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PILOT PUMPING TEST FOR THE GROUNDWATER OPERABLE UNIT AT THE WELDON SPRING SITE

WELDON SPRING SITE REMEDIAL ACTION PROJECT
WELDON SPRING, MISSOURI

APRIL 1998 **REV. 0**

U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

Prepared by MK-Ferguson Company and Jacobs Engineering Group

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ES&H Manager	4/10/98 Date
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Engineering Manager	4-20-98 Date
Project Quality Manager	21 April 98 Date
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Weldon Spring Site Remedial Action Project

Pilot Pumping Test for the Groundwater Operable Unit at the Weldon Spring Site

Revision 0

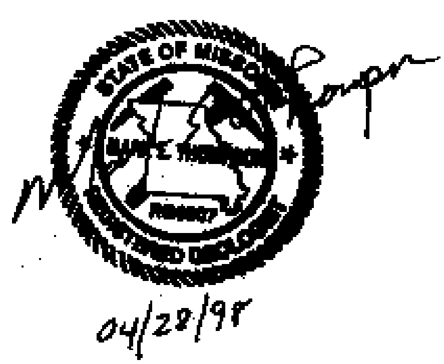
April 1998

Prepared by

MK-FERGUSON COMPANY
and
JACOBS ENGINEERING GROUP
7295 Highway 94 South
St. Charles, Missouri 63304

for the

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under Contract DE-AC05-86OR21548



ABSTRACT

The *Pilot Pumping Test for the Groundwater Operable Unit at the Weldon Spring Site* outlines pumping tests that are being proposed in the area of trichloroethene (TCE) at the Weldon Spring Chemical Plant.

The objectives of the aquifer pumping tests are to:

- Determine aquifer responses to groundwater withdrawal that may be used to further characterize aquifer properties in the area south and southwest of Raffinate Pits 3 and 4.
- Evaluate the applicability of remediation technologies based upon the aquifer pumping test results.
- Obtain samples and resulting data to further define the areal and vertical extent of TCE contamination.

Data from the tests on aquifer performance and response to pumping will be used to better evaluate options under consideration for remediation of TCE.

Aquifer characteristics expected to be defined by the results of the pumping tests include aquifer hydraulic conductivity, transmissivity, storativity or specific yield, maximum sustained pumping rate, radius of influence, vertical and horizontal aquifer anisotropy, and aquifer boundary conditions.

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1. INTRODUCTION

The volatile organic compound trichloroethene (TCE) has been detected in the uppermost groundwater-bearing stratigraphic unit, the weathered Burlington-Keokuk Limestone, south and southwest of Raffinate Pits 3 and 4 at the Weldon Spring Chemical Plant. The concentrations of TCE in this area range from less than 10 µg/l up to 1,300 µg/l. The proposed remediation goal (PRG) for TCE is 5.0 µg/l. The areal and vertical extent of the groundwater impact has been estimated by utilizing groundwater analytical results of samples collected since June 1996. Samples have been collected from both existing chemical plant wells and adjacent Weldon Spring Training Area wells. The source of the contamination has not been positively identified, but it is believed to have originated from beneath the raffinate pits as a single-event release.

Remediation technologies have been evaluated for feasibility of groundwater remediation in this area in accordance with the *Feasibility Study for the Groundwater Operable Unit* (Ref. 1). The practicality and effectiveness of remediation techniques are largely dependent upon hydrogeological characteristics of the affected aquifer. Due to the high degree of secondary porosity heterogeneity (variable fracture densities), the aquifer characteristics in the affected area cannot be directly correlated to those areas which have been characterized by previous aquifer tests. Therefore, pumping tests in the area of TCE impact are proposed to provide information that will support the final proposed plan for remedial action for groundwater.

1.1 Purpose

The objectives of the aquifer pumping tests are to:

- Determine aquifer responses to groundwater withdrawal that may be used to further characterize aquifer properties in the area south and southwest of Raffinate Pits 3 and 4.
- Evaluate the applicability of remediation technologies based upon the aquifer pumping test results.
- Obtain samples and resulting data to further define the areal and vertical extent of TCE contamination.

Data from the tests on aquifer performance and response to pumping will be used to better evaluate options under consideration for remediation of TCE.

Aquifer characteristics expected to be defined by the results of the pumping tests include aquifer hydraulic conductivity, transmissivity, storativity or specific yield, maximum sustained pumping rate, radius of influence, vertical and horizontal aquifer anisotropy, and aquifer boundary conditions.

1.2 Scope

Pumping tests are generally performed to evaluate the production capabilities of wells and to determine aquifer properties and boundary conditions. The following three pumping tests are proposed for this pilot study:

- A step-drawdown test (single well, variable discharge).
- A single pumped well, constant discharge test.
- A long-term constant discharge test with multiple observation wells.

The rationale for performing these three tests is summarized in the following test descriptions.

1.2.1 Single Well Variable Discharge Test

A single well variable discharge drawdown test, or step-drawdown test, is performed to determine the relationship between well discharge and drawdown (specific capacity). The primary objective of the test is to determine the optimum sustained pumping rate for subsequent pumping tests.

The well is pumped at a low constant discharge rate until the water level stabilizes. Then the pump rate is increased and the well is pumped again until the water level stabilizes. This process is repeated, with each step consisting of a pumping duration of at least 0.5 hour to 2 hours. In general, three to four steps are adequate to determine the pumping rate to drawdown relationship, which can then be used to choose the optimum sustainable pumping rate for the constant rate test. Pumping rates will be determined following well development, after which preliminary estimates of well drawdown and recovery rates can be made.

A variety of methods are in use to determine aquifer transmissivity using step-drawdown test results, although this is not a primary objective for this test. It does not provide data needed to estimate aquifer storativity (confined aquifer) or specific yield (unconfined aquifer). These characteristics are required to accurately define the effective radius of the well (the distance measured from the center of the well at which aquifer drawdown equals the drawdown measured at the well screen). Results from the sustained pumping tests will be used to determine these characteristics.

1.2.2 Single Well Constant Discharge Test

A single well constant discharge test is a test of well performance using water level changes within the pumped well itself; no observation wells are used. For the purpose of this investigation, the single well test will be used to: (1) determine the transmissivity of the aquifer at the test location, (2) observe primary and secondary porosity responses to sustained pumping, and (3) estimate the radius of influence for placement of observation wells.

Aquifer transmissivity is defined as the rate of flow under a unit hydraulic gradient through a cross-section of unit width over the whole saturated thickness of the aquifer or the product of the hydraulic conductivity and the saturated thickness of the aquifer. It can be estimated in the single well test by using aquifer drawdown measurements plotted versus time with a straight-line method, given that the well is pumped sufficiently to eliminate effects of well-bore storage.

If the transmissivity of an aquifer is high, the cone of depression within the zone of influence is generally broad and flat, and if transmissivity is low the cone is steep and narrow. Single well, constant drawdown tests can be used directly to estimate the radius of influence in a homogeneous medium, but such conditions do not exist in the weathered Burlington-Keokuk. However, the results from this test should be useful in estimating the appropriate distances for installation of observation wells which will be used in subsequent tests during this study.

1.2.3 Multiple Well Constant Discharge Test

A multiple well constant discharge pumping test will be performed if the single well test results indicate sufficient drawdown and steady state conditions can be established with sustained pumping. The constant discharge pumping test with multiple observation wells will be performed to evaluate the following: (1) hydraulic conductivity, (2) transmissivity, (3) specific yield, if possible (4) the area of pumping influence, (5) aquifer boundary conditions, and (6) vertical and horizontal anisotropy.

The specific yield is the yield of drainable water from an unconfined aquifer per unit of surface area of the aquifer per unit decline of the potentiometric surface. This characteristic is critical in determining the feasibility of sustained pumping for remediation purposes, since the saturated thickness of the weathered Burlington-Keokuk is limited (approximately 25 ft).

Data from this test will be used for distance-drawdown analyses, which provide values for transmissivity and specific yield. The geometry of the cone of depression or zone of pumping influence and anisotropy across the area will also be determined using drawdown values measured in the observation wells.

2. TECHNICAL WORK PLAN

The proposed location of the pilot groundwater pumping study is near the suspect clean soils pile along the southwest fence line of the raffinate pit area (753270E, 1042100N) where groundwater is impacted with trichloroethene (TCE). The selection of this site was based upon the following rationale:

- The location is situated in a bedrock low or paleochannel feature through which the TCE is most likely migrating due to preferential flow in highly fractured limestone associated with these features.

- The location is downgradient of the well with the highest detected TCE concentration.

- Lithologic data from borings and aquifer hydraulic conductivities from previous aquifer performance tests suggest greater groundwater mobility (more favorable for sustained pumping) in this area than the majority of the site.

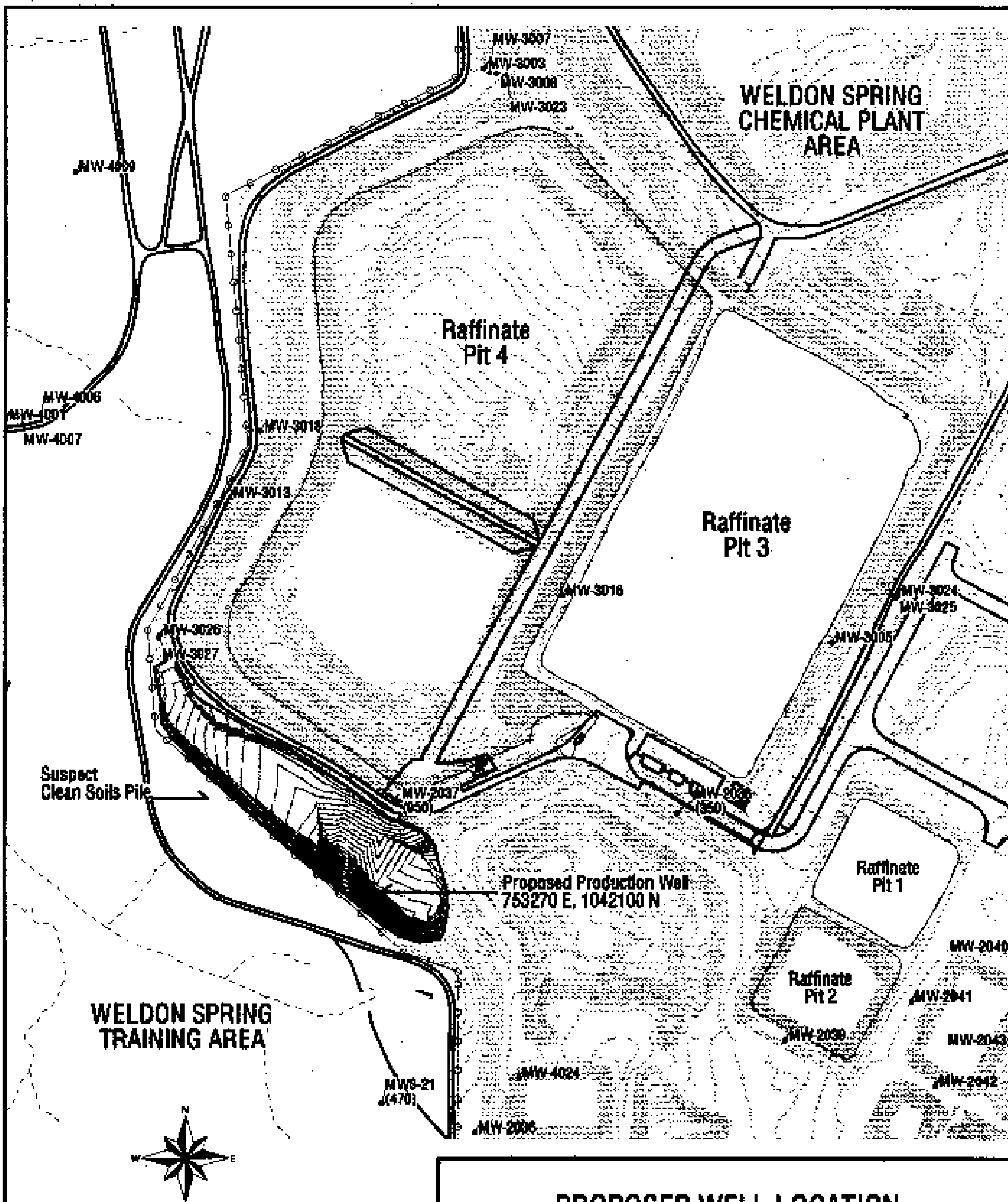
Figure 2-1 shows the proposed location with respect to the detected TCE groundwater contamination. The top of the bedrock paleochannel is shown in Figure 2-2.

Implementation of the study will initially require installation of a pumping well of sufficient diameter and depth to provide a well volume suitable for sustained pumping. Additionally, several observation piezometers will be installed within 100 ft of the pumping well. Groundwater sampling for TCE and other contaminants of concern will be conducted during the pumping tests. The tentative schedule for work during 1998 is to install the pumping well in early April, conduct single well variable discharge and constant discharge pump tests in early May, install observation piezometers in mid to late May, and conduct the multiple well pumping test during June. Completion of these activities is projected for July 1, 1998.

2.1 Well Installation

2.1.1 Pumping Well

The pumping well, or production well, will be installed along the chemical plant fence line approximately at Missouri State Plane coordinates 753,270 E and 1,042, 100 N (Figure 2-1). If packer tests suggest the permeability at this location is too low for a pumping well, this location will be completed as an observation well and an alternate pumping location will be selected. The exact location will be determined in the field based on accessibility and results of field testing. The well borehole should be advanced through unconsolidated materials to bedrock, then



● Monitoring Well ID
(November 1997 TCE concentration, µg/l)

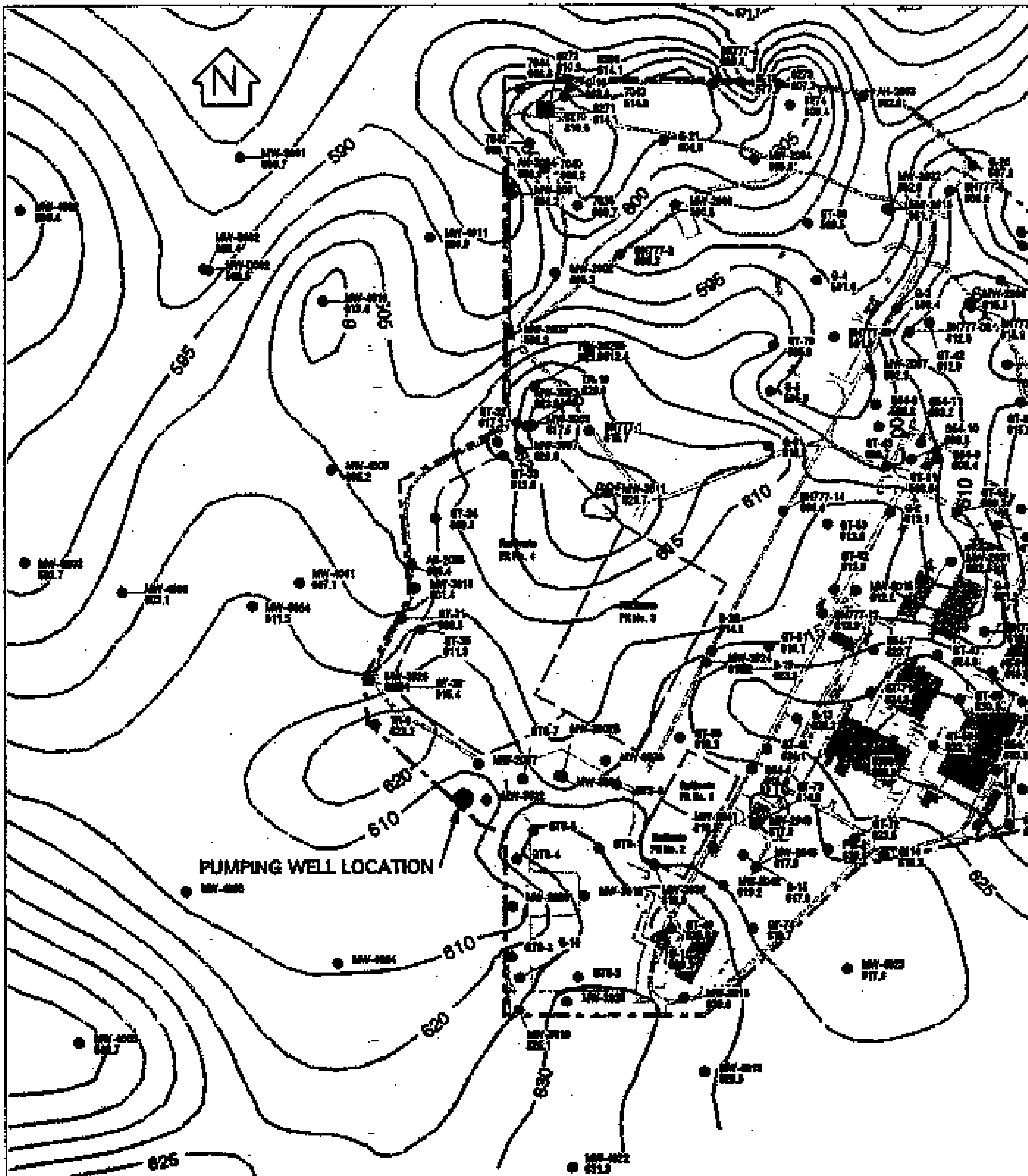
50 25 0 50 METERS

150 75 0 150 FEET

**PROPOSED WELL LOCATION
FOR GWOU PUMP TEST
AND TCE CONTAMINANT CONCENTRATIONS**

Figure: 2-1

REPORT NO.: DOE/OR/21548-731		EXHIBIT NO.: G/CP/392/0398
ORIGINATOR: MT	DRAWN BY: WSSRAP GIS	DATE: 04/06/98



BEDROCK - TOP OF WEATHERED BURLINGTON-KEOKUK

FIGURE 2-2

REPORT NO.:	DOE\OR\21548-731	EXHIBIT NO.:	A/CP/015/0398		
ORIGINATOR:	MET	DRAWN BY:	GLN	DATE:	3/20/98

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continuously cored until the weathered unit is completely penetrated, approximately 50 ft to 60 ft below grade, as determined by the in-field geologist. Drilling activities will be performed as specified in the task descriptions for WP-510. The bedrock core samples will be logged according to Procedure ES&H 4.4.7, with particular emphasis on visual indications of groundwater occurrence and loss of drilling fluid (potable water) circulation.

Constant head packer tests shall be performed at 10 ft intervals from the top of bedrock as the coring progresses. Core logging will be performed by the Project Management Contractor (PMC) or its designated representative.

Upon completion of the rock coring, the borehole will be secured and left idle for a period of at least 24 hours to allow the groundwater level to reach equilibrium. Any excess borehole depth (overdrilled during coring below the desired screen interval) shall be infilled with sodium bentonite pellets or grout. The borehole shall be reamed to a diameter of 10 in. prior to installation of 6-in. diameter polyvinyl chloride (PVC) screen and well casing.

The rationale for selection of PVC as the well construction material includes the following: the levels of TCE are expected to be less than 1 mg/l, the well is not intended for long-term monitoring, abandonment is less troublesome, and PVC is less costly. Although it is well documented that PVC may absorb volatile organic compounds, it is not expected that this characteristic will interfere with groundwater analytical results (false negatives) because samples being collected for TCE analysis during the pumping tests will not have had any potential for long-term contact with the well construction material (WSSRAP Environmental Safety and Health Department Position Paper: *Use of PVC as an Acceptable Material for Well Construction*. Position Paper No. 1, Rev. A DIN51944). If it is determined that the well will be used for long-term monitoring, the well will be retrofitted with 2 in. stainless steel construction materials.

The screened interval will be 10 ft to 20 ft in length and the depths of emplacement will be determined by the PMC geologist, based upon the results of packer tests and lithologic logs. The screened interval shall be sand-packed from the bottom plug below the screen up to 3 ft to 5 ft above the screen. A minimum of 3 ft of sodium bentonite pellets shall be emplaced above the sand pack and adequately hydrated if necessary, to provide a competent bentonite seal above the screened interval. The remaining annular space will be filled with a high-solids bentonite grout up from the bentonite seal to ground surface.

Well development will proceed after a period of at least 24 hours from grout placement. Development will proceed according to Procedure ES&H 4.4.8 until the produced water is clear and the pH stabilizes, or until the PMC geologist determines that the well is adequately developed. Disposition of developed groundwater is discussed in Section 2.4. Groundwater samples will be collected during and after the well is developed, as discussed in Section 2.3. The completed well will be secured with a lockable, above-grade casing protector. The well will be identified as MW-3028.

2.1.2 Observation Wells

A maximum of five observation wells will be installed at locations within 100 ft of the pumping well. Selection of locations will be made following analysis of data obtained from the single well constant discharge pumping test (Section 2.2.2) which will be performed upon completion of the pumping well installation.

The observation wells shall be constructed of 2-in. PVC screens and riser pipes, installed to depths of 40 ft to 60 ft below grade. Continuous bedrock cores will be collected and logged according to Procedure ES&H 4.4.7 and packer tested every 10 ft as coring proceeds. When the borehole is completed to the desired depth, it shall be secured and allowed to remain idle at least 24 hours to allow the potentiometric surface to equilibrate.

The borehole shall be reamed using rotary wash methods to accept installation of 2-in. diameter screen and riser pipe.

The screened interval for each well shall be 10 ft in length, and for at least three wells, the screen shall be emplaced across the potentiometric surface. At least one of the wells will have the screen placed across the lower portion of the weathered unit that will be used to assess vertical anisotropy. The annular space around the screens shall be sand-packed to 3 ft to 5 ft above the screened interval, and a minimum of 3 ft of sodium bentonite pellets shall be placed above the sand. A bentonite slurry will be used to fill the remaining annular space from the top of the bentonite pellets up to ground surface.

The piezometers shall be developed according to Procedure ES&H 4.4.8 until the produced water runs clear and the pH stabilizes or until the PMC geologist determines that the development is adequate.

2.2 Pumping Tests

All pumping tests will be conducted in the newly installed production well with a stainless steel, submersible, variable pumping rate electric pump installed 1 ft to 2 ft above the well sump or bottom cap. Prior to all tests, groundwater levels in the pumping well and observation wells, if applicable, will be recorded. Notes will also be made as to whether the levels are stabilized.

Pressure transducers and electric data loggers will be used to measure changes in water levels as the tests proceed. Flow rate measurements will be recorded at least hourly during the initial stages of each test. Produced groundwater will be discharged into a holding tank for temporary storage. Transport and disposition are discussed in Section 2.4 of this document.

2.2.1 Single Well Variable Discharge Test

The single well variable discharge test, or step-drawdown test will be conducted after the production well is adequately developed and the groundwater potentiometric surface has reached equilibrium. This test will be performed to determine a sustainable pumping rate for subsequent tests. Prior to initiating the step-drawdown test, the groundwater levels will be measured and recorded in the production well and in monitoring wells MW-2036, MW-2037,MW-2038, MW-3027, and MWS-21 (Figure 2-1). It should be noted that the monitoring well water levels and any associated drawdown affects from the step test will not be used for long-term pump rate calculations, but may be used to provide preliminary information regarding hydraulic communication between these locations in the event that groundwater level drawdown, if any, is detected at these locations after the test well is pumped.

Prior to starting the test recordings, the pump will be secured in the well, tested, and set for the desired pump rate for the first (lowest pump rate) test. When pump performance is deemed adequate, the pump will be stopped and the water level will be allowed to reach equilibrium before the data is recorded. Pumping for the first step of the test will begin in the well after the pressure transducer has been secured at least 8 ft and no more than 22 ft below the stabilized potentiometric surface within the production well. The data logger will record the pressure transducer water level readings in logarithmic time intervals and the pump increased pumping rates for each subsequent test.

Before beginning each step of the test, the pump will be started during the first log cycle of the recordings (within 3 seconds). Each step will be chronographed and the times of pumping and recovery will be recorded. It is expected that the initial pumping rate will be less than 1 gal per minute, with a duration of approximately 1 hour. The actual initial rate selection will be based upon well performance observed during the well development.

The second test step will begin with the pumping rate increased. At least three of these steps will be performed to determine the aquifer transmissivity and well loss constant from which a sustainable pumping rate will be ascertained for the long-term, constant discharge tests.

Times of each test will be recorded and water levels in the monitoring wells will be measured and recorded immediately after the step-drawdown test is completed. It is expected that the pumping portion of the step-drawdown test can be completed in 1 day.

2.2.2 Single Well Constant Discharge Test

The single well constant discharge pump test will consist of pumping the production well at the optimum rate as determined from the step-drawdown test. Water levels in the production well and monitoring wells listed in the previous section will be measured and recorded. Pressure transducers and electronic data loggers will be used to monitor water level changes in the wells. Barometric pressure readings which coincide with the times of pumping and recovery will be recorded at the WSSRAP meteorological station. The times of pumping and recovery will be recorded.

The selected pumping rate will be set and the test will begin when the water level in the production well is stabilized. The data logger will be started and pumping will begin within the first log cycle of time. The well will be pumped at a constant rate for a minimum of 72 hours and will continue until the influence of primary porosity is apparent and the steady state is achieved. In the event of pump failure, two backup pumps will be available for immediate replacement in the production well. A gasoline-powered electric generator will be at the well site to provide electricity in the event of a power failure. Pumping rates will be checked every 15 minutes during the first 2 hours of the test, then hourly for the remainder of the test.

Upon completion of pumping the well, the water level in the well will continue to be measured and recorded until the groundwater level fully recovers.

2.2.3 Multiple Well Constant Discharge Test

The multiple well test will be designed and implemented following completion and analyses of the single well tests. It is expected that three to five newly installed observation wells will be utilized to measure drawdown responses to constant discharge from the production well. Water levels from the observation wells will be measured following well completion and development. Pressure transducers will be placed in the production well and each observation well when it has been determined that groundwater has reached equilibrium in the wells and the levels have been recorded. The pump will be calibrated to discharge at the rate predetermined from results of the single well tests. The time of starting the pump will be recorded and the data loggers will be set to collect water level readings in logarithmic time.

The pump will be started during the first log cycle of data logging, and discharge rates will be checked every 10 minutes for the first 2 hours of the test, or until it has been determined that the pump performance is satisfactory. Thereafter, the production rate will be checked hourly. Hourly barometric pressure readings that coincide with the time of pumping will be available from the Weldon Spring Site Remedial Action Project (WSSRAP) meteorological station. The production well will be pumped for an estimated 240 hours or until it is determined that steady state conditions have been realized. The time of pump shutdown will be recorded and the data loggers will continue to collect groundwater level readings in the production well and observation wells until the water levels have fully recovered.

2.3 Groundwater Quality Monitoring

Groundwater samples will be collected for field parameter measurements (pH, Eh, dissolved oxygen specific conductance) and for TCE/PCE analysis before and during the pumping tests. Samples will be collected, identified, and analyzed as specified in Section 3.2. The data will be used to determine whether any upward or downward trends in contaminant concentrations become apparent as the aquifer responds to pumping. The analyses will also be used to determine disposition of the groundwater produced during the tests.

Samples for TCE/PCE analysis from the production well and from existing monitoring wells MW-2036, MW-2037, MW-2038, MW-3027, and MWS-21 will be collected the week before pumping is scheduled to begin for the step-drawdown test. Additional samples for nitrate, nitroaromatic compounds, iron, manganese, and total uranium will also be collected only from the production well in the week before pumping. The results will be used as baseline values for groundwater quality, and will be used to represent the contaminant concentration for which treatment considerations and requirements must be made for the water produced during the tests. The treatment requirements may change if samples collected during subsequent pump tests so indicate. Wastewater treatment is discussed in Section 2.6.

Additional sampling for TCE/PCE will be conducted during the single well constant discharge test. One sample will be collected from the production well during the first 30 minutes of the test, and at least one additional sample will be collected at the end of the test. Analytical results from these samples will be used to make adjustments, if any, to handling and treatment of the water produced during the final, multiple well pump test, which will produce the greatest amount of water.

Sample numbering will follow Procedure ES&H 4.1.1, *Numbering System for Environmental Samples and Sampling Locations*. Sample forms from Procedure ES&H 4.4.1, *Groundwater Sampling*, will be completed for each sample, with at least the following information:

- Sample ID Number
- Location
- Date
- Time of Collection
- Sample collection method
- Preservation
- Name(s) of sampler(s)

Chain-of-custody forms for laboratory samples will be completed and placed in the sample coolers. Sample coolers prepared for shipment will be sealed with chain-of-custody control seals signed and dated by the shipper. Chain-of-custody forms will be prepared in accordance with Procedure ES&H 4.1.2, *Initiation, Generation, and Transfer of Environmental Chain of Custody*.

TCE (VOA) samples will be collected directly from the pump. The samples will be placed in two 40 ml glass vials with no head space. Samples collected for nitrate will be preserved with sulfuric acid to a pH <2 in a 250 ml plastic bottle. Samples collected for nitroaromatics will be placed in 1 liter amber glass bottles and cooled on ice. Samples collected for total uranium will be placed in 250 ml plastic bottles and for metals in 500 ml bottles preserved with nitric acid to a pH <2. The samples will then be placed on ice in coolers while in the field. Sample labels will be completed and attached to all containers prior to placement in the coolers. Sample collection and labeling of containers will be in accordance with Procedure ES&H 4.4.1, *Groundwater Sampling*, and ES&H 4.1.1, *Numbering System for Environmental Samples and Sampling Locations*. Sample locations, samples collected, and related data will be recorded in a logbook at the time of collection in accordance with Procedure ES&H 1.1.4, *Logbook Procedure*, and on the groundwater sampling data sheet in accordance with Procedure ES&H 4.4.1, *Groundwater Sampling*.

2.4 Preservation Methods and Sample Containers

Preservation methods and containers for all samples collected will be in accordance with the requirements specified by the selected analytical methods. Table 2-1 details the requirements for each parameter.

When an off-site laboratory is used, samples will be packaged and transported to the laboratory in accordance with U.S. Department of Transportation Requirements, the *Site Consolidation Transportation Activity Manual* (Ref. 2), and Weldon Spring Site Remedial Action Project (WSSRAP) procedures. A separate custody record must accompany each sample cooler or package (Ref. 3).

Table 2-1 Sample Preservation and Collection Details

ANALYSIS	CONTAINER SIZE AND TYPE	PRESERVATIVE
TCE/PCE, VOA only	2-40 ml glass vial	2 drops of HCL cooled on ice, no head space
Nitrate	250 ml plastic	H_2SO_4; pH <2
Nitroaromatics	1 liter glass	Cooled on ice
Uranium, total	250 ml plastic	HNO_3 to pH <2
Metals (iron, manganese)	500 ml plastic	HNO_3 to pH <2

2.5 Quality Control Samples

Quality control samples will be collected to ensure consistent and accurate performance of sample collection and laboratory analysis. Table 2-2 provides a summary list of the quality control samples that will be collected to support the final survey.

Table 2-2 Field Quality Control Sample Summary

QUALITY CONTROL SAMPLE TYPE	FREQUENCY	PURPOSE
Matrix Spike/Matrix Spike Duplicate or Matrix Duplicate	1 per 20 or 1 per 14 days [a]	Assess matrix and possible interlaboratory variability
Field Replicate	1 per 20	Assess matrix and interlaboratory variability
Trip Blank[b]	1 per shipment	Assess impact of ambient conditions on samples during transportation

(a) Whichever is of higher frequency.
(b) Collected together on the same day.

2.6 Management of Samples for Off-Site Transportation

Groundwater samples collected for contaminant analysis and planned for off-site shipment are required to comply with the WSSRAP transportation requirements. The requirements for shipping of environmental samples are detailed in Environmental Compliance Departmental Instruction ECDI-3, *Hazardous Material/Sample Transportation Activity (HMSTA) Operations*. This instruction specifies that the sampler securely close, label, and chemically preserve samples before submittal to shipping. This procedure also requires that specific sample characteristics be determined to assess whether samples require special handling as hazardous materials.

The applicable sample characteristics are identified as part of this sampling plan to project and identify specialized transportation requirements for this sampling activity. All off-site sample shipments will require completion of a Transportation Certification Form. All personnel requesting shipment of samples to off-site laboratories are required to be trained in ECDI-3 and site-specific DOT regulation training.

2.6.1 PCBs Determination

All samples must be identified as to whether they contain PCBs. Samples likely containing PCBs include petroleum products or residues. If samples show an oily sheen, then petroleum products are likely present. The presence of petroleum residues shall be identified on the Transportation Certification Form.

Samples containing PCB materials greater than 50 ppm require that a TSCA PCB mark be placed on the sample container. If the sample contains more than 1 lb of PCBs, then the material must certify whether it contains a reportable quantity under 40 CFR 172.101 Table 1. The concentration and quantity of PCBs must be identified on the Transportation Certification Form. If the samples do not contain PCBS, this information should also be identified.

Groundwater samples from the WSCP area have been sampled for PCBs and no detectable PCB compounds have been identified to date. Therefore, no PCB labeling or special handling requirements are anticipated for this activity.

2.6.2 Radioactive Material Determination

Samples collected in a designated Radioactive Material Management Area (RMMA) such as the raffinate pit area require a radiological survey to determine whether samples are radioactive above 2000 pCi/ml. Samples will be surveyed at Access Control in accordance with Procedure ES&H 2.3.8s, *Contamination Survey*. A radiological concentration will be estimated by access control personnel. If a sample has potential to exceed the estimated 2000 pCi/ml concentrations, a subsample must be analyzed by the on-site radiological laboratory prior to shipment. A copy of all surveys and radiological laboratory data must be provided to the shipping department prior to authorization to ship samples. The radioactive materials determination will be documented on the Transportation Certification Form.

For this sampling activity, it is not expected that groundwater samples collected from the designated areas will be radioactive above 2000 pCi/ml. Groundwater samples collected from nearby well locations have not exceeded 60 pCi/l for total uranium.

2.6.3 Friable Asbestos

Samples containing friable asbestos greater than 1% require special transportation requirements. A designation of whether or not friable asbestos is contained with samples to be shipped must be identified on the Transportation Certification Form.

No friable asbestos is projected to be found in the groundwater samples for this activity.

2.6.4 Characteristic or Listed Hazardous Wastes

Samples prepared for shipment must be reviewed to determine if they are defined as characteristic or listed waste under 40 CFR 261.24. The characteristics reviewed are, ignitability, corrosivity, reactivity, and toxicity. Samples collected at the WSSRAP other than for waste characterization are unlikely to meet ignitability characteristics. Corrosivity is determined by measuring the pH of an aqueous solution prior to sample preservation as presented in Section 3.3.6. If the pH is less than 2.0 or higher than 12.5, it is potentially corrosive and should be indicated on the Transportation Certification Form. Reactivity is characterized as a solid waste that is a cyanide or sulfide bearing waste or capable of detonating. Reactivity should be identified as characteristic waste.

Samples should also be identified as containing compounds with toxicity characteristics above the maximum concentrations listed in Table 1 of 40 CFR 261.24. For groundwater, if the concentration levels in samples exceed the listed concentrations, a waste code must be identified. For solid compounds, if the concentration of the sample exceed twenty times the listed concentrations, the waste code must be identified since the material may potentially exceed TCLP levels. The waste codes are required to be identified on the Transportation Certification Form.

For this sampling activity, the compounds that are most likely to be found in the groundwater samples based on prior sampling data are uranium, nitroaromatics, nitrate, and trichloroethylene (TCE). Only toxicity is considered to be a potentially applicable characteristic for review. TCE has been found in groundwater at concentrations up to 1000 ug/l in the raffinate pit area. These levels exceed the maximum concentration level listed as characteristic (500 ug/l). Previously collected groundwater samples have contained the nitroaromatic compound 2,4-DNT. These samples have ranged from not-detected to 8.00 ug/l. These levels do not exceed the maximum concentration level listed as characteristic (130 ug/l). Therefore, only a waste code of D040 for TCE must be identified on the Transportation Certification Form under characteristics or listed hazardous waste.

2.6.5 Biological Determination

Biological samples (urine, fecal samples) collected for bioassay determination must be identified on the Transportation Certification Form. A maximum size for transportation of bodily fluids/excretion samples is 50 ml/g.

This sampling activity does not include sampling of biological materials.

2.6.6 Preservation Guidelines

Samples that are chemically preserved in accordance with analytical methods are required to comply with sample preservation limits set in ECDI-3. Samples will be collected for volatile organic compounds, uranium, nitrate, and nitroaromatics for this sampling program. Samples for volatiles analysis will require preservation with HCL, which shall not exceed 4% of the weight or approximately 4 drops per 40 ml. Nitrate samples will be preserved with sulfuric acid and shall not exceed 15% of the weight or approximately 2 ml. Uranium samples will be preserved with nitric acid not to exceed 15% of the sample weight.

The pH of the groundwater samples prior to preservation will be recorded as part of the field parameter measurements and will be recorded in the logbook and on the sample container. The pH of groundwater samples is approximately 7.5. Preservation guidelines will be maintained during sample preparation.

2.7 Management and Disposition of Investigation Derived Wastes

All waste streams generated during these activities will be managed in accordance with ECDI-18, *Handling and Disposition of Site Generated Wastes*. Wastes generated during well drilling will be soil and rock cuttings; core and drilling water will be handled as specified in Task Description 1 Work Package 510. The anticipated wastes generated during pump test operations will be personal protective equipment (PPE), miscellaneous trash, water used for decontamination, and extracted groundwater.

The PPE and miscellaneous trash that meet the requirements stated below and as detailed in CM&O-20, *Building 434 Compactor/Crusher Operations* will be considered compactible trash and placed in radiological bags, marked with the date and "GWOU PUMP TEST" and taken to Building 434 for compaction. Materials not meeting these requirements are considered noncompactible trash and will be marked with the date and "GWOU PUMP TEST" and placed in the noncompactible trash Sea-Land containers at the asbestos storage area (ASA). The requirements for compactible trash are as follows:

- Waste must NOT contain:
  - Rigid objects longer than 22.5 in.
  - Free liquids of any type including water.
  - Pressurized containers.
  - Metal objects (drums and depressurized cans are acceptable).
  - Free chemicals in any form.
  - Asbestos

The extracted groundwater will be containerized in drums and held in 55-gallon drums inside a metal tub for secondary containment. The wastewater will initially be held at Decontamination Pad 4 at the chemical stabilization and solidification (CSS) pilot scale facility and transferred to a 5,000 gal tank for storage prior to treatment. The groundwater extracted from the well will be transported directly to the site water treatment plant (SWTP) for treatment. Wastewater disposition will be conducted by the Compliance Department and coordinated with the site water treatment plant process engineer. When the tests are complete, the 55-gallon containers will be decontaminated in accordance with ECDI-10, *Container Management Instruction* and taken to Building 434 for safe compaction. The metal tub will be decontaminated and returned to the storage location. Any water used for decontamination (i.e., water used to decontaminate the static water level (SWL) indicator or other miscellaneous equipment) will be placed in a 5-gallon container that is covered when not in use. A Disposition Documentation Form (DDF) will be required to disposition this container at the Building 434 decon pad sump. All containers and tanks will be marked with a hazardous waste mark (D040) and appropriate DOT designation.

The Compliance Department will be notified for disposition of other wastes types that may be generated during this work.

2.8 Field Implementation Summary

The following summarizes the sequence of pumping test events and is intended as a guideline to facilitate field implementation of the technical work plan:

1. A production well will be installed in the predetermined (or alternate if conditions warrant) location.

   a. Rock core will be continuously collected and logged until it is determined that the weathered unit is fully penetrated.

b. Packer tests will be conducted as the borehole is advanced to identify permeable zones.

c. A 6-in. PVC well will be completed in the boring which fully penetrates the weathered unit.

d. The well will be developed and the potentiometric surface will be allowed to stabilize.

e. Groundwater samples for TCE/PCE will be collected from the production well and from monitoring wells MW-2036, MW-2037, MW-2038 and MWS-21 (see Sections 2.3 and 3.2), and shipped off-site for analysis.

2. A single well step-drawdown test will be performed.

a. Water levels will be checked in the production well and in monitoring wells MW-2036, MW-2037, MW-2038, MW-3027, and MWS-21.

b. A pressure transducer will be secured in the production well and data logger calibrated and set to record in log time.

c. The initial pumping rate will be calibrated.

d. The data logger will be turned on and the time recorded.

e. The pump will be started within 3 seconds of turning on the data logger, and the pump rate immediately checked.

f. The pumping will continue for approximately 60 minutes, with production rates checked every 15 minutes during the test.

g. The pump will be shut off, and the data logger will be left recording.

h. Water levels in the monitoring wells will be checked and recorded immediately after pumping stops.

i. The data logger will be stopped and the time logged when it is determined by the PMC geologist that the well is sufficiently recovered.

j. The test will be repeated at least twice (Items c through) with incremental pump increases with each repetition.

k. Water levels at locations previously measured will be rechecked.

l. Step test data will be downloaded to a computer and plotted to calculate the well loss coefficient and optimum pumping rate for subsequent pumping tests using standard methods.

3. A single well constant discharge pump test will be performed:

   a. Water levels will be checked in the production well and in monitoring wells MW-2036, MW-2037, MW-2038, MW-3027, and MWS-21.

   b. Pressure transducers will be secured in the monitoring wells and production well, calibrated, and set to record in log time.

   c. The optimum pump rate will be set.

   d. The data loggers for the monitoring wells and production well will be turned on and the times recorded.

   e. The pump will be started within 3 seconds of turning on the data logger in the production well and the pump rate immediately checked and calibrated.

   f. The pumping will continue for approximately 72 hours at the predetermined optimum rate, with production rates checked every 15 minutes the first hour, and hourly thereafter during the test.

   g. Groundwater from the production well will be sampled for TCE, nitroaromatics, nitrate, iron, manganese, and total uranium during the first hour of the test, and shipped off-site for analysis.

   h. When it is determined that the pumping time is sufficient, a groundwater sample for TCE/PCE will be collected, the pump will be shut off, and the data loggers will be left recording during wells recovery.

   i. The data loggers will be stopped and the times logged when the PMC geologist determines that the wells is sufficiently recovered.

   j. Barometric pressure readings correlating to the time of pumping will be obtained from the meteorological station.

   k. Data from the production well drawdown will be used to determine transmissivity and estimate radius of influence.

   l. Data from the monitoring wells will be downloaded and reviewed to determine if any influence from pumping (fracture communication) extended out to these locations.

4. If it is determined that sustained pumping will produce a measurable radius of influence observation wells will be installed at three to five locations around the pumping well. Locations will be determined using data from the 72-hour single well test.

   a. Rock borings will be drilled in selected locations and advanced at least 8 ft below the potentiometric surface. At least one boring will be advanced to a depth that will allow monitoring of the lower portion of the weathered unit.

   b. The borings will remain open at least 24 hours until the potentiometric surface stabilizes.

   c. Two-inch PVC observation wells will be completed in the boreholes at depths that place the potentiometric surface within the upper 5 ft of the 10 ft screen lengths.

   d. The wells will be developed and the water levels will be allowed to stabilize.

5. A multiple well, constant discharge pumping test will be performed.

   a. Water levels will be checked in the production well, observation wells, and in monitoring wells MW-2036, MW-2037, MW-2038, MW-3027, and MWS-21.

   b. Pressure transducers will be secured in the observation wells and production well, calibrated, and data loggers set to record in log time.

   c. The optimum pump rate will be calibrated and set.

   d. The data loggers in the observation wells and production well will be turned on and the times recorded.

   e. The pump will be started within 3 seconds of turning on the data logger in the production well and the pump rate immediately checked.

   f. Pumping will continue for approximately 240 hours, with production rates checked every 15 minutes the first hour and hourly thereafter during the test.

   g. Groundwater from the production well will be sampled for TCE during the first hour of the test, and shipped off-site for analysis.

   h. When it is determined that the pumping time is sufficient, a groundwater sample for TCE/PCE will be collected, the pump will be shut off, and the data loggers will be left recording during well recovery.

i. The data loggers will be stopped and the times logged when it is determined by the PMC geologist that the wells are sufficiently recovered.

j. Barometric pressure readings correlating to the time of pumping will be obtained from the meteorological station.

k. Water levels in the production well, observation piezometers, MW-2036, MW-2037, MW-2038, MW-3027, and MWS-21 will be checked and recorded.

l. Data from the production well and observation wells data loggers will be downloaded to a computer. Diagnostic plots will be prepared to facilitate data interpretation and analysis.

3. DATA REDUCTION AND ANALYSIS

3.1 Pumping Tests

The purpose of pump tests is chiefly to evaluate aquifer properties and boundary conditions by pumping water from a well and measuring discharge and associated drawdowns in the production well and observation wells, and then using the rates and measurements in the appropriate flow equation for the desired characteristics. A variety of pumping test data analytical methods have been developed for interpretation of the results. The methods selection will be based upon results from previously conducted aquifer characterization studies at the chemical plant and from diagnostic data plots of newly acquired data to identify the predominant groundwater flow system, thereby reducing the analytical method alternatives.

The initial step in analysis of the data will be to correct the observations for any external influences. Water levels in the production well and observation wells taken several days prior to and after the pump tests will be used to assist in determining whether any events other than pumping influenced the water levels. In addition, water level hydrographs from nearby wells determined to be uninfluenced by pumping may be used to ascertain whether influences from external events have been introduced. Additional adjustments to water levels may be required if barometric pressure fluctuates during the pump tests and recovery periods.

Prior to selection of a method of data analysis, diagnostic plots will be constructed consisting of log-log plots of drawdown versus time, semi-log plots of drawdown versus time, and drawdown versus distance to the pumped well. The drawdown relationships, or curves, shown by the diagnostic plots will be used to select the most appropriate analytical technique.

3.1.1 Single Well Variable Discharge Test

The variable rate test data will be analyzed prior to conducting the single well, constant discharge test in order to determine the optimum pumping rate for the production well. The objective of the test is to use the data to calculate well loss coefficient, from which the optimum rate is determined, using operations such as the Hantush-Bierschenk method or the Eden-Hazel method (Ref. 2). Both methods are based upon the original equation of Jacob (1947) (Ref. 2).

3.1.2 Single Well Constant Discharge Test

Data from the single well constant discharge test will be reduced and analyzed prior to selection of observation well locations for the multiple well test. Selection of the analytical method will be made after diagnostic plots of the data are made. The Jacob's straight-line or Warren-Root's straight-line (Ref. 2) for fractured aquifers are potential methods for analysis of this single well test.

3.1.3 Multiple Well Constant Discharge Test

Straight-line and curve-fitting methods may be used in calculating aquifer properties from this test. Both distance-drawdown and time-drawdown data plots will be constructed from the results of this test. If the data plots indicate double-porosity aquifer characteristics (discernible early-time, intermediate-time, late-time responses), methods such as Bourdet-Gringarten curve-fit or Kazemi et al's straight-line (Ref. 2) may be used to analyze the data if double-porosity effects are discernible in the test data.

3.2 Groundwater Quality Analytical Results

Laboratory analytical results of groundwater samples collected will be reviewed in accordance to Procedure ES&H 1.1.7. The data will be presented in the completion report (Section 4) for the investigation. The data will be in a format that presents the results with respect to the time of sampling and with respect to the investigation activities that were ongoing during the sampling. Any apparent trends in contaminant concentrations will be noted and checked for statistical significance.

4. REPORTING

An interim report will be prepared following analysis of data from the single well constant discharge pumping test.

When all tests have been completed and the data evaluated, a completion report will be generated that will present the findings of the investigation. The report will include summaries of the field procedures, pumping test data plots, pump test data evaluation methods and results, and groundwater quality analytical results. Discussions of the results will accompany the summaries.

5. REFERENCES

1. Argonne National Laboratory. *Feasibility Study for Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area and the Ordnance Works Area, Weldon Spring, Missouri.* DOE/OR/21548-569. Prepared for the U.S. Department of Energy, Oak Ridge Operations Office. St. Charles, MO. March 1998.

2. Kruseman, G.P. and N.A. deRidder, with assistance from J.M.Verweij. *Analysis and Evaluation of Pumping Test Data, Second Edition.* Institute for Land Reclamation and Improvement/ILRI Publication 47. Wageningen, The Netherlands. 1990.

PROCEDURES

CM&O-20, *Building 434 Compactor/Crusher Operations*
ES&H 1.1.7, *Reporting Above Normal Values From Environmental Monitoring Networks*
ES&H 4.4.7, *Soil, Rock Core, and Rock Chip Borehole Logging*
ES&H 4.4.8, *Monitoring Well Installation and Development*

DEPARTMENTAL INSTRUCTIONS

ECDI-10, *Container Management Instruction*
ECDI-18, *Handling and Disposition of Site Generated Wastes*