well number, date, time, and initials of field personnel obtaining measurements.
3. One of the field team members will uncap the well and record in a bound field logbook the photoionization detector readings (HNu) of the headspace at the top of casing (TOC), in the breathing zone, and in the ambient air (background).
4. Measure the length of the riser stickup from ground surface to the measuring point marked at the TOC, and record the length of the riser stickup to the nearest 0.01 foot. If no mark is present, all measurements will be performed on the north side of the stickup, and a measuring point will be marked on the stickup using a permanent marker.

5. Insert the water-level indicator probe until it reaches water. Measure depth to water from the same measuring point marked at the TOC, and record the value to the nearest 0.01 foot.

6. If there is a discrepancy between the previously accepted stickup measurement and the current stickup measurement, measure and record the total depth of the well for confirmation that measurements are being performed on the correct well.

7. Retrieve the water-level indicator probe and thoroughly rinse the cable and probe with deionized water as they are withdrawn from the well. Avoid allowing rinse water to flow into the well.

8. Compare total depth, water-level, and stickup measurements to previous measurements (where applicable) listed in the RMA Section Plots and Well Summary Report (D. P. Associates, Inc., 1991). If discrepancies are observed, a second measurement will be performed and documented as such.

9. Record well conditions (e.g., cracked casing, missing cap, prairie dog burrows) and any other pertinent observations.

10. Ensure that all labels and flagging clearly indicate well location and well number.

11. Police the area to ensure that all equipment and materials have been retrieved, that litter has been collected, and that the well cap is secure.

Groundwater Sampling Procedures

The onsite FOC will prepare a daily schedule of field activities and provide each FTL with a prepared sample cooler. Each cooler will contain sample containers, packing material, labels, COC forms, and ice. Each FTL will also be provided with a well information file, which will include previous water-level data, expected casing volume, and any comments generated during previous sampling events. FTLs will be responsible for ensuring that sample and field kits are complete and that all instruments and sampling equipment are clean and fully operational.

Upon arrival at the well site, the following procedure will be implemented:

1. One of the field team members will uncap the well and record background, breathing zone, and casing headspace readings from the HNu, as described previously for water-level measurements. If the HNu readings are high, the field team will inform the FOC by radio. The FOC and task chemist will determine if the laboratory will be notified of the possibility of classifying the well as a class III well for gas chromatography/mass spectrometry (GC/MS) analysis. (HLA, 1992c).

2. Record well number, date, pertinent observations (e.g., weather, well condition), casing diameter, screened interval, and field instrument identification numbers.

3. Place a sheet of plastic on the ground surface around the well stickup.

4. Measure and record well stickup, depth to water, and total well depth to the nearest 0.01 foot. Measure from the measuring point marked at the TOC, and compare measured values with previous measurements; investigate and document any discrepancies. All equipment used downhole to obtain water-level and total depth measurements will be decontaminated with deionized water.

5. Calculate and record casing volume; compare with previously recorded casing volumes to ensure relative comparability. A sheet listing casing volumes on the basis of height of the water column and well diameter will be provided for all field personnel.

6. Calibrate field instruments for monitoring pH, temperature, conductivity, alkalinity, and dissolved oxygen (for pumped wells only) against known standards. Record instrument calibration responses, times, and calibration standards used.

7. Whether to pump or bail a well will be decided by the onsite FOC on the basis of the well's hydraulic characteristics. In general, wells containing less than 4 gallons per casing volume will be purged and sampled by bailing, and all other wells will be pumped.

8. Two methods are employed for purging and sampling wells, depending on whether the well is to be pumped or bailed. In both cases (bailing or pumping), it is preferred that a minimum of five casing volumes be purged from the well to allow water that may have been standing in the well casing and filter pack to be removed, allowing the sample to be representative of aquifer conditions. The minimum requirements are to obtain three or more consecutive stabilized parameter measurements (and no less than five casing volumes) in which each parameter measurement (pH, electrical conductivity, temperature, and dissolved oxygen) differs by no more than 10 percent from the previous parameter measurement.

   If a well is to be bailed, the water column should be purged from the top of the column. The bailer is lowered into the water slowly to minimize agitation. Well parameters should be monitored carefully to ensure that all water standing in the well casing and filter pack is removed from the well before sampling. Some wells will dewater. Other wells may appear to dewater if bailed too quickly. It may, therefore, be necessary to carefully monitor the well's response when bailing low-production wells to ascertain how many casing volumes can be effectively purged before sampling.

   If a well is to be pumped, the standing water column in the well should also be purged from the top to the bottom of the screened interval. In many cases, the pump has a higher flow capacity than the well, and the well will appear to dewater. Care should be exercised to reduce the pump flow rate so that it equals the well's recharge potential. On occasion, it may be necessary to reposition the pump to progressively deeper locations in the well. Upon completion of purging all five casing volumes from the well, and stabilization of parameter measurements, the optimal sampling depth should be at the middle of the well's screened interval. Purge water from all pumped wells will pass through an in-line flow cell fitted with the required instrument probes. The flow cell allows for real-time monitoring of sample parameters (pH, electrical conductivity, temperature, and dissolved oxygen) as well as the physical characteristics of the water passing through the cell.

9. A portion of the initial water purged from the well will be collected and the following information recorded: sample parameter values (pH, temperature, electrical conductivity at 25 degrees Celsius [°C] or normalized to 25°C, and dissolved oxygen), time, air-monitoring instrument readings, pumping rate, and purged volume removed. Similarly, this information will be documented as each casing volume is removed. All purged water will be collected in portable tanks at the well site and transported to the decontamination pad for disposal.

10. A minimum of five casing volumes will be removed from each well before sampling. However, samples will not be collected until sample parameters from three consecutive casing volumes have stabilized. Wells that dewater before the removal of five casing volumes or stabilization are exempt from these requirements. If the well dewaters, samples will be collected, based on their previously-determined priority (see item 15), within 24 hours following well-dewatering.

11. An alkalinity titration will be performed on a portion of the well water collected after the fifth or final casing volume has been removed. Titration values required to reach colorimetric end points will be recorded along with associated pH values (measured simultaneously), in accordance with the GMP QCP (HLA, 1992c).

12. Sample parameters will also be measured and recorded immediately before sample collection. Sample labels will be completed to include the following information: well number, time, date, and sampler's signature.

13. If the well is pumped, samples will be collected directly from a sampling spigot on the pump discharge line at low flow rates to avoid agitating samples and possibly degassing volatiles. These samples will be obtained from the spigot that is plumbed into the discharge line upstream from the in-line flow cell. If the well is bailed, samples will be collected from bottom-decanting bailers.

14. All sample bottles will be supplied certified clean by the vendor (with premeasured preservatives when applicable) and will not be rinsed with well water before filling. Sample fractions will normally be filled in the following order: (1) volatile organic aromatics (VOAs) (two 40-ml amber glass bottles); volatile organohalogens (VOHs) (two 40-ml amber glass bottles); volatile hydrocarbons (two 40-ml amber glass bottles); (2) dibromochloropropane (DBCP) (three 40-ml amber glass bottles); (3) GC/MS volatile fraction (two 40-ml amber glass bottles); (4) organosulfur and organochlorine compounds (two 1-liter amber glass bottles); (5) diisomethylphosphonate/dimethylmethylphosphonate (DIMP/DMMP) (one 1-liter amber glass bottle); (6) nitrogen-phosphorus pesticides (one 1-liter amber glass bottle); (7) GC/MS semivolatile fraction (one 1-liter amber glass bottle); (8) isopropylmethyl phosphonic acid (IMPA) (two 1-liter amber glass bottles); (9) nitrate/nitrite (one 4-ounce plastic bottle); (10) anions (one 1-liter plastic bottle); (11) cyanide (one 1-liter plastic bottle); (12) thiodyglycol

(two 1-liter amber glass bottles); (13) inductively-coupled plasma (ICP) metals and cations (one 500-ml plastic container); (14) arsenic (one 500-ml plastic container); (15) mercury (one 500-ml plastic container). The VOC, VOH, DBCP, and GC/MS sample fractions will be filled completely and capped tightly to avoid air bubbles. Except for metals, all remaining sample fractions will be filled to a minimum of 90 percent capacity. The contract laboratory will send the following sample fraction bottles filled with premeasured preservatives:

- Volatile fraction: Analyses for the volatile fraction will require seven 40-ml VOA bottles prepreserved with concentrated HCl. One of the 40-ml bottles will be used by the field team to check for proper preservation of pH ≤ 2. If the pH of the sacrificial sample is greater than 2, the field team will add 1 drop of HCl to the sacrificial sample bottle and recheck for a pH of ≤ 2. The process will be repeated until a pH of ≤ 2 has been achieved. The same number of drops of HCl will be added to each of the six 40-ml sample bottles.

- Nitrate fraction: Analyses for the nitrate fractions will require one 4-ounce plastic bottle prepreserved with 1:1 solution of H_2SO_4. Field samplers will pour a small amount of the groundwater sample onto pH paper to check for a pH of ≤ 2. If needed, 1 drop of H_2SO_4 will be added to the nitrate sample bottle. The pH will be checked again by the same procedure until a pH of ≤ 2 is measured.

- Cyanide fraction: Analyses for the cyanide fractions will require one 1-liter amber glass bottle prepreserved with 1:1 solution of NaOH. The cyanide fraction will be checked by the field team to ensure that the sample has been preserved to a pH ≥ 12. If the pH needs to be adjusted, the field team will add 1:1 NaOH to a pH of ≥ 12.

- Dissolved metals fraction: Analyses for the dissolved metals fractions will require three 500-ml plastic bottles preserved with 1:1 HNO_3. If the samples are collected by pumping, the pump will be stopped and a 0.45-micron nitrocellulose or cellulose acetate in-line filter will be attached to the discharge line. The pump will be restarted and the first 50 to 100 ml of filtrate will be discarded to minimize possible contamination. Samples of the filtered water will then be collected in designated containers prepreserved with dilute to a pH of ≤ 2. If the samples are obtained by the bailing technique, field filtration equipment will be available. The filtering device will contain a filter support of plastic or Teflon® with a disposable ungridded 0.45-micron nitrocellulose or cellulose acetate filter. The unfiltered groundwater will be poured from the bailer into a clean container for ease of use. The unfiltered water will be pumped from the clean container through the filtering device. To minimize possible contamination, the first 50 to 100 ml of filtrate will be discarded. Samples of the filtered water will then be collected in designated containers prepreserved with dilute HNO_3 to a pH of ≤ 2. The pH of the samples will be checked by pouring a small amount of the sample onto the pH indicator paper. If the pH needs to be adjusted, the field team will add 1:1 HNO_3 to a pH of ≤ 2.

All sample fractions will be placed in the cooler under ice immediately upon filling. Sampling technique, sample depth, and fractions collected will be recorded on FDSs, COC forms, and the sample tag.

15. For wells that dewater or have low production capacity, samples will be collected in the following order:

   a. Analyses not retained on the prior sampling round

   b. Volatile fractions: volatile organic aromatics, volatile organohalogens, volatile hydrocarbons

   c. DBCP

   d. Volatiles by GC/MS

   e. Organochlorine and organophosphorus compounds and pesticides: organosulfur and organochlorine compounds, DIMP/DMMP, nitrogen-phosphorus pesticides

   f. Semivolatiles by GC/MS

   g. Agent products by ion chromatography (IMPA)

   h. Metals: ICP metals and cations, arsenic, mercury

   i. Other inorganics: nitrate/nitrite, anions, cyanide

   j. Agent products by high performance liquid chromatography (thiodiglycol)

   k. Any spare sample volume bottles required on the COC

   l. Duplicates (Duplicates will not be collected from a poor producing well. The sampling team will contact the FOC and task quality assurance (QA) officer who will reassign the duplicate to a different well.)

16. The FTL will sign and date FDSs after ensuring that they have been completed and that the information has also been recorded in the field logbook. The FTL will complete the COC form when relinquishing custody of the samples.

17. All sampling equipment will be thoroughly decontaminated at the well site before storage. Except for pumps, all equipment will be cleaned in a solution of Contracting Officer's Representative (COR)-approved water and Alquinox® detergent and triple-rinsed with deionized water. To decontaminate the inside of the pump, a volume of deionized water equal to three times the volume of the pump and hoses will be pumped through the line. All decontamination water will be placed in portable tanks at the well site and transported to the decontamination pad for disposal. All cleaned equipment will be wrapped and stored in clean plastic sheeting.

18. The final activity at the well will be to remove all sampling equipment and debris from the area.

19. At the end of each day, portable tanks will be emptied at the South Plants Decontamination Facility (SPDF) bulk liquid storage tanks. The volume of purge water transferred to the SPDF will be recorded, and a copy of this inventory will be delivered to the SPDF subcontractor.

In addition to the above listed procedures, the following guidelines will be used to mitigate problems that could adversely affect sample integrity:

1. Avoid agitation of VOC samples collected from either pumps or bailers that will reduce air stripping of volatiles and allow for the collection of more representative samples.

2. Sampling equipment, including pumps, hoses, bailers, rope, etc., should contact only the well or a clean plastic surface. Equipment should never contact the ground or any other surface that has the potential to transmit contaminants. This equipment should always be encased or wrapped in clean plastic during transport.

3. Change gloves frequently when handling downhole instruments. Always change gloves after working with compressors or other equipment before sampling. New gloves will be worn at the start of well purging and changed immediately before sample collection.

4. When working with downhole equipment (e.g., bailers, pumps) either decontaminate tools after use or decontaminate the equipment before reentering the well.

5. Avoid splashing waste or dirt on plastic sheeting. If the sheeting becomes dirty, replace with clean plastic sheeting and dispose the dirty sheeting in the proper manner.

6. Vent gasoline engines downwind at least 30 feet from the well. Gas tanks should never be filled in the field. Keep all sampling equipment away from areas where gasoline spills or leaks may occur.

7. Replace all dropped bottles, lids, or septa with counterparts from the kit. Avoid contact with edges of lids or inside surfaces of sample bottles.

8. Ensure that septa and Teflon® cap liners are in good condition. Check that septa are oriented with Teflon® side down. When full, septa bottles should be transported upside down.

9. Avoid sampling when precipitation or windblown dust may contaminate the sample.

10. Do not dip pH indicator paper into acidified samples; check by pouring a small amount of sample on the paper. Volatile fractions will be checked for proper preservation by collecting one additional sacrificial sample.

11. To avoid unnecessary agitation of the water column, bailers should be lowered slowly into the well. A knot tied in the bailing rope approximately 2 feet above the static water level will serve as a marker below which the bailer will be lowered very slowly.

12. Ensure that a stainless-steel protector is emplaced over the well head, on 2-inch-diameter wells, before bailing. This protector will prevent the bailing rope from cutting into the top edge of the polyvinyl chloride casing.

13. When using a disposable 0.45-micron filter, discard the èntire assembly after filtering; disposable filters are not reused. Also, discard the silicon rubber tubing used to connect the filter capsule to the spigot.

14. Sample bottles will be filled from a pump discharge line located upstream of the flow cell.

15. When abrupt increases are observed in dissolved oxygen readings, a bailer will be used in place of the pump to sample the well. When pumps malfunction, they may aerate samples and should be repaired immediately.

16. Check all documentation to ensure that corrections are properly recorded. Also, check that all signatures and dates on forms are present and correct.

17. In the field, field team members will check all forms to ensure that they are legible and correct.

Chain-of-Custody

The FOC will place the correct COC forms within the designated sample cooler before relinquishing the cooler to the FTL. These forms are an inventory of the samples and of those persons with access to the samples. The forms will be transported with the samples at all times. Possession of the samples will begin with the sample collectors. All subsequent sample transfers will require the relinquisher and the receiver to sign, date, and record the time of transfer on the COC forms.

Data on final COC forms will be checked by the FOC and will include the sample number, sampler's signature, collection date and time, fractions collected, and sample depth. The FOC will obtain these data from the FDSs transmitted by the sampling teams.

Sample Shipment

By the end of each sampling day, all samples should be brought back to the sample handling trailer for packaging. The FOC will complete the COC forms and review field logbooks and FDSs for errors and omissions.

Sample fractions will be repackaged with a layer of blue ice below and above the samples, in heavy-duty coolers to maintain sample temperatures of 4°C. COC forms will be placed in waterproof bags in their corresponding coolers. All coolers will be sealed and wrapped in accordance with individual shipping requirements. Evidence tape will be placed across each cooler to ensure that the contents are not violated during shipping. The last person to sign the COC form for each cooler will sign and date the evidence tape. The COC forms will be signed over to the transport courier, and the coolers will be delivered to the laboratory. The samples will be shipped by air (Federal Express) freight on a daily basis.