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SOUTHFIELD PUMPING TEST - (PSP FOR SOUTHFIELD PUMPING TEST REV. 0 - JANUARY 1995)

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Department of Energy
Fernald Environmental Management Project
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JAN 12 1995

DOE-0409-95

Mr. James A. Saric, Remedial Project Director
U.S. Environmental Protection Agency
Region V - 5HRE-8J
77 W. Jackson Boulevard
Chicago, Illinois 60604-3590

Mr. Tom Schneider, Project Manager
Ohio Environmental Protection Agency
401 East 5th Street
Dayton, Ohio 45402-2911

Dear Mr. Saric and Mr. Schneider:

SOUTHFIELD PUMPING TEST

The Department of Energy, Fernald Area Office (DOE-FN) will conduct a pumping test in the Great Miami Aquifer beneath the Southfield Area of the Fernald Environmental Management Project (FEMP). Enclosed for review is a work plan that describes the location and test methodology. Data collected as a result of the test will be used to refine hydraulic input parameters to the groundwater flow models utilized for design of the Great Miami Aquifer remediation system.

If you or your staff have any questions or concerns regarding this document, please contact Kathi Nickel at (513) 648-3166.

Sincerely,

Johnny Reising
for Jack R. Craig
Fernald Remedial Action
Project Manager

FN:Nickel

Enclosure: As Stated

Recycled and Recyclable

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RESTORATION MANAGEMENT CORPORATION

CERCLA/RCRA UNIT 5 (CRU5)

PROJECT SPECIFIC PLAN FOR SOUTHFIELD PUMPING TEST REVISION 0 JANUARY 1995

Table of Contents

1. INTRODUCTION

This work plan provides guidance for conducting a multiple-well pumping test in the South Field of the FEMP, hereinafter referred to as the South Field Pumping Test (Figure 1). Data collected from the pumping test will be used to check the accuracy of hydraulic parameters being used for the initial design of the Great Miami Aquifer (GMA) groundwater extraction remediation system, documented in the OU5 Feasibility Study (FS) Report.

Specifically, drawdown data collected from the pumping test will be used to calculate hydraulic parameters that effect remediation operations. The calculated hydraulic parameters will be compared to modeled values of hydraulic parameters to assess the adequacy of the model and the extraction system design.

A system of pumping wells has been proposed in the OU5 FS Report for cleanup of the GMA (Figure 2). The design of this pumping system is based heavily upon modeling predictions made using a SWIFT flow and transport model (DOE 1994a). Hydraulic conductivity is zoned in this groundwater model to match existing pumping test data (Figure 1). Modeled hydraulic conductivity ranges from 270 ft/day to 638 ft/day. Pumping tests have been performed in 3 of the 4 most important hydraulic conductivity zones. The model zone that is lacking a pumping test contains the South Field area where most of the extraction wells are needed for cleanup (Figure 2). Hydraulic conductivity for this zone is currently modeled at 638 ft/day. The pumping test will provide hydraulic data which can be used to assess whether or not the operational range of the model is adequate.

Data collected from the pumping test will be used to calculate and/or assess hydraulic conductivity, storage, and anisotropy. Decisions which will be enhanced the collection of this data include: placement of the individual wells within the extraction system; the depth of pumping; the length of the screens in the pumping wells; the number of pumping wells needed to achieve cleanup goals; and the pumping rate of each individual well.

2.0 MANAGEMENT AND RESPONSIBILITIES FOR THE PUMPING TEST

Project lead is responsible for:

- The safe and prompt completion of project activities.
- Designing the test, locating wells, and allocating responsibilities so that project objectives are met.
- Assuring that data is collected and analyzed properly.
- Completing a pumping test report that details testing activities and presents results.
- Determining the step test and constant rate test pumping rates.
- Establishing facility ownership of any newly installed

wells for maintenance purposes.
- Coordinating the collection of data from the FEMP weather station.

Project engineer is responsible for:
- Procuring needed materials and funding for the testing program.

Driller is responsible for:
- On-site operations of each drilling rig.

Geologist in charge is responsible for:
- Documenting the geology of each boring.
- Being present whenever a borehole is being advanced and during well development activities.
- Generating subsurface logs for each boring, for complete and accurate generation of a daily log of project activities, and for preparing lithologic logs in the field.
- Documenting lithology and depositional features of rotosonic cores.
- Photographing of rotosonic cores.
- Sampling of rotosonic cores.
- Handling and storage of rotosonic cores.

Hydrogeologist in charge is responsible for:
- On-site coordination of the pumping test, including instrumentation set up in the field and data collection.
- Documenting the test setup including preparation of a diagram of equipment used in the pumping test (dimensions, depth of water intakes, locations of gauges, etc.).
- Determining that all test equipment is in proper working order before the start of the test.
- Securing all field instrumentation after completion of the pumping test.

3.0 BACKGROUND

3.1 Geology of the Test Area

The South Field testing area is situated over the New Haven Trough, a large buried valley whose axis roughly extends in a northeast - southwest orientation (Figures 3 & 4). The New Haven Trough is bounded by Ordovician age shale and limestone bedrock along the floor and walls. At the testing location the depth to bedrock is approximately 155 feet below the ground surface (bgs). The New Haven Trough was carved into the shale bedrock during the Pleistocene and subsequently filled with sand and gravel in what was most probably a braided stream environment. Glaciation during Wisconsin time deposited a layer of clay rich till over the sand

and gravel outwash deposits. At the test location the sand and gravel, which comprises the matrix of the Great Miami Aquifer (GMA), is approximately 150 feet thick. The GMA is an unconfined, anisotropic, heterogeneous aquifer which has been designated as a sole-source aquifer for this region.

A semiconfining clay layer (known as the blue clay) divides the aquifer into an upper and lower zone. The blue clay is not present at the test location but it is present approximately 1200 feet to the north of the test location (Figure 5). The closest wells to the test location, that extend down to bedrock are 4014 and 4398. Correlation between these two wells indicates that the test area should consist of, in descending order: 5 to 7 feet of brown clay, 5 to 10 feet of gray clay, 10 to 20 feet of unsaturated sand and gravel, and approximately 135 feet of saturated sand and gravel; total depth to bedrock ranging from 155 feet to 172 feet. Pumping from the test well should not encounter any boundary effects from the walls of the New Haven Trough located thousands of feet to the north and south.

There are no surface water bodies present in the immediate area of the pumping test. One intermittently flowing stream (Paddy's Run) is present approximately 1000 feet west of the test area. The Storm Sewer Outfall Ditch is located approximately 400 feet north of the test site. Sections of both of these surface features are in direct physical contact with sand and gravel in the GMA and represent recharge zones to the aquifer. Monitoring of precipitation, GMA water levels, and flow in these surface features will be conducted to support the pumping test.

3.2 Hydrology of the Test Area

The GMA is a textbook example of a glacio-fluvial buried valley aquifer. Since 1948, 11 pumping tests have been conducted near the FEMP for the purpose of determining horizontal hydraulic conductivity (K_h) within the GMA. Table 1 shows values of K_h calculated from these 11 tests. The average K_h is 386 ft/day with a minimum of 120 ft/day and a maximum of 774 ft/day.

This range of K_h probably reflects textural changes which resulted from depositional conditions. The sand and gravel of the GMA were deposited in a braided stream environment. The criss-crossing of channels and changing depositional energies created permeability trends that may be responsible for the range of K_h (Figure 6). A ratio of vertical to horizontal hydraulic conductivity of .05 to .19 was calculated from the pumping test performed for the South Plume Removal Action (DOE 1993). The coefficient of storage for the GMA has been estimated to be 0.2 (Spieker, 1962) and transmissivity has been estimated to be approximately 300,000 gpd/ft (Spieker and Norris 1962).

Approximately three years of water elevation data exists for the test area. Data collected in 1993 reveals that flow is either to the east or southeast. The water table under the test area dips to the east in January and April (when water levels are high) and to the southeast in July and October (when water levels are low). Water table maps are provided in Attachment A. Data collected from wells 2387, 3387, 2049, 3049, and 2390, and 3390 (Figure 7) indicate that seasonally the water table rises and falls approximately 7 feet; from a low of approx. 518 feet amsl to 525 feet amsl. Hydrographs are provided in Attachment A.

A pumping test in the GMA was conducted at one of the Albright and Wilson alternate supply wells in the Fall of 1991. The well is located approximately 5940 feet west of the South Field pumping test area. The step test consisted of three steps, each lasting approximately 111.5 minutes. Discharge rates for each step were 130 gpm, 205 gpm, and 375 gpm (DOE 1992). A constant rate test was conducted for 72 hours at a flow rate of 380 gpm. Drawdown during the 72 hour constant rate test, in observation wells located 25 feet from the pumping well, was not large enough to provide for the calculation of aquifer properties. The aquifer was not stressed enough, indicating that much higher pumping rates are required if GMA aquifer properties are to be calculated in this area.

In the spring of 1993, a pumping test was performed on one of the South Plume Removal Action wells. The well is located approximately 2400 feet to the south of the South Field pumping test area. The test consisted of six steps, each lasting approximately 100 minutes. Discharge rates for each step were 200 gpm, 275 gpm, 350 gpm, 425 gpm, 575 gpm, and 750 gpm (DOE, 1993). A constant rate test was conducted for seven days at a flow rate of 425 gpm. Drawdown of approximately 1 foot was recorded in observation wells located approximately 200 feet away.

Gamma logs collected from the pumping wells of the two sites record that the South Plume area contains more gamma-bearing sediments than the alternate water supply well area. Higher gamma readings indicates that the sand and gravel of the GMA contain a higher percentage of silt and clay. A change in silt and clay content between the two areas was not recorded in visual descriptions of the sediment which were collected when the wells were drilled.

The Albright and Wilson alternate water supply wells are located in the center of the New Haven Trough over one of the deepest areas. The South Plume Removal Action wells are located towards the edge of the New Haven Trough across the mouth of a smaller channel that runs south, out of the New Haven Trough (the Paddys Run Outlet) (Figure 4). Paddys Run Outlet is a minor buried valley that connects to the New Haven Trough, which is a major buried valley.

It appears that the sand and gravel in the center of the New Haven Trough contain a smaller percentage of clay than the sand and gravel located along the edge of the New Haven Trough. A smaller percentage of clay would provide for larger values of hydraulic conductivity. A pumping well in the South Field pumping test area should be able to sustain a greater discharge rate than a pumping well in the South Plume Removal Action area.

Given what is known about the South Field pumping test area, pumping in the area should create a broad flat cone of depression. Effects due to physical hydraulic boundaries are not expected. Information collected from two previous pump tests indicates that in order to calculate aquifer properties, the aquifer will need to be pumped for at least 72 hours at a rate much greater than 380 gpm. The step test will need to go up to at least 750 gpm. The step test for the South Field, outlined in this plan in Section 6, will range from approximately 300 to 1200 gpm. The screen should be approximately 40 feet long, and situated approximately 5 feet beneath the lowest recorded water level, as outlined in Section 5.1.

3.2 Water Quality of the Test Area

Water quality within the test area has been characterized in detail in the OU5 RI Report. The contaminant of concern for the area is uranium. Unfiltered samples collected from Type 2 wells in 1993 indicate that total uranium concentrations in the area range from 111 ppb to 329 ppb (DOE, 1994b, Plate E-77). Maximum concentrations ever recorded from the water table zone for the area range from 163 ppb to 492 ppb (DOE, 1994b, Plate E-81). Unfiltered samples collected from Type 3 wells (approximately 50 to 60 feet beneath the water table) indicate that total uranium concentrations range from 3.4 to 110 ppb (DOE 1994b, Plate E-78). The 110 ppb concentration is not validated. Maximum validated concentrations for total uranium ever recorded from this depth range from 3.4 ppb to 81.7 ppb (DOE 1994b, Plate E-82). Data is tabulated in Attachment B.

4.0 Procedures

All pumping test activities will be performed in accordance with requirements contained in the Fernald Environmental Management Project, Sitewide CERCLA Quality Assurance Project Plan (SCQ) (WEMCO 1992). Table 2 lists the guidelines which will be followed for well drilling, installation activities, and testing of any collected samples. Table 3 lists the guidelines that will be followed for conducting the pumping test.

Drilling using a rotosonic drilling method creates the need to supplement existing SCQ requirements for the purpose of dealing with the resulting rotosonic cuttings. In this work plan these cuttings will be referred to as a core. The following additional activities will need to be conducted for the cores:

- Field documentation and photographing of the rotosonic cores
- Field screening of the rotosonic cores for radioactive contamination
- Sampling of rotosonic cores
- Field storage and shipment of the rotosonic cores
- Final storage of rotosonic cores

Additional guidelines for these activities are provided in Section 5.2

5.0 DESIGN AND INSTALLATION OF WELLS

5.1 Well Placement and Design

The observation wells will be oriented parallel to the axis of the New Haven Trough (roughly 30 degrees north of east) and perpendicular to the axis of the trough (roughly 30 degrees west of north). The testing network will consist of one pumping well and six observation wells. Four of the observation wells will be situated parallel to the axis of the trough and 2 of the observation wells will be situated perpendicular to the axis of the trough. This placement will provide data on the anisotropic character of the aquifer.

Anisotropy is a common feature in water-laid sediment (i.e., glacial outwash deposits). Aquifers that are anisotropic on both the horizontal and vertical planes are said to exhibit three-dimensional anisotropy, with principal axes of hydraulic conductivity in the vertical direction, the horizontal direction parallel to stream flows that prevailed in the past, and the horizontal direction at a right angle to those flows (Kruseman & de Ridder 1989).

The pumping well is referred to in this plan as the "control well". The control well will be constructed of 12 inch ID stainless steel. A 2-inch stilling pipe located inside of the screen and a 2-inch PVC well located outside of the screen, but within the borehole will be used to assess well efficiency. The 2-inch stilling pipe inside of the screen will have a 5-foot screen and will be used to collect water level measurements. The top of the screen will be located at the an elevation that corresponds to 10 feet above the base of the screen in the control well. The 2-inch PVC well located outside of the screen but within the borehole, will have a 5-foot screen to measure water levels; see Table 4. The top of the screen will be located at an elevation that corresponds to 10 feet above the base of the screen in the control well.

The control well will be screened across a 40-foot interval, with the top of the screen located 5 feet below the lowest recorded seasonal water level for the area. The lowest seasonal water level is 518 feet amsl. Screen type and slot size for the control well will be selected based upon the results of sieve analyses. It is anticipated something close to a stainless steel, 0.020 to 0.060-inch slot range, continuous wire wrapped screen will be selected. The total depth of the control well will be approximately 77 feet.

The observation wells will be constructed of 2-inch ID PVC. The observation wells will be located 25 feet, 50 feet, and 100 feet away from the control well as outlined in Figure 8. The observation wells will be screened across a 5-foot interval, with the base of the screens coinciding with the mid-point of the length of the screen in the control well (Kruseman & de Ridder 1989). Screen type and slot size for the observational wells will be selected based upon the results of sieve analyses. It is anticipated something close to a 0.020-inch slot PVC screen will be selected. The total depth of the observation wells will be approximately 57 feet.

All wells will be completed using a natural filterpack. GMA sediment will be allowed to collapse around the well screen. This may change pending the results of sieve analyses. A filter pack may be used if the small slot size dictated by natural development limits the transmitting capacity of the screen so that the desired yield cannot be obtained.

Groundwater modeling is being conducted to optimize the design of the pumping test. Well spacing and screening depths outlined in this Work Plan could be revised based on the outcome of the modeling. If changes are indicated, a change to the Work Plan will be implemented. Modeling results will be reported in the Pumping Test Report referred to in Section 8 of this Work Plan.

5.2 Well Installation

All borings (control and observation wells) will be drilled using a rotosonic drilling rig. A continuous rotosonic core will be collected from four borings (control well and the three observation wells located farthest away from the control well) down to bedrock (approximately 155 to 172 feet). A continuous rotosonic core will be collected from the other three observation wells down to a depth of approximately 90 feet. The casing from the rotosonic rig, in the holes cored to bedrock, will be pulled up as a mixture of sand and bentonite is tremied into the collapsing hole. The injecting of bentonite is an added precaution to assure that no open hole is left under the depth of the screen should the formation beneath the that no open hole is left under the depth of the screen should the formation beneath the screen not collapse completely upon withdraw of the casing.

The control well will be installed in two steps because the rotosonic drilling rig cannot cut an 18 inch diameter hole. The control well will first be cored to bedrock using a 6 to 8 inch rotosonic drilling tool. The casing from the rotosonic will be pulled back to a depth of approximately 90 feet below the ground surface while a mixture of sand and bentonite is tremied into the collapsing hole. The rotosonic casing will then be pulled up the last 90 feet and the formation will be allowed to collapse back into the hole. The boring will then be redrilled to a depth of approximately 90 feet using either a cable tool or air rotary rig creating a hole with an 18-inch ID to accommodate both a 12-inch internal diameter (ID) casing and a 2-PVC piezometer outside of the casing but within the boring.

The rotosonic drilling method was chosen for sample collection because it provides a continuous sample or core very efficiently. Such a sample is necessary to detect and document depositional features such as cross bedding, fining up and down sequences, etc. An understanding of the depositional features will aid in optimizing the cleanup of the GMA.

The drilling program will consist of the following:

- A continuous rotosonic core will be collected from each boring to a depth of approximately 90 feet. Four of the borings will have cores collected down to bedrock (approx. 155 - 172 feet).

- The rotosonic core will be described in the field by a geologist (Munsell color, USCS Soil Classification, textural description, and depositional features) before any extraction of samples. A soil classification log will be completed that will also record depositional features such as cross bedding, fining up and down sequences. The entire core will be photographed.

- Water samples will be collected from each well every 10 feet (beginning at the water table, approximately 20 to 37 feet bgs) for total uranium analysis to the proposed screen depth (approximately 11 samples per well, 77 samples total) using a packer tool designed to work within the rotosonic drilling bit. Water samples will be collected every 15 feet below the proposed screen depth in the holes that are cored to bedrock. Samples will be used to construct a uranium contamination profile of the pumping test area and to match with sediment sampling to calculate the soil to water partition coefficient (K_d).

- Sediment samples will be extracted from the core every 10 feet (beginning at the water table, approximately 20 to 37 feet bgs) and every 10 feet across the proposed screen depth, to correspond to the depth of the water sampling (approx. 11 samples per well, 77 samples total). Sediment samples will be collected every 15 feet below the proposed screen depth in the holes that are cored to bedrock. The sediment samples will be tested for uranium. Uranium concentrations in sediment will be compared to uranium concentrations in groundwater to calculate a K_d.

- Sediment samples will be extracted from the core (every 15 feet) and submitted to a lab for sieve analysis (ASTM D 422) for grain-size determination and USCS soil classification (approximately 10 to 11 samples per well, 70 to 77 samples total).

- Sediment samples will be extracted from the core (every 5 feet) across the intended screen interval for the purpose of determining screen size and filter pack material (approx 14 samples).

- The remaining core will be saved and archived for future use.

5.3 Well Development

Surging techniques (surge blocks) and pumping will be used to develop the wells. Fines will be removed from the borehole as often as possible (Driscoll 1986). Development will continue until the turbidity of the water is clear, the nephelometric turbidity unit (NTU) reading has stabilized to five NTU or less, and pH, specific conductivity, temperature, and dissolved oxygen readings have stabilized. This development method is subject to change pending results of the sieve analysis. If a large amount of fines are present in the area, an alternate development method may be preferred. Surging techniques are recommended in the FEMP SCQ for high yield aquifers such as the GMA.

6.0 TESTING PROGRAM

A five step testing program will be conducted:

1) Pre-test monitoring
2) A 12 hour step drawdown test (SDT)
3) SDT recovery monitoring
4) A 72 hour constant rate pumping test (CRT), (longer if delayed yield appears to be a factor)
5) CRT recovery monitoring

The following measurements will be taken in support of the pumping test:

- Water levels in the Great Miami Aquifer (feet)
- Discharge rate from the control well (gpm)
- Atmospheric pressure (lbs of mercury)
- Precipitation (inches)
- Temperature (degrees celsius)
- Water levels in Paddys Run and the SSOD (feet)
- Water quality (dissolved oxygen, pH, temperature, uranium) of discharge Water

6.1 Test Equipment

The following equipment will be required to conduct the testing program:

<u>For the pumping system</u>

- A submersible or vertical shaft turbine pump that can be accommodated by the control well with a check valve to prevent water from siphoning back into the well. The pump must be capable of operating accurately between 300 gpm and 1200 gpm against the static and friction head necessary to pump the water to the Great Miami River.

- A power source sufficient to operate the pump (including fuel), and capable of continuous operation for as long as 8 days, with a backup. If an internal-combustion engine is used, it shall be equipped with a tachometer.

- Piping and necessary fittings from the pump to the South Plume recovery system force main with a minimum capacity of 1200 gpm.

- Power source for ancillary field equipment (including lighting system for night work).

- A primary and backup gate valve to control discharge from the test well.

- A digital flow meter and totalizer to measure flow in gpm and total discharge in gallons.

- An analog flow meter and totalizer to measure flow in gpm and total discharge in gallons.

- A sampling port on the flow line for the collection of groundwater samples.

- A lighting system for night work.

To measure flow rates

- A stop watch.
- A field notebook and flow rate recording forms.

To measure GMA water levels

- 10 transducers, 8 to be used to monitor immediate pumping test area (control well, one in and one outside of screen) and 6 observation wells), 2 to be used to monitor background wells.
- 2 eight-channel data logger systems to record pressure readings from transducers in the immediate pumping test area. One will serve as a backup.
- 3 one-channel data logger systems to record pressure readings from transducers in background wells. One will serve as a backup.
- 2 one channel data logger systems to record pressure readings from transducers in the immediate pumping test area. One will serve as a backup.
- 12 electric water level measuring tapes.
- Distilled water and towels for decontaminating probes and tapes.
- Field notebook and water level recording forms.

To collect GMA groundwater samples

- Sample bottles and shipping containers.
- Turbidity meter.
- pH, specific conductance, temperature, and dissolved oxygen probes and meters.

To monitor surface water/aquifer interactions

- Two transducers.
- Two single channel data loggers.
- Two float-type automatic water level chart recorders.

Misc.

- 4 flashlights.
- Indelible pens and/or pencils.
- Health and safety equipment and clothing.
- Portable lap top computer, equipped with Lotus 123 and Wordperfect.
- Semilog and log-log graph paper for plotting drawdown data.
- Portable phones.
- Extra batteries for water level probes and flashlights.

6.2 Equipment Shakedown

To minimize unforeseen problems, all equipment will be subjected to a performance shakedown 2 days before being used. Power supplies, the pump, flow lines and discharge collection systems, valves, gauges, meters, lighting, recorders, data loggers, and any other equipment subject to mechanical, structural, and/or electrical failure will be inspected and field tested before start up of the pumping test. The shakedown test will include a practice run that replicates the first step of the step drawdown test and a demonstration of the 1200 gpm pumping rate. Records of the shakedown will be maintained by the operator(s).

6.3 Management of Pumped Groundwater

All pumped groundwater from both the step test and the constant rate test will be sent to the force main which runs through the storm water retention basin valve house, the parshall flume and ultimately to the Great Miami River. The concentration of uranium discharge to the river will not exceed allowable levels.

If all seven steps of the step test are conducted as planned (range of 300 gpm to 1200 gpm), 525,000 gallons of discharge water will be produced. The amount of water produced by the constant rate pumping test will vary depending upon the pumping rate and the duration of the pumping. Assuming a pumping rate of approximately 600 gpm, a 3-day test would produce 2,592,000 gallons of water. A 7-day test would produce 6,048,000 gallons of water.

Monitoring
Pumped groundwater will be sampled for total suspended solids and dissolved oxygen. A water sample will be collected to measure total suspended solids during the first step of the step test, and

during the last 100 minutes of the constant rate test.

A dissolved oxygen reading will be taken from the pumped groundwater once during each step of the step test, and every 12 hours during the constant rate test.

6.4 Pretest Monitoring

Pretest monitoring will be conducted to assess local water level trends, recharge patterns, and the barometric efficiency of the control and the observation wells. Results of the monitoring will be used to adjust drawdown measurements recorded during the pumping tests, if deemed appropriate.

- Local water level trends: The pumping test is scheduled for the winter-spring time frame when water levels should be at a seasonal high (approximately 525 feet amsl). Water levels will be measured once a day for a minimum period of one month immediately before the start of the testing program to determine how water levels are trending, and predict how the trend will continue through the pumping test. Water levels will be collected from the following existing monitoring wells (2386, 2387, 2049, 2390, 2015, 2434, 2166, 2398, 2399, 2044, 2070) at least daily.

  Monitoring Well 2044 is located approximately 2500 feet northwest of the pumping test area and Monitoring Well 2070 is located approximately 1,500 feet southeast of the pumping test area. Water levels in both of these wells should not be effected by the pumping test, and will serve as background wells when the test is conducted. The rest of the wells circle the pumping test area, approximately 500 feet to 1000 feet away from the control well. Water levels in these wells may be effected by the pumping test. Monitoring of these wells will also continue throughout the testing program, including the recovery period.

- Recharge patterns: The test area is located just south of the storm sewer outfall ditch and east of Paddys Run. The beds of both of these surface drainage features lie directly upon the GMA in certain areas, making these locations recharge areas to the aquifer. If a precipitation event occurs during the testing period, recharge could cause water levels in the area of the pumping test to rise. Any rise in water level, due to recharge, will affect aquifer parameter calculations. Such rises need to be accounted for in the calculations.

  A piezometer cluster will be installed using either a hand auger or small boring tool into the beds of both the storm sewer outfall ditch and Paddys Run to monitor both the water table of the GMA directly below the drainage feature, and water levels in the drainage features should a precipitation event occur.

Each cluster will consist of two wells. A 2-inch PVC well with a 15-foot screen set in the water table of the GMA and a 4-inch stilling well. The base of the screen in the GMA will be located 10 feet below the water table. The elevation of the water table will be monitored using a pressure transducer and a data logger. The 4-inch PVC stilling well will be equipped with a continuous float recorder to measure flow levels if flow occurs.

The continuous float recorder will provide continuous measurements of water levels should flow occur. The transducer located in the GMA beneath the stilling well will be set to take pressure readings every 1/2 hour. A survey of the cross section of each stream ditch, at the location of the float recorder, will be made.

- Barometric efficiencies: The barometric efficiency of the control well and each observation well completed will be determined.

  Changes in atmospheric pressure produce fluctuations in wells in confined aquifers. The water level in a well in a confined aquifer is in contact with the atmosphere. The water level represents a balance between hydrostatic pressure in the aquifer and barometric pressure in the atmosphere. Water levels will fall as barometric pressures rise. Generally barometric efficiency is not noticeable in unconfined aquifers. In water table aquifers, changes in barometric pressure tend to be transmitted equally to the water table in both the aquifer and in the well.

  The barometric efficiency of the control well and the observation wells, in the immediate area of the pumping test, will be determined. Water level, atmospheric pressure, and temperature measurements will be recorded every hour for a minimum period of 48 hours to determine the barometric efficiency.

- Weather data: The FEMP weather station will be used for the collection of precipitation, barometric pressure, and temperature data. Hourly measurements will be provided throughout the testing program, including recovery periods, and for the purpose of determining barometric efficiencies noted above.

6.5 Step Drawdown Test (SDT)

A step drawdown test will be conducted for the purpose of determining a fixed rate for the constant rate test (CRT). Data collected from the South plume pumping test and the installation of the Albright and Wilson alternate water supply well has been used to help determine the pumping range and number of steps in the test. This discussion is presented in the hydrology section of this work plan.

The step drawdown test will begin with a pumping rate of 300 gpm. Each step will be conducted for approximately 100 minutes. Pumping will be increased by 150 gpm each step of the test. Seven steps will be planned, resulting in a pumping rate that ranges up to 1200 gpm. If all seven steps are conducted as planned the test will produce approximately 525,000 gallons of water and last approximately 12 hours.

Monitoring:

- Water levels in the control well and the six closest observation wells will be monitored automatically using pressure transducers and data loggers according to the time intervals presented in Table 5. At least one of the six observation wells will be equipped with an independent water level measurement instrument to ensure that early time data (first few minutes) is not lost.

  Water levels in existing monitoring wells 2386, 2387, 2049, 2390, 2015, 2434, 2166, 2398, and 2399 will be measured manually at least once during each step, using an electronic tape, to detect possible drawdown.

- Discharge rate: Will be recorded once every minute for the first 10 minutes of pumping for each step and once every 10 minutes for remainder of the step.

Criteria for Termination of the Step Test:

All seven steps will be conducted unless the "hydrologist in charge" decides that enough data has been collected to determine a constant rate of pumping for the constant rate pumping test. If pumping is disrupted the hydrologist in charge will determine when the test can be resumed. Restart of the test will depend upon the degree of the disruption and how fast water levels recover to pre-pumping conditions.

6.6 SDT Recovery Monitoring

Water levels will continue to be monitored automatically in the control well and six closest observation wells following the step drawdown test until it has been determined that water levels have risen to pretest elevations. The rising of water levels will be recorded in the same sequence as during pumping. Using the data logger system, measurements will be recorded automatically at the intervals shown in Table 5. At least one observation well will be equipped with an independent water level measurement instrument to ensure that early time recovery data is not lost.

Monitoring will continue for approximately 24 hours or until three successive water level measurements at 1-hour intervals show less than a 0.1-foot difference in recovery at the control well.

If drawdown in any of the other wells monitored once during the step test indicate drawdown (2386, 2387, 2049, 2390, 2015, 2434, 2166, 2398, 2399) then recovery will be monitored manually. A measurement will be taken at least every 100 minutes using an electronic tape.

It is anticipated that recovery will occur in approximately 24 hours. The objective of this monitoring is to document that water levels have returned to prestep test elevations before the commencement of the constant rate test.

6.7 Constant Rate Test (CRT)

The flow rate for the constant rate test (CRT) will be determined from results of the step drawdown test. The gate valve will be adjusted two days before the start of the CRT test. The flow rate will be large enough to produce drawdown in the six closest observation wells, but small enough to allow the CRT to run for a maximum of seven days, if needed to reach steady state conditions. Flow will be maintained for a minimum period of 72 hours and until the effects of delayed yield have been assessed; which may require up to seven days of pumping. Discharge will be maintained within + or - 5 percent of the designated rate.

Monitoring:

- Water Levels:

Drawdown in the control well and closest observation wells will be recorded automatically using pressure transducers and data loggers. Water levels in these wells will also be monitored with manual water level indicators at a minimum of once every 100 minutes during the test to assess the accuracy of the automatic system. Data logger measurement frequencies are tabulated in Table 5. The data logger will be downloaded every 24 hours (at a minimum) during the course of the test.

Water levels in existing Monitoring Wells 2386, 2387, 2049, 2390, 2015, 2434, 2166, 2398, and 2399 will be measured manually at least once every 10 minutes for the first 100 minutes of the test and once every 100 minutes for the remainder of the test, using an electronic tape, to detect possible drawdown. If drawdown is detected, the frequency of monitoring will be increased. The hydrologist in charge will decide upon an appropriate increase.

- Discharge Rate:

Discharge will be checked and recorded every minute for the first 10 minutes of pumping, every 10 minutes for the next 100 minutes of pumping, and then every 100 minutes thereafter. Discharge will be adjusted as needed to maintain the desired discharge.

- Criteria for termination of the CRT:

The CRT will, at a minimum, be conducted for 72 hours. The project lead will determine when the test can be terminated after the 72 hour minimum has been reached. Additional pumping may be needed to check for delayed yield effects. The test will not extend past 7 days or 10,000 minutes.

If pumping is disrupted the hydrologist in charge will determine when the test can be resumed. Restart of the test will depend upon the degree of the disruption and how fast water levels recover to prepumping conditions.

6.8 CRT Recovery Monitoring

Water levels will continue to be monitored automatically in the control well and six closest observation wells following the CRT until it has been determined that water levels have risen to pre-test elevations. The rising of water levels will be recorded in the same sequence as during pumping. Using the data logger system, measurements will be recorded automatically at the intervals shown in Table 5. At least one observation well will be equipped with an independent water level measurement instrument to ensure that early time recovery data is not lost.

Monitoring will continue for approximately 24 hours or until three successive water level measurements at one hour intervals show less than 0.1-foot difference in recovery at the control well.

If drawdown in any of the other wells monitored manually during the CRT indicate drawdown (2386, 2387, 2049, 2390, 2015, 2434, 2166, 2398, and 2399), then recovery will be monitored manually. A measurement will be taken at least every 100 minutes using an electronic tape.

It is anticipated that recovery will occur in approximately 24 hours. The objective of this monitoring is to document that water levels have returned to prestep test elevations.

7.0 Decision Points and Contingencies

Pumping test plans need to maintain a small degree of flexibility to address new information learned through the drilling and installation of the test wells. As data is collected during well drilling and well completion (sediment samples and sieve analysis data), decision points will be reached where contingencies may need to be considered. These decision points and possible contingencies are outlined below:

1) Interpretation of rotosonic cores collected from the control well and observation wells can be used to assess how well the test design deals with vertical textural variability caused by depositional features (e.g., cross bedding, fining up or down sequences, etc.).

   Just as horizontal hydraulic conductivity varies spatially in a horizontal plane (see discussion in hydrology section of this work plan) the distribution of hydraulic conductivity could also change with depth. This is expected in a braided stream deposit. Textural pathways could create preferential flow pathways that have relatively higher hydraulic conductivities than the surrounding sand and gravel. Contaminants will move through the pathways of least resistance.

   If drilling reveals that a zone of relative apparent high hydraulic conductivity exists, the position or length of some or all of the screens in the control and observation wells may need to be changed to encounter the zone. The need for additional wells will also be evaluated.

2) Sieve analyses will be used to select the size of the screens in both the control well and observation wells. If the sieve analyses indicate that the small slot size dictated by natural development limits the transmitting capacity of the screen so that the desired yield cannot be obtained, a quartz sand filter pack will need to be evaluated in place of natural filterpack. The completion method may also need to be evaluated and changed. Surging may not be the best method to use if a high percentage of clay is present in the sand and gravel.

8.0 Data Analysis and Reporting

Data collected from the pumping test will be used to calculate and/or assess hydraulic conductivity, storage, and anisotropy.

All water-level data and flow data will be expressed in units of feet and gallons per minute. Drawdown will be corrected for natural recharge, storm-induced recharge, atmospheric pressure, and partial penetration effects before selection and use of an analytical model. The effect that well-bore storage has on early time data will be assessed.

Log-log and semi-log plots of drawdown vs. time will be prepared to aid in the selection of an analytical model and to assess if deviation from theoretical curves has occurred. Theoretical solutions to well-flow problems are usually not unique (Kruseman & de Ridder 1989). Several different solutions may need to be looked at depending upon the results of the test. The rationale used to support the selection of an analytical solution will be documented in a pumping test report.

All measurement data collected and used for the purpose of determining aquifer parameters will be tabulated and presented in a pumping test report. Graphs and tables of data will be used as appropriate to aid in the data reduction process. Printouts of data logger tapes and original field documentation will be maintained in project files according to procedures at the FEMP. The pumping test report will contain background information on the testing activities, a description of the pumping test, and the analysis of the data, including the calculated aquifer parameters.

9.0 Health and Safety

A project specific Health and Safety Plan has been prepared for this project.

10.0 Quality Assurance/Quality Control

All work will be conducted in accordance with the requirements of the overall quality assurance program at the FEMP. Drilling, sampling, well installation, pumping test activities, and laboratory testing shall be assigned the proper quality level. 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 FERMCO 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 FEMP SCQ (WEMCO 1992).

11.0 References

DOE, 1992, South Groundwater Contamination Plume, Removal Action, Part 1, Alternate Water Supply, Installation and Test of a Test Well, Fernald Environmental Management Project, Fernald, Ohio, U.S. Department of Energy, Fernald Office, Cincinnati, Ohio.

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DOE, 1994a, April, 1994, SWIFT Great Miami Aquifer Model, Summary of Improvements Report, Draft Final Revision B, Fernald Environmental Management Project, U.S. Department of Energy, Fernald Office, Cincinnati, Ohio.

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Driscoll, F.G., 1986, Groundwater and Wells, 2nd Edition, Johnsons Division, St. Paul Minnesota.

Kruseman, G.P., de Ridder, N.A., 1989, Analysis and Evaluation of Pumping Test Data, ILRI Publication 47, International Institute for Land Reclamation and Improvement, Wageningen, The Netherlands.

Spieker, A.M., Norris, S.E., 1962, Ground-Water Movement at the AEC Feed Materials Production Center Located Near Fernald, Ohio, U.S. Geological Survey, Columbus, Ohio.

WEMCO, 1992, Fernald Environmental Management Project, Sitewide CERCLA Quality Assurance Project Plan, U. S. Department of Energy, Fernald Office, Cincinnati, Ohio.

Table 1
Hydraulic Conductivity
From Pumping Tests in the Great Miami Aquifer Near the FEMP

Reference	Location	Hydraulic Conductivity[a] (ft/day)	cm/s
Dove, 1961	SOWC Wells/A	375 to 400	1.3×10^{-1} to 1.4×10^{-1}
Smith, 1962	Bolton Wellfield/B	328	1.2×10^{-1}
Klaer, 1948	Bolton Wellfield/B	120	4.2×10^{-2}
Kazmann, 1950	SOWC Wells/A	318 to 369	1.1×10^{-1}
Klaer and Kazmann, 1943	Hamilton South Wellfield/C	313 to 324	1.3×10^{-1}
Speiker and Norris, 1962	FEMP Production Well/D	267	1.1×10^{-1}
Lewis, 1968	SOWC Wells/A	334 to 404	1.2×10^{-1} to 1.4×10^{-1}
Smith, 1960	ChemDyne - Hamilton/E	214 to 412	7.5×10^{-2} to 1.5×10^{-1}
DOE, 1993	Fernald - FEMP Removal Action 3/F	413	1.5×10^{-1}
Smith, 1962	Ross - west bank of Great Miami River/G	534	1.9×10^{-1}
Smith, 1960	New Miami - mouth of Four Mile Creek/H	774	2.7×10^{-1}

[a]Summary statistics:

Minimum K_h	=	120 ft/day	4.2×10^{-2} cm/s
Maximum K_h	=	774 ft/day	2.7×10^{-1} cm/s
Average K_h	=	386 ft/day	1.4×10^{-1} cm/s
Standard deviation	=	164 ft/day	5.8×10^{-2} cm/s

Table 2
SCQ WELL INSTALLATION GUIDELINES
(WEMCO 1992a)

GUIDELINES	REFERENCE
Administrative	
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	
General drilling practices	Section 5.2.1 and Appendix J, Subsection J.4.2
Subsurface soil sampling	Appendix K, Subsection K.5.3
Monitoring well/piezometer design, installation and abandonment	Section 5.2.2, Appendix Subsection J.4.3, *EM-GW-004
Well development	Section 5.2.3 and Appendix J, Subsection J.4.4
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
Sampling of cores	
Documenting cores	
Laboratory Tests	
Grain size analysis	ASTM D 422

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

Table 3
PUMP TEST GUIDELINES

Guidelines	Reference
Administrative	
Chain-of-custody	SCQ, Section 7.1
Corrective action	SCQ, Section 15.2
Daily logs	SCQ, Section 5.1 and Appendix J, Subsection J.4.1
Variances	SCQ, Section 15.4
Field	
Ground water level measurement	SCQ, Appendix K, Subsection K.4.2.1
Aquifer/permeability testing	SCQ, Section 5.2.5 and Appendix J, Subsection J.4.6
Measurement of discharge orifice weir	SCQ, Appendix K
Groundwater sampling	SCQ, Appendix K
Field screening of samples for radioactive contamination	SCQ, Appendix K, Subsection K.5.3.2
Decontamination	SCQ, Appendix K, Subsection K.11
Field storage and shipment of samples	SCQ, Appendix K, Subsection K.10
Field calibration requirements	SCQ, Appendix I
Field analytical methods	SCQ, Appendix K, Subsection K.4.1
temperature	SCQ, Appendix K, Subsection K.4.1.1
pH	SCQ, Appendix K, Subsection K.4.1.2
specific conductance	SCQ, Appendix K, Subsection K.4.1.3
dissolved oxygen	SCQ, Appendix K, Subsection K.4.1.4
Laboratory Tests	
Total uranium	Attachment I, Volume V, Method No. FM-RAD-0120

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

TABLE 4
SPECIFICATION FOR CONTROL WELL

PARAMETER	CRITERIA
Location of Control Well	1,380.721 E, 476,860 N 1927 State Planer Coordinates
Ground Surface Elevation	Approximately 550 feet amsl
Static water level depth (Relative to ground surface)	Between approximately 25-32 feet (525-518 feet amsl)
Anticipated drawdown	4 feet @ 1000 gpm (K_h = 638 ft/day)
Depth to base of well screen	77 feet (473 feet amsl) 40 foot screen, top is 5 feet beneath low water table)
Screen	Stainless steel, 0.020", con't. wire wrapped screen.
Filter Pack	Natural
Boring	18 inch
Casing	12 inch
Pump Inlet Placement	10' from base of screen
Pump Type	Submersible or vertical turbine shaft. Capable of pumping 1,200 gpm against static and friction head necessary to pump the water to the SWRB.
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. 3) Flow Measurement-2 Flow meters on discharge line, one for backup 4) Sampling-Sampling port on discharge line before the first flow meter
Drawdown Measurement	1) 2 inch stilling pipe inside the well 2) 2 inch pvc piezometer in the filter pack
Sump	5 foot below base of screen

Table 5
Groundwater Level Measurement Schedule

TIME SINCE START OF PUMPING	APPROXIMATE TIME INTERVALS
0-20 Seconds	0.5 Seconds
20-60 Seconds	1 Second
1-10 Minutes	12 Seconds
10-100 Minutes	2 Minutes
100-1000 Minutes	20 Minutes
1000 - Completion of Test	200 Minutes

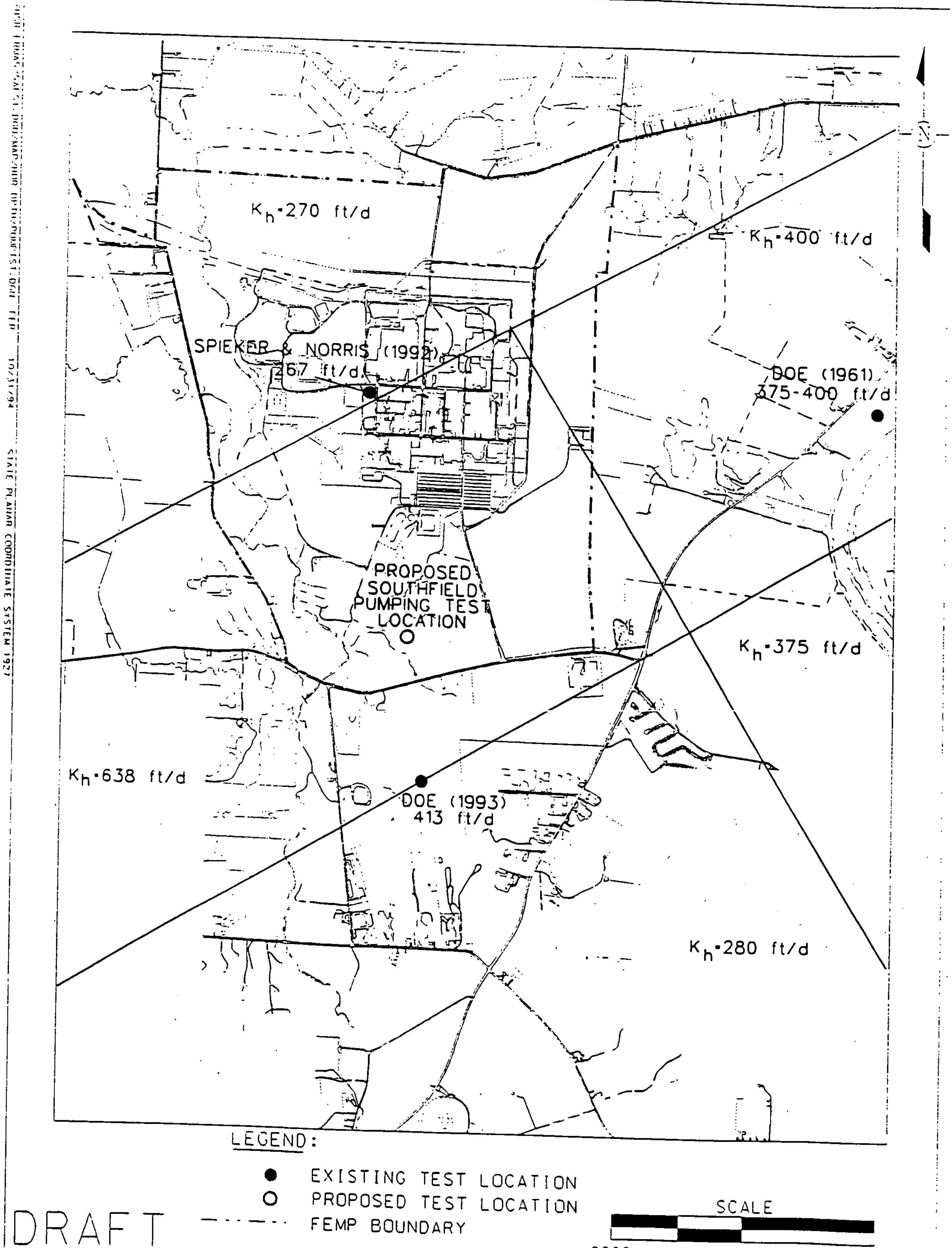
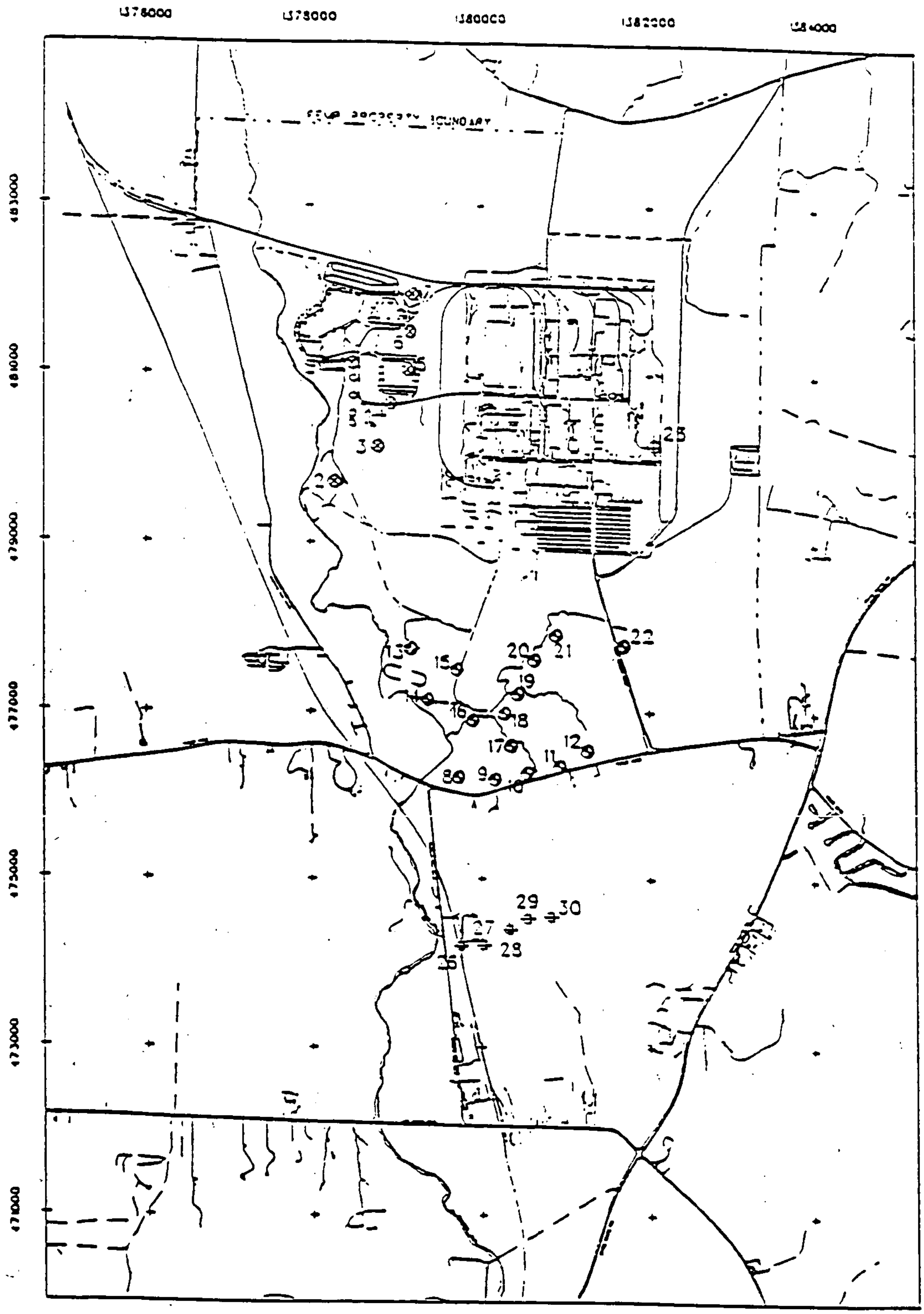


FIGURE 1. LOCATION OF PUMPING TES

ZONATION OF MODELED

PROPOSED EXTRACTION SYSTEM

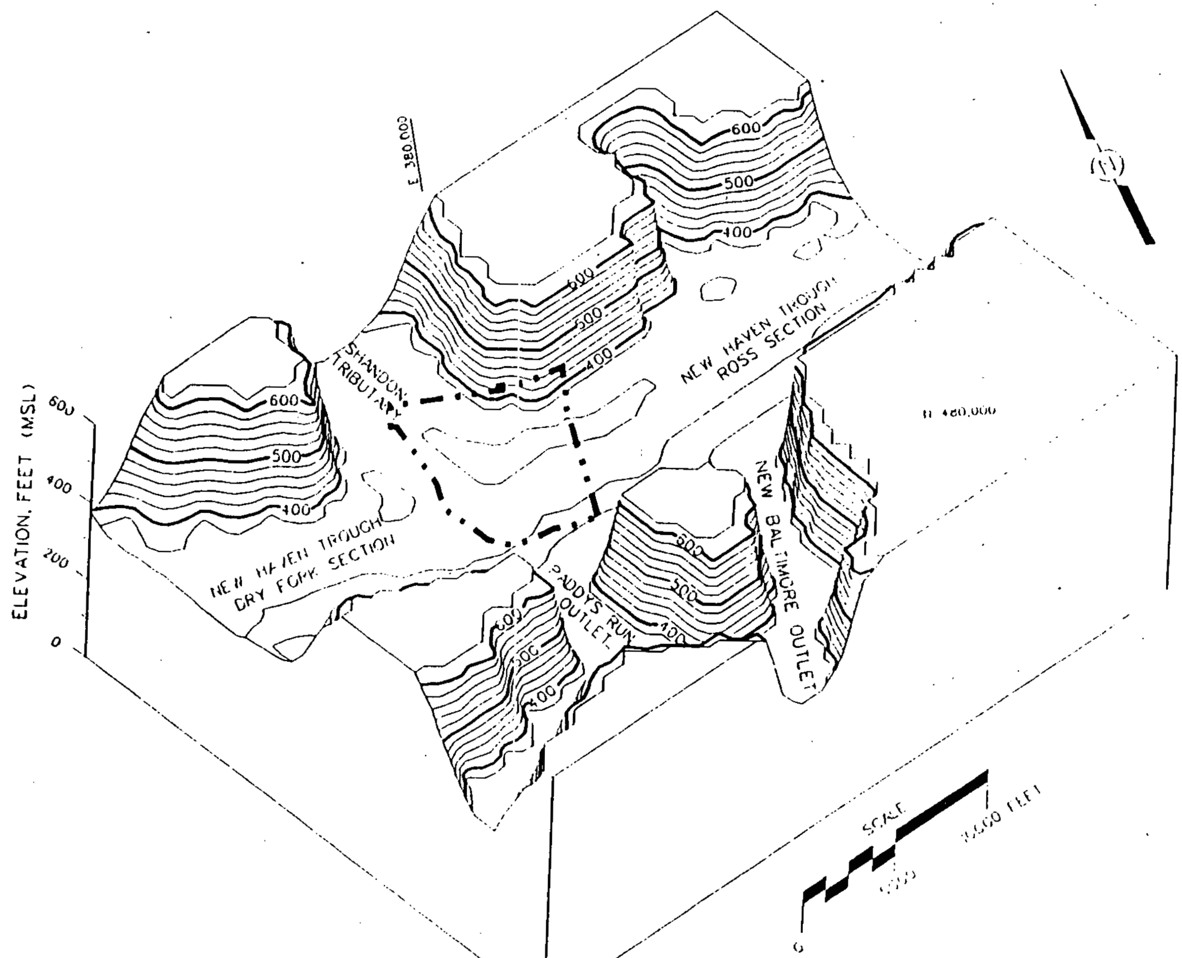


LEGEND:

- ⊗ SYSTEM 1 EXTRACTION WELL
- SYSTEM 2 EXTRACTION WELL
- ϕ SYSTEM 3 EXTRACTION WELL
- SYSTEM 4 EXTRACTION WELL

0 1000 2000 FT
SCALE

FIGURE 2



NOTE:
VERTICAL EXAGGERATION
= 20X

DRAFT
FINAL

LEGEND:
400 CONTOUR
FEMP BOUNDARY

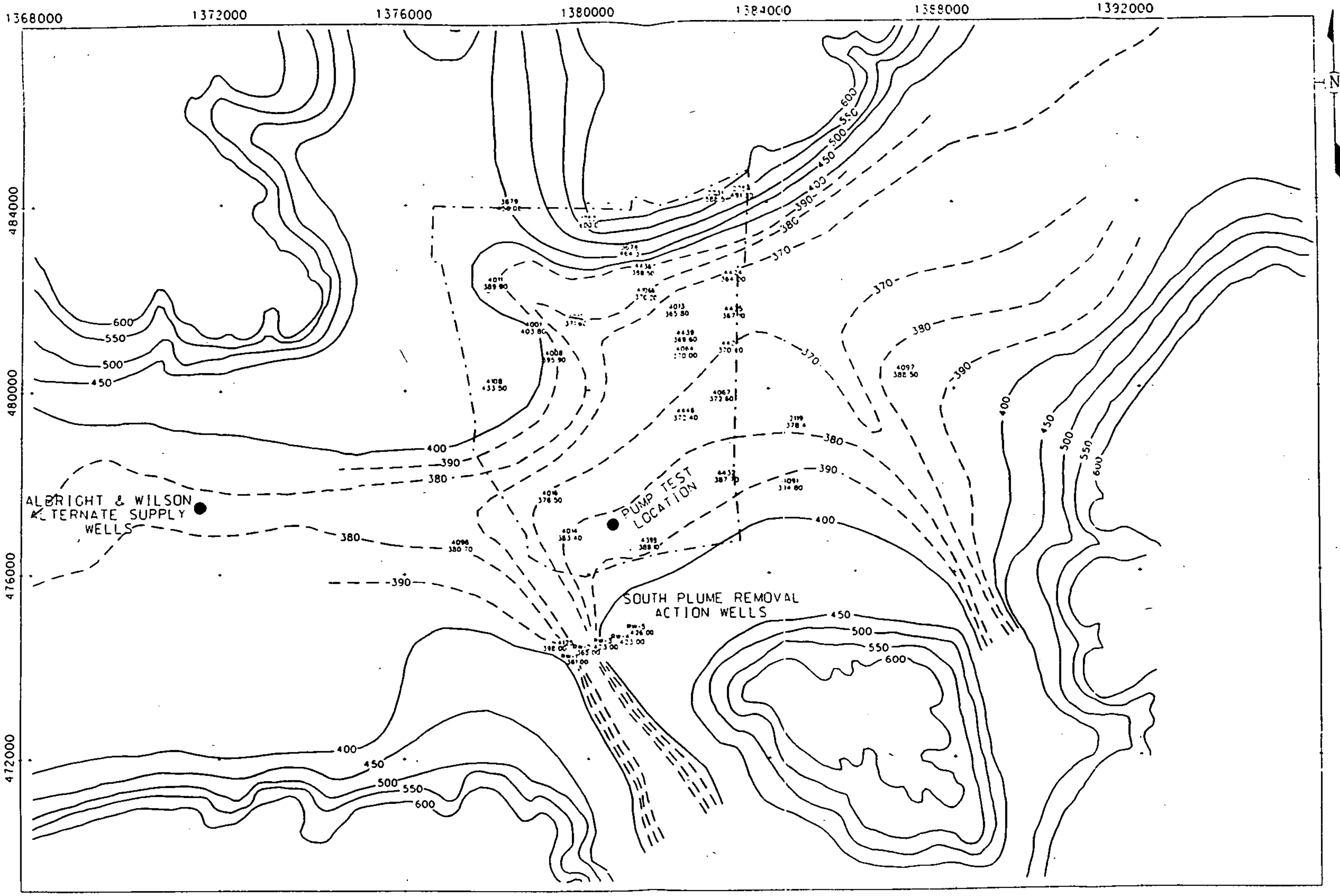
FIGURE 3. 3-DIMENSIONAL
BEDROCK CONFIGURATION

000032

6479

STATE PLANAR COORDINATE SYSTEM 1927
6-10-94

6470



LEGEND:

FEMP BOUNDARY
10 FOOT BEDROCK CONTOUR (RI/FS WELL DATA)
50 FOOT BEDROCK CONTOUR (WATKINS & SPIEKER, 1971)
WELL/BORING NUMBER
BEDROCK ELEVATION

SCALE
2500 1250 0 2500 FEET

DRAFT
FINAL

FIGURE 4. BEDROCK TOPOGRAPHIC SURFACE

STATE PLANAR COORDINATE SYSTEM 1927

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000034

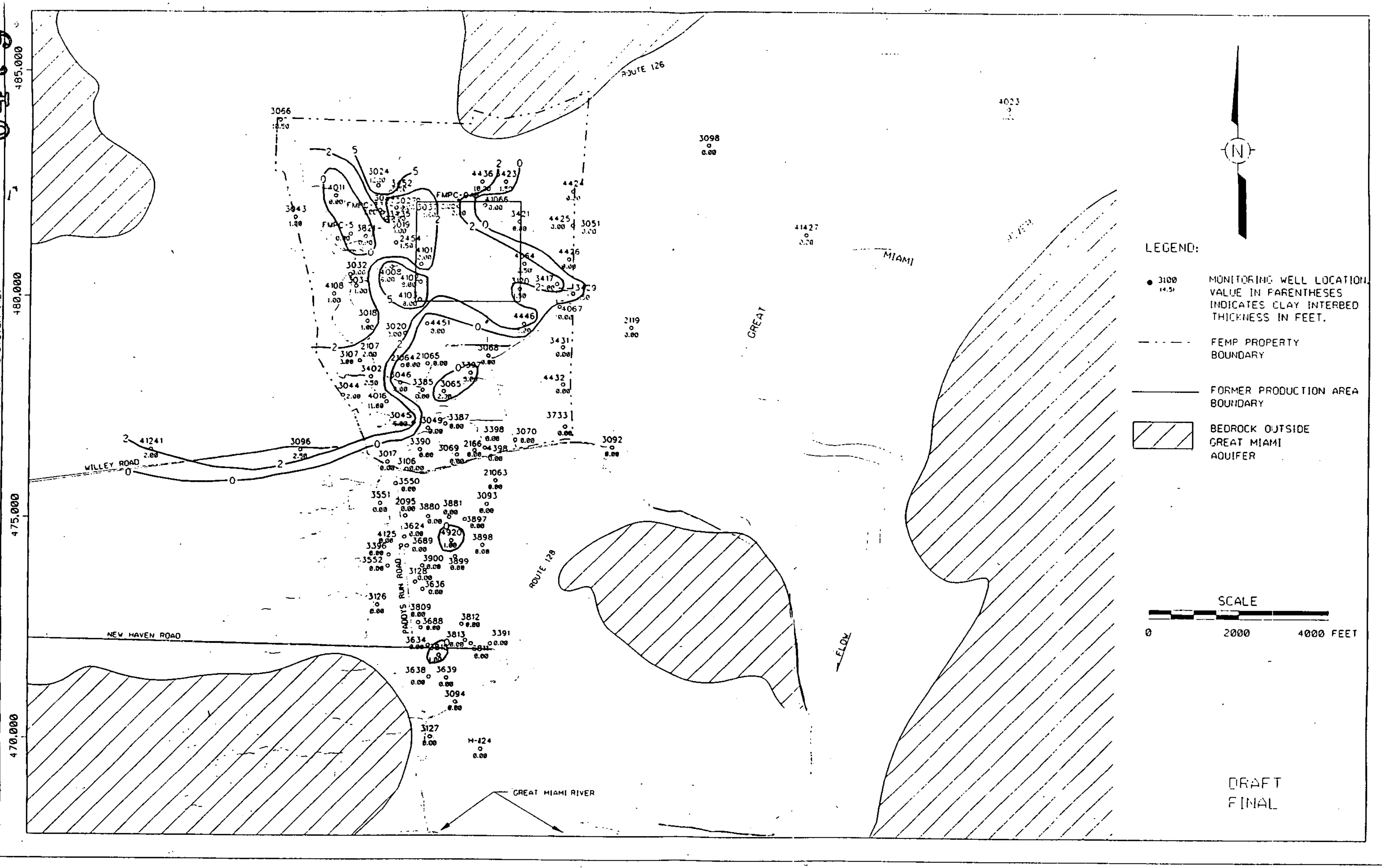


FIGURE 5
CLAY INTERBED ISOPACH

CONCEPTUAL PERMEABILITY TRENDS IN SAND

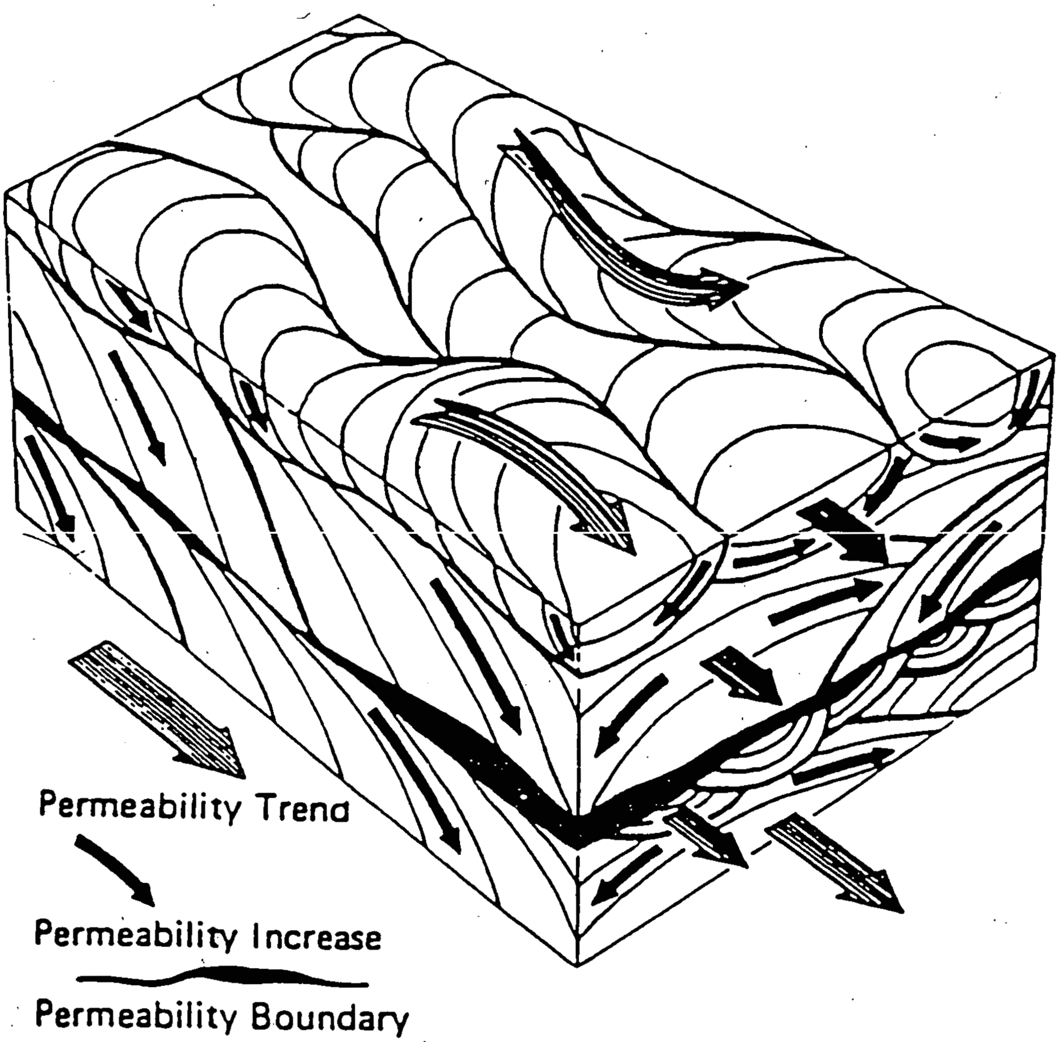
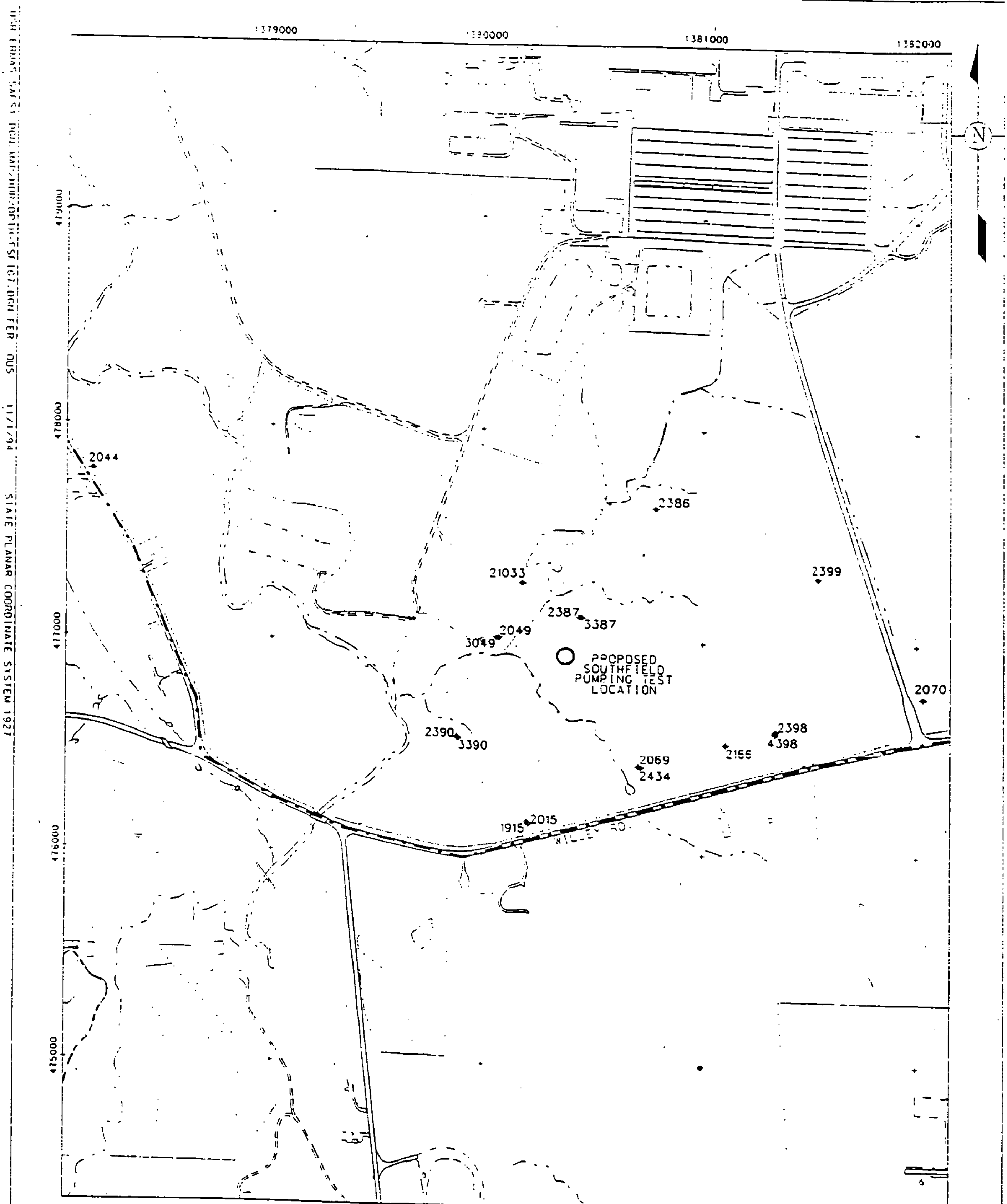


Figure 6



LEGEND:

O PROPOSED TEST LOCATION

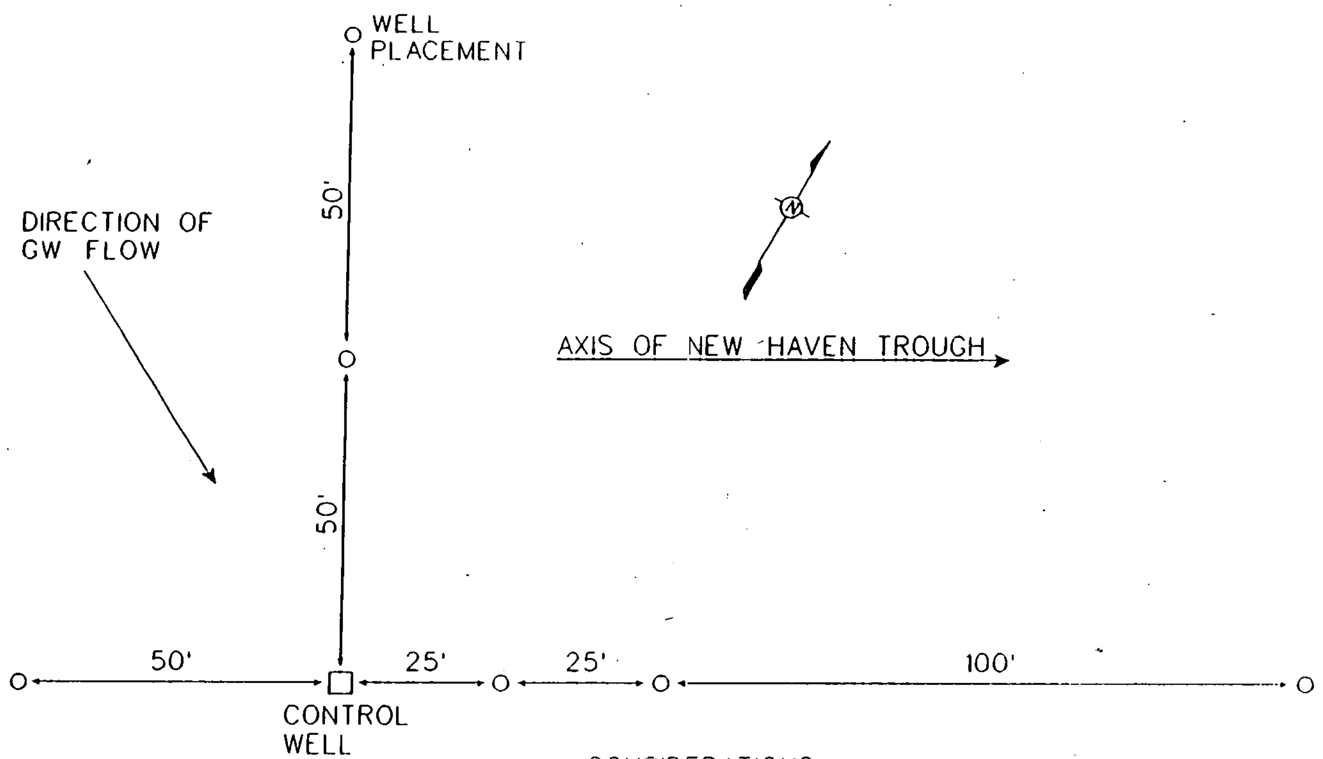
—·—·— FEMP BOUNDARY

SCALE

650 325 0 650 FEET

DRAFT

FIGURE 7. PUMPING TEST AREA



CONSIDERATIONS:

- UNCONFINED AQUIFER ≈ 135' THICK
- HIGH TRANSMISSIVITY - CONE OF DEPRESSION SHOULD BE BROAD AND FLAT
- DRAWDOWN DIFFERENCES CAUSED BY STRATIFICATION DIMINISH WITH DISTANCE FROM THE PUMPING WELL
- FINAL WELL SPACING DEPENDENT UPON SLUG TEST AND MODELING RESULTS

DRAFT

/USR/ERMAS/SAFSI/DGN/MAP/HOR/DPTH/FIG8.DGN FER OU5 11/1/94

FIGURE 8. PUMPING TEST NETWORK

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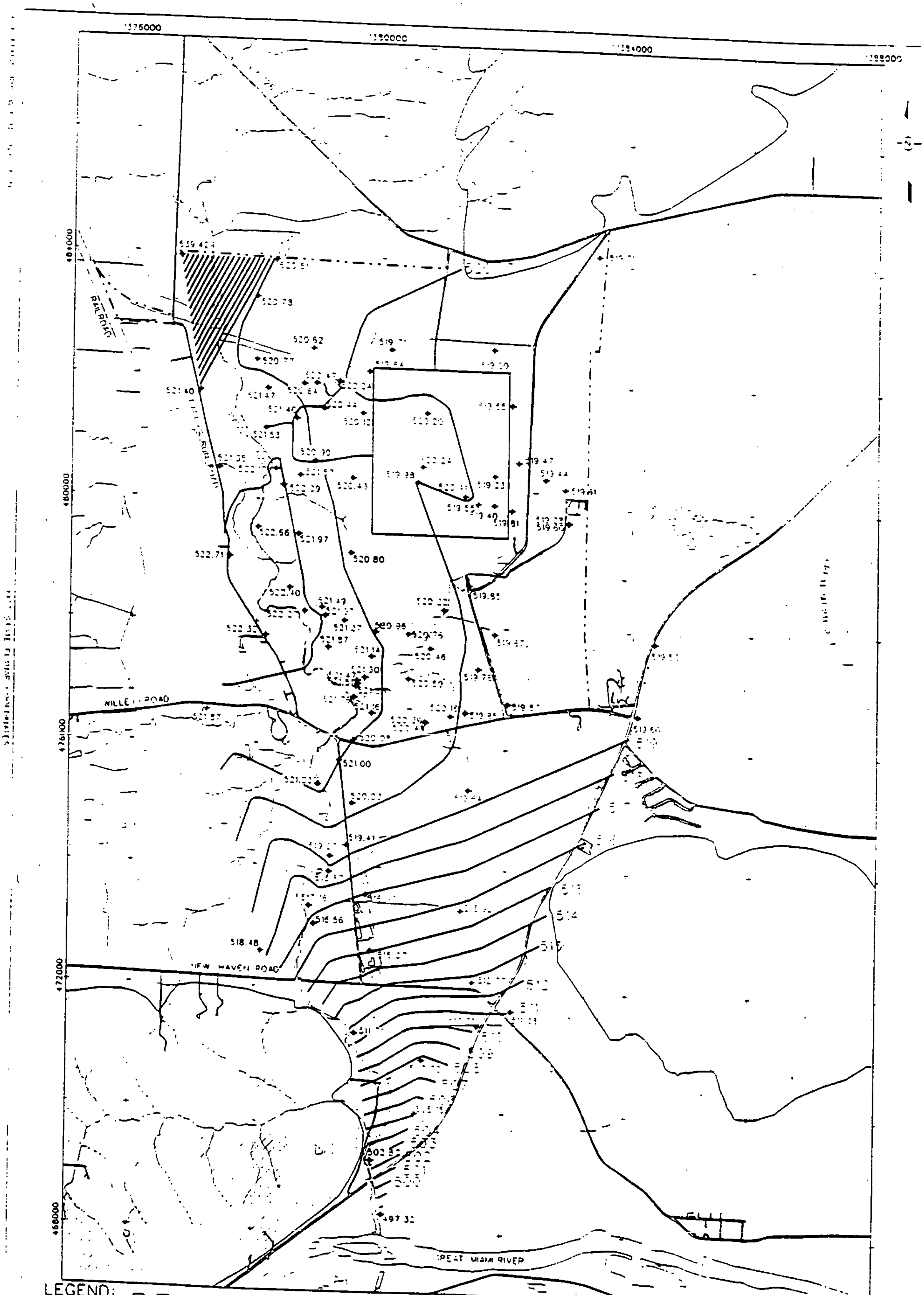
ATTACHMENT A

WATER TABLE MAPS AND HYDROGRAPHS



LEGEND:

DRAFT

516.22 GROUNDWATER ELEVATION (FT)

FEMP BOUNDARY

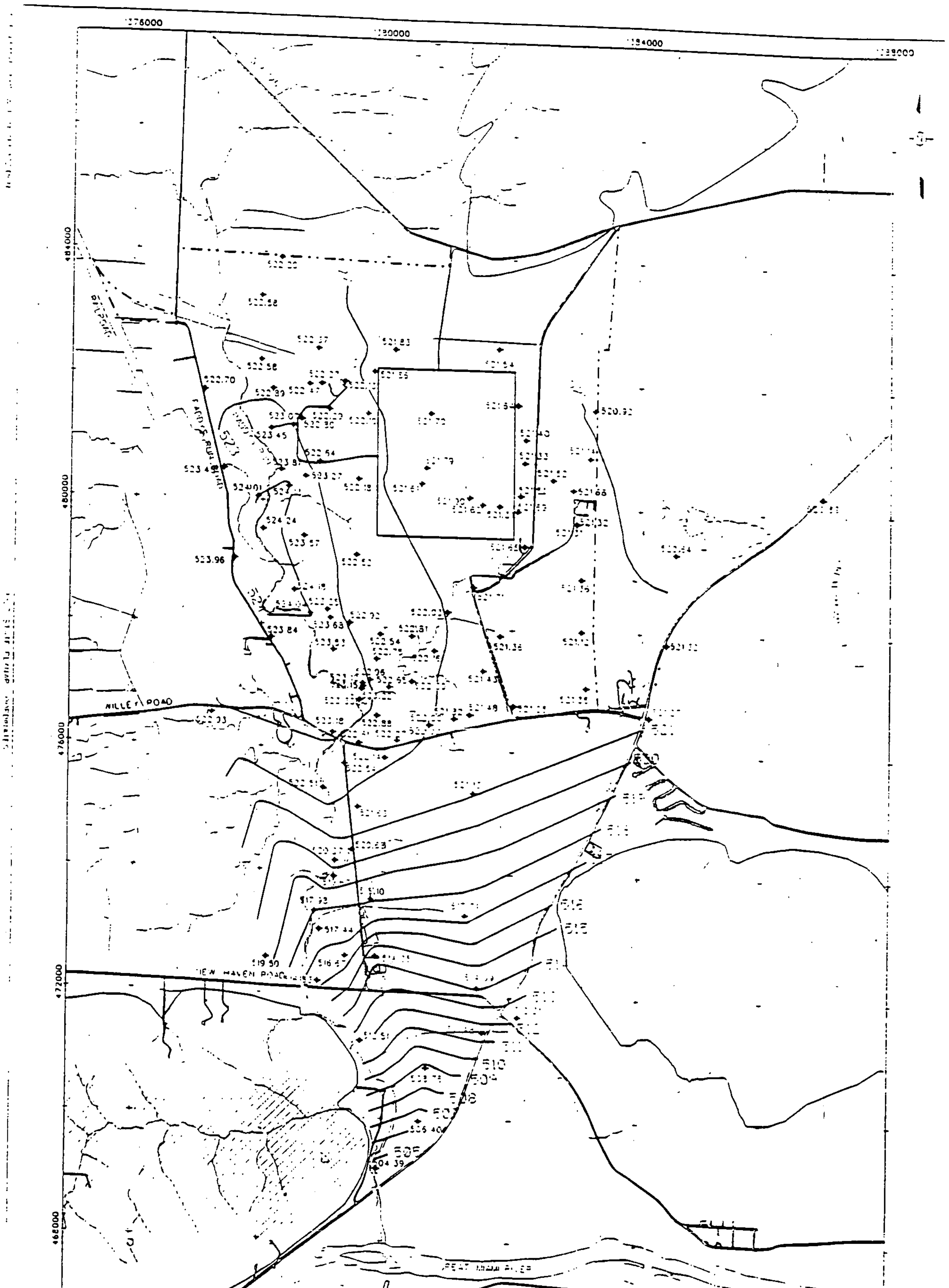
GROUNDWATER ELEVATION CONTOURS

FEMP PRODUCTION AREA BOUNDARY

SEE APPENDIX K FOR NONREPRESENTATIVE DATA

BEDROCK

6479



LEGEND:

DRAFT

516.22 GROUNDWATER ELEVATION (FT)

FEMP BOUNDARY

GROUNDWATER ELEVATION CONTOURS

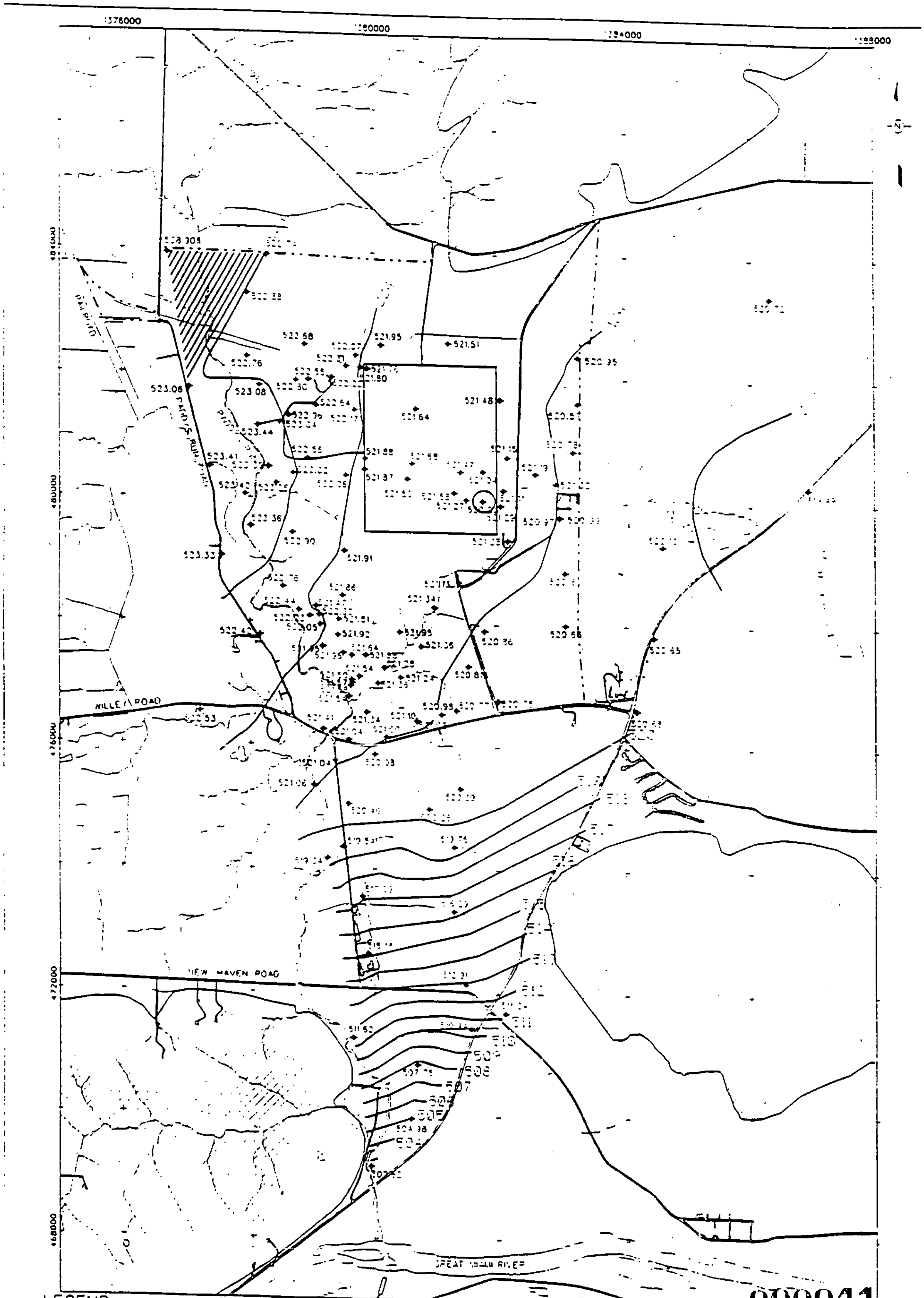
FEMP PRODUCTION AREA BOUNDARY

SEE APPENDIX K FOR NONREPRESENTATIVE DATA

BEDROCK

000040

6479



000041

LEGEND:

DRAFT

516.22 GROUNDWATER ELEVATION (FT)

FEMP BOUNDARY

GROUNDWATER ELEVATION CONTOURS

FEMP PRODUCTION AREA BOUNDARY

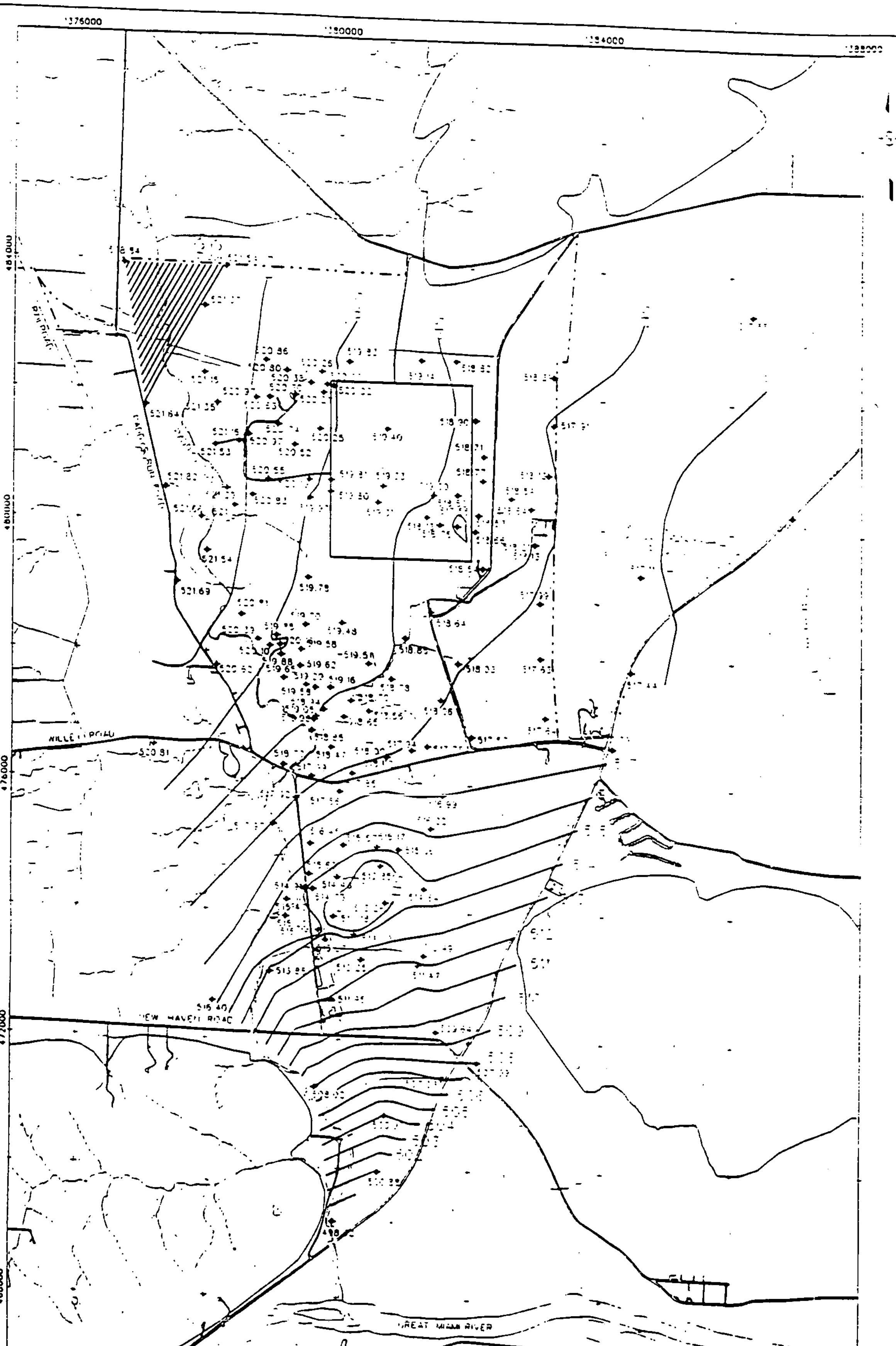
BEDROCK

SEE APPENDIX FOR K NONREPRESENTATIVE DATA

0 500 1500 FEET

FIGURE 3-55

6470



LEGEND:

DRAFT

516.22 GROUNDWATER ELEVATION (FT)

FEMP BOUNDARY

GROUNDWATER ELEVATION CONTOURS

FEMP PRODUCTION AREA BOUNDARY

SEE APPENDIX K FOR NONREPRESENTATIVE DATA

000042

FIGURE 3-56. GROUNDWATER ELEVATIONS, TYPE 2 WELLS, OCTOBER 1993

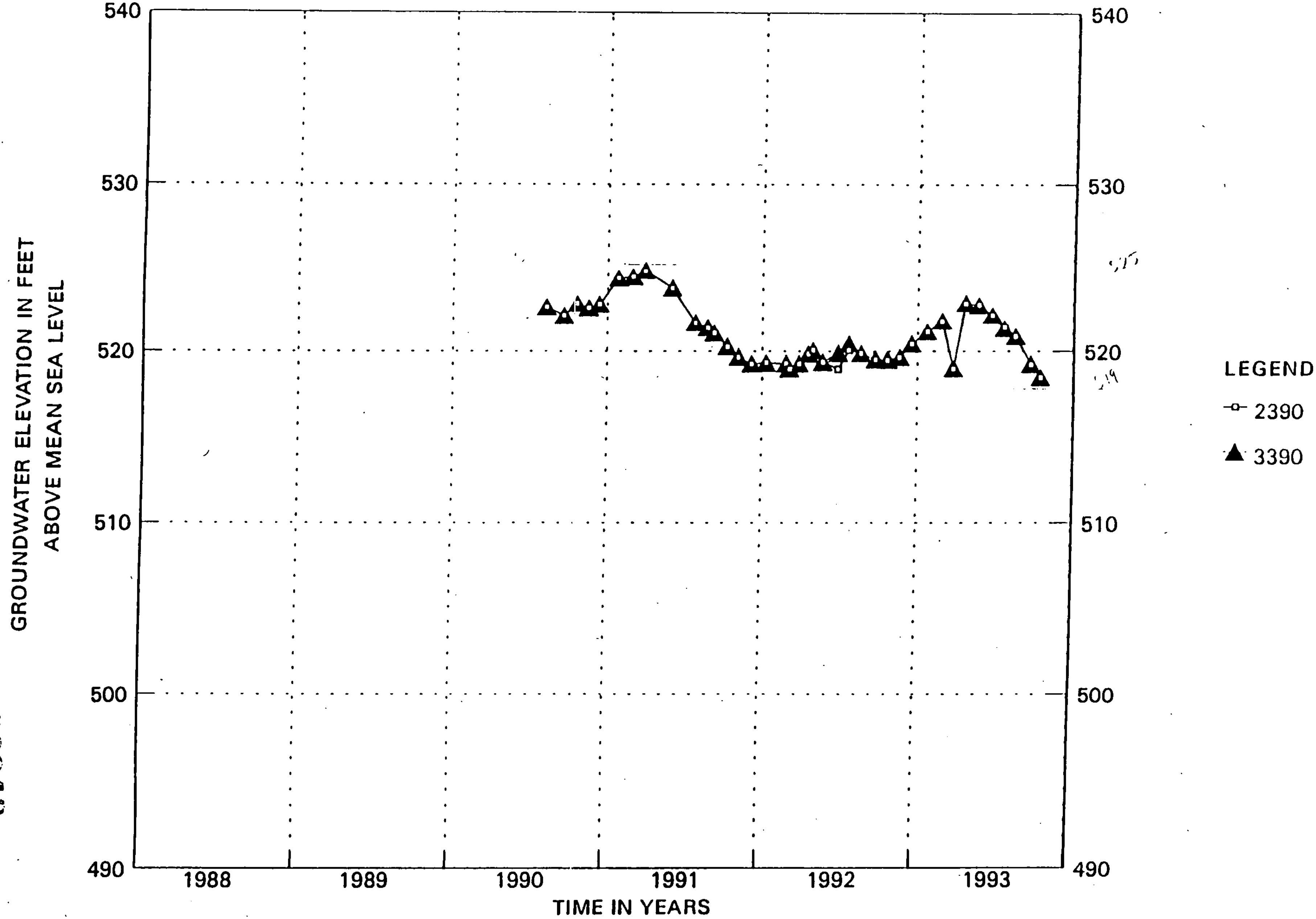


Figure L - 424 HYDROGRAPH FOR WELL CLUSTER 390

000043

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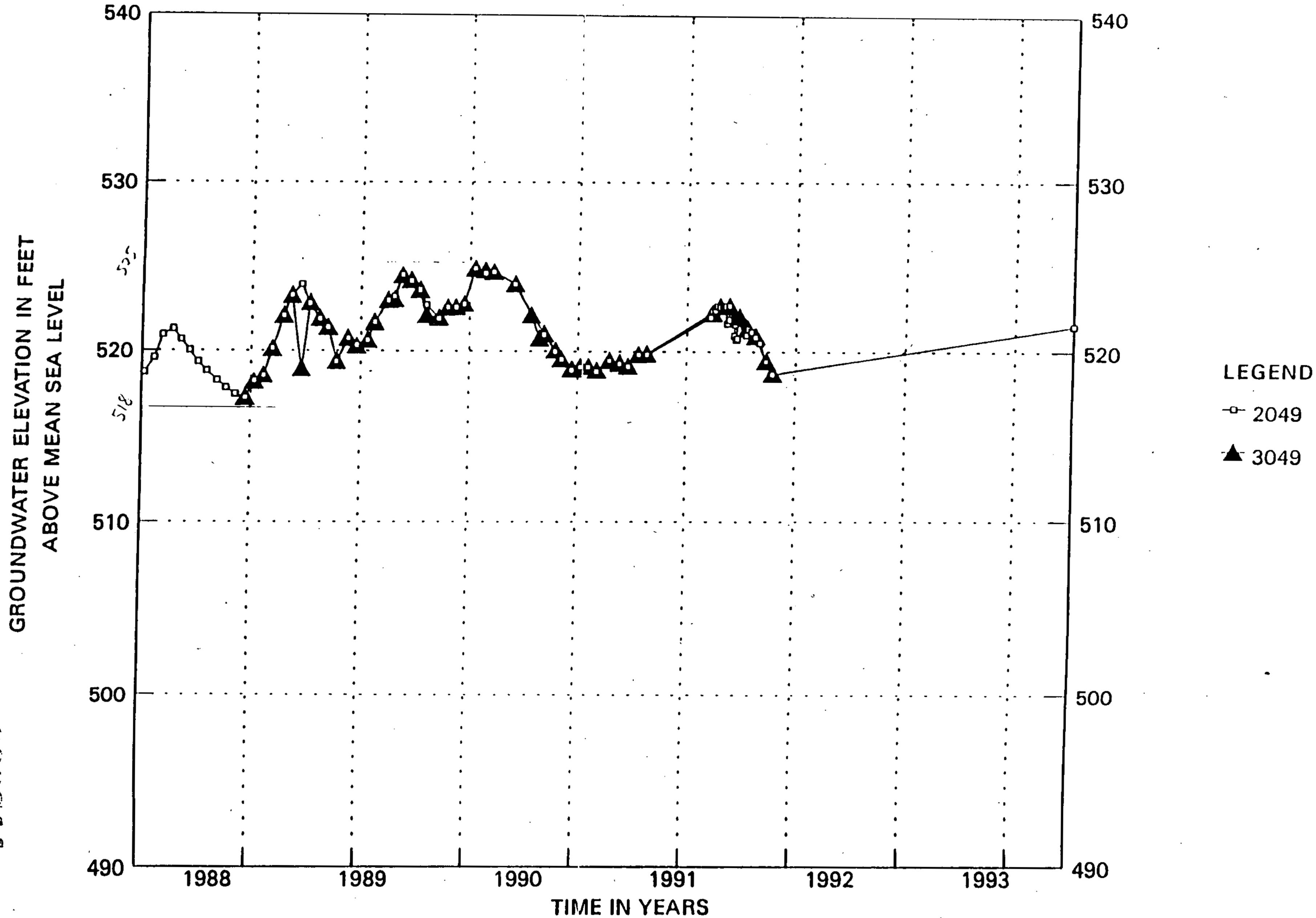

Figure L- 378 HYDROGRAPH FOR WELL CLUSTER 049

0000044

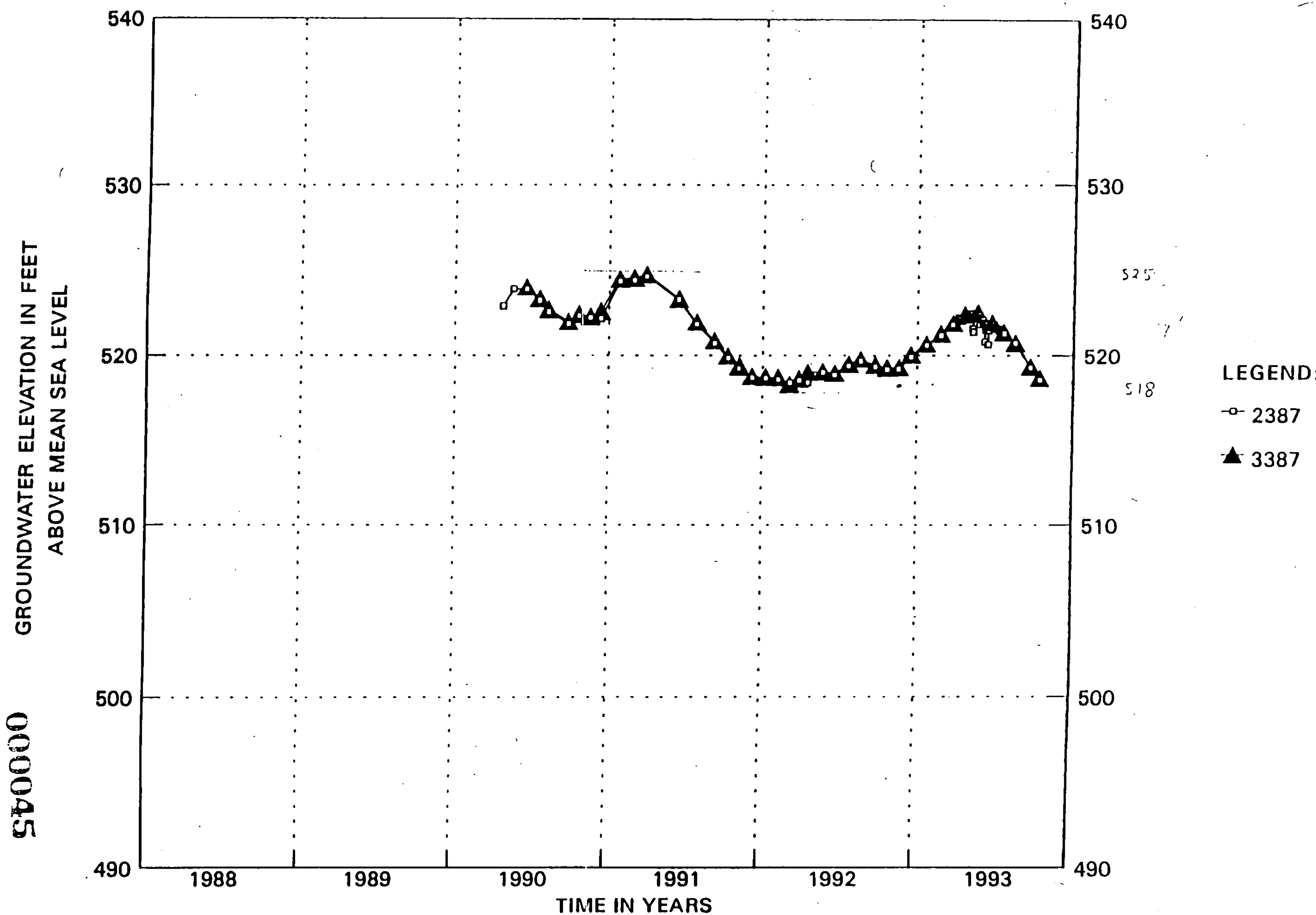

Figure L - 421 HYDROGRAPH FOR WELL CLUSTER 387

000045

6249

ATTACHMENT B

WATER QUALITY DATA

Well		Result	Units	Qual.	QA Type	Suffix	Filter	Lab Qual.	Lab. Result	DL	Lab	Matrix
1,1,1-Trichloroethane												
4015	02/02/93		ug/L		NORMAL	NONE	UNFILTER	J	0.90		DATAC	GROUND WATER
2015	04/19/88	6.0000	ug/L	-	NORMAL	NONE	UNFILTER				IT	GROUND WATER
Acetone												
2398	08/19/92		ug/L		NORMAL	NONE	UNFILTER	J	4.00		DATAC	GROUND WATER
2386	11/10/92		ug/L		NORMAL	NONE	UNFILTER		20.00	4.30	DataC	GROUND WATER
Aluminum												
3390	02/02/91	0.0600	mg/L	J	NORMAL	NONE	FILTERED		0.06		IT	GROUND WATER
2049	07/30/89	0.1330	mg/L	-	NORMAL	NONE	FILTERED				IT	GROUND WATER
Antimony												
2434	09/10/92	8.2000	ug/L	-	WATER TR	NONE	*U	B	8.20		IT	GROUND WATER
3015	02/08/93		ug/L		DUPLICAT	NONE	FILTERED		129.00		DATAC	GROUND WATER
Arsenic												
4015	11/09/88	0.0030	mg/L	-	NORMAL	NONE	*F		0.00		IT	GROUND WATER
2015	02/06/89	0.0020	mg/L	-	NORMAL	NONE	FILTERED				IT	GROUND WATER
Barium												
2069	04/24/88	0.0200	mg/L	-	NORMAL	NONE	*F		0.02		IT	GROUND WATER
3049	01/31/89	0.0230	mg/L	J	NORMAL	NONE	FILTERED				IT	GROUND WATER
Beryllium												
4015	02/02/93		ug/L		NORMAL	NONE	FILTERED	B	1.10		DATAC	GROUND WATER
2386	09/02/92		ug/L		NORMAL	NONE	FILTERED	B	1.50		DATAC	GROUND WATER
Bromomethane												
3387	11/19/92		ug/L		DUPLICAT	NONE	UNFILTER	B	2.50	1.00	LOCKH	GROUND WATER
2386	09/02/92		ug/L		DUPLICAT	NONE	UNFILTER	B	2.80	1.00	LOCKH	GROUND WATER
Cadmium												
3015	03/01/90	0.0040	mg/L	NV	NORMAL	NONE	FILTERED		0.00		IT	GROUND WATER
3015	06/02/88	0.0030	mg/L	-	NORMAL	NONE	*F				IT	GROUND WATER
Calcium												
2069	09/24/91	51.0000	mg/L	NV	NORMAL	NONE	FILTERED		51.00		NET	GROUND WATER
2390	09/05/90	110.0000	mg/L	-	NORMAL	NONE	FILTERED				IT	GROUND WATER
Cesium-137												
3069	07/27/93	2.7000	pCi/L	NV	NORMAL	NONE	UNFILTER		2.70	2.70	CORE	GROUND WATER

000047

Well		Result	Units	Qual.	QA Type	Suffix	Filter	Lab Qual.	Lab. Result	DL	Lab	Matrix
3069	07/27/93	2.7000	pCi/L	NV	NORMAL	NONE	UNFILTER		2.70	2.70	CORE	GROUND WATER
Chloroform												
2398	02/03/93		ug/L		NORMAL	NONE	UNFILTER	J	1.00		DATAC	GROUND WATER
2015	03/01/90	2.0000	ug/L	J	NORMAL	NONE	UNFILTER	J	2.00		IT	GROUND WATER
Chromium												
2015	09/24/91	0.0041	mg/L	NV	NORMAL	NONE	UNFILTER		0.00		NET	GROUND WATER
3069	01/24/89	0.0210	mg/L	J	NORMAL	NONE	FILTERED				IT	GROUND WATER
Cobalt												
2434	01/25/93	0.0065	mg/L	NV	NORMAL	NONE	UNFILTER		0.01	0.01	NET	GROUND WATER
2398	09/17/93	7.2000	ug/L	-	NORMAL	NONE	UNFILTER	B	7.20		NET	GROUND WATER
Copper												
2386	05/10/90	0.0100	mg/L	J	NORMAL	NONE	*F		0.01		IT	GROUND WATER
3015	02/07/89	0.0120	mg/L	-	NORMAL	NONE	FILTERED				IT	GROUND WATER
Di-n-butyl phthalate												
2398	07/22/93	2.0000	ug/L	J	NORMAL	NONE	UNFILTER	J	2.00		NET	GROUND WATER
2434	07/28/93	52.0000	ug/L	-	NORMAL	NONE	UNFILTER		52.00		NET	GROUND WATER
Dieldrin												
3069	07/27/93	0.0160	ug/L	J	NORMAL	NONE	UNFILTER	J	0.02		NET	GROUND WATER
3069	07/27/93	0.0160	ug/L	J	NORMAL	NONE	UNFILTER	J	0.02		NET	GROUND WATER
Endosulfan-I												
3069	07/27/93	0.0250	ug/L	J	NORMAL	NONE	UNFILTER	JP	0.03		NET	GROUND WATER
3069	07/27/93	0.0250	ug/L	J	NORMAL	NONE	UNFILTER	JP	0.03		NET	GROUND WATER
Gross Alpha												
2434	01/25/93	1.4000	pCi/L	NV	NORMAL	NONE	UNFILTER		1.40	0.70	CORE	GROUND WATER
2386	07/11/90	3.5300	pCi/L	NV	NORMAL	NONE	*U				IT	GROUND WATER
Gross Beta												
2434	01/25/93	1.2000	pCi/L	NV	NORMAL	NONE	UNFILTER		1.20	0.40	CORE	GROUND WATER
3069	06/13/90	38600.0000	pCi/L	NV	NORMAL	NONE	UNFILTER		38600.00		IT	GROUND WATER
Iron												
2386	05/10/90	0.0190	mg/L	J	NORMAL	NONE	*F		0.02		IT	GROUND WATER
3049	01/31/89	0.1500	mg/L	J	NORMAL	NONE	FILTERED				IT	GROUND WATER

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Well		Result	Units	Qual.	QA Type	Suffix	Filter	Lab Qual.	Lab. Result	DL	Lab	Matrix
Lead												
3387	09/07/90	0.0030	mg/L	J	NORMAL	NONE	*F		0.00		IT	GROUND WATER
2049	07/30/89	0.0030	mg/L	-	NORMAL	NONE	FILTERED				IT	GROUND WATER
Magnesium												
2069	09/24/91	18.0000	mg/L	NV	NORMAL	NONE	FILTERED		18.00		NET	GROUND WATER
2049	08/03/88	24.0000	mg/L	J	NORMAL	NONE	*F				IT	GROUND WATER
Manganese												
3390	02/02/91	0.0050	mg/L	-	NORMAL	NONE	FILTERED		0.01		IT	GROUND WATER
2398	02/11/91	13.2000	ug/L	-	NORMAL	F	FILTERED	B			IT	GROUND WATER
Mercury												
2399	11/18/92		ug/L		NORMAL	NONE	FILTERED		0.10	0.10	DATAC	GROUND WATER
2069	07/26/88	0.0005	mg/L	-	NORMAL	NONE	*F				IT	GROUND WATER
Methylene chloride												
4015	02/02/93		ug/L		NORMAL	NONE	UNFILTER	BJ	0.60		DATAC	GROUND WATER
3387	11/19/92		ug/L		DUPLICAT	NONE	UNFILTER	B	1.70	0.78	LOCKH	GROUND WATER
Molybdenum												
2386	05/10/90	0.0110	mg/L	J	NORMAL	NONE	*F		0.01		IT	GROUND WATER
3049	01/31/89	0.0370	mg/L	J	NORMAL	NONE	FILTERED				IT	GROUND WATER
Neptunium-237												
4015	03/11/91	0.0695	pCi/L	NV	NORMAL	NONE	UNFILTER		0.07		IT	GROUND WATER
2166	09/29/92	0.3000	pCi/L	J	NORMAL	NONE	FILTERED	U	2.00		IT	GROUND WATER
Nickel												
3015	03/11/91	0.0050	mg/L	NV	NORMAL	NONE	UNFILTER		0.01		NET	GROUND WATER
3390	08/15/90	0.0070	mg/L	-	NORMAL	NONE	*F				IT	GROUND WATER
Phenol												
2049	12/17/93	3.0000	ug/L	J	DUPLICAT	NONE	UNFILTER	J	3.00		DATAC	GROUND WATER
2049	12/17/93	4.0000	ug/L	J	NORMAL	NONE	UNFILTER	J	4.00		DATAC	GROUND WATER
Plutonium-238												
3398	07/22/93	2.7000	pCi/L	NV	NORMAL	NONE	UNFILTER		2.70	0.90	CORE	GROUND WATER
3398	07/22/93	2.7000	pCi/L	NV	NORMAL	NONE	UNFILTER		2.70	0.90	CORE	GROUND WATER
Plutonium-239/240												
3398	07/22/93	0.6000	pCi/L	NV	NORMAL	NONE	UNFILTER		0.60	0.50	CORE	GROUND WATER

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Well		Result	Units	Qual.	QA Type	Suffix	Filter	Lab Qual.	Lab. Result	DL	Lab	Matrix
2398	07/22/93	1.4000	pCi/L	NV	NORMAL	NONE	UNFILTER		1.40	0.40	CORE	GROUND WATER
Potassium												
4015	11/09/88	1.4500	mg/L	J	NORMAL	NONE	*F		1.45		IT	GROUND WATER
4015	06/02/88	1.7400	mg/L	-	DUPLICAT	NONE	*F				IT	GROUND WATER
Radium-226												
4015	09/05/90	0.1310	pCi/L	NV	NORMAL	NONE	UNFILTER		0.13		IT	GROUND WATER
2015	08/03/88	1.5000	pCi/L	-	NORMAL	NONE	*U				IT	GROUND WATER
Radium-228												
2434	01/25/93	0.8000	pCi/L	NV	NORMAL	NONE	UNFILTER		0.80	0.40	CORE	GROUND WATER
4015	06/02/88	3.0000	pCi/L	J	DUPLICAT	NONE	*U				IT	GROUND WATER
Selenium												
3015	02/07/89	0.0020	mg/L	J	NORMAL	NONE	FILTERED		0.00		IT	GROUND WATER
3069	11/07/88	0.0020	mg/L	J	NORMAL	NONE	FILTERED				IT	GROUND WATER
Silicon												
3049	04/26/90	2.0000	mg/L	-	NORMAL	NONE	FILTERED		2.00		IT-KN	GROUND WATER
2069	04/25/90	2.1000	mg/L	-	NORMAL	NONE	FILTERED				IT	GROUND WATER
Silver												
3015	03/01/90	0.0110	mg/L	-	NORMAL	NONE	FILTERED		0.01		IT	GROUND WATER
2398	02/11/91	25.1000	ug/L	-	NORMAL	F	FILTERED				IT	GROUND WATER
Sodium												
4015	06/02/88	6.0500	mg/L	NV	DUPLICAT	D	UNKNOWN		6.05		IT	GROUND WATER
2015	08/03/88	11.0000	mg/L	J	NORMAL	NONE	FILTERED				IT	GROUND WATER
Strontium-90												
2166	11/17/92	1.7200	pCi/L	J	NORMAL	NONE	FILTERED	U	5.00		IT	GROUND WATER
3069	04/25/90	6.2100	pCi/L	-	NORMAL	NONE	*U				IT	GROUND WATER
Technetium-99												
3398	09/17/93	1.4600	pCi/L	J	NORMAL	NONE	UNFILTER	U	1.40	15.40	CORE	GROUND WATER
2398	09/17/93	17.8000	pCi/L	-	NORMAL	NONE	UNFILTER		17.80	15.50	CORE	GROUND WATER
Tetrachloroethene												
3398	04/13/93	1.0000	ug/L	J	NORMAL	NONE	UNFILTER	J	1.00		NET	GROUND WATER
3398	04/13/93	1.0000	ug/L	J	NORMAL	NONE	UNFILTER	J	1.00		NET	GROUND WATER

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Well		Result	Units	Qual.	QA Type	Suffix	Filter	Lab Qual.	Lab. Result	DL	Lab	Matrix
Thallium												
3049	06/10/93	2.4000	ug/L	-	DUPLICAT	NONE	FILTERED	B	2.40		NET	GROUND WATER
2399	04/24/93	15.6000	ug/L	NV	NORMAL	D	UNFILTER		15.60		DATAC	GROUND WATER
Thorium, Total												
2434	01/25/93	0.3000	ug/L	NV	NORMAL	NONE	UNFILTER		0.30		CORE	GROUND WATER
2387	06/29/90	5.6900	ug/L	-	NORMAL	NONE	*U				IT	GROUND WATER
Thorium-228												
2434	07/28/93	0.1000	pCi/L	J	NORMAL	NONE	UNFILTER		0.10	0.10	CORE	GROUND WATER
2386	07/11/90	2.1600	pCi/L	J	NORMAL	NONE	*U				IT	GROUND WATER
Thorium-230												
2399	04/22/93	0.1000	pCi/L	J	DUPLICAT	NONE	FILTERED		0.10	0.10	CORE	GROUND WATER
2387	06/29/90	1.6800	pCi/L	J	NORMAL	NONE	*U				IT	GROUND WATER
Thorium-232												
3398	09/17/93	0.1500	pCi/L	J	NORMAL	NONE	UNFILTER	U	0.10	0.20	CORE	GROUND WATER
2049	04/08/88	1.6000	pCi/L	J	NORMAL	NONE	*U		1.60		IT	GROUND WATER
Uranium, Total												
4015	08/12/92		ug/L		NORMAL	NONE	UNFILTER		0.10	0.10	WMCO	GROUND WATER
2015	08/03/88	178.0000	ug/L	-	DUPLICAT	NONE	*U				IT	GROUND WATER
Uranium-234												
3398	07/22/93	0.3000	pCi/L	J	NORMAL	NONE	UNFILTER		0.30	0.10	CORE	GROUND WATER
3049	04/26/90	5.9600	pCi/L	-	DUPLICAT	NONE	*U				IT	GROUND WATER
Uranium-235												
3069	06/13/90	0.0200	pCi/L	NV	NORMAL	NONE	UNFILTER		0.02		WMCO	GROUND WATER
2049	12/17/93	0.7807	pCi/L	-	DUPLICAT	NONE	UNFILTER		0.78		ORAS	GROUND WATER
Uranium-235/236												
2386	04/24/93	0.1000	pCi/L	-	NORMAL	NONE	UNFILTER		0.10	0.10	CORE	GROUND WATER
2387	04/25/90	7.6300	pCi/L	-	NORMAL	NONE	*U				IT	GROUND WATER
Uranium-236												
3069	06/13/90	0.0090	pCi/L	NV	NORMAL	NONE	UNFILTER		0.01		WMCO	GROUND WATER
2049	12/17/93	0.0534	pCi/L	J	NORMAL	NONE	UNFILTER		0.05		ORAS	GROUND WATER
Uranium-238												
3398	09/17/93	0.2700	pCi/L	J	NORMAL	NONE	UNFILTER		0.20	0.10	CORE	GROUND WATER

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Well		Result	Units	Qual.	QA Type	Suffix	Filter	Lab Qual.	Lab. Result	DL	Lab	Matrix
2387	06/29/90	108.0000	pCi/L	-	NORMAL	NONE	-*U				IT	GROUND WATER
Vanadium												
2386	05/10/90	0.0170	mg/L	J	NORMAL	NONE	*F		0.02		IT	GROUND WATER
2386	07/11/90	0.0130	mg/L	-	NORMAL	NONE	FILTERED				IT	GROUND WATER
Zinc												
3015	03/11/91	0.0200	mg/L	NV	NORMAL	NONE	UNFILTER		0.02		NET	GROUND WATER
2015	03/01/90	243.0000	ug/L	J	NORMAL	NONE	FILTERED	E	243.00		IT	GROUND WATER
bis(2-Ethylhexyl)phthalate												
2049	12/17/93	2.0000	ug/L	J	DUPLICAT	NONE	UNFILTER	J	2.00		DATAC	GROUND WATER
2015	04/19/88	1.0000	ug/L	J	NORMAL	NONE	UNFILTER	J			IT	GROUND WATER

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