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SOUTH PLUME GROUNDWATER RECOVERY SYSTEM DESIGN, MONITORING, AND EVALUATION PROGRAM PLAN

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South Plume Groundwater Recovery System Design, Monitoring, and Evaluation Program Plan

Environmental Remedial Action Project
Fernald Environmental Management Project
Fernald, Ohio

WEMCO Subcontract No. 2-21487
July 15, 1992
Revision No. 0

(Formerly the O&M Manual)

Operable Unit 5, Project Order 37

PARSONS

Fairfield Executive Center
6120 South Gilmore Road
Fairfield, Ohio 45014

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LIST OF ACRONYMS AND ABBREVIATIONS

AWWT	Advanced Waste Water Treatment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DMEPP	South Plume Recovery System - Design, Monitoring and Evaluation Program Plan
DOE	United States Department of Energy
EE/CA	Engineering Evaluation/Cost Analysis
FEMP	Fernald Environmental Management Project
IAWWT	Interim Advanced Waste Water Treatment
Ohio EPA	Ohio Environmental Protection Agency
O&M	Operation and Maintenance
PRRS	Paddys Run Road Site
QAPjP	Draft FEMP CERCLA Quality Assurance Project Plan
RI/FS	Remedial Investigation/Feasibility Study
SOWC	Southwest Ohio Water Company
SWRB	Storm Water Retention Basin
US EPA	United States Environmental Protection Agency
WEMCO	Westinghouse Environmental Management Company of Ohio

SECTION 1

INTRODUCTION

1.1 Purpose and Description

This Design, Monitoring, and Evaluation Program Plan (DMEPP) (formerly the Operation and Maintenance Manual)~~(O&M Manual)~~ has been prepared to delineate a program of ~~operation and maintenance~~ design confirmation, monitoring and evaluation activities associated with the groundwater recovery system for the south groundwater contamination plume (south plume) removal action at the Fernald Environmental Management Project (FEMP) near Fernald, Ohio. The south plume removal action is required pursuant to the 1990 Consent Agreement between the United States Environmental Protection Agency (US EPA) and the United States Department of Energy (DOE).

To facilitate more efficient design and construction, the south plume removal action has been divided into five parts:

Part 1) Alternative Water Supply
Part 2) Pumping and Discharge System
Part 3) Interim Advanced Wastewater Treatment System
Part 4) Groundwater Monitoring and Institutional Controls
Part 5) Groundwater Modeling and Geochemical Investigation

~~An O&M Manual~~ The DMEPP is needed to confirm the design assumptions and to effectively operate the groundwater recovery system over a period of time. ~~The O&M Manual~~ The DMEPP is required in the ~~approved~~ Part 2 - Pumping and Discharge System and Part 3 - Interim Advanced Wastewater Treatment System Work Plan ~~dated March 1991~~ Westinghouse Environmental Management Company of Ohio (WEMCO 1992a). This document fulfills this requirement.

~~This O&M Manual consists of three parts:~~

~~1) Volume I - Operation Methodology - This portion of the O&M Manual~~
The DMEPP describes system objectives and management programs to help ensure that the system meets these objectives. These management programs are a design confirmation program, a monitoring program, and an evaluation/response program. The detailed operation and maintenance procedures will be included in a separate document.

~~2) Volume II - Detailed Operation - This portion of the O&M Manual defines specific procedures associated with operation of the system equipment.~~

~~3) Volume III - Maintenance - This portion of the O&M Manual defines the specific procedures associated with maintaining the system equipment.~~

1.2 Background

Operable Unit 5 (OU-5) - Environmental Media, of the FEMP Remedial Investigation/Feasibility Study (RI/FS), includes those environmental media that serve as migration pathways and/or environmental receptors of radiological or chemical releases from the FEMP. RI/FS findings have determined that a uranium contaminant plume exists in an area outside of FEMP property to the south ~~(see Figure 1-1)~~. Because of the associated potential threats to human health and the environment, a removal action to address this plume outside of the FEMP boundary has been planned. The 1990 Consent Agreement between the DOE and the US EPA, Section IX, A.3, requires the submission of a proposal for additional monitoring wells, Engineering Evaluation/Cost Analysis, and a work plan for the south plume removal action.

The Engineering Evaluation/Cost Analysis - South Plume (South Plume EE/CA) (DOE 1990a) was initially submitted in May 1990; and after the public comment process (and resolution to the dispute between the US EPA and DOE), it was finalized in November 1990. The South Plume EE/CA selected alternative 4 which included groundwater pumping and discharge, an alternative water supply for two industrial users, installation of an Interim Advanced Waste Water Treatment System (IAWWT), and enhanced monitoring and institutional controls. The initial location of recovery wells, based on groundwater modeling simulations, was along New Haven Road just west of its intersection with State Route 128 (see ~~Figure 1-1~~ Section 2 for maps and further description).

As a result of information obtained recently from a separate remedial investigation that is being performed at the Paddys Run Road Site (PRRS), additional concerns have been identified in the South Plume area. The PRRS consists of several industries (e.g., Mobil Mining and Minerals Co. Inc., Albright & Wilson Americas Co., and Rutgers and Nease) that, over the past years, have reportedly released both organics and inorganics into the environment which have now found their way to the Great Miami aquifer. Some of these contaminants include cumene, toluene, benzene, arsenic, mercury, and others. The PRRS plume has been determined to extend to very near the location of the proposed recovery well field as described in the November 1990 South Plume EE/CA. Therefore, operation of a uranium recovery well field at the location originally described could result in the extraction and discharge of PRRS contaminants to the Great Miami River (IAWWT system will only address uranium) and could result in the further spreading of the PRRS contaminants as has been predicted by computer modeling.

As a result of these conditions, it has been deemed necessary to relocate the Part 2 well field to an area north of the PRRS. Modeling efforts have been performed to determine a location where pumping of the recovery well field will not significantly affect the PRRS plume and will not draw PRRS contaminants into the recovery well field. In addition, it was necessary to alter the November 1990 South Plume

EE/CA with an addendum entitled "Explanation of Significant Differences" which restructured the EE/CA objectives to accommodate these conditions.

This relocation of the Part 2 well field has generated several additional requirements. The new location is in an area of higher uranium concentration which jeopardizes the equivalent mass treatment concept as described in the November 1990 EE/CA. Accordingly, the Part 3 IAWWT system will be expanded in size to provide the additional treatment necessary to meet the previously agreed to equivalent mass discharge concept.

In addition, the relocated well field is upgradient of an area of known 30 μg/l uranium contamination. The computer model for the south plume predicts that other areas could also exist where the level of uranium concentration is above 30 μg/l (DOE 1992a). Therefore, an additional investigation will be performed under a new Part 5 of the south plume removal action (DOE 1992b). The Part 5 investigation will include hydropunching and soil vapor survey of the area south and north of the well field ~~to New Haven Road~~. The investigation will identify the location of the 30 μg/l uranium isopleth. Because the US EPA has recently issued a proposed revised limit of 20 μg/l for uranium in drinking water, the investigation will also identify the location of the 20 μg/l isopleth. The information obtained will be used to allow the FEMP to limit access to this water until additional response action in ~~final remediation of~~ this area is implemented. The data from this investigation will also be used to define the vertical length of recovery well screen (see Section 3 below).

Currently, it is envisioned that the remediation of the south plume will be addressed by dividing the area into 3 zones. The purpose of the zones is to distinguish the areas of contamination for purposes of treatment. The zones are as follows:

1) Zone 1 would be the area of aquifer containing only uranium as the contaminant of concern. This will be the area addressed by the south plume removal action project described in the EE/CA, as modified above.

2) Zone 2 would be the area of aquifer containing uranium, inorganics, and organics as contaminants of concern. This area will need to be addressed jointly by the FEMP and PRRS.

3) Zone 3 would include inorganics and organics as contaminants of concern. The area may also contain uranium contamination, but at a level below that specified in the FEMP Operable Unit 5 Record of Decision (ROD). This area will need to be addressed solely by the PRRS, but will need to be coordinated with FEMP efforts for Zones 1 and 2.

1.3 Objectives

The South Plume EE/CA identified one primary and two secondary objectives for the south plume removal action:

1) Primary--Protection of public health by limiting access to and use of groundwater with uranium concentrations exceeding the derived concentration limit of 30 μg/l for uranium in drinking water, as well as other appropriate, risk-based levels for various potential exposure scenarios.

2) Secondary
   (1) Protection of the groundwater environment which, in this case, is represented by a sensitive, sole-source aquifer.
   (2) Control of plume migration toward additional receptors further south.

For the pumping and discharge system (Part 2) portion of the removal action, specific objectives need to be restated and expanded to take into account the impact of the PRRS and to clarify the specific performance criteria for evaluation of the system. The groundwater recovery system needs to meet--to the extent possible--the following four objectives:

1) The groundwater recovery wells need to be pumped at a sufficient rate to create a hydraulic barrier along a line running approximately perpendicular to the longitudinal axis of the plume in the shallow portion of the Great Miami Aquifer, creating an elongated groundwater trough. This hydraulic barrier needs to extend sufficiently outward from the centerline of the plume to intercept the width of the Zone 1 plume ~~or~~ as defined by contamination above the ~~30~~ 20 μg/l total uranium level.

2) The magnitude of the hydraulic trough needs to be minimized while still meeting Objective 1 in order to minimize the impact on the overall hydrogeologic system. If extensive capture zones are created, then the PRRS plumes may be pulled toward the recovery wells. Also, minimal disturbance to the local hydrologic system is desired to prevent impacts on groundwater users in the area, to minimize the possible velocity increases of movement of on-site plumes, and to not significantly deflect the PRRS contaminant flow trajectory. The recovery wells, therefore, need to create a hydraulic sink to prevent plume movement by the wells and to minimize capture zones and large scale reversals of groundwater flow.

3) Contamination within the aquifer needs to be removed as soon as feasible to prevent further plume movement and degradation of the groundwater environment. Removal of contaminants near the source or in the shallow portion of the aquifer is more efficient and prevents further damage. The recovery system should be operated to prevent further spread of contamination.

4) The operation of the removal action recovery system needs to be consistent with the final site remediation. This standard is difficult because the final site remediation systems are unknown at the present time. However, probably the most relevant issue regarding impacts of pump and treat systems is the possible expansion of other plumes caused by increasing hydraulic slope, thus increasing potential spread of contamination. This issue is the basis of Objective 2 which requires the minimizing of impacts on the natural system.

To meet the multiple objectives requires that the system balance the two opposing factors of creating sufficient drawdown to prevent migration around, between, or beneath the recovery wells and of minimizing drawdown to prevent gradient changes over a large area. Therefore, the system must be evaluated in relation to balancing these objectives. The primary objective (Objective 1) will carry more weight. However, any recommended change to operation or design of the system needs to evaluate its impact on all the objectives.

1.4 Overview of the Operation Methodology

Figure 1-1 ~~2~~ presents an overview of the program, defined in Volume I--Operation Methodology, to start up and operate the recovery system within the stated objectives. Four types of activities are defined as horizontal blocks across the page: design/construct, operation, modeling, and monitoring. Also, the three programs defined in this document: monitoring, design confirmation, and evaluation/response are defined by different colors. Deliverables associated with tasks are enclosed in ovals. Copies of these deliverables will be provided to the US EPA and Ohio EPA.

The purpose of the design confirmation program (represented as yellow blocks on Figure 1-1 ~~2~~) is to test the design basis with a dynamic test of the system and adjust parameters, if necessary, based on the results of this test. The design confirmation program is described in detail in Section 3. This program consists of a pumping test ~~at start-up~~; verification of the extraction well depth prior to the installation of the five extraction well casings; validation of the groundwater model based on the results of the pump test; and model recalibration (if necessary) based on model validation, pump test results, and other monitoring data. ~~Three~~ Five deliverables accompany these activities:

1) Pump Test and Model Validation Work Plan (see Appendix A)
2) Verification of Extraction Well Depth Letter Report
3) Pump Test Report
4) Model Validation Report
5) Model Recalibration Report (if necessary)

The purpose of the monitoring program (represented as green blocks on Figure 1-1 ~~2~~) is to take environmental samples and measurements over time to provide data for the performance of the system. The monitoring program is described in detail in Section 4. This program consists of routine monitoring

at specified intervals. The data collected will be fed into the evaluation/response program (see description below). ~~The sitewide monitoring plan will be updated with additional provisions required for this removal action.~~ One deliverable accompanies these activities:

1) Groundwater Monitoring and Response Plan (see Appendix B)

The purpose of the evaluation/response program (represented as blue blocks on Figure 1-1 ~~2~~) is to analyze whether the system is meeting its objectives and to respond accordingly. The evaluation/response program is described in detail in Section 5. This program consists of periodic system evaluations; development of system modifications; and implementation of either design, operation, or monitoring program changes (as needed). Four deliverables accompany these activities:

1) System Evaluation Report
2) System Modification Report (if necessary)
3) Construction Documents (if necessary)
4) Revised O&M Manual (if necessary)

Figure 1-1
Operation Methodology Logic Diagram for the The South Plume Recovery System

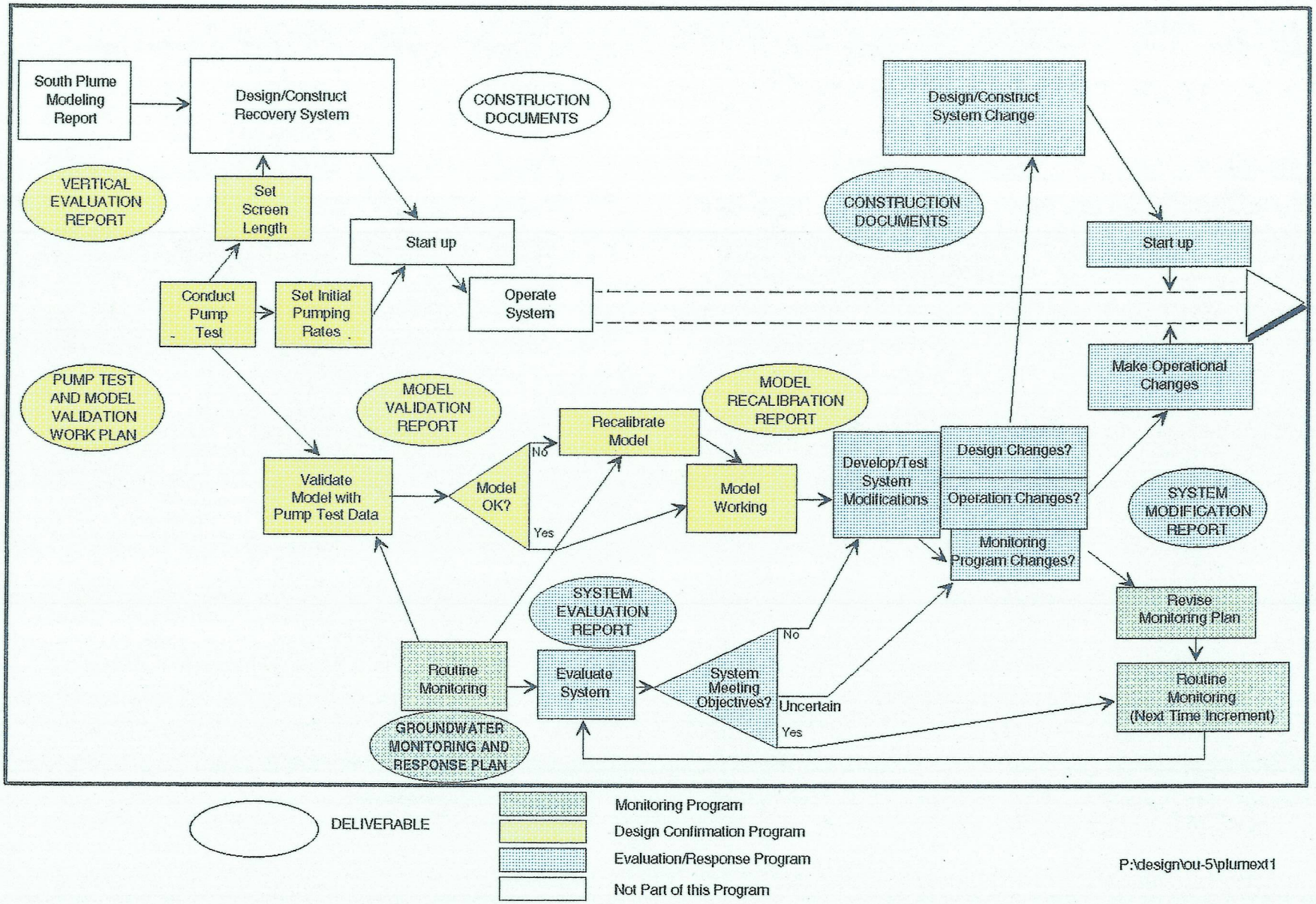

Figure 1-12 - Operation Methodology Logic Diagram for The South Plume Recovery System

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SECTION 2

TECHNICAL PROJECT SUMMARY

2.1 Hydrogeologic Summary

The hydrogeologic setting is defined to provide the appropriate background for the operation of the groundwater recovery system. The following summary has been developed from previously written documents (DOE 1990a, DOE 1990b, WEMCO 1992a).

The FEMP and the South Plume area is located above an extensive aquifer system known as the Great Miami Aquifer. This aquifer system extends over 100 miles from the Ohio River to the northeast. This aquifer has been designated a "sole source aquifer" because of its significance as a water supply. The aquifer system consists of a linear system of branching bedrock channels varying in width from less than a mile to several miles wide and up to 200 feet deep. These bedrock valleys formed as a result of pleistocene glaciation and subsequently filled with coarse grained glacial outwash materials and varying amounts of glacial till. In the vicinity of the FEMP, five branches of the system converge. Figure 2-1 shows these branches of the aquifer and depicts generalized flow directions in the aquifer system.

The bedrock in the vicinity of the FEMP is predominantly flat-lying olive gray Ordovician shales with thin, interbedded layers of limestone. This shale forms the floor and valley walls of the bedrock channels in the vicinity of the site. In the vicinity of the FEMP, the buried channel is generally carved into this shale between 60 to more than 200 feet below the pre-erosional land surface.

Approximately 150 feet of regionally extensive Pleistocene glacial valley fill deposits unconformably overlie the shales in the bedrock channel. As indicated by the study area map (Figure 2-2) and typical hydrogeologic cross sections from the South Plume area (Figures 2-3 and 2-4), the buried valley is about one half to over two miles wide and is U-shaped, having a broad, relatively flat bottom and steep valley walls. Interbedded glacial till deposits occur within the outwash deposits, but in most cases are of limited lateral extent. The till deposits are composed primarily of poorly sorted pebbles, cobbles, and boulders in a predominantly clay matrix.

Within some areas, till deposits overlie the bedrock uplands and portions of the outwash materials where they form the thick unconsolidated sediment layers beneath the soil zone. This glacial till is composed of dense, silty clay that varies in composition vertically and laterally. The silty clay till contains lenses of poorly sorted fine- to medium-grained sand and gravel, silty sand, and silt with layers of silty clay. The FEMP lies on top of one these terrace remnants (consisting of till) left after the establishment of the present day Great Miami River channel. The lower reaches of Paddys Run have cut through this till and lie on the sands and gravels of the buried outwash deposits.

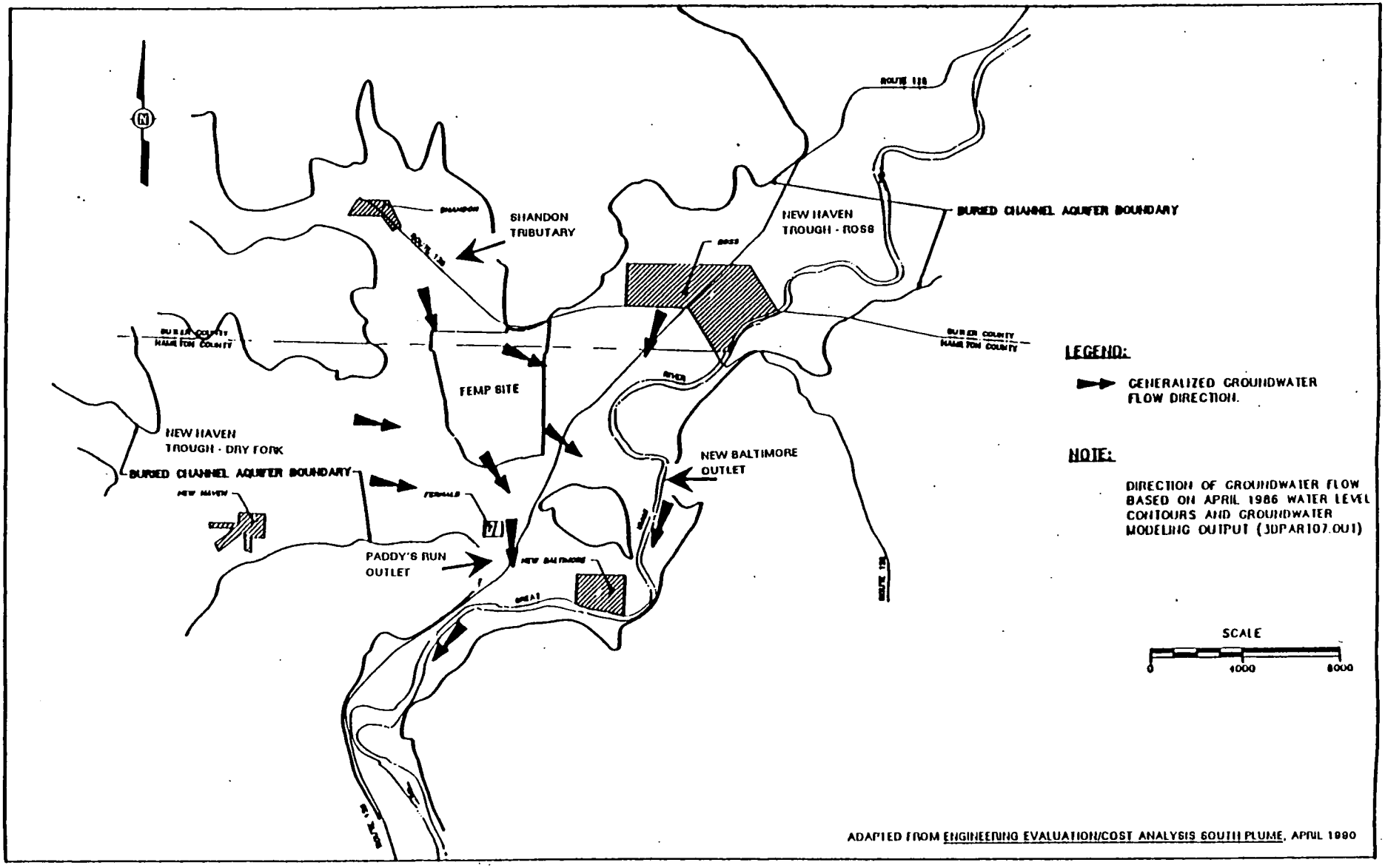

Figure 2-1 - Generalized Groundwater Flow in Buried Channel Aquifer

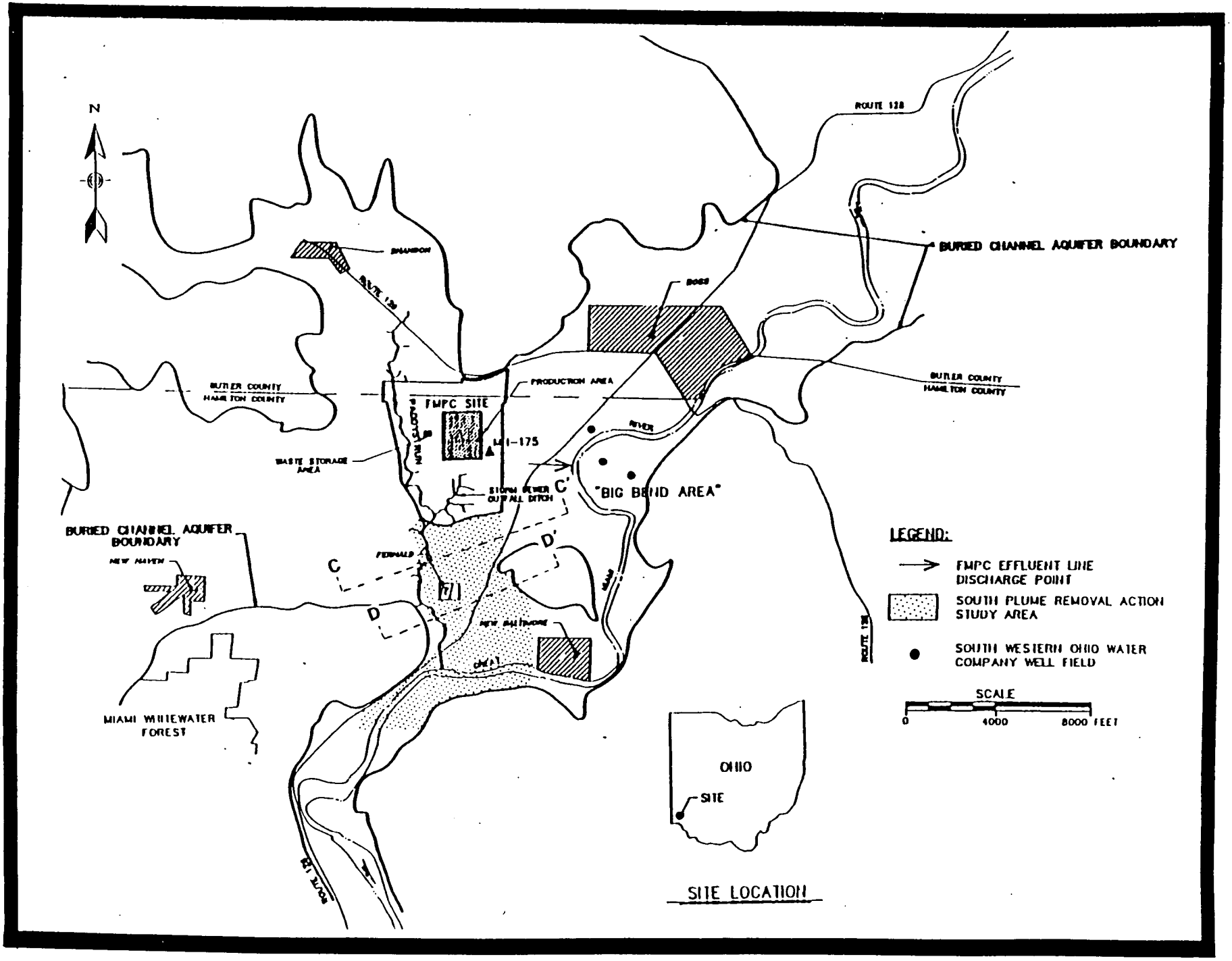

Figure 2-2 - Site Location Plan

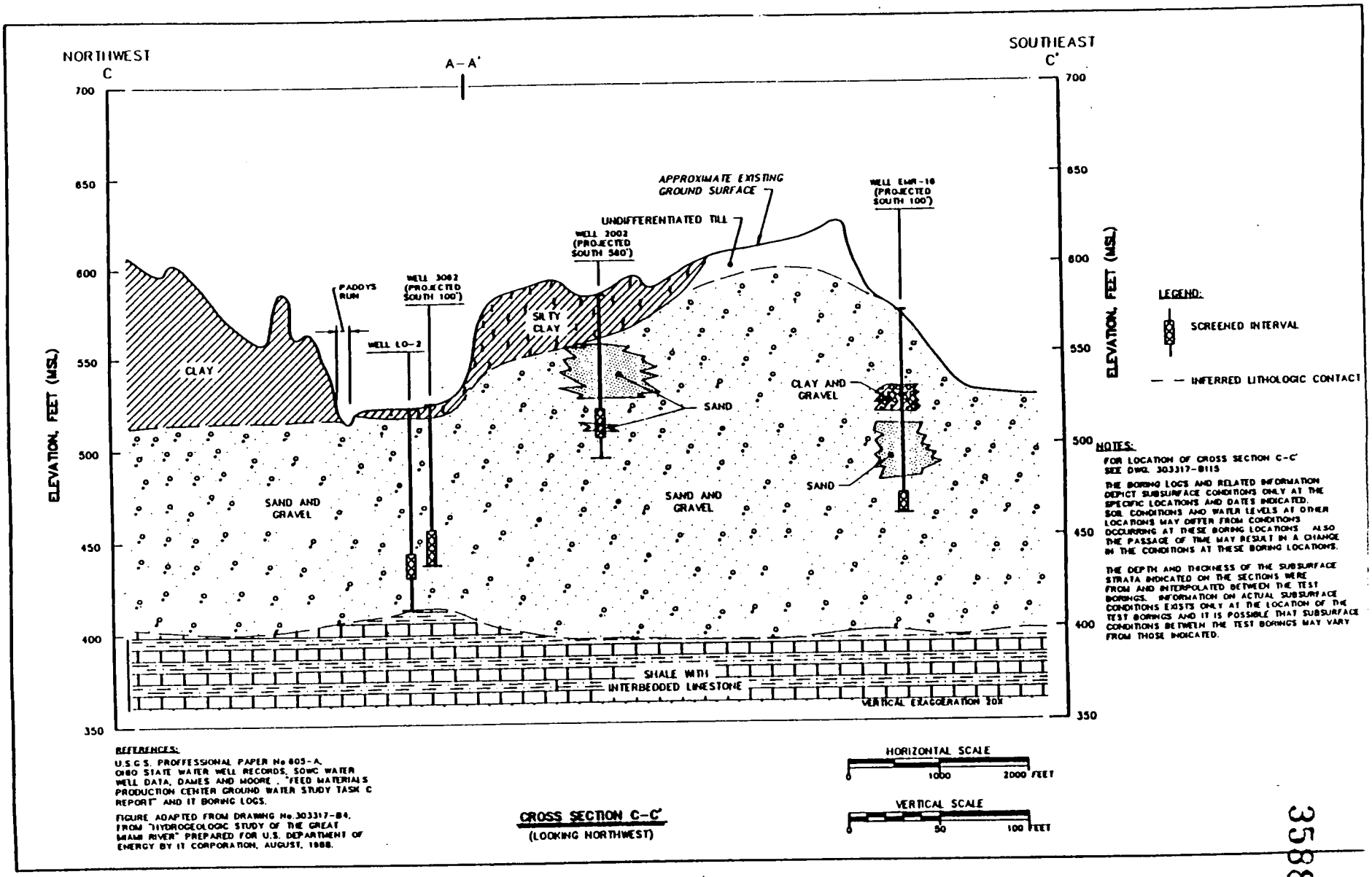

Figure 2-3 - Cross Section C-C'

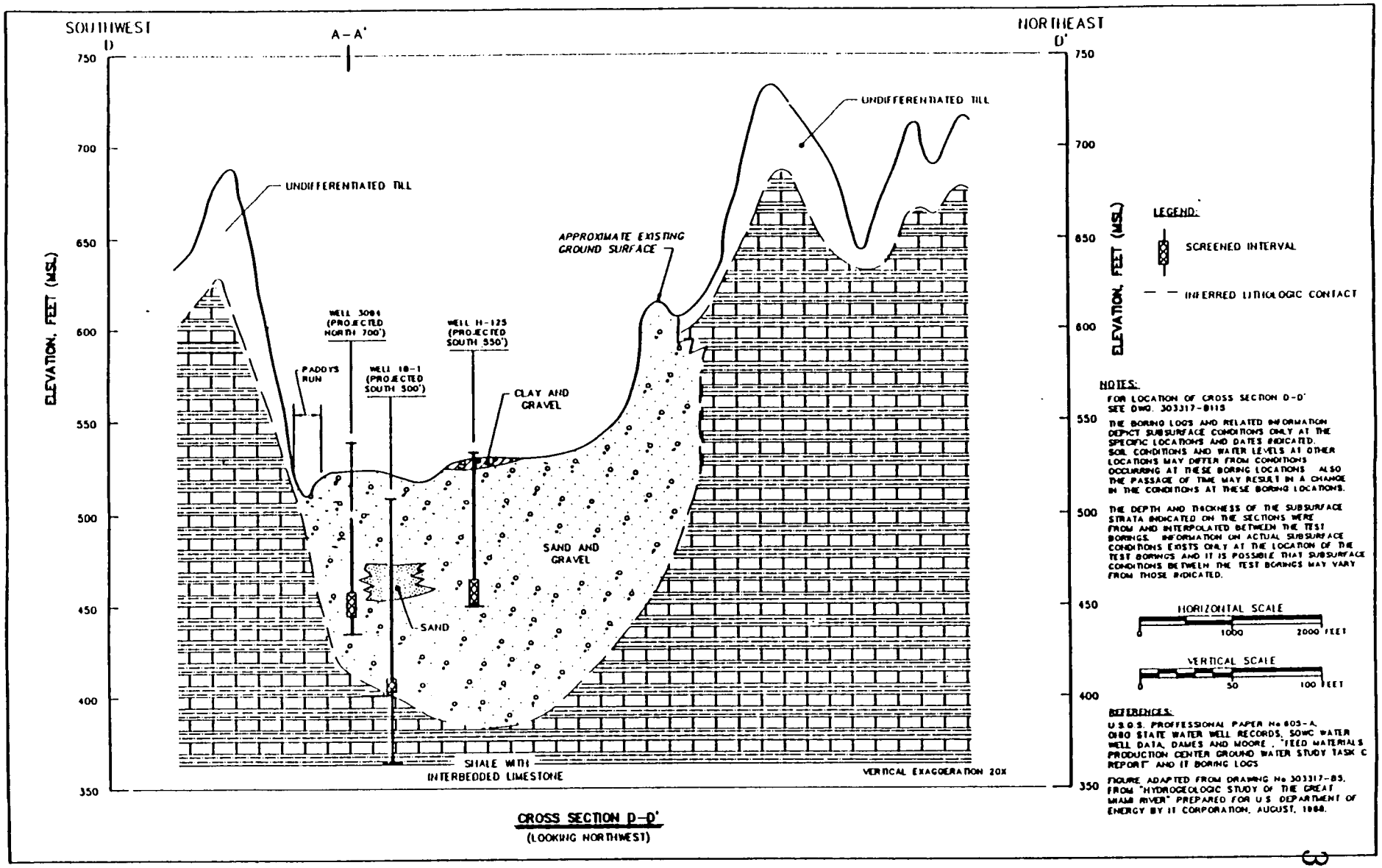

Figure 2-4 - Cross Section D-D'

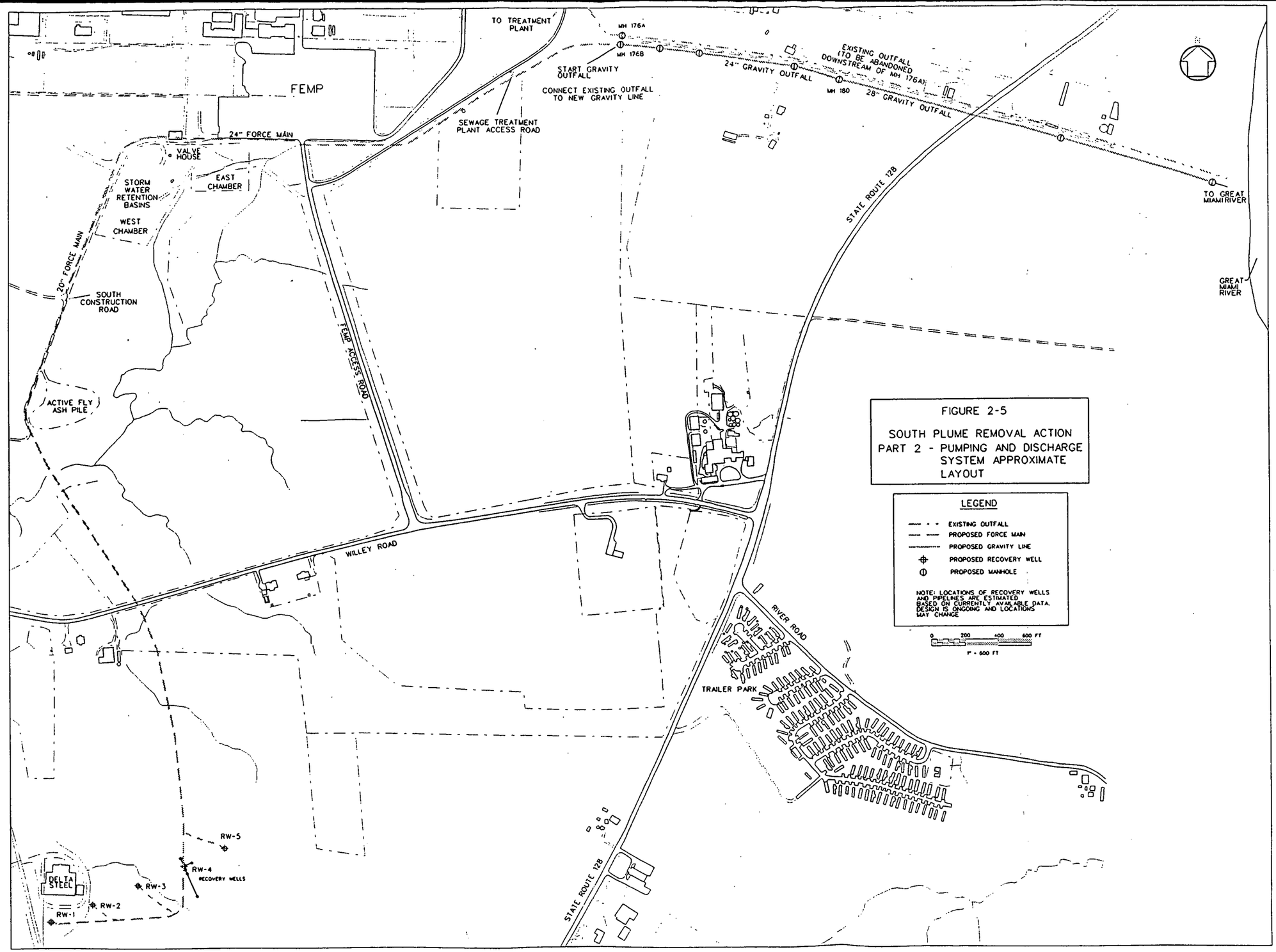

Figure 2-5 - Pumping and Discharge System Approximate Layout

The line of recovery wells (oriented about 25 degrees north of due east) will be located approximately perpendicular to the axis of the south plume approximately 1,600 feet south of Wiley Road and just east of Paddys Run Road. The line of wells will be approximately 1,200 feet long from the first to the fifth well with each well spaced approximately 300 feet apart. The well casings will be sized to accommodate maximum flow of 800 gpm and will be screened at the top 40 feet (to be verified - see Section 3) of the saturated zone of the aquifer. Model simulations (DOE 1992) have set flows for four wells spaced at 350 feet apart at 500 gallons per minute (gpm) for a total of 2000 gpm. To add conservatism to the design, the original line of wells have been lengthened slightly (approximately 100 feet) and a fifth well has been added. Pumps are sized for a nominal 400 gpm each (total 2000 gpm and a maximum flow of 650 gpm each (total 3250 gpm) so that flows may be increased if necessary.

Groundwater from the south plume will be conveyed from the South Plume to the Great Miami River by a combination of a force main and gravity sewer (Figure 2-5). The force main and gravity sewer have been designed for excess capacity to allow additional future flow. The 20-inch force main (capacity of 5000 gpm) picks up flow from the five recovery wells, runs north cross country, and bears northwest across Wiley Road to the western corner of the active fly ash pile. The force main turns to the northeast at the active fly ash pile and runs along the South Construction Road to the western and northern edges of the Storm Water Retention Basin (SWRB) west chamber to a new valve house just north of the SWRB. The valve house has been designed to allow a future diversion of the force main flow to a new Advanced Wastewater Treatment Plant (AWWT) and the return pumping of the future AWWT discharge flow to the force main and gravity sewer. From the valve house, a 24-inch force main runs 1,400 feet east and then follows the sewage treatment plant access road to the northeast joining a new gravity pipeline at new Manhole No. 176B. The new 24-inch gravity line runs approximately parallel to the existing outfall line MH 180B, changes to a 28-inch line at a flatter slope (capacity 7000 gpm) and continues to the Great Miami River (a total of 4000 lineal feet). When the new gravity line is completed, the existing outfall line will be connected to the new line at Manhole 176B and the portion downstream of Manhole 176B abandoned. Additional wyes with valves and blind flanges have been left within the proposed wellfield and along the 20-inch force main including the south field areas to allow for additional connections if future wells are needed.

Instrumentation systems will provide the ability to control the system operation and to measure operating parameters. Each pump will be operated with a flow control valve to throttle the flow on the discharge pipe of each well. Flow will be measured at each discharge line with flowmeters and on site in the force main at the valve house. Adjustments to flow at individual pumps can be made by throttling the valves. The capability of remotely (on site) monitoring the performance of the pumping wells will be included in the design.

SECTION 3

DESIGN CONFIRMATION PROGRAM

3.1 Introduction

A design confirmation program has been included within the DMEPP to verify and improve (if necessary) the design and operation of the recovery system. Because of the high transmissivity of the aquifer, the long duration and high pumping rates necessary for an unconfined aquifer pumping test and the extreme difficulties of managing large volumes of uranium-contaminated water, a site-specific pump test could not be performed until water handling facilities were available. In addition, the complexities of land aquisition, design and construction interdependencies, and Consent Agreement schedules required that recovery well design preceed prior to and in parallel with conducting the pump test and collecting additional characterization data. Therefore, an approach to meet the Consent Agreement schedule was developed. The approach consisted of using the groundwater model and field data to preliminarily design the system, add conservatism and flexibility into the design, include confirmation processes to check the design, and provide a mechanism to make future changes to the design.

The recovery system design was based primarily on the SWIFT III site flow and contaminant transport groundwater model simulations. This modeling was applied and documented in the South Plume Removal Action Groundwater Modeling Report (DOE 1992a) prepared specifically to simulate and optimize the recovery system locations and pumping rates. Because the model contains certain inherent limitations (for example, estimation of physical parameters and simplifications of the physical system), a design confirmation program was developed to assure the successful operation of the groundwater recovery system. Portions of this design confirmation program will be conducted prior to construction of the recovery wells. In the event that the pump test or monitoring results indicate a problem with the operating range provided by the design, an engineering change proposal will be processed to modify the design of the recovery system.

The model accuracy issues can be divided into two basic questions:

1. Is the horizontal plume system and predicted model capture accurately portrayed?

2. Is the vertical plume system and predicted model capture accurately portrayed?

The program developed to address these issues is described below.

3.1.1 Horizontal Capture

Because of the fast track schedule and the reluctance of land owners to allow the use of property, planar definition of well locations (x and y coordinates) had to be defined early in the design effort without the benefit of the results of the pump test or the Part 5 characterization. The approach to dealing with this situation consists of the following steps:

1. Baseline Conceptual Design - The groundwater model, with particle tracking, was used to set preliminary recovery well locations and flowrates which would establish a hydraulic barrier minimizing impact on PRRS plumes (DOE 1992a). The model predicted capture of the plume with 4 wells along a 1080 foot line pumping a total of 2000 gpm.

2. Design Flexibility and Conservatism - Because of potential accuracy issues associated with the model, operational flexibility was incorporated into the recovery well design. Five wells were placed over a 1200 foot line increasing well coverage and density. Pumping rate capacity was increased over 60 percent to 3250 gpm for the well field (including the throttling capability to allow the operation at any lower flow rate). Wyes, valves and blind flanges were left at many locations in the force main to simplify future connections (if required). Excess capacity (approximately 5000 gpm) was incorporated into the force main design to allow for future connections.

3. Additional Characterization and System Evaluation- The Part 5 investigation, routine sampling programs, the pump test, and the proposed additional south plume monitoring wells will provide additional information regarding the aquifer system and the extent of horizontal contamination in the south plume. Because of the schedule and land owner issues discussed above, these data can not be used to revise the locations of the recovery wells; however, these data (as available) will be utilized to set the initial pumping rates of the recovery system. Moreover, the system evaluation process (see Section 4) will periodically assess the system and determine if the removal action objectives are being met. Pumping rates may be altered or additional recovery wells may be constructed if they are needed to meet the system objectives.

4. Model Validation - Because of the reliance of the design on the flow model, a test will be performed on the model to determine the accuracy the flow portion of the model. Based on the results of the test, the model will be recalibrated, if necessary. In addition, a refined model grid has been created in the south plume area by telescoping the solute transport subgrid. This new grid will provide better resolution of the model in this vicinity by providing smaller cells. The validated and telescoped model will provide a better tool for understanding and evaluating the south plume recovery system.

3.1.2 Vertical Capture

Vertical definition of the length of the recovery well screen does not require the long lead times that establishment of well locations require, provided the horizontal well locations remain fixed. Thus, screen depths can be set based on the latest available data. New data that will become available include the results of the pump test and results from the hydropunched samples from the Part 5 investigation and the south plume monitoring wells. The approach to dealing with this situation consists of the following steps:

1. Baseline Conceptual Design - Preliminary screen lengths were set based on the modeled uranium plume, monitoring data and particle tracking simulations. The modeled plume and available monitoring data showed that the plume was primarily at shallow depths in the 2000 series wells. The particle tracking was accomplished by seeding particles at various depths and locations and determining capture of these particles by pumping at selected depths (DOE 1992a).

2. Design Flexibility and Conservatism - Because of potential accuracy issues associated with the model, operational flexibility was incorporated into the recovery well design. Five wells were placed over a 1200 foot line increasing well coverage and density. Pumping rate capacity was increased over 60 percent to 3250 gpm for the well field (including the throttling capability to allow the operation at any lower flow rate). Wyes, valves and blind flanges were left at many locations in the force main to allow and simplify future connections (if required). Excess capacity (approximately 5000 gpm) was incorporated into the force main design to allow for future connections.

3. Additional Characterization and System Evaluation- The Part 5 investigation, routine sampling programs, the pump test, and the proposed additional south plume monitoring wells will provide additional information regarding the aquifer system, vertical capture, and the extent of vertical contamination in the south plume prior to construction. Hydropunching in the Part 5 investigation and for the south plume monitoring wells will provide depth discrete samples over the entire depth of the aquifer (DOE 1992b). The pump test contains provisions for defining vertical capture as a function of pumping rate. With these data, the vertical length of screen of the remaining recovery wells will be established (see discussion below under item 5). In addition, the system evaluation process (see Section 4) will periodically assess the system and determine if the removal action objectives are being met. Pumping rates may be altered or additional recovery wells will be constructed if they are needed to meet the system objectives.

4. Model Validation - Because of the reliance of the design on the flow model, a test will be performed on the model to determine the accuracy the flow portion of the model. Based on the results of the test, the model will be recalibrated, if necessary. In addition, a refined model grid

has been created in the south plume area by telescoping the solute transport subgrid. This new grid will provide better resolution of the model in this vicinity by providing smaller cells. The validated and telescoped model will provide a better tool for understanding and evaluating the south plume recovery system.

5. Preparation of Vertical Capture Letter Report - A letter report will be prepared to analyze and verify the vertical location of the recovery well screens. This report will be prepared using recently available monitoring data, the Part 5 characterization data (including the south plume monitoring wells hydropunch samples), and the pump test data. This letter report will be prepared prior to the installation of the rest of the recovery well casings. This report will require preparation under an accelerated schedule because of the construction schedule requirement to start recovery well installation immediately after the pump test. Changing screen lengths may have an impact on the horizontal capture. Therefore, the establishment of screen lengths will be limited based on horizontal capture objectives. In addition, flow rates may be increased to compensate for any additional length. This report will also define the initial pumping rates for the recovery system using the latest available data as a basis. If findings dictate a different course of action, a schedule variance will be requested from Ohio EPA and US EPA and further analysis using the latest available information including model simulations will be performed to determine appropriate screen lengths.

3.2 Pumping Test

~~A~~ Step- drawdown and constant rate pumping tests will be conducted on the test well ~~one of the completed recovery wells~~. The Pump Test and Model Validation Work Plan ~~will~~ describes, in detail, rates, locations of pumped and observation wells, and pump test procedures. This section and Section 3.3 describe the philosophy and requirements for this work plan which is included as Appendix A.

The step-drawdown test well will be pumped at three different rates over uniform intervals that are specified in the Pump Test and Model Validation Work Plan (Appendix A). The constant rate test will be run at the optimum rate indicated by the step drawdown test. This rate will range between 500 and 1,200 gpm. The constant rate test will be conducted over a 72 hour period or until water levels substantially stabilize. The maximum duration for conducting both tests (including recovery periods between tests) will be 12 days.~~The pump test will be conducted near the maximum rate attainable (600 to 700 gallons per minute based on preliminary design information) in order to evaluate conditions over as large an area as possible. The test will be carried out for 72 hours or until water levels substantially stabilize. The maximum duration of the test will be 7 days.~~ The particular well for testing was selected based on representativeness of location (interior wells preferred) and depth, availability of monitoring points at comparable aquifer depths, and other system restrictions. Pump test water will be discharged through the new force main to the ~~new FEMP Great Miami River outfall~~ SWRB. This pump test ~~will not be conducted until~~ water will be treated by the SWRB- Interim Advanced Waste Water Treatment

Plant to the maximum extent practical ~~is operational~~. Detailed description of the handling of pump test water is contained in the Pump Test and Model Validation Work Plan.

Water elevations in a minimum of four monitoring wells or observation wells will be continuously measured ~~at prescribed intervals~~ during the test (both during the pumping of the test well and during the recovery period). These wells may be existing monitoring wells, new monitoring wells associated with the south plume removal action, other recovery wells, or observation wells constructed for the test. These wells will be selected based on screen elevations, screen lengths, and well locations in respect to the pumped well.

The distance between these wells and the recovery well will be based on ~~groundwater model simulations conducted for Part 5 of this work~~ scoping calculations using estimated aquifer parameters. Three wells will be in one direction from the recovery well. ~~Two of these wells will be in a couplet consisting of a 2000 Series (water table) and a 3000 Series (mid-aquifer) depth monitoring or observation well to define vertical gradients at this location. In the same direction, another 2000 series depth well will be monitored.~~ The other observation well will be at 90 degrees to the orientation of the other three observation wells to indicate the shape of the cone of influence and anistrophic (preferred orientation) characteristics of the hydraulic conductivity distribution. Depths of piezometers will be based on the chosen method of analysis. At one location, multiple screened intervals of piezometers will be located to determine depth of influence. If appropriately located, additional monitoring wells will also be utilized in the pumping test to further delineate the hydraulic conductivity distribution.

Water levels will be continuously measured with multichannel data loggers and strip recorders in the recovery well and in the selected observation and monitoring wells during pumping of the test well and during the recovery period of the constant rate test. ~~These time intervals will be initially closely spaced; and as the test continues, they will be spaced further apart following standard pump test protocols.~~ Water samples will be collected from the pumped well ~~and selected monitoring wells at more widely spaced intervals~~ and analyzed for total uranium. These water samples will also be analyzed for temperature, specific conductance, and pH in the field to determine water chemistry changes during the test. It is projected that four samples will be taken the first day of the test and two samples on each of the remaining days.

Except as noted below, procedures for conducting the pump test and associated measurements, sampling, and analysis will be developed in accordance with the ~~approved~~ draft FEMP Sitewide CERCLA Quality Assurance Project Plan (QAPjP) (WEMCO 1992b). Because of the need for a quick response, site laboratories will be utilized for total uranium analysis. As a confirmation, 10 percent of the samples will be split and sent to laboratories approved in the FEMP QAPjP.

Standard hydrogeologic software packages will be utilized to analyze the data and to determine hydraulic conductivity and storativity values. The data will also be analyzed for vertical flow characteristics and for the presence or absence of boundaries affecting flow.

3.3 Model Validation

The south plume area of the existing groundwater flow model domain will be validated by comparing the pump test hydraulic results with the groundwater model simulating the same conditions. This model validation will be performed during the first quarter after the system is operational so that a validated model may be used to help design system modifications in subsequent quarters. The Pump Test and Model Validation Work Plan describes in detail the evaluation criteria and validation procedures (see Appendix A).

The recovery well and applicable monitoring and observation wells will be located on the existing groundwater model grid, and pumping will be simulated in the model at the actual flow rate of the pump test. Other model assumptions such as depth of screen penetration of aquifer will be matched to field conditions to the extent possible. The model will be utilized in a transient mode to determine the changes over time in water levels at the recovery well and observation wells. The simulated changes and the pump test measured changes will be compared at applicable time intervals and in a steady state mode.

After the groundwater recovery wells are operational, a second experiment will be performed comparing the water elevations produced by the constant pumping of the recovery wells versus a modeled steady state simulation of these recovery wells pumping at this assigned rate. This data will become available after continuous operation of a month or more of the multiple recovery wells. Monthly water level readings during the first quarter of operation will be utilized for this test.

The results of this model validation activity will be described in a report. Model versus pump test results will be analyzed and conclusions will be stated regarding the ability of the model to match the above two tests. Recommendations will also be made, if warranted, regarding recalibration of the model.

3.4 Model Recalibration

If the model validation conclusions and recommendations deem it necessary, the model will be recalibrated in the vicinity of the south plume to approximate the conditions determined by the pump test and the model validation procedure. The recalibrated model will then be ready for use in supporting activities to develop system modifications.

Model recalibration will be conducted in accordance with procedures established in the ~~RI/FS model work plan~~ Pump Test and Model Validation Work Plan (see Appendix A). Calibration criteria will be established prior to recalibrating the model. Repeated simulations using varying hydraulic conductivity distributions will be conducted to attempt to bring the model heads within the established calibration criteria. When the model has met the calibration criteria, two simulations will be run to confirm the new model assumptions. One, the pump test simulation matching the performed pump test will be rerun in transient and steady state modes, and the results will be compared and evaluated. Two, simulation of the recovery well pumping (of all wells) will be compared to the actual drawdown produced and measured (steady state). These results will also be compared and evaluated.

The calibration process is iterative and may require the adjustment of other parameters (infiltration, boundaries, etc.) in order to bring the model within the established criteria. A model recalibration report will be written which describes the recalibration assumptions, procedures, simulations, results, and which draws conclusions based on these results. This report will be provided to the US EPA and the Ohio EPA for information purposes.

SECTION 4

MONITORING PROGRAM

4.1 Introduction

Groundwater elevation and geochemical data will be collected at specified time intervals and locations to provide data for evaluating the system and to assist in validating and recalibrating the groundwater model. ~~The sitewide monitoring program will be revised to include this additional monitoring, i.e., a separate monitoring plan will not be developed for the south plume removal action.~~ This section describes the monitoring requirements for the routine monitoring program. ~~which will need to be incorporated in the sitewide Monitoring Program.~~ The specifics of the monitoring program are contained in the South Plume Groundwater Monitoring and Response Plan included as Appendix B. Monitoring associated with the pump test is not included in this section but rather is described under the pump test.

4.2 Objectives

The objectives of the monitoring program for the south plume removal action are:

1) To delineate the cone of depression caused by the recovery wells
2) To provide supporting hydraulic data for the model validation and model calibration tasks
3) To delineate the uranium concentration distribution in the vicinity of the recovery wells
4) To anticipate the uranium concentrations that will be pumped in the future
5) To determine the potential impact of plumes from the Paddy Run Road Site

The following describes a program constructed to meet these objectives. Specifics of this program are contained in the South Plume Groundwater Monitoring and Response Plan (see Appendix B).

4.3 Water Level Measurements

Water levels will be measured at recovery wells, south plume monitoring wells, and selected additional monitoring or observation wells ~~(see Table 4-1 and Figure 4-1)~~(see the South Plume Groundwater Monitoring and Response Plan - Appendix B). The frequency of these measurements will be as follows:

Time Increment	Frequency
1st week of operation	Daily
1st month of operation	Weekly

1st ~~quarter~~ year of operation	Monthly
Subsequent operation	Quarterly

The above schedule of measurements has been selected to have more frequent data collection at the beginning of recovery pump operation because of transient effects. Measurements are made monthly over the first year to build a database for the system evaluation process. As operation continues and a relative steady state is achieved, the water levels will change less with time and quarterly readings will provide a picture of annual variation.

Data from monitoring wells in the area of the pumping wells, ~~will be~~ measured for groundwater elevations as part of the regular sitewide monitoring program, will also be evaluated to provide as complete a picture as possible.

Procedures for measuring water levels will be in accordance with the approved FEMP QAPP and the ~~sitewide monitoring plan~~ South Plume Groundwater Monitoring and Response Plan (see Appendix B). The evaluation of this data is described in Section 5.

4.4 Geochemical Monitoring

Samples will be collected at recovery wells and south plume monitoring wells and will be analyzed for total uranium, pH, specific conductance, and temperature ~~(see Table 4-1 and Figure 4-1)~~(see the South Plume Groundwater Monitoring and Response Plan- Appendix B). Selected monitoring wells south of the recovery wells will be sampled and analyzed for volatile organic compounds (VOCs) and inorganics in order to directly determine if the Paddy Run Road Site organic or inorganic plume is expanding toward the recovery wells. These monitoring wells will ~~serve as a barrier to~~ provide advance information if the plume is migrating. ~~Part 5 of the removal action~~ The South Plume Groundwater Monitoring and Response Plan (see Appendix B) ~~will locate~~ indicates specific monitoring wells ~~to~~ that will provide this barrier monitoring and ~~will identify~~ specific indicator parameters that will be monitored ~~for this monitoring~~.

The frequency of these measurements will be as follows:

Time Increment	Frequency
1st week of operation	Daily
1st month of operation	Weekly
1st quarter of operation	Monthly
Subsequent operation	Quarterly

Like the water level measurement program, more samples will be collected at the beginning of the program when there are more transient effects. Because of the distance between the PRRS organic plume and the recovery wells, only the monthly and quarterly scheduled samples will be collected for PRRS organics.

Except as noted below, procedures for sampling and analysis of monitoring wells will be in accordance with the ~~approved~~ FEMP QAPjP and the ~~sitewide monitoring plan~~ South Plume Groundwater Monitoring and Response Plan (see Appendix B). Because of the need for a quick response so that system evaluations and adjustments can be accomplished in a timely manner, on-site laboratories will be used for total uranium and PRRS organic and inorganic parameter analysis. In the event the on-site lab cannot meet project needs for PRRS parameters, an off-site lab capable of Level 3 Data Quality Objective will be utilized. As a confirmation, 10 percent of the samples will be split and sent to laboratories approved in the FEMP QAPjP. The evaluation of this data is described in Section 5.

SECTION 5

EVALUATION/RESPONSE PROGRAM

5.1 Introduction

The purpose of the Evaluation/Response Program is to analyze whether the system is meeting its objectives and to take appropriate action to bring it back in conformance with its objectives. Monitoring data will be utilized to evaluate whether the system is meeting its objectives. If this evaluation determines that the program objectives are being met, then no further action will be taken until the next monitoring period when the data is again evaluated. If the evaluation shows that the system is not meeting its objectives, then the model (and other analytical tools) will be utilized to develop modifications to bring the system in line with its objectives. Possible system changes may involve design, operation, or monitoring program modifications. This section of the DMEPP defines the general requirements for the Evaluation/Response Program. Specifics of the Evaluation/Response Program are described in detail in the South Plume Groundwater Monitoring and Response Plan (see Appendix B).

Because of spatial and temporal variations in the hydrogeologic system that is being analyzed, system evaluation and follow-on activities will be performed according to the following schedule:

Time Increment	Frequency
1st year	Quarterly
Subsequent years	Semi-annually

This schedule does not completely coincide with the monitoring schedule. Certain system evaluations will cover more than a single monitoring data set and will analyze available data sets at the time of evaluation.

5.2 System Evaluation

At each scheduled time interval, a system evaluation will be performed. The purpose of this evaluation is to determine whether the system is meeting the defined objectives. ~~Since the criteria is primarily qualitative or perhaps semi-quantitative, the evaluation needs to analyze the data in several ways.~~ Factors that will be considered include the following:

1) The present distribution of groundwater elevations in planar view and vertical section.

2) The change over time in the distribution of groundwater elevations.

3) The flow rate of pumping over the last evaluation cycle.

4) The rainfall over the last evaluation cycle.

5) Other aquifer stresses such as nearby production wells occurring over the last evaluation cycle.

6) The present distribution of uranium concentration in planar view and vertical section.

7) The change over time in uranium concentration.

8) The present distribution of PRRS organic and inorganic constituents.

9) The change-over time of PRRS organic and inorganic constituents.

10) Other geochemical factors.

Specific criteria for the system evaluation based upon these factors are presented in the South Plume Groundwater Monitoring and Response Plan (see Appendix B). Based upon these criteria ~~the consideration of these factors~~, it will be determined whether the system is meeting its objectives. Statistical procedures will be used~~, as appropriate,~~ to determine significance of changes. These statistical procedures will be included in the South Plume Groundwater Monitoring and Response Plan. This evaluation will need to balance possibly competing objectives. This evaluation will need to be cognizant of time and spatial variability and will need to react to general trends but not to every possible system upset; i.e., a global approach needs to be taken. Conclusions and recommendations to this system evaluation may state that:

1) The system is not meeting its objectives.

2) Specific changes need to be made to the system to bring it in line with the objectives.

3) The monitoring program needs to be changed to determine if objectives are met. The evaluation may recommend the specific monitoring program changes (frequency, locations, parameters, etc.) that need to be made.

4) The system is functioning in accordance with its objectives and recommends that no changes be made.

5) The system has met its objective. The evaluation may recommend ceasing operation of the system and continuation of monitoring for a specified period as a confirmation.

A system evaluation report will be prepared containing the described analysis, conclusions, and recommendations. The system evaluation report may recommend minor pumping rate changes to accommodate seasonal variation or other temporal factors without triggering the more formal system modification process described below. This report will be submitted to the US EPA and Ohio EPA for information purposes.

5.3 Development of System Modifications

If recommended by the system evaluation report, an effort will be undertaken to develop system modifications. The groundwater model will be utilized to assist in this development effort by allowing the simulation of possible system changes and an analysis of the effects of these changes. Other analytical tools may also be used to assist in this effort.

Potential modifications identified in the system evaluation report will be classified as either system problems or as system optimization issues. System problems are defined as a situation identified in the system evaluation report which may compromise the four objectives stated in Section 1. These types of situations include significant upgradient contamination circumventing the hydraulic barrier created by the recovery wells; a southerly extending capture zone causing PRRS contaminants to migrate toward the recovery wells or to significantly deflect; or a situation which somehow compromises the long term remediation of the site. System optimization issues are primarily efficiency issues that do not affect the system's ability to meet the objectives. These type of issues include minor adjustment of pumping rates or cycles to increase efficiency, save power, etc.; a minor adjustment to prevent a system problem in the future; or minor changes in the monitoring program (adding a constituent or an existing well to the program). System optimization changes may be handled as part of the system evaluation report and may not require the system modification process as determined by the complexity of the recommended change.

Different response actions and schedules will be carried out for system problems versus system optimization issues. System problems will be reacted to with an aggressive schedule. The system modification report will be completed within 60 days after the system evaluation report is submitted. If construction is necessary then an aggressive design and construction schedule will also be pursued. This schedule, included and justified in the system modification report, will be based on the complexities of the design and the scope of construction. If very serious situations are encountered as identified in the system evaluation report, it may be necessary to implement immediate "interim measures" such as adjustment of pumping rates using the best data available. The US EPA and Ohio EPA will be informed if "interim measures" are instituted. However any "interim measures" will be checked with the formal system evaluation and modification process and final adjustments will be made.

Attempts will be made to anticipate future problems so that system problems can be prevented and a proactive approach to modifying the system can be carried out. The monitoring program and the system evaluation report will provide a periodic review of the system and will identify existing problems and

conclude if there are future problems which demand attention, thereby preventing the need for aggressive schedules or "interim measures". System optimization issues will be reacted to within a more normal schedule typically by submission of the system modification report within 90 days.

Three types of system modifications are possible. These are described in the following sections.

5.3.1 Operation Changes

The preferred choice in modifying the system will be with an operating change. Specific operating changes include:

1) Varying the constant pumping rate of any pump. Different rates may be applicable to each pump depending on the identified need of the system.

2) Instituting pulsed pumping (stop/start cycles) at any pump. Different pulsed pumping rates and intervals may be applicable to each pump depending on the identified need of the system.

3) Turning off a particular pump depending on the needs of the system.

A system modification report will describe the simulations and analysis conducted to arrive at the selected operational changes. This report will also analyze the effect of the change on other parts of the removal action. Upon finalizing this report, the operational changes will be implemented by operating personnel. This report will be submitted to the US EPA and Ohio EPA for review and approval.

5.3.2 Design Changes

If an operational change is unable to modify the system sufficiently to bring it in line with the objectives, then a design change may have to be conducted. Design changes typically will require that new recovery wells be added to the system with the location determined by the needs of the system. Design changes may dictate accompanying operational or monitoring modifications.

The system modification report will describe the simulations and analysis used to arrive at the design change and will recommend a particular system addition. Based on the recommendations of this report, detailed design activities will commence. Factors involved in the design include the procurement of easement, the need for ancillary equipment to support the new recovery well(s), and the schedule of design and construction.

~~The design agency will produce~~ After completion of appropriate construction documents, the job will be bid and a construction contractor will be selected. The construction contractor will construct the new system component, and another startup procedure will commence. The DMEPP ~~O&M Manual~~ will be

updated (if required) to reflect the new components in the system. The revised DMEPP will be submitted to the US EPA and Ohio EPA for review and approval.

5.3.3 Monitoring Program Changes

Changes in the monitoring program may be recommended directly from the system evaluation report or may be recommended in the system modification report (see Figure 1-1 ~~2~~). Monitoring program changes do not necessarily need to go through a system modification development since changes could be very routine (for example, adding a parameter, an existing well, or changing a sampling frequency). Other monitoring program changes may accompany an operational or design change to match the monitoring program to the new system parameters. New monitoring wells will require a minimal design activity since established procedures will be followed. Increased frequency of monitoring during start up may be required to accompany a major system change.

The ~~sitewide monitoring program~~ South Plume Groundwater Monitoring and Response Plan will need to be changed or amended when monitoring program changes are prescribed. This revised plan will be submitted to the US EPA and Ohio EPA for review and approval.

SECTION 6

REFERENCES

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(WEMCO 1992a) Westinghouse Environmental Management Company of Ohio, February 1992. *South Groundwater Contamination Plume Removal Action - Part 2 - Pumping and Discharge System and Part 3 - Interim Advanced Wastewater Treatment System Work Plan - FEMP Revision 1*. WEMCO.

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APPENDIX A TO THE DESIGN, MONITORING, AND EVALUATION PROGRAM PLAN

Appendix A

South Plume Groundwater Recovery System Pump Test and Model Validation Work Plan

Environmental Remedial Action Project
Fernald Environmental Management Project
Fernald, Ohio

WEMCO Subcontract No. 2-21487
July 15, 1992
Revision No. 0

Operable Unit 5, Project Order 37

PARSONS

Fairfield Executive Center
6120 South Gilmore Road
Fairfield, Ohio 45014

South Plume Groundwater Recovery System
Pump Test And Model Validation Work Plan

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LIST OF ACRONYMS AND ABBREVIATIONS

ASI/IT	Advanced Sciences, Inc./International Technology
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DMEPP	South Plume Recovery System - Design, Monitoring, and Evaluation Program Plan
DOE	United States Department of Energy
ERA	Environmental Remedial Action
FEMP	Fernald Environmental Management Program
FMPC	Feed Materials Production Center
GMRP	Groundwater Monitoring and Response Plan
Ohio EPA	Ohio Environmental Protection Agency
PTP	Pump Test and Model Validation Work Plan
QAPjP	Draft Sitewide CERCLA Quality Assurance Project Plan
QAPP	Quality Assurance Project Plan (RI/FS Work Plan, Volume V)
RI/FS	Remedial Investigation/Feasibility Study
RW	Recovery Well
SPPZ	South Plume Piezometer
SSLS	Storm Sewer Lift Station
SWRB	Storm Water Retention Basin
USCS	Unified Soil Classification System
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WEMCO	Westinghouse Environmental Management Company of Ohio

SECTION 1

INTRODUCTION

1.1 Purpose

The Pump Test and Model Validation Work Plan (PTP) provides specific guidance in implementing the tasks of the design confirmation program described in Section 3 of the South Plume Groundwater Recovery System - Design, Monitoring, and Evaluation Program Plan (DMEPP). The design confirmation program described in the DMEPP consists of three components:

1) Pump test
2) Groundwater model validation
3) Groundwater model recalibration (if necessary)

The goal of the design confirmation program is to verify the design (and change if necessary) and improve the operation of the south plume recovery wells. An additional goal is to enhance confidence in the groundwater model by validating the model with pump test and recovery well operation data. The model validation will determine if recalibration is required. Recalibration will further refine the input parameters of the model and make it more reflective of the groundwater flow conditions at the site. The validated and recalibrated (if necessary) groundwater model will then be used for periodic recovery well system evaluations that will determine if the recovery system is meeting the removal action objectives. The recovery system evaluation is discussed in the South Plume Groundwater Monitoring and Response Plan (GMRP) in Appendix B of the DMEPP.

1.2 Content of the Pump Test and Model Validation Work Plan

The PTP includes the following:

1) Design information on recovery well RW-4 (the test well) and the piezometer and observation well network

2) Details of the pump test implementation and analysis of resulting data

3) Methods for model validation consisting of comparing pump test and operational recovery system data with SWIFT III groundwater model simulations

4) Methods for any required recalibration of the groundwater model

1.3 Approach and Rationale

A five-well recovery system will be constructed to capture uranium-contaminated groundwater and to prevent further expansion of the South Plume (Figure 1-1). Each well will pump groundwater at rates ranging from 400 to 650 gpm per well. The selection of approximate well locations and the pumping range was based on SWIFT III groundwater modeling simulations (ASI/IT 1992). The SWIFT groundwater model of the site has never been formally validated. Therefore, a design confirmation program consisting of a pump test, model validation, and model recalibration was included as part of the start-up process for the recovery system. Results from the pump test will be used to set initial recovery well pumping rates. After the recovery system is operational, well field monitoring of groundwater elevation data and pump test data will be used to validate the groundwater model. Once validated and recalibrated (if necessary), the model will be used to predict the effects of recovery well pumpage, to aid in system evaluation, and to select pumping rates over the life of the recovery system.

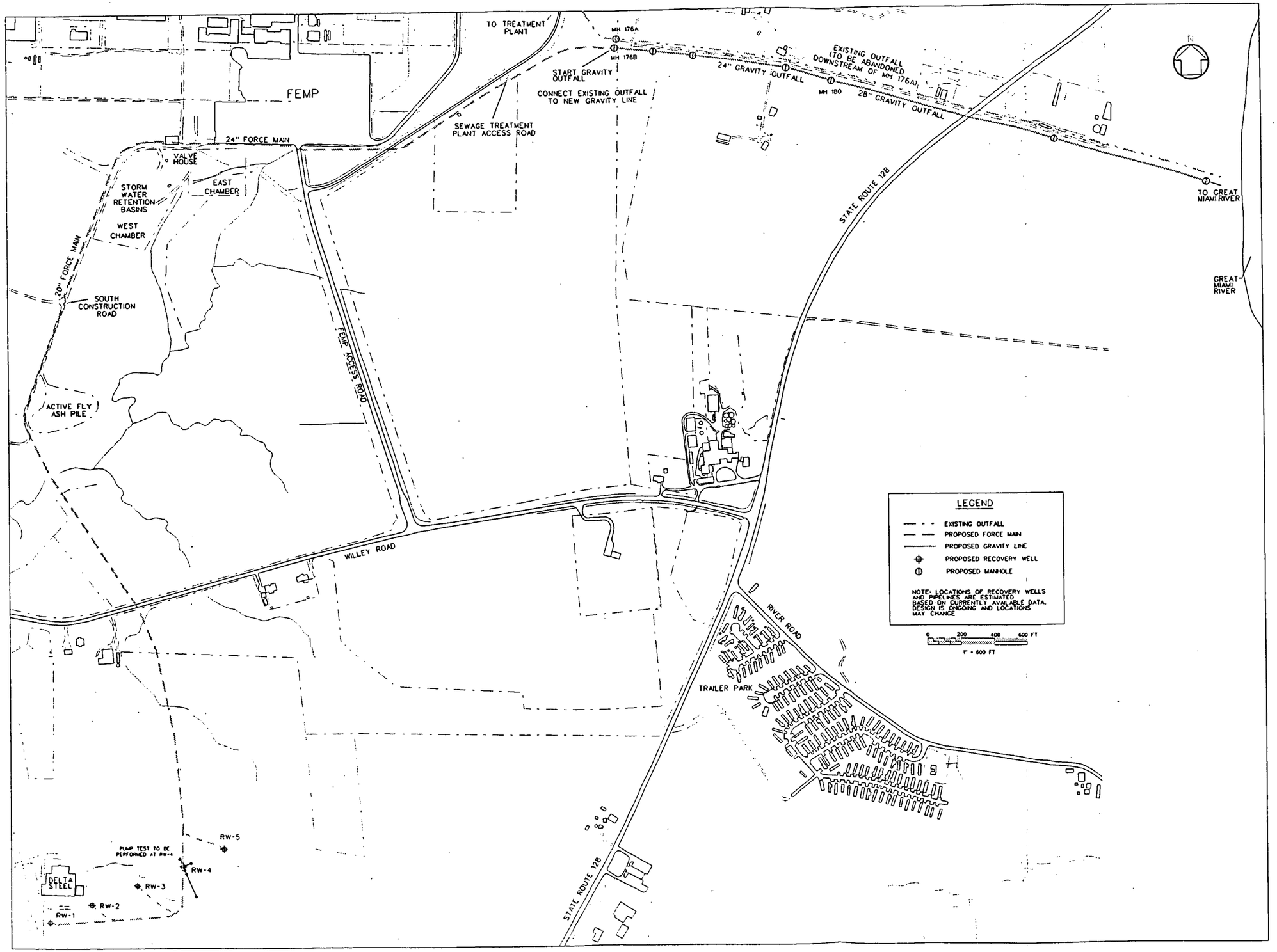

Figure 1-1 - Recovery System Site Plan

SECTION 2

GROUNDWATER PUMPING TEST

2.1 Objective

The pump test acquires data for calculating hydraulic properties of the Great Miami Aquifer. Data from this test will be analyzed using selected methods to determine the hydraulic conductivity, storativity, and anisotropic conditions that may exist in the vicinity of the proposed recovery well field. This information will also be used to help set screened intervals of the recovery wells, for setting initial pumping rates for the recovery system, and for validating the groundwater model. Over the course of the test, samples will be collected periodically from the pumped well to assess changes in groundwater geochemistry and to project uranium concentration of the pumped groundwater.

The pumping test will be performed in three stages. The first stage will involve a step drawdown test to determine the optimum flow rate for the constant rate test. The second stage of the pump test will be a 72-hour (or longer, if required) constant rate test. Unless otherwise suggested by the step-drawdown test, it is projected that the constant rate test will use a flow rate of approximately 1,200 gpm. The high flow rate is necessary to stress this aquifer sufficiently so that measurable drawdowns can be achieved in the piezometers and observation wells, particularly at distances greater than 100 feet. The third stage of the test will consist of an aquifer recovery period where groundwater elevations will be observed and recorded in the piezometers, monitoring/observation wells, and the recovery well immediately after the constant rate test pumping has ceased. Successful pump tests at or near this flow rate have been documented in the Venice (now Ross) area (Dove 1961) and at the Chem Dyne Superfund Site in Hamilton, Ohio (CH_2M Hill 1984).

2.2 Management and Responsibilities for Pump Test

Figure 2-1 shows the organizational relationship between the contractors who will be involved in the pumping test. Recovery well RW-4 will be used as the test well; therefore, performance of the test requires coordination between the recovery system design contractor (A.M. Kinney) and the contractor responsible for designing the pumping test (PARSONS). The recovery well used as the test well and any new piezometers used as observation wells will be designed by A.M. Kinney. This document provides design criteria to A.M. Kinney so that the test well and piezometers will meet the specific requirements of the pump test. Field activities associated with the pumping test will be implemented in accordance with this work plan and associated specifications provided by PARSONS. Several agencies, contractors, and subcontractors will be directly or indirectly involved in performing the pumping test. Table 2-1 provides the groups who may be called on to provide instructions and responses to contingencies and field changes during construction of the wells and performance of the pump test. Thirty days prior to drilling

Figure 2-1 - Pump Test Management Organization

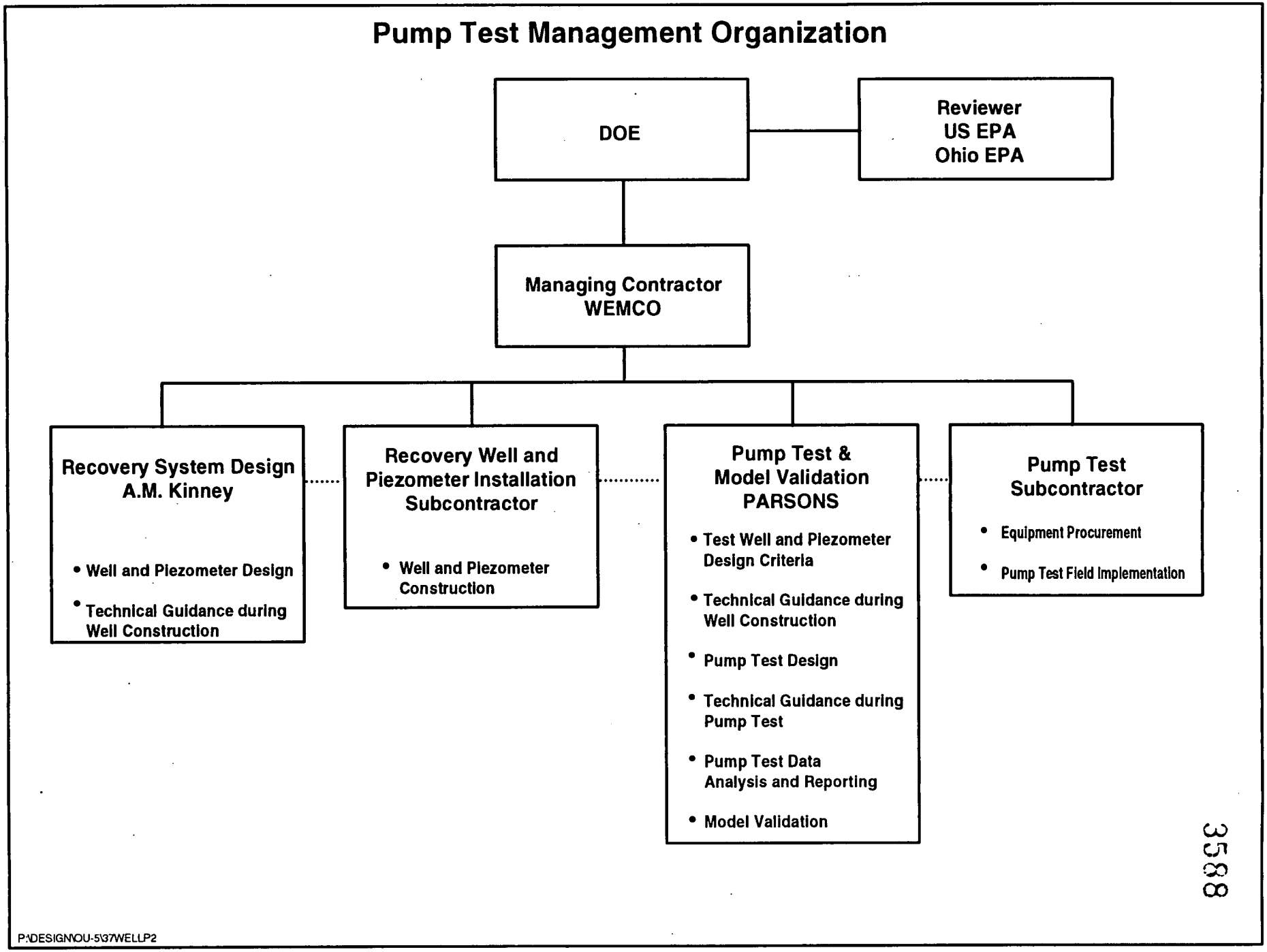

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Table 2-1 - Agencies, Contractors, and Subcontractors Providing Response to Field Changes and Contingencies

Organization	General Responsibilities
Construction Management	Recovery system installation
Data Logger and Pressure Transducer Supplier	Drawdown and recovery measurement
United States Department of Energy (DOE)	Policy and procedural guidance
Drilling Contractors	Well installation
Emergency Response	Health and Safety - fire, ambulance, hospital, and police
A.M. Kinney	Well specifications Procedures and overall recovery system design
Miscellaneous Suppliers	Miscellaneous
Ohio Environmental Protection Agency (Ohio EPA)	Regulatory requirements
PARSONS	Well and pump test requirements
Test Pump Supplier	Pump installation and operation
United States Environmental Protection Agency (US EPA)	Regulatory requirements
Westinghouse Environmental Management Company of Ohio (WEMCO)	Procedural Guidance

and testing, the managing contractor shall prepare a list of representatives (with phone numbers) from each group in Table 2-1. This list will be provided to all parties involved in the test.

2.3 Well Placement and Design

The pump test well (RW-4) and observation wells will be designed by A.M. Kinney. PARSONS, as pump test designer, defines specific criteria for A.M. Kinney to incorporate into their design. These specific criteria are included below. PARSONS and A.M. Kinney will provide on-site technical guidance during well construction.

2.3.1 Test Configuration

Piezometers are located to be consistent with data analysis techniques so that the aquifer's hydraulic properties may be estimated accurately. Figure 2-2 illustrates locations for the test well (RW-4), piezometers, and monitoring wells in the area. Certain monitoring wells that currently exist or that will be installed prior to the pumping test will also be used as observation wells. Monitoring wells, proposed in accordance with the South Plume Groundwater Monitoring and Response Plan (Appendix B of the DMEPP), are shown on Figure 2-2 as these are projected to be installed prior to the commencement of the pump test. Staff gauges will be located in Paddys Run to monitor any effects of the stream as a boundary to the test. Staff gauge locations are shown on Figure 2-2. Figure 2-3 presents the layout of piezometers to be installed in connection with this pump test.

Piezometers SPPZ-2, 3, and 4 are aligned southeast of RW-4 at distances of 25, 50, and 200 feet respectively (see Figure 2-3) so that straight line distance drawdown methods of aquifer analysis can be applied. These distances were selected based on the analysis described in Subsection 2.3.2 below. Piezometers SPPZ-1 and 5 are located in different quadrants than SPPZ-2, 3, and 4 so that the effects of anisotropy can be measured. These piezometers are screened at approximately the same depth as the screen bottom of RW-4 so that methods of aquifer analysis for partially penetrating wells can be applied (see Subsection 2.5). In order to assess the test well's vertical influence, other piezometers will be installed in the vicinity of SPPZ-2 at incrementally greater depths.

For the pump test, observation wells are divided into two groups, primary and secondary, as shown on Tables 2-2 and 2-3. Primary wells, which include a control (background) well and the observation wells closest to the pumping well, will have water levels automatically measured either periodically (data logger) or continuously (chart recorder) during the pump test and will be the wells used for curve-matching analysis. Monitoring well 2015 will serve as the control (background) well and will be measured automatically with a chart recorder. Secondary wells, monitoring wells farther from the pumping well, will have water elevations measured with steel tapes or electric sounders during the pump

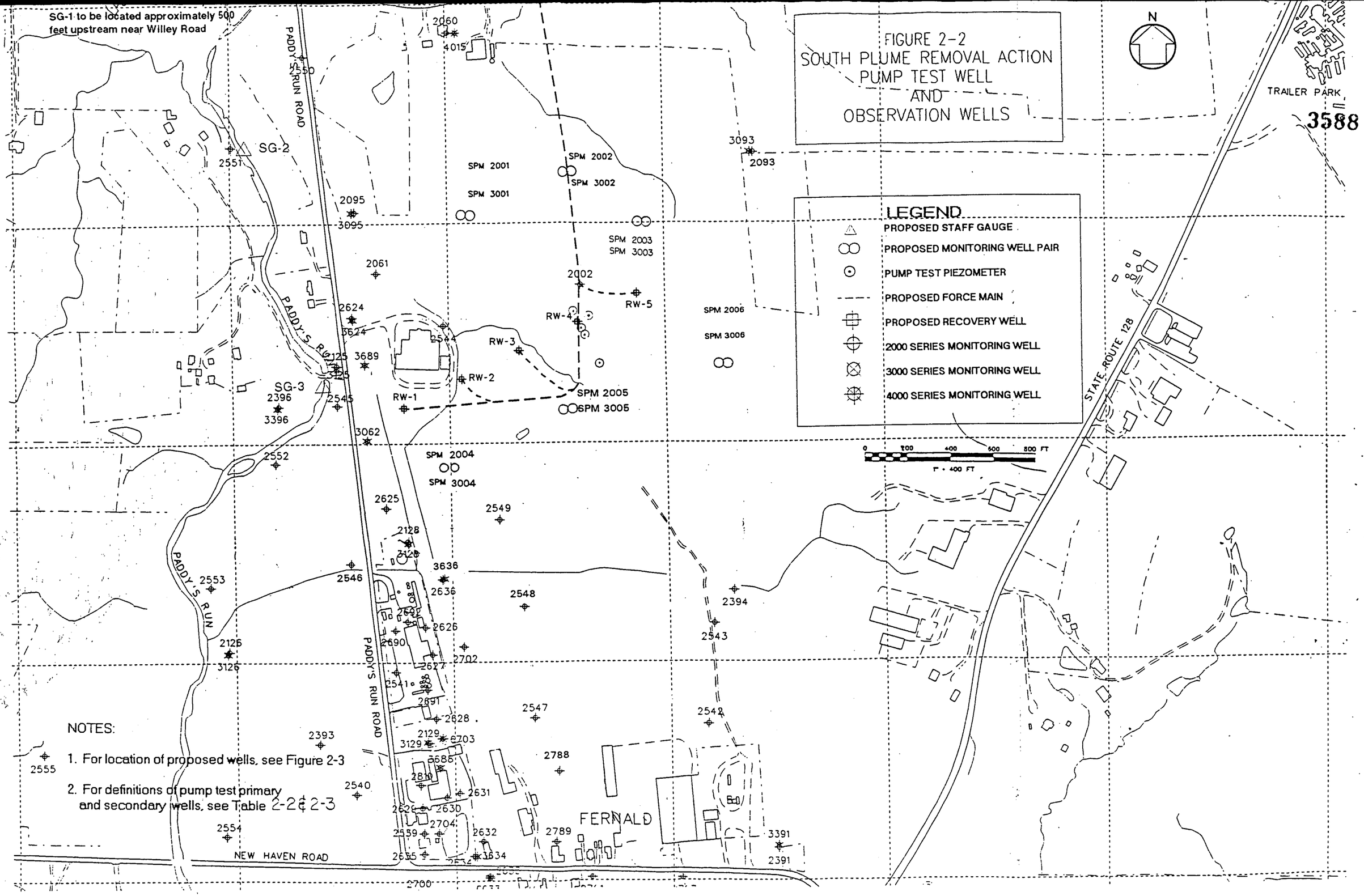

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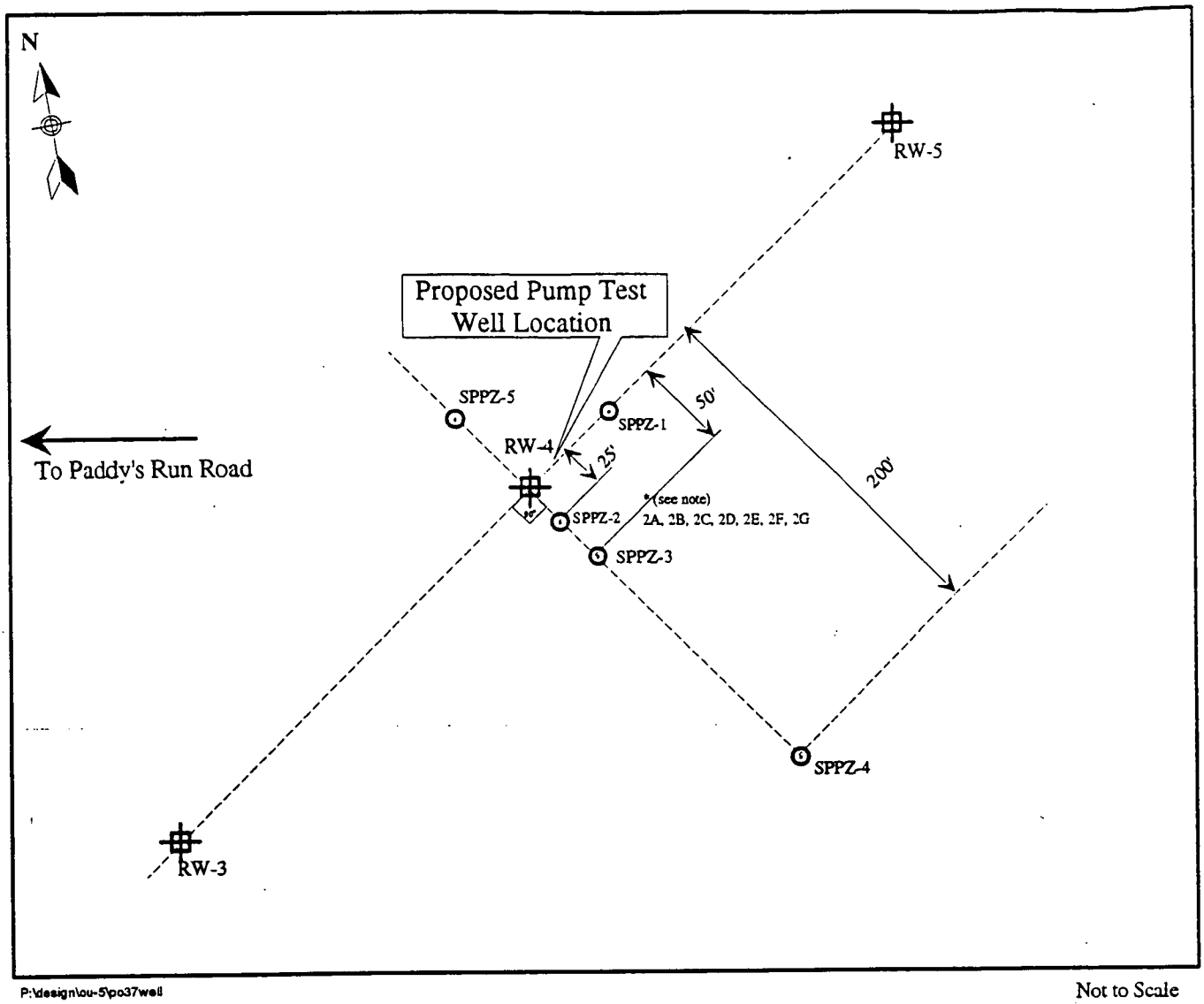
Figure 2-2 - Pump Test Network Configuration



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Not to Scale

⊙ Proposed piezometer

⊕ Proposed recovery well location

---------- Bearing Line

Note: SPPZ-2 consists of 2A, 2B, 2C, 2D, 2E, 2F, 2G

Figure 2-3 - Proposed Locations for Piezometers

Table 2-2 - Pump Test Primary Observation Wells and Piezometers and Measurement Requirements

Primary Wells	Measurement Device	Minimum Measurement Frequency
SPPZ-1	Transducer/Datalogger	1) Daily readings 7 days before test 2) During test, see Table 2-9.
SPPZ-2A	Transducer/Datalogger	
SPPZ-2B	Transducer/Datalogger	
SPPZ-2C	Transducer/Datalogger	
SPPZ-2D	Transducer/Datalogger	
SPPZ-2E	Transducer/Datalogger	
SPPZ-2F	Transducer/Datalogger	
SPPZ-2G	Transducer/Datalogger	
SPPZ-3	Transducer/Datalogger	
SPPZ-4	Transducer/Datalogger	
SPPZ-5	Transducer/Datalogger	
2002	Transducer/Datalogger	
SPM-2001	Float/Recorder	Continuous for 7 days before test through end of recovery period.
SPM-2003	Float/Recorder	
SPM-2005	Float/Recorder	
SPM-2006	Float/Recorder	
2015	Float/Recorder	

Table 2-3 - Pump Test Secondary Observation Wells and Measurement Requirements

Secondary Wells	Measurement Device	Measurement Frequency
SPM-3001	Steel tape or electric sounder	Daily readings from 7 days before test through the end of the recovery period. Two readings the first day of test, one before pump start up and one after pump start up.
SPM-3002	Steel tape or electric sounder	
SPM-3003	Steel tape or electric sounder	
SPM-3004	Steel tape or electric sounder	
SPM-3005	Steel tape or electric sounder	
SPM-3006	Steel tape or electric sounder	
SPM-2002	Steel tape or electric sounder	
SPM-2004	Steel tape or electric sounder	
SPM-2006	Steel tape or electric sounder	
2128	Steel tape or electric sounder	
3128	Steel tape or electric sounder	
2636	Steel tape or electric sounder	
3636	Steel tape or electric sounder	
2548	Steel tape or electric sounder	
2549	Steel tape or electric sounder	
2543	Steel tape or electric sounder	
2394	Steel tape or electric sounder	
2093	Steel tape or electric sounder	
3093	Steel tape or electric sounder	
3015	Steel tape or electric sounder	
2106	Steel tape or electric sounder	
3106	Steel tape or electric sounder	
2095	Steel tape or electric sounder	
3095	Steel tape or electric sounder	
2544	Steel tape or electric sounder	
2624	Steel tape or electric sounder	
3624	Steel tape or electric sounder	
2125	Steel tape or electric sounder	
3125	Steel tape or electric sounder	
2625	Steel tape or electric sounder	

test, and with less frequency. Steel tapes will be available as back-up measuring devices in the event of electric sounder failure. Some of these wells may show drawdown at these more remote locations due to non-homogeneous or anisotropic conditions; however, the data cannot be treated as reliable for curve matching analysis. Tables 2-2 and 2-3 show the frequency of measurements. If recovery wells RW-1, 2, 3, and 5 have been installed prior to the pumping test, arrangements will be made to monitor their water levels as well.

2.3.2 Basis of Observation Well Layout

The pumping test layout, described in Subsection 2.3.1, was based on field data from similar pumping tests and supported with simplified scoping calculations. The field data includes information from the pumping tests for the Albright and Wilson alternate water supply (located approximately 1 mile southwest of the Fernald Environmental Management Project [FEMP]) (ASI/IT 1991), the collector wells near Venice, Ohio (approximately 1 mile east of the FEMP) (Dove 1961), and the Chem Dyne Site in Hamilton, Ohio (approximately 10 miles northeast of the FEMP) (CH_2M Hill 1984). The scoping calculations were performed using the USGS 3-D groundwater model MODFLOW (McDonald and Harbaugh 1988).

Field data plots were available for several wells on the Venice test. The test well was pumped at approximately 1,000 gpm; after 12 hours, the observation wells exhibited approximate drawdowns of 2.5, 1.5, and 0.75 feet at distances of 50, 100, and 200 feet respectively from the test well. In the Chem Dyne test, data on only one observation well was available; however, after pumping the test well at approximately 1,000 gpm for 14 hours, the observation well exhibited slightly less than 3 feet of drawdown at a distance of 53 feet from the test well. The Albright and Wilson alternate water supply pumping test only stressed the aquifer at 380 gpm. Observation wells were located at distances of 25 and 300 feet from the test well. After pumping the test well for 72 hours, no drawdown occurred in either of the observation wells. From distance drawdown plots of the Venice test data, it is estimated that approximately 3 to 4 feet of drawdown will occur at a distance of 25 feet from the test well if it is pumped at 1,200 gpm.

Simplified simulations of the proposed pump test were performed using MODFLOW. The model was configured to simulate drawdown effects caused by a partially penetrating well by creating a simplified two-layer system with pumping simulated in the top layer. A 30 x 30 cell grid was developed with cell dimensions of 25 feet in the "x" and "y" directions, and simplified boundary conditions were created. A two-layer system was created in the "z" direction. The upper layer was 135-feet thick with a saturated thickness of 35 feet. The lower layer was 120-feet thick and fully saturated. A well was centered on the grid and, by pumping only the upper layer, the effects of partial penetration were simulated. Boundary conditions included no-flow boundaries on the initial and terminating cell columns of the grid and constant head boundaries (set at 900 feet) on the uppermost and lowermost rows of the grid. The model was operated in steady-state mode, and drawdown effects were produced for 24 hours of pumpage.

Various flow rates were used including the projected flow rate of 1,200 gpm for the proposed pump test. Hydraulic conductivity values from the Venice test (Dove 1961), the SWIFT III model (ASI/IT 1990), and a value similar to the Chem Dyne test were used. Table 2-4 shows the drawdown results of these simulations.

At distances of 100 to 300 feet, the model predicted drawdown similar to the data acquired in the Venice test when using hydraulic conductivity values similar to those used in the SWIFT model (4.5×10^2 feet/day) and derived from the Venice test (3.87×10^2); however, the model predicted lower drawdown values at distances from 25 to 100 feet. When a hydraulic conductivity value similar to that derived from the Chem Dyne test was used (1.47×10^2), the predictions for drawdowns matched more closely to well drawdowns lying at distances of 25 to 100 feet away from the pumped well, but were not as close to drawdown data over 100 feet away.

Given the low drawdowns at distances greater than 200 feet for pump tests performed in the vicinity of the FEMP and similar model results, the piezometer locations described above were selected.

2.3.3 Procedures for Well/Piezometer Construction

Regardless of management responsibility, the installation of all wells and piezometers shall be consistent with guidelines provided in the draft "FEMP Sitewide Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Quality Assurance Project Plan" (QAPjP) (WEMCO 1992a). Exceptions to these procedures shall be approved by WEMCO, PARSONS, and A.M. Kinney prior to implementation.

Procedures pertaining to well installation activities are referenced to the section of the QAPjP in Table 2-5. A.M. Kinney will develop specifications for recovery well and piezometer construction from the QAPjP and any applicable task-specific procedures.

2.3.4 Design and Installation of Test Well (RW-4)

Design considerations (PARSONS 1992a) regarding the construction of the test well were prepared and submitted to WEMCO. This information, revised to incorporate recent comments, has been included in this document. In order to accommodate the high flow rates anticipated for the pumping test, the design of RW-4 will be different from the other four recovery wells. Table 2-6 details the specific design requirements for RW-4. Drilling will be in accordance with Subsection 5.2.1 of QAPjP. The test well will be drilled by approved methods to an approximate depth of 110 feet below ground level (40 feet below the top of the water table). Drilling and well construction specifications will be prepared by the design contractor, A.M. Kinney.

Table 2-4 - Model Drawdown Results
(Pump Rate 1,200 gpm)

Hydraulic Conductivity (Distance from Pumping Well (ft)	**25**	**50**	**75**	**100**	**125**	**150**	**175**	**200**
IT Swift K=450 ft/day	2.0	1.3	1.0	1.0	0.7	0.6	0.6	0.5
Dove/Spieker K=387 ft/day	2.2	1.4	1.1	1.0	0.8	0.8	0.7	0.6
K=200 ft/day	3.6	2.6	2.2	1.9	1.6	1.5	1.3	1.2

Note: Drawdown measured in feet
K = hydraulic conductivity

Table 2-5 - Well Installation Procedures

	REFERENCE
Administrative Procedures	**FEMP QAPjP (Draft March 1992)**
Chain-of-Custody	Section 7.1
Corrective Action	Section 15.2
Daily Logs	Section 5.1 and Appendix J, Subsection J.4.1
Variances	Section 15.4
Field Procedures	
General Drilling Practices	Section 5.2.1 and Appendix J, Subsection J.4.2
Subsurface Sampling	Appendix K, Subsection K.5.3
Monitoring Well/Piezometer Design, Installation, and Abandonment	Section 5.2.2 and Appendix J, Subsection J.4.3 *EM-GW-004
Well Development	Section 5.2.3 and Appendix J, Subsection J.4.4
Borehole Geophysical Logging	Section 5.3.1
	Section 5.2.5 and Appendix J, Subsection J.4.6
Field Screening of Samples for Radioactive Contamination	Appendix K, Subsection K.5.3.2
Decontamination	Appendix K, Subsection K.11
Field Storage and Shipment of Samples	Appendix K, Subsection K.10
Laboratory Test Procedures	
Grain Size Analysis	Attachment I, Volume V, Method No. FM-GTT-0031

* Well abandonment will also follow this procedure listed in the *WEMCO Environmental Monitoring Procedures Manual, Rev. 28 (June 16, 1992).*

Table 2-6 - Test Well (RW-4) Design Requirements

Parameter	Criteria
Pump Test Well (RW-4)	Estimated State Coordinates - 474514 N and 1380608 E
Static Water Level Depth (Relative to ground surface)	Approximately 65 to 70 feet
Base of Well Screen Depth (Relative to ground surface)	Approximately 105 to 110 feet
Anticipated Drawdown	10-20 feet at 1,200 gpm
Well Size	Sufficient diameter to pump 1,200 gallons per minute and meet screen entrance and uphole velocity requirements. Uphole velocity less than 5 feet/second
Screen	1) Screen interval from top of water table to 40 feet below water table 2) Screen entrance velocity less than or equal to 0.1 feet/second
Pump Inlet Placement	Below base of screen
Pump Flow Rate	Variable - between 500 and 1,200 gpm with ability to sustain a maximum 1,200 gpm for 12 days. Up to 21 million gallons of water may be pumped to the SWRB and gravity outfall during the test.
Pump Type	Anticipate submersible or vertical shaft turbine
Pumping Appurtenances	1) Backflow preventer - check valve to prevent water in discharge line from re-entering well 2) Flow Control - variable speed drive or throttled discharge valve 2) Flow measurement - flow meter and orifice weir on discharge line 3) Sampling - sampling port on discharge line
Drawdown Measurement	Configuration of well and pump shall allow for the measurement of water elevation in the pump test well and the filter pack immediately outside the test well screen. Stilling pipe consisting of one-inch PVC pipe inside the well is recommended. A one-inch ID stainless-steel pipe or well with a screen length equivalent to the test well shall be installed in the filter pack at the same depth as the test well.

Representative split spoon samples will be taken every 10 feet over the 40-foot screened interval for screen slot determination. Based on nearby well data, split spoon sampling will be from 70 feet to 110 feet below ground surface. Samples will be classified in accordance with the USCS. Samples will be retained by the field geologist and archived as directed by WEMCO. Split spoon samples will be selected for sieve and other geotechnical parameter analyses as determined by PARSONS or A.M. Kinney. When the recovery well boring has reached total depth, a natural gamma borehole survey will be taken through the casing to determine the presence of clay layers in the sand and gravel aquifer. Table 2-5 references procedures for acquiring borehole geophysical logs. For comparison purposes, boring logs for wells in the area of RW-4 are enclosed in Attachment A.

Prior to selection of the well screen, grain size analysis will be performed by the well screen manufacturer in accordance with methods referenced in Table 2-5. This analysis will ensure that the proper slot size (and gravel pack if required) is selected that will meet minimum requirements for screen entrance velocity and that the structural integrity of the screen will be maintained. The screened interval of the test well shall have a slot size of sufficient open area to maintain a screen entrance velocity at or below 0.1 feet/second. If a gravel pack is required, the material shall consist of clean, smoothly rounded grains.

Well development will be conducted as specified by A.M. Kinney. No procedures for recovery wells currently exist under the draft FEMP sitewide QAPjP; therefore, procedures and standards shall be developed by A.M. Kinney and approved by WEMCO. Well development specifications should meet standards for production wells with special consideration to the fact that RW-4 will flow for 3 to 12 days at a rate (1,200 gpm) that is two to three times its normal operating range. Cuttings from the recovery well drilling and development operations will be drummed and disposed as directed by the Site Managing Contractor. Groundwater from development operations will be discharged to the Storm Water Retention Basin (SWRB) via the new force main or as directed by the Site Managing Contractor.

2.3.5 Design and Installation of Piezometers

A total of eleven piezometers will be required for the pump test. Five 2-inch ID piezometers (SPPZ-1, 2A, 3, 4, and 5) will be installed at a depth of approximately 110 feet below the ground surface (40 feet below the top of the water table) at the locations shown in Figure 2-3. In order to assess the test well's vertical influence, four 2-inch ID piezometers (SPPZ 2B, 2C, 2D and 2E) will be installed and screened at 10-foot increments below the base of SPPZ-2A with the deepest set at approximately 150 feet below ground level. The actual depth of each well will depend on the elevation of the water table at each location and the depth to bedrock. At the same location, two additional piezometers will be set at approximately 40 foot increments to a depth of approximately 230 feet below ground level. One of these piezometers (SPPZ-2G) will be set in sand and gravel material immediately above bedrock. The other (SPPZ-2F) will be screened at a depth midway between SPPZ-2E and SPPZ-2G. The field geologist will be responsible for selecting the total depth of each well.

Table 2-7 presents design criteria for the piezometers. The screened interval will be 5 feet at the base of each piezometer. For Piezometers SPPZ-1, 3, 4, and 5, continuous corings (3 inch ID minimum) will be collected over the screened interval. Samples will be classified in accordance with the USCS. To gain a better understanding of the aquifer's vertical heterogeneity, a continuous core (3 inch ID minimum) will be required from the deepest piezometer in the SPPZ-2 cluster. The core will be taken from 10 feet above the water table to the base of the boring (top of bedrock). No coring will be required from any other piezometers in the SPPZ-2 cluster. Core samples will be selected for sieve and other geotechnical parameter analysis as determined by the pump test analyzer (sample analysis is the responsibility of the pump test analyst). At total depth, a natural gamma log will be run at all the piezometer locations (only at the deepest piezometer at SPPZ-2), so that changes in lithology can be correlated accurately in the vicinity of the pump test.

A natural filter pack will be used that allows the aquifer material to collapse around the screen. Piezometers will be developed and their integrity will be tested in accordance with methods prescribed in the QAPjP (WEMCO 1992a) as referenced in Table 2-5. Cuttings will be drummed and disposed of as prescribed by the site managing contractor. A representative from PARSONS will be available for consultation on site during piezometer installation.

After the complete recovery system is operational for 3 months and the necessary information has been acquired for the model validation effort, piezometers SPPZ 1, 3, 4, and 5 will be abandoned. The piezometers will be abandoned in accordance with procedures referenced in Table 2-5 and in accordance with WEMCO Groundwater Programs Procedure EM-GW-0004. Piezometers SPPZ 2A, 2B, 2C, 2D, 2E, 2F, and 2G will become permanent monitoring wells.

2.4 Aquifer Test Design and Field Implementation

As discussed in Subsection 2.1, data will be acquired in three stages during the pumping test:

1) A step drawdown test
2) A 72-hour constant rate test (longer if required by delayed yield effects)
3) A water level recovery period

Each stage of the test will be used to define the next stage. Each stage is detailed in the following sections. Figure 2-4 is a schedule of activities (not including well drilling) associated with the performance of the pumping test. This pump test design is based on Stallman (1971), U.S. Department of the Interior (1981), Driscoll (1986), Walton (1987), and Kruseman and deRidder (1990).

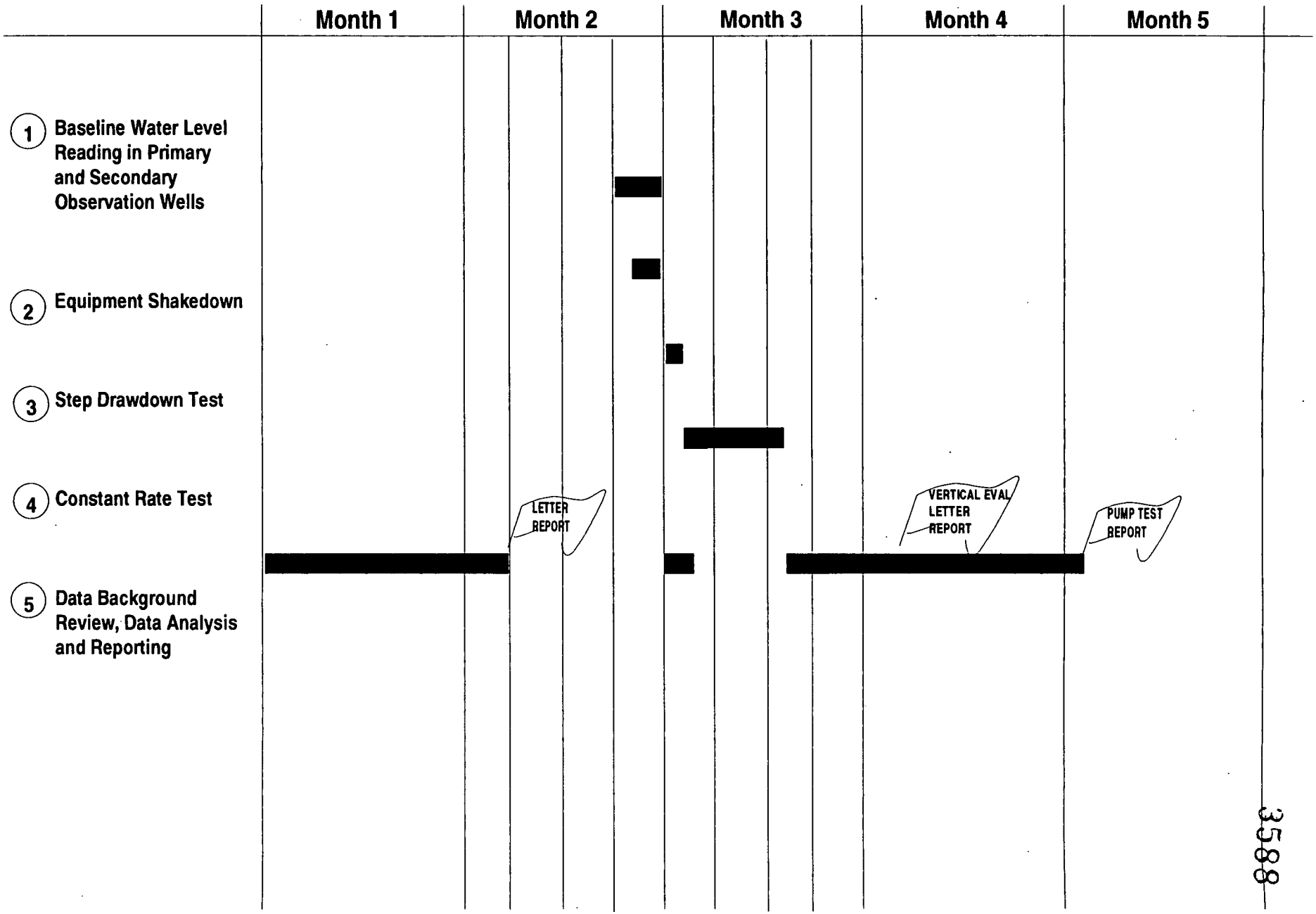
Table 2-7 - Piezometer Design Requirements

Parameter	Requirement
Casing Diameter	2-inch minimum ID PVC or stainless steel[1]
Screen Diameter	2-inch minimum ID PVC or stainless steel[1]
Screen Slot Size	0.01-inch
Screen Interval	5-foot section of screen will be placed at the base of the piezometer. Bottom of the screen will be approximately 40 feet below the top of the water table, except for SPPZs 2B, 2C, 2D, 2E, 2F and 2G.
Locations in relation to RW-4 (see Figure 2-3)	1. SPPZ-1 50 feet northeast; depth approx. 110 feet 2. SPPZ-2A 25 feet southeast; depth approx. 110 feet 3. SPPZ-2B 25 feet southeast; depth approx. 120 feet 4. SPPZ-2C 25 feet southeast; depth approx. 130 feet 5. SPPZ-2D 25 feet southeast; depth approx. 140 feet 6. SPPZ-2E 25 feet southeast; depth approx. 150 feet 7. SPPZ-2F 25 feet southeast; depth approx. 190 feet 8. SPPZ-2G 25 feet southeast; depth approx. 230 feet 9. SPPZ-3 50 feet southeast; depth approx. 110 feet 10. SPPZ-4 200 feet southeast; depth approx. 110 feet 11. SPPZ-5 50 feet northwest; depth approx. 110 feet
Estimated State Planar Coordinates for Wells and Clusters[2]	1. SPPZ-1 474, 534N; 1,380, 654E 2. SPPZ-2 A, B, C, D, E, F, G 474,491N; 1,380,618E 3. SPPZ-3 474,468N; 1,380,628E 4. SPPZ-4 474,330N; 1,380,686E 5. SPPZ-5 474,560N; 1,380,588E

1 Piezometer Cluster SPPZ-2A, 2B, 2C, 2D, 2E, 2F, and 2G will be constructed of stainless steel materials. All other piezometers will use PVC materials.

2 Locations provided by A.M. Kinney on May 15, 1992.

Figure 2-4
Pump Test Schedule



2.4.1 Required Personnel

During actual performance of the pumping test, the following personnel will be required at various times on site:

1) Task Manager: Responsible for overall coordination of the project

2) Lead Pump Test Specialist: Responsible for test setup and procedures

3) Technicians: Responsible for data collection and well measurements

4) Data Logger Equipment Specialist (manufacturer's representative): Responsible for setup, verification, and operation of datalogger and pressure transducer data collection devices

5) Field Labor Foreman and Crew: Responsible for heavy equipment moving and piping hookups and assisting in operation of discharge lines

6) Pump Operator (and Helper if required): Responsible for operating the pump and maintaining flow at required levels and also responsible for power source

7) Analytical Lab Specialist: Responsible for collecting groundwater samples during the test

All managers, specialists, operators, and technicians shall possess the necessary skills and experience to perform their respective tasks during the pumping test. Participants shall be able to address contingencies competently and efficiently so that valuable time and data is not lost. Margins for error will be very small because of the difficulty and expense in repeating the pump test exercise. All field contingencies should be resolved to the fullest extent possible during the equipment shakedown period described below. An experienced team will maximize the likelihood of a successful test.

2.4.2 Test Equipment

The following equipment will be required:

1) Submersible or vertical shaft turbine pump that can be accommodated by the test well with check valve to prevent water from siphoning back into the well. Pump must be capable of pumping 1,200 gpm against static and friction head necessary to pump the water to the SWRB.

2) Power source for the pump capable of continuous operation for as long as 12 days. If an internal-combustion engine, it shall be equipped with a tachometer.

3) Piping and necessary fittings from the pump to the force main with a minimum capacity of 1,200 gpm.

4) Power source for the ancillary field equipment.

5) Gate valve or other flow control device to control discharge from the test well.

6) Flow meter with a totalizer to measure flow in gallons per minute and total discharge in gallons.

7) An orifice weir (for backup flow measurement) with manometer tube, to be installed at the SWRB discharge point.

8) Sixteen channel data logger with 16 transducers with necessary fittings and cables (Hermit by In Situ, or equivalent). Data logger and transducer system shall be capable of recording at rates as frequently as two readings per second. Transducers shall be sized for appropriate pressure ratings.

9) A single channel data logger and transducer for backup purposes, particularly during recovery period.

10) Four gear-driven, float-type automatic water level chart recorders (Stevens Type F or equal).

11) Twenty steel tapes with chalk or electrical water level measuring tapes (both types at least 200 feet long and graduated in hundredths of a foot) for water level measurement.

12) Stop watches and digital wrist watches capable of being synchronized within 1 second for each member of the pump test team.

13) Light plant for overnight activities.

14) Portable hand-held lighting (e.g., flashlights and lanterns) for each member of the team.

15) Hand-held radio communicators as determined by the field task manager.

16) A weather station capable of measuring barometric pressure, temperature, and rainfall; the FEMP meteorological tower is suitable if approval is secured.

17) Combined pH, specific conductance, and dissolved oxygen meter.

18) Thermometers (at least two).

19) Sample bottles and shipping containers.

20) Portable computer.

21) Log-log 3- by 5- cycle and semi-log 3-cycle graph paper for plotting drawdown data.

22) Distilled water and equipment for decontamination of probes and steel tapes.

23) Sampling port on flowline for groundwater sampling.

24) Health and safety equipment and clothing.

25) Indelible pens and/or pencils.

26) Field notebook and water level recording forms.

27) Pump Operator's Field Log.

28) Three staff gauges located in Paddys Run (see Figure 2-2).

2.4.3 Procedures

Procedures for performing the tasks associated with the pump test will be consistent with guidelines provided in the draft FEMP QAPjP (WEMCO 1992a) and new procedures developed as part of this PTP. These procedures are referenced in Table 2-8. The new procedures are described in detail in Attachment B. Exceptions to these procedures will be approved by WEMCO and PARSONS prior to implementation.

Table 2-8 - Pump Test Procedures

Administrative Procedures	**Reference***
Chain-of-Custody	Section 7.1
Corrective Action	Section 15.2
Daily Logs	Section 5.1 and Appendix J, Subsection J.4.1
Variances	Section 15.4
Field Procedures	
Ground Water Level Measurement	Appendix K, Subsection K.4.2.1
Water Level Measurements - Metal Tape	New Procedure, Attachment B of PTP
Water Level Measurement Form	New Procedure, Attachment B of PTP
Aquifer/Permeability Testing	Section 5.2.5 and Appendix J, Subsection J.4.6
Measurement of Discharge Orifice Weir	New Procedure, Attachment B of PTP
Groundwater Sampling	New Procedure, Attachment B of PTP
Field Screening of Samples for Radioactive Contamination	Appendix K, Subsection K.5.3.2
Decontamination	Appendix K, Subsection K.11
Field Storage and Shipment of Samples	Appendix K, Subsection K.10
Field Calibration Requirements	Appendix I
Field Analytical Method for Natural Water Samples	Appendix K, Subsection K.4.1
Field Test:	
Temperature	Appendix K, Subsection K.4.1.1
pH	Appendix K, Subsection K.4.1.2
Specific Conductance	Appendix K, Subsection K.4.1.3
Dissolved Oxygen	Appendix K, Subsection K.4.1.4
Laboratory Test Procedures	
Total Uranium	Attachment I, Volume V, Method No. FM-RAD-0120

*Note: Reference sections are from FEMP QAPjP (Draft March 1992) except for new procedures included in Attachment B.

2.4.4 Equipment Shakedown and Background Data

In order to minimize unforeseen problems, all equipment will be subjected to a performance shakedown at least 2 days prior to the test. Power supplies, the pump, flow lines and discharge collection systems, valves, gages, meters, lighting, recorders, dataloggers, communicators, and any other equipment subject to mechanical, structural, and/or electrical failure will be inspected and field tested prior to startup of the pumping test. Records shall be maintained by the operator(s).

Water level measurements of the test well, piezometers, and primary observation wells will be collected four times a day for 1 week prior to the start of the test. Continuous recorders will be installed in four of the monitoring wells that will not be equipped with pressure transducers and allowed to collect data for 1 week prior to the test. Records shall be maintained by the operator(s).

2.4.5 Handling of Pump Test Water

For the Great Miami Aquifer, the effects of delayed yield are likely to occur but not before 7 days of pumping at 1200 gpm. The test might actually take 12 days before these effects are seen, however, provisions for pump test discharge will assume a 7 day test. During the first 24 hours, approximately 1.73 million gallons of water will be produced and discharged through the new force main to the SWRB. This water will be routed to and treated by the SWRB-Interim Advanced Waste Water Treatment (IAWWT) Plant (300 gpm nominal capacity). After 24 hours, the full existing pumping capacity of the SWRB (minimum 550 gpm) will be used with the excess capacity pumped around the IAWWT and discharged directly to the river. This will result in a maximum accumulation of 6.2 million gallons of water during a 7 day test. The SWRB will remain at the 550 gpm rate for a sufficient period after the test to draw down the level of the SWRB.

Similarly, the Storm Sewer Lift Station (SSLS) will be used to minimize the amount of runoff water accumulating in the SWRB during the test. Also, the 550 gpm pumping rate will be used, if necessary, prior to the test so that the SWRB is at a low level when the test commences.

In the event that construction work is completed to the extent that a tie-in to the existing 16-inch gravity outfall could allow direct discharge to the Great Miami River, that option will be considered. The US EPA will be informed if this change is made.

By conducting this test over a 7-day period with substantial accumulation of groundwater in the retention basins, the SSLS must be activated, and remain activated even during a significant rain event, to prevent the basins from overflowing. Standard procedure during a rain event is to deactivate the SSLS thus allowing runoff to collect in the retention basin for quiescent settling of solids prior to discharge to the river. If a rain event occurs during this pump test, and with the SSLS activated, the potential exists for

TSS excursions above the NPDES effluent limitations at both the SSLS (30 mg/l monthly average; 45 mg/l daily maximum) and Manhole 175 (30 mg/l monthly average; 45 mg/l daily maximum). Mass loading limitations for TSS, and other regulated pollutants, may also be adversely impacted. Moreover, because this groundwater has a low dissolved oxygen content there is concern that without additional aeration, the NPDES effluent limitation, requiring a minimum effluent dissolved oxygen level of 5.0 ppm, can probably not be achieved. Dissolved oxygen is a State of Ohio Water Quality Standard.

In addition, pursuant to the Director's Findings and Orders effective June 26, 1987, the FEMP has been required to construct the retention basins with capacity to "...collect and hold all stormwater runoff from the FMPC process area, including the FMPC parking lots, resulting from a 10-year, 24-hour storm event." The FEMP would be vulnerable in handling such a storm during the pump test when a significant accumulation of groundwater is stored in the retention basins.

The FEMP will require relief from any enforcement actions relative to NPDES permit/Clean Water Act compliance, the causes of which are directly attributable to the discharge of the accumulated groundwater during this pump test.

2.4.6 Step Drawdown Test

A step drawdown test will be conducted to determine well yield and optimum pumping rate for the constant rate pumping test. The test well will be pumped at three successively higher rates: 600, 900, and 1,200 gpm. Each step will have a duration of 2 hours, or longer if the water level in the pumping well has not stabilized. During each step period, flow will be maintained at + or - 5 percent (within the tolerance interval suggested by Stallman, 1971) of the designated rate by means of a throttling device or other flow control method. Records of the test including time durations shall be maintained by the equipment operators and the Lead Pump Test Specialist (or his designated assistant).

Water levels will be automatically measured in the test well, and primary observation wells will be recorded with pressure transducers linked to a data logger. Water levels also will be monitored periodically using electrical water level indicators and/or steel measuring tapes so that data logger readings can be cross checked. Tables 2-2 and 2-3 list all the wells and piezometers to be used for observation purposes during the test and the method of water level measurement. Information from the drawdown measurements will be used to determine if the well can pump at a sufficiently high rate to stress the aquifer adequately.

Water level measurements shall be recorded on a form similar to that shown in Attachment B. Water levels will be measured relative to the top of the well casing reference point. Installation, calibration, and use of the datalogger and pressure transducer system will be accomplished by a representative of the manufacturer/supplier.

2.4.7 Constant Rate Test

After the step drawdown test and before commencement of the constant rate test, the aquifer must be allowed to recover and stabilize at or near pre-pumping levels. For this test, the aquifer should recover and stabilize until the day following the step drawdown test, 12 hours or a period equal to the duration of the step test, whichever is longer.

The test well will be pumped at a constant rate of 1,200 gpm (unless the step drawdown test suggests differently) for a period of 72 hours or until the effects of delayed yield are observed (which may require 7 to 12 days of pumping). The maximum duration of the test will be 12 days. Discharge will be maintained within + or - 5 percent of the designated rate by means of a throttled gate valve or other flow control method. Discharge will be checked and adjusted as necessary every 10 minutes during the first hour of pumping and at 30 minute intervals thereafter. The discharge and time of measurement will be recorded, and any adjustment will be noted. The flow rate will be recorded every minute for the first 10 minutes of the test and every 5 minutes thereafter.

As in the step test, drawdown in the test well and the primary observation wells will be recorded automatically with the pressure transducer and datalogger system. Also, water levels in these wells will be monitored with manual water level indicators every 20 minutes during the first 1,000 minutes of the test and hourly for the remainder of the test. Time will be recorded in minutes. The water level drawdown data, measured in feet, will be plotted against a logarithmic time scale; therefore, water level data will be collected more frequently during the early time portion of the test to provide sufficient data points for curve matching analysis. Measurement intervals for piezometers and wells are defined according to Table 2-9 (In Situ, Inc. 1992 and Walton 1987). Since the datalogger transducer system will be preprogrammed to collect more data points at the beginning of the test and is capable of recording at rates as frequently as two readings per second, sufficient data points will be available for the logarithmic data plots. The data logger will be downloaded at least every 24 hours during the course of the test.

Groundwater samples will be collected from the pumping well four times during the first day of the constant rate test and two times on each remaining day of the test. The samples will be field tested for pH, specific conductance, dissolved oxygen, and temperature. Samples will also be analyzed for total uranium content using the FEMP on-site laboratory. Procedures are in Table 2-8.

2.4.8 Aquifer Recovery Measurements

The water level recovery measurements will begin simultaneously with pump shutdown. The monitoring of rising water levels will be recorded in the same manner as during pumping. Using the data logger system, measurements will be recorded automatically at 0.5 second intervals during the first 10 minutes of recovery, at 1-minute intervals for the next 10 minutes, at 5-minute intervals for the next 100 minutes,

and at 15- minute intervals until required recovery is achieved. At least one piezometer or the test well will be equipped with an independent water level measurement system to assure that early time recovery data is not lost. Measurements will continue for approximately 24 hours or until three successive water level measurements at 1-hour intervals show less than 0.1-foot difference in recovery at the test well (Unites States Department of the Interior 1981).

2.5 Aquifer Test Reporting

2.5.1 Data Analysis

Based on the observed response of the aquifer, appropriate analytical techniques will be selected to calculate the aquifer properties. The screen of RW-4 has been specified to penetrate only the top 35 feet of the aquifer. Since the well penetrates less than 85 percent of total aquifer thickness, the test well is defined as a partial penetration of the unconfined aquifer (Todd 1980). For the step drawdown test, methods based on Jacobs' equations (Walton 1987) and the Hantusch-Bierschenk method (Kruseman and deRidder 1990) will be used to calculate well yield and well efficiency.

Table 2-9 - Measurement Intervals for Piezometers and Observation Wells

Time Since Start of Pumping	Approximate Time Intervals
Primary Observation Wells and Piezometers (Connected to Data Logger)	
0 - 10 Seconds	0.5 Seconds
10 - 20 Seconds	1 Second
20 - 120 Seconds	5 Seconds
2 - 10 Minutes	30 Seconds
10 - 100 Minutes	2 Minutes
100 - 1,000 Minutes	10 Minutes
1,000 - 10,000 Minutes	100 Minutes
10,000 Minutes - Shutdown of the Pump	500 Minutes
Secondary Observation Wells and Piezometers	
0 - 24 Hours	2 Times per Day
24 Hours - Shutdown of Pump	1 Time per Day

For the constant rate test, a delayed yield response is quite possible if not probable from this type of aquifer. For time drawdown analysis, methods have been developed by Neuman and Streltsova (Kruseman and deRidder 1990) and also Lohman (1972). If semi-confined conditions exist, other analytical methods described by Walton, Hantush, and Neuman-Witherspoon (Kruseman and deRidder 1990) will be applied. The Theis method will be applied regardless of aquifer type. The Straight-line (Cooper-Jacob) method of aquifer analysis will be plotted for the southeast trending line of piezometers (SPPZ-2, 3, and 4); however, this method assumes fully penetrating conditions. This method will be used strictly for comparative purposes.

If the aquifer demonstrates semi-confined behavior during the test, estimates of aquifer horizontal anisotropy will be derived using methods developed by Papadopulos and Hantush. Effects of vertical anisotropy will be calculated for semi-confined conditions using methods developed by Weeks and Hantush. For unconfined conditions, vertical anisotropy will be calculated using methods derived by Streltsova or Neuman (Kruseman and deRidder 1990).

2.5.2 Pump Test Report

A report will be prepared immediately after completion of the pump test to document the results of the pump test effort. This report will be independent from the Model Validation Report defined in the DMEPP, although data and analysis from this report will be used in preparing the Model Validation Report. The Pump Test Report will contain background information, a description of the pump test, the analysis of the data including the calculated hydraulic parameters, groundwater quality from the pumped well, and conclusions and recommendations. Copies of tabulated and graphed data sets, assumptions used in data analysis, and associated backup data will also be included.

The report writing effort will commence 2 months prior to the projected date of pump test implementation and will include the collection of the background information specified below. This information will be collected to anticipate any issues that might affect pump test implementation or data analysis. A letter report containing this data will be completed 2 weeks prior to the commencement of the pump test. This letter report will identify issues that may affect implementation of the pump test. At the completion of the pump test, the remaining portions of the report will be written. The report will be issued 6 to 8 weeks after completion of the pumping test.

In addition, a vertical capture letter report will be written 2 weeks after the pump test. This letter report will recommend screen lengths for the recovery wells and set the initial recovery well pumping rates. The content of this report is described in Subsection 3.1.2 of the DMEPP text.

Prior to the test, the following information will be gathered:

1) Records of groundwater elevations from one well in the vicinity of the test equipped with a pressure transducer and recorder for 2 months prior to the test

2) Records of temperature, humidity, barometric pressure, and precipitation for a period of 1 year preceding the proposed test date

3) Available stream gaging data for the Great Miami River in the vicinity of the site and Paddys Run so that fluctuations can be determined

4) Identification of any nearby pumping wells including pumping rates that might cause interference with the test well

5) Identification of any surface discharge to groundwater which might affect the test data

2.6 Health and Safety

Health and safety requirements for well drilling, soil investigations, pump testing, and groundwater sampling shall be provided in a site-specific health and safety plan. The contractor responsible for field implementation of these activities shall prepare and administer this plan. The work to be performed shall be consistent with the health and safety plan prepared for the South Groundwater Contamination Plume Removal Action Part 2 and Part 3 (WEMCO 1992b). WEMCO will provide the necessary work permits required by FEMP procedures. Also, WEMCO will provide the necessary health and safety supervision and personnel to conduct this work safely.

Subcontractor personnel shall have completed the necessary FEMP training and medical monitoring requirements prior to commencement of work on this project. Training and medical monitoring requirements are defined by WEMCO.

SECTION 3

MODEL VALIDATION AND RECALIBRATION

3.1 Purpose

The groundwater flow model constructed for the Environmental Remedial Action (ERA) Project was developed for the following purposes: (1) to help characterize and evaluate existing groundwater flow conditions under the FEMP and surrounding areas; (2) to support the solute transport modeling which is helping to characterize and predict the rate of migration of contaminant plumes originating from the FEMP; and (3) to support the development and implementation of the response program to capture and treat the contaminated groundwater that has formed the South Plume. Although this validation work plan contributes to all three of these objectives, its primary focus is on the third objective: to contribute to the development of the most effective response program for the South Plume. Validation of the SWIFT III site flow model will increase confidence in the recovery design as it has been developed and will improve the operation of the south plume recovery wells as the program is implemented. The validated and recalibrated (if necessary) model will be used in the periodic system evaluation program defined in the DMEPP.

In order to use the model to evaluate the design, it is necessary to assure that the model is properly calibrated. The SWIFT site model was calibrated to water level data from April 1986 (DOE 1990). The same report presents the results of a preliminary validation in which the model, under steady-state conditions, was used to match water levels in the drought period in May 1988. During this validation exercise, drought conditions were accurately matched with the model by changing recharge and stream boundary conditions while leaving parameters related to unchanging geologic conditions constant.

This work plan presents the approach to validating the model under both transient and steady-state conditions by using the model to simulate the following conditions: (1) a transient 3- to 12-day aquifer test and (2) a five-well pumping program for plume containment/capture under steady-state conditions. The results from these simulations will be compared with the results of actual data from the aquifer test and pumping program. Validation is necessary since a calibrated model can contain parameter values that may still be non-unique and inaccurate. The validation process enhances confidence in the model's accuracy, making it a more predictive tool.

It should be noted that the validation program defined herein is only for the south plume area. While it will improve overall confidence in the model, it is not intended to comprehensively validate the site SWIFT Model in the entire study area. Improving and validating the model will be a continuous effort and will consist of additional tasks.

3.2 Objectives

The objective of the model validation task is to prove that the model can predict groundwater flow conditions under a set of hydrogeologic stresses that differ from those defined during model calibration. Model validation will be tested by simulating the aquifer test and pumping program described in Sections 1 and 2 of this report.

A successful validation reflects on the accuracy and versatility of the model. This is an indication that the model is not only numerically correct, but that it is capable of evaluating transient conditions and new steady-state conditions both of which differ considerably from the conditions simulated by the initial steady-state calibrated model.

3.3 Approach and Rationale

The groundwater flow model of the FEMP site area, embodied in the SWIFT III computer code, will be validated by simulating a transient pumping event at a location near the distal end of the South Plume, and then by simulating the effects of a five-well pumping program in the same location. As detailed in Section 2 of this work plan, the aquifer test pumping event will be 3 to 12 days in duration and will draw water from the top 35 feet of the Great Miami Aquifer. The pumping well will only partially penetrate the aquifer. A model simulation of these conditions will result in an expanding cone of depression that is caused by drawdown or head loss within the pumping cell in the model and within the cells surrounding the pumping cell. The model will be programmed to calculate heads for the following time steps, one for the day prior to pumping, one for each days of simulated pumping, and two steps for a 2-day recovery period after pumping stops. Values of head for all active cells within the model will be computed and written to a file for each of these days. Modeled drawdowns within the immediate underlying layer will also be evaluated and compared with the data collected in the field. Any unexpected boundaries that are unrepresented in the model should be identified during the analysis of the pump test data.

The simulation for the five-well pumping program will be conducted in the same manner using data from the first quarter of recovery well operation. The major differences will be the simulation of steady-state conditions and the stressing of a greater portion of the aquifer.

The steps in the validation process are as follows:

1) Design an aquifer test (or pumping program) that will sufficiently stress the hydrogeologic system. Locate the monitoring points so that the measured drawdown can be readily compared with drawdown computed by the model, given its level of resolution (see Section 2).

2) Conduct the Test - Carefully monitor the aquifer's response in enough locations to characterize the cone of depression adequately (see Section 2).

3) Analyze the pump test data. Calculate transmissivity (T), hydraulic conductivity, and specific yield (Sy) (unconfined conditions) or storativity (confined conditions) values for each point that was monitored during the test (see Section 2).

4) Using the site model as previously calibrated, simulate the pump test in a transient mode and compare the results with the field pump test data. Also with the previously calibrated model, simulate steady-state by pumping the five-recovery well system and comparing the results with first quarter monitoring well results when the recovery system becomes operational. For the transient case, run the test simulation with one-time step for each of day of the test. Save the head arrays for each time step and for the steady-state case.

5) For all locations (either confined or unconfined) compare the hydraulic conductivity and transmissivity values obtained from the pump test with the corresponding values existing in the model. If there are significant differences, provisionally revise the model as needed. Use the storativity and specific yield values from the aquifer test for the areas near the test. Re-run the model if significant changes are made to hydraulic conductivity values. Re-check the model's calibration.

6) Using the site model as provisionally revised, simulate the pump test in a transient mode and compare the results with the field pump test data. Also with the provisionally revised model, simulate steady state pumping by the 5 recovery well system and compare with first quarter monitoring well results. For the transient case, run the test simulation with one-time step for each day of the test. Save the head arrays for each time step and for the steady-state case.

7) Compare the model head outputs for each case to the values collected from the field. Using GEOSTAT, perform the same statistical analyses used for calibration (Subsection 3.3). Apply the calibration criteria determine if the match is close enough.

8) Perform a visual comparison of the two data sets for each case by constructing contour plots. Make a qualitative comparison of the results.

9) The model is validated for a particular case if the match is close enough to meet the established criteria. If the match fails these tests, adjust storage values and re-run the model.

10) Prepare the model validation report. Evaluate the results of the four cases used for comparison described above. Draw conclusions and make recommendations. It is expected that conclusions will state that (1) the model is validated as originally calibrated, (2) the model requires fine tuning

similar to the provisional revision or (3) more significant recalibration is needed including adjusting boundary conditions and/or hydraulic conductivity values in other portions of the model (see Section 4).

3.4 Comparison of Model and Field Test Results

Model validation is a comparison of two surfaces, one based on field measurements and one derived by the model. The validation effort is basically a process of calibrating the model to a second set of target head data in the area of the pump test. The model validation process is based on meeting pre-established criteria and best professional judgment.

For consistency, this comparison of surfaces should use the same statistical methods and criteria that were used for calibration. This type of comparison will be made; however, beyond statistical comparison, a more qualitative comparison will be performed by peer reviewers (hydrogeologists) of the validation exercise. The professional opinion of peer reviewers is required when difficulties are encountered in meeting all the criteria that are affected by the many spatial and temporal variables involved in a transient test. The comparisons and conclusions regarding the validity of results will be summarized as described in Subsection 3.5

To perform visual comparison between the field and model results, both data sets will be imported into a software package that will grid and contour the data. The contour plots will depict the potentiometric surface or water table. The software to be used for producing these plots will be either SURFER (Version 4.0; Golden Software) or Intergraph surface-generating software. In either case, one of several available statistical processes can be selected to produce the regular-spaced grid that is contoured.

During an earlier effort to calibrate the groundwater flow model to the 1986 and 1988 water level data, an evaluation of the various gridding algorithms was provided in SURFER (DOE 1990) was performed. It was found that kriging produced the most accurate and realistic contour plots. Although it is likely that kriging will be used during the validation exercise, a similar evaluation of the various gridding options available in the application software (SURFER or Intergraph) will be performed.

To calculate residual values (observed minus computed hydraulic head), the model output will be interpolated to obtain the model-based values of hydraulic head for the same locations at which field data were collected. The computed residual values will be posted on a set of plots. On each plot, residuals will be posted at the location of the monitoring points. These residual plots will be contoured to determine if trends are present.

The residual data sets will also undergo a series of statistical analyses that were applied during SWIFT site model calibration (DOE 1990). To summarize, these statistics are:

1) Mean Residual -- A negative value indicates that computed hydraulic head values are, on the average, greater than observed hydraulic heads. A positive value has the opposite meaning. The value of this parameter must be reasonably close to zero, otherwise bias exists in the computed hydraulic heads. The predetermined criterion is +/- 0.5 foot.

2) Mean of the Absolute Values of the Residuals -- This parameter is a measure of the average difference between the observed and computed values without regard to the sign of these deviations. The optimal value is zero. The predetermined criterion is +/-2.0 feet.

3) Residual Standard Deviation -- This is a measure of the degree of variance of the residuals from their mean. The optimal value is zero. The greater the value, the poorer the fit. The predetermined criterion is 20 percent of the total drawdown.

4) Regression Coefficient Between Measured and Computed Values -- This is a measure of the tendency of computed hydraulic heads to increase as corresponding measured hydraulic heads increase. The optimal value is one, indicating a 1:1 correspondence between computed and measured values. The predetermined criterion is 0.95.

5) Nearest Neighbor Autocorrelation, Unit Normal Deviate -- This value is used to test for significant spatial clustering of positive or negative residuals. Significant spatial clustering is indicated by a value greater than 1.645 (IT Corporation 1987). This value will be used for the predetermined criterion.

To calculate these statistics, GEOSTAT (IT Corporation 1987), a statistical program for examining the goodness of fit of groundwater modeling data, or a similar program, will be used.

3.5 Pump Test and Model Validation Report Preparation

This report will be written to present and document the objectives, assumptions, methods, results, conclusions, and recommendations of the pump test/model validation task. The report will be structured to highlight those objectives. Since the primary objectives of the pump test and model validation are to evaluate as well as confirm the conditions represented by the calibrated model, the report will focus on the pump test results and the fit between the pump test and the simulation provided by the model. Graphical depictions of both field-measured and modeled drawdown, and the variation of these drawdowns with time, will be an important portion of the report.

Model simulations representing the five-well pumping system will also be presented and accompanied with a discussion on the perceived effectiveness of the program, as predicted by the model.

If efforts to prove that the model is valid are unsuccessful, the recommendation section of the report will outline an approach to recalibrate and, ultimately, to validate, the model.

3.6 Recalibration

If efforts to validate the model are not successful, the model will be recalibrated. An invalidated model implies that one or several fundamental conditions embodied in the model may not accurately reflect true site conditions. Under such conditions, the model will be recalibrated by carefully changing values for key aquifer parameters applied within the model. The calibration criteria described in Subsection 3.3 of this report will be applied.

SECTION 4

QUALITY ASSURANCE/QUALITY CONTROL

All work will be conducted in accordance with the requirements of the overall quality assurance program at the FEMP which is described in the Sitewide Quality Assurance Program Description. Drilling, sampling, well and piezometer installation, pump testing, and laboratory testing shall be assigned the proper quality level by WEMCO. Site Policy and Procedure Number FMPC-711 provides guidelines for matching of quality program requirements to the quality levels. Specific quality items will be reviewed by WEMCO to verify that the quality requirements are adequate and consistent with the assigned quality level. Field Quality control should also be consistent with guidance provided in the draft FEMP QAPjP (WEMCO 1992a). For items not covered in the QAPjP, guidance may be obtained (with FEMP management approval) from the Remedial Investigation/Feasibility Study (RI/FS) Work Plan, Volume V, "Quality Assurance Project Plan (QAPP)," Revision 3, March, 1988 (DOE 1988).

SECTION 5

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ATTACHMENT A

WELL INSTALLATION AND SOIL SAMPLING RECORDS

MONITORING WELL INSTALLATION RECORD

PROJECT NAME: Fernald RI/FS
PROJECT NO. : 602.3.2
BORING NO. : 2002
WELL NUMBER: 2002

FIELD ENG./GEO.: E. TROLLINGER DATE: 04/12/89
CHECKED BY : W. A. HERTEL DATE: 05/05/89
N,E COORDINATES: 474718.98, 1380615.0
DATE OF INSTAL.: 04/14/89

BOREHOLE DRILLING

DRILLING METHOD: Cable Tool
DRILLING FLUID(S) USED: (in Feet)
FLUID: WATER FROM: 0.0TO: 83.0
FLUID: N/A FROM: N/ATO: N/A
NOTES/COMMENTS:

TYPE OF BIT: Flat Head Hammer
IS CASING TEMPORARY?: No
CASING TYPE : MONITORING WELL
CASING DIAM.:
CASING SIZE(S) USED: (in Feet)
SIZE: 10 FROM: 0.0 TO: 83.0
SIZE: N/A FROM: N/A TO: N/A

WELL DESCRIPTION

TYPE: MONITORING WELL
DIAMETER OF PERFORATED SECTION:
PERFORATION TYPE: Slots
AVG. SIZE OF PERFORATIONS: 0.010 (In.)
TOTAL PERFORATED AREA: 15. Ft.
NOTES/COMMENTS:

RISER PIPE MATERIAL: Stainless Steel
RISER PIPE DIAMETERS:
O.D.: 4 3/8 In. I.D.: 4.0 In.
LENGTH OF 1ST PIPE SECTION: 10.0 Ft.
2ND PIPE SECTION: 5.0 Ft.
3RD PIPE SECTION: Not Noted
COMMENTS

RISER JOINING METHOD: THREADED, FLUSH JOINTED

PROTECTION SYSTEM

RISER PROTECTIVE PIPE LENGTH: 5.0 Ft.
PROTECTIVE PIPE O.D.: 10.7 In.
• RISER PROTECTIVE PIPE HINGED L

OTHER PROTECTION (* NOTED BELOW)

ITEM	DISTANCE ABOVE/BELOW GROUND SURFACE	ELEVATION MSL
TOP OF RISER PIPE	2.0 Ft.	586.79
GROUND SURFACE	0.0	N/A
BOTTOM OF PROTECTIVE PIPE	2.5 Ft.	

BOREHOLE FILL MATERIALS	TOP	BOTTOM	TOP	BOTTOM
Grout/Slurry	0.0	51.0	N/A	N/A
Bentonite Pellets	51.0	56.0	N/A	N/A
Sand	56.0	81.5	N/A	N/A
PERFORATED SECTION	63.0	78.0	N/A	N/A
WELL TIP	79.5		N/A	
BOTTOM OF BOREHOLE	83.0		N/A	
GWL AFTER INSTALLATION	69.9		N/A	

WAS THE WELL FLUSHED AFTER INSTALLATION? : No
WAS A SENSITIVITY TEST PERFORMED ON THE WELL : No

VISUAL CLASSIFICATION OF SOILS

3588

PROJECT NUMBER: 602 3.2	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 2002	COORDINATES: NORTH 474,718.98 EAST 1,380,615.04	DATE: 04/02/89
GROUND ELEVATION:	GWL: Depth N/A Date/Time N/A	DATE STARTED: 04/02/89
ENGINEER/GEOLOGIST: E. TROLLINGER	Depth N/A Date/Time N/A	DATE COMPLETED: 04/14/89
DRILLING METHODS: CABLE-TOOL		PAGE 1 OF 6

DEPTH	SAMPLE / DATE / TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REMARKS
1.5	32295 04/02/89 0938	1 2 6	8	STIFF, DARK YELLOWISH BROWN, (10 YR 4/6), ORGANIC SILTY CLAY, LOW TO MED. PLASTICITY, WET.	OL	1.5	BГ = 60 cpm
3.0	32296 04/02/89 0943	3 8 10	8	STIFF, DARK YELLOWISH BROWN, (10 YR 4/6) ORGANIC SILTY CLAY, LOW TO MED. PLASTICITY, WET.	OL	1.5	BГ = 60 cpm
4.5	32297 04/02/89 0945	9 14 16	9	HARD, GRAY, (10 YR 5/1), SANDY CLAY, MOIST, LOW PLASTICITY.	CL	4.5	BГ = 60 cpm
6.0	32298 04/02/89 0950	14 21 25	7	VERY STIFF, YELLOWISH BROWN, (10 YR 5/4), GRAVELLY CLAY, MED. PLASTICITY, MOIST.	CL	4.0	BГ = 60-80 cpm
7.5	32299 04/02/89 1010	15 25 30	10	VERY STIFF, YELLOWISH BROWN - GRAY, (10 YR 4/4), CLAY, SOME COARSE SAND, LOW TO MED. PLASTICITY, MOIST.	CL	4.0	BГ = 60-80 cpm
9.0	32300 04/04/89 1015	9 17 10	12	HARD, DARK YELLOWISH BROWN - GRAY, (10 YR 4/6) GRAVELLY, SILTY CLAY, MOIST. MED. PLASTICITY.	CL	>4.0	BГ = 60-80 cpm
10.5	32301 04/04/89 1030	15 22 32	13	HARD, DARK GRAYISH BROWN, (10 YR 4/2) SANDY CLAY, TRACE OF FINE GRAVEL, MOIST. MED. PLASTICITY.	CL	>4.0	BГ = 80 cpm
12.0	32302 04/04/89 1046	10 14 14	14	VERY STIFF, DARK GRAYISH BROWN, (2.5 Y 4/2), CLAY, TRACE OF COARSE SAND, MOIST. MED. PLASTICITY.	CL	3.75	BГ = 60 cpm
13.5	32303 04/04/89 1115	6 10 14	8	VERY STIFF, DARK GRAY, (2.5 Y 4/0), CLAY, TRACE OF COARSE SAND, MED PLASTICITY, MOIST.	CL	2.50	BГ = 60 cpm
15.0	32304 04/04/89 1127	5 12 17	10	VERY STIFF, DARK GRAY, (2.5 Y 4/0), CLAY, TRACE OF COARSE SAND, MED. PLASTICITY, MOIST.	CL	2.50	BГ = 60 cpm

NOTES:
SAMPLING PERFORMED IN ACCORDANCE WITH ASTM STANDARDS, COLOR DESCRIBED BY MUNSELL COLOR CHART.

PROJECT NUMBER: 602 3.2	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 2002	COORDINATES: NORTH 474,718.98 EAST 1,380,615.04	DATE: 04/02/89
GROUND ELEVATION:	GWL: Depth N/A Date/Time N/A	DATE STARTED: 04/02/89
ENGINEER/GEOLOGIST: E. TROLLINGER	Depth N/A Date/Time N/A	DATE COMPLETED: 04/14/89
DRILLING METHODS: CABLE-TOOL		PAGE 2 OF 6

DEPTH	SAMPLE	DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REMARKS
16.5	32305	04/04/89 1136	5 10 11	10	VERY STIFF, DARK GREENISH GRAY, (2.5 Y 4/0), CLAY, TRACE OF COARSE SAND, MED. PLASTICITY, MOIST.	CL	3.50	BΓ = 60 cpm
18.0	32306	04/04/89 1345	5 12 14	8	VERY STIFF, DARK GRAY, (2.5 Y 4/0), CLAY, TRACE OF COARSE SAND AND FINE GRAVEL, MED. PLASTICITY, MOIST.	CL	3.75	BΓ = 60 cpm
19.5	32307	04/04/89 1405	5 5 7	6	STIFF, DARK GRAY, (2.5 Y 4/0), CLAY, TRACE OF COARSE SAND AND ORGANIC DEBRIS - WOOD, ETC.., MED. PLASTICITY, MOIST TO WET.	CL	2.00	BΓ = 40-60 cpm
21.0	32308	04/04/89 1425	5 7 7	7	VERY STIFF, DARK GRAY, (2.5 Y 4/0), CLAY, TRACE OF FINE GRAVEL, MED. PLASTICITY, WET.	CL	2.50	BΓ = 40-60 cpm
22.5	32309	04/04/89 1600	3 5 8	5	VERY STIFF, DARK GRAY, (2.5 Y 4/0), SANDY CLAY, TRACE OF FINE GRAVEL, MED. PLASTICITY, MOIST.	CL	2.50	BΓ = 40-60 cpm
24.0	32310	04/04/89 1615	5 7 10	8	VERY STIFF, DARK GRAY, (10 YR 4/1), SILTY CLAY, TRACE OF FINE GRAVEL, MED. PLASTICITY, MOIST.	CL	2.75	BΓ = 40-60 cpm
25.5	32311	04/04/89 1630	5 9 10	8	VERY STIFF, DARK GRAY, (10 YR 4/1), CLAY, TRACE OF GRAVEL .50 IN, AND SOME SILT THROUGHOUT, MED. PLASTICITY, MOIST.	CL	2.75	BΓ = 60 cpm
27.0	32312	04/04/89 1645	5 8 11	7	VERY STIFF, DARK GRAY-BROWN, (10 YR 5/6), SILTY CLAY, TRACE OF FINE GRAVEL, MED. TO LOW PLASTICITY, MOIST.	CL	3.50	BΓ = 40-60 cpm
28.5	32313	04/04/89 1700	7 8 20	9	MEDIUM DENSE, YELLOWISH BROWN-GRAY, (10 YR 5/6), VERY SILTY CLAY, SILT TRACE, OF FINE GRAVEL, MOIST.	ML	N/A	BΓ = 40-60 cpm
30.0	32314	04/04/89 1715	22 21 14	10	DENSE, YELLOWISH BROWN, (10 YR 5/6), POORLY GRADED SAND, MOIST	SP	N/A	BΓ = 40-60 cpm

NOTES:
SAMPLING PERFORMED IN ACCORDANCE WITH ASTM STANDARDS, COLOR DESCRIBED BY MUNSELL COLOR CHART.

FERNALD RI/FS

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 602 3.2	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 2002	COORDINATES: NORTH 474,718.98 EAST 1,380,615.04	DATE: 04/02/89
GROUND ELEVATION:	GWL: Depth N/A Date/Time N/A	DATE STARTED: 04/02/89
ENGINEER/GEOLOGIST: E. TROLLINGER	Depth N/A Date/Time N/A	DATE COMPLETED: 04/14/89
DRILLING METHODS: CABLE-TOOL		PAGE 3 OF 6

DEPTH	SAMPLE	DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REMARKS
35.0								
36.5	32315 04/05/89 1515		42 50 50	10	VERY DENSE, DARK YELLOWISH BROWN, (10 YR 4/4), WELL GRADED SAND TRACE OF FINE GRAVEL, DRY.	SW	N/A	βΓ = 30-40 cpm
40.0								
41.5	32316 04/05/89 1700		47 50	6	VERY DENSE, DARK YELLOWISH BROWN, (10 YR 4/4), POORLY GRADED SAND, TRACE OF FINE GRAVEL, DRY.	SP	N/A	βΓ = 40 cpm
45.0								

NOTES:
SAMPLING PERFORMED IN ACCORDANCE WITH ASTM STANDARDS, COLOR DESCRIBED BY MUNSELL COLOR CHART.

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FERNALD RI/FS

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 602 3.2	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 2002	COORDINATES: NORTH 474,718.98 EAST 1,380,615.04	DATE: 04/02/89
GROUND ELEVATION:	GWL: Depth N/A Date/Time N/A	DATE STARTED: 04/02/89
ENGINEER/GEOLOGIST: E. TROLLINGER	Depth N/A Date/Time N/A	DATE COMPLETED: 04/14/89
DRILLING METHODS: CABLE-TOOL		PAGE 4 OF 6

DEPTH	SAMPLE	DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REMARKS
46.5	32317	04/06/89 1010	50	4	VERY DENSE, YELLOWISH BROWN, (10 YR 4/4), WELL GRADED SAND, MOIST.	SW	N/A	BΓ = 40-50 cpm
50.0								
51.5	32318	04/06/89 1035	42 50	7	VERY DENSE, YELLOWISH BROWN (10 YR 4/4), WELL GRADED SAND, MOIST.	SW	N/A	BΓ = 40 cpm
55.0								
56.5	32319	04/11/89 1045	42 50	6	VERY DENSE, DARK YELLOWISH BROWN (10 YR 4/4), POORLY GRADED SAND, MOIST.	SP	N/A	BΓ = 40 cpm
60.0								

NOTES:
SAMPLING PERFORMED IN ACCORDANCE WITH ASTM STANDARDS, COLOR DESCRIBED BY MUNSELL COLOR CHART.

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FERNALD RI/FS

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 602 3.2	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 2002	COORDINATES: NORTH 474,718.98 EAST 1,380,615.04	DATE: 04/02/89
GROUND ELEVATION:	GWL: Depth N/A Date/Time N/A	DATE STARTED: 04/02/89
ENGINEER/GEOLOGIST: E. TROLLINGER	Depth N/A Date/Time N/A	DATE COMPLETED: 04/14/89
DRILLING METHODS: CABLE-TOOL		PAGE 5 OF 6

DEPTH	SAMPLE DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REMARKS
61.5	32320 04/11/89 1130	50 50	7	VERY DENSE, DARK YELLOWISH BROWN, (10 YR 4/4) WELL GRADED GRAVELLY SAND, MOIST.	SW	N/A	BΓ = 50-60 cpm
65.0							
66.5	32321 04/11/89 1400	50 50	6	VERY DENSE, GRAYISH BROWN, (10 YR 4/2) SANDY, FINE, WELL GRADED GRAVEL, MOIST TO WET.	GW	N/A	BΓ = 60 cpm
70.0							
71.5	32322 04/11/89 1450	5 8 30	9	DENSE, BROWN, (10 YR 4/3) POORLY GRADED SAND, WET.	SP	N/A	BΓ = 60 cpm
75.0							

NOTES:
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DRAFT

FERNALD RI/FS

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 602 3.2	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 2002	COORDINATES: NORTH 474,718.98 EAST 1,380,615.04	DATE: 04/02/89.
GROUND ELEVATION:	GWL: Depth N/A Date/Time N/A	DATE STARTED: 04/02/89
ENGINEER/GEOLOGIST: E. TROLLINGER	Depth N/A Date/Time N/A	DATE COMPLETED: 04/14/89
DRILLING METHODS: CABLE-TOOL		PAGE 6 OF 6

DEPTH	SAMPLE	DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REMARKS
76.5	32323	04/11/89 1515	13 12 25	12	DENSE, BROWN, (10 YR 4/3) WELL GRADED, GRAVELLY SAND, WET.	SW	N/A	βΓ = 60 cpm
80.0								
81.5	32324	04/11/89 1556	10 14 18	10	DENSE, BROWN, (10 YR 4/3) SANDY, WELL GRADED GRAVEL, WET.	GW	N/A	βΓ = 60 cpm

BOTTOM OF BORING 83.0

NOTES:
SAMPLING PERFORMED IN ACCORDANCE WITH ASTM STANDARDS, COLOR DESCRIBED BY MUNSELL COLOR CHART.

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MONITORING WELL INSTALLATION RECORD

PROJECT NAME: Fernald RI/FS
PROJECT NO. : 602.3.2
BORING NO. : 3093
WELL NUMBER: 3093

FIELD ENG./GEO.: M. SLUSARSKI DATE: 06/07/88
CHECKED BY : Not Noted DATE: N/A
N,E COORDINATES: 475318.41, 1381389.9
DATE OF INSTAL.: 06/07/88

BOREHOLE DRILLING

DRILLING METHOD: Cable Tool
DRILLING FLUID(S) USED: (in Feet)
FLUID: WATER FROM: 0.0TO: 155.0
FLUID: N/A FROM: N/ATO: N/A
NOTES/COMMENTS:

TYPE OF BIT: Flat Head Hammer
IS CASING TEMPORARY?: No
CASING TYPE : MONITORING WELL
CASING DIAM.: 4 In.
CASING SIZE(S) USED: (in Feet)
SIZE: 10 FROM: 0.0 TO: 155.0
SIZE: N/A FROM: N/A TO: N/A

WELL DESCRIPTION

TYPE: MONITORING WELL
DIAMETER OF PERFORATED SECTION:
PERFORATION TYPE: Screen
AVG. SIZE OF PERFORATIONS: 0.010 (In.)
TOTAL PERFORATED AREA: 10. Ft.
NOTES/COMMENTS:

RISER PIPE MATERIAL: Stainless Steel
RISER PIPE DIAMETERS:
O.D.: 4 3/8 In. I.D.: 4 In.
LENGTH OF 1ST PIPE SECTION: 2 Ft.
2ND PIPE SECTION: 5 Ft.
3RD PIPE SECTION: 10 Ft.
COMMENTS

RISER JOINING METHOD: SCREW TYPE FLUSH JOINT THREADED

PROTECTION SYSTEM

RISER PROTECTIVE PIPE LENGTH: 5 Ft.
PROTECTIVE PIPE O.D.: 10 3 In.
• LOCKING CAP

OTHER PROTECTION (* NOTED BELOW)

ITEM	DISTANCE ABOVE/BELOW GROUND SURFACE	ELEVATION MSL
TOP OF RISER PIPE	2.0 Ft.	587.64
GROUND SURFACE	0.0	N/A
BOTTOM OF PROTECTIVE PIPE	2.5 Ft.	

BOREHOLE FILL MATERIALS	TOP	BOTTOM	TOP	BOTTOM
Grout/Slurry	0.0	126.0	N/A	N/A
Sand	126.0	145.0	N/A	N/A
PERFORATED SECTION	133.0	143.0	N/A	N/A
WELL TIP	145.0		N/A	
BOTTOM OF BOREHOLE	155.0		N/A	
GWL AFTER INSTALLATION	67.0		N/A	

WAS THE WELL FLUSHED AFTER INSTALLATION? : No
WAS A SENSITIVITY TEST PERFORMED ON THE WELL : No

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 602 3.2	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 3093	COORDINATES: NORTH 475,318.41 EAST 1,381,389.92	DATE: 05/24/88
GROUND ELEVATION:	GWL: Depth N/A Date/Time N/A	DATE STARTED: 05/24/88
ENGINEER/GEOLOGIST: M. SLUSARSKI	Depth N/A Date/Time N/A	DATE COMPLETED: 06/07/88
DRILLING METHODS: CABLE-TOOL		PAGE 1 OF 11

DEPTH	SAMPLE	DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REMARKS
1.5	10105	05/24/88 1502	3 6 6	14	VERY SOFT, YELLOW-BROWN (10YR 6/3) SILTY CLAY, WITH ROOTLETS, DRY.	CL	<.25	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
3.0	10106	05/24/88 1510	4 8 8	10	VERY STIFF, YELLOW-BROWN (10YR 4/4) SILTY CLAY, DRY.	CL	3.0	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
4.5	10107	05/24/88 1514	6 12 16	14	VERY STIFF, YELLOW-BROWN (10YR 5/3) CLAY, SOME SILT, DRY.	CL	3.0	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
6.0	10108	05/24/88 1521	20 18 15	18	VERY STIFF, YELLOW-BROWN (10YR 5/3) CLAY, SOME SILT, DRY.	CL	3.0	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
7.5	10109	05/24/88 1528	13 18 18	18	VERY SOFT, YELLOW-BROWN (10YR 5/4) CLAY, SOME SILT, DAMP.	CL	<.25	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
9.0	10110	05/25/88 0755	4 8 18	14	VERY STIFF, YELLOW-BROWN (10YR 5/4) CLAY, SOME SILT, SOME FINE GRAVEL, DAMP.	CL	3.0	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
10.5	10111	05/25/88 0814	7 12 20	12	VERY STIFF, YELLOW-BROWN (10YR 5/4) CLAY, SOME SILT, SOME FINE GRAVEL, TRACE MEDIUM GRAVEL (.25" TO .50"), DAMP.	CL	3.0	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
12.0	10112	05/25/88 0832	7 15 21	12	VERY STIFF, YELLOW-BROWN (10YR 5/4) CLAY, SOME SILT, SOME FINE GRAVEL, TRACE MEDIUM GRAVEL (.25" TO .50"), DAMP.	CL	3.0	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
13.5	10113	05/25/88 0905	6 17 17	14	VERY STIFF, YELLOW-BROWN (10YR 5/4) CLAY, SOME SILT, SOME FINE GRAVEL, TRACE MEDIUM GRAVEL (.25" TO .50"), DAMP. VERY STIFF, GREY (5Y 4/1) CLAY, SOME SILT, SOME FINE GRAVEL, TRACE MEDIUM GRAVEL (.5"), DAMP.	CL	3.0	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
15.0	10114	05/25/88 0922	7 11 15	4	STIFF, GREY (5Y 4/1) CLAY, SOME SILT, SOME FINE GRAVEL, DAMP.	CL	1.5	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm

NOTES:
CONTRACTOR: PENNDRILL, RIG: BUCYRUS-ERIE, DRILLER: DAVE NEWMAN, ASSISTANT: BOB JOHNSON. SAMPLES COLLECTED AS PER ASTM STANDARD PENETRATION TEST. COLORS IDENTIFIED USING MUNSELL COLOR CHART. BACKGROUND LEVELS: HNU=0PPM, a=0-5 CPM, g=5-10 CPM, LEL02

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 602 3.2	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 3093	COORDINATES: NORTH 475,318.41 EAST 1,381,389.92	DATE: 05/24/88
GROUND ELEVATION:	GWL: Depth N/A Date/Time N/A	DATE STARTED: 05/24/88
ENGINEER/GEOLOGIST: M. SLUSARSKI	Depth N/A Date/Time N/A	DATE COMPLETED: 06/07/88
DRILLING METHODS: CABLE-TOOL		PAGE 2 OF 11

DEPTH	SAMPLE / DATE / TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REMARKS
16.5	10115 05/25/88 0935	6 11 15	16	STIFF, GREY (5Y 4/1) CLAY, SOME SILT, SOME FINE GRAVEL, DAMP.	CL	2.0	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
18.0	10116 05/25/88 0950	6 9 11	6	STIFF, GREY (5Y 4/1) CLAY, SOME SILT, SOME FINE GRAVEL, DAMP.	CL	2.0	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
19.5	10117 05/25/88 1109	6 15 15	14	STIFF, GREY (5Y 4/1) CLAY, SOME SILT, SOME FINE GRAVEL, DAMP.	CL	2.0	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
21.0	10118 05/25/88 1130	9 9 18	14	STIFF, GREY (5Y 4/1) CLAY, SOME SILT, SOME FINE GRAVEL, DAMP.	CL	2.0	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
22.5	10119 05/25/88 1324	5 25 23	14	STIFF, GREY (5Y 4/1) CLAY, SOME SILT, SOME FINE GRAVEL, DAMP. STIFF, GREY (5Y 4/1) CLAY, SOME SILT, SOME FINE GRAVEL, SOME MEDIUM GRAVEL (.25" TO .75"), DRY. S	CL CL CL	2.0 2.0 2.0	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
24.0	10120 05/25/88 1340	6 16 13	8	STIFF, GREY (5Y 4/1) CLAY, SOME SILT, SOME FINE GRAVEL, TRACE SAND, TRACE COARSE GRAVEL (1.0"), DAMP.	CL	2.0	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
25.5	10121 05/25/88 1355	2 4 6	8	STIFF, GREY (5Y 4/1) CLAY, SOME SILT, SOME FINE GRAVEL, DAMP.	CL	2.0	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
27.0	10122 05/25/88 1411	9 11 13	14	STIFF, GREY (5Y 4/1) CLAY, SOME SILT, SOME FINE GRAVEL, DAMP.	CL	1.5	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
28.5	10123 05/25/88 1430	6 7 9	12	STIFF, GREY (5Y 4/1) CLAY, SOME SILT, SOME FINE GRAVEL, DAMP.	CL	1.5	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
30.0	10124 05/25/88 1445	5 7 9	12	STIFF, GREY (5Y 4/1) CLAY, SOME SILT, SOME FINE GRAVEL, DAMP.	CL	1.5	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm

NOTES:

FERNALD RI/FS

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 602 3.2	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 3093	COORDINATES: NORTH 475,318.41 EAST 1,381,389.92	DATE: 05/24/88
GROUND ELEVATION:	GWL: Depth N/A Date/Time N/A	DATE STARTED: 05/24/88
ENGINEER/GEOLOGIST: M. SLUSARSKI	Depth N/A Date/Time N/A	DATE COMPLETED: 06/07/88
DRILLING METHODS: CABLE-TOOL		PAGE 3 OF 11

DEPTH	SAMPLE	DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REMARKS
31.5	10125	05/25/88 1539	4 8 10	12	STIFF, GREY (5Y 4/1) CLAY, SOME SILT, SOME FINE GRAVEL, DAMP.	CL	2.0	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
33.0	10126	05/25/88 1600	3 7 13	14	STIFF, GREY (5Y 4/1) CLAY, SOME SILT, SOME FINE GRAVEL, DAMP. HARD, BROWN (10YR 4/3) CLAY, SOME FINE GRAVEL, SOME SAND, DRY. M	CL CL SM	2.0 >4.0 N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
35.0								
36.5	10127	05/25/88 1655	21 25 22	14	DENSE, YELLOW-BROWN (10YR 5/4) WELL GRADED, GRAVELLY SAND, DRY	SW	N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
40.0								
41.5	10128	05/26/88 0805	35 >5	12	VERY DENSE, YELLOW-BROWN (10YR 5/4) WELL GRADED GRAVELLY SAND, DRY.	SW	N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
45.0								

NOTES:

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FERNALD RI/FS

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 602 3.2	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 3093	COORDINATES: NORTH 475,318.41 EAST 1,381,389.92	DATE: 05/24/88
GROUND ELEVATION:	GWL: Depth N/A Date/Time N/A	DATE STARTED: 05/24/88
ENGINEER/GEOLOGIST: M. SLUSARSKI	Depth N/A Date/Time N/A	DATE COMPLETED: 06/07/88
DRILLING METHODS: CABLE-TOOL		PAGE 4 OF 11

DEPTH	SAMPLE DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REMARKS
46.5	10129 05/26/88 0925	16 60 50	12	VERY DENSE, YELLOW-BROWN (10YR 5/4) WELL GRADED GRAVELLY SAND, DRY.	SW	N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
50.0							
51.5	10130 05/26/88 0958	18 21 26	12	VERY DENSE, YELLOW-BROWN (10YR 5/4) POORLY GRADED FINE SAND, DRY.	SP	N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
55.0							
56.5	10131 05/26/88 1055	>5	4	VERY DENSE, YELLOW-BROWN (10YR 5/4) WELL GRADED GRAVELLY SAND, DRY.	SW	N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
60.0							

NOTES:

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FERNALD RI/FS

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 602 3.2	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 3093	COORDINATES: NORTH 475,318.41 EAST 1,381,389.92	DATE: 05/24/88
GROUND ELEVATION:	GWL: Depth N/A Date/Time N/A	DATE STARTED: 05/24/88
ENGINEER/GEOLOGIST: M. SLUSARSKI	Depth N/A Date/Time N/A	DATE COMPLETED: 06/07/88
DRILLING METHODS: CABLE-TOOL		PAGE 5 OF 11

DEPTH	SAMPLE / DATE / TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REMARKS
61.5	10132 06/01/88 0912	15 21 23	12	DENSE, YELLOW-BROWN (10YR 5/4) POORLY GRADED FINE SAND, TRACE FINE GRAVEL, DRY.	SP	N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
65.0							
66.5	10133 06/01/88 0940	45 50	14	VERY DENSE, YELLOW-BROWN (10YR 5/4) WELL GRADED GRAVELLY SAND, DRY.	SW	N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
70.0							
71.5	10134 06/01/88 1135	8 25 25	14	VERY DENSE, YELLOW-BROWN (10YR 5/4) POORLY GRADED GRAVELLY SAND, TRACE COARSE GRAVEL (1.0" - 1.5"), WET.	SP	N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
75.0							

NOTES:

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FERNALD RI/FS

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 602 3.2	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 3093	COORDINATES: NORTH 475,318.41 EAST 1,381,389.92	DATE: 05/24/88
GROUND ELEVATION:	GWL: Depth N/A Date/Time N/A	DATE STARTED: 05/24/88
ENGINEER/GEOLOGIST: M. SLUSARSKI	Depth N/A Date/Time N/A	DATE COMPLETED: 06/07/88
DRILLING METHODS: CABLE-TOOL		PAGE 6 OF 11

DEPTH	SAMPLE DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REMARKS
76.5	10135 06/01/88 1345	22 46 50	14	VERY DENSE, YELLOW-BROWN (10YR 5/4) POORLY GRADED GRAVELLY SAND, TRACE COARSE GRAVEL (1.0" - 1.5"), WET.	SP	N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
80.0							
81.5	10136 06/01/88 1448	5 5 6	12	MEDIUM DENSE, YELLOW-BROWN (10YR 5/3) POORLY GRADED GRAVELLY FINE SAND, WET.	SP	N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
85.0							
86.5	10137 06/01/88 1552	8 19 28	14	DENSE, YELLOW-BROWN (10YR 4/3) WELL GRADED GRAVEL, SOME SAND, WET.	GW	N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
90.0							

NOTES:

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FERNALD RI/FS

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 602 3.2	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 3093	COORDINATES: NORTH 475,318.41 EAST 1,381,389.92	DATE: 05/24/88
GROUND ELEVATION:	GWL: Depth N/A Date/Time N/A	DATE STARTED: 05/24/88
ENGINEER/GEOLOGIST: M. SLUSARSKI	Depth N/A Date/Time N/A	DATE COMPLETED: 06/07/88
DRILLING METHODS: CABLE-TOOL		PAGE 7 OF 11

DEPTH	SAMPLE DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REMARKS
91.5	10138 06/01/88 1642	2 3 5	1	VERY LOOSE, YELLOW-BROWN (10YR 5/4) WELL GRADED GRAVELLY SAND, WET.	SW	N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
95.0							
96.5	10139 06/02/88 0842	8 23 36	14	VERY DENSE, GREY-BROWN (10YR 5/2) WELL GRADED GRAVELLY SAND, WET.	SW	N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
100.0							
101.5	10140 06/02/88 0941	11 11 9	16	MEDIUM DENSE, GREY-BROWN (10YR 5/2) WELL GRADED GRAVELLY SAND, WET.	SW	N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
105.0							

NOTES:

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FERNALD RI/FS

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 602 3.2	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 3093	COORDINATES: NORTH 475,318.41 EAST 1,381,389.92	DATE: 05/24/88
GROUND ELEVATION:	GWL: Depth N/A Date/Time N/A	DATE STARTED: 05/24/88
ENGINEER/GEOLOGIST: M. SLUSARSKI	Depth N/A Date/Time N/A	DATE COMPLETED: 06/07/88
DRILLING METHODS: CABLE-TOOL		PAGE 8 OF 11

DEPTH	SAMPLE DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REMARKS
106.5	10141 06/02/88 1148	11 18 23	14	DENSE, GREY-BROWN (10YR 5/2) WELL GRADED GRAVELLY SAND, WET.	SW	N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
110.0							
111.5	10142 06/02/88 1406	4 7 10	12	MEDIUM DENSE, GREY-BROWN (10YR 5/2) WELL GRADED GRAVELLY SAND, WET.	SW	N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
115.0							
116.5	10143 06/02/88 1625	15 25 39	14	VERY DENSE, GREY-BROWN (10YR 5/2) WELL GRADED GRAVELLY SAND, WET.	SW	N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
120.0							

NOTES:

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VISUAL CLASSIFICATION OF SOILS

3588

PROJECT NUMBER: 602 3.2	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 3093	COORDINATES: NORTH 475,318.41 EAST 1,381,389.92	DATE: 05/24/88
GROUND ELEVATION:	GWL: Depth N/A Date/Time N/A	DATE STARTED: 05/24/88
ENGINEER/GEOLOGIST: M. SLUSARSKI	Depth N/A Date/Time N/A	DATE COMPLETED: 06/07/88
DRILLING METHODS: CABLE-TOOL		PAGE 9 OF 11

DEPTH	SAMPLE / DATE / TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REMARKS
121.5	10144 06/03/88 0835	10 9 12	14	MEDIUM DENSE, GREY-BROWN (10YR 5/2) WELL GRADED SAND, SOME FINE GRAVEL, WET.	SW	N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
125.0							
126.5	10145 06/03/88 1034	11 25 40	14	VERY DENSE, GREY-BROWN (10YR 5/2) WELL GRADED SAND, SOME FINE GRAVEL, WET.	SW	N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
130.0							
131.5	10146 06/03/88 1115	16 14 15	12	MEDIUM DENSE, GREY-BROWN (10YR 5/2) WELL GRADED GRAVELLY SAND, WET.	SW	N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
135.0							

NOTES:
DEPTH TO WATER TABLE: 0742 06-03-88: 67.3 FT

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VISUAL CLASSIFICATION OF SOILS

3588

PROJECT NUMBER: 602 3.2	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 3093	COORDINATES: NORTH 475,318.41 EAST 1,381,389.92	DATE: 05/24/88
GROUND ELEVATION:	GWL: Depth N/A Date/Time N/A	DATE STARTED: 05/24/88
ENGINEER/GEOLOGIST: M. SLUSARSKI	Depth N/A Date/Time N/A	DATE COMPLETED: 06/07/88
DRILLING METHODS: CABLE-TOOL		PAGE 10 OF 11

DEPTH	SAMPLE DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REMARKS
136.5	10147 06/03/88 1405	28 32 50	18	VERY DENSE, GREY-BROWN (10YR 5/2) WELL GRADED GRAVELLY SAND, WET.	SW	N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
140.0							
141.5	10148 06/03/88 1515	3 3 12	14	MEDIUM DENSE, GREY-BROWN (10YR 5/2) POORLY GRADED SAND, WET.	SP	N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
145.0							
146.5	10149 06/03/88 1655	4 40 25	14	VERY DENSE, GREY-BROWN (10YR 5/2) POORLY GRADED SAND, SOME FINE GRAVEL, WET.	SP	N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
150.0							

NOTES:

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VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 602 3.2	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 3093	COORDINATES: NORTH 475,318.41 EAST 1,381,389.92	DATE: 05/24/88
GROUND ELEVATION:	GWL: Depth N/A Date/Time N/A	DATE STARTED: 05/24/88
ENGINEER/GEOLOGIST: M. SLUSARSKI	Depth N/A Date/Time N/A	DATE COMPLETED: 06/07/88
DRILLING METHODS: CABLE-TOOL		PAGE 11 OF 11

DEPTH	SAMPLE	DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REMARKS
151.5	10150	06/04/88 1016	28 40 37	14	VERY DENSE, GREY-BROWN (10YR 5/2) WELL GRADED GRAVELLY SAND, TRACE COARSE GRAVEL (1.0" - 1.5"), WET.	SW	N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm
155.0								
156.5	10151	06/04/88 1220	>5	6	VERY DENSE, GREY-BROWN (10YR 5/2) CLAYEY GRAVEL, SOME SAND, SOME COARSE GRAVEL (1.0" - 1.5"), WET.	GC	N/A	Hnu= 0 ppm α = 0-5 cpm βΓ = 5-10 cpm

BOTTOM OF BORING 155.0

NOTES:
DEPTH TO WATER TABLE: 0812, 06-04-88: 67.1 FT., DEPTH TO WATER TABLE: 0730, 06-05-88: 67.6 FT, MATERIALS USED IN WELL COMPLETION: 10-20 SAND (100 LB SACKS):10 SACKS, BENTONITE PELLETS: 2 BUCKETS, VOLCLAY GROUT: 06-05-88/10 BAGS, 06-06-88/21 BAGS,

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MONITORING WELL INSTALLATION RECORD

PROJECT NAME: Fernald RI/FS
PROJECT NO. : 602.3.2
BORING NO. : 3125
WELL NUMBER: 3125

FIELD ENG./GEO.: M. SLUSARSKI DATE: 11/20/89
CHECKED BY : W. HERTEL DATE: 12/05/89
N,E COORDINATES: 474344.53, 1379479.8
DATE OF INSTAL.: 11/20/89

BOREHOLE DRILLING

DRILLING METHOD: Cable Tool
DRILLING FLUID(S) USED: (in Feet)
FLUID: WATER FROM: 0.0TO: 85.0
FLUID: N/A FROM: N/ATO: N/A
NOTES/COMMENTS:

TYPE OF BIT: Flat Head Hammer
IS CASING TEMPORARY?: No
CASING TYPE : MONITORING WELL
CASING DIAM.: 4.0 In. ID
CASING SIZE(S) USED: (in Feet)
SIZE: 10. FROM: 0.0 TO: 85.0
SIZE: N/A FROM: N/A TO: N/A

WELL DESCRIPTION

TYPE: MONITORING WELL
DIAMETER OF PERFORATED SECTION:
PERFORATION TYPE: Slots
AVG. SIZE OF PERFORATIONS: .010 (In.)
TOTAL PERFORATED AREA: 10. Ft.
NOTES/COMMENTS:

RISER PIPE MATERIAL: Stainless Steel
RISER PIPE DIAMETERS:
O.D.: 4 3/8 In. I.D.: 4.0 In.
LENGTH OF 1ST PIPE SECTION: 1.7 Ft.
2ND PIPE SECTION: 5.0 Ft.
3RD PIPE SECTION: 10.0 Ft.
COMMENTS

RISER JOINING METHOD: SCREW TYPE FLUSH JOINT THREADED

PROTECTION SYSTEM

RISER PROTECTIVE PIPE LENGTH: 5.0 Ft.
PROTECTIVE PIPE O.D.: 10 3 In.
* HINGED LOCKING COVER W/ PADLOC

OTHER PROTECTION (* NOTED BELOW)

ITEM	DISTANCE ABOVE/BELOW GROUND SURFACE	ELEVATION MSL
TOP OF RISER PIPE	2.0 Ft.	529.46
GROUND SURFACE	0.0	527.3
BOTTOM OF PROTECTIVE PIPE	2.5 Ft.	

BOREHOLE FILL MATERIALS	TOP	BOTTOM	TOP	BOTTOM
	0.0	1.0	N/A	N/A
Grout/Slurry	1.0	57.0	N/A	N/A
Sand	57.0	78.0	N/A	N/A
PERFORATED SECTION	63.0	73.0	N/A	N/A

WELL TIP	74.7	N/A
BOTTOM OF BOREHOLE	86.5	N/A
GWL AFTER INSTALLATION	N/A	N/A

WAS THE WELL FLUSHED AFTER INSTALLATION? : No
WAS A SENSITIVITY TEST PERFORMED ON THE WELL : No

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 602 3.2	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 3125	COORDINATES: NORTH 474,344.53 EAST 1,379,479.82	DATE: 11/16/89
GROUND ELEVATION: 527.3	GWL: Depth N/A Date/Time N/A	DATE STARTED: 11/16/89
ENGINEER/GEOLOGIST: M. SLUSARSKI	Depth N/A Date/Time N/A	DATE COMPLETED: 11/20/89
DRILLING METHODS: CABLE-TOOL		PAGE 1 OF 6

DEPTH	SAMPLE DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REMARKS
1.5	32368 11/16/89 0914	3 8 7	8	FIRM, BROWN (10 YR 4/2) SILTY CLAY, TRACE SAND, TRACE GRAVEL (.25 IN) DAMP.	CL	2.0	Hnu= 0 ppm α = 0 cpm βΓ = 40-80 cpm
3.0	32369 11/16/89 0921	6 5 9	12	FIRM, BROWN (10 YR 4/3) SILTY CLAY, TRACE SAND, TRACE GRAVEL (.25 IN) DAMP.	CL	2.0	Hnu= 0 ppm α = 0 cpm βΓ = 40-80 cpm
4.5	32370 11/16/89 0925	7 11 10	12	MEDIUM DENSE, YELLOW-BROWN (10 YR 5/4) POORLY GRADED GRAVELLY SAND, DAMP.	SP	N/A	Hnu= 0 ppm α = 0 cpm βΓ = 40-80 cpm
6.0	32371 11/16/89 0930	8 6 11	12	MEDIUM DENSE, YELLOW-BROWN (10 YR 5/4) POORLY GRADED GRAVELLY SAND, DAMP.	SP	N/A	Hnu= 0 ppm α = 0 cpm βΓ = 40-80 cpm
10.0							
11.5	32372 11/16/89 1355	13 13 24	12	MEDIUM DENSE, YELLOW-BROWN (10 YR 5/4) POORLY GRADED SAND, TRACE OF GRAVEL (.25 - .50 IN) WET.	SP	N/A	Hnu= 0 ppm α = 0 cpm βΓ = 40-80 cpm
15.0							

NOTES:
SAMPLES COLLECTED PER ASTM STANDARD PENETRATION TEST. COLORS IDENTIFIED USING MUNSELL COLOR CHART.

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FERNALD RI/FS

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 602 3.2	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 3125	COORDINATES: NORTH 474,344.53 EAST 1,379,479.82	DATE: 11/16/89
GROUND ELEVATION: 527.3	GWL: Depth N/A Date/Time N/A	DATE STARTED: 11/16/89
ENGINEER/GEOLOGIST: M. SLUSARSKI	Depth N/A Date/Time N/A	DATE COMPLETED: 11/20/89
DRILLING METHODS: CABLE-TOOL		PAGE 2 OF 6

DEPTH	SAMPLE DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REMARKS
16.5	32373 11/16/89 1525	29 25 21	12	DENSE, YELLOW-BROWN (10 YR 5/4) POORLY GRADED SAND, TRACE GRAVEL (.25 IN) WET.	SP	N/A	Hnu= 0 ppm α = 0 cpm βΓ = 40-80 cpm
20.0							
21.5	32374 11/16/89 1555	2 2 5	14	LOOSE, YELLOW-BROWN (10 YR 5/4) POORLY GRADED SAND ("BLOW SAND") TRACE GRAVEL (.25 IN) WET.	SP	N/A	Hnu= 0 ppm α = 0 cpm βΓ = 40-80 cpm
25.0							
26.5	32375 11/16/89 1720	11 17 18	12	DENSE, YELLOW-BROWN (10 YR 5/4) WELL GRADED SAND, TRACE GRAVEL (.25 - .75 IN) WET.	SW	N/A	Hnu= 0 ppm α = 0 cpm βΓ = 40-80 cpm
30.0							

NOTES:
SAMPLES COLLECTED PER ASTM STANDARD PENETRATION TEST. COLORS IDENTIFIED USING MUNSELL COLOR CHART.

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VISUAL CLASSIFICATION OF SOILS

3588

PROJECT NUMBER: 602 3.2	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 3125	COORDINATES: NORTH 474,344.53 EAST 1,379,479.82	DATE: 11/16/89
GROUND ELEVATION: 527.3	GWL: Depth N/A Date/Time N/A	DATE STARTED: 11/16/89
ENGINEER/GEOLOGIST: M. SLUSARSKI	Depth N/A Date/Time N/A	DATE COMPLETED: 11/20/89
DRILLING METHODS: CABLE-TOOL		PAGE 3 OF 6

DEPTH	SAMPLE DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REMARKS
31.5	32376 11/17/89 0910	5 7 10	10	MEDIUM DENSE, BROWN (10 YR 5/4) WELL GRADED SAND, TRACE GRAVEL (.25 IN) WET.	SW	N/A	Hnu= 0 ppm α = 0 cpm βΓ = 40-80 cpm
35.0							
36.5	32377 11/17/89 1025	9 12 12	12	MEDIUM DENSE, BROWN (10 YR 5/4) WELL GRADED SAND, TRACE GRAVEL (.25 IN) WET.	SW	N/A	Hnu= 0 ppm α = 0 cpm βΓ = 40-80 cpm
40.0							
41.5	32378 11/17/89 1120	7 10 12	8	MEDIUM DENSE, BROWN (10 YR 5/4) WELL GRADED GRAVELLY SAND, WET	SW	N/A	Hnu= 0 ppm α = 0 cpm βΓ = 40-80 cpm
45.0							

NOTES:
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VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 602 3.2	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 3125	COORDINATES: NORTH 474,344.53 EAST 1,379,479.82	DATE: 11/16/89
GROUND ELEVATION: 527.3	GWL: Depth N/A Date/Time N/A	DATE STARTED: 11/16/89
ENGINEER/GEOLOGIST: M. SLUSARSKI	Depth N/A Date/Time N/A	DATE COMPLETED: 11/20/89
DRILLING METHODS: CABLE-TOOL		PAGE 4 OF 6

DEPTH	SAMPLE / DATE / TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REMARKS
46.5	32379 11/17/89 1345	20 34 39	12	VERY DENSE, BROWN (10 YR 5/4) WELL GRADED GRAVELLY SAND, WET.	SW	N/A	Hnu= 0 ppm α = 0 cpm βΓ = 40-80 cpm
50.0							
51.5	32380 11/17/89 1500	7 11 17	12	MEDIUM DENSE, BROWN (10 YR 5/4) WELL GRADED SAND, TRACE GRAVEL (.25 IN) WET.	SW	N/A	Hnu= 0 ppm α = 0 cpm βΓ = 40-80 cpm
55.0							
56.5	52381 32381 11/17/89 1625	11 25 50	18	VERY DENSE, BROWN (10 YR 5/2) POORLY GRADED SAND, TRACE OF GRAVEL (.25 IN) WET.	SP	N/A	Hnu= 0 ppm α = 0 cpm βΓ = 40-80 cpm
60.0							

NOTES:
SAMPLES COLLECTED PER ASTM STANDARD PENETRATION TEST. COLORS IDENTIFIED USING MUNSELL COLOR CHART.

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FERNALD RI/FS

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 602 3.2	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 3125	COORDINATES: NORTH 474,344.53 EAST 1,379,479.82	DATE: 11/16/89
GROUND ELEVATION: 527.3	GWL: Depth N/A Date/Time N/A	DATE STARTED: 11/16/89
ENGINEER/GEOLOGIST: M. SLUSARSKI	Depth N/A Date/Time N/A	DATE COMPLETED: 11/20/89
DRILLING METHODS: CABLE-TOOL		PAGE 5 OF 6

DEPTH	SAMPLE	DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REMARKS
61.5	32382	11/17/89 1700	6 11 15	14	MEDIUM DENSE, BROWN (10 YR 5/2) POORLY GRADED SAND, TRACE GRAVEL (.25 - .50 IN) WET.	SP	N/A	Hnu= 0 ppm α = 0 cpm βΓ = 40-80 cpm
65.0								
66.5	32383	11/18/89 0925	35 35 35	10	VERY DENSE, BROWN (10 YR 5/2) WELL GRADED SAND, TRACE GRAVEL (.25 - 1.0 IN) WET.	SW	N/A	Hnu= 0 ppm α = 0 cpm βΓ = 40-80 cpm
70.0								
71.5	32384	11/18/89 1015	8 9 10	14	MEDIUM DENSE, BROWN (10 YR 5/2) WELL GRADED GRAVEL-SAND MIXTURE, WET.	GW	N/A	Hnu= 0 ppm α = 0 cpm βΓ = 40-80 cpm
75.0								

NOTES:
SAMPLES COLLECTED PER ASTM STANDARD PENETRATION TEST. COLORS IDENTIFIED USING MUNSELL COLOR CHART.

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FERNALD RI/FS

VISUAL CLASSIFICATION OF SOILS

PROJECT NUMBER: 602 3.2	PROJECT NAME: FMPC RI/FS	
BORING NUMBER: 3125	COORDINATES: NORTH 474,344.53 EAST 1,379,479.82	DATE: 11/16/89
GROUND ELEVATION: 527.3	GWL: Depth N/A Date/Time N/A	DATE STARTED: 11/16/89
ENGINEER/GEOLOGIST: M. SLUSARSKI	Depth N/A Date/Time N/A	DATE COMPLETED: 11/20/89
DRILLING METHODS: CABLE-TOOL		PAGE 6 OF 6

DEPTH	SAMPLE DATE TIME	BLOWS ON SAMPLE	RECOVERY INCHES		USCS SYMBOL	TSF	REMARKS
76.5	32385 11/18/89 1200	17 34 36	12	VERY DENSE, BROWN (10 YR 4/2) WELL GRADED GRAVELLY SAND, WET.	SW	N/A	Hnu= 0 ppm α = 0 cpm βΓ = 40-80 cpm
80.0							
81.5	32386 11/18/89 1350	4 4 6	12	LOOSE, BROWN (10 YR 4/2) POORLY GRADED SAND, TRACE GRAVEL (.25 IN) WET.	SP	N/A	Hnu= 0 ppm α = 0 cpm βΓ = 40-80 cpm

BOTTOM OF BORING 86.5

NOTES:
SAMPLES COLLECTED PER ASTM STANDARD PENETRATION TEST. COLORS IDENTIFIED USING MUNSELL COLOR CHART.

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ATTACHMENT B

PROCEDURES

Water Level Measurements - Metal Tape

The steel tape method for measuring the depth to water is a simple and reliable method in observation wells between 1-1/2 and 6 inches in diameter. The steel tape method utilizes a steel tape with a popper. The popper is a metal cylinder 1 to 1-1/2 inches in diameter and 2 to 3 inches long with a concave undersurface and is fastened to the end of a steel tape. The steel tape with a popper is used in the following manner.

1) Chalk the steel tape with either carpenter's chalk or ordinary blackboard chalk which changes shade upon becoming wet.

2) Extend the chalked steel tape with a popper into the well. A few inches above the water the popper should be dropped to hit the water surface, where it will make a distinct "pop."

3) Adjust the length of the tape to determine the point at which the popper just hits the surface.

4) Extend a portion of the chalked tape below the water surface. Take a reading at a designated measuring point at the top of the casing. All water level measurements shall be taken from the same measuring point.

5) Retract the metal tape. The line of the color change of the chalked portion of the tape denotes the length of tape immersed in water.

6) Subtract the length of color change of the chalked portion of the tape from the reading at the measuring point for the depth to water.

Cascading water in a well may mask the mark of the true water level on the tape. In small-diameter wells, the volume of the weight may cause the water level to rise in the pipe, and the measurement may be somewhat inaccurate. Operating noises and lack of clearance may hinder the use of poppers.

Source: Bureau of Reclamation, 1981. *Groundwater Manual, Revised Edition, U.S. Department of the Interior.* Washington, D.C.: U.S. Government Printing Office.

Testing of Observation Wells

To determine the response to changing water stages, each observation well or piezometer should be tested as follows:

1) Inject a known volume of water into each well and measure subsequent decline of water level. The initial rise of water should be dissipated within a few minutes (to within about 0.01 of the initial rise) if the observation well is to reflect changes of head in the aquifer during the test.

2) Total depth, diameter, and screened interval should be known for each observation well and recorded in the field log book.

3) Radial distances from the control well to each observation well shall be measured.

Source: Bureau of Reclamation, 1981. *Groundwater Manual, Revised Edition,* U.S. Department of the Interior. Washington, D.C.: U.S. Government Printing Office.

Stallman, R.W., 1971. *Aquifer Test Design, Observation, and Data Analysis, Technicians of Water Resources Investigations of the U.S. Geological Survey,* Book 3, Chapter B1.

Measurement of Discharge - Orifice Meter

When used in conjunction with a pipeline, the orifice may be placed at the end of the pipeline, or it may discharge into a tank or reservoir which feeds the pipeline. The pipe and orifice shall be sized based on the attached table. To assure accurate measurements, the pipe orifice assemblies shall be installed as follows:

1) Position the manometer tube tap at least three pipe diameters from the orifice plate and accurately located on the horizontal diameter of the pipe.

2) Place the manometer tube tap at least 10 pipe diameters ahead of an elbow, valve, reducer, or similar fitting.

3) The manometer tap fitting should have an inside diameter of 1/8 to 1/4 inch and must be smooth and flush with the inside surface of the pipe.

4) The pipe should be placed truly horizontal by measuring with a carpenters level.

5) The pipe shall be full of water at all times, and the water must fall freely from the orifice into the air without any obstructions.

6) Before each measurement, the bottom of the pipe immediately behind the orifice plate shall be cleaned of sand or other debris.

7) The interior of the pipe shall be clean, smooth, and free of grease.

8) The manometer hose and gage should be free of air bubbles whenever a reading is being made.

9) Manometer readings shall not register less than 1 inch greater than the inside radius of the pipe nor greater than 60 inches. If readings are more or less than these values, the orifice size should be changed.

10) There shall be no leaks between the pump head and the orifice plate.

11) Lower the hose and tube below the manometer tap and allow water to flow through it for a short time to clear all air bubbles and sand from the system prior to making a reading.

Surging commonly associated with many pumps shall be dampened to permit easier more accurate readings to be made. If regular surging is evident in the tube, the range of such surging shall be noted and the mean taken of the readings.

When very large discharges are to be measured or the range of discharges to be measured exceeds that of a single orifice, an arrangement using two pipe orifices is suggested.

Source: Bureau of Reclamation, 1981. *Groundwater Manual, Revised Edition,* U.S. Department of the Interior. Washington, D.C.: U.S. Government Printing Office.

Groundwater Sampling

The primary technical consideration in groundwater sampling is to obtain a representative sample of the groundwater body at the well location. The following minimum guidelines and techniques are required during sample withdrawal.

1) Set up sampling equipment to avoid interference with sampling activities.

2) Place plastic sheeting on ground, if necessary, to prevent spillage of water and to avoid contamination of equipment by contact with ground or other uncontrolled surface.

3) Avoid effects of the following conditions to ensure representative samples of groundwater.
   (1) Sample temperature may change rapidly after it is brought to the surface.
   (2) The pH may change from loss of carbon dioxide through degassing or adsorption, which could affect alkalinity and oxidation of certain compounds.
   (3) Dissolved gases may be lost as a result of a pressure change.
   (4) Organic samples may be affected by volatilization, adsorption, photodegradation, or contamination from sampling materials or airborne gases.

4) Complete a groundwater sample collection form for each sample with information specified in FEMP draft QAPP, Appendix K, Subsection K.9 plus the following data.
   (1) Description of water level measuring point
   (2) Depth to water
   (3) Depth of well from well construction diagram
   (4) Well casing diameter and borehole diameter from well construction diagram
   (5) Monitored interval and screen length

5) Purge water caught between sample port and flow line.

6) Obtain samples from sample port in accordance with the stability and volatility of parameters to be tested in the following order.
   (1) Field Measurements (temperature, pH, specific conductance, and dissolved oxygen)
   (2) Volatile organic compounds
   (3) Total organic halogens
   (4) Total organic carbon
   (5) Extractable organic compounds
   (6) Total Metals
   (7) Dissolved metals
   (8) Phenols
   (9) Cyanide

(10) Sulfate and chloride

(11) Turbidity

(12) Nitrate and ammonia

(13) Radionuclides

7) Collect excess water generated during sampling in appropriate containers.

8) Dispose of water that is believed (based on past sampling data) not to contain constituents classified as hazardous waste under the Resource Conservation and Recovery Act (RCRA).

9) Store water that has unknown constituents and is potentially hazardous waste in a designated area until classification is determined (based on analysis of the water for Toxicity Characteristic Leaching Procedure parameters) and a disposal method chosen. Observe Resource Conservation and Recovery Act (RCRA) requirements for duration of storage.

10) Decontaminate sampling equipment between wells.

11) Take field measurements at well site on unpreserved samples as described in the FEMP QAPP (draft), Appendix K subsection K.4.1. Keep samples collected for field measurements separate from samples preserved for shipment to laboratory.

12) Number and label samples as specified in the FEMP QAPP, Section 7.

13) Store and preserve samples as specified in the FEMP QAPP, Appendix A, Table 6-1.

14) Complete Sitewide Analysis Request Custody Record (SAR/CR) (Form 7-1, Appendix B) as Specified in the FEMP QAPP, Section 7.

Source: WEMCO/FEMP QAPjP, 1992

South Plume Groundwater Recovery System Pump Test
Water Level Measurement Form

Elevation (MSL): _____ top of casing

Observation well/piezometer no.: _____

Pumped well no.: _____

Pump test performed by(Name): _____

Company: _____

Reference point measurements by: _____

Method of measurement: _____

Depth Correction: _____

b = _____

Average Q at end of test _____ gpm r = ____ ft.

r^2 = _____

Date	Hour:Min	t (min)	t′ (min)	t/t′	s (ft.)	s′ (ft.)	(s_p - s′)	Meter Reading (gals.)	Ave. Q	Remarks

b = aquifer thickness (ft)
r = distance from pumped well to observation well or piezometer (ft.)
Q = flow rate (gpm)

s = measured drawdown (ft.)
s′ = residual drawdown (ft.) at t′
s_p = drawdown at end of pumping period (final s)
t = elapsed time since pumping began (min)
t′ = elapsed time since pumping stopped (min)

Reference: Bureau of Reclamation (1981) and Stallman (1971)

3588

B

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APPENDIX B TO THE DESIGN, MONITORING, AND EVALUATION PROGRAM PLAN

Appendix B

South Plume Groundwater Recovery System
South Plume Groundwater Monitoring and Response Plan

Environmental Remedial Action Project
Fernald Environmental Management Project
Fernald, Ohio

WEMCO Subcontract No. 2-21487
July 15, 1992
Revision No. 0

Operable Unit 5, Project Order 37

PARSONS

Fairfield Executive Center
6120 South Gilmore Road
Fairfield, Ohio 45014

South Plume Removal Action
South Plume Groundwater Monitoring and Response Plan

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LIST OF ACRONYMS AND ABBREVIATIONS

ANOVA	Analysis of Variance Procedure
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DMEPP	South Plume Groundwater Recovery System - Design, Monitoring, and Evaluation Program Plan
DOE	United States Department of Energy
FEMP	Fernald Environmental Management Project
GMRP	Groundwater Monitoring and Response Plan
Ohio EPA	Ohio Environmental Protection Agency
PRRS	Paddys Run Road Site
QAPjP	Quality Assurance Project Plan
WEMCO	Westinghouse Environmental Management Company of Ohio

SECTION 1

INTRODUCTION

1.1 Purpose

The primary purpose of the South Plume Groundwater Monitoring and Response Plan (GMRP) is to define a system evaluation and response program that will evaluate the effectiveness of the South Plume groundwater recovery system. The South Plume Groundwater Recovery System - Design, Monitoring and Evaluation Program Plan (DMEPP) (see main text) defined the general requirements of this program in Sections 4 and 5. The DMEPP divides this program into two mutually dependent activities:

1) South Plume Groundwater Monitoring
2) South Plume System Evaluation and Response

As stated in the DMEPP, groundwater monitoring wells (both existing and proposed) will be utilized to collect groundwater elevation and chemical data at specified time intervals and locations. Periodic system evaluations are performed to determine if the recovery system continues to meet its objectives despite spatial and temporal changing variables and proposes a process of corrective action through routine changes or through a more formal system modification procedure.

The GMRP defines the specific requirements for these activities. The GMRP includes definition of the following:

1) Management responsibilities and schedule

2) The monitoring well network layout

3) Design information for new well construction

4) Details of water level measurements, groundwater sampling and analysis, and other data acquisition methods

5) System response criteria

6) Recovery well design criteria

7) Data reduction and analysis tasks

8) Statistical methods

9) Reporting requirements

1.2 Management and Responsibilities

Figure 1-1 shows the relationships between the organizations who will be involved in groundwater monitoring and system evaluation. PARSONS, as monitoring and system evaluation program designer, provides design criteria for new monitoring wells. PARSONS also defines recovery well design criteria to the extent that system evaluation requirements affect the well design. A.M. Kinney is responsible for designing the recovery and monitoring wells. PARSONS provides well sampling requirements to Westinghouse Environmental Management Company of Ohio (WEMCO) Environmental Monitoring, who will conduct the actual monitoring.

Field activities associated with drilling, measuring, and sampling will be conducted in accordance with this work plan. PARSONS and A. M. Kinney will provide technical guidance during associated field activities.

1.3 Program Schedule

Figure 1-2 shows the schedule of the monitoring program and the system evaluation and response program. Implementation of this program will be dependent on the acquisition of baseline data and the construction and start-up of the recovery system.

In an effort to provide timely reporting, system evaluations are scheduled to be completed 90 days after the end of a particular quarter. A 30 days lab turnaround is assumed for this schedule. The results of confirmatory split samples sent to off-site labs approved in the Fernald Environmental Management Project (FEMP) Sitewide Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Quality Assurance Project Plan (QAPjP) (WEMCO 1992b) will not be available for a particular quarter so unconfirmed data will be used. Best professional judgement will be used to eliminate the use of suspect data when confirmatory data is pending. Since system evaluations are a continuous process, any data not available at the time of one evaluation will be included in the next scheduled evaluation.

Figure 1-1 - South Plume Monitoring Management Organization

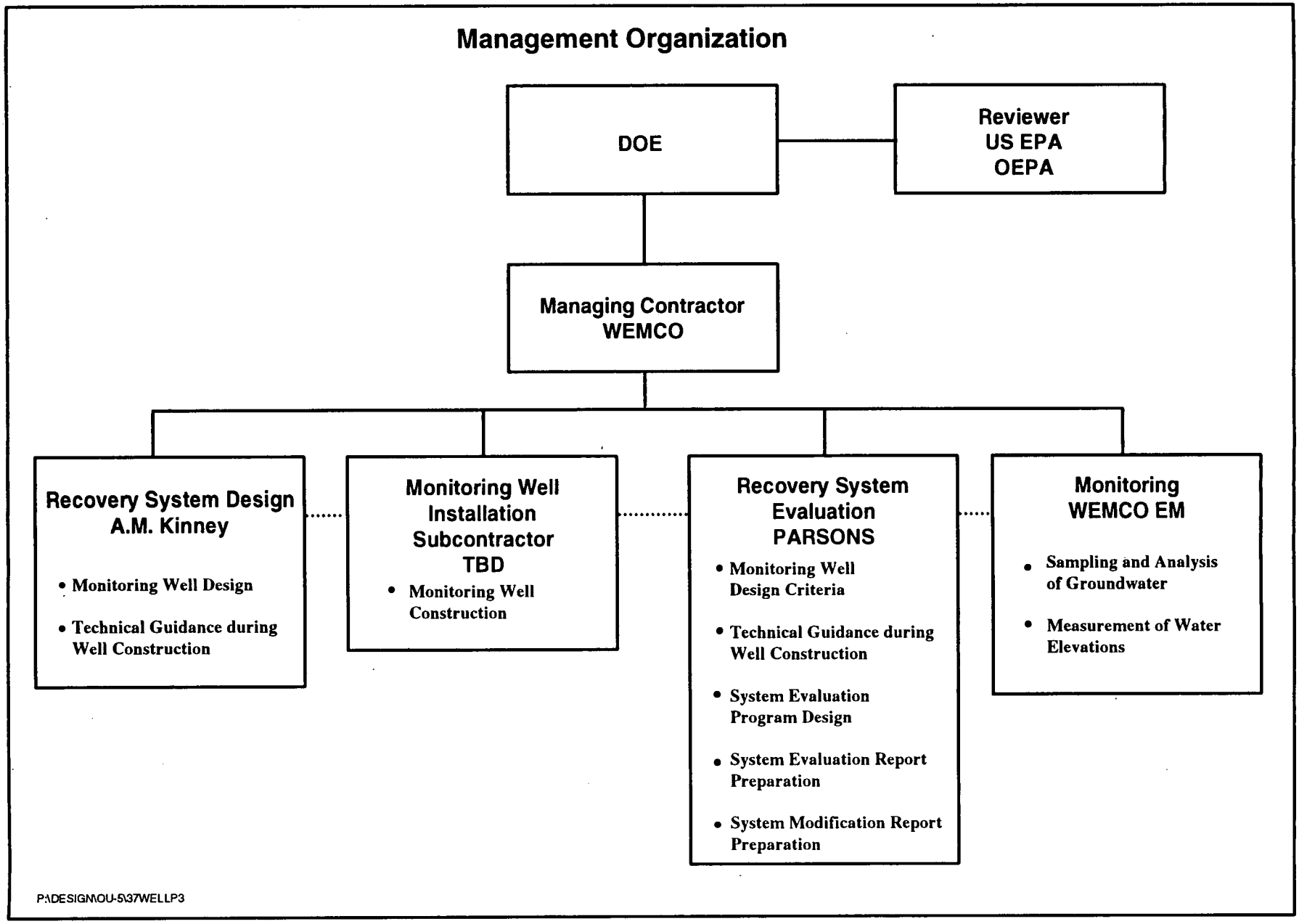


FIGURE 1-2 - MONITORING AND SYSTEM EVALUATION PROGRAM SCHEDULE

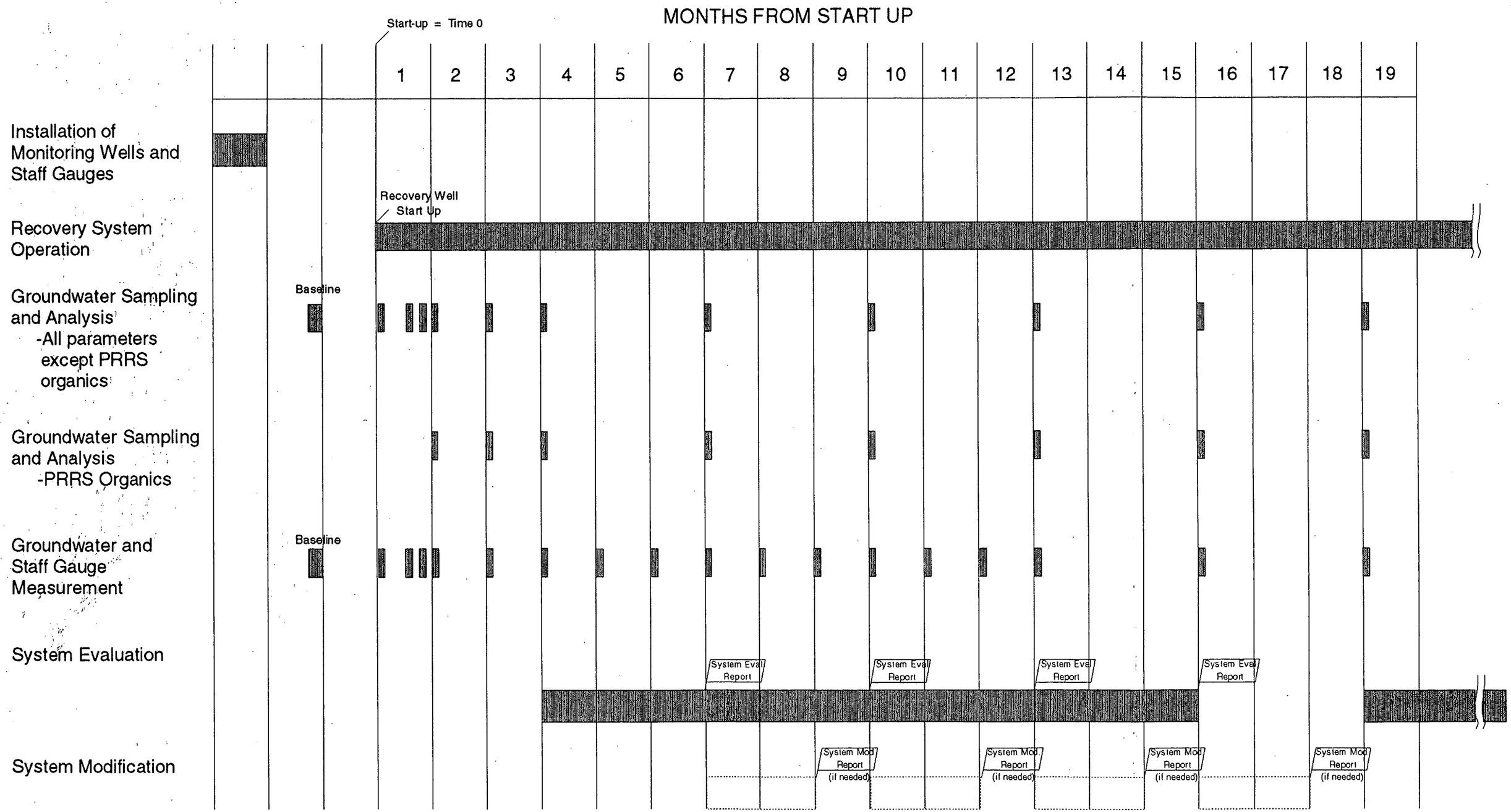


Figure 1-2 - Monitoring and System Evaluation Program Schedule

SECTION 2

GROUNDWATER MONITORING

2.1 Objectives

As stated in Section 3 of the DMEPP, the objectives of the South Plume Groundwater Monitoring Program are:

1) To delineate the cone of depression caused by the recovery wells
2) To provide supporting hydraulic data for the model validation and model calibration tasks
3) To delineate the uranium concentration distribution in the vicinity of the recovery wells
4) To anticipate the uranium concentrations that will be pumped in the future
5) To determine the potential impact of plumes from the Paddys Run Road Site (PRRS)

To meet the objectives stated above, two types of field data will be collected from monitoring wells in the vicinity of the recovery wells: hydraulic (groundwater elevation) data and groundwater quality data. Since hydraulic and groundwater quality data are time dependent, these field data will be collected at specified intervals (see Figure 1-2). Additional monitoring wells are proposed to increase the data coverage of the south plume area.

2.2 Data Collection Network

Table 2-1 summarizes the data collection approach along with well location considerations for each of the five objectives stated above. The first two objectives require the collection of hydraulic data to define and evaluate the capture zone created by the recovery wells. The last three objectives require sampling and analysis for applicable constituents. Objectives 4 and 5 also require supporting hydraulic data. The "Considerations" field in Table 2-1 selects applicable considerations for each objective. In some cases, these considerations are used to meet more than one objective. Each of these considerations is discussed in relation to proposed monitoring wells in the following text.

Twelve monitoring wells will be installed as six pairs. Each pair will consist of a 2000 series and a 3000 series monitoring well. Figure 2-1 shows the proposed monitoring wells along with more than 70 existing wells in the South Plume area. These wells include United States Department of Energy (DOE) monitoring wells, PRRS monitoring wells, and private water supply wells. Most are available to the DOE for sampling; most of these wells are concentrated in the western portion of the study area especially along Paddys Run Road, with less dense coverage in other portions of the study area. Many of these existing wells are appropriately located to support south plume monitoring efforts.

Table 2-1 - Considerations in Collection of Hydraulic and Groundwater Quality Data

Objective	Approach	Considerations
1) To delineate the cone of depression caused by the recovery wells	Water elevation data collected at appropriate wells and stream stations	1) Location within cone of depression 2) Coverage of area by existing wells 3) Presence of Recharge Boundaries (Paddys Run)
2) To provide supporting hydraulic data for the model validation and model calibration tasks	Water elevation data collected at appropriate wells and stream stations	1) Location within cone of depression 2) Coverage of area by existing wells 3) Presence of Recharge Boundaries (Paddys Run)
3) To delineate the uranium concentration distribution in the vicinity of the recovery wells	Uranium sampling data collected at appropriate wells	1) Coverage of area by existing wells 2) Line system of monitoring north of recovery wells 3) Line system of monitoring south of recovery wells
4) To anticipate the uranium concentrations that will be pumped in the future	Uranium sampling data collected at appropriate wells supported by water elevation data	1) Line system of monitoring north of recovery wells 2) Warning time (function of distance north) 3) Spacing based on uranium plume features
5) To determine the potential impact of plumes from the Paddys Run Road site	PRRS parameter sampling data collected at appropriate wells supported by water elevation data	1) Line system of monitoring south of recovery wells 2) Warning time (function of distance south) 3) Spacing based on PRRS plume(s) features

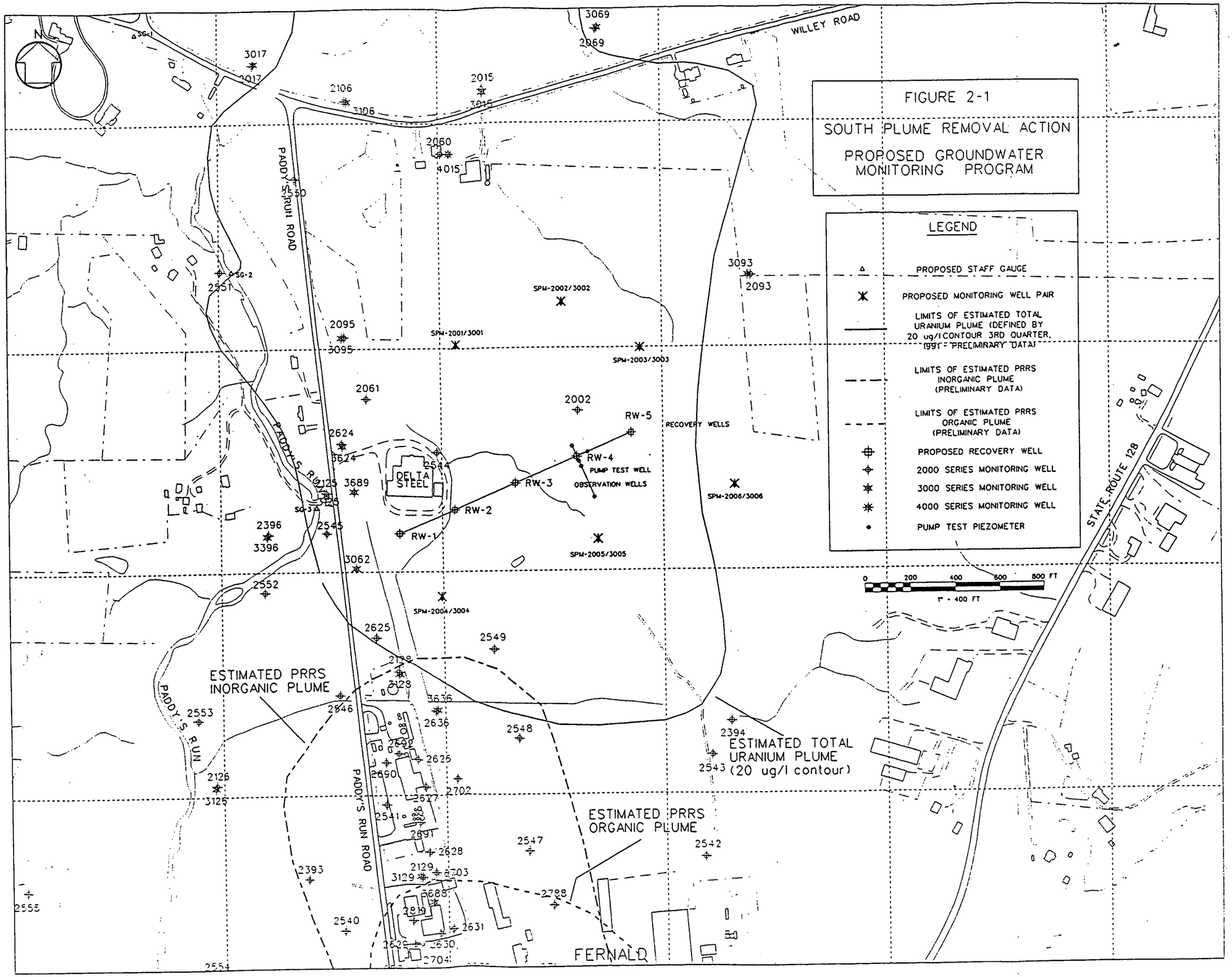


Figure 2-1 - Proposed Groundwater Monitoring Program

Figure 2-1 shows the estimated extent of the total uranium plume (using the 20 μg/l isopleth from 4th quarter 1991 values in the 2000 series wells) and of the PRRS inorganic and organic plumes (using values above background from 4 rounds of 1991 data). These depictions of plumes are based on the most recent, although preliminary, data (WEMCO 1992a; Ohio Environmental Protection Agency [Ohio EPA] 1992).

2.2.1 Proposed Monitoring Wells North of Recovery Wells

Three paired wells are proposed approximately 400 to 700 feet north of the recovery well line (SPM-2001/3001, SPM-2002/3002, and SPM-2003/3003 on Figure 2-1). These three new well pairs along with two existing paired 2000 and 3000 series wells (2095, 3095, 2093, and 3093) will generally form a southwest/northeast trending line of monitoring wells to the north of the five well recovery system.

The locations of the new north monitoring wells were selected to fulfill the monitoring program objectives. These wells will be installed 400 to 700 feet north of the recovery wells to measure drawdown associated with recovery system pumping (modeling predicts approximately 1.8 to 2.4 feet of drawdown at this distance with total well field pumping at 2,000 gpm (DOE 1992). Using the Darcy Equation with gradients predicted by modeling (DOE 1992) and a hydraulic conductivity value of 450 feet/day (DOE 1990) and 1 as the retardation coefficient, a groundwater travel time is calculated as approximately 57 to 100 days over the 400 to 700 feet. Since uranium does retard to some degree in porous flow systems, this travel time represents a conservative low level. This distance will provide a sufficient time frame to react to trends reflected in monitoring wells prior to the arrival at the recovery wells. These locations provide a reasonable warning time while still providing a location within the projected cone of depression. In addition, other monitoring wells north and south of this line of wells will be measured and sampled to discern trends, thus additional supporting data will be provided. These proposed wells also provide two new monitoring locations in an area where there are few wells.

The wells of this line are spaced approximately 500 feet apart between the SPM-2001/3001 and the SPM-2002/3002 pairs, and 400 feet apart between the SPM-2002/3002 and SPM-2003/3003 pairs. Based on a recent plume definition from groundwater monitoring data, the plume is over 2000 feet wide at the 10 μg/l total uranium contour north of the monitoring wells at Willey Road (Figure 2-1); therefore, this spacing is sufficient to estimate the size and concentration of the plume passing this point (i.e., important trends will not be missed). To provide an additional level of protection, additional existing wells will also be monitored at locations between these wells (see Sections 2.4 and 2.5 for definition of sampling and measurement program).

2.2.2 Proposed Monitoring Wells South of Recovery Wells

Three additional paired wells are proposed south of the recovery wells. These three new well pairs (SPM-2004/3004, SPM-2005/3005, SPM-2006/3006 on Figure 2-1) will form a southwest/northeast trending line approximately 350 feet south of the recovery well system.

The locations of the new south monitoring wells were also selected to fulfill the monitoring program objectives. These south monitoring wells will provide drawdown data south of the recovery wells, to determine and forewarn if northward migration from PRRS is occurring, and to determine if the uranium plume is escaping past the recovery wells. At approximately 350 to 400 feet from the line of recovery wells, these wells will measure drawdown associated with recovery well pumping (modeling predicts 2.5 to 3.0 feet of drawdown at this distance with total well field pumping at 2,000 gpm [DOE 1992]). Potential northward migration from the PRRS would be discovered by sampling new wells SPM-2004/3004, as well as existing wells 2549 and 2625 for PRRS inorganic parameters (see Figure 2-1). Sections 2.4 and 2.5 below describe the measurement and sampling program.

It is not anticipated that the PRRS organic plume could migrate as far north as the new line of monitoring wells; however, if northward migration did occur, sampling for organics at SPM-2004/3004 as well as SPM-2005/3005 and existing wells 2702 and 2548, would detect this northward migration (see Figure 2-1). In addition, the two easterly well pairs (SPM-2005/3005 and SPM-2006/3006) will provide monitoring information in a location that has few monitoring wells.

The distance between the line of proposed monitoring wells and the recovery wells was selected based on groundwater travel time and drawdown factors. Since model simulations (DOE 1992) show a slight gradient from the recovery wells to the south monitoring wells, then flow should occur in a generally southern direction although at a slower rate than north of the recovery wells. The 350 foot distance was chosen to provide a reasonable travel time for determining if uranium contamination is passing the recovery wells or for determining if PRRS constituents are migrating toward the recovery wells. A shorter distance between south monitoring wells and recovery wells (than the equivalent north distance) was selected because of this time factor and because the natural gradient restricts the development of the drawdown impacts to the south.

2.2.3 Stream Gauging

Three staff gauges will be installed along the 2000 foot reach of Paddys Run west and north of the recovery wells (see Figure 2-1) to measure the effects of the recovery system on Paddys Run. The staff gauges will be used to monitor Paddys Run stream elevation under transient (during the pumping test and early recovery system start-up) and steady state (achieved after recovery system start-up) conditions. The

results of these measurements will help to determine if Paddys Run interferes as a recharge boundary to the recovery system.

2.3 Monitoring Well Construction

Locations and criteria for monitoring well construction are defined in Table 2-2. These locations may be minimally altered based on field constraints. Screen depths will conform to the established 2000 and 3000 well series depths. The 2000 series monitoring wells will be installed at the water table using 15-foot screens. The screens in the 2000 series wells will extend 5 feet above the water table surface. The 3000 series wells will be screened approximately 50 to 65 feet (depending on well location) below the water table surface using 10-foot screens.

Drilling and well construction specifications will be prepared by the design contractor, A.M Kinney. Procedures for monitoring well construction will be in accordance with the FEMP Sitewide CERCLA QAPjP, March 1992, draft (QAPjP) (WEMCO 1992b). Table 2-3 lists the procedures from the QAPjP for performing the activities.

Split spoon samples will not be required in the glacial overburden and the upper unsaturated sands of the Great Miami Aquifer. Continuous corings (minimum 3 inches in diameter) will be collected over the screened interval of each well. Samples will be classified in accordance with the Unified Soil Classification System. Samples will be retained by the field geologist and archived as directed by WEMCO. Soil samples will be selected for sieve and other geotechnical parameter analyses as determined by PARSONS or A.M. Kinney. Gamma ray logs will be run from surface to total depth on the deepest well of each well pair.

2.4 Water Level Measurements

Water levels will be measured at staff gauges, recovery wells, south plume monitoring wells, and selected existing monitoring wells. The locations and frequency of these measurements are shown on Table 2-4.

The schedule of measurements shown on Table 2-4 has been selected to obtain more frequent data measurements at the beginning of recovery pump operation because of transient effects. Measurements are made daily over the first week, weekly over the first month, and monthly over the first year to build a database for the system evaluation process. As operation continues and a relative steady state is achieved, the water levels will change less with time and quarterly readings will be sufficient to provide a picture of annual variation.

Table 2-2 - Criteria for Monitoring Well Construction

Well Number	Location Coordinates	Approx. Depth (ft.)	Screen Length (ft.)	Materials
SPM-2001	475018 N 1380070 E	80	15	Casing: 2-inch (minimum) ID stainless steel; Screen: 0.01 inch slot stainless steel set at base of boring; Filter Pack: Natural
SPM-3001		145	10	
SPM-2002	475205 N 1380545 E	80	15	
SPM-3002		145	10	
SPM-2003	475000 N 1380900 E	80	15	
SPM-3003		145	10	
SPM-2004	473890 N 1379990 E	25	15	
SPM-3004		75	10	
SPM-2005	474142 N 1380700 E	85	15	
SPM-3005		150	10	
SPM-2006	474384 N 1381318 E	85	15	
SPM-3006		150	10	

Table 2-3 - Well Installation Procedures

Administrative Procedures	REFERENCE QAPjP (WEMCO 1992b)
Chain-of-Custody	Section 7.1
Corrective Action	Section 15.2
Daily Logs	Section 5.1 and Appendix J, Subsection J.4.1
Variances	Section 15.4
Field Procedures	
General Drilling Practices	Section 5.2.1 and Appendix J, Subsection J.4.2
Subsurface Sampling	Appendix K, Subsection K.5.3
Monitoring Well/Piezometer Design, Installation, and Abandonment	Section 5.2.2 and Appendix J, Subsection J.4.3
Well Development	Section 5.2.3 and Appendix J, Subsection J.4.4
Borehole Geophysical Logging	Section 5.3.1
Field Screening of Samples for Radioactive Contamination	Section 5.2.5 and Appendix J, Subsection J.4.6
Decontamination	Appendix K, Subsection K.11
Field Storage and Shipment of Samples	Appendix K, Subsection K.10
Well Maintenance	Section 5.2.4 and Appendix J, Subsection J.4.7

Table 2-4 - Wells Requiring Water Elevation Measurements and Frequency of Measurements

Recovery Wells	South Plume Monitoring Wells/ Staff Gauges	Other Monitoring Wells	Frequency of Measurements For All Wells in Program	
RW-1	SPM-2001	2002		
RW-2	SPM-3001	2093		
RW-3	SPM-2002	3093		
RW-4	SPM-3002	2544		
RW-5	SPM-2003	2061		
	SPM-3003	2095		
	SPM-2004	3095		
	SPM-3004	2624		
	SPM-2005	3624		
	SPM-3005	2125	1st Week of Operation	Daily
	SPM-2006	3125		
	SPM-3006	2396	1st Month of Operation	Weekly
	SG-1	3396		
	SG-2	2552	1st Year of Operation	Monthly
	SG-3	3062		
		2625	Subsequent Operation	Quarterly
		2128		
		3128		
		3636		
		2636		
		2549		
		2548		
		2543		
		2394		

Table 2-5 - Procedures for Groundwater Measurements, Sampling, and Analysis

Administrative Procedures	REFERENCE QAPjP (WEMCO 1992b)
Chain-of-Custody	Section 7.1
Corrective Action	Section 15.2
Daily Logs	Section 5.1 and Appendix J, Subsection J.4.1
Variances	Section 15.4
Data Validation	Appendix D
Field Procedures	
Groundwater Level Measurement	Appendix K, Subsection K.4.2.1
Groundwater Sampling	Appendix K, Subsection K.4.2
Collection of Quality Assurance/Quality Control (QA/QC) Samples	Appendix K, Subsection K.5.4
Field Screening of Samples for Radioactive Contamination	Appendix K, Subsection K.5.3.2
Decontamination	Appendix K, Subsection K.11
Field Storage and Shipment of Samples	Appendix K, Subsection K.10
Field Calibration Requirements	Appendix I
Field Analytical Methods for Natural Water Samples	Appendix K, Subsection K.4.1
Field Test:	
Temperature	Appendix K, Subsection K.4.1.1
pH	Appendix K, Subsection K.4.1.2
Specific Conductance	Appendix K, Subsection K.4.1.3
Dissolved Oxygen	Appendix K, Subsection K.4.1.4
Laboratory Test Procedures	
Organics, Inorganics, and Radionuclides	Attachment I

Data from monitoring wells, not listed on Table 2-4 and measured for groundwater elevations as part of the regular sitewide monitoring program, will be used as supporting data.

Procedures for measuring water levels will be in accordance with the QAPjP (WEMCO 1992b). Table 2-5 defines the procedures for activities associated with water level measurements.

2.5 Groundwater Sampling and Analysis

Samples will be collected at recovery wells, south plume monitoring wells, and other selected existing area wells and will be analyzed for total uranium, pH, specific conductance, dissolved oxygen, and temperature. Selected monitoring wells will be sampled and analyzed for Volatile Organic Compounds (VOCs) and inorganics in order to directly determine if the Paddys Run Road Site organic or inorganic plume is expanding toward the recovery wells. The QAPjP procedures related to sampling are shown on Table 2-5. Table 2-6 defines the sampling and analytical methods that will be used for the South Plume groundwater monitoring program while Table 2-7 defines the wells that will be sampled and the corresponding constituent analysis that will be required.

Similar to water elevations, more samples will be collected at the beginning of the program when transient conditions are most prevalent (see Figure 1-2 for schedule). In order to establish a recovery system evaluation baseline, program wells (see Table 2-7) will be similarly sampled prior to system start-up.

Except as noted below, procedures for sampling and analysis of monitoring wells will be in accordance with the QAPjP (WEMCO 1992b). Table 2-5 lists the procedures associated with groundwater sampling and analysis. Because of the need for quick response, on-site laboratories will be used for total uranium and PRRS organic and inorganic parameter analysis so that system evaluations and adjustments can be accomplished in a timely manner. In the event the on-site lab cannot meet project needs for the PRRS parameters, an off-site capable of Level 3 Data Quality Objective will be utilized. As a confirmation, 10 percent of the samples will be split and sent to outside laboratories approved in the FEMP QAPjP.

Table 2-6 - Sampling and Analysis Parameters and Methods

Parameter Group	Description	Compound	FEMP QAPjP Method*
A	Field Parameters	pH, SC, T, DO	Appendix K Subsec. K.4.1.4
B	Radionuclides	Total Uranium	FM-RAD-0120
C	PRRS Inorganics	Arsenic	FM-INO-0010
		Sodium	FM-INO-0020
		Potassium	FM-INO-0030
		Phosphorus (total)	FM-CON-0220
D	PRRS Organics	Benzene	FM-ORG-0050
		Ethylbenzene	
		Cumene (isopropyl benzene)	
		Xylene	
		Toluene	

* QAPjP (WEMCO, 1992b)

Table 2-7 - Sampling Requirements

Monitoring Locations	Parameter Group
RW-1 through RW-5	A, B
SPM-2001 through 2003 SPM-3001 through 3003	A, B
SPM-2004 through 2006 SPM-3004 through 3006	A, B, C, D[1]
2002, 2093, 3093, 2095, 3095, 2061, 2544, 2624, 3624, 2125, 3125, 2545	A, B
2625, 2128, 3128, 2636, 3636, 2548, 2549	A, B, C, D[1]

Notes: 1. Because of the distance between the recovery wells and the organic plume, samples for organic analysis will not be collected for the daily and weekly start-up sampling periods.

2. Frequency of measurements (exceptions stated in Note 1 above).

1st Week of Operation	Daily
1st Month of Operation	Weekly
1st Quarter of Operation	Monthly
Subsequent Operation	Quarterly

SECTION 3

PERFORMANCE EVALUATION AND RESPONSE

3.1 Purpose

The purpose of the evaluation/response program is to determine whether the groundwater recovery system is meeting its objectives and, if not, to take appropriate action to bring it back in conformance with its objectives. Using background information and monitoring data periodically collected in accordance with Section 2, an evaluation is performed at scheduled intervals. If this evaluation shows that the program objectives are being met, then no further action will be taken at that time. If the evaluation shows that the system is not meeting its objectives, then the groundwater model (and other analytical tools) will be utilized to develop modifications to bring the system in line with its objectives. Possible system changes may involve design, operation, or monitoring program modifications.

Section 5 of the DMEPP presents the general requirements of the system evaluation and response program. In accordance with the DMEPP, a more detailed presentation of this program is provided in this section including a specific discussion of system response criteria, data analysis tasks, statistical procedures, and reporting requirements. Because the system modification program is contingent upon findings in the system evaluation report and because its scope is variable based on the system evaluation findings and the system needs, only general requirements may be established for the system modification report. Therefore, the description of the system modification program in the DMEPP provides sufficient detail.

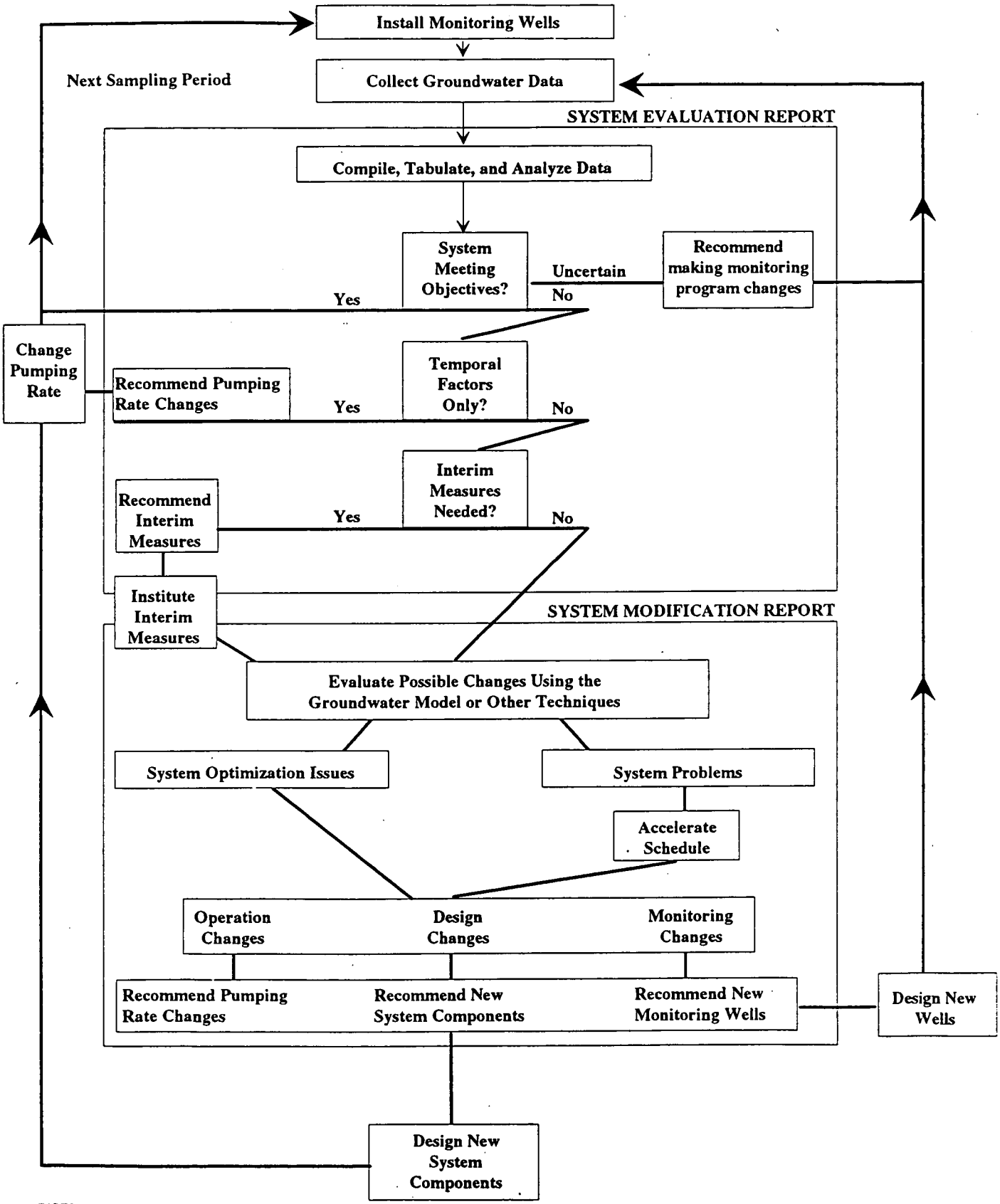
Figure 3-1 summarizes the system evaluation process and the decision making logic in the system evaluation report and the system modification report. The text in the DMEPP and the following sections describes the system evaluation process in more detail.

3.1.1 Objectives of System Evaluation

The DMEPP defines four overall objectives for the south plume removal action. In summary, these objectives are:

1) The groundwater recovery wells need to be pumped at a sufficient rate to create a hydraulic barrier to intercept the width of the Zone 1 plume as defined by contamination above the 20 μg/l total uranium level.

Figure 3-1
Flowchart of Evaluation and Response Program Logic



P:\DESIGN\OU-5\37WELL4.DRW

Figure 3-1 - Flow Chart of Evaluation and Response Program Logic

2) The magnitude of the hydraulic trough needs to be minimized to prevent PRRS plumes from being pulled toward the recovery wells or significantly deflected.

3) Contamination within the aquifer needs to be removed as soon as feasible to prevent further plume movement and degradation of the groundwater environment.

4) The operation of the removal action recovery system needs to be consistent with the final site remediation.

In essence, these objectives reduce to two factors; creating sufficient drawdown to prevent migration around, between, or beneath the recovery wells (Objectives 1 and 3) and minimizing drawdown to prevent gradient changes over a large area (Objectives 2 and 4). Therefore, the system will be evaluated in relation to balancing these two factors.

3.2 System Response Criteria

The most effective method of operating the recovery well system would be with definitive criteria. These criteria would define the action to be taken in response to a particular variable value or change. For example, a defined change in groundwater elevation at a particular monitoring well or a defined change in uranium concentration may require an alteration of the recovery well pumping rate. In the south plume case, certain variables allow the development of more quantitative response action more than others. The aquifer hydraulic parameters appear to be more predictable than the chemical analysis parameters. Therefore, it is easier to define a systematic response to a finding for the hydraulic system parameters.

It would be best to establish quantitative type criteria which will provide a definitive response to a finding and if possible allow automatic feedback response to changes in a particular variable. The definition of feedback response-type operation is most effectively developed through groundwater monitoring and modeling. However, three obstacles exist which prevent the establishment of this type of criteria at the present time.

1) The SWIFT groundwater flow model has never been formally validated in the vicinity of the south plume; consequently, the model may be inaccurate and calculations performed with the model may also be inaccurate.

2) There is no operating history of the system since the recovery wells do not presently exist. New monitoring wells have been located as part of this plan. A time dependent database of monitoring data is needed to obtain a picture of the system parameters and to support modeling efforts.

3) The SWIFT model was calibrated to steady-state conditions. Seasonal and transient conditions may be encountered in the field that are different. Feedback response criteria need to be built on seasonal effects.

Efforts are underway or available to overcome these obstacles. The site groundwater SWIFT model will be validated and recalibrated in the vicinity of the south plume with a pump test and with first quarter monitoring data. Monitoring data will be collected during the start up and operation of the recovery system. The refined model will be used to simulate possible transient effects caused by a decrease or increase in rainfall or effects caused by the changes in Paddys Run stage. However, this data or analysis will not be available until the system has been operated for at least one quarter.

Therefore, only general criteria are developed in this document along with the requirements for developing more definitive criteria in the periodic system evaluation reports. Criteria development will be to some extent an iterative process responsive to increases in understanding of the recovery system. The periodic system evaluation report will provide a mechanism to define these criteria.

3.2.1 General Response Criteria

The system evaluation report will determine whether the system is meeting its objectives and whether system changes are needed. This evaluation will use standard scientific and engineering decision making techniques. This evaluation will need to be cognizant of time and spatial variability and will need to react to general trends but not to every possible system upset; i.e., a global approach needs to be taken.

Table 3-1 shows a sample of possible field findings and interpretations of these findings. Statistical procedures described in Section 3.4 will be used to determine trends or significance of changes. Determination of action to these findings will be through an assessment of all data collected and engineering and scientific judgement. The first few system evaluations will be somewhat qualitative; as data is collected and the model is refined, the evaluations will be more quantitative.

3.2.2 Hydraulic System Response Criteria

Groundwater hydraulic criteria will be established as part of the first system evaluation report. This criteria will be based on the results of the pump test and on the results of the first quarter monitoring. Subsequent system evaluation reports may modify these criteria based on subsequent monitoring and analysis.

The design of the recovery system has included a significant range of pumping capacity (2000 to 4000 gpm with all wells pumping) to allow flexibility in operation. Lower flow rates could be achieved by only pumping selected wells. For example, only wells RW-1, 3, and 5 could be pumped at 400 gpm for

a total of 1200 gpm. Many other options are possible since each well could be pumped at different rates. This may be desirable if, for example, an edge of the plume needs to be captured at a particular end of

Table 3-1 - Potential Findings and Responses

General Finding Based on Evaluation	Objective Affected*	Tentative Conclusion
Minimal drawdown in recovery and monitoring wells in south plume area	1	Capture zone appears insufficient to prevent migration past recovery wells
Upward trend in uranium concentration data in down gradient monitoring wells	1	Capture zone appears insufficient to prevent migration past recovery wells
Upward trend in PRRS inorganic concentration data in south boundary well	2	Capture zone affecting areas south and reversing flow
Upward trend in PRRS organic concentration data in south boundary well	2	Capture zone affecting areas far south and reversing flow
South monitoring wells show significant reversal of gradient	2	Capture zone affecting areas south and reversing flow
South monitoring wells or other monitoring suggest deflection of PRRS plumes	2	Capture zone affecting areas south
North monitoring wells show significant drawdown and long range effects of pumping	4	Capture zone affecting areas north
Recovery wells show very little uranium capture	3	Clean water being pulled from uncontaminated areas
Monitoring data shows plume movement around recovery wells	1	Capture zone not wide enough

* (Re: Section 3.1.1, Objectives of System Evaluation)

the well field. With this extensive flexibility, it is expected that the chief method of system fine tuning or modification will be through the changing of pumping rates.

Groundwater hydraulics data analysis will provide the primary source of information for control of the system. As discussed above, the groundwater model will be an important tool for establishing criteria. After the model validation and recalibration is completed, the model will be more accurate and can be used as a method of developing criteria. Model refinement will be supported by the collection of new monitoring data.

The chief issue facing hydraulic control of the system are effects caused by temporal variation of recharge and variation in stream stage. Generally these effects are seasonal, but they could occur over longer time cycles (wet or dry years). The model will be used to simulate possible transient effects caused by a decrease or increase in recharge or effects caused by the changes in Paddys Run flow and elevation. Pumping at different rates for different values of rainfall and stream stage will be simulated to determine drawdown effects at various locations and to establish sensitivity of these parameters versus pumping. Based on these simulations and the associated monitoring data, the drawdown control criteria will be established.

It is reasonable to assume that the defined control criteria will only operate within a certain range. This range, based on historical monitoring data or system behavior predicted from model simulations, will be established for recovery wells and monitoring wells. If appropriate, control charts will be developed for these wells which define these limits. Because the plume may change with time and plume movement is, to a large degree, determined by groundwater hydraulics, this criteria will need to be periodically reviewed.

3.2.3 Chemical System Response Criteria

Chemical system response criteria will be established as part of the first system evaluation report. Subsequent system evaluation reports may modify these criteria based on subsequent monitoring and analysis.

Uranium and PRRS data analysis will also provide data for control of the system. Unlike hydraulic control described above, it is more difficult to establish specific finding-response criteria for chemical system control. These difficulties exist because of precision problems in groundwater sampling, varying contaminant source or plume concentrations, complicated chemical interactions between liquid and solid media, and other heterogeneous effects associated with contaminant transport. The contaminant transport system has more difficulties in reaching equilibrium than the flow system and consequently effects are more difficult to predict. In essence, the groundwater chemical system is more complicated than the hydraulic system.

The primary methods for evaluating the data is by trend analysis for each parameter at each monitoring location and by globally looking at spatial distribution of uranium. Statistical methods (see Section 3.4) will be used to determine whether a particular monitored constituent is increasing, decreasing, or not significantly changing. In certain cases there is a fairly clear interpretation of a particular trend result, while in other situations it is much less clear. For PRRS parameters, an increasing trend in a previously uncontaminated well would strongly suggest northward migration of a PRRS plume. Uranium data is more complicated. If, for example, uranium levels increase in monitoring wells downgradient of the recovery wells, it may or may not be the result of the plume passing the recovery wells. Other interpretations could be precision problems, desorption of uranium, or even a reversal of gradient could cause a more contaminated portion of the plume to move to that well location. For these reasons; it is important to not overreact to findings, but to inspect all of the data and to respond to more general and confirmed trends. Since objectives need to be balanced, there is a real possibility that overreaction could result in creating additional, perhaps more serious, system problems. Thus, a conservative approach to change will be followed.

The collection of monitoring data over time and the groundwater model will be important tools for understanding the chemical system and establishing more rigorous response criteria. Baseline values of constituents will be established with monitoring data and general trends over time will be seen. Once the flow model is validated and recalibrated as described above, particle tracking will be used to determine capture zones at the prescribed pumping rate. In performing the periodic system evaluations, particle tracking may be used to explain findings. The solute transport part of the groundwater model may also be used in response to a particular finding. Over time, a better understanding of system behavior will be developed. As part of the periodic system evaluation report, more quantitative response criteria will be defined as the system is better understood.

3.2.4 Recovery Well Design Criteria

Based on the above discussion, the system evaluation process requires that certain elements be incorporated in the design of the recovery wells. These are:

1) Each recovery well needs instrumentation with the ability to continuously measure drawdown in the well.

2) Each recovery well needs a method of controlling pumping rate within the prescribed range of 400 to 800 gpm (IT 1992).

3) Each recovery well needs instrumentation capable of accurately measuring flowrate on the pump discharge.

4) If consistent with other design elements, each recovery well should have instrumentation with the ability to adjust pumping rate as a function of well drawdown, i.e., with the ability to maintain constant drawdown. Manual procedures to perform this function will be acceptable.

3.3 Data Analysis

An important part of the system evaluation is the analysis of the monitoring data collected in accordance with Section 2. The first system evaluation effort will be more involved with the development of baseline data and the conceptual model. Subsequent evaluations will be simpler and will build on the content of the initial evaluation.

Standard data compilation, tabulation, and analysis techniques will be used. State-of-the-art software packages will be utilized as part of this effort. In addition, it is projected that a GIS system with incorporated data analysis software packages will be the primary system used to allow the rapid development of the many graphs and plots, streamlining the data analysis effort. Since the GIS system contains both database and graphical information, it allows the rapid correlation of related data sets.

The data that will be collected can be divided into three categories for analysis. In the following sections, tasks for these three categories are defined.

3.3.1 Aquifer Hydraulics Data Analysis

Data evaluation tasks that will be performed relating to groundwater hydraulics are described below:

1) Background data from the south plume study area will be reviewed. Baseline hydraulic system parameters including the identification of boundary conditions, recharge, and discharge areas will be determined. Significant pumping in the area will be determined. Conceptual model of groundwater flow based on this data will be developed.

2) Rainfall, stream gaging data, and recovery well pumping data over period of evaluation will be compiled and tabulated. Summary statistics (mean, minimum, maximum, range, standard deviation) on data will be performed. The data over the period of evaluation will be graphed.

3) Groundwater elevation data for each well will be compiled and tabulated. Summary statistics (mean, minimum, maximum, range, standard deviation) on data by well will be performed.

4) Groundwater elevations will be graphed over time to discern trends. Comparison graphical techniques (multiple line, stacked bar) to discern relationships across wells will be used. Rainfall, stream gaging and pumping data will be compared and correlated.

5) Contour plots of 2000 and 3000 series wells groundwater elevations for selected representative time measurement events will be created. Flow pattern changes over time will be evaluated.

6) Three cross sections will be defined for analysis, two parallel to the recovery well line and one perpendicular to the recovery well line. Groundwater pressure distribution will be depicted for each cross section for selected representative time measurement events.

7) Vertical gradients at each well cluster in the program will be assessed. These vertical gradients will be plotted and contoured in plan view to determine spatial distribution and to discern patterns.

8) The above data sets will be correlated by inspection of tables, graphs, and plots to determine possible relationships between parameters.

3.3.2 Uranium Data Analysis

Data evaluation tasks that will be performed relating to the total uranium distribution are described below:

1) Background data from the south plume study area will be reviewed. Uranium plume system including the identification of potential source areas, existing plume concentrations, general flow patterns, uranium transport properties, aquifer properties, and major ion and anion concentrations in groundwater will be reviewed. A conceptual model of uranium contaminant transport based on this data will be developed.

2) Total uranium data for each well will be compiled and tabulated. Summary statistics (mean, minimum, maximum, range, standard deviation) on data for each well will be calculated.

3) Uranium data will be graphed over time to discern trends. Comparison graphical techniques (multiple line, stacked bar) will be used to discern relationships across wells.

4) Contour plots of 2000 and 3000 series wells uranium concentrations for selected representative time measurement events will be developed. Concentration pattern changes over time will be evaluated.

5) Three cross sections for analysis; two parallel to the recovery well line and one perpendicular to the recovery well line will be considered. Uranium concentration distribution will be depicted for each cross section for selected representative time measurement events.

6) Statistics will be performed on the total uranium data to determine if a particular well's concentration is increasing or decreasing over time or if a significant change has occurred.

3.3.3 PRRS Constituent Data Analysis

Data evaluation tasks that will be performed relating to the PRRS constituent distribution are described below:

1) Background data from the south plume study area will be reviewed. Available data on the PRRS plume system including the identification of potential source areas, constituents of concern, and background concentrations in groundwater will be reviewed. A conceptual model of PRRS plumes will be developed based on this data.

2) PRRS indicator inorganic and organic data by well will be compiled and tabulated. Summary statistics (mean, minimum, maximum, range, standard deviation) will be calculated on well data.

3) If appropriate, PRRS indicator data will be graphed over time to discern trends and use comparison graphical techniques (multiple line, stacked bar) to discern relationships across wells.

4) If appropriate, contour plots of 2000 and 3000 series wells PRRS indicator concentrations for selected representative time measurement events will be created. Concentration pattern changes over time will be evaluated.

5) Statistics will be performed on the PRRS indicator data to determine if a particular well's concentration is increasing or decreasing over time or if a significant change has occurred.

3.4 Statistical Analysis

Analytical results obtained from groundwater sampling will be statistically examined as appropriate at selected wells to determine whether there has been a statistically significant change in the concentrations of constituents of concern. Descriptive statistical functions which will be included in these examinations will include the mean, range, standard deviation, variance, maximum, and minimum. Other statistical functions will be applied as necessary. It is expected that the primary statistical analysis will be to determine trends at a particular well or to determine whether a change is significant. In response to particular situations, a concentration versus standard or upgradient to downgradient comparison may be necessary. Several statistical procedures are specified below to allow the flexibility to respond to changes in monitoring conditions. Different databases available at different wells will also affect the selection of statistical methods. The statistical procedures specified here cover several anticipated conditions. However, should these procedures prove inadequate for a currently unforeseen situation, additional statistical procedures may be necessary.

3.4.1 Trend Analysis

Statistical procedures will be used to determine time dependent changes in concentrations at a particular well. Different tests may be used as described below depending on the data sets.

1) Mann-Kendall Test - The Mann-Kendall test is a nonparametric test for trend and can be viewed as a nonparametric test for zero slope of the linear regression of time ordered data versus time. This procedure allows for missing values, data that do not conform to any particular distribution, and use of data reported as trace or less than the detection limits by assigning them a common value that is smaller than the smallest measured value in the data set. This approach can be used because the Mann-Kendall test uses only the relative magnitudes of the data rather than their measured values (Gilbert 1987, p. 217).

2) Sen's Nonparametric Estimator of Slope - Sen's method estimates the true slope (change per unit time) at a sampling station by using a simple nonparametric procedure. This method is not greatly affected by gross data errors or outliers, and it can be computed when data are missing. Sen's estimator is closely related to the Mann-Kendall test. Sen's estimator can be calculated for only one datum in each time period or for multiple observations in one or more time periods Gilbert, 1987, p. 217).

3) Seasonal Kendall Test - The seasonal Kendall test is a generalization of the Mann-kendall test. It was developed for use with 12 seasons (months). The test consists of computing the Mann-Kendall test statistic S and its variance separately for each month with data collected over several years (Gilbert, 1987, p. 225).

3.4.2 Background to Downgradient Well Comparisons

Statistical procedures will be used to compare background to downgradient concentrations. Different tests may be used as described below depending on the percentage of non detections.

1) Cochran's Approximation to Behrens-Fisher Student's t-Test - If 0 to 15 percent of the observations are below the detection limit, Cochran's Approximation to Behrens-Fisher Student's t-Test will be the primary statistical procedure for downgradient to upgradient well data comparisons. An analysis of variance procedure (ANOVA) may be performed in cases where the Student's t-Test proves to be inadequate and also to provide some assurance against false positive or negatives.

2) ANOVA - If 15 to 60 percent of the observations are below the detection limit, then an ANOVA will be the first choice for the determination of statistical significance. A one-way analysis of variance statistical procedures will be used to determine whether differences in mean

concentrations among wells or groups of wells are statistically significant. A one-way parametric analysis of variance procedure will be used for situations where data for a monitoring parameter are available from several wells but only for one time period, or when data which do not exhibit seasonality are available from several wells for several time periods. A one-way nonparametric analysis of variance procedure will be used for interwell comparisons when the data or the residuals from a parametric ANOVA have been found to be significantly different from normal and when a log transformation fails to adequately normalize the data.

3) Test of Proportions - In situations where 60 to 99 percent of the observations are below the detection limit, a test of proportions may be used to compare the background well data with the downgradient well data. A higher proportion of quantitated values in the downgradient wells may indicate the presence of contamination.

3.4.3 Comparisons with Regulatory Standards

Statistical procedures will also be utilized when comparisons are being made between concentrations of monitored constituents in wells and regulation specified concentration limits. The mean well concentration will be compared against the set standards through the construction of a confidence level. These techniques may be useful to determine if the recovery system has met a clean-up standards at some future date.

1) Using the 99th percentile of the t-distribution for the mean concentration, confidence intervals may be constructed with downgradient well data. Once constructed, the interval may be compared with the regulatory-based standard to determine whether the mean concentration significantly exceeds the standard. This statistical procedure will be used for both normal and log-normal data. Log-normal data will be compared to the log-normal of the regulation specified limit. If the well data do not adequately follow the normal distribution even after logarithm transformation, a nonparametric confidence interval will be constructed using a minimum of seven observations in order to obtain a one-sided significance level of 10 percent (confidence of 90 percent). This may require pooling of data from two or more wells or sampling periods.

2) Tolerance Intervals Based on the Normal Distribution - Tolerance intervals may be constructed from data on downgradient wells. The tolerance limit may then be compared with regulatory standards. If the tolerance limit falls above the standard, this would indicate statistically significant evidence of concentrations above the limit. A coverage and a tolerance coefficient of 95 percent will be employed providing at least a 95 percent confidence level.

3.5 Reporting

Because of spatial and temporal variations in the hydrogeologic system that is being analyzed, system evaluation reports will be prepared according to the following schedule:

Time Increment	Frequency
1st year	Quarterly
Subsequent years	Semi-annually

This schedule does not completely coincide with the monitoring schedule. Certain system evaluations will cover more than a single monitoring data set and will analyze available data sets at the time of evaluation.

Each periodic evaluation will be built on data gathered during the previous evaluation cycle; therefore, subsequent evaluations will include the previous and current evaluation periods data. The initial evaluation will also include baseline data prior to pumping. The system evaluation can be divided into groundwater hydraulics and chemistry parts as described below.

A system evaluation report will be prepared containing the described analysis, conclusions, and recommendations. Table 3-2 shows a sample outline for this report. The system evaluation report may recommend minor pumping rate changes to accommodate seasonal variation or other temporal factors without triggering the more formal system modification process described below. This report will be submitted to United States Environmental Protection Agency (US EPA) and Ohio EPA for information purposes.

Conclusions and recommendations to this system evaluation may state that:

1) The system is not meeting its objectives and a system modification report needs to be conducted.

2) Interim measures should be undertaken to expeditiously solve a serious problem. A subsequent system evaluation report will be submitted.

3) Operation parameters require adjustment for seasonal or temporal affects and a system modification report is not needed.

4) Operation parameters require adjustment for system optimization or efficiency reasons. The system evaluation may either specify the change or recommend a system modification report depending on the complexity of the proposed change.

5) The monitoring program needs to be changed to determine if objectives are met. The evaluation may recommend the specific monitoring program changes (frequency, locations, parameters, etc.) that need to be made.

6) The system is functioning in accordance with its objectives and recommend that no changes be made. Another system evaluation will be performed according to the schedule.

7) The system has met its objective. The evaluation may recommend ceasing operation of the system and continuation of monitoring for a specified period as a confirmation.

As stated above, response criteria will be established as part of the first system evaluation report. Subsequent system evaluation reports may modify this criteria based on subsequent monitoring and analysis.

Table 3-2 - Outline of System Evaluation Report

I. Introduction

II. Baseline Data

A. Hydraulic System
1. Background Review
2. Conceptual Model

B. Uranium Chemistry System
1. Background Review
2. Conceptual Model

C. PRRS Constituent System
1. Background Review
2. Conceptual Model

III. Current Monitoring Period Results

A. Groundwater Elevation Data
1. Tabulated Summary
2. Space Relationships
3. Time Relationships
4. Statistics

B. Rainfall, Stream Gaging and Recovery Well Pumping Data
1. Tabulated Summary
2. Space Relationships
3. Time Relationships
4. Statistics

C. Uranium Data
1. Tabulated Summary
2. Space Relationships
3. Time Relationships
4. Statistics

Table 3-2 - Outline of System Evaluation Report (Continued)

D. PRRS Inorganic and Organic Data
   1. Tabulated Summary
   2. Space Relationships
   3. Time Relationships
   4. Statistics

E. Cross Correlation of Data Sets
   1. Space Relationships
   2. Time Relationships
   3. Statistics

IV. Development of Evaluation Criteria

A. Modeling Of Recharge and Stream Stage

B. Definition of Future Operating Criteria

V. Conclusions and Recommendations

A. Summary of Findings

B. Conclusions

C. Recommendations

SECTION 4

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