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Remedial Investigation Report for the Eastern Michaud Flats Site

Part II
Appendices K – T for Surface and Subsurface Characterizations

Prepared for
FMC Corporation
J.R. Simplot Company

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Appendix K

Groundwater Flow Modeling Report

Remedial Investigation/Feasibility Study

Groundwater Flow Modeling Report

Prepared for:
FMC Corporation
J.R. Simplot Company

for the
Eastern Michaud Flats Site

September 1995

Bechtel
Bechtel Environmental, Inc.

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Section 1

Introduction

This report presents the results of a groundwater flow modeling study conducted by Bechtel Environmental, Inc. (BEI), in support of the Fate and Transport analysis of the Remedial Investigation (RI) for the Eastern Michaud Flats (EMF) Site (Figure 1). The model depicts the physical characteristics of the groundwater flow from beneath the facilities to the Portneuf River.

Key findings of this study are summarized below:

(1) Groundwater flowing beneath the facilities discharges primarily to Batiste and Swanson Road Springs and to the Portneuf River as baseflow; groundwater underflowing the facilities does not discharge to the Portneuf River or to springs at points north of Batiste Spring.

(2) The Portneuf River is an effective hydraulic barrier. Impacted groundwater does not flow east of the Portneuf River. Impacted groundwater does not flow west or north from the former ponds at FMC. The northern limit of the groundwater originating beneath the facilities is bounded by groundwater flowing to the southeast from the Michaud Flats. These flowpaths coincide with the interpreted extent of EMF-related constituents presented in the PSCS and RI.

(3) Fluxes of groundwater beneath known sources are a relatively minor portion of the regional water budget (as further detailed in Section 5.4 of the RI Report). This finding can be directly linked to groundwater geochemistry data to further characterize transport of EMF-related constituents.

(4) Long-term groundwater quality will not be negatively impacted by future scenarios, especially considering (a) the closure of FMC's Pond 8S, (b) the closure of the former east overflow pond, and (c) changes made by Simplot regarding the manner in which slurry is applied to the gypsum stack.

1.1 BACKGROUND

Numerical groundwater flow modeling was selected as a tool to study the complex relationships between groundwater flow patterns, local geologic features, local water production wells, surface waters, and other features that might influence the transport of site-related constituents. Given the complex hydrogeology found at this site, a three-dimensional flow model was developed by incorporating several elements to describe the site hydrogeology in the numerical model. The spatial distribution of the geologic features was interpreted from available information, which included numerous boring logs, well driller's logs, and previous reports published by others. Water level measurements were taken by Simplot and FMC (the Companies), which constitute a portion their ongoing water monitoring programs. Additional measurements and

boring logs were obtained from literature [USGS, PEI Associates, and Geraghty and Miller] and from the state of Idaho. Hydraulic conductivities of the different geologic materials were defined by numerous slug tests, pumping tests, and falling head permeability laboratory tests. Figures 1 and 2 identify the locations of most wells used in this study.

The numerical model development process tested the spatial relationships between the numerous observations and calibrated these interpretations into a comprehensive "best fit" model. The model describes the fluxes of groundwater through the aquifers, the local recharge rates, the influence of pumping wells, and spring flows throughout the model area.

1.2 STUDY OBJECTIVES

Objectives of the study were to:

(1) Describe groundwater source-sink relationships, groundwater flow paths, and quantitatively test the validity of the conceptual model developed in the Preliminary Site Characterization Summary (PSCS) (BEI, January 1994), as well as to report recently collected data.

(2) Describe flowpath changes that may occur by changing the production well pumping schemes.

(3) Investigate the potential for migration of site-related constituents along deeper groundwater flow paths.

This document is organized as follows:

- Section 1 is an introduction.
- Section 2 provides a brief description of the geology and hydrogeology, and presents new data made available since the PSCS was issued. This document is addressed to readers who are familiar with the details of the EMF-site geology, hydrogeology, and hydrology through their review of the PSCS and/or the following sections of the RI report, Part II: 3.1 - Geology, 3.2 - Hydrology, 3.3 - Hydrogeology, and 4.4 - Nature and Extent of EMF Constituents in Groundwater.
- Section 3 describes the computer modeling codes used in this study.
- Section 4 describes the process of proceeding from a conceptual model to a numerical model and discusses the basis for input parameter values.

- Section 5 discusses model calibration and defines what is an acceptable flow model, based on observed data. This section also presents a summary of the sensitivity analysis.
- Section 6 describes the groundwater particle tracking results from the different modeled scenarios.
- Section 7 summarizes the observations made during this study.

Section 2

Physical Framework – Geology, Hydrogeology, and Surface Water

This report builds on the PSCS and RI Report interpretations made regarding the hydrogeologic factors that influence the nature and extent and subsequent fate and transport of EMF-related constituents in groundwater. Those portions of the RI Report that develop and present the conceptual model include:

- Sections 3.1, 3.2, and 3.3 — providing a detailed description of local and regional geology, surface water hydrology, and hydrogeology.
- Section 4.4 — presenting results of the nature and extent of constituents in groundwater.

These sections of the RI Report provide the necessary description of the hydrogeologic framework and they will not be repeated here. If this appendix is presented as a "stand-alone" modeling report, the above-mentioned sections of the RI Report would be inserted here, in their entirety. Table 1 is a summary of the aquifer framework within the model study area. Some of the more important hydrogeologic data used in this modeling study are presented in Tables 2, 3, and 4.

2.1 SURFACE WATER FEATURES (SUMMARY OF MATERIAL NOT PRESENTED IN RI REPORT AND OTHER REFERENCES)

Surface water features within the model study area include the Portneuf River, Batiste Spring, Swanson Road Spring, and several springs located along the east side of the Portneuf River. There are other man-made and intermittent surface water features within the study area, including lined ponds at FMC, the Taghee Irrigation Canal, ponds at the City of Pocatello Sewage Treatment Plant (STP), and the FMC Industrial Waste Water (IWW) ditch. Lined ponds were not considered in this modeling study because they are not significant sources of recharge to groundwater.

2.1.1 Springs and River

There is evidence that the Portneuf River gains water not only from spring discharge, but also through direct groundwater discharge through the riverbed. This evidence, based on a preliminary water balance presented in the PSCS (which was further refined as part of this study and is described in Section 5) indicates that total flow gained in the river cannot be accounted for by summing the known spring discharges, STP discharge, and other known discharges. Another line of evidence is anecdotal. Field personnel working in support of the RI reported "clear water" zones downstream of the I-86 bridge. These "clear water" zones appear to be caused by dilution of cloudy river water (higher suspended sediment) with groundwater discharging into the river. These zones appear in the middle of the river, not along banks where springs discharge. Measured river flows and spring discharges are summarized in Table 5.

2.1.2 Recharge

Regional average recharge was derived from published values of less than 10% of mean annual precipitation (Wood and Low, 1986). For this study, 10% of the mean annual precipitation (10.86 inches x 0.10 = 1.09 inches per year) measured at the Pocatello Airport is considered the average recharge over the study area.

Known areas of increased recharge during the period study relative to the average regional value were the gypsum stack, Pond 8S, the losing reach of the Portneuf River, the Taghee Canal, and the unlined portion of the FMC IWW ditch. Recharge rates for these areas are summarized in Table 6 and discussed in more detail below. A recent study of evapotranspiration and water storage in the vadose zone by INEL (INEL, 1991) was evaluated and found not to be a limiting factor in the model.

2.1.2.1 FMC Pond 8S

Pond 8S recharge has been studied as part of a solute transport study, and a resulting value of 15.3 gpm was estimated (BEI, 1993 - Pond 8S Solute Transport Study). The pond has been filled, dewatered and is currently being closed. It will not be a significant recharge source in the future.

2.1.2.2 Simplot Gypsum Stack

The gypsum stack recharge rate is a crude estimate; however, there is a known upper limit. Simplot pumps approximately 1,500 gpm of slurry to the gypsum stack. There is a 40–50% solids content in the slurry, which means there is 750–800 gpm of water available for recharge to the groundwater. It is likely that a significant portion of this water is evaporated prior to infiltrating to the subsurface. For this study it was assumed the evaporation rate is 200–250 gpm and the remaining 500 gpm is recharged to the groundwater from the gypsum stack. This estimate was deemed conservative for this modeling study, since steady state conditions were assumed and the true operation of the gypsum stack may not actually approach steady state conditions. Actual gypsum stack operations may result in lower recharge because: (1) the gypsum decant recovery system recovers water infiltrating through the stack from a series of lateral drains, and (2) applying slurry to alternating parts of the gypsum stack for a period of several weeks or months may not allow the system to approach equilibrium conditions. This practice of applying slurry may actually enhance evaporative losses, thereby reducing the amount of recharge.

Hydrographs of monitoring wells located adjacent to the gypsum stack indicate that water table fluctuations are driven largely by where the gypsum slurry is being applied to the gypsum stack. For example, water level fluctuations of more than 40 feet were noted in Wells PEI-2 and PEI-3, located between the upper and lower gypsum stacks along the eastern portion of the upper gypsum stack. The rise in water levels began when the slurry was applied to the eastern portion of the gypsum stack, and water levels began dropping when the slurry was applied to the western portion of the stack. Since 1988 these large fluctuations in groundwater levels no longer occur because Simplot has been alternating slurry applications to the east or west side of the stack on a 6-month cycle instead of the original 24-month cycle. More recently, Simplot has been applying slurry in 4 to 6 week cycles over the eastern upper stack, western upper stack, and lower gypsum stack.

Reduced permeability in the underlying silts occurs as a result of chemical precipitation as gypsum stack leachate enters the soil column. Permeability reduction has been documented in lab tests that leached gypsum slurry supernatant through natural soils (Cochrane, 1980).

A north-south trending bedrock ridge was noted on the original topography beneath the upper gypsum stack. This ridge may provide a partial barrier to groundwater flow, exerting local control on flow paths of the water infiltrated from the gypsum stack and essentially separating the mounding effects between the east and west side of the upper gypsum stack.

2.1.2.3 FMC IWW Ditch

The FMC IWW ditch is a narrow, slag-bottom ditch. Since water loss measurements are not available for the IWW ditch, the recharge rate over the unlined section of the ditch was estimated to be similar to Pond 8S.

2.1.2.4 Taghee Irrigation Canal

The Taghee canal loses water at a rate of 50 cubic feet per minute when losses are measured over the entire 10 mile run of the canal (Jacobson, 1982). Reports from field personnel indicate that the Taghee Canal contains standing water through the winter months, within the model area. Since river water is not added to the canal during the winter months, the standing water in the canal indicates that losses through the study area are minimal compared to the overall water budget of the study area.

2.1.2.5 Irrigated Farmland

Several irrigated fields lie northwest of FMC, north of I-86. These fields are used for potato, alfalfa, and grain crops, which require up to 30 - 40 inches of applied water during the growing season. The applied irrigation water is approximately 3 to 4 times the mean annual precipitation; however, irrigation water is applied over the months of highest evapotranspiration.

2.2 RECENT DATA

This section describes recently obtained data relating to the regional and local hydrogeology, obtained from the June 1994 field program or other sources. These data include:

- Twelve borings drilled at the EMF site in June 1994 (Borings 160, 161, 162, 163, 164, 334, 335, 521, 522, 523, 524, and 525)
- Well driller's logs for 4 monitoring wells and one production well north of the EMF facilities
- Logs and pumping test summaries for the City of Pocatello municipal water supply wells
- Pumping test summaries for FMC-5 and SWP-5 from the Companies' files
- Twenty-four slug tests performed in March 1994
- Seven flow measurements along the Portneuf River and at discharge measurements at springs
- Water levels in all wells and the Portneuf River measured in June 1994

Highlights of the recent June 1994 sampling program are detailed below, providing new information and reinforcing a number of assumptions made that pertain to the design of the conceptual groundwater model.

Three borings (521, 522, and 523) were drilled north of FMC, near the Williamsen water-supply well (Figure 2). These wells were drilled to provide water quality data in the area between the Williamsen well and Lindley well. Two shallow and one deep groundwater monitoring wells were installed in these borings and sampled during the June 1994 sampling event. Water levels collected from a shallow/deep well pair (Wells 521 and 522) show a minor (-0.26 ft head differential) downward vertical gradient in this area. Basalt was encountered at a depth of 260 feet.

Borings 334 and 335 were drilled near Simplot production wells SWP-4 and SWP-5 (Figure 2). Two-inch diameter piezometers were installed in these borings specifically for collecting groundwater head measurements near these production wells. Nested piezometers were constructed in Boring 335. One piezometer was screened through the deeper gravel unit from which SWP-5 is pumping , while another was screened through the upper gravel unit, through which SWP-5 is not screened. Approximately 15 feet of bentonite seal was placed between the two piezometers in this boring to prevent vertical migration between the two gravel units.

Borings 524 and 525 were drilled approximately 150 feet north of the Batiste Spring building (Figure 2). These wells were installed to collect lithologic and water level data in support of this study. A shallow/deep well pair was installed in these borings. Silty gravels were logged to a depth of 112 feet below ground surface (bgs). A clay was encountered from 112 to 122 feet bgs, and a basalt underlies this clay. Although there were no distinct silt units encountered in these borings, the logs indicate a transition from extremely coarse, bouldery gravels immediately south of Batiste Spring to a siltier gravel north of Batiste Spring. This transition may reflect either a waning flood stage with a lower-energy depositional environment or significant reworking of flood deposits by the ancestral Portneuf River.

Borings 160, 161, 163, and 164 were drilled along the FMC–Simplot fenceline in the Bannock Range (Figure 2). Borings 160 and 161 were drilled within 220 feet of Well 304. Boring 160 encountered rhyolite at a depth of 107 feet bgs, significantly shallower than rhyolite encountered at Well 304 (295 feet bgs). This boring was abandoned and Boring 161 was drilled. Groundwater was encountered in a fractured rhyolite zone at a depth of approximately 150 feet bgs. This is approximately the same depth that groundwater was initially encountered in Well 304; however, the occurrence of rhyolite in Boring 161 was much shallower than the bedrock encountered in Well 304.

The rhyolite encountered in Borings 163 and 164 (Figure 2) was much shallower than the volcanic rock encountered in Well 333. The monitoring well installed in Boring 164 was screened in a sand unit encountered below a rhyolite unit. These observations support the interpretation that groundwater flow in the Bannock Range occurs primarily within the sediment-filled valleys and through interflow sediments within the Bannock Range.

Well logs were obtained from the state of Idaho for USGS shallow monitoring wells located north of I-86, for Chevron Tank Farm shallow monitoring wells, for water supply wells at Rowlands Creamery, and for Indian Springs Trout Farm (Figure 2). These wells are located in the Michaud Flats and Portneuf River areas. The driller's notes from the USGS wells indicate silty gravel is the first encountered saturated

material, similar to the silty gravels observed north of Batiste Spring. The Indian Spring Trout Farm drill log indicates that the first saturated zone is a confined, gravel unit approximately 12 feet thick, and the deeper gravel unit is flowing artesian, discharging 75 gpm at the ground surface (Appendix A).

The pump test in Well SWP-5, conducted in 1959, indicated 3 feet of drawdown at a flow rate of 4,000 gpm over 14 hours. The lack of significant drawdown observed at flows in excess of 2 times average production flows indicates an extremely high transmissivity in the area of SWP-5. This is further supported by the 48-hour pumping test at Well SWP-7 conducted on May 13 and 14, 1993, where a transmissivity of 227,000 ft^2/day was calculated. Pumping tests performed in FMC production wells FMC-5 and FMC-6 indicated transmissivities up to 35,000 ft^2/day in the deeper aquifer.

City of Pocatello wells are located within the Pocatello Aquifer east of the EMF site. These wells are screened through "red lava rock" and coarse gravels. Pumping test summaries are included on the well logs in Appendix A. These summaries indicate average flow rate, duration of test, and maximum drawdown observed during the test. In numerous wells, flow rates were greater than 1,000 gpm, the tests lasted 24 to 48 hours, and maximum drawdowns were on the order of 0.5 to 5 feet. This information indicates that the Pocatello Aquifer along the east side of the Portneuf River is prolific and highly transmissive.

Hydraulic conductivities calculated from slug tests performed by Hydrometrics, Inc. in March 1994 are summarized in Table 2. Flow gauging information is summarized in Table 5 and the flow gauging stations are shown in Figure 1.

Computer Code Descripton – Modflow and Modpath

The United State Geological Survey (USGS) MODFLOW finite-difference code (McDonald and Harbaugh, 1988) was used to simulate the groundwater flow. Bechtel's modeling staff has applied this code on many projects, and Bechtel has pre-processing and post-processing programs integrated with the code. The MODFLOW version used for the EMF model included pre-conditioned conjugate-gradient solver PCG2 (Hill, 1990) and the revised block-centered flow package BCF3 (Goode and Appel, 1992).

MODFLOW simulates three-dimensional groundwater flow for a multilayered system. The layers can be simulated as confined, unconfined, or a combination of confined-unconfined. MODFLOW permits simulation of flow associated with hydrologic stresses such as wells, areal recharge, evapotranspiration, drains, and streams. The mesh is composed of rectangular cells each of which have a specified top and bottom elevation (or thickness), specified width and length, and specific hydraulic properties (hydraulic conductivity and specific yield or storativity). Flow between layers is determined based on a "leakance factor," which is calculated from the vertical hydraulic conductivities and saturated thicknesses of the adjacent layers. MODFLOW can simulate either steady-state or transient conditions. For this study, generalized steady-state conditions were used.

Model cells can be specified as constant-head, no-flow (inactive), or variable head (active). Areal recharge occurring as a result of precipitation that percolates to the groundwater system or occurring as pond leakage can be applied at individual cells. Ponds and streams can be specified as constant-head cells or as "river" cells, in which a conductance factor determines the flow entering or leaving those cells. "Drain" cells simulate the effect of springs where flow out of a spring occurs only when the head in a layer rises above the specified spring elevation.

Groundwater flow paths are plotted using the USGS code MODPATH. This computer code is a post-processor that uses MODFLOW input and output files to plot "particle tracks." These particle tracks are defined by the cell-to-cell flow rates and hydraulic heads as the particle moves through the model domain. Time steps of these particles can be generated since the particle velocities (distance/time) are also described.

Use of MT3D (a numerical solute transport model) was considered as a tool in the modeling study. The investigators realized that a numerical solute transport model would require difficult calibration, numerous uncertain inputs, and possibly additional inputs to MODFLOW. These are time-consuming and resource-consuming tasks which were not needed for the purpose of estimating fluxes. Thus, with respect to the needs of the remedial investigation, MT3D modeling would not provide additional or more accurate information than that developed by the more direct methods used. Some of the factors relating to the decision not to use MT3D are described below.

Because it is not possible to accurately quantify each source contribution, solute flux calculations based on MT3D would be subject to considerable uncertainty. Apportioning constituent loadings amongst many potential sources would be difficult due to operational

changes over the RI period (i.e., pond closures, changes in gypsum stack slurry application, etc.).

The uncertainty associated with source loadings is compounded by the limitations of the flow model to accurately simulate groundwater conditions in the southern parts of the model area, where many of the potential sources are located. Simplifying assumptions were used for the southern model area; problems in meeting calibration targets for this area are noted in Appendix K of Part II of the RI Report.

Chemical species identified as emanating from various EMF facilities, including a wide variety of existing and inactive sources, fall generally into two categories; they either precipitated/adsorbed within the unsaturated zone or were transported in groundwater without much apparent attenuation by chemical processes. Radiological constituents are associated with volcanic rocks of the Bannock Range and their occurrence in groundwater is not related to the releases to groundwater from the EMF facilities. Hence, modeling of reactive solute transport was considered to be unnecessary.

Groundwater Flow Model Construction

Conversion of the conceptual model into a numerical model involves interpretations of large amounts of data. It also requires numerous simplifications and assumptions regarding the current understanding of the flow system. The overall impact these simplifications have on the flow model was assessed during model calibration and the sensitivity analysis. The simplifications and assumptions that have been implemented are described in this section.

4.1 MODEL BOUNDARIES

Several factors influenced the selection of model boundaries (Figure 1). The southern model boundary was selected within the Bannock Range and south of the FMC old pond area to reduce potential boundary effects in the FMC and Simplot source areas. The western boundary was selected for the same reason. The eastern boundary extends beyond the Portneuf River to allow for potential underflow and to model the river gain/loss within the model domain rather than have gain/loss dictated by boundary fluxes or heads. The northern model boundary was selected to reflect where the groundwater underflowing the source areas ultimately discharges. This was established at a point along the river north of Batiste Spring.

4.2 MODEL LAYERS - CONCEPTUAL TO NUMERICAL MODEL

Section 2.4 describes two distinct aquifer zones near the former FMC ponds and immediately north of the Simplot gypsum stack. The upper aquifer (upper gravel zone) is confined by an overlying silt unit (upper silt) throughout large portions of the model domain. There is another silt unit underlying the upper gravel zone that is even more extensive throughout the model domain. This lower silt (AFLB) acts as an aquitard for the deeper aquifer, which consists of gravels and basalt. Neither silt unit is present along the Portneuf River, where thick, highly permeable, unconfined gravels were encountered throughout the saturated zone.

A four-layer, three-dimensional model was developed. The model layers, corresponding geologic formations, and hydrostratigraphic terms are summarized in Table 1.

4.2.1 Model Layer 1

Model layer 1 consists of the upper silt in the Michaud Flats, the upper gravel zone near the Portneuf River, and the volcanics and sediments in the Bannock Range. Although the upper silt unit is not fully saturated throughout its entire areal extent, there are areas where there is a substantial saturated thickness. The upper silt may exert some control

over infiltration from recharge, especially in the old pond area at FMC and the upper gypsum stack area at Simplot (Figure 6). A silt unit was encountered in the well at Indian Springs Trout Farm, indicating a localized presence of an upper silt along the Portneuf River. However, these silt lenses were not incorporated into layer 1 around the Indian Springs Trout Farm well, due to uncertainty regarding the well location and the absence of the upper silt in other borings east of the Portneuf River.

Vertical hydraulic conductivities of the silt were based on falling head permeability laboratory tests, conducted on numerous silty soil samples collected for the Pond 8S modeling study (BEI, March 1993). These values range from 0.00039 to 24.66 ft/day. Horizontal hydraulic conductivities of the silt were assumed to be an order of magnitude greater than the vertical hydraulic conductivity yielding values ranging from 0.283 to 0.71 ft/day.

Within the Bannock Range, layer 1 was defined along the south boundary as a homogeneous layer with the base elevation defined as 50 feet below the groundwater levels. This is a simplification made for modeling purposes. The elevations of layer 1 were then contoured from the elevations along the southern boundary to the elevations of the base of the silt unit further north. Although layer 1 in the model permits saturated flow in the Bannock Range area, it should be noted that there are potentially large blocks of impermeable rhyolite present. There are insufficient data to accurately map interflow zones that may transmit groundwater and properly assign hydraulic characteristics to theses zones. In the model, layer 1 in the Bannock Range was assigned a low hydraulic conductivity value (0.283 ft/day) to impede groundwater flow and to partially simulate the effects resulting from low permeability rhyolite and basalt flows. A higher hydraulic conductivity was assigned to a region within the Bannock Range associated with the sediment-filled stream channel along the FMC-Simplot fenceline. This region was assigned a hydraulic conductivity of 0.71 ft/day based on slug test results from Wells 301 and 304.

4.2.2 Model Layer 2

Model layer 2 incorporates the upper gravel zone throughout the Michaud Flats and Portneuf River. In the Bannock Range layer 2 is similar to layer 1, being best described as low permeability bedrock with a higher permeability zone associated with the sediment-filled stream channel. Hydraulic conductivity zones for layer 2 were mapped for the model domain using slug test results and pumping test results (Figure 4). Lithologic information from boring logs was also used to confirm the hydraulic conductivity zones in layer 2. There is a strong correlation between the decreasing

hydraulic conductivity values and the increasing silt content of the aquifer material described on the boring logs.

Layer 2 also includes parts of the Bannock Range.

4.2.3 Model Layer 3

This layer describes the lower silt unit or AFLB, which is present in numerous well logs throughout the model domain in the Michaud Flats area. Silt was not encountered in wells drilled adjacent to the Portneuf River south of Batiste Spring nor in the wells drilled 150 feet north of the spring. It is present around the Simplot production wells and beneath the FMC old ponds and is also present in wells north of the freeway.

Layer 3 in the Bannock Range is similar to layers 1 and 2 in that it was defined as having a thickness of 50 feet along the southern model boundary. The elevations of layer 3 were then contoured from the elevations along the southern boundary to the elevations of the base of the lower silt unit further north.

Hydraulic conductivities for the silt were determined from the model calibration and compared to the hydraulic conductivities used for the upper silt (layer 1 of Table 2). Hydraulic conductivities for the gravel zones that lie within the Portneuf River area were based on slug test and pumping test results.

Figures 5 and 7 illustrate the contours on the top of the lower silt and the bottom of the lower silt, respectively. Figure 8 is an isopach map showing mapped thicknesses of this silt.

4.2.4 Model Layer 4

Layer 4 includes the deeper gravel and bedrock portions of the deeper aquifer. Because these are hydraulically interconnected, transmissivities were used for layer 4 rather than defining hydraulic conductivities and aquifer thicknesses for the deeper gravels. In effect, the deeper gravels and the underlying basalt aquifer were modeled as a single layer. Base elevations of this aquifer were estimated for plotting particle tracks, but these elevations do not necessarily define the base of the deeper aquifer.

In the Bannock Range, layer 4 was assigned higher permeabilities than those assigned to layers 1, 2, and 3. From the available information, it appears groundwater flowing through the Bannock Range flows through deeper interflow zones or through the higher permeability sediments of the sediment-filled stream channel.

Figure 9 shows the distribution of measured hydraulic conductivities and estimated transmissivity in the deeper aquifer. Reported transmissivities in the deeper aquifer are up to 440,000 ft^2/day (Jacobson, 1982). Values of 220,000 to 280,000 ft^2/day appear to be more representative for the deeper aquifer in the Michaud Flats area (Table 2).

4.3 MODEL GRID

The model grid is shown in Figure 10a. This grid is dense (50-foot by 50-foot cells) in the region encompassing Batiste Spring, Swanson Road Spring, the Simplot production wells, and the Portneuf River area. This area appears to be a region of strongly convergent flowpaths, making a dense grid spacing imperative for resolving the flowpaths. At FMC, the cells are 100 feet by 100 feet, again to resolve the converging groundwater flowpaths. This spacing is wider since the converging flow does not appear to be quite as strong and the groundwater flow velocities appear to be significantly less in these areas of the model domain.

Grid spacing in the Bannock Range and near the model boundaries is coarser for several reasons: the amount of data to constrain the model in these areas is limited, flowpath resolution near the boundaries is less critical, and the larger grid spacing increases computational efficiency.

The dense grid spacing in the interior model domain can be supported for the upper zone given the density of borings, slug tests, pumping tests, head measurements, and other observations. There are less data to confirm the hydraulic parameters for the deeper aquifer.

4.4 BOUNDARY CONDITIONS

For steady-state modeling, MODFLOW requires either a constant flux for each cell at the model boundary, a constant head, or no flow. Constant head boundaries were generally used, since estimating fluxes along the boundaries would have contributed additional uncertainty to the model (Figures 10b-e). Boundary heads along the northern model boundaries were established using data collected in 1981 and 1987 and the June 1994 shallow groundwater contours (Figure 3b). Southern model boundary heads were established using data collected in 1993 and 1994 (Figures 3a, 3b and 11a).

Portions of the boundaries along the Portneuf River and Bannock Range were assigned no flow sections where flowpaths were considered to parallel the model boundary. Boundaries of layers 1 and 3, where represented as silt, were also assigned as no flow (Figures 10b and 10d), since the flux would be significantly less than that through the gravels in layers 2 and 4, and also to allow the model to calculate vertical gradient

across the silt based on heads in the gravel layers. Where constant heads were used along the eastern model boundary, heads were defined by water levels in Wells 512 and 513, two gravel pits with standing water at surveyed elevations, and City of Pocatello Wells #18 and #32. The water in the gravel pits was assumed to be in hydraulic communication with the upper gravels and representative of water table conditions.

The southern boundary heads are defined by the Idaho Power well (Kinport), Wells 301, PEI-1, and PEI-5. Wells PEI-1 and PEI-5 provided observed heads for layers 1 and 2, and Well 301 and the Idaho Power well were used to set boundary heads for layers 3 and 4. Wells PEI-1 and PEI-5 were abandoned in 1992. Groundwater contours for the deeper aquifer were contoured through the Bannock Range using very limited data and should not be regarded as a well-defined interpretation of water levels in deeper saturated zones throughout the Bannock Range.

Even though there is sparse information regarding the boundary heads along the southern boundary, this boundary has little overall impact on the flow model due to low hydraulic conductivities, as illustrated in the sensitivity analysis in Section 5.3 of this report.

Northern and western boundary conditions were set after drawing "composite" groundwater contour plots using Geraghty and Miller's 1981 groundwater data, USGS 1981 and 1987 data, and the August 1993 and June 1994 data collected from the EMF monitoring network. This compositing of data might have significant effects on the model solutions if the 1981 data were significantly different than the August 1993 data. Long-term hydrographs from FMC TW-series wells indicate that 1981 water levels were approximately 0.5 to 4 feet higher than the August 1993 heads and model boundary heads along the northern and western boundaries were lowered to best reflect current conditions.

4.5 RIVER AND SPRINGS

Surveyed elevations along the Portneuf River were used to define the river stage elevations through the model domain. Survey points include the Highway 30 bridge, the Batiste Lane bridge, the Simplot pipeline overpass, and a point near the Rowlands Creamery. The river stage elevations were measured in June 1994. Conductance through the riverbed was estimated from the vertical hydraulic conductivity of silts and an assumed thickness of the riverbed along the losing portion of the Portneuf River. Conductance along the gaining portion of the river was estimated from vertical hydraulic conductivities of coarse gravels.

Springs along the Portneuf River were modeled using drain cells set at surveyed elevations. These elevations were surveyed for Batiste Spring, Swanson Road Spring, and several others further north. Elevations for springs along the east bank were not available for this study but were assumed equivalent to the elevations of Batiste and Swanson Road Springs. Drain cell conductances were estimated based on initially assumed horizontal hydraulic conductivities of the drain cells.

4.6 PRODUCTION WELL FLOW RATES

Average flows from production wells at FMC and Simplot have been documented through water budgets at the FMC plant and through measured flow rates at Simplot production wells. Table 4 summarizes the long-term average flow rates for the FMC and Simplot production wells. Table 4 also summarizes the USGS data available for well yields of local irrigation wells. An average of these flows was assigned to irrigation wells within the model domain. Wells screened in more than one aquifer zone (SWP-4) have production rates proportioned to each zone based on the ratio of transmissivities estimated for each zone.

While irrigation well usage varies seasonally, the production rates from the Simplot and FMC wells are fairly constant. Simplot and FMC have varied their overall production well pumping scheme over the years, with Simplot making changes as recently as November 1993, when SWP-7 was brought on-line and SWP-4 was taken off-line as a main production well. FMC has used various combinations of production wells, pumping from a combination of two or more wells at any given time. The overall production rate has been constant since the late 1970s when FMC began recycling process water and pumping less groundwater for production needs.

4.7 RECHARGE RATES

As discussed in Section 2.3.2, the average recharge from precipitation was estimated to be 1.09 inches per year. Recharge from Pond 8S (when it was active) was estimated from a previous study (BEI, 1993) as 15.3 gpm. This same rate was used for the IWW ditch. No additional recharge was simulated for the Taghee Canal or irrigated farmland. The impact these simplifications had on modeling results were tested in one of the sensitivity cases (Appendix B). At the upper gypsum stack, 500 gpm were assumed to be recharged under steady-state conditions over the western half of the gypsum stack. All recharge values used in the model simulations are summarized in Table 6.

Model Calibration

The flow system at EMF is known to vary over time in terms of regional seasonal water level changes. There are also changes in groundwater flow related to the stage of the Portneuf River, annual precipitation, and groundwater extraction rates. However, the general groundwater flow patterns do not seem to change markedly with time. Defining conditions that represent long-term averages for groundwater flow are critical for obtaining an accurate numerical solution to groundwater flow. The first step is defining long-term average conditions of salient features in the flow system that impact flow patterns and transport pathways.

The model was calibrated using the scenario where Simplot production wells SWP-4 and SWP-5 were pumping and initial target heads in the aquifers were those measured in August 1993 (Figure 3a). The four-layer flow model was developed in stages. For the numerous runs conducted during calibration, a simplified two-layer model was first developed. This two-layer model used a simpler description of the silt beds in the model domain for increased computational efficiency. In the two-layer model, the upper silt was included as a confining elevation for the upper gravel unit and the lower silt was included as a leakance term between the upper gravel and the deeper aquifer. Final model runs were performed using the four-layer model. The two-layer model was used for the sensitivity analysis. Simulated contour patterns for the two-layer and four-layer models are similar for the upper gravel unit and the deeper aquifer.

5.1 CALIBRATION TARGETS

Calibration targets were prioritized into two categories; those terms that define the primary features of the flow system throughout the study area, and those terms that define local features. Primary features of the flow system are: observed contour patterns, vertical head differentials, and river/spring discharge rates. Local features are: measured heads at individual wells and estimated underflows along the southern model boundary. Section 5.1.1 through 5.1.5 present specific calibration targets.

5.1.1 Contour and Flow Patterns

General flow patterns beneath the EMF site have been characterized and constrained using numerous wells with quarterly water elevation measurements, contour plots, and geochemistry data for numerous constituents. Where groundwater gradients are relatively flat (north of Simplot and west of FMC) the water chemistry helped resolve subtle changes in flow patterns.

The calibration targets for the flow model in terms of flow patterns are: the modeled contour patterns must reflect the converging flow pattern through the north-central FMC area, with Michaud Flats groundwater flowing east-southeast and Bannock Range groundwater flowing north-northwest prior to entering this zone (Figures 3a and 3b). The gypsum stack influences should be evident as far west as Well 142 but there should be no flow patterns that indicate

transport from the gypsum stack to Wells 305, 328, PEI-4, or PEI-6. The model should also show a flow pattern that restricts northward flow through Wells 502 and TW-11S because the historic chemistry data indicate these wells are not impacted by site-related constituents. The general flow pattern of a thermal plume detected in Wells 108 and 146 must also be apparent in the simulated flow patterns. Flow patterns must also show a source/sink relationship between known EMF sources and Batiste and Swanson Road springs, because water chemistry data indicate that these springs are impacted by site-related constituents.

5.1.2 Vertical Head Differentials

The primary calibration targets for vertical head differentials are areal distribution and direction of vertical gradients. In other words, the simulated vertical gradients between layer 2 and layer 4 (upper gravel and deeper aquifer) must be the same direction as the average observed gradient at each well pair. The overall magnitude of the simulated head differentials must be of the same order of magnitude as observed gradients.

5.1.3 River and Spring Discharge Rates

The average measured river gain through the model domain is approximately 81 cfs (cubic feet per second), including spring discharges but not including discharges to the river from the STP, FMC IWW discharge, irrigation returns, or any other external discharges (Table 5). Simulated river discharge must fall within 10% of the average measured river gain through the model domain. Discharge at drain nodes coincident with Swanson Road and Batiste Springs should also be within 10% of the observed discharge rates. In specific terms, the calibration targets are 73 to 89 cfs for total river and spring discharges, 3.6 to 4.6 cfs for Swanson Road Spring, and 5.2 to 6.3 cfs for Batiste Spring. The derivation of these targets is discussed below.

Total river discharge was calculated using the average flow increase over five monitoring periods from the Batiste Lane Bridge (Station 16) to north of the model boundary (Station 10). The average gain in river flow between these points was pro-rated or length-averaged over the portion of the river within the model domain. Stations 16 and 10 are approximately 5,000 feet apart and Station 10 is approximately 1,250 feet north of the model boundary. Assuming an even gain in the river per unit length, approximately 75% of the river gain observed between Station 10 and 16 occurs in the river reach incorporated in the flow model. The observed average river gain is 127 cfs and 75% of this is 97.5 cfs. Subtracting external discharges to the river between the flow monitoring points, the total average groundwater discharge to the river and springs is approximately 81 cfs (Table 5).

The length-averaged river gain was further supported by flow measurements collected on June 22, 1994. These flow measurements indicated a river gain of approximately 78 to 111 cfs between the Simplot pipeline overpass and the north boundary of the model area (Table 5).

Batiste Spring discharges approximately 5.7 cfs and Swanson Road Spring discharges approximately 4.2 cfs (Table 5). Swanson Road Spring discharges through a short, narrow channel directly to the Portneuf River. Batiste Spring discharges to a channel that flows parallel to the Portneuf River and ultimately enters the river near the northern flow model boundary. It appears that groundwater discharges to the spring channel as underflow because there is a distinct increase in flow rates from the discharge weir at the spring house to the point where the spring channel discharges to the river. Flow in the spring channel where it discharges to the river was measured at 12 cfs in June 1994.

5.1.4 Heads at Individual Wells

Recent mean water elevations at shallow and deep monitoring wells were calculated using the four quarterly measurements from June 1994, March 1994, December 1993, and August 1993. Hydrographs were plotted using all available water level measurements for each monitoring well at the EMF site through March 1994 (Appendix C). In general terms, the water level trends reflect seasonal changes with lower water levels in summer months due to increased irrigation pumping and decreased net recharge while fall, winter, and spring water levels are typically higher. There are specific regions where the hydrographs show distinctly different characteristics.

In the western region of the model domain (100-series wells and TW-series wells), the hydrographs appear to reflect seasonal trends, with an annual low in the summer months. Typical historical fluctuations are on the order of 1 to 3 feet (Figure 12a). Wells located along the Portneuf River and north of Simplot have seasonal variations, but these variations are not as consistent as those observed in the western region. Water level fluctuations are typically on the order of 1 to 1.5 feet (Figure 13).

Wells located within the Simplot facilities appear to be influenced by the gypsum stack operations and the Simplot production wells. Given the temporal variations in gypsum stack operations and the production well usage, the water levels in these wells do not show seasonal trends. Water levels fluctuate in wells near the gypsum stack up to 40 feet or more, whereas in wells located near the production wells the water levels fluctuate on the order of 1 to 1.5 feet.

Based on the ranges of fluctuations and the mean values of observed water levels, the calibration targets were defined as follows:

- Wells Located West of the FMC-Simplot Fenceline — Modeled water levels should be within 2 feet of the observed range for the upper gravel zone and deep aquifer. For wells located near the Bannock Range/Michaud Flats transition or wells nearest the flow model boundaries, these criteria are relaxed. In these cases, if modeled heads provided an accurate representation of the contour patterns, this was deemed acceptable (Figures 12a, 12b, 14a and 14b).

- Wells Located Adjacent to the Gypsum Stack in Low Permeability Bannock Range Aquifer Materials — As described earlier, the differences between actual gypsum stack operations and the way these operations were simulated in the flow model may lead to discrepancies between simulated water levels and observed data. Therefore, no definite calibration targets were specified for wells located adjacent to the gypsum stack.
- Wells Located Near the Simplot Production Wells — Modeled water levels should be within 2 feet of the recent mean water level since wells in this area show less overall fluctuations through time (Figures 13, 14a and 14b).
- Wells Located Along the Portneuf River and North of Simplot — Modeled water levels should be within 2 feet of the recent mean water level since wells in this region have lesser fluctuations through time (Figures 12b and 13b).

5.1.5 Flux Through the Southern Model Boundary

As discussed in Section 2.1.1, the source of groundwater underflow into the model domain through the southern boundary is recharge within the relatively small watersheds of the Bannock Range. This recharge was estimated using the total combined area of these watersheds defined by surface topography and assuming an upper limit of recharge equal to 1.5 times the recharge estimated for the Michaud Flats based on the assumption that higher elevations may receive greater amounts of precipitation. This crude estimate yields an underflow rate of approximately 3 cfs across the model's southern boundary. The calibrated model's simulated underflow should be within a factor of three of this estimated underflow. Greater or lesser amounts of underflow may have significant impacts on flow patterns, simulated fluxes, and subsequent transport modeling of EMF-related constituents.

5.2 CALIBRATION RESULTS

This section presents the groundwater flow modeling results and compares the model output to observed data. In general, the flow model satisfies the calibration targets described in the previous section.

5.2.1 Contour Patterns – Upper Gravel and Deep Aquifer

The modeled contour patterns for groundwater elevations below 4,400 feet in the upper gravels are somewhat similar to those developed by interpreting the observed data (Figures 3b and 15). There is a distinct flow convergence zone in the north-central FMC area and in the eastern Simplot area. Modeled contour patterns for groundwater elevations above 4,400 feet in the Bannock Range and along the FMC/Simplot fenceline are a crude approximation of interpreted contours. This is due primarily to the sensitivity of these contours with respect to interpreted transitions between the highly contrasting hydraulic conductivity zones.

The modeled groundwater contours reflect the increasing horizontal gradients observed north of the FMC – Simplot fenceline; however, the magnitude of the gradient increase is not as great in the modeled contours when compared to the observed data. This may stem from an overestimation of the hydraulic conductivity at FMC (modeled heads slightly lower than observed) and an underestimation of hydraulic conductivities in the area immediately north and west of the Simplot production wells (modeled heads slightly higher than observed). This was explored during the calibration process and it was determined that the selected hydraulic conductivities best reflect heads for long-term average conditions. These heads were slightly higher, on average, than the recent mean values, and in some cases slightly higher than the observed range of values.

The modeled contour patterns in the deeper aquifer are very similar to those interpreted from recent and historic data (Figures 11a, 11b, and 16). There is a pronounced "sink" or low point in the contours associated with the river discharge zone near the I-86 bridge, Batiste and Swanson Road springs, and the Simplot production wells. There is also a small cone of depression associated with the FMC-3 production well.

Simulated contours for both the upper gravel zone and the deeper aquifer show the effects of the boundaries between low permeability Bannock Range material and higher permeability Michaud Flats and Portneuf River aquifer materials. These effects display the sensitivity of the model output to interpretations made when preparing the hydraulic conductivity maps. The contours in the Bannock Range indicate fully saturated conditions throughout the model layers which is a simplification of a very complex flow system. There are very few wells to verify water levels in each model layer throughout this region.

5.2.2 Vertical Gradients Between Upper Gravel Zone and Deep Aquifer

The flow model, as described by the input parameters in Section 4 and related figures, satisfies the calibration targets for vertical gradients. Vertical head differentials between the deeper aquifer and upper gravel zones are very consistent with the observed data in terms of the distribution and direction of these gradients; however, the modeled head differentials are approximately one-half the observed head differentials near the FMC – Simplot northern fenceline area at well pairs 109/110, 330/331, 311/312 and 309/310 (Figure 14c). The modeled head differentials are lower than observed head differentials due to the higher modeled heads in the upper zone throughout this area (Table 3).

The modeled vertical head differentials along the Portneuf River are in very good agreement with the observed values. There are slight differences in heads between shallow and deeper gravels where the Portneuf River is considered a losing stream (Well pairs 510/511, 506/507, 508/509; Table 3), with a distinct increase in vertical gradients associated with the gaining reach of the river near well pairs 504/505 and 503/519 (Table 3).

5.2.3 River and Spring Discharge Rates

The calibrated model scenario yielded a river and spring combined discharge of 74 cfs compared to an average discharge of 81 cfs observed through the model domain (Table 5). River losses to the aquifer in the flow model were negligible, on the order of 1 cfs, which is in agreement with the measured flows in the losing reach of the river that show the river loses approximately 2.6 cfs (± 4.9 cfs) from the Highway 30 bridge to the Simplot pipeline overpass.

The four–layer model discharges much less water to the drain cells that represent Swanson Road and Batiste Springs than the reported flow rates at these springs (4.2 cfs and 5.7 cfs, respectively). During calibration with the two-layer model, approximately 3 cfs were discharging at the drain cells that represent these two springs (combined flow of approximately 6 cfs). Discrepancies in flow apportioning between the four–layer flow model and the two–layer flow model arise due to the complexities associated with assigning base elevations to drain cells and vertical conductance terms between layers in the four–layer model. Drain cells (springs) were assigned base elevations defined by the midpoint between the river elevation and the riverbed elevation in the four-layer model. In many cases this provided only 1.5 feet of saturated gravels supplying horizontal flow to the spring cells. In the two–layer flow model, the base elevations of the drain cells were defined by the base elevation of the upper aquifer zone, permitting horizontal flow through the drain cells over a much greater saturated thickness.

These discrepancies between the two–layer and four–layer model support the concept that the springs are most likely discharging groundwater flowing through the upper 5 to 15 feet of saturated gravels while deeper groundwater is discharging through the riverbed directly into the Portneuf River. Horizontal groundwater fluxes through the upper 1.5 feet of saturated gravels, as depicted in the four–layer model, do not supply the volume of water that actually discharge from the springs and additional groundwater is most likely supplied to the springs from a vertical flow component.

5.2.4 Modeled Heads vs Observed Heads in Monitoring Wells

In an earlier section, it was indicated that modeled heads vs. observed heads were specified as secondary calibration criteria; more emphasis was placed on modeling contour patterns and discharge rates. If contour patterns are accurately simulated near the known source areas and known discharge areas, accurate flowpaths will be simulated and the simulated water level at an individual well becomes less critical. For example, if the model predicted water levels 10 feet higher than observed water levels at wells near Swanson Road Spring, this would have major impacts on the simulated contour patterns and flowpaths; if the criterion used for contour patterns is met, the simulated water level near Swanson Road Spring cannot exceed observed water levels by 10 feet; however, it may exceed observed water levels by 2.25 feet (the target is 2.0 feet).

The modeled heads were compared to the calibration targets discussed above (Figures 12(a, b), 13, and 14(a-c)). Modeled water levels in shallow wells located west of the FMC – Simplot fenceline were within 2.0 feet of the historic range measured at all wells except Wells 101, 110, and 516 (Table 7). At Well 110, the modeled water level was 3.10 feet above the recent mean value, and at Well 101 the modeled head was 4.57 feet above the recent mean value. At Well 516 the modeled head was 4.46 feet higher than the recent mean.

Modeled heads further east and north of Well 101 are within the specified ranges and therefore, the modeled head at Well 101 was not deemed critical in terms of impact on modeled groundwater flow patterns and fluxes. The modeled head was within 3.2 feet of the historic range of water levels. Modeled heads at Wells 110 and 516 were higher than previously observed values by 2.84 and 4.21 feet, respectively. These wells lie within the area where gradient steepens between the Simplot and FMC facilities. Small errors in the interpretations of the hydraulic conductivity zones, aquifer thicknesses, and hydraulic conductivity values may have all contributed to the head residuals at these wells. Overall impact on the flow model is minimal in terms of contour patterns, flowpaths, heads in nearby wells, and discharge to the river and to the springs.

Modeled heads in shallow wells near the Simplot production wells were within 2.0 feet of the recent mean values with the exception of Wells 312 and 331. These wells had modeled heads that were 2.48 and 2.22 feet higher, respectively, than recent mean values. At both points, the modeled heads were within 2.5 feet of the historic observed range. Since Well 331 was within 2.0 feet of the observed range and Well 312 is near the transition between the Bannock Range and Michaud Flats, and since the modeled heads had no significant impact on overall contour patterns, these modeled water levels were deemed acceptable.

Shallow Wells 328, 507, 509, and 511 are located near the Portneuf River and all had modeled water levels that were greater than 2.0 feet that recent mean and 2.0 greater than the observed maximum water level. The modeled water levels were 2.32 feet, 2.96 feet, 2.43 feet, and 2.71 feet above the historic maximum. In deep Wells 506, 508, and 510 the modeled water levels were 2.96, 2.49, and 2.80 feet higher than the recent mean water levels (Table 8). The impact this has on the flow model and overall flow patterns is minimal since wells closer to the Simplot production wells, springs, and source areas all have modeled water levels within the specified calibration ranges. In addition, the vertical head differentials were accurately modeled throughout this area.

Shallow monitoring Wells 307, 313, and 323 are located within the Bannock Range area adjacent to the Simplot gypsum stack. The modeled heads were -5.70 feet, 9.95 feet, and 12.92 feet different from the recent mean, respectively. These were accepted due to the manner in which gypsum stack operations were simulated.

Monitoring wells located in the Bannock Range area in deeper saturated zones were not within the historic observed ranges (Wells 142, 300, 301, 304, 305, 306, and 315; Tables 7 and 8). This is due to the complex geology within the Bannock Range which makes it difficult to accurately map hydraulic conductivity zones and assign the proper parameters to each zone. In addition, steady-state gypsum stack conditions were assumed and this will have a major impact on the modeled heads in this area of the flow model. The Bannock Range area also has very steep horizontal gradients and the largest cell dimensions are in the gradient direction, further decreasing the reliability of comparing modeled heads to observed heads. In Sensitivity Run #4, discussed in Appendix B, by simply extending the low permeability zone to the north, including the area of Wells 300, 306, and 305, the modeled heads are very close to the observed values.

5.2.5 Water Balance

The volumetric budget for the groundwater flow model (scenario #2), in cumulative flow rates (cubic feet per day), is presented in Table 9. Examples of model input and output files for scenario #2 are provided in electronic format in Appendix K.

TABLE 9
VOLUMETRIC BUDGET FOR SCENARIO #2, IN CUBIC FEET PER DAY

IN	
STORAGE	0.00000
CONSTANT HEAD CELLS	9.9914E+06
WELLS	0.00000
DRAINS	0.00000
RECHARGE	1.3163E+05
RIVER LEAKAGE	1.1525E+05
TOTAL IN	10.238E+06
OUT	
STORAGE	0.00000
CONSTANT HEAD CELLS	3.4025E+06
WELLS	9.4592E+05
DRAINS	6.2207E+05
RECHARGE	0.00000
RIVER LEAKAGE	5.2672E+06
TOTAL OUT	10.238E+06
IN - OUT	564.00
PERCENT DISCREPANCY	0.01%

5.3 SENSITIVITY ANALYSIS

The uncertainties associated with model input parameters may have significant impacts on model output and subsequent interpretations made on the basis of the model output. The simpler two-layer model was used in this sensitivity analysis. Although the two-layer model does not incorporate as much site-specific data, the general agreement between two-layer model output and the four-layer model output was acceptable, justifying the use of the two-layer model in the sensitivity analysis. The two layer model provided the opportunity to make more sensitivity runs to test the model sensitivity to more input parameters compared with the four-layer model.

A sensitivity analysis was performed to assess the changes in the model output to the uncertainties associated with the input parameters. For this study, the sensitivity runs were made using the input parameters associated with the model scenario 2. That is, Simplot's gypsum stack is assumed to be active, Simplot's production well SWP-4 and SWP-5 are pumping, and FMC's production wells are pumping. In each sensitivity case, one parameter was changed to investigate the relative magnitude of changes in the model output. The simplified two-layer model used for calibration was used for the following six sensitivity runs:

- Sensitivity to the K value (hydraulic conductivity) in model layer 1 (upper gravel zone), in which the river is located;
- Sensitivity to the T value (transmissivity) in model layer 2 (deeper aquifer) immediately beneath the river;
- Sensitivity to the T values assigned to the Bannock range in layer 2 (deeper aquifer; increased overall T);
- Sensitivity to the T values assigned to the Bannock range in layer 2 (deeper aquifer; decreased overall T);
- Sensitivity to natural recharge; and
- Sensitivity to variations in the constant head specified along the eastern boundary.

(Note: The final 4-layer model runs did not simulate extraction of shallow groundwater at the Simplot production wells SWP-4, SWP-5, or SWP-7. The sensitivity runs presented here assumed a 175 gpm extraction rate at SWP-4 and 100 gpm at SWP-5 based on the original flow model (BEI August 1994). The sensitivity analysis was not re-done because it would not affect the conclusions on the model's sensitivity.)

5.3.1 Sensitivity Analysis Evaluation Criteria

Model sensitivity runs were evaluated using the same calibration targets that define long-term average conditions of the groundwater flow system. These are:

(1) River and spring discharge;

(2) Potentiometric head contour patterns in the upper gravel zone and deeper aquifer;

(3) Distribution of vertical head differentials throughout model domain.

In addition, particle tracks plotted from each sensitivity case were compared to the particle tracks from the calibrated model.

5.3.2 Summary of Results

The detailed descriptions and results of the six sensitivity model runs are presented in Appendix B. This section summarizes the key findings of the analysis. Groundwater particle tracks were generated for all six sensitivity runs. The particle starting points were the same for each scenario to illustrate relative changes to groundwater flowpaths associated with each change to the input parameters (Figure 17).

Two key points were apparent after reviewing the results of the sensitivity analysis. First, the selected input parameters for the calibrated model provide the best fit between observed data and simulated groundwater conditions. Second, the general flowpaths illustrated by the groundwater particle paths display some degree of sensitivity to the input parameters, but the overriding factors controlling groundwater flow are still apparent.

For example, in all six scenarios the particle beginning near Pond 8S discharges to the drain cells or river cells between Batiste and Swanson Road Springs. The hydraulic sink formed by the river and springs is the overriding control on these flow patterns regardless of the K zone change, eastern boundary condition, or transmissivity of strata in the Bannock Range.

In two cases (Sensitivity Cases #1 and #3), the groundwater particle through the Michaud Flats north of I-86 veered northward near the Highway 30 and I-86 junction and ultimately discharged at the river near the northern model boundary. In the other four sensitivity cases this particle discharged at the drain cells associated with Batiste Spring. Groundwater flowpaths determined by geochemistry data support the scenarios where this particle discharges at Batiste Spring.

The sensitivity analysis provides a reasonable evaluation of the impact the major assumptions, simplifications, and estimations may have on the general groundwater flow patterns, river discharge, and other model output. Uncertainty associated with one single parameter did not have an impact so large as to completely alter the general groundwater flow patterns in the upper gravel zone. Large changes made to a single input parameter did have local impacts on groundwater flow patterns but did not cause major changes in groundwater flow patterns throughout the entire model domain.

Model Scenarios

Three groundwater flow scenarios were modeled to represent variations in EMF facility operations and the impact these changes have on steady-state flow conditions. The first scenario represents long-term average, current operating conditions at the facilities. The second scenario represents a long-term average, pumping condition using Simplot production well SWP-4 in place of SWP-7. The third scenario simulates a future scenario where gypsum stack recharge ceases, Pond 8S is closed, and the FMC and Simplot production wells are no longer pumping.

Groundwater particle tracks are plotted for each scenario. Their starting positions are the same for particles starting in the uppermost saturated zone (model layer 1) and the deeper aquifer (model layer 4). Particle tracks initiate at the same points for each scenario to assess the sensitivity of groundwater flowpaths to production well operations. This provides a reasonable estimate of the changes in groundwater transport pathways that may occur as a result of changes in the production well pumping scheme.

The reader is advised not to relate the density of groundwater particle tracks to groundwater fluxes and associated constituent fluxes through the aquifer zones. For example, in the region where particle tracks converge near Batiste Spring and Swanson Road Spring, it can be shown the chemical concentrations are lower in this groundwater than in the groundwater immediately beneath the source areas at Simplot and FMC. The particle tracks indicate the general flowpath groundwater will take through the different regions of the model study area; they do not relate directly to chemical concentrations in the groundwater as it moves from a source area to a discharge area.

There are certain associations between water supply wells and particle tracks that may be misleading. Taken out of context, the particle tracks may be misleading. For example, particles originating from the deeper aquifer beneath source areas are shown to flow into production wells. Groundwater impacts to the deeper aquifer are minimal in terms of concentrations and areal extent. Water sampled from deeper monitoring wells adjacent to these production wells and water samples from the production wells themselves indicate that no production well is pumping groundwater with elevated concentrations of EMF-related constituents. Shallow groundwater particle tracks originating near Pond 8S flow very near the New Pilot House Well. Because this well is pumping from a hydraulically separate deeper aquifer, the constituents associated with this particle are not pumped into the New Pilot House Well.

6.1 SCENARIO 1: SIMPLOT WELLS SWP-5 AND SWP-7 PUMPING

This scenario illustrates groundwater flow patterns that result from pumping at FMC production wells and Simplot's production wells SWP-5 and SWP-7, using average long-term pumping rates. Groundwater contour plots for the upper gravel zone (model layer 2) and the deeper aquifer (model layer 4) are illustrated in Figures 15 and 16. These contour patterns show a cone of depression in the deeper aquifer as a result of pumping from SWP-5 and SWP-7. There is also a cone of depression near FMC-3 and FMC-1. Contours in the deeper zone illustrate the hydraulic sink or discharge area associated with the springs and Simplot production wells.

Groundwater particle tracks beginning in model layer 1 (Figure 18) illustrate the general flow patterns that were generated from the four-layer model run. The easternmost particle tracks flow to the northwest, beneath the former east overflow pond and change direction to the north-northeast near the northern Simplot fenceline. These particle tracks terminate in the drain cells associated with Swanson Road and Batiste Springs.

Particles initiating in layer 1 at Pond 8S and north of I-86 show little or no horizontal movement through the silt overlying the upper gravel zone. These particles begin horizontal movement upon entering the upper gravel zone (model layer 2). The particle originating in the Michaud Flats moves into model layer 1, where the silt unit pinches out. This particle begins flowing in an east-southeast direction, converging with the particle that originates near Pond 8S, which flows northeast. Both particle tracks terminate in the drain cells associated with Batiste Spring. The particle originating at Pond 8S in model layer 1 tracks near the New Pilot House well, but note that this well is screened in the deeper aquifer (model layer 4). The particle from Pond 8S is not affected by pumping from the New Pilot House well and does not intersect the screened interval.

Shallow particles originating east of the Portneuf River migrate through model layer 1 and enter model layer 2 near the river. This is not indicative of downward vertical migration; rather, it is an effect of the model layer base elevations. Layer 1 base elevations at the drain cells were significantly higher than the base elevations further away from the river. The change in color of the particle tracks indicates that the particles flow beneath the drain cells and discharge at the river.

Particle tracks originating in the deeper aquifer illustrate the effects of FMC and Simplot's production wells in the deeper aquifer (Figure 19). FMC-1 captures deeper, unimpacted groundwater underflowing the Pond 8S area, while the Simplot production wells capture the deeper groundwater that underflows the western and central gypsum stack area. Although Wells SWP-5 and SWP-7 extract over 3,000 gpm of groundwater

from the deeper aquifer, the capture zones are limited due to the high transmissivity. Particle tracks originating from the deeper aquifer east of the Portneuf River flow through the deeper gravels, moving upward into shallower zones as they approach the river and springs. The particles move through model 4 into layers 2 and 3, and ultimately are discharged at the river.

In summary, the particle tracks describe groundwater flow patterns that coincide with those interpreted by Geraghty and Miller (1981) and Jacobson (1984), and the flow patterns are further supported by data collected for the RI (Figures 3b and 11b). FMC's production wells appear to be capturing deeper groundwater that underflows the known source areas.

The shallow groundwater underflowing the former east overflow pond does not appear to be captured by SWP-5 or SWP-7. It ultimately discharges at Swanson Road Spring and possibly Batiste Spring. Shallow groundwater underflowing the old FMC ponds and Pond 8S discharges at Batiste Spring, but does not discharge north of Batiste Spring.

6.2 SCENARIO 2: SIMPLOT PRODUCTION WELLS SWP-4 AND SWP-5 IN USE

Simplot brought SWP-7 on-line in November 1993 for production water, and SWP-4 is now used as a backup water supply well. Well construction details for SWP-4 indicate that the screened interval is significantly shallower than the screened sections of SWP-5 and SWP-7, indicating that past operations may have exerted more hydraulic control in the upper gravel zone than current conditions. This model scenario investigates that possibility. In this scenario, Well SWP-7 was turned off and the equivalent flow rate was assigned to SWP-4.

The simulated heads in scenario 2 are not different in the shallow aquifer (Figure 20) compared to scenario 1 (Figure 15). Simulated heads in the deeper aquifer are slightly different (Figure 21) compared to scenario 1 (Figure 16) in that the cone of depression associated with the Simplot production wells is located at SWP-4.

Particle tracks originating in model layer 1 at Pond 8S, north of I-86, and east of the Portneuf River were not affected by the change in pumping wells at Simplot (Figure 22). Groundwater particle tracks originating east of the Simplot production wells and within the joint fenceline area of the two facilities ultimately terminate at Swanson Road and Batiste Spring.

Particle tracks originating in model layer 4 are slightly different than those plotted for scenario 1 (Figures 19 and 23). In scenario 2, most of the particles originating east of the

Simplot production wells terminate at SWP-4. One of the particles moves from the deeper aquifer into the upper gravel zone and discharges at Swanson Road Spring, bypassing the production wells. In this scenario, it appears that SWP-4 has a large capture zone in the deeper zone to the east and also extracts deeper groundwater underflowing the Bannock Range.

The groundwater particle originating in the deeper aquifer north of I-86 is not deflected to the south as markedly as it was in scenario 1, indicating Simplot production wells SWP-4 and SWP-5 have less influence to the north in the deeper aquifer.

In summary, Simplot's production well pumping scheme appears to have a slight impact on groundwater flowpaths.

6.3 SCENARIO 3: NO PUMPING FROM EMF PRODUCTION WELLS, NO RECHARGE FROM POND 8S OR GYPSUM STACK

This scenario was used to investigate potential changes in groundwater transport pathways upon cessation of plant operations (no production well pumping; no recharge at gypsum stack or Pond 8S). Groundwater contours from this scenario show no major changes in either the upper gravel zone or the deeper aquifer (Figures 24 and 25). The cone of depression associated with the deeper pumping wells at FMC and Simplot are absent in Figure 25. The regional groundwater low point, or hydraulic sink, is still present in this scenario (Figure 25).

The particle tracks originating in model layer 1 (upper gravel zone and silt zone where present) indicate that groundwater underflowing known source areas discharges at Batiste and Swanson Road Springs (Figure 26). The capture zone established by the Simplot production wells is noticeably absent in this scenario; however, the overall changes to the groundwater particle tracks are minimal (Figure 27).

The particle originating at the Pond 8S area follows the same course in this scenario as it did in the two previous scenarios. This indicates that groundwater flowpaths from the FMC source area to the springs is not affected by FMC or Simplot production well pumping. The particle originating north of I-86 converges with the Pond 8S particle track, indicating that the zone where groundwater flow converges is not created by production well pumping. Instead, it is an effect of the aquifer zones described in the previous sections. An important difference between this scenario and the previous two scenarios is evident in the track this particle takes after flowing east toward the river. Beginning at a point near the I-86/Highway 30 junction, this particle migrates almost due north, eventually discharging to the river (Figure 26). In the previous two scenarios this particle discharged at Batiste Spring.

All particle tracks beginning in model layer 4 discharge at the river and springs. No particle track discharges to the local production wells (Figure 27). The regional hydraulic sink formed by the river is the overriding feature controlling groundwater flow patterns.

Summary

The groundwater flow modeling provided the opportunity to explore and quantify the groundwater flow regime at the EMF site. Numerically testing the conceptual model provided additional support for the initial conceptual model presented in the PSCS (BEI, 1994), and also yielded some important changes to the conceptual model.

Key findings of this study are summarized below:

(1) Numerical groundwater flow simulations and evaluation of hydrogeologic data indicate that the groundwater underflowing the EMF facilities is captured by facility production wells or eventually discharges to the Portneuf River through baseflow or via adjacent springs. Shallow groundwater flows northeasterly and discharges to the Portneuf River between Batiste Springs and Interstate 86. Deeper groundwater beneath the facilities is captured onsite by the production wells or flows upward into the shallow aquifer where the American Falls Lake Beds are absent and also discharges to the Portneuf River. Groundwater flowing beneath the facilities does not discharge to either the river or springs north of Batiste Spring.

(2) The Portneuf River is an effective hydraulic barrier. Impacted groundwater does not flow east of the Portneuf River. Impacted groundwater does not flow west or north from the former ponds at FMC.

(3) Fluxes of groundwater beneath known sources are a relatively minor portion of the regional water budget. This finding can be directly linked to groundwater geochemistry data to further characterize transport of EMF-related constituents.

(4) Long-term groundwater quality will not be negatively impacted by future scenarios, especially considering (a) the closure of FMC's Pond 8S, (b) the closure of the former east overflow pond, and (c) changes made by Simplot regarding the manner in which slurry is applied to the gypsum stack.

General groundwater flow patterns that were interpreted from groundwater contour plots and geochemistry data were supported in the numerical flow model. However, the degree of hydraulic control exerted by the Simplot production wells was likely overestimated in the initial conceptual model. The production wells at Simplot do not appear to control off-site migration of the shallow impacted groundwater underflowing the gypsum stacks. While capture may not be achieved in the shallow aquifer, there is a definite flow component from deeper groundwater beneath the gypsum stack area to the Simplot production wells.

The initial data interpretations indicated that the Simplot production wells hydraulically contained FMC-derived constituents from the old FMC pond areas. This

is not supported by the numerical flow model. In all three modeling scenarios, the particle originating beneath Pond 8S does not flow to the Simplot production wells; instead, it discharges at Batiste Spring.

The extent of EMF-related constituents in the upper gravel zone appears confined to areas south of Batiste Spring (see Section 4.4 of RI Report - Part II). The groundwater particle originating north of I-86 discharged at Batiste Spring in two scenarios.

Overall flow patterns are controlled more by the aquifer framework and the Portneuf River, rather than EMF-related activities or irrigation pumping from wells in the Michaud Flats. For example, a convergence of groundwater flow through north-central FMC was simulated even when all pumping from the EMF production wells ceased.

The model did not show shallow groundwater movement from the upper gravel zone (model layer 2) into deeper zones (model layers 3 and 4), providing limited insight into pathways in the deeper aquifer.

The amount of groundwater discharging at the river and springs along the western side of the Portneuf River is a fraction of the amount water discharged to the river from the eastern side, where the Pocatello aquifer is hydraulically connected to the river.

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TABLE 1
SUMMARY OF HYDROSTRATIGRAPHY IN THE EMF STUDY AREA

	HYDROGEOLOGIC REGIMES							
Geologic Formations	MICHAUD FLATS	Aquifer Framework (Model Layer)	NORTHERN PORTNEUF RIVER	Aquifer Framework (Model Layer)	SOUTHERN PORTNEUF RIVER	Aquifer Framework (Model Layer)	BANNOCK RANGE*	Aquifer Framework (Model Layer)
Youngest	Quaternary Loess and Gravel Units	Unsaturated	Quaternary Loess and Gravel Units	Unsaturated	Quaternary Loess and Gravel Units	Unsaturated	Quaternary Loess and Gravel Units	Unsaturated
	Younger Alluvium (possible local lacustrine deposits)	**Upper Silt layer 1**	**Younger Alluvium**	**Upper Gravel layer 1**	**Younger Alluvium**	**Upper Gravel Zone layer 1**	Colluvial and Alluvial Deposits (Present as fill in incised stream valleys)	— layer 1
	Aberdeen Terrace Deposits	**Upper Gravel Zone layer 2**	Absent	—	Absent	—	Absent	—
	Absent	—	**Older Alluvium**	**Upper Gravel Zone layer 1**	**Older Alluvium**	**Upper Gravel Zone layer 2**	Absent	— layer 2
	Michaud Gravel	**Upper Gravel Zone layer 2**	**Michaud Gravel**	**Upper Gravel Zone layer 2**	**Michaud Gravel**	**Upper Gravel Zone layer 3**	Absent	— layer 2
	American Falls Lake Beds (AFLB)	**Lower Silt layer 3**	**American Falls Lake Beds (AFLB)**	**Lower Silt layer 3**	Absent	—	Absent	— layer 3
	AFLB Fluviatile Facies - Sunbeam Formation	**Deeper Aquifer layer 4**	**AFLB Fluviatile Facies - Sunbeam Formation**	**Deeper Aquifer layer 4**	**AFLB Fluviatile Facies - Sunbeam Formation**	**Deeper Aquifer layer 4**	Sunbeam Formation (occurs as sediments between volcanic flows)	— layer 3
Oldest	**Basalt flows (Pleistocene)**	**Deeper Aquifer layer 4**	**Basalt flows (Pleistocene)**	**Deeper Aquifer layer 4**	**Basalt flows (Pleistocene)**	**Deeper Aquifer layer 4**	Starlight Fm (Tertiary Rhyolite)	— layer 4

* Bannock Range Hydrostratigraphy is not correlative with Michaud Flats or Portneuf River Hydrostratigraphy (see text in Section 2).

Key

	Silt and clay aquitard units
	Gravel, sand, and boulder units
	Basalt

TABLE 2

TABLE 2
HYDRAULIC CONDUCTIVITIES AND TRANSMISSIVITIES OF EMF AQUIFER SYSTEM

	Shallow Wells	Hydraulic Conductivity cm/s	Hydraulic Conductivity ft/day	Type of Test	Source
MICHAUD FLATS	104	4.45E-02	126	Slug Test	BEI
	108	1.01E-01	286	Slug Test	BEI
	110	3.80E-02	108	Slug Test	BEI
	111	1.40E-01	397	Slug Test	BEI
	113	1.40E-01	397	Pumping Test	BEI
	126	5.85E-02	166	Slug Test	BEI
	134	1.09E-01	309	Slug Test	BEI
	135	3.15E-02	89.3	Slug Test	BEI
	139	1.90E-02	53.9	Slug Test	BEI
	140	9.70E-02	275	Slug Test	BEI
	146	6.10E-02	173	Slug Test	Hydrometrics
	148	2.45E-02	69.5	Slug Test	Hydrometrics
	150	3.55E-01	1000	Pumping Test	BEI
	153	3.30E-01	935	Slug Test	BEI
	154	1.74E-02	49.3	Slug Test	Hydrometrics
	501	9.05E-02	257	Slug Test	BEI
	514	3.92E-02	111	Slug Test	Hydrometrics
	515	1.05E-02	29.8	Slug Test	Hydrometrics
	516	2.33E-02	66.0	Slug Test	Hydrometrics
BANNOCK RANGE	106	4.30E-03	12.2	Slug Test	Hydrometrics
	142	7.00E-04	1.98	Slug Test	BEI
	300	2.43E-04	0.69	Slug Test	Hydrometrics
	301	1.00E-05	0.03	Slug Test	BEI
	304	4.95E-04	1.41	Slug Test	Hydrometrics
	306	1.17E-03	3.32	Slug Test	Hydrometrics
	307	9.91E-02	281	Slug Test	Hydrometrics
	308	2.51E-02	71.2	Slug Test	Hydrometrics
	313	1.80E-02	51.0	Slug Test	BEI
	316	1.02E-02	28.9	Slug Test	BEI
	323	1.20E-03	3.40	Slug Test	Hydrometrics
	325	5.45E-03	15.5	Slug Test	BEI
	333	9.91E-03	28.1	Slug Test	Hydrometrics
	PEI-2	1.00E-03	2.83	Pumping Test	PEI
	PEI-5	4.50E-04	1.28	Pumping Test	PEI
PORTNEUF RIVER	312	1.40E+00	3970	Pumping Test	BEI
	318	1.40E-03	3.97	Slug Test	BEI
	324	5.45E-02	154	Slug Test	BEI
	327	1.18E-01	334	Slug Test	Hydrometrics
	328	1.84E-01	522	Slug Test	Hydrometrics
	502	1.39E-01	394	Slug Test	Hydrometrics
	503	1.68E+00	4760	Slug Test	BEI
	505	3.66E-01	1038	Slug Test	Hydrometrics
	507	6.40E-01	1810	Slug Test	BEI
	517	7.20E-01	2040	Slug Test	BEI
	518	1.49E-01	422	Slug Test	Hydrometrics

	Deep Wells	Hydraulic Conductivity cm/s	Hydraulic Conductivity ft/day	Type of Test	Source
MICHAUD FLATS	103	5.20E-03	14.7	Slug Test	BEI
	107	2.20E-02	62.4	Slug Test	BEI
	109	5.15E-03	14.6	Slug Test	BEI
	125	7.22E-02	205	Slug Test	Hydrometrics
	133	1.20E-01	340	Slug Test	BEI
	145	2.15E-01	609	Slug Test	BEI
	500	6.70E-02	190	Slug Test	BEI
BANNOCK RANGE	315	1.19E-02	33.7	Slug Test	BEI
PORTNEUF RIVER	311	8.60E-04	2.44	Slug Test	BEI
	317	9.90E-03	28.1	Slug Test	BEI
	319	1.00E-02	28.4	Slug Test	BEI
	321	1.50E-01	425	Slug Test	BEI
	322	2.80E-01	794.7	Pumping Test	BEI
	329	3.65E-01	1030	Slug Test	BEI
	330	5.64E-02	160	Slug Test	Hydrometrics
	504	7.10E-02	201	Slug Test	Hydrometrics
	506	2.30E-01	652	Slug Test	BEI
	512	5.80E-01	1640	Slug Test	BEI
	519	1.59E-02	45.0	Slug Test	Hydrometrics

	Production Wells	Transmissivity (ft^2/day)	Transmissivity (gpd/ft)	Type of Test	Source
MICHAUD FLATS	FMC-6	7370	55130	Pumping Test	BEI
	32ACD1	35100	262550	Pumping Test	USGS
	32DDC1	135700	1015000	Pumping Test	USGS
	33BAA1	21900	163810	Pumping Test	USGS
	33CCD1	41400	309670	Pumping Test	USGS
	34ADD1	40400	302190	Pumping Test	USGS
	34DCC1	36600	273770	Pumping Test	USGS
	35DDC1	164400	1229700	Pumping Test	USGS
	3ACD1	41200	308176	Pumping Test	USGS
	3BDC1	444000	3321100	Pumping Test	USGS
	4BBA1	38500	287980	Pumping Test	USGS
	5BDA1	36800	275260	Pumping Test	USGS
	8ADA1	27300	204200	Pumping Test	USGS
	9CAC1	199000	1488500	Pumping Test	USGS
	12BBC1	54700	409160	Pumping Test	USGS
PORTNEUF RIVER	SWP-7	227270	1700000	Pumping Test	Simplot

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BEI = Bechtel Environmental, Inc., Preliminary Site Characterization Summary for the Eastern Michaud Flats site, January, 1994
PEI = PEI Associates, Inc., Evaluation of Waste Management for Phosphate Processing, April 1985
Hydrometrics = Hydrometrics, Inc., Hydraulic Conductivity Testing of Existing Well Sites at the Eastern Michaud Flats Site, Pocatello, Idaho, April 1994
USGS = United States Geological Survey, Water-Resources Investigations Report 84-4201, Hydrogeology of Eastern Michaud Flats, Fort Hall Indian Reservation, Idaho
Simplot = J.R. Simplot files
FMC = FMC files

Hydraulic conductivity at Well 318 not used in K-zone mapping due to potential precipitation reactions in formation related to mixing of low pH water with groundwater.
Transmissivity at Well 311 not used due to possible grout contamination in filter pack.

TABLE 2 - *continued*
HYDRAULIC CONDUCTIVITIES USED IN EMF GROUNDWATER MODELING STUDY

Boring/Well Identification	Approximate Sample Depth (ft)	Sample Composition	Saturated Hydraulic Conductivity (cm/sec)
140	10.5	Silt	1.7E-6
140	21.0	Silt	4.0E-6
140	30.5	Silt	3.4E-5
140	40.5	Sandy Gravel	7.2E-4
140	61.0	Silt	1.2E-5
140	71.0	Clayey Silt	2.9E-6
140	80.5	Clayey Silt	4.8E-6
149	10.5	Clayey Silt	1.1E-5
149	40.5	Silty Clay	2.9E-6
150	10.5	Silt	1.6E-5
150	20.5	Silt to Silty Clay	4.5E-6
150	30.5	Silt	2.6E-5
150	40.5	Silt	3.8E-6
150	50.5	Silt	9.8E-6
150	60.5	Silt	1.5E-5
150	70.5	Silt	4.4E-6
150	80.5	Silt	8.1E-3
150	90.5	Silt	1.6E-6
150	90.5	Silt	1.6E-6
150	100.5	Silt	7.3E-6
151	16.5	Gravelly Peat	8.8E-6
151	26.0	Silt	7.5E-6
151	40.5	Silt	5.5E-6
151	50.5	Silt	1.2E-5
151	61.0	Silt	2.2E-5
151	69.5	Silty Gravel	8.7E-3
151	80.5	Sandy Silt	6.2E-5
151	91.0	Sandy Silt	2.7E-5
151	101.0	Gravelly, Sandy Silt	5.5E-6
151	111.0	Silt to Silty Clay	4.0E-7
151	116.5	Clay	5.1E-7
B-12	21.0	Silt	5.0E-6
B-12	30.5	Silt	7.0E-6
B-12	40.5	Silt	4.1E-6
B-12	50.5	Sandy Silt	1.9E-6
B-12	61.0	Silty Sand	2.1E-5
B-12	70.5	Silty Sand	3.6E-5
B-12	80.5	Silty Sand	2.3E-5
B-12	96.5	Gravelly Silt to Silty Sand	3.3E-6
B-13	10.5	Sandy Silt	4.0E-7
B-13	20.5	Silt	1.5E-5
B-13	30.5	Silt	1.1E-6
B-13	40.5	Silt	3.3E-6
B-13	50.5	Silty Gravel to silt	2.6E-6
B-13	60.5	Sandy Silt	4.2E-6
B-13	70.5	Sand	1.6E-5
B-13	80.5	Silt	1.1E-5
B-13	90.5	Silt	4.2E-5
B-13	110.5	Clay	1.4E-7

Notes: Laboratory analyses performed by Sergent, Hauskins, and Beckwith.
Sample composition identified from geologic logs in Appendix A of RI Report.

TABLE 3
VERTICAL HEAD DIFFERENTIAL BETWEEN SHALLOW AND DEEP WELL PAIRS

Well Pair	Mean Head Differential	Minimum Head Differential	Maximum Head Differential	Modeled Head Differential	Difference between Modeled and Mean
101/102	0.02	-0.45	0.23	-2.62	2.64
103/104	-0.02	-0.99	0.29	1.59	1.61
107/108	1.15	0.66	2.00	0.78	0.37
109/110	6.31	5.15	8.08	2.50	3.81
117/118	0.40	0.01	0.49	1.56	1.16
125/126	0.70	-0.33	7.70	-2.62	3.32
133/134	0.51	-0.43	4.97	0.21	0.30
144/145	0.24	0.13	0.44	0.81	0.57
309/310	5.03	2.97	5.81	2.13	2.90
312(311/329)	4.96	4.24	5.69	0.98	3.98
315/316	3.84	3.28	4.15	-0.73	4.57
317/318	0.83	0.32	1.07	-0.05	0.88
319/320	3.86	3.04	4.33	0.65	3.21
330/331	3.73	1.09	5.07	1.48	2.25
503/519	1.29	0.71	2.42	1.43	0.14
504/505	3.39	3.62	3.14	1.29	2.10
506/507	0.04	0.01	0.06	0.05	0.01
508/509	0.28	0.25	0.30	0.34	0.06
510/511	0.00	-0.07	0.04	0.09	0.09
512/513	2.11	1.29	2.69	2.14	0.03

Note: Positive head differential indicates upward vertical gradients, negative differentials indicate downward vertical gradients.
Well Pair 125/126 is influenced by pumping from FMC-3. Well Pair 144/145 influenced by former production well FMC-2.

TABLE 4
WELL PUMPING RATES USED IN FLOW MODELING

Well No.	Screened Zone	Scenario 1 Flow Rates (gpm)	Scenario 2 Flow Rates (gpm)	Scenario 3 Flow Rates (gpm)
SWP-7	Deep	2000	0	0
SWP-4	Deep	0	2000	0
SWP-5	Deep	1000	1000	0
FMC-1	Deep	350	350	0
FMC-3	Deep	525	525	0
IRR	Deep	1000	1000	0
Kinport	Shallow/Deep	4	4	0
Lindley	Shallow	10	10	0
New Pilot House	Deep	15	15	0
Williamsen	Deep?	5	5	0
Tank Farm	Deep	1000	1000	0

TABLE 5

TABLE 5
PORTNEUF RIVER AND SPRING FLOW MEASUREMENTS

Station Name		Simulated Discharge Rates (cfs)	Average Measured Flow (cfs)	Error	Range	
					Maximum	Minimum
Gaining Reach of River	North boundary of GW flow model		186*	22	208	164
	Station 10 Downstream of north boundary of GW flow model– Station 10 reflects flow contributed from non-groundwater sources listed below		273		626	152
	Station 16 - Batiste Lane Bridge – Station 16 reflects flow contributed from FMC IWW discharge		142		386	20.2
	Average gain from 16 to 10 (from five flow gauging periods)		127			
	River gain measured on June 22		106		111	78
Losing Reach of River	Upstream - Highway 30 Bridge		67*	3.3	70	63
	Downstream - Simplot Pipeline		64*	5.1	69	59
Springs	Swanson Road Spring	3	4.2*	0.2	4.4	4
	Batiste Spring	7	5.7**			
	Batiste Spring channel at discharge point	12	12***			
Non-Groundwater Derived Flows to River	Pocatello STP		11			
	FMC IWW		1.4			
	Irrigation Return		3			
	Total		15.4			
Flow gain along river through model domain (0.75 x average flow gain from Station 16 to Station 10 minus non-groundwater discharges to river)		74	81			
River flow gain through model domain measured on June 22, 1994		74	78 to 111			

*One value measured on June 22, 1994.
**Value reported in Perry, 1990.
***Twelve cfs measured on June 22, 1994; twenty-one cfs reported in STP study (1989).

[ ] Denotes calibration target

River Flow Measurements						
	Aug-92	Oct-92	Feb-93	Apr-93	Jun-94	Average
Station 10	164	203	152	626	220	286
Station 16	20.2	81	149	386	76	159
River Gain	144	122	3	240	144	127

TABLE 6
RECHARGE RATES USED IN GROUNDWATER FLOW MODEL

Recharge Zone	Recharge Rate (ft/day)	Data Source
Pond 8S	0.024	Pond 8S Solute Transport Study (BEI, 1993). Used net recharge of 15.3 gpm.
IWW Ditch	0.024	Estimated similar to Pond 8S recharge rate.
Gypsum Stack	0.037	Estimated from information supplied by Simplot. Used net recharge of 500 gpm.
Natural Recharge	0.00025	Estimated—10% of mean annual precipitation reported at Pocatello Airport Weather Station. (10.86 inches per year)

(1) In Scenario 3, recharge at Pond 8S, the gypsum stack, and the IWW ditch were assumed to be equal to natural recharge.

(2) See Section 2.4 for discussion of recharge rates.

TABLE 7

TABLE 7
COMPARISON BETWEEN MODELED WATER LEVELS AND MEASURED WATER LEVELS
WELLS SCREENED IN SHALLOW AQUIFER

WESTERN MODEL AREA

Well Number	Modeled Water Level	Historic Low	Historic High	Recent Mean (8-93 to 6-94)	Modeled Water Level Compared to Recent Mean	Modeled Water Level within 2 ft. of Recent Mean?	Modeled Water Level within 2 ft. of Historic Range?	Well Number	Modeled Water Level	Historic Low	Historic High	Recent Mean (8-93 to 6-94)	Modeled Water Level Compared to Recent Mean	Modeled Water Level within 2 ft. of Recent Mean?	Modeled Water Level within 2 ft. of Historic Range?
101	4401.94	4395.73	4398.80	4397.37	4.57	no	no	135	4393.67	4394.17	4397.49	4395.70	-2.03	no	yes
104	4394.55	4395.30	4398.62	4396.66	-2.11	no	yes	136	4391.76	4393.63	4399.15	4395.27	-3.50	no	yes
106	4393.67	4394.69	4397.85	4396.20	-2.53	no	yes	137	4399.27	4395.52	4398.32	4396.99	2.28	no	yes
108	4392.08	4392.36	4395.70	4394.62	-2.54	no	yes	139	4395.46	4394.10	4397.25	4396.03	-0.57	yes	yes
110	4387.48	4383.81	4384.64	4384.38	3.10	no	no	140	4394.19	4393.41	4396.84	4395.28	-1.09	yes	yes
111	4391.92	4391.81	4395.19	4393.40	-1.48	yes	yes	141	4393.83	4394.04	4396.85	4395.56	-1.73	yes	yes
112	4393.58	4393.10	4396.82	4394.99	-1.40	yes	yes	143	4392.65	4393.66	4396.11	4395.25	-2.60	no	yes
113	4397.63	4394.53	4400.65	4396.62	1.01	yes	yes	145	4391.50	4392.36	4394.73	4393.94	-2.44	no	yes
114	4397.30	4394.02	4397.83	4396.44	0.85	yes	yes	146	4390.31	4389.26	4391.12	4390.58	-0.27	yes	yes
115	4396.88	4394.40	4397.73	4396.32	0.56	yes	yes	147	4399.45	4395.28	4398.76	4397.58	1.88	yes	yes
116	4394.63	4394.67	4399.23	4397.38	-2.75	no	yes	148	4398.80	4395.24	4398.62	4397.42	1.39	yes	yes
118	4394.06	4394.83	4398.15	4396.24	-2.18	no	yes	149	4399.56	4395.67	4398.25	4396.84	2.72	no	yes
119	4394.11	4394.89	4397.89	4396.28	-2.17	no	yes	150	4394.18	4395.10	4397.53	4396.51	-2.33	no	yes
120	4394.15	4395.04	4397.92	4396.39	-2.24	no	yes	151	4393.98	4394.07	4396.32	4395.27	-1.29	yes	yes
121	4392.72	4393.28	4396.68	4394.68	-1.96	yes	yes	152	4394.16	4395.10	4397.60	4396.55	-2.39	no	yes
122	4392.15	4392.32	4395.62	4393.94	-1.79	yes	yes	154	4401.16	4396.34	4399.31	4398.12	3.04	no	yes
123	4391.98	4392.66	4396.37	4394.25	-2.26	no	yes	158	4394.46	4396.35	4398.32	4397.33	-2.87	no	yes
124	4397.36	4394.90	4398.41	4396.93	0.42	yes	yes	159	4393.99	4394.12	4396.68	4395.49	-1.50	yes	yes
126	4395.93	4394.27	4397.77	4396.34	-0.41	yes	yes	514	4395.17	4393.66	4396.75	4395.73	-0.57	yes	yes
127	4395.63	4394.18	4398.20	4396.25	-0.62	yes	yes	515	4392.81	4392.24	4396.57	4394.28	-1.47	yes	yes
128	4395.99	4394.22	4398.05	4395.86	0.14	yes	yes	516	4389.55	4384.66	4385.34	4385.09	4.46	no	no
131	4394.65	4394.49	4403.95	4396.08	-1.43	yes	yes	TW-10S	4403.20	4397.23	4402.01	4400.16	3.05	no	yes
132	4394.36	4394.60	4397.59	4396.16	-1.79	yes	yes	TW-5S	4392.37	4393.19	4397.18	4394.36	-1.98	yes	yes
133	4393.37	4391.16	4396.93	4394.77	-1.39	yes	yes								

GYPSUM STACK AREA AND SIMPLOT PRODUCTION WELL AREA

Well Number	Modeled Water Level	Historic Low	Historic High	Recent Mean (8-93 to 6-94)	Modeled Water Level Compared to Recent Mean	Modeled Water Level within 2 ft. of Recent Mean?	Modeled Water Level within 2 ft. of Historic Range?
307	4396.06	4399.02	4402.51	4401.76	-5.70	no	no
308	4394.02	4395.44	4399.88	4397.62	-3.59	no	yes
323	4413.37	4399.42	4400.88	4400.45	12.92	no	no
324	4388.16	4385.90	4386.43	4386.29	1.87	yes	yes
325	4386.91	4383.89	4384.94	4384.70	2.21	no	yes
333	4427.24	4428.62	4429.61	4429.33	-2.09	no	yes
312	4387.37	4383.84	4385.10	4384.89	2.48	no	no
313	4398.11	4386.53	4388.53	4388.15	9.95	no	no
316	4388.44	4386.68	4388.24	4388.01	0.42	yes	yes
310	4389.23	4387.31	4390.48	4389.28	-0.05	yes	yes
320	4386.00	4383.39	4384.24	4384.02	1.98	yes	yes
326	4386.41	4386.28	4388.19	4387.91	-1.50	yes	yes
331	4386.31	4383.78	4384.62	4384.09	2.22	no	yes
332	4387.19	4385.30	4386.13	4385.55	1.64	yes	yes

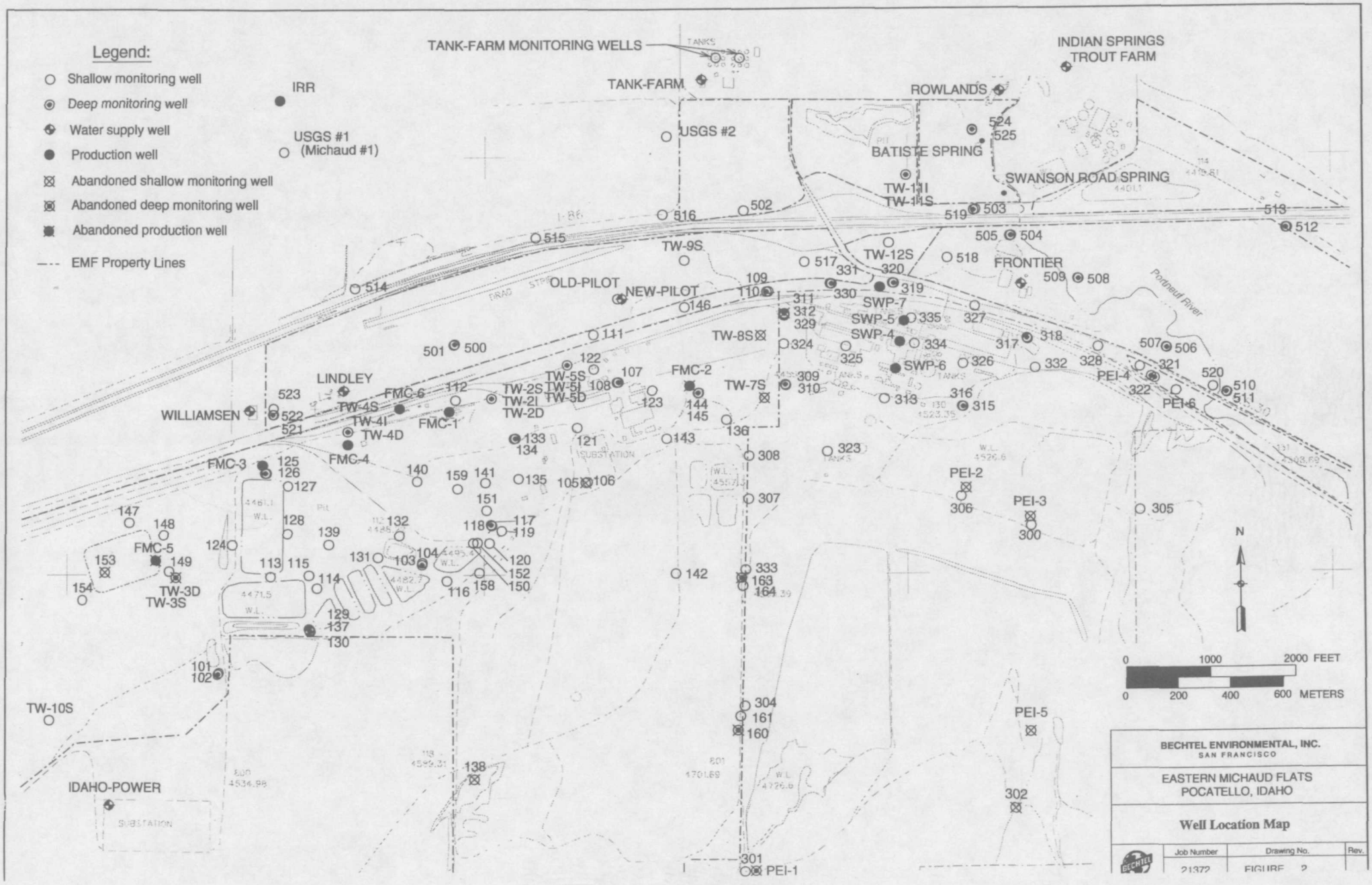
PORTNEUF RIVER AREA AND AREA NORTH OF SIMPLOT

Well Number	Modeled Water Level	Historic Low	Historic High	Recent Mean (8-93 to 6-94)	Modeled Water Level Compared to Recent Mean	Modeled Water Level within 2 ft. of Recent Mean?	Modeled Water Level within 2.0 ft. of Historic Range?
502	4387.22	4383.48	4384.58	4384.00	3.22	no	no
503	4384.64	4383.01	4383.74	4383.45	1.19	yes	yes
505	4385.03	4383.45	4384.24	4383.94	1.10	yes	yes
507	4388.80	4385.25	4386.18	4385.84	2.96	no	no
509	4387.21	4384.27	4385.12	4384.78	2.43	no	no
511	4389.38	4385.92	4387.04	4386.67	2.71	no	no
513	4391.03	4389.62	4390.83	4390.32	0.72	yes	yes
517	4386.39	4383.80	4384.68	4384.30	2.09	no	yes
518	4385.60	4383.61	4384.17	4384.00	1.60	yes	yes
520	4389.36	4386.49	4387.72	4386.97	2.39	no	yes
TW-11S	4384.92	4383.26	4384.24	4383.75	1.17	yes	yes
TW-12S	4385.92	4383.55	4384.50	4384.08	1.84	yes	yes
TW-9S	4389.38	4384.26	4387.37	4384.90	4.47	no	yes
321	4388.79	4385.79	4387.02	4386.66	2.13	no	yes
327	4386.17	4383.57	4384.36	4384.17	2.01	no	yes
328	4387.93	4384.97	4385.82	4385.61	2.32	no	no
318	43[illegible].87	4384.18	4385.13	4384.92	1.95	yes	yes

TABLE 8
COMPARISON BETWEEN MODELED WATER LEVELS AND MEASURED WATER LEVELS
WELLS SCREENED IN MODEL LAYERS 3 AND 4

WESTERN MODEL AREA							
Well Number	Modeled Water Level	Historic Low	Historic High	Recent Mean (8-93 to 6-94)	Modeled Water Level Compared to Recent Mean	Modeled Water Level within 2 ft. of Recent Mean?	Modeled Water Level within 2 ft. of Historic Range?
102	4399.32	4395.56	4398.93	4397.35	1.98	yes	yes
103	4396.14	4395.35	4398.20	4396.73	-0.59	yes	yes
107	4392.86	4393.05	4396.96	4394.84	-1.98	yes	yes
109	4389.98	4388.96	4392.10	4390.54	-0.56	yes	yes
117	4395.62	4395.27	4398.16	4396.66	-1.04	yes	yes
125	4393.31	4393.97	4405.06	4396.06	-2.75	no	yes
129	4397.36	4395.38	4398.32	4396.69	0.67	yes	yes
130	4397.47	4395.57	4398.48	4397.08	0.39	yes	yes
133	4393.59	4393.45	4396.50	4395.29	-1.70	yes	yes
142 (a)	4413.90	4418.77	4422.05	4420.69	-6.79	no	no
144	4392.31	4392.80	4394.89	4394.17	-1.86	yes	yes
500 (b)	4393.80	4375.11	4396.83	4390.44	3.37	no	no
TW-3D	4397.84	4396.20	4401.26	4397.42	0.42	yes	yes
TW-5D/I	4393.06	4393.57	4397.10	4394.72	-1.66	yes	yes
GYPSUM STACK AREA AND SIMPLOT PRODUCTION WELL AREA							
Well Number	Modeled Water Level	Historic Low	Historic High	Recent Mean (8-93 to 6-94)	Modeled Water Level Compared to Recent Mean	Modeled Water Level within 2 ft. of Recent Mean?	Modeled Water Level within 2 ft. of Historic Range?
300 (c)	4390.13	4422.64	4429.78	4423.94	-33.81	no	no
301 (c)	4601.25	4617.68	4620.73	4619.26	-18.01	no	no
304 (c)	4515.86	4551.83	4560.47	4559.07	-43.21	no	no
305 (c)	4390.69	4394.91	4396.95	4396.48	-5.79	no	no
306 (c)	4390.06	4420.46	4423.52	4420.90	-30.84	no	no
309	4391.36	4392.91	4394.54	4394.09	-2.73	no	yes
315 (c)	4387.71	4390.27	4392.31	4392.02	-4.31	no	no
319	4386.65	4386.71	4388.38	4387.85	-1.20	yes	yes
329	4388.35	4388.76	4390.34	4389.72	-1.37	yes	yes
330	4387.79	4385.35	4389.69	4387.89	-0.10	yes	yes
PORTNEUF RIVER AREA AND AREA NORTH OF SIMPLOT							
Well Number	Modeled Water Level	Historic Low	Historic High	Recent Mean (8-93 to 6-94)	Modeled Water Level Compared to Recent Mean	Modeled Water Level within 2 ft. of Recent Mean?	Modeled Water Level within 2 ft. of Historic Range?
317	4386.82	4384.93	4386.14	4385.89	0.93	yes	yes
504	4386.32	4386.64	4387.77	4387.35	-1.03	yes	yes
506 (d)	4388.85	4385.28	4386.24	4385.89	2.96	no	no
508 (d)	4387.55	4384.52	4385.42	4385.07	2.49	no	no
510 (d)	4389.47	4385.85	4387.05	4386.67	2.80	no	no
512	4393.17	4391.69	4393.24	4392.52	0.65	yes	yes
519	4386.07	4383.89	4385.65	4384.74	1.33	yes	yes
TW-11I	4386.85	4386.98	4388.42	4387.95	-1.10	yes	yes

(a) Well located in Bannock Range area; little impact in model interior.
(b) Two out of eight water level measurements suspect; 20 foot differentials noted over one quarter; modeled head actually closer to measured values.
(c) Wells located near gypsum stack in Bannock Range area; heads affected by K zone mapping; little impact in model interior.
(d) Wells located near Portneuf River affected by boundary heads and K values assigned to deeper aquifer; little impact on interior model results.



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SAN FRANCISCO

EASTERN MICHAUD FLATS
POCATELLO, IDAHO

Well Location Map

Job Number	Drawing No.	Rev.
21372	FIGURE 2	

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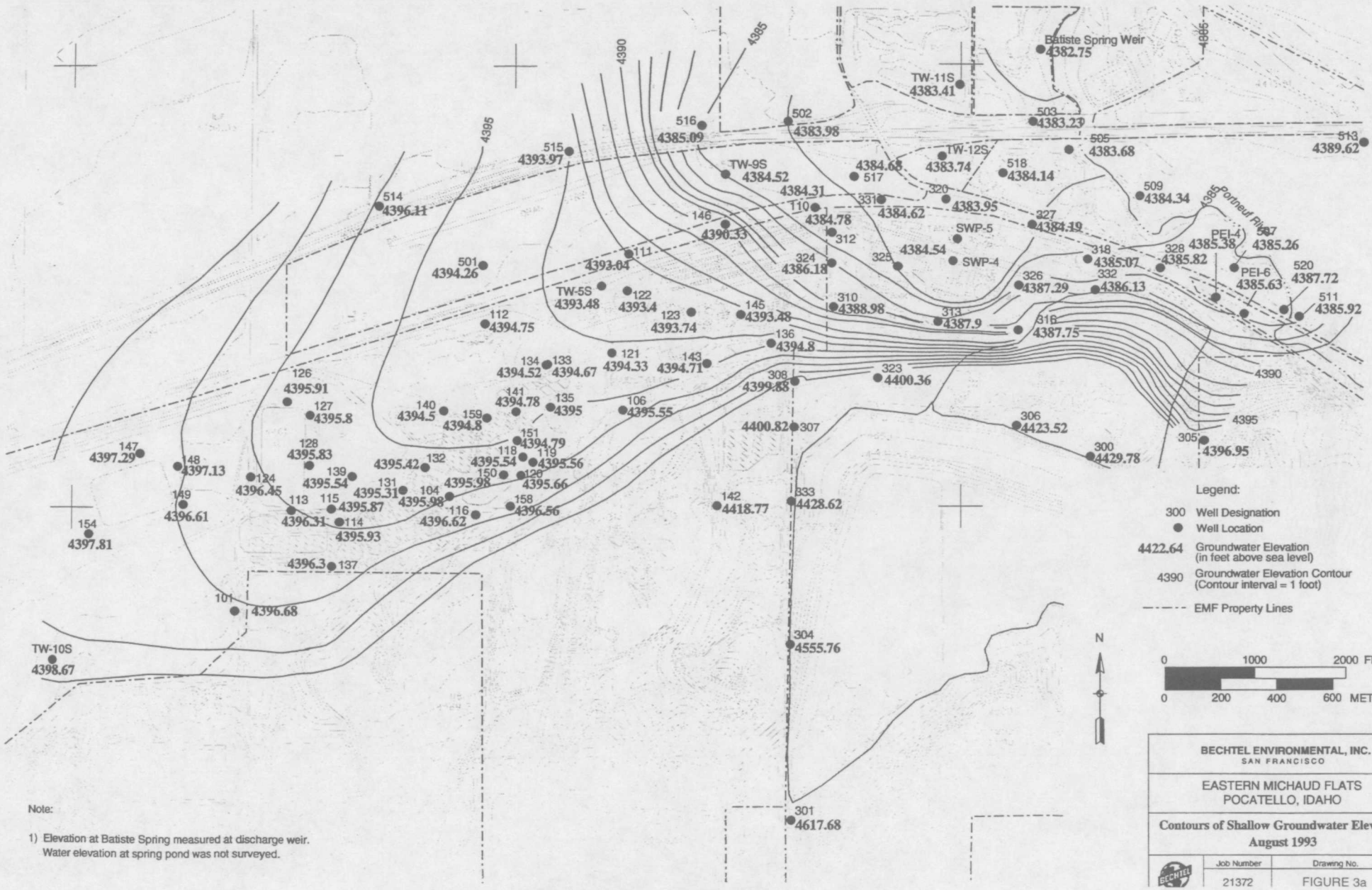

Note:

1) Elevation at Batiste Spring measured at discharge weir. Water elevation at spring pond was not surveyed.

BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

EASTERN MICHAUD FLATS
POCATELLO, IDAHO

Contours of Shallow Groundwater Elevations
August 1993

Job Number	Drawing No.	Rev.
21372	FIGURE 3a	

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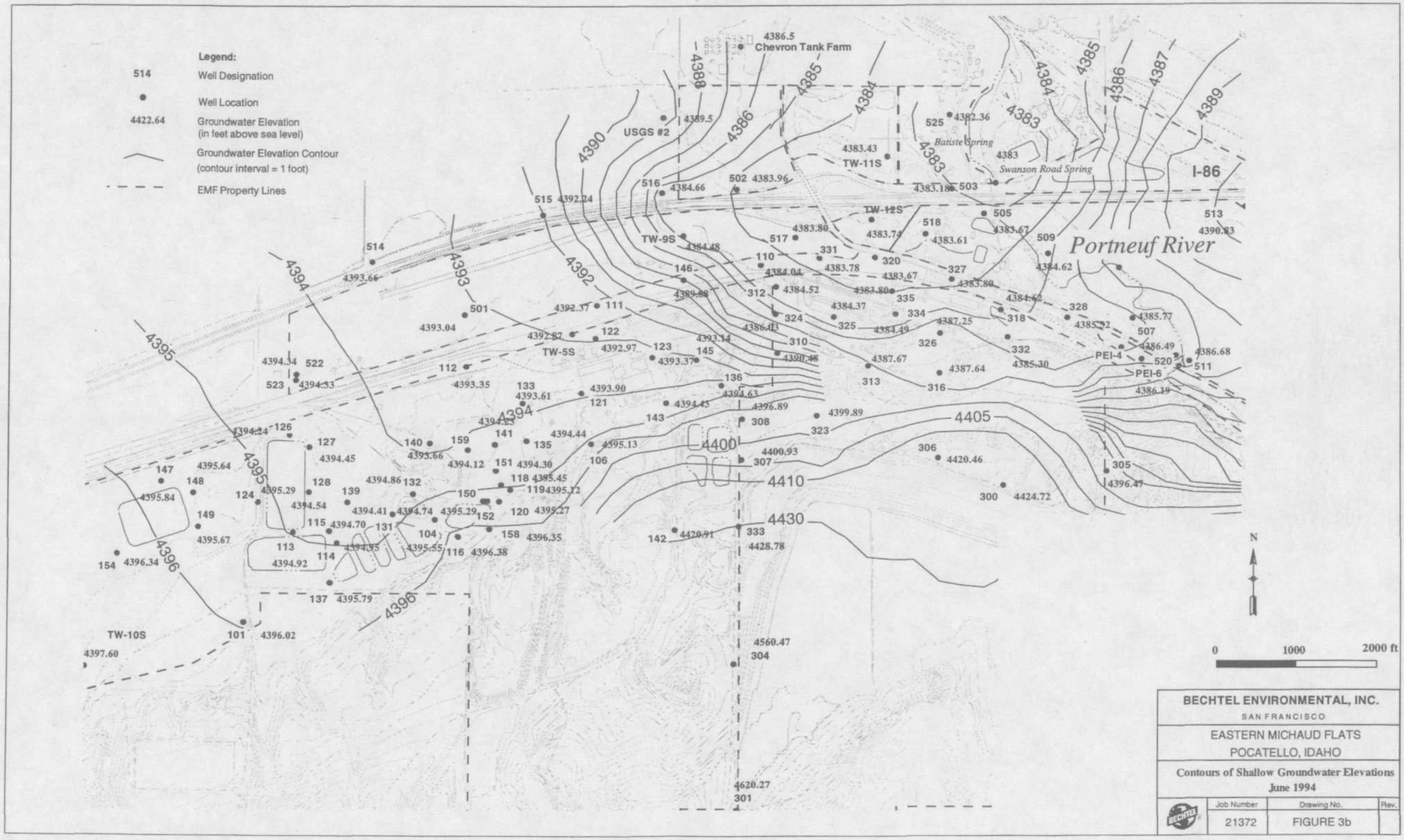
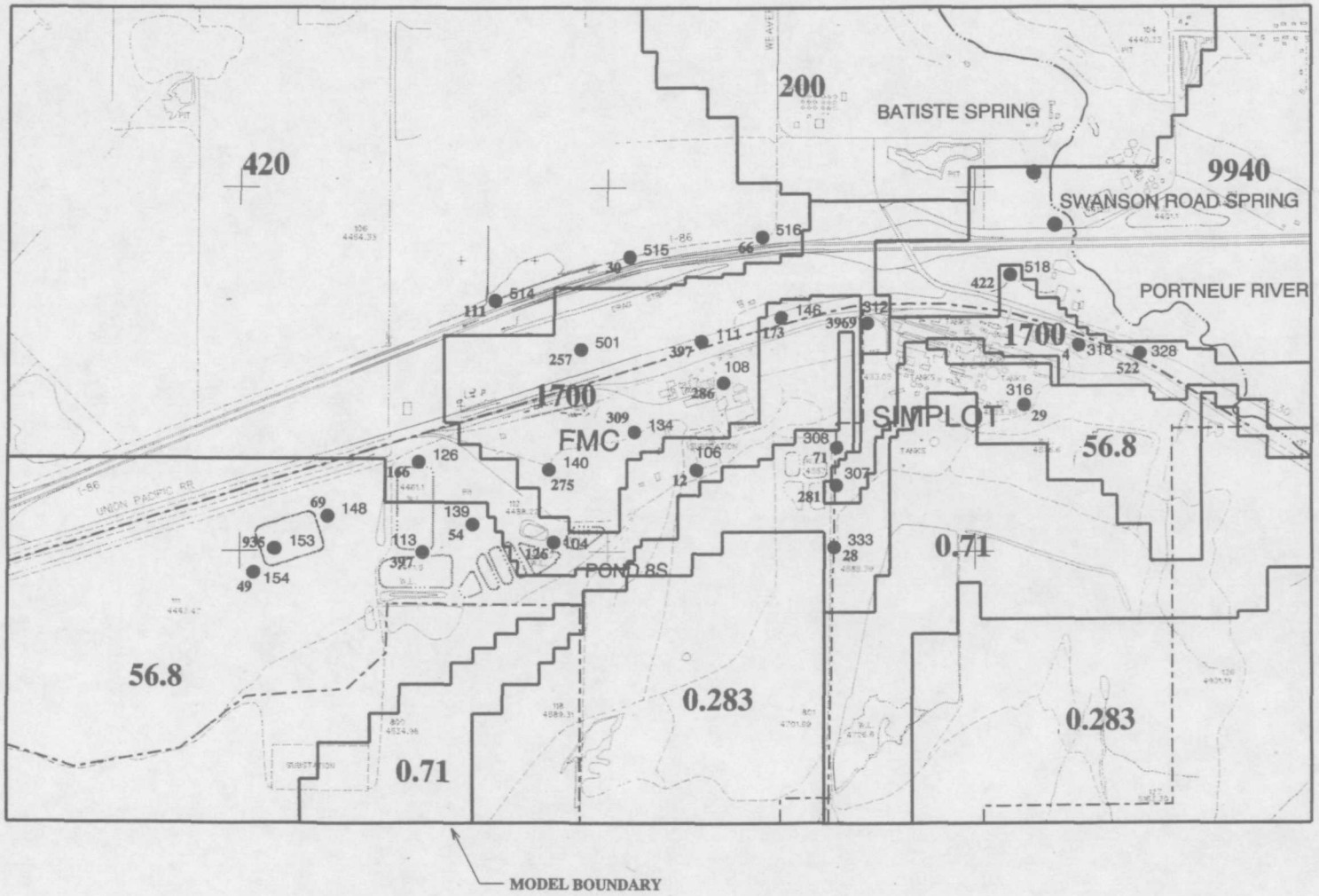


BECHTEL ENVIRONMENTAL, INC. SAN FRANCISCO		
EASTERN MICHAUD FLATS POCATELLO, IDAHO		
Contours of Shallow Groundwater Elevations June 1994		
Job Number	Drawing No.	Rev.
21372	FIGURE 3b	



Legend

518 Well Location and Designation
422 Hydraulic Conductivity in ft/day

1700 Hydraulic Conductivity (K) used in model (ft/day)

N

0 1500 3000 FEET
0 300 600 900 METERS

BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

EASTERN MICHAUD FLATS
POCATELLO, IDAHO

Shallow Aquifer K Values
and K Zones (Model Layer 2)

Job Number	Drawing No.	Rev.
21372	FIGURE 4	

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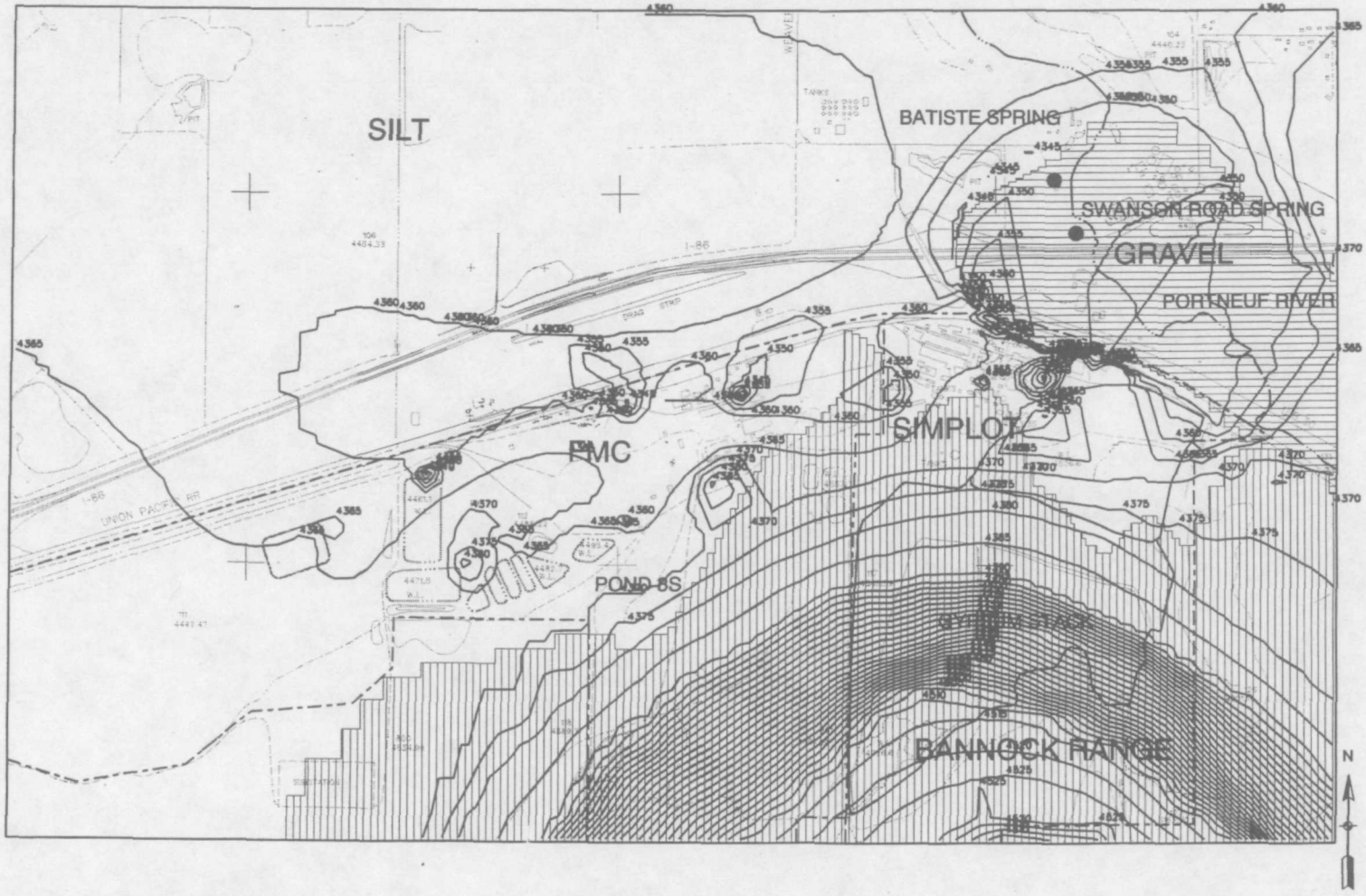

Legend:

Gravel
(Silt Not Present)

Bannock Range Lithologies

0 1500 3000 FEET
0 300 600 900 METERS

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EASTERN MICHAUD FLATS
POCATELLO, IDAHO

Contours on Top of Lower Silt
(Base Elevations Model Layer 2)

Job Number	Drawing No.	Rev.
21372	FIGURE 5	

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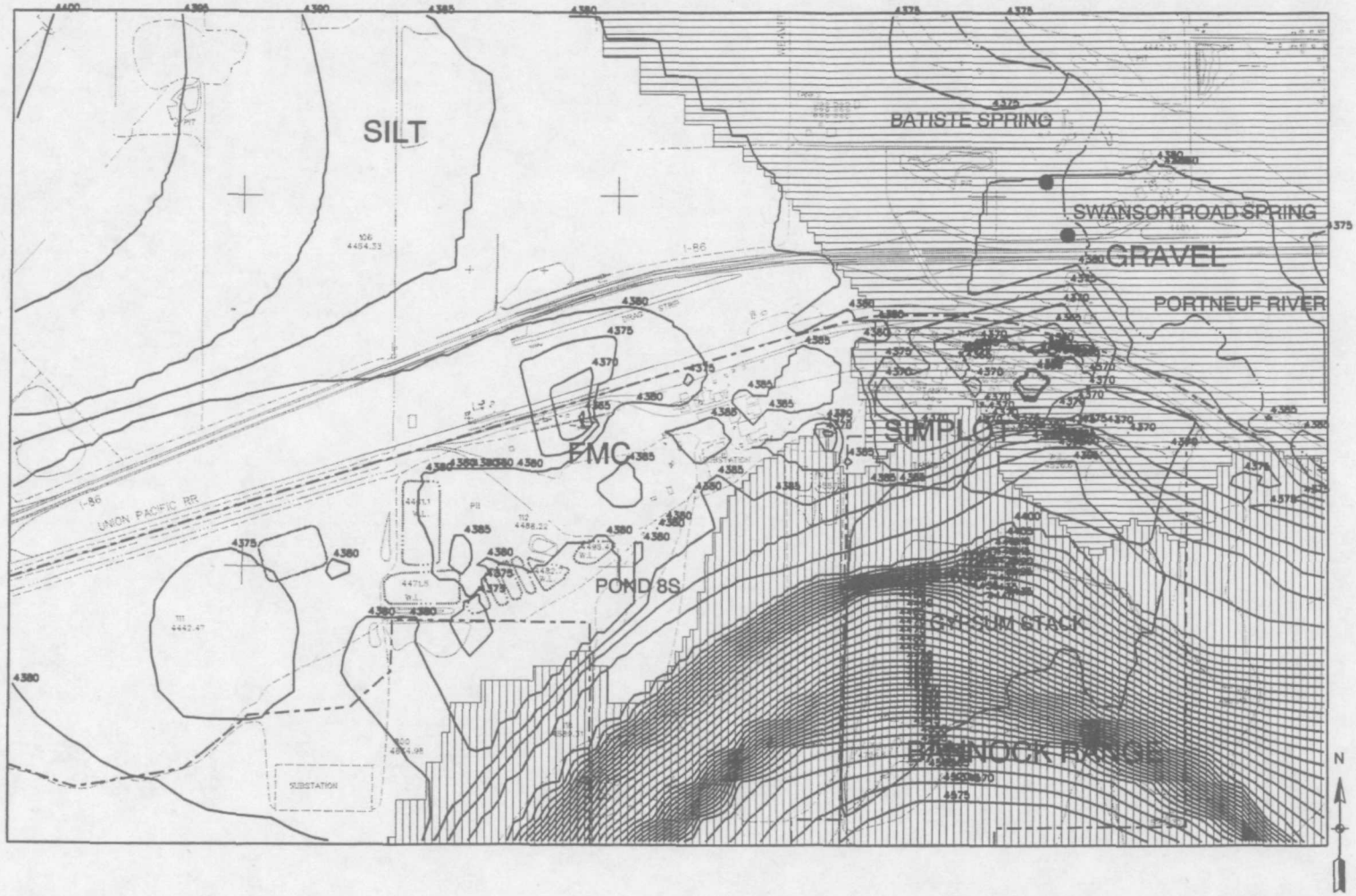

Legend:

Gravel
(Silt Not Present)

Bannock Range Lithologies

0 1500 3000 FEET
0 300 600 900 METERS

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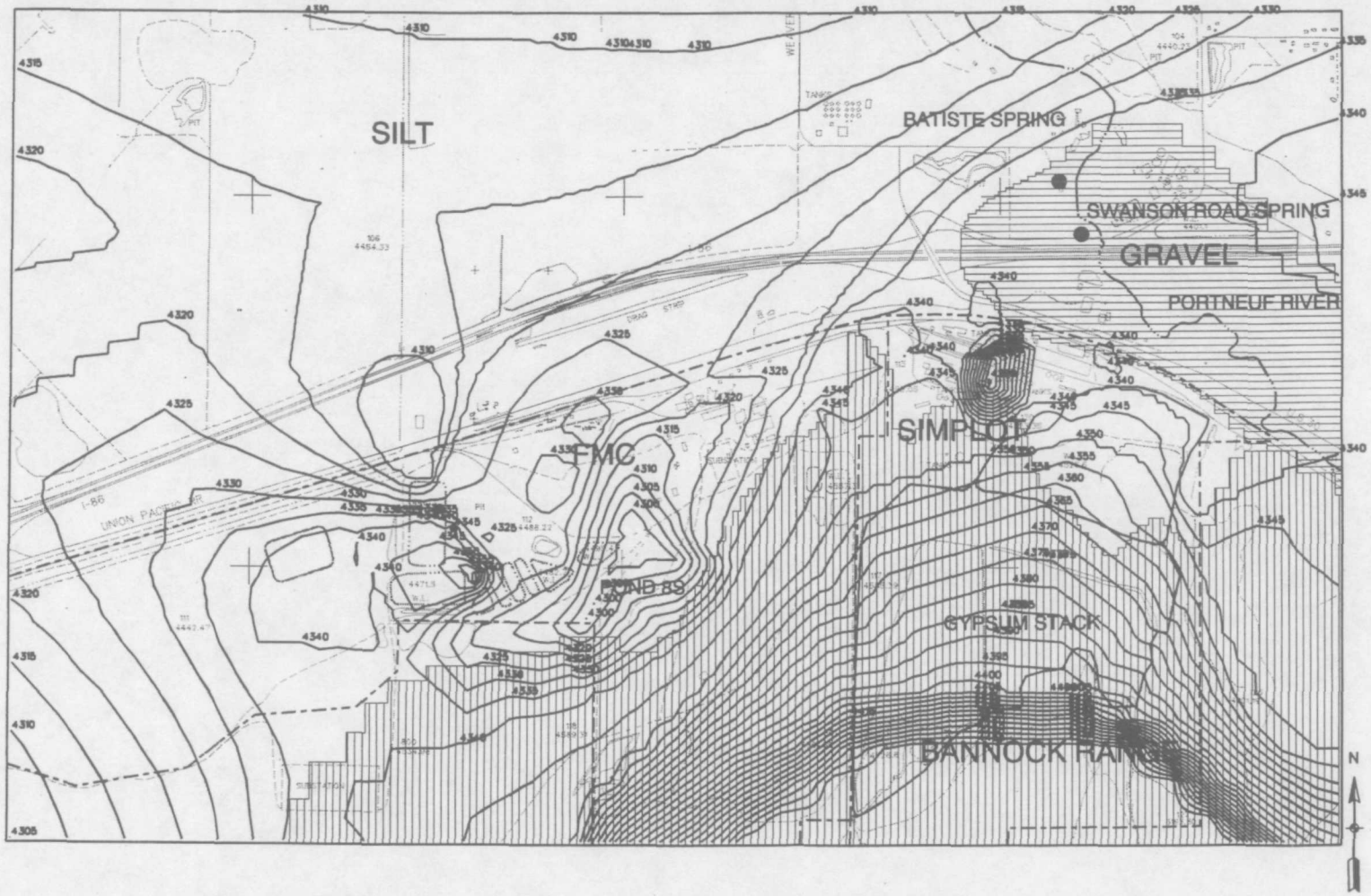
EASTERN MICHAUD FLATS
POCATELLO, IDAHO

Contours at Base of Upper Silt/Top of Upper Gravel Zone (Base Elevations Model Layer 1)

Job Number	Drawing No.	Rev.
21372	FIGURE 6	



Legend:

Gravel
(Silt Not Present)

Bannock Range Lithologies

0 1500 3000 FEET
0 300 600 900 METERS

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EASTERN MICHAUD FLATS
POCATELLO, IDAHO

Contours at Base of Lower Silt//Top of Deeper Aquifer (Base Elevations Model Layer 3)

Job Number	Drawing No.	Rev

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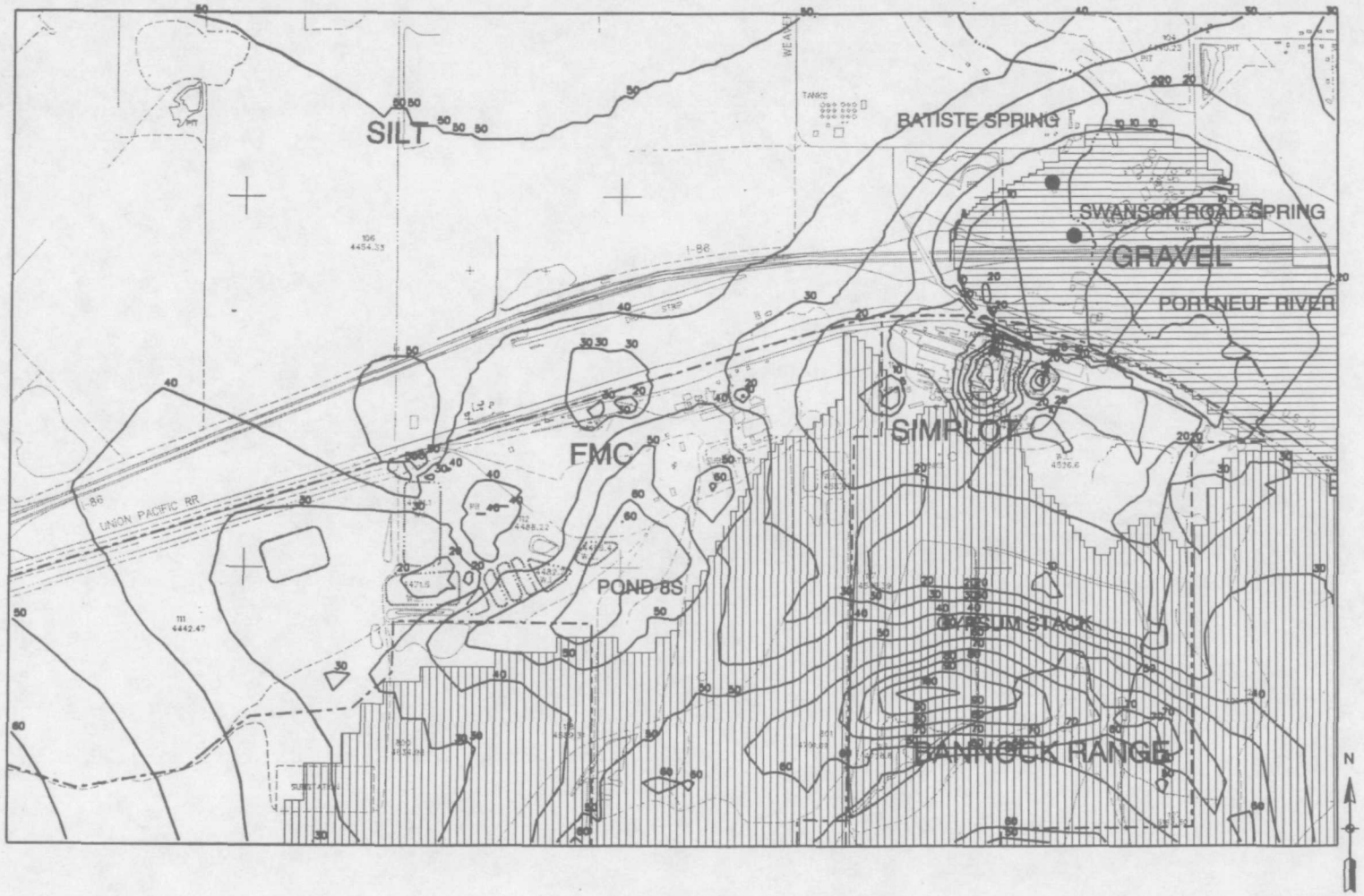

Legend:

Gravel
(Silt Not Present)

Bannock Range Lithologies

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POCATELLO, IDAHO

Isopach Map of American Falls Lake Beds

Job Number	Drawing No.	Rev.
21372	FIGURE 8	

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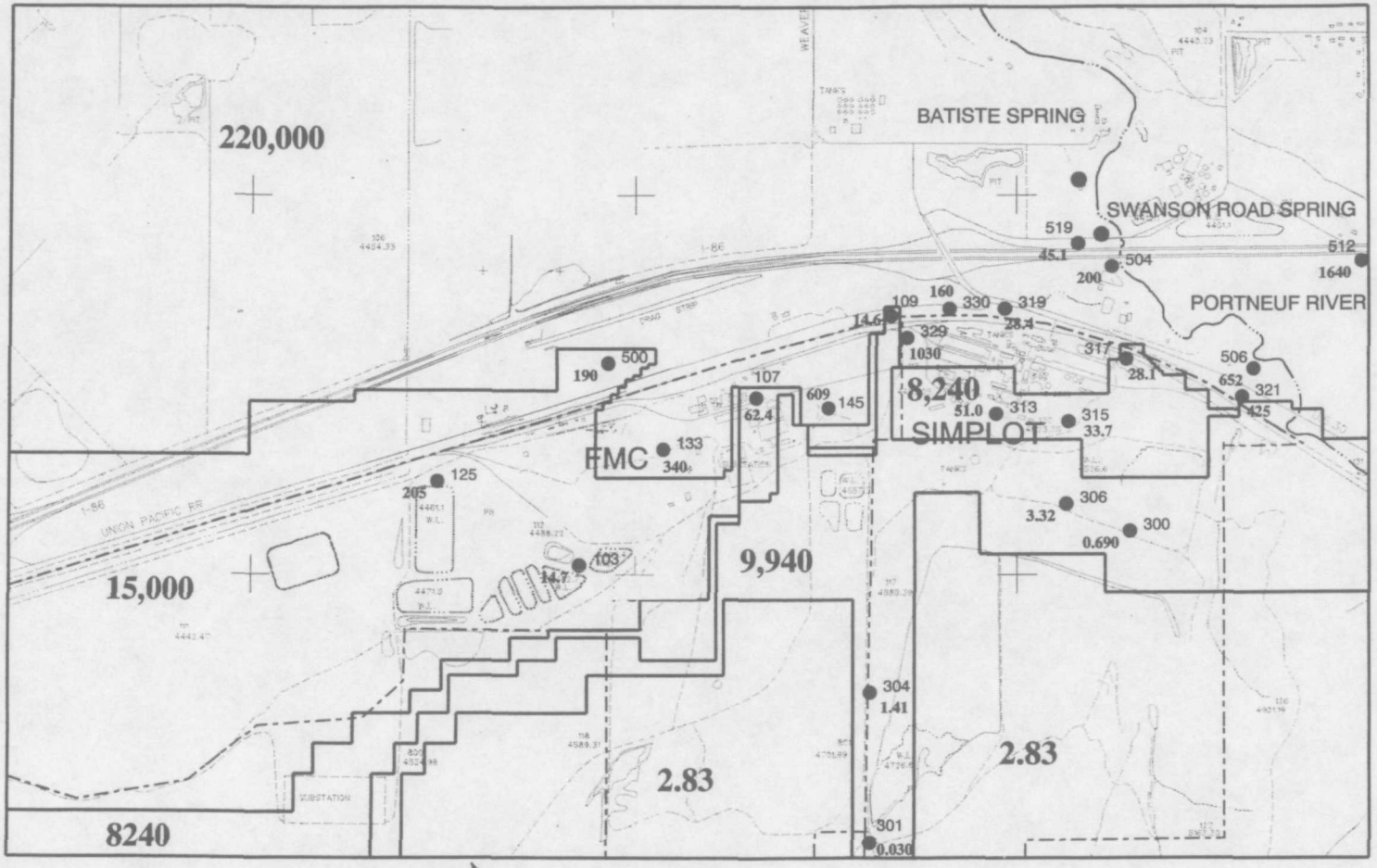

Legend

518 — Well Location and Designation

422 — Hydraulic Conductivity in ft/day

15,000 — Transmissivity used in Model (ft^2/day)

Note: K-values were converted to transmissivity

N

0 1500 3000 FEET

0 300 600 900 METERS

BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

EASTERN MICHAUD FLATS
POCATELLO, IDAHO

Deeper Aquifer T Values
and T Zones (Model Layer 4)

Job Number	Drawing No.	Rev.
21372	FIGURE 9	

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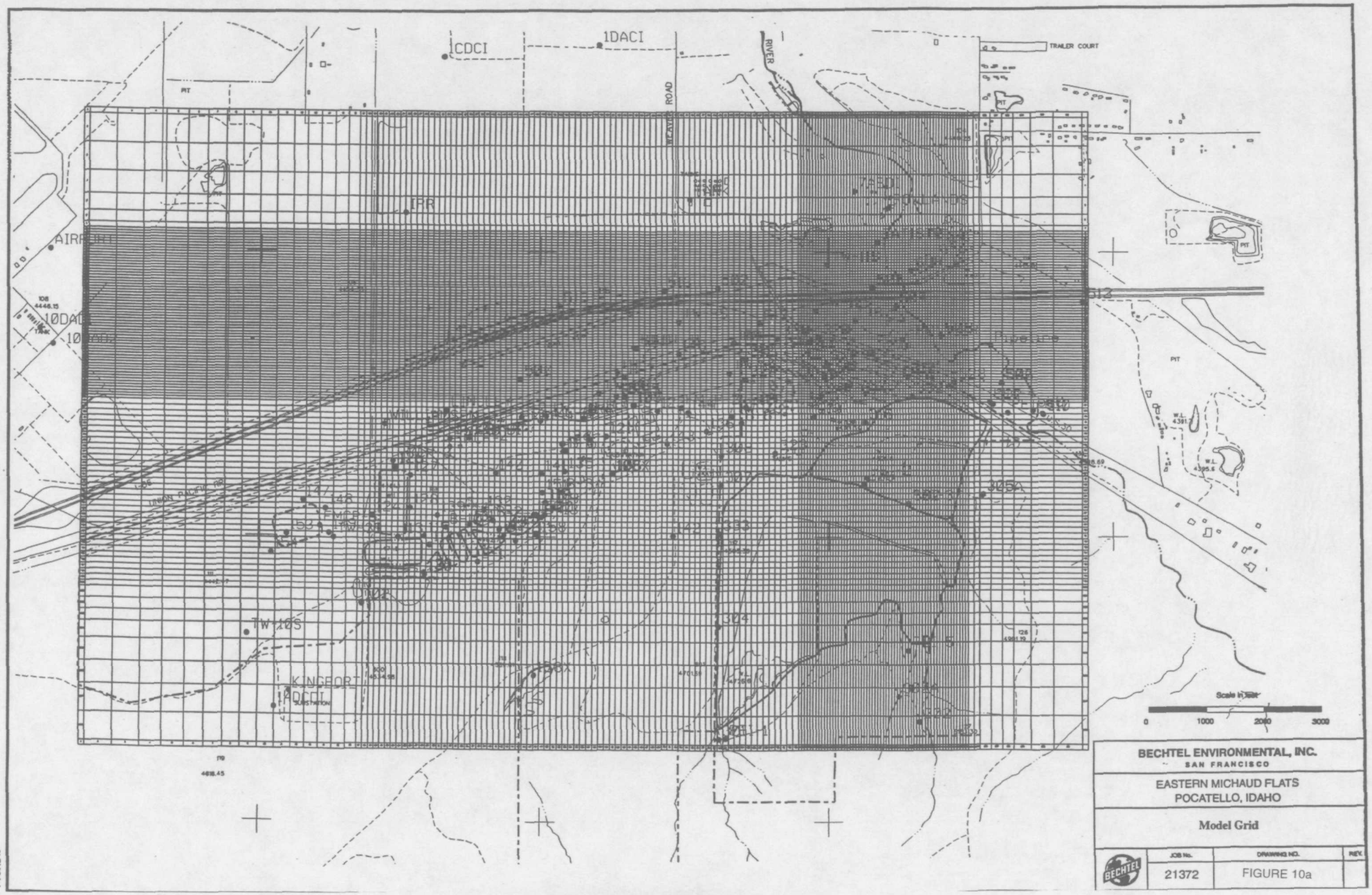

83-1477D.034a
7-1-94 rs/ 0

EXPLANATION

NO FLOW CELLS

CONSTANT HEAD CELLS

0 1500 3000 FEET

0 300 600 900 METERS

BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

EASTERN MICHAUD FLATS
POCATELLO, IDAHO

BOUNDARY CONDITIONS
LAYER 1

Job Number	Drawing No.	Rev.
21372	FIGURE 10b	

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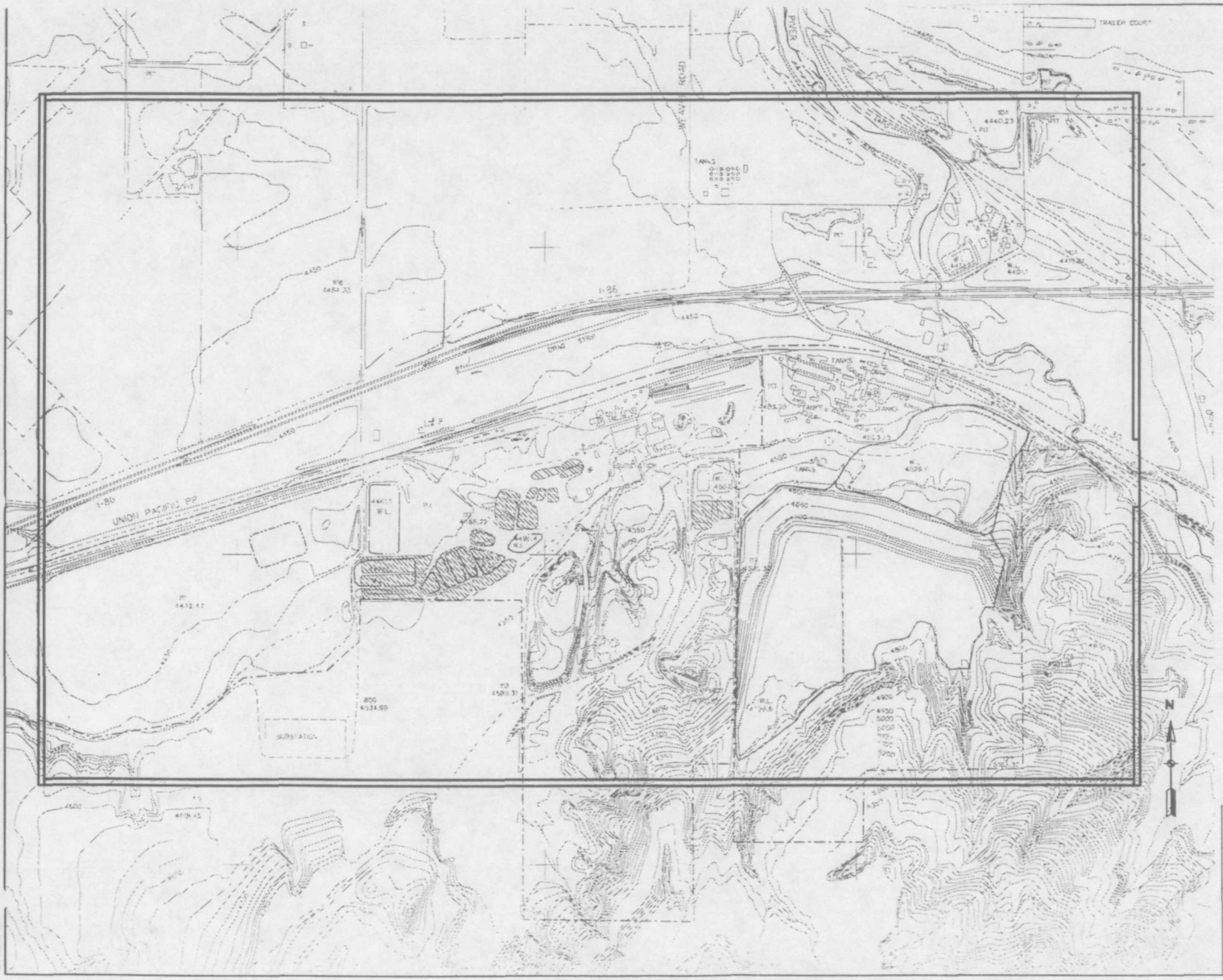

EXPLANATION

NO FLOW CELLS

CONSTANT HEAD CELLS

0 1500 3000 FEET

0 300 600 900 METERS

BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

EASTERN MICHAUD FLATS
POCATELLO, IDAHO

BOUNDARY CONDITIONS
LAYER 2

Job Number	Drawing No.	Rev.
21372	FIGURE 10c	

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EXPLANATION

NO FLOW CELLS

CONSTANT HEAD CELLS

0 1500 3000 FEET

0 300 600 900 METERS

BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

EASTERN MICHAUD FLATS
POCATELLO, IDAHO

BOUNDARY CONDITIONS
LAYER 3

Job Number	Drawing No.	Rev.
21372	FIGURE 10d	

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EXPLANATION

NO FLOW CELLS

CONSTANT HEAD CELLS

0 1500 3000 FEET

0 300 600 900 METERS

BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

EASTERN MICHAUD FLATS
POCATELLO, IDAHO

BOUNDARY CONDITIONS
LAYER 4

Job Number	Drawing No.	Rev.
21372	FIGURE 10e	

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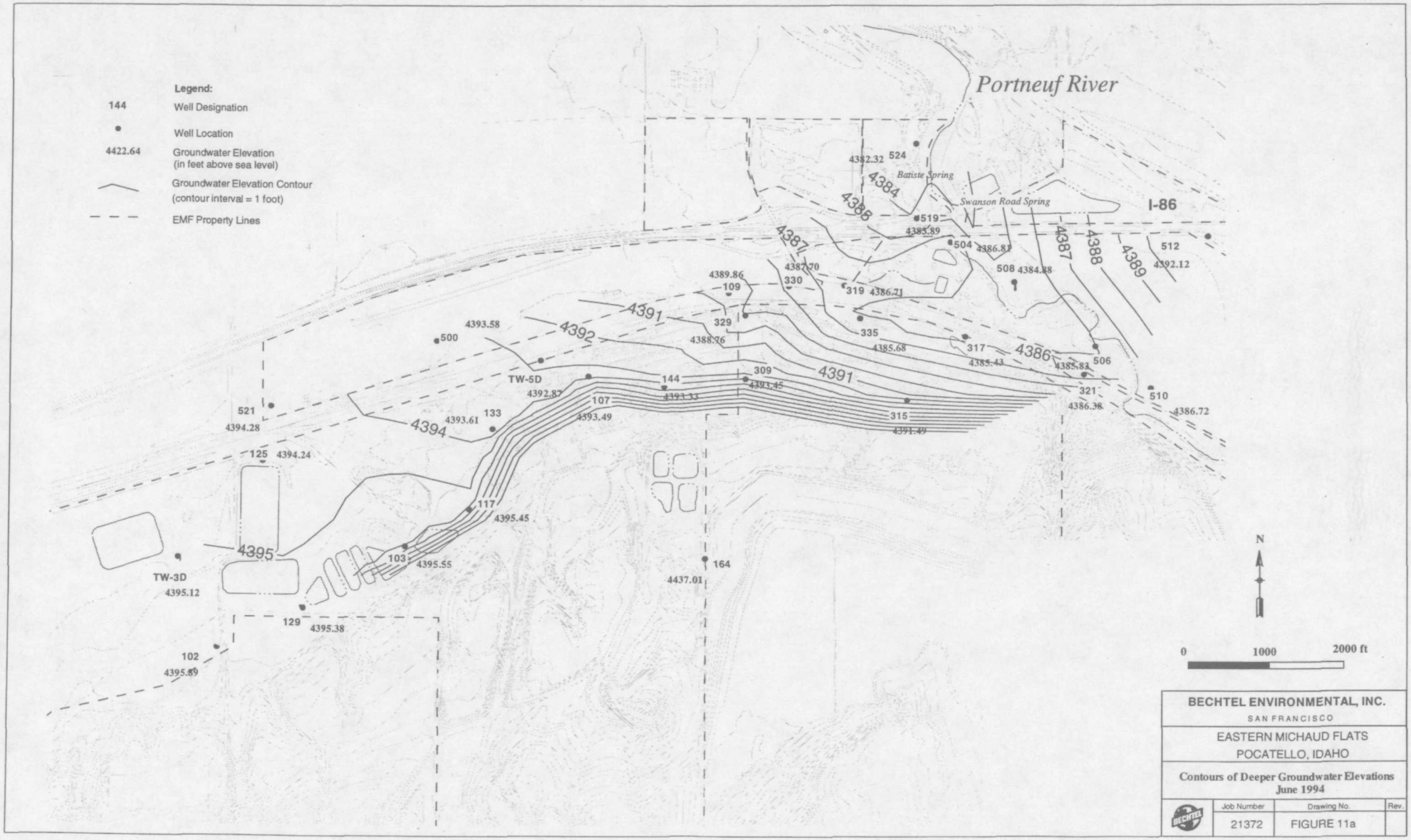
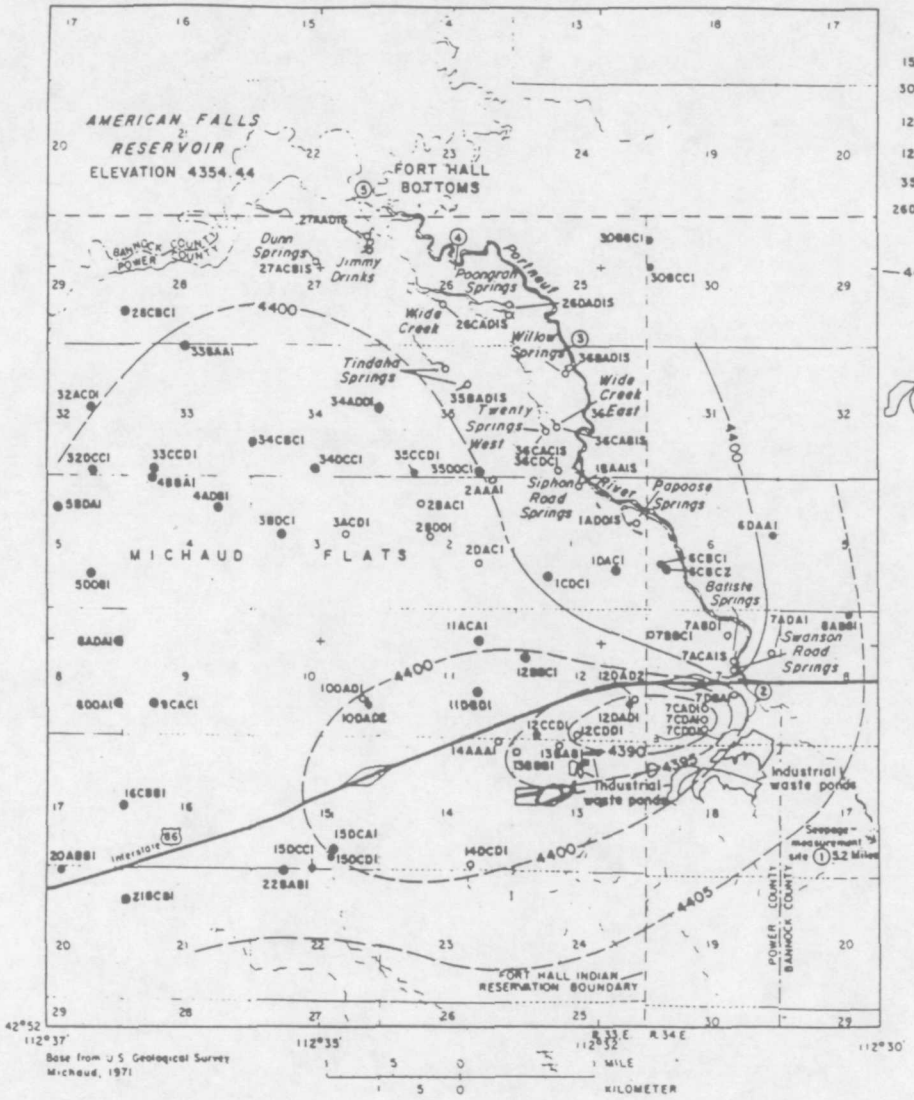


BECHTEL ENVIRONMENTAL, INC. SAN FRANCISCO		
EASTERN MICHAUD FLATS POCATELLO, IDAHO		
Contours of Deeper Groundwater Elevations June 1994		
Job Number	Drawing No.	Rev.
21372	FIGURE 11a	



EXPLANATION

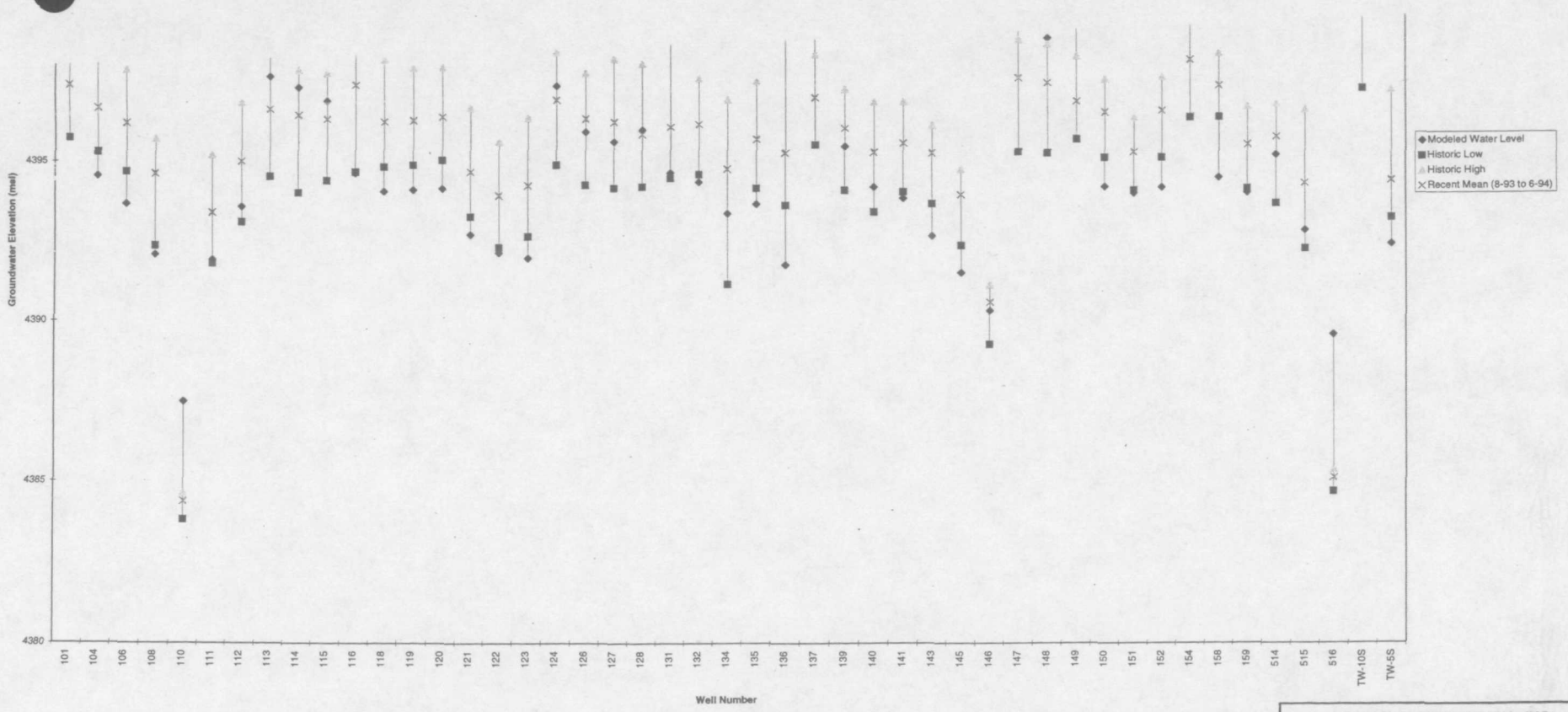
15DCA1	Irrigation well and number
30BBC1	Domestic well and number
12CDD10	Industrial or public supply well and number
12DAD1	Unused well and number
35CCD1	Observation well and number
26DAD1S	Spring and number
—4400—	Potentiometric-surface contour, spring 1981, dashed where approximately located. Contour interval 5 feet. National Geodetic Vertical Datum of 1929.
4	Seepage-measurement site and number
	Industrial waste site

Figure 5.--Potentiometric surface of the artesian aquifer, March 1981, and well and spring locations.

N

Reference: Jacobson, N.D., 1982, "Ground-water conditions in the eastern part of Michaud Flats, Fort Hall Indian Reservation, Idaho", USGS Open File Report 82-570

BECHTEL ENVIRONMENTAL, INC. SAN FRANCISCO		
EASTERN MICHAUD FLATS POCATELLO, IDAHO		
Groundwater Contours in Deeper Aquifer - March 1981		
Job Number	Drawing No.	Rev.
21372	FIGURE 11b	



BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

EASTERN MICHAUD FLATS
POCATELLO, IDAHO

Modeled vs. Observed Heads -
Upper Gravel Zone in Western Model Area

JOB No.	DRAWING NO.	REV.
21372	FIGURE 12a	

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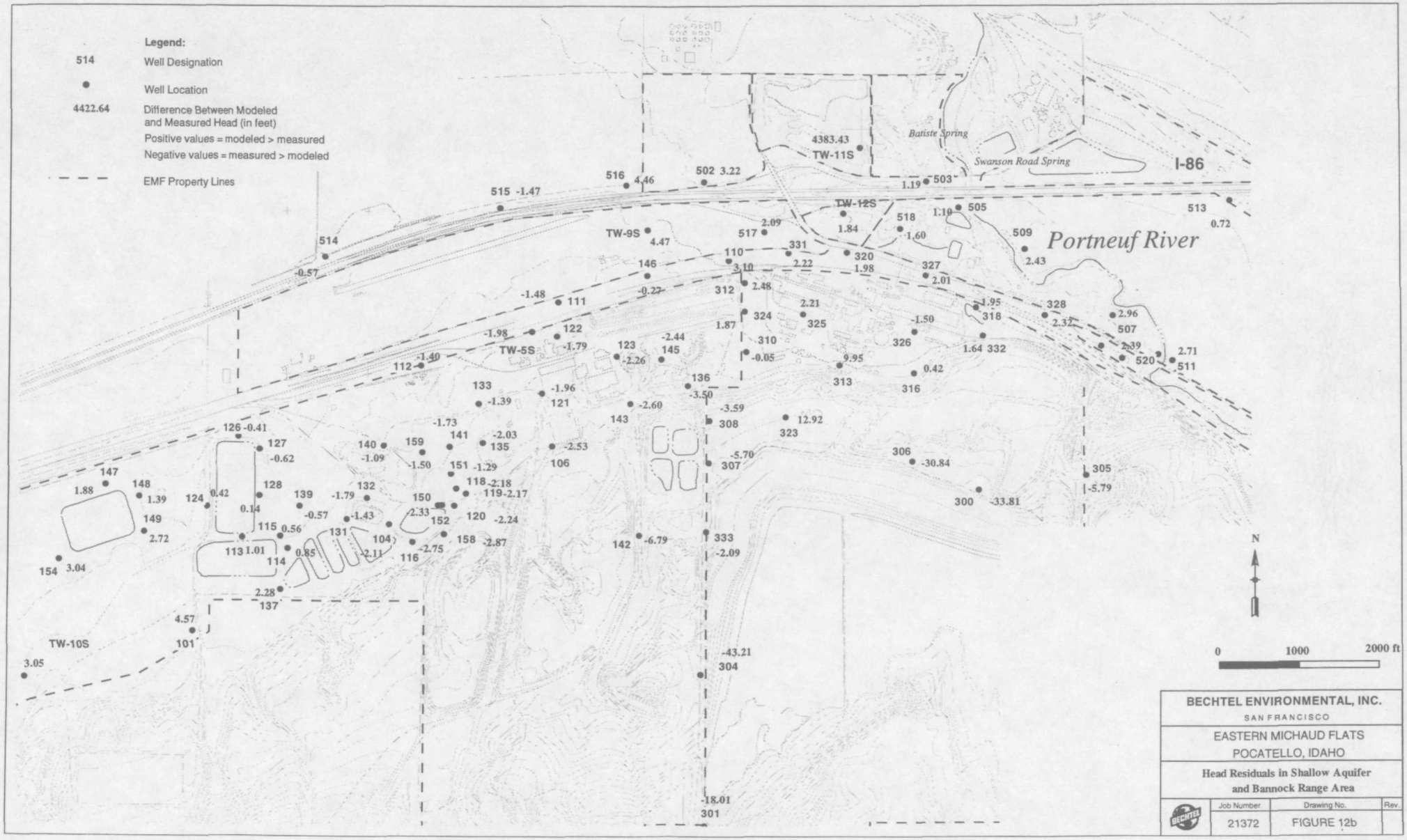
7-1-94 rs/ 20

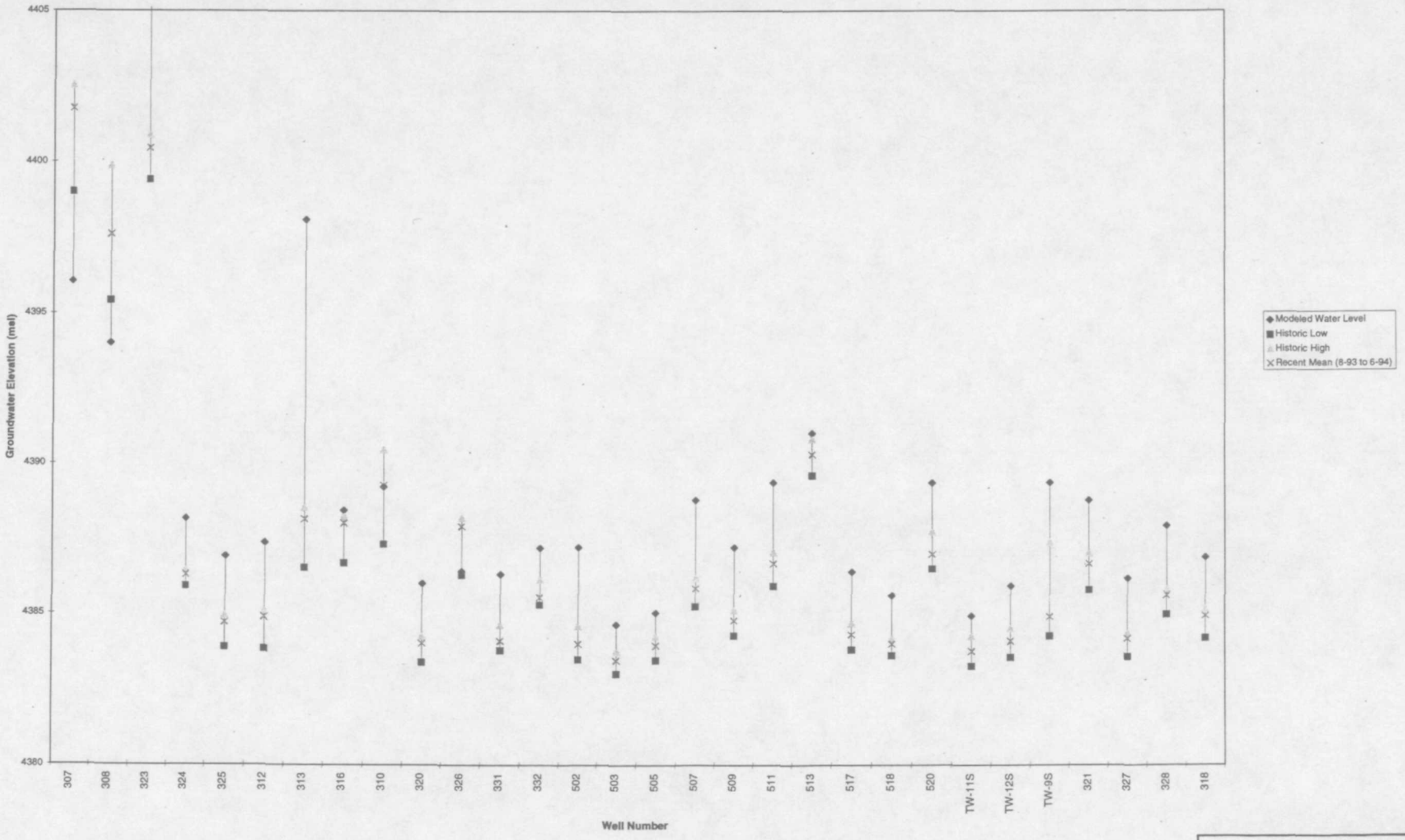


BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

EASTERN MICHAUD FLATS
POCATELLO, IDAHO

Head Residuals in Shallow Aquifer and Bannock Range Area

Job Number	Drawing No.	Rev.
21372	FIGURE 12b	



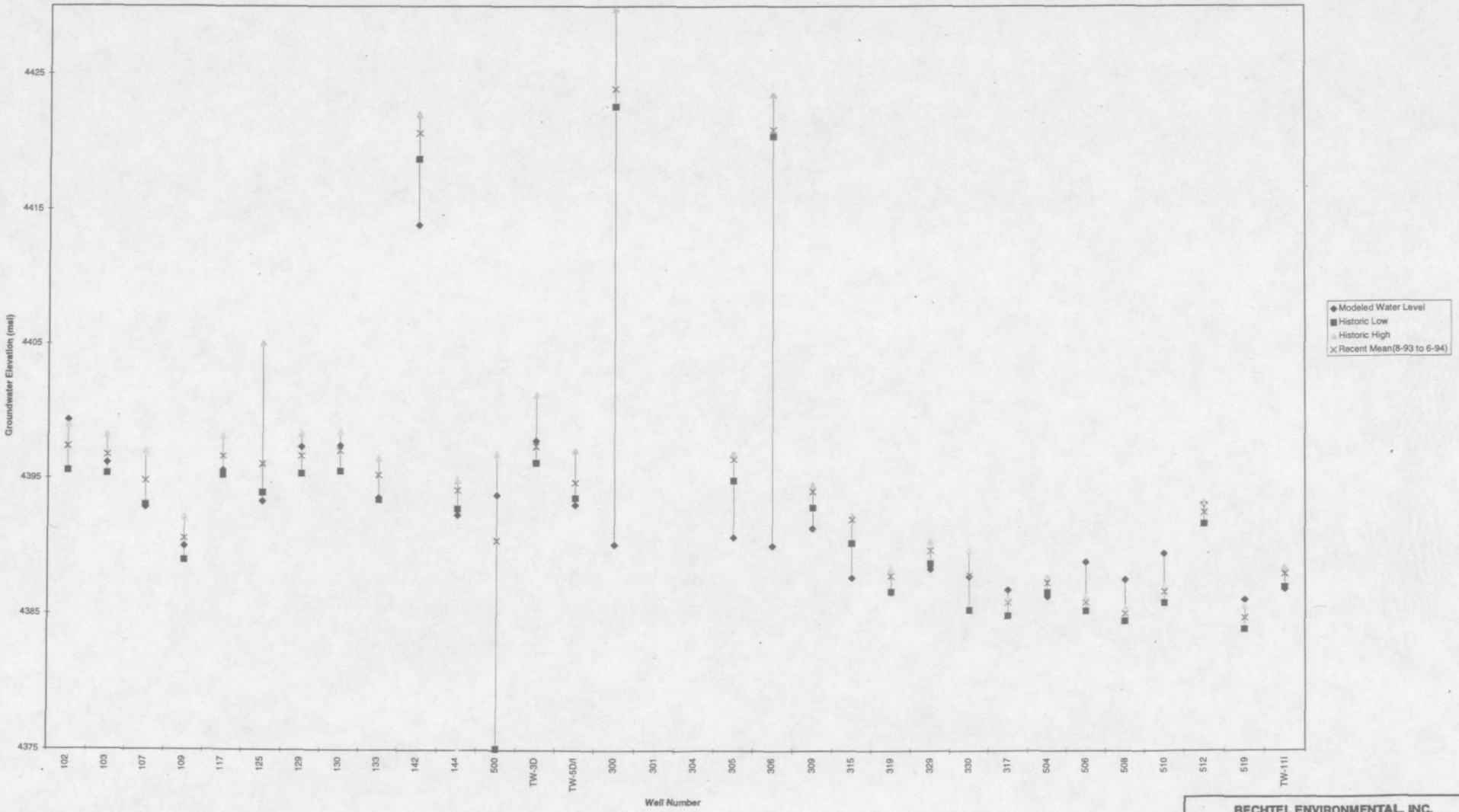
BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

EASTERN MICHAUD FLATS
POCATELLO, IDAHO

Modeled vs. Observed Heads - Upper Gravel Zone in Eastern Model Area

JOB No.	DRAWING NO.	REV.
21372	FIGURE 13	

85-1477b.034a
7-1-94 IW JD



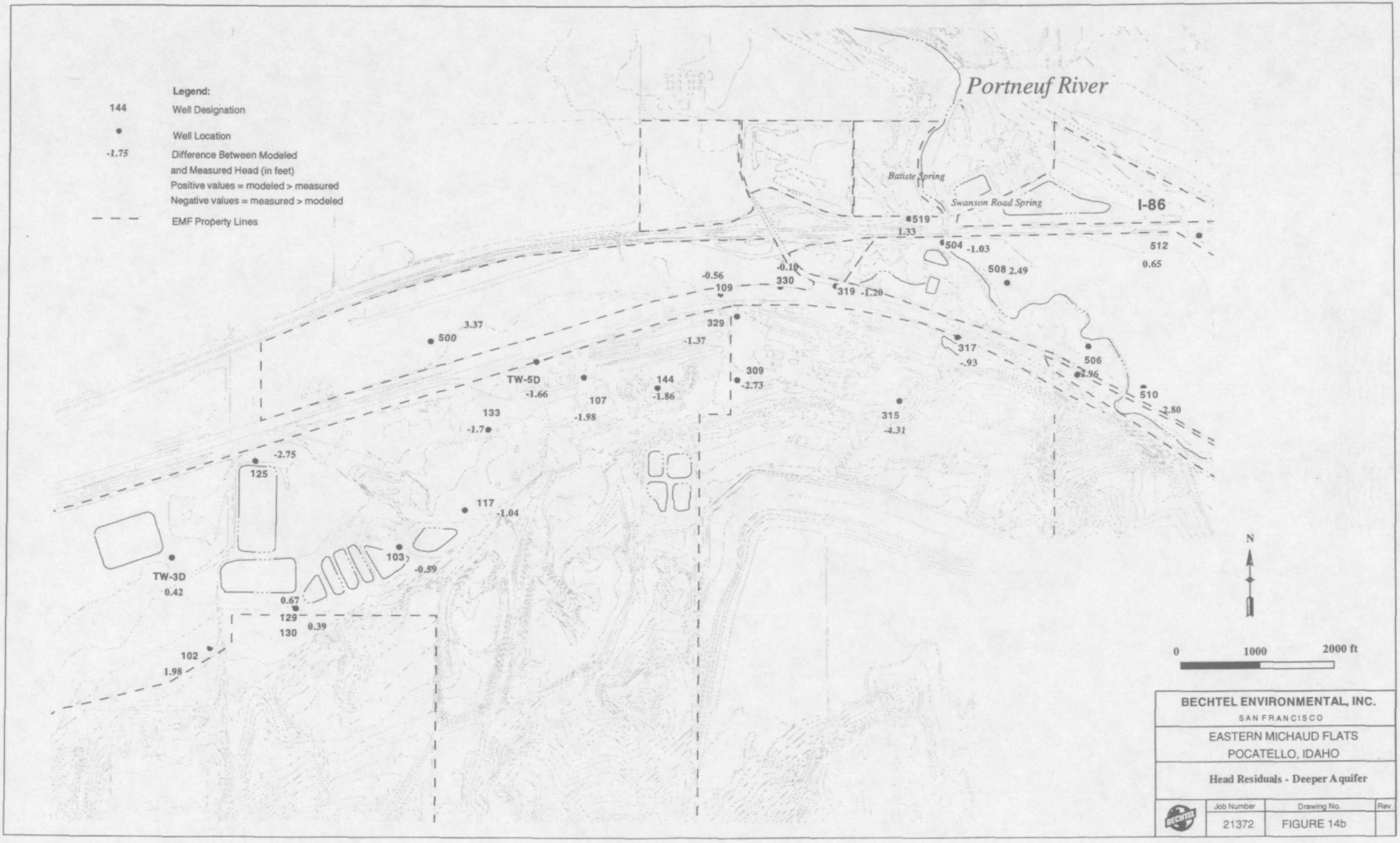
BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

EASTERN MICHAUD FLATS
POCATELLO, IDAHO

Model vs. Observed Heads - Deeper Aquifer

JOB No.	DRAWING NO.	REV.
21372	FIGURE 14a	

95-1477b.034a
7-11-94 rw /3

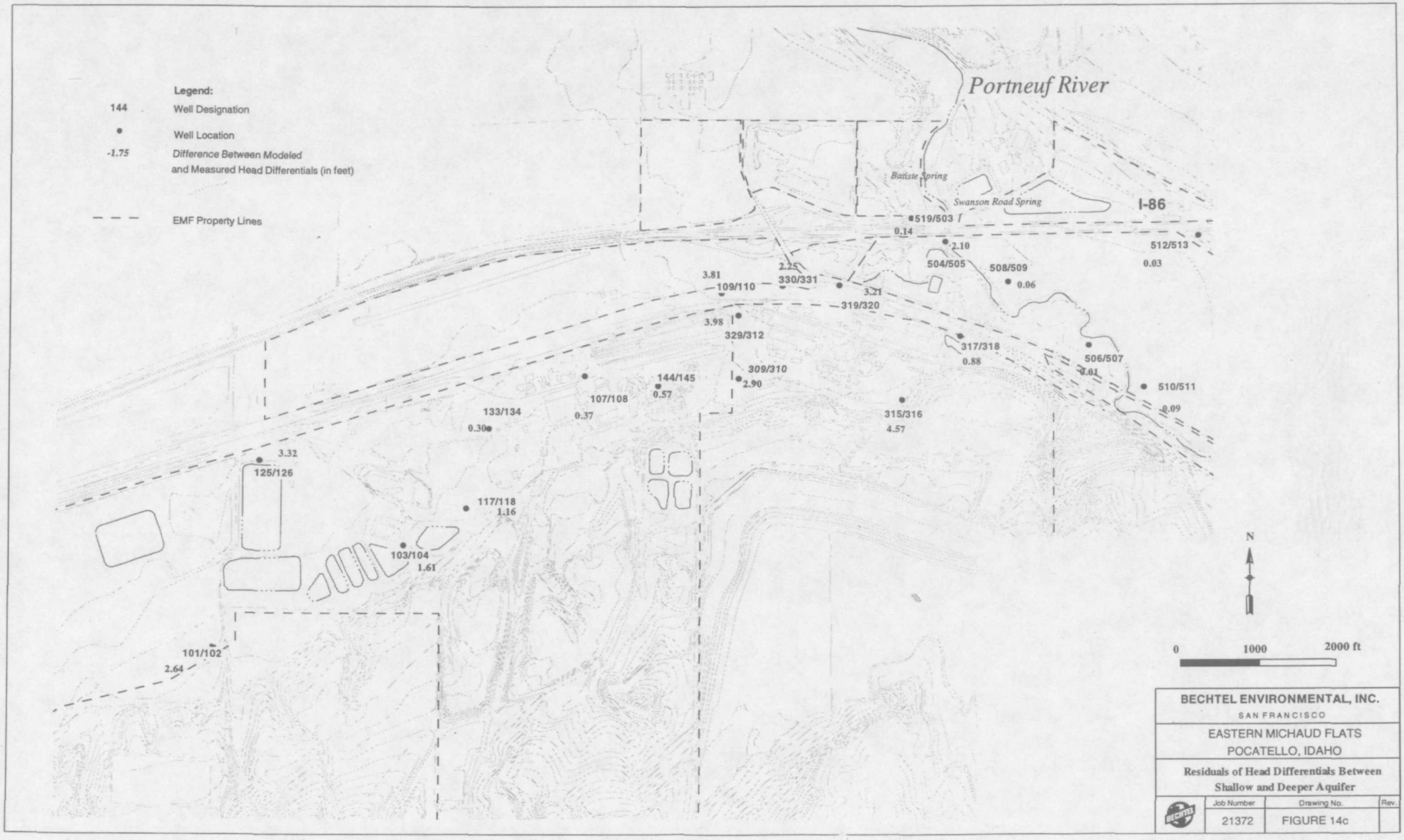


BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

EASTERN MICHAUD FLATS
POCATELLO, IDAHO

Head Residuals - Deeper Aquifer

Job Number	Drawing No.	Rev.
21372	FIGURE 14b	


Legend:
144 Well Designation
Well Location
-1.75 Difference Between Modeled and Measured Head Differentials (in feet)
EMF Property Lines
Portneuf River
Batiste Spring
Swanson Road Spring
I-86
519/503
0.14
2.10
512/513
0.03
504/505
508/509
0.06
3.81
109/110
2.25
330/331
3.21
319/320
3.98
329/312
317/318
0.88
506/507
0.01
510/511
0.09
309/310
2.90
144/145
0.57
107/108
0.37
133/134
0.30
315/316
4.57
3.32
125/126
117/118
1.16
103/104
1.61
101/102
2.64
N
0
1000
2000 ft
BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO
EASTERN MICHAUD FLATS
POCATELLO, IDAHO
Residuals of Head Differentials Between Shallow and Deeper Aquifer
Job Number
21372
Drawing No.
FIGURE 14c
Rev.

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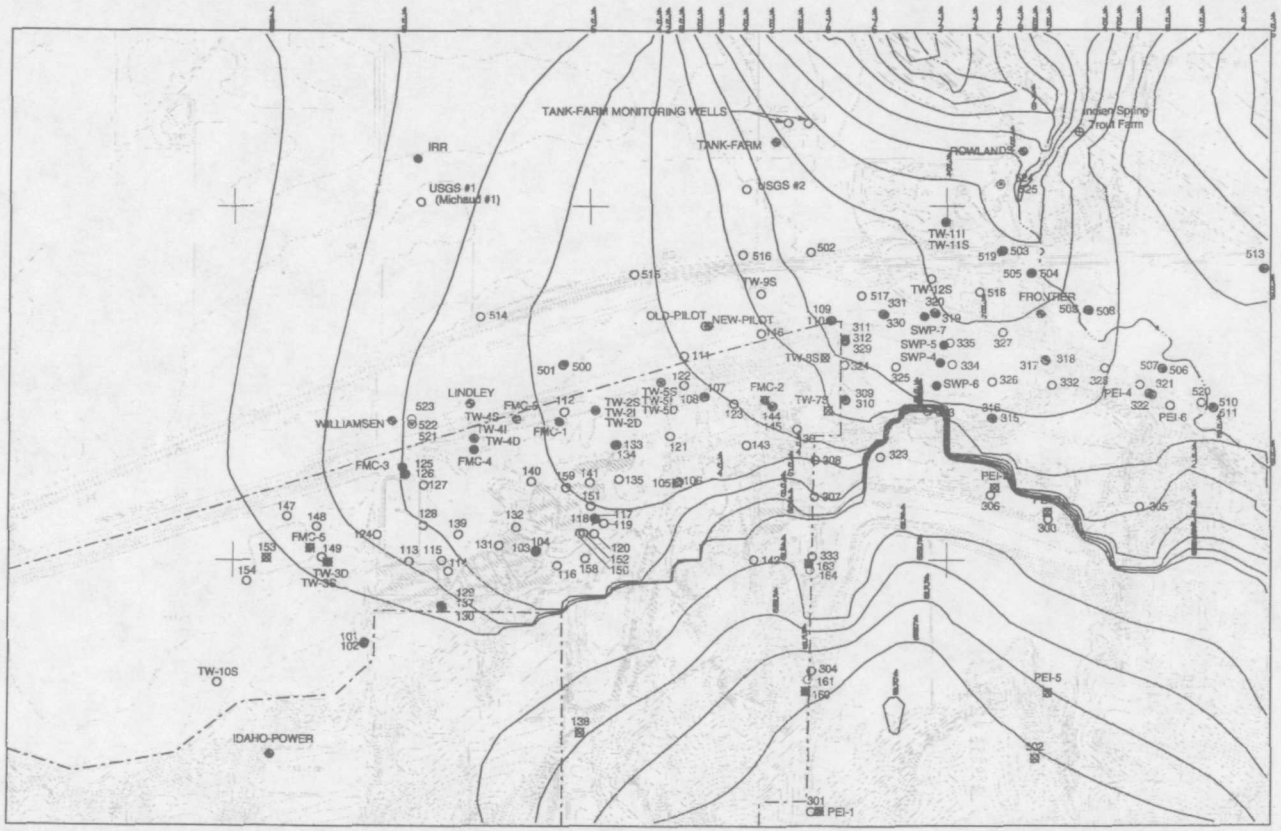

Legend:

- Shallow monitoring well
- Deep monitoring well
- Water supply well
- Production well
- Abandoned shallow monitoring well
- Abandoned deep monitoring well
- Abandoned production well

0 1750 3500

N

BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

EASTERN MICHAUD FLATS
POCATELLO, IDAHO

Modeled Groundwater Contours in Shallow Aquifer - Scenario 1

Job Number	Drawing No.	Rev.
21372	FIGURE 15	

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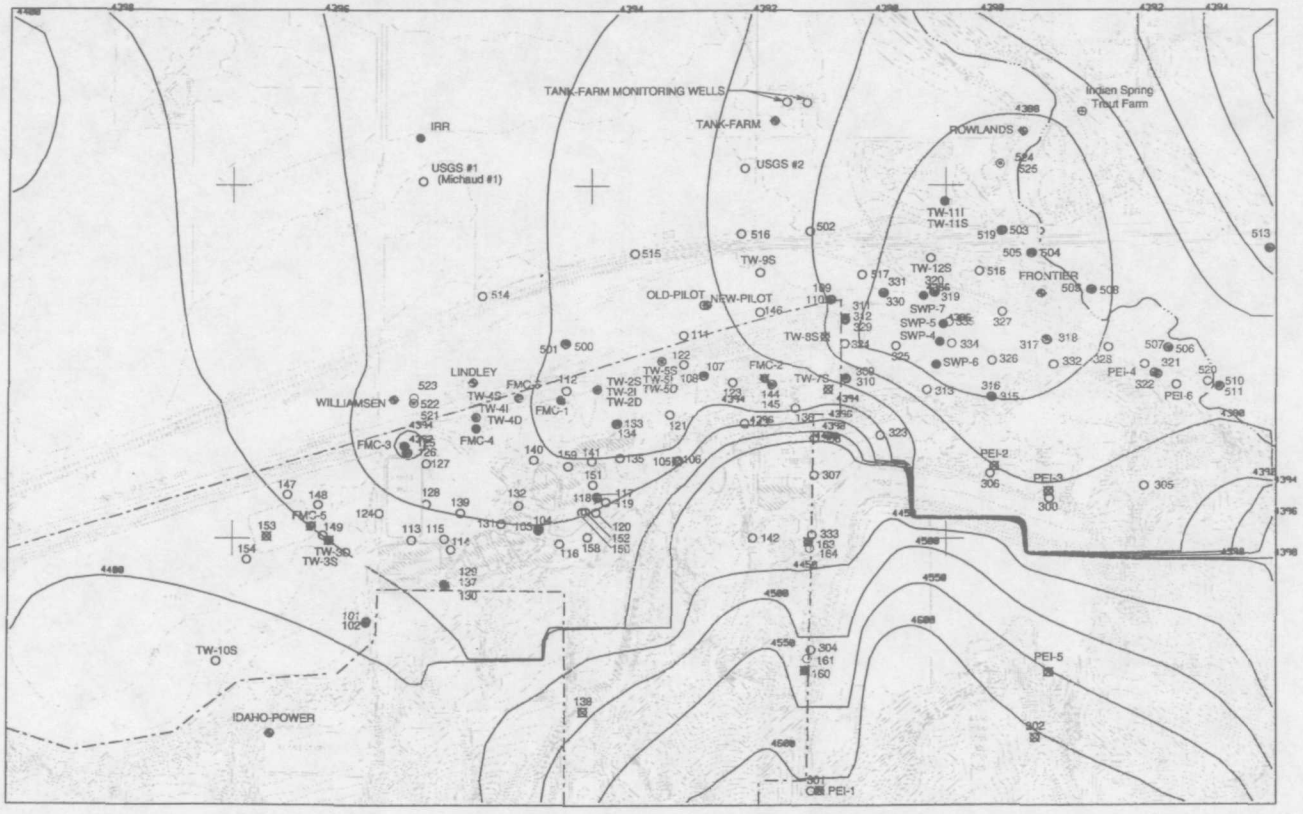


Legend:

- Shallow monitoring well
- Deep monitoring well
- Water supply well
- Production well
- Abandoned shallow monitoring well
- Abandoned deep monitoring well
- Abandoned production well

0 1750 3500

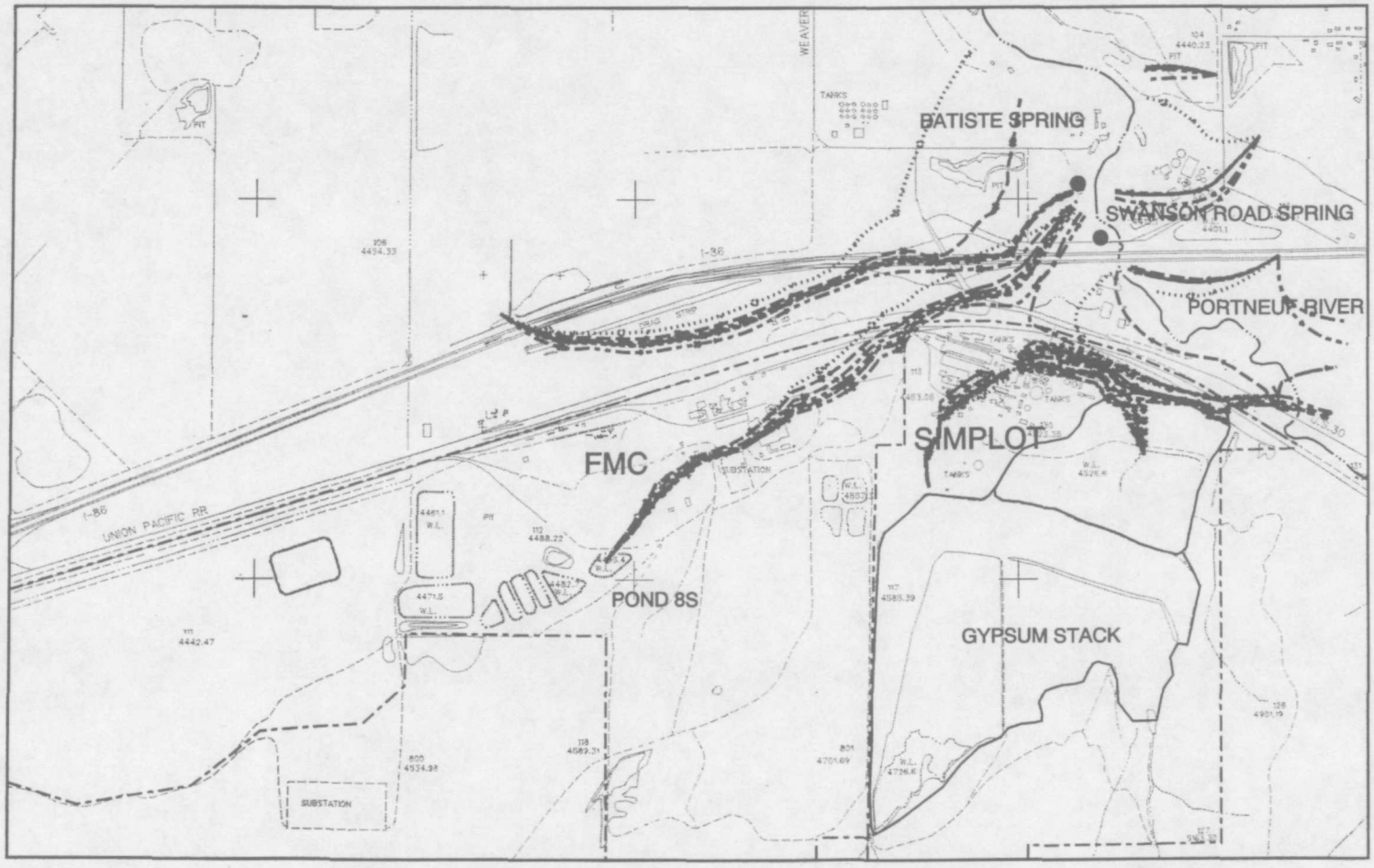
N

BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

EASTERN MICHAUD FLATS
POCATELLO, IDAHO

Modeled Groundwater Contours in Deeper Aquifer - Scenario 1

Job Number	Drawing No.	Rev.
21372	FIGURE 16	



Legend:

- Pumping Well
- Spring Location
- Particle Track of Sensitivity Case 1
- Particle Track of Sensitivity Case 2
- Particle Track of Sensitivity Case 3
- Particle Track of Sensitivity Case 4
- Particle Track of Sensitivity Case 5
- Particle Track of Sensitivity Case 6

N

0 1500 3000 FEET

0 300 600 900 METERS

BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

EASTERN MICHAUD FLATS
POCATELLO, IDAHO

Composite of Particle Tracks for Sensitivity Cases 1 thru 6

Job Number	Drawing No.	Rev.
21372	FIGURE 17	

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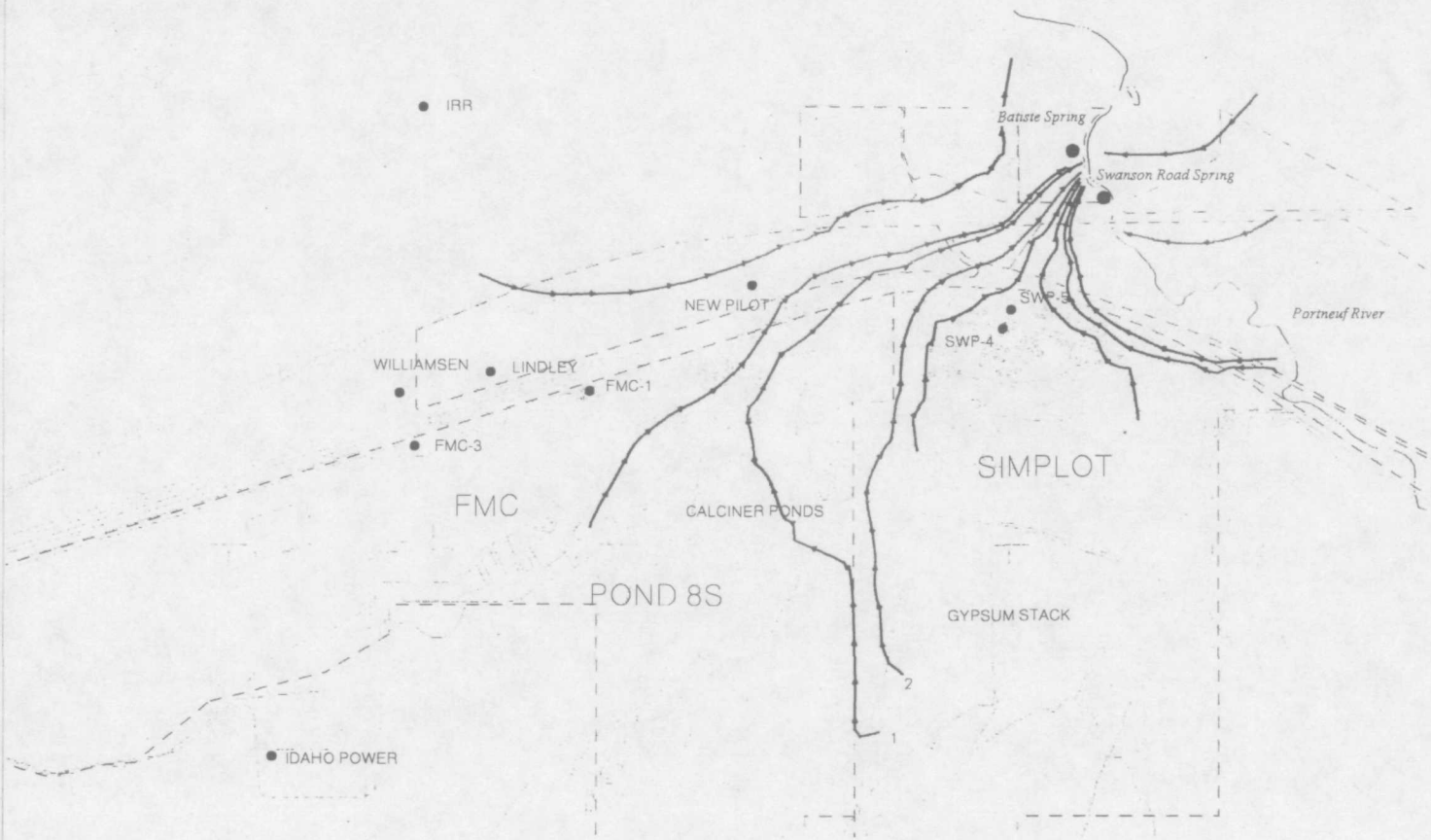
DAF hydrol dgn

Note: The groundwater model was used to generate these particle tracks. However, due to limited data in the area south of the Calciner Ponds and in the vicinity of the Gypsum Stack, particle tracks 1 and 2 in this area are conceptual.



EXPLANATION

- Pumping Well
- Spring Location

Particle Track in Model Layer 1

Particle Track in Model Layer 2

Particle Track in Model Layer 3

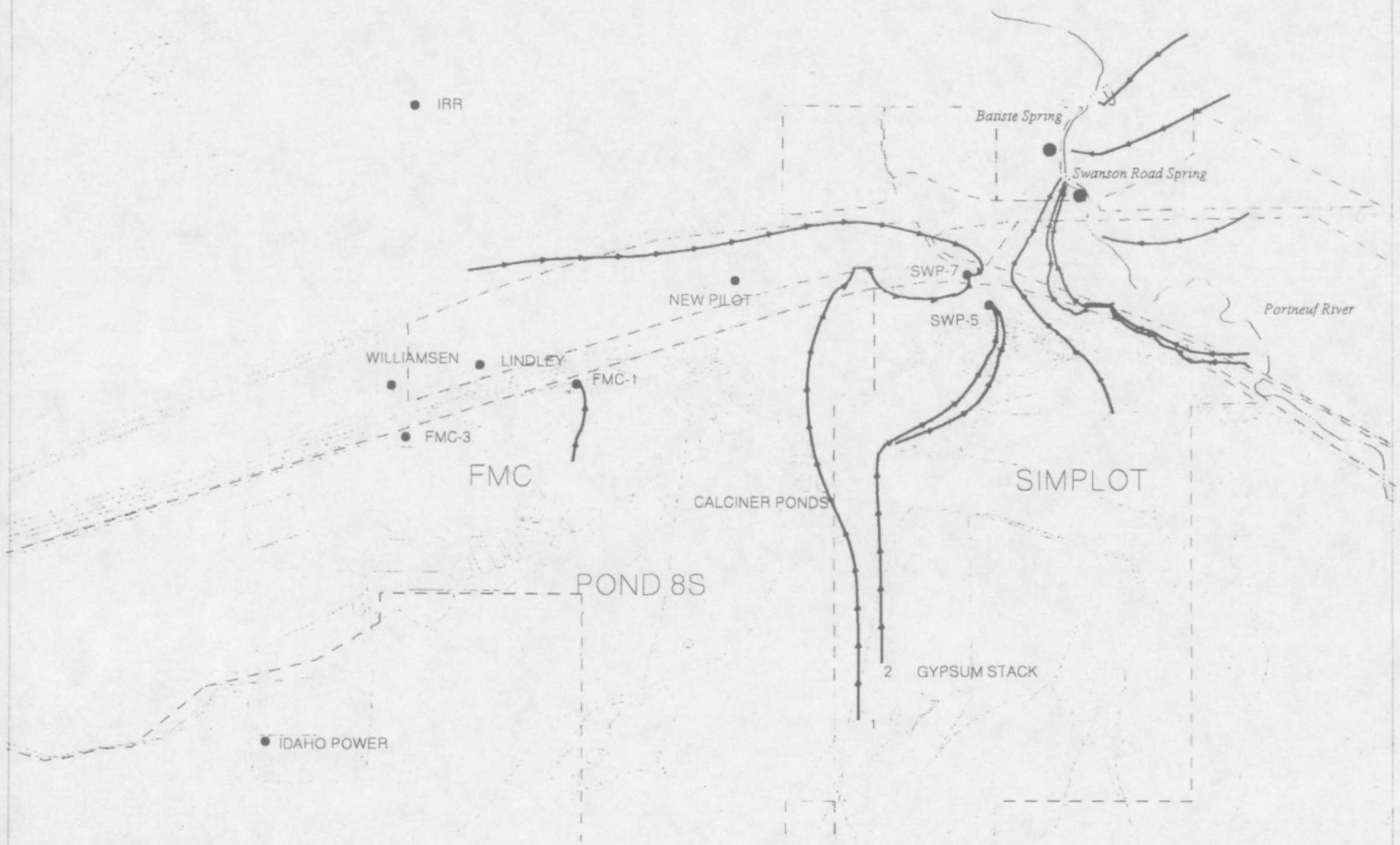
Particle Track in Model Layer 4

0 2500 5000 feet

N

BECHTEL ENVIRONMENTAL, INC. SAN FRANCISCO		
EASTERN MICHAUD FLATS POCATELLO, IDAHO		
Groundwater Particle Tracks Starting Points in Layer 1 - Scenario 1		
Job Number	Drawing No.	Rev.
21372	FIGURE 18	

Note. The groundwater model was used to generate these particle tracks. However, due to limited data in the area south of the Calciner Ponds and in the vicinity of the Gypsum Stack, particle tracks 1 and 2 in this area are conceptual.



EXPLANATION

- Pumping Well
- Spring Location
- Particle Track in Model Layer 1
- Particle Track in Model Layer 2
- Particle Track in Model Layer 3
- Particle Track in Model Layer 4

0 2500 5000 feet

N

BECHTEL ENVIRONMENTAL, INC. SAN FRANCISCO			
EASTERN MICHAUD FLATS POCATELLO, IDAHO			
Groundwater Particle Tracks Starting Points in Layer 4 - Scenario 1			
BECHTEL	Job Number	Drawing No.	Rev.
	21372	FIGURE 19	

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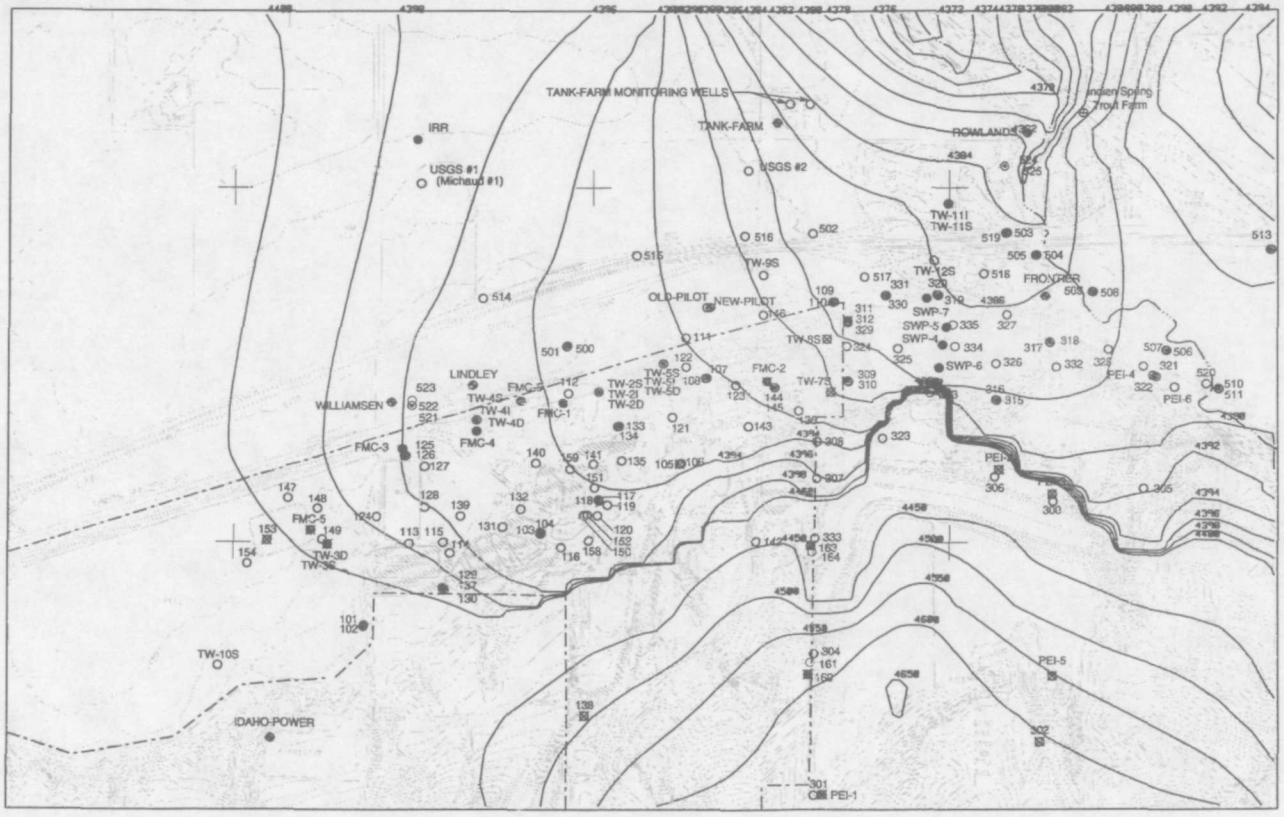


Legend:

- Shallow monitoring well
- Deep monitoring well
- Water supply well
- Production well
- Abandoned shallow monitoring well
- Abandoned deep monitoring well
- Abandoned production well

0 1750 3500

N

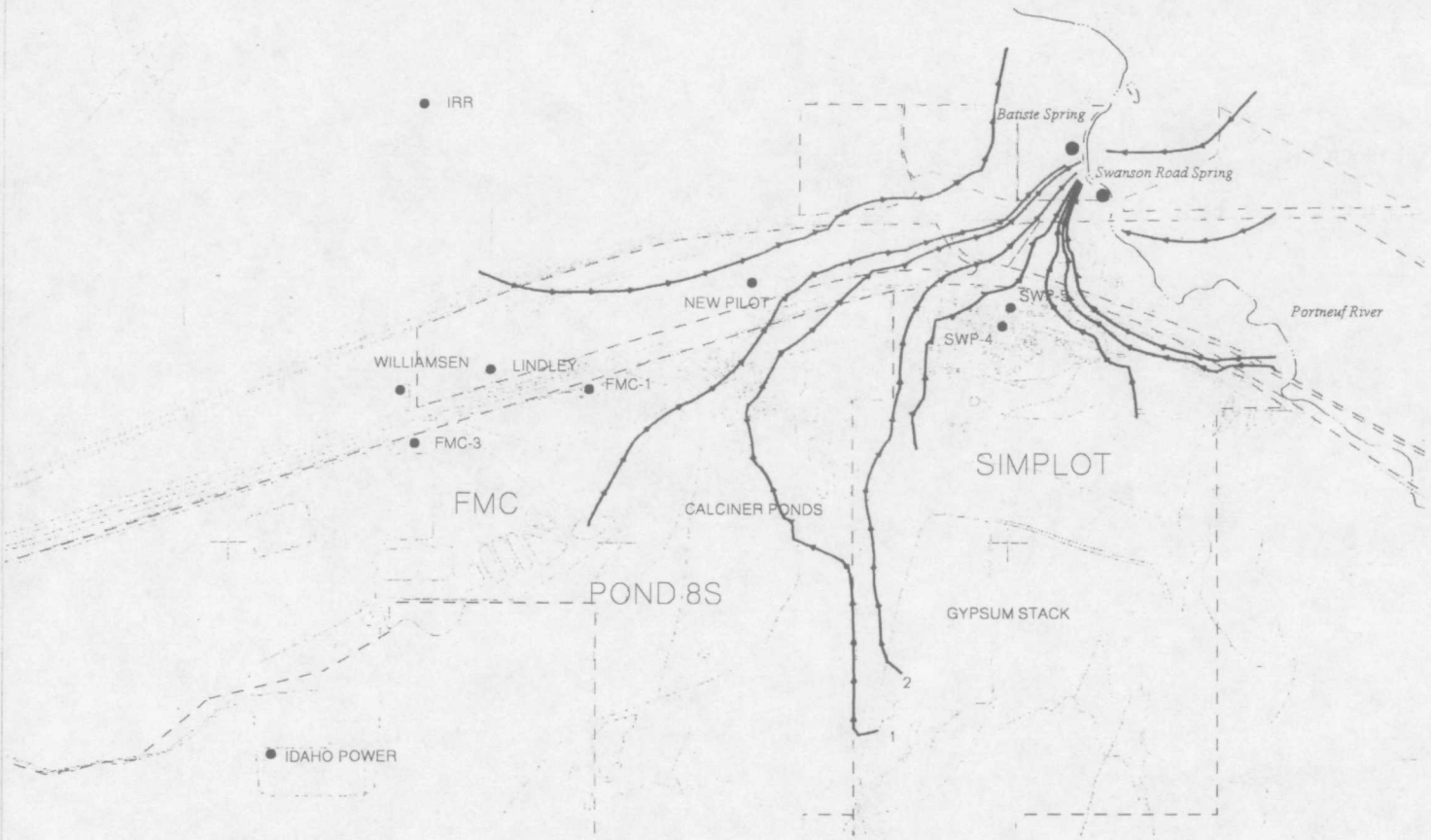
BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

EASTERN MICHAUD FLATS
POCATELLO, IDAHO

Modeled Groundwater Contours in Shallow Aquifer - Scenario 2

Job Number	Drawing No.	Rev.
21372	FIGURE 20	

Note: The groundwater model was used to generate these particle tracks. However, due to limited data in the area south of the Calciner Ponds and in the vicinity of the Gypsum Stack, particle tracks 1 and 2 in this area are conceptual.



EXPLANATION

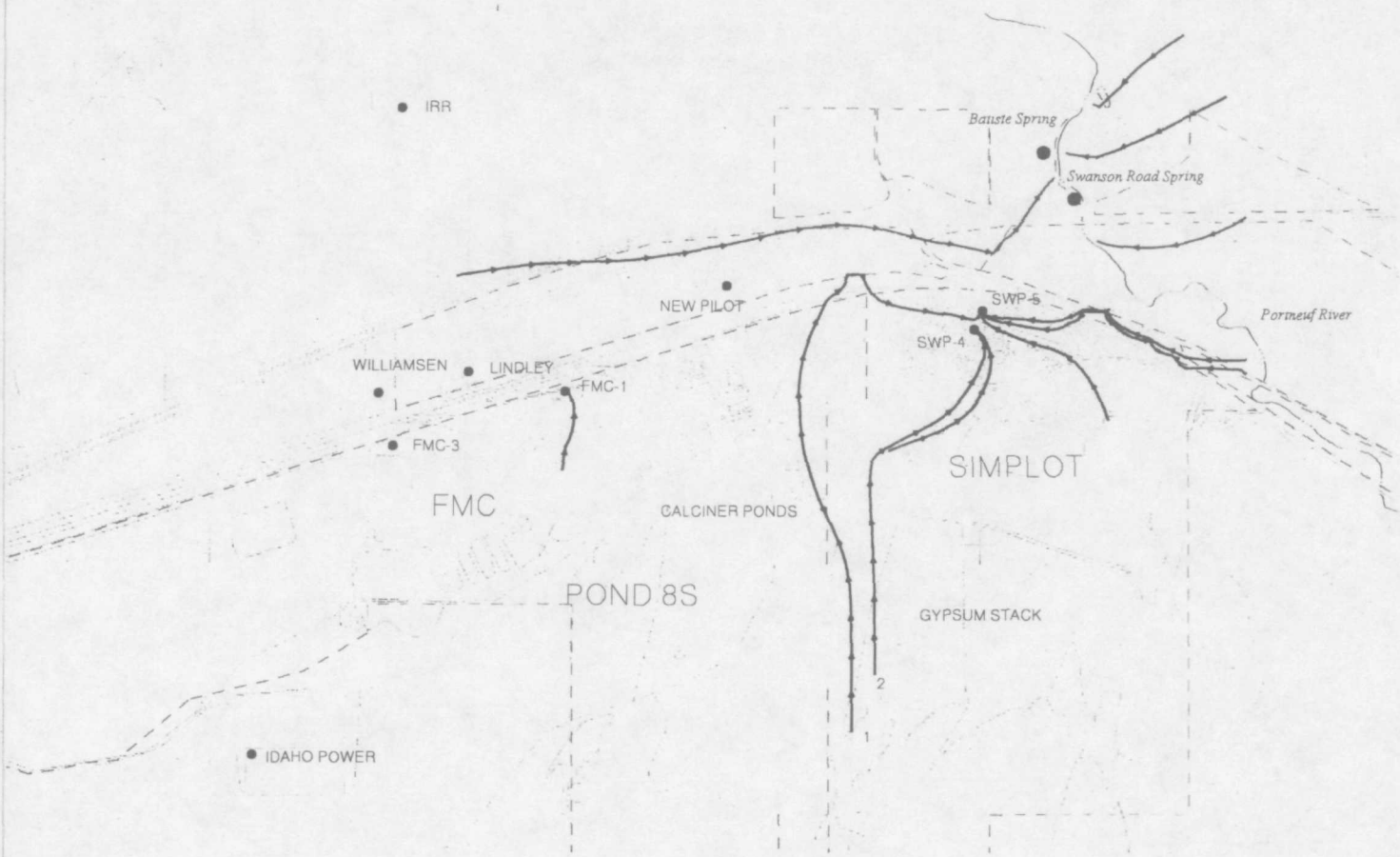
- Pumping Well
- Spring Location
- Particle Track in Model Layer 1
- Particle Track in Model Layer 2
- Particle Track in Model Layer 3
- Particle Track in Model Layer 4

0 2500 5000 feet

N

BECHTEL ENVIRONMENTAL, INC. SAN FRANCISCO		
EASTERN MICHAUD FLATS POCATELLO, IDAHO		
Groundwater Particle Tracks Starting Points in Layer 1 - Scenario 2		
Job Number	Drawing No.	Rev.
21372	FIGURE 22	

Note. The groundwater model was used to generate these particle tracks. However, due to limited data in the area south of the Calciner Ponds and in the vicinity of the Gypsum Stack, particle tracks 1 and 2 in this area are conceptual.



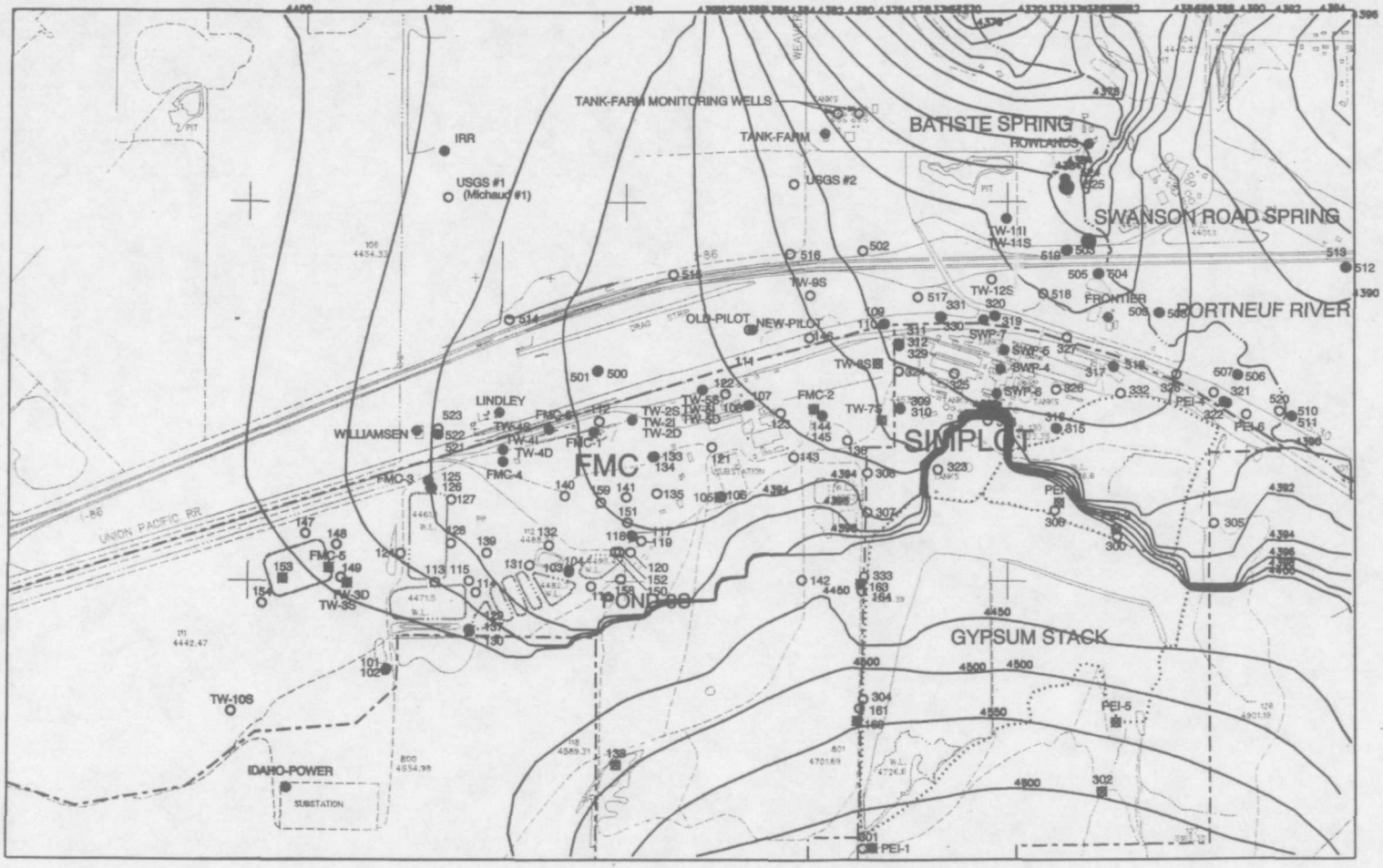
EXPLANATION

- Pumping Well
- Spring Location
- Particle Track in Model Layer 1
- Particle Track in Model Layer 2
- Particle Track in Model Layer 3
- Particle Track in Model Layer 4

0 2500 5000 feet

N

BECHTEL ENVIRONMENTAL, INC. SAN FRANCISCO			
EASTERN MICHAUD FLATS POCATELLO, IDAHO			
Groundwater Particle Tracks Starting Points in Layer 4 - Scenario 2			
BECHTEL	Job Number	Drawing No.	Rev.
	21372	FIGURE 23	



Legend:

- Shallow monitoring well
- Deep monitoring well
- Water supply well
- Production well
- Abandoned shallow monitoring well
- Abandoned deep monitoring well
- Abandoned production well
- Modeled Groundwater Contour (Contours for elevations <4400' are 2' intervals >4400' are 50' intervals)

0 1500 3000 FEET
0 300 600 900 METERS

BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

EASTERN MICHAUD FLATS
POCATELLO, IDAHO

Modeled Groundwater Contours in Shallow Aquifer - Scenario 3

Job Number	Drawing No.	Rev.
21372	FIGURE 24	

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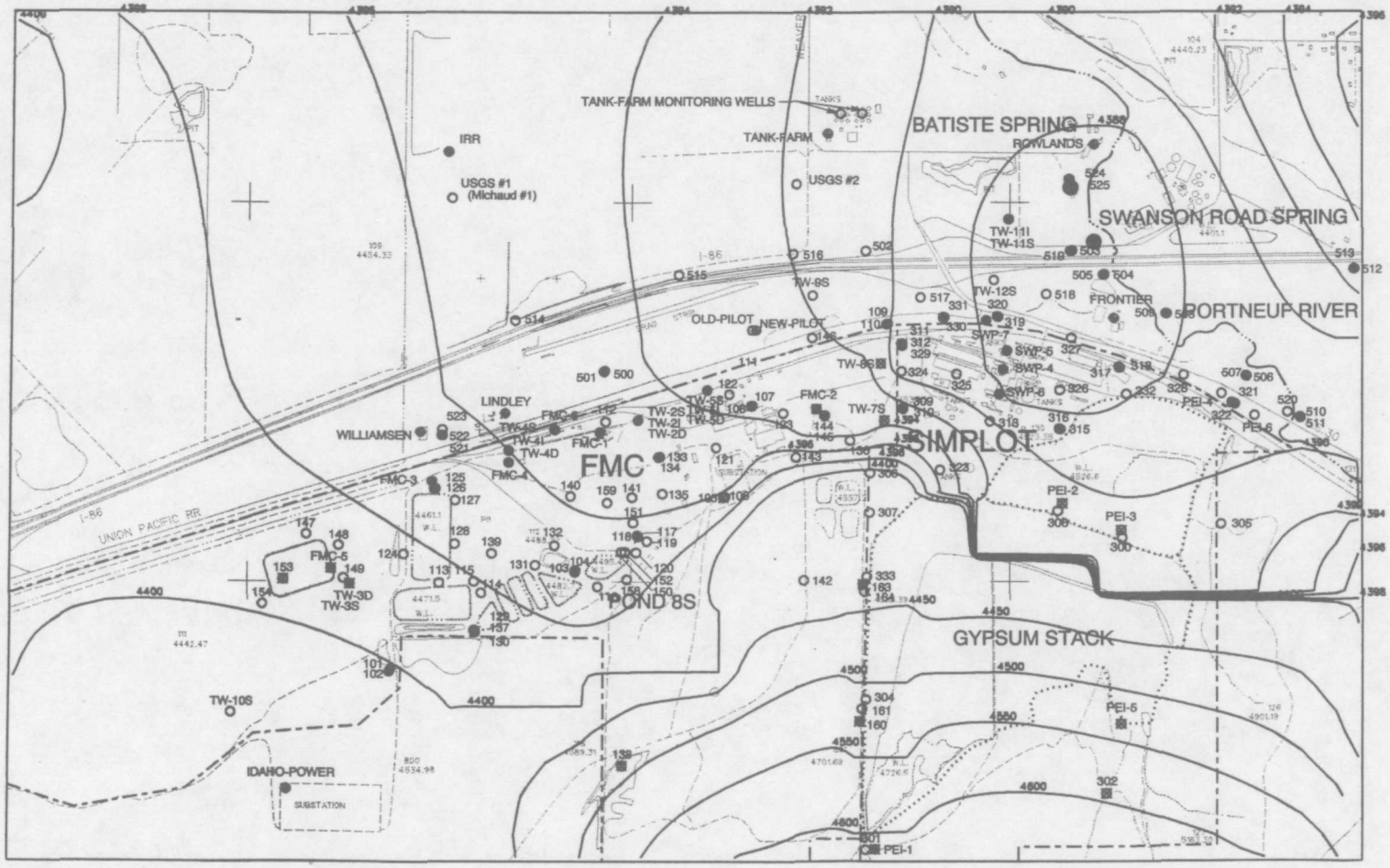

Legend:

- Shallow monitoring well
- Deep monitoring well
- Water supply well
- Production well
- Abandoned shallow monitoring well
- Abandoned deep monitoring well
- Abandoned production well
- Modeled Groundwater Contour (Contours for elevations <4400' are 2' intervals >4400' are 50' intervals)

N

0 1500 3000 FEET

0 300 600 900 METERS

BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

EASTERN MICHAUD FLATS
POCATELLO, IDAHO

Modeled Groundwater Contours in Deeper Aquifer - Scenario 3

Job Number	Drawing No.	Rev.
21372	FIGURE 25	

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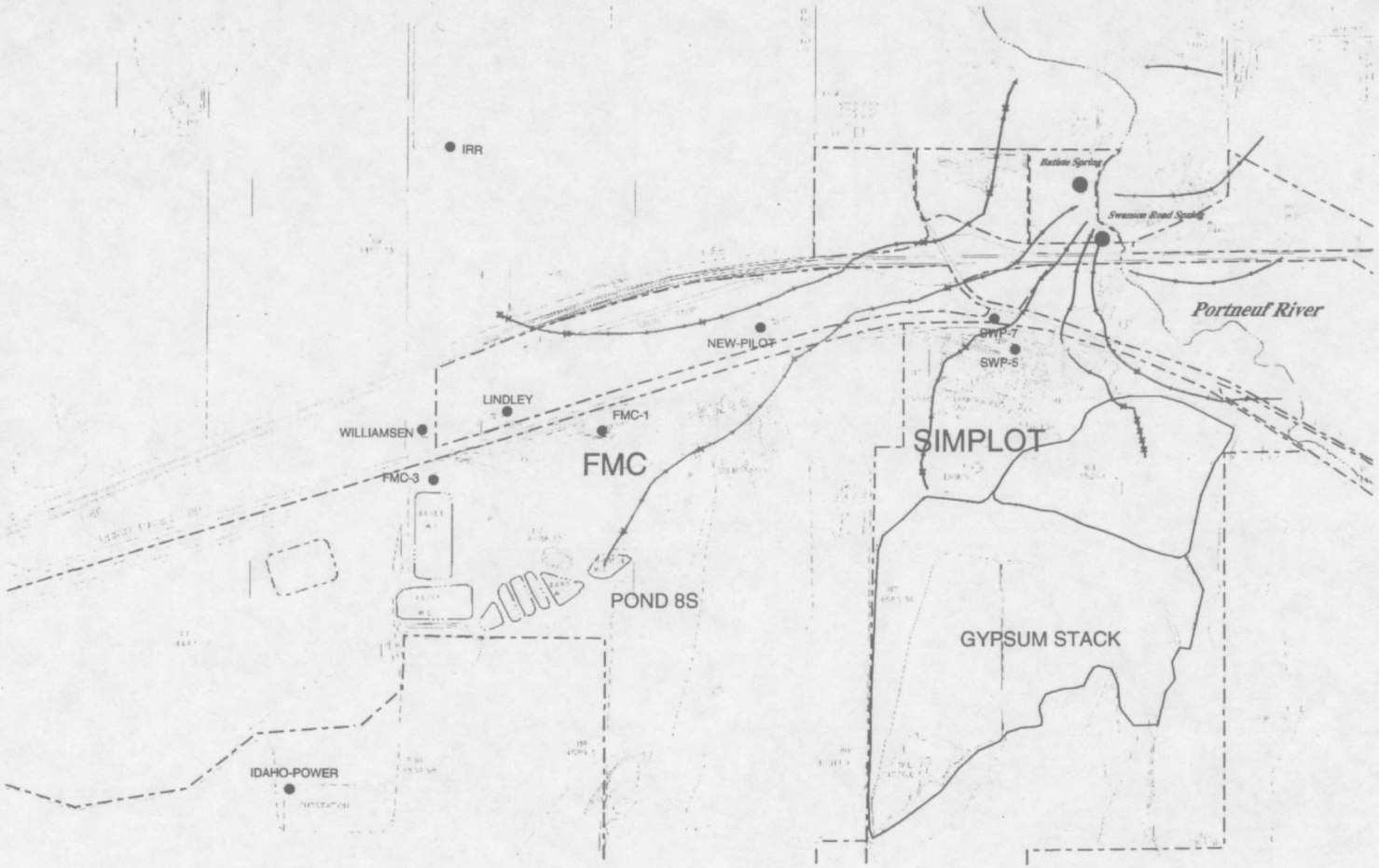
ws off 9, 10, 11, 12, 17 , 20, 25, 26, 27)



Legend:

- Pumping Well
- Spring Location
- Modeled Groundwater Particle Track (arrows show flow direction and x marks one-year travel time intervals)
- Particle in Model Layer1
- Particle in Model Layer2
- Particle in Model Layer3
- Particle in Model Layer4

N

0 1500 3000 FEET

0 300 600 900 METERS

BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

EASTERN MICHAUD FLATS
POCATELLO, IDAHO

Groundwater Particle Tracks
Starting Points in Layer 1 - Scenario 3

Job Number	Drawing No.	Rev.
21372	FIGURE 26	

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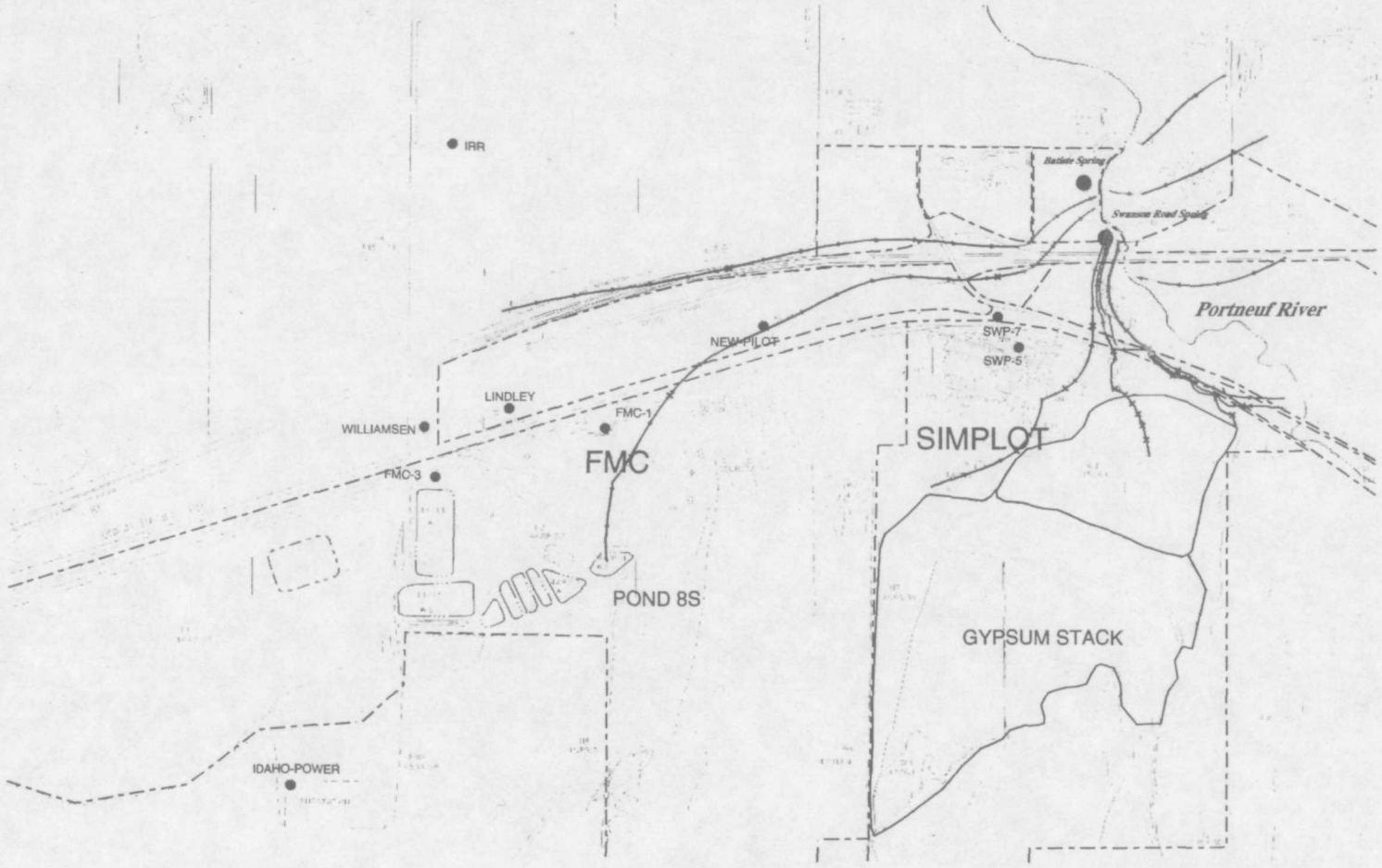
2/95dw lw:8, 11, 19, 2,
dgn



Legend:

- Pumping Well
- Spring Location
- Modeled Groundwater Particle Track (arrows show flow direction and x marks one-year travel time intervals)
- Particle in Model Layer1
- Particle in Model Layer2
- Particle in Model Layer3
- Particle in Model Layer4

N

0 1500 3000 FEET

0 300 600 900 METERS

BECHTEL ENVIRONMENTAL, INC.
SAN FRANCISCO

EASTERN MICHAUD FLATS
POCATELLO, IDAHO

Groundwater Particle Tracks
Starting Points in Layer 4 - Scenario 3

Job Number	Drawing No.	Rev.
21372	FIGURE 27	

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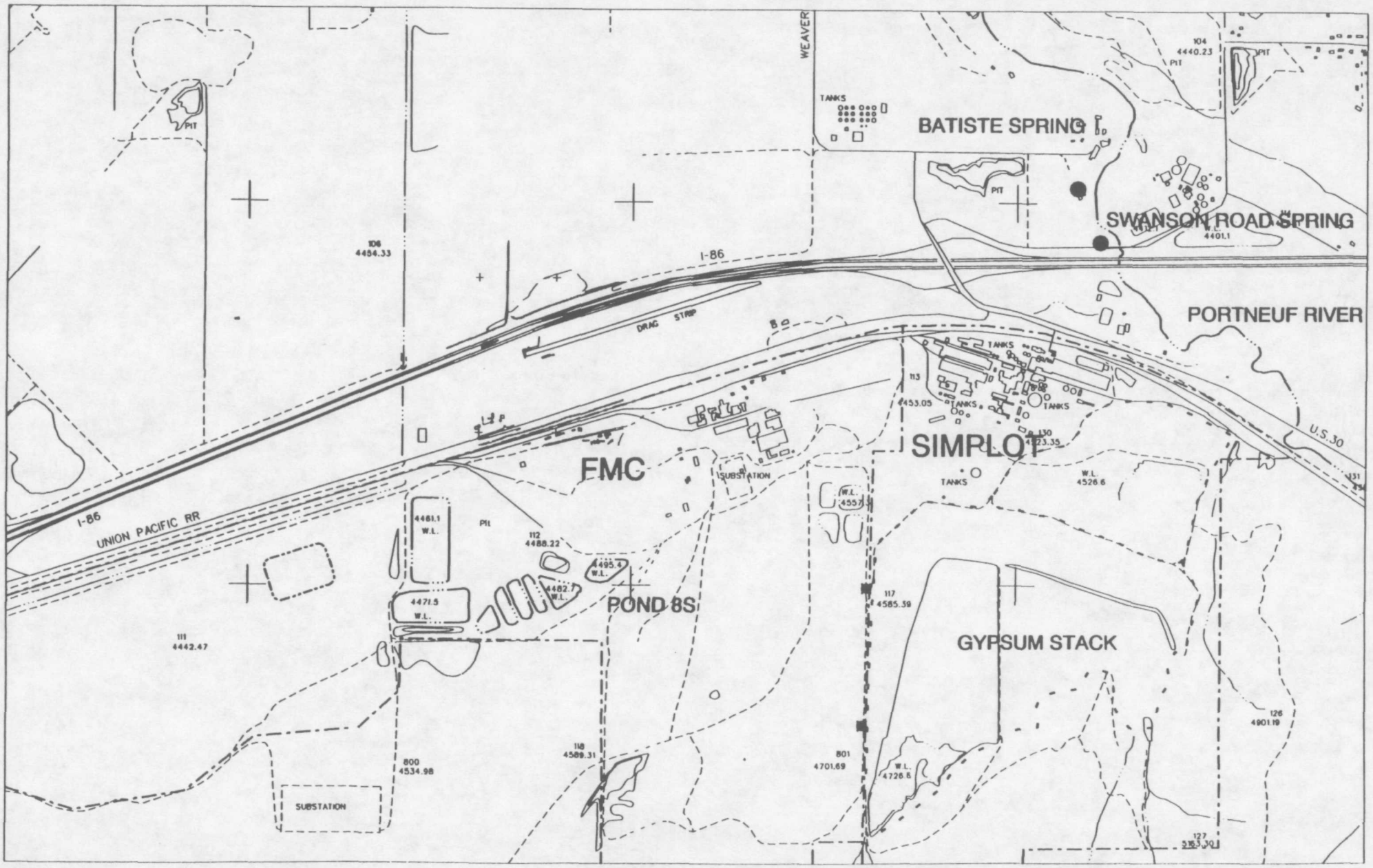
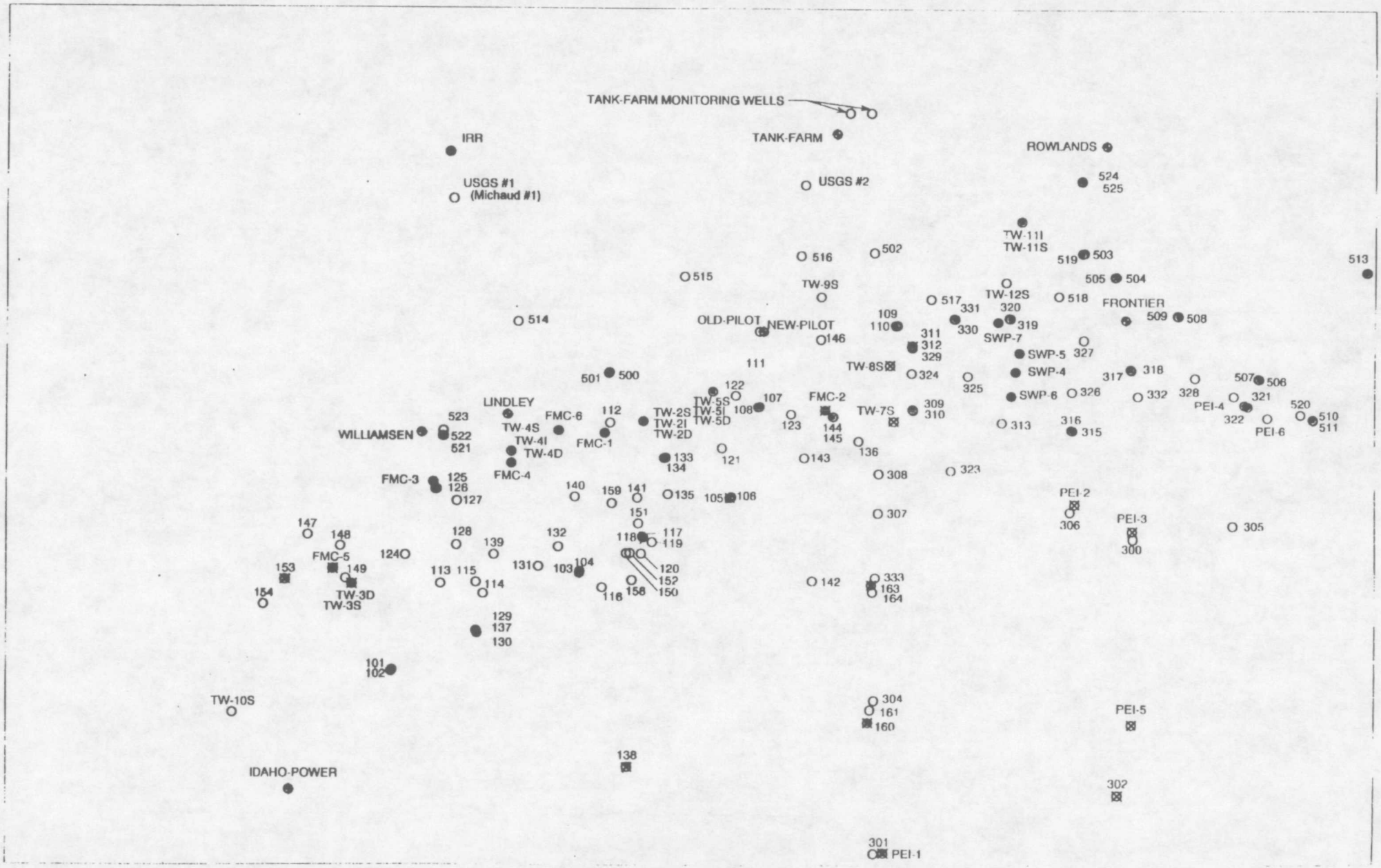
Appendix A
Well Logs

[Well Logs for the Groundwater Flow Modeling Study Report are now presented in the RI Report – Part II. They are in Appendix B.]

Appendix B
Sensitivity Analysis


WEAVER
TANKS
BATISTE SPRING
PIT
104
4440.23
PIT
PIT
SWANSON ROAD SPRING
4401.1
PIT
106
4454.33
I-86
DRAG STRIP
PORTNEUF RIVER
TANKS
113
4453.05
TANKS
TANKS
130
4423.35
U.S.30
SIMPLOT
FMC
SUBSTATION
TANKS
W.L.
4526.6
W.L.
4557
I-86
UNION PACIFIC RR
4481.1
W.L.
PIT
112
4488.22
4495.4
W.L.
4482.7
W.L.
4471.5
W.L.
POND 8S
117
4585.39
GYPSUM STACK
111
4442.47
126
4901.19
118
4589.31
800
4534.98
801
4701.69
W.L.
4726.6
SUBSTATION
127
5153.30


TANK-FARM MONITORING WELLS
TANK-FARM
IRR
ROWLANDS
USGS #1
(Michaud #1)
USGS #2
524
525
TW-11I
TW-11S
516
502
519
503
513
515
505
504
TW-9S
TW-12S
320
517
331
518
FRONTIER
509
508
514
OLD-PILOT
NEW-PILOT
109
110
146
311
312
329
330
319
SWP-7
327
SWP-5
111
TW-8S
324
SWP-4
317
318
501
500
122
325
507
506
TW-5S
TW-5I
TW-5D
107
108
FMC-2
SWP-6
326
332
328
321
LINDLEY
112
TW-2S
TW-2I
TW-2D
123
144
145
TW-7S
309
310
313
316
315
PEI-4
322
PEI-6
520
510
511
523
FMC-6
WILLIAMSEN
522
521
TW-4S
TW-4I
TW-4D
FMC-1
133
134
121
143
136
FMC-4
FMC-3
125
126
127
140
159
141
135
105
106
308
323
PEI-2
306
307
PEI-3
300
305
147
148
151
128
139
132
118
117
119
FMC-5
124
149
153
154
TW-3D
TW-3S
113
115
114
131
103
104
120
152
150
158
116
142
333
163
164
129
137
130
101
102
TW-10S
304
161
160
PEI-5
138
IDAHO-POWER
302
301
PEI-1

Sensitivity Analysis

B.1 INTRODUCTION

This appendix presents and discusses the details of the sensitivity analysis performed as part of this groundwater modeling study. The simplified two-layer model was used to perform this sensitivity analysis to investigate the model's sensitivity to more parameters rather than a more limited analysis performed on the four-layer model. There were differences between the two-layer and four-layer model output, but there is general agreement in flowpaths, contour patterns, head residuals, vertical gradients, and discharge rates between the two versions of the model. The six sensitivity cases were described in Section 5.3 and are reiterated below:

- Sensitivity to the K value (hydraulic conductivity) in model layer 1 (upper gravel zone), in which the river is located;
- Sensitivity to the T value (transmissivity) in model layer 2 (deeper aquifer) immediately beneath the river;
- Sensitivity to the T values assigned to the Bannock range in layer 2 (deeper aquifer; increased overall T);
- Sensitivity to the T values assigned to the Bannock range in layer 2 (deeper aquifer; decreased overall T);
- Sensitivity to natural recharge; and
- Sensitivity to variations in the constant head specified along the eastern boundary.

The evaluation criteria were also previously presented in Section 5.3 and are repeated below:

(1) River and spring discharge;

(2) Potentiometric head contour patterns in the upper gravel zone and deeper aquifer;

(3) Distribution of vertical head differentials throughout model domain.

In addition, particle tracks plotted from each sensitivity case were compared to the particle tracks from the calibrated model.

Each sensitivity case is presented with text describing the changes made to the flow model with the change noted on an applicable plot. Transparent overlays of the site map and the well locations are provided for the readers. These overlays will aid in following the detailed discussions. For each sensitivity run there are three plots; one

illustrates the simulated groundwater contours for the upper gravel zone, one illustrates the contours in the deeper aquifer, and one plot shows the simulated vertical head differentials between the upper gravel zone and deeper gravel.

In the contour plots, numbers posted near each symbol represents the difference between the simulated water level and the measured water level from August 1993. Where the numbers are negative the simulated head is higher than the measured head; positive numbers indicate the simulated head is lower than measured head.

In the plots of vertical head differentials, the numbers associated with each symbol represent the magnitude of the simulated head differential between the upper gravel zone and the deeper aquifer. Negative values indicate downward vertical gradients and positive numbers indicate upward vertical gradients.

The summary figure illustrating the groundwater particle tracks from the six sensitivity cases was presented in the main body of this report as Figure 17. The reader should refer to Figure 17 when comparing relative changes of groundwater particle tracks for each sensitivity case.

B.2 SENSITIVITY CASE #1 - DECREASED HYDRAULIC CONDUCTIVITY IN LAYER 1 (UPPER GRAVEL ZONE) - NEAR PORTNEUF RIVER

The K value in the region near the Portneuf River in the upper gravel zone was decreased from an initial value of 9,940 ft/day to 700 ft/day. The 700 ft/day corresponds to some of the lower K values from slug tests in that region. The calibration results indicated that a relatively high K value was needed in this region of the model to match all calibration targets; however, the calibrated value of 9,940 ft/day is at the high end of reported values for slug tests and pumping tests performed in the Michaud Gravels.

Results of this model run show the total river and spring discharge decreases from 74 cfs to 32 cfs. This sensitivity case discharge is less than one-half the calibration target for total discharge to the river and springs. Contour patterns and particle tracks are significantly different when compared to the calibrated model. Vertical head differentials and the heads at individual wells also show a much different distribution over the model area. In general, decreasing the hydraulic conductivity in the upper gravel zone near the Portneuf River causes larger differences between model output and calibration targets.

Changes were noted in the contour patterns in the upper gravel zone and the deeper aquifer. The regional depression in heads in the deeper aquifer is not as pronounced in this sensitivity run when compared to the calibrated model. This change in contour patterns coupled with the decreased discharge to the river indicates that lower hydraulic conductivity in the upper gravel zone reduces the potential discharge to the river from the deeper aquifer. Other changes in the upper gravel zone contour patterns are a less pronounced sink associated with Batiste Spring and a steeper gradient near the river, south of Swanson Road Spring.

The general pattern or areal distribution of vertical gradients is not much different between the calibration case and this sensitivity case. Reducing the horizontal K value near the Portneuf River decreased the vertical gradients along the losing reach of the river and increased vertical gradients near the FMC-Simplot fenceline.

Reducing the K value near the Portneuf River results in increased shallow groundwater elevations near the Simplot production wells and adjacent to the Portneuf River. Simulated heads at FMC increased in response to decreasing the K value in the upper gravel zone near the Portneuf River. Modeled heads in the deeper aquifer increased near the Portneuf River, but remained very close to the calibration target levels in other areas.

Particle tracks generated from this sensitivity are different than those generated from the calibrated model run. For example, the particle track starting north of I-86 does not move east-southeast then track to the east; rather, it begins an eastward track and then shifts to the northeast eventually terminating at the river near the northern model boundary.

The particle starting its track at FMC Pond 8S does not show the eastern deflection when it nears the Simplot production wells. In this sensitivity run, this particle tracks on a northeast course straight to the river. The point where this particle discharges is at the drain node near Batiste Spring.

Particle tracks beginning east of the Simplot production wells either terminate at the production wells, or at the Portneuf River. In this sensitivity run, the particle track ending at the river enters the river cells at a point several hundred feet south of the same particle in the calibrated model.

K values - .ayer-1

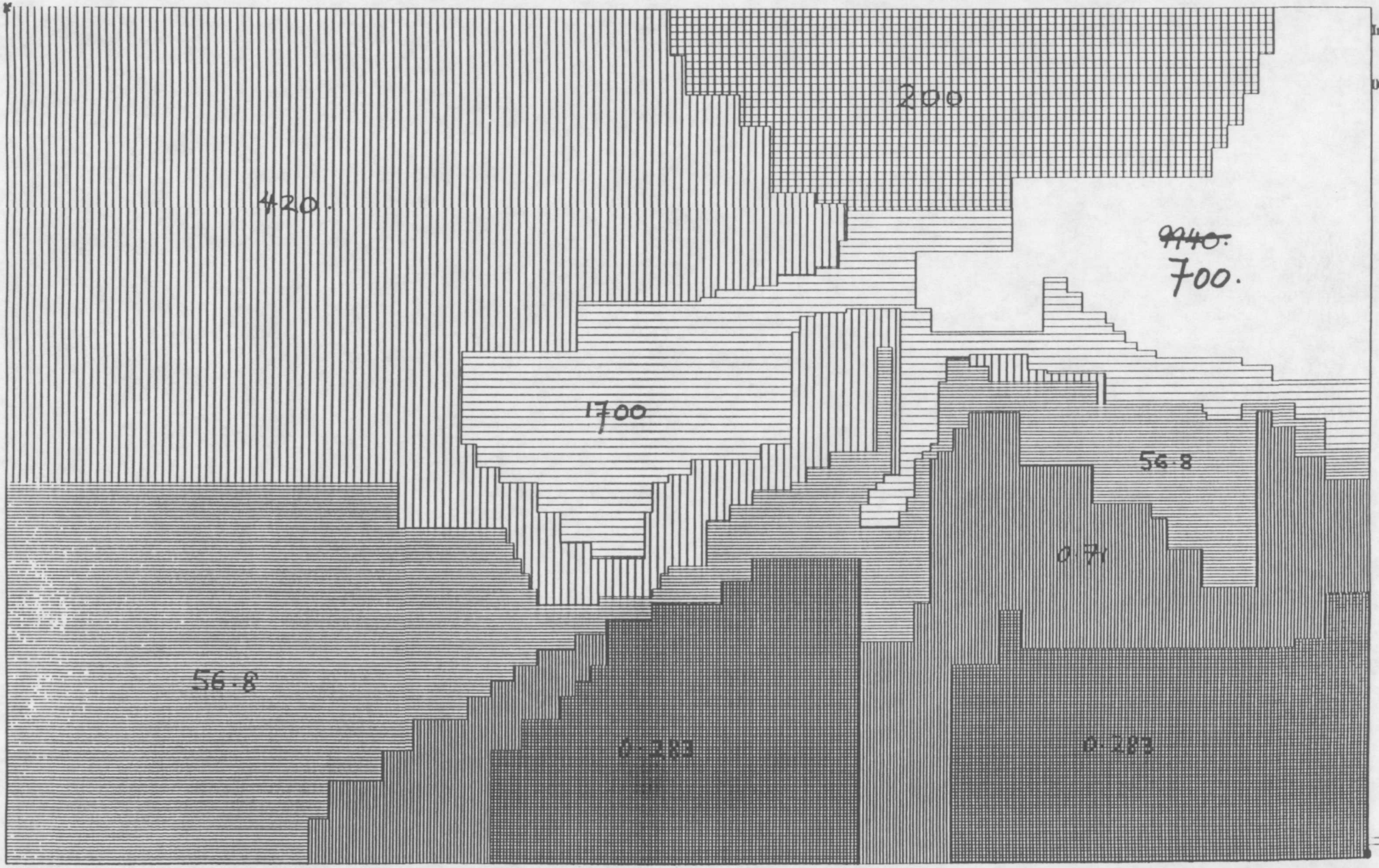
[ft/d]

Sensitivity Case #1 - Hydraulic Conductivity (ft/day) Zones in Upper Gravel Zone
(Model Layer 1 in Two-layer Model)
Scale: 1 inch = 1750 feet (1:21000)

L1.H

Input

06/30

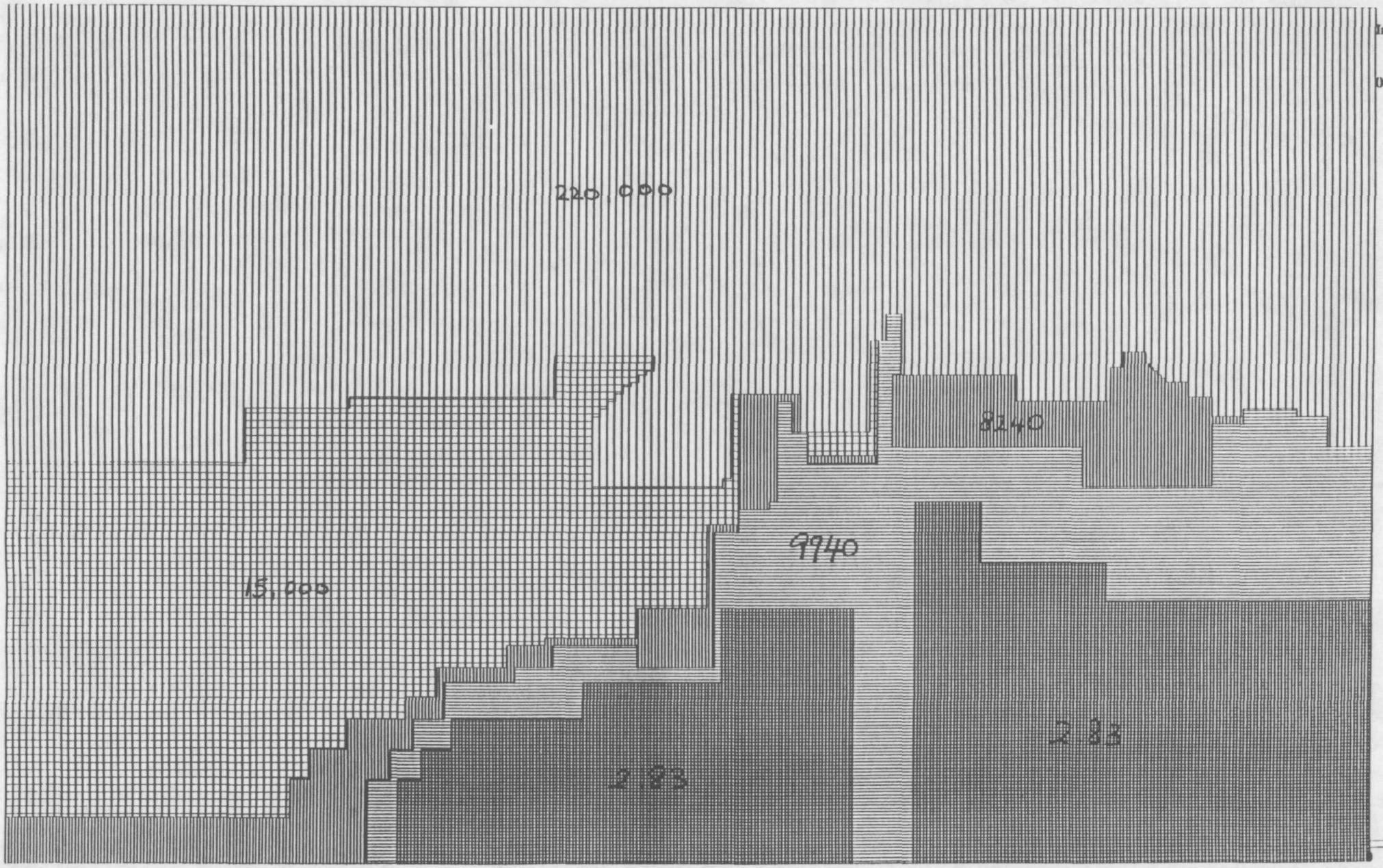


T values - Layer - 2.
[ft²/d]

L2.T

Sensitivity Case #1 - Transmissivity (ft²/day) Zones in Deeper Aquifer (Model Layer 2 in Two-layer Model)

Scale: 1 inch = 1750 feet (1:21000)

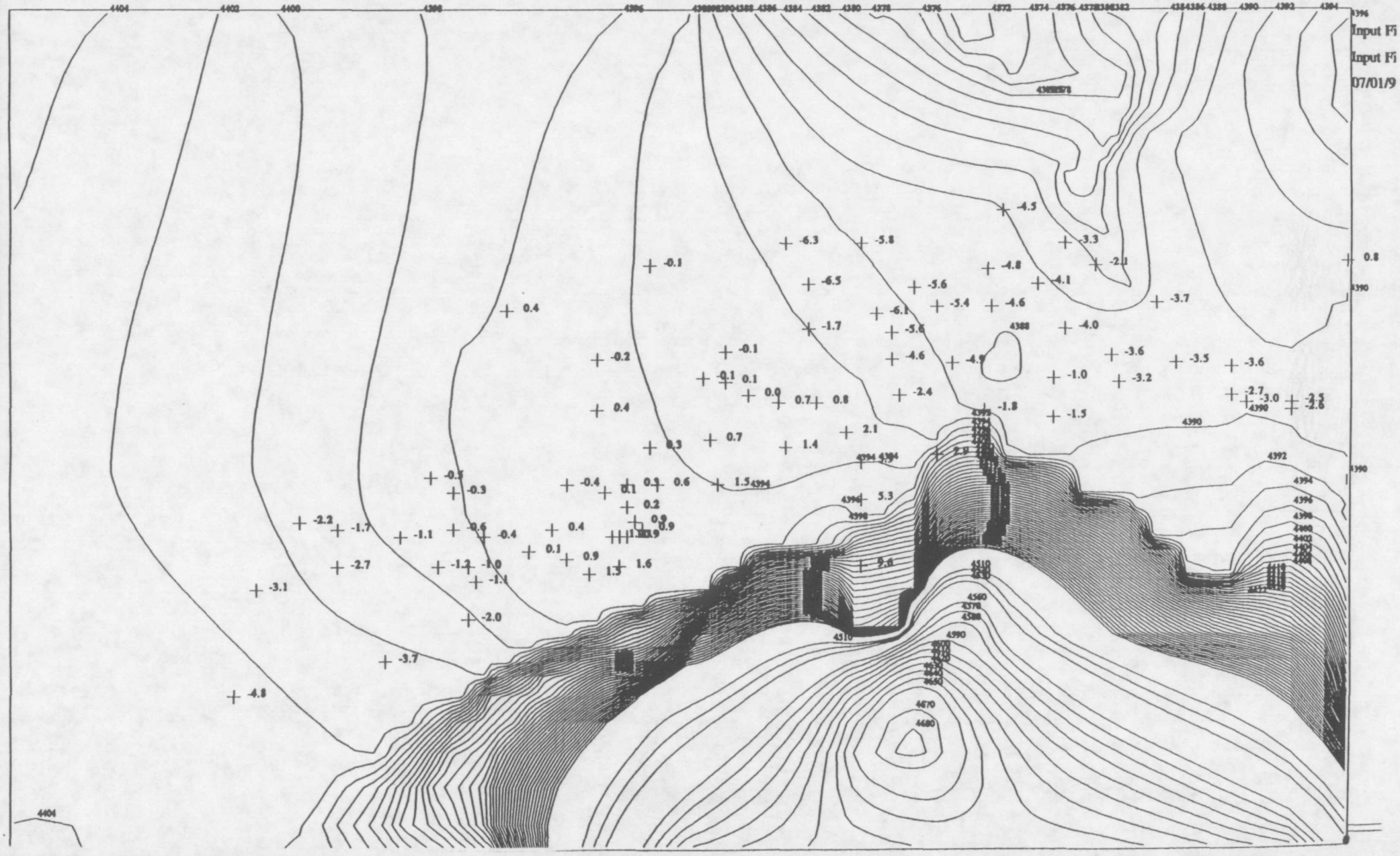


Input

06/30

Sensitivity Case #1 - Contoured Heads in Upper Gravel Zone (Model Layer 1 in Two-layer Model)

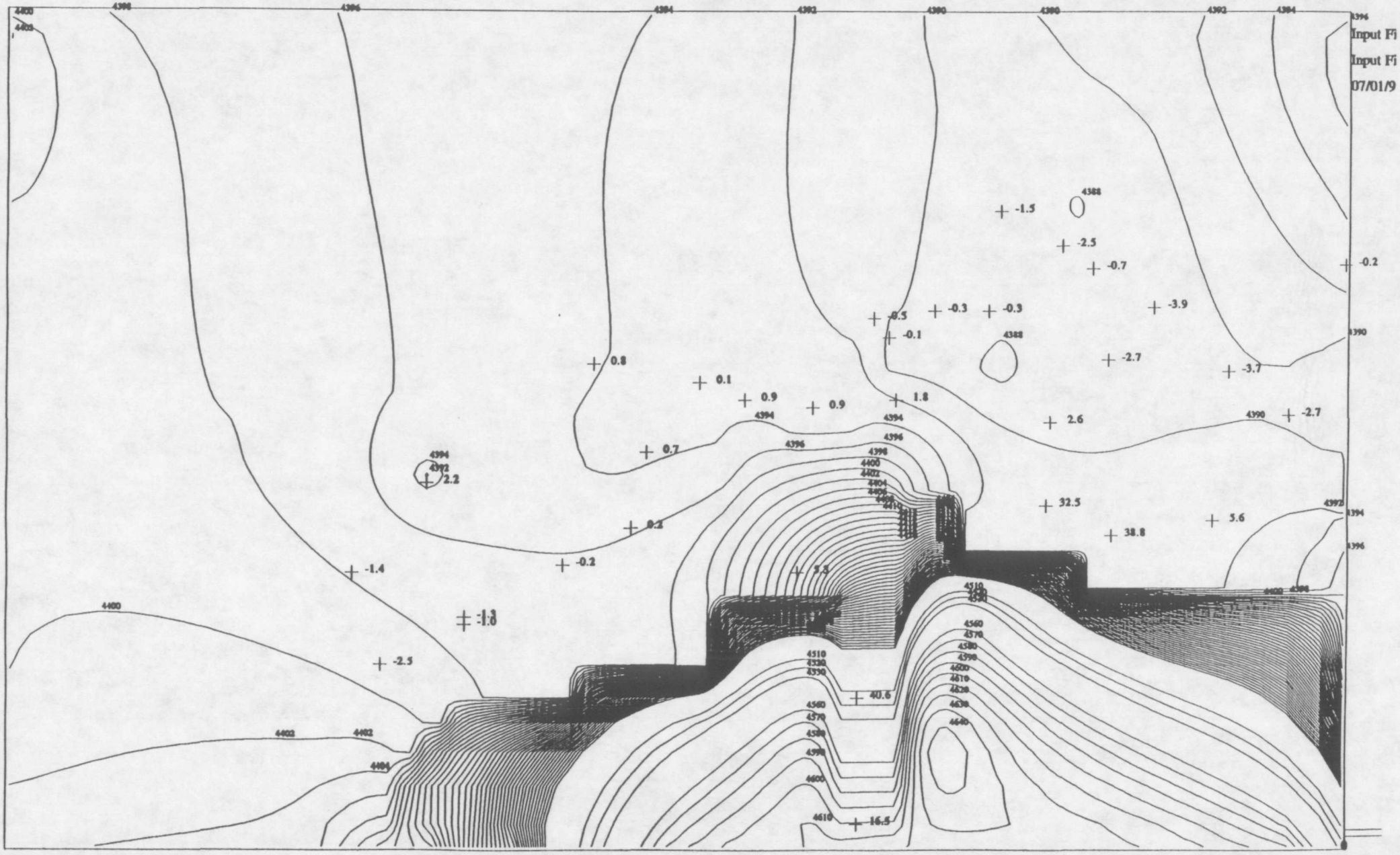
Scale 1 inch = 1750 feet (1:21000)



Sensitivity Case #1 - Contoured Heads in Deeper Aquifer (Model Layer 2 in Two-layer Model)

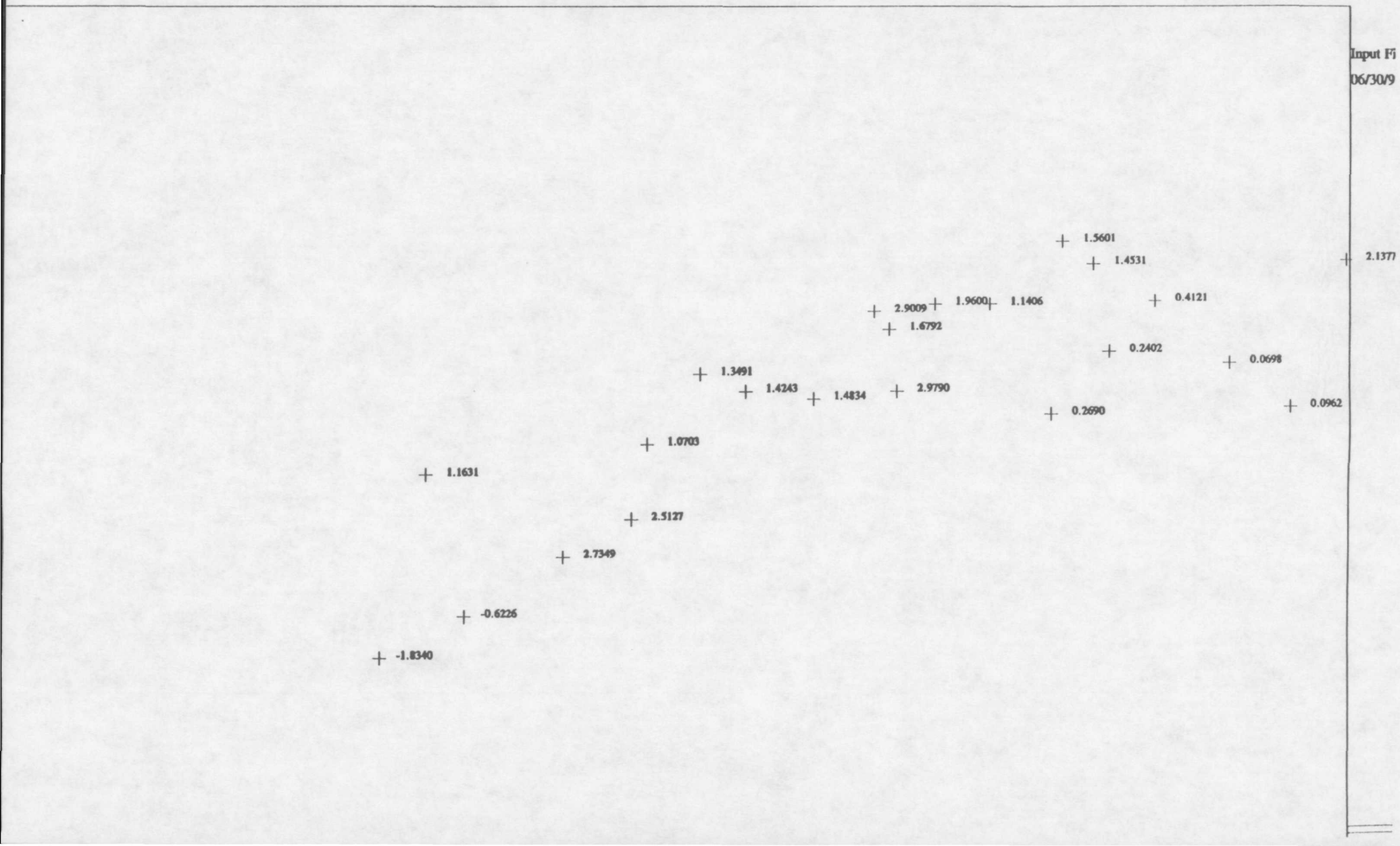
L2.RSI

Scale 1 inch = 1750 feet (1:21000)



Sensitivity Case #1 - Vertical Head Differentials Between Upper Gravel Zone and Deeper Aquifer (Model Layers 1 and 2 in Two-layer Model)

Scale 1 inch = 1750 feet (1:21000)



E_DW

Input Fi

06/30/9

B.3 SENSITIVITY CASE #2 – DECREASED TRANSMISSIVITY IN LAYER 2 (DEEPER AQUIFER) – NORTHERN ONE-THIRD OF MODEL AREA

The calibrated model used a transmissivity value of 220,000 ft^2/day for the deeper aquifer beneath the Michaud Flats and the Portneuf River area. Recall that the deeper aquifer is comprised of deeper confined gravels and the underlying basalt. Both units have high T values and are hydraulically interconnected; however, a measured combined transmissivity had to be estimated for these units. The estimated T value used in the calibrated model was an upper estimate based on reported T values for the Michaud Flats area (Table 2); therefore, this sensitivity case uses a lower T value of 80,000 ft^2/day.

Total river and spring discharge is 51 cfs in this model case, compared to 67 cfs in the calibrated model. In the deeper aquifer, a reduction in transmissivity causes a much more pronounced cone of depression associated with the Simplot and FMC production wells. Modeled heads associated with the deeper aquifer are much lower than the calibrated modeled heads and are not within the historic ranges of observed water levels. Vertical head differentials are in better agreement with observed data in an area west of the Simplot production wells, in the north-central FMC area, but the head differentials near the river are significantly lower than the observed data and the simulated differentials in the calibrated model.

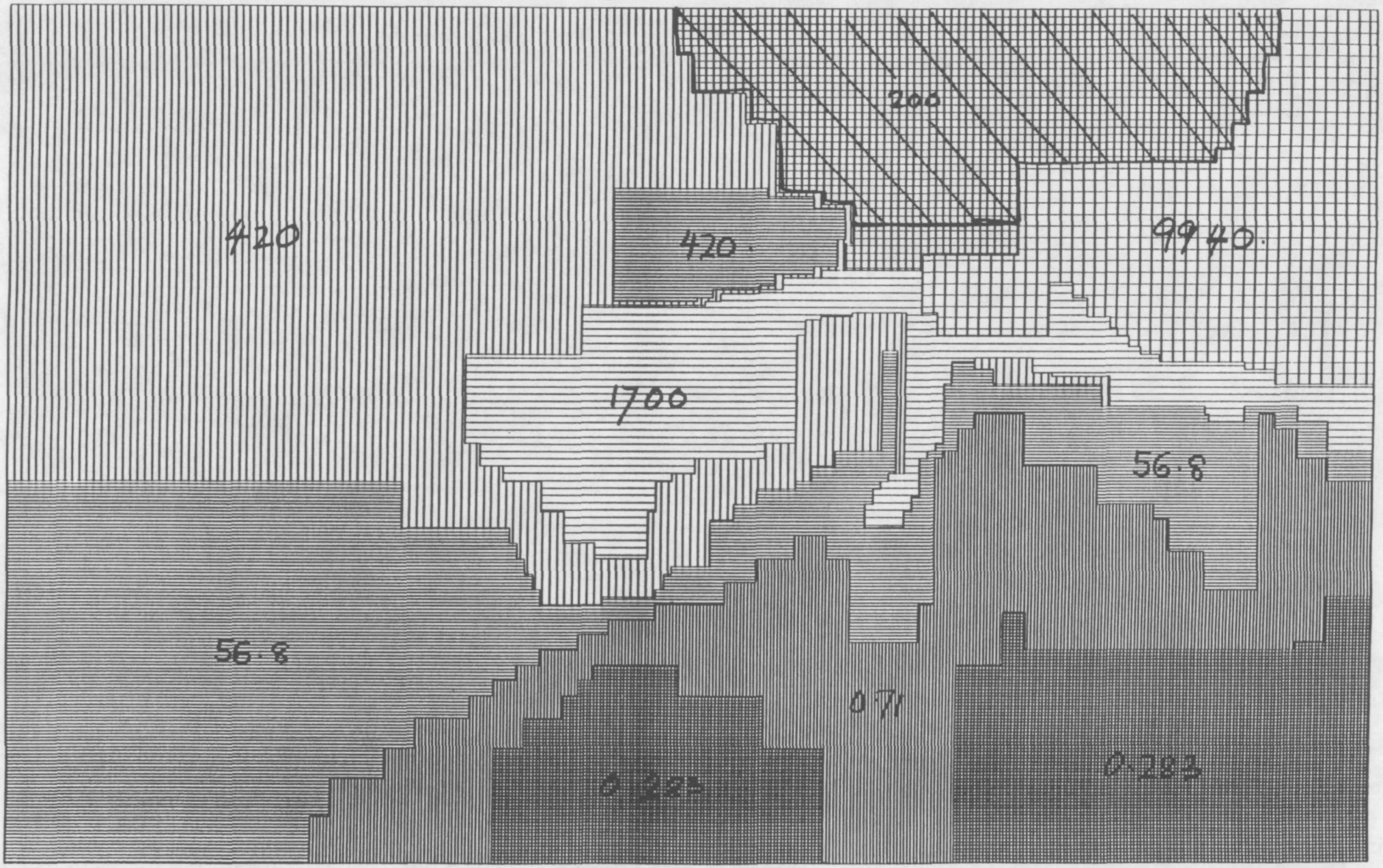
Groundwater particle tracks through the upper gravel zone illustrate a large capture zone associated with the Simplot production wells in this sensitivity case. All particle tracks with starting points between the river and the production wells terminate at the production wells, indicating what would be interpreted as increased hydraulic containment of the easternmost source areas at Simplot. This flow pattern is not in agreement with the geochemical data, which indicate most of the shallow groundwater underflowing the lower gypsum stack and former east overflow pond is not captured by the production wells.

2

Sensitivity Case #2 - Hydraulic Conductivity Zones in Upper Gravel Zone (Model Layer 1 in Two-layer Model)

Scale: 1 inch = 1750 feet (1:21000)

SENS 2

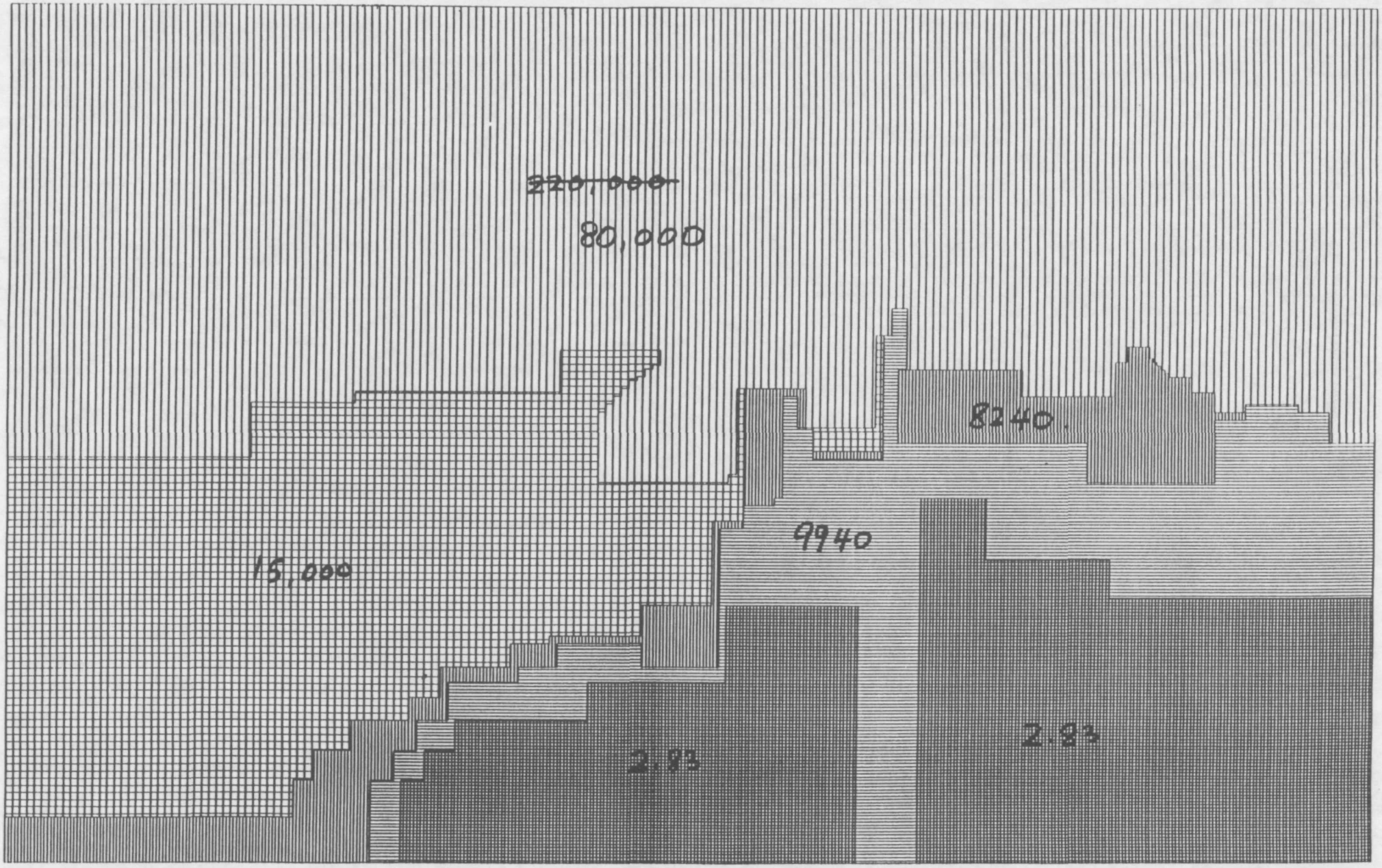


2

2-LAYER MODEL: LAYER 2 TRANSMISSIVITIES (SQ F

Sensitivity Case #2 - Transmissivity (ft^2/day) Zones in Deeper Aquifer (Model Layer 2 in Two-layer Model)

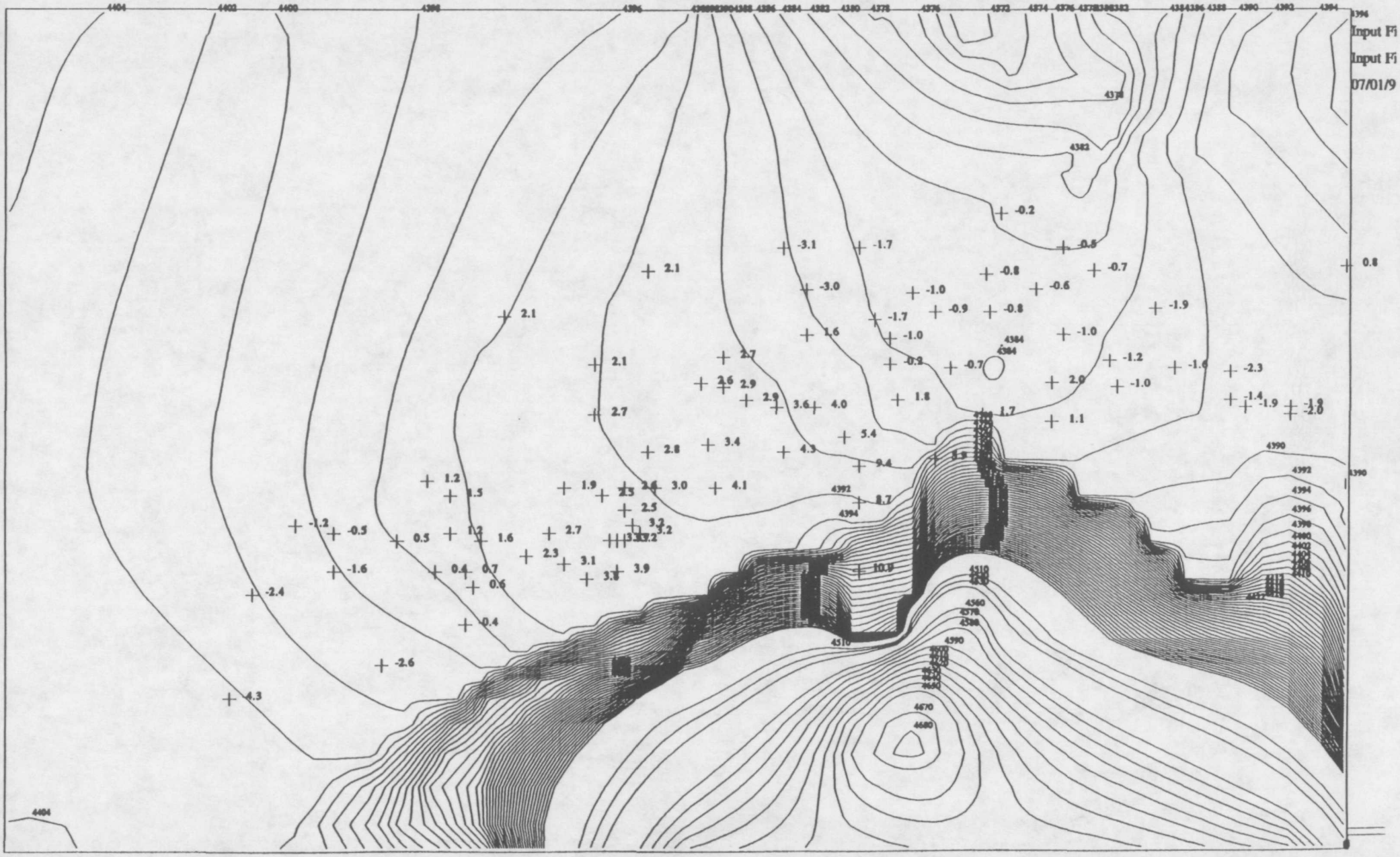
Scale: 1 inch = 1750 feet (1:21000)



Sensitivity Case #2 - Contoured Heads in Upper Gravel Zone (Model Layer 1 in Two-layer Model)

Scale 1 inch = 1750 feet (1:21000)

L1.RSI

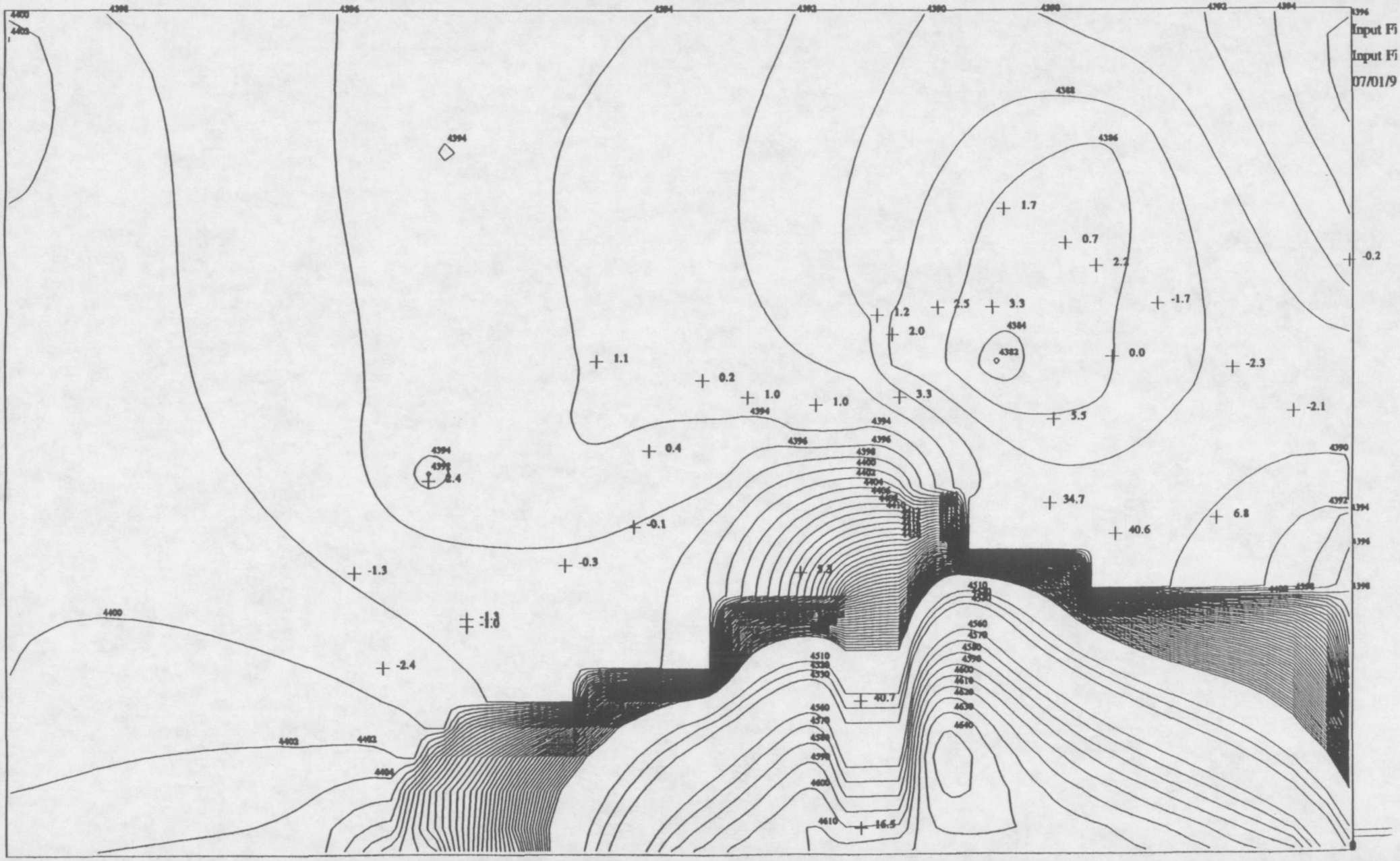


2

Sensitivity Case #2 - Contoured Heads in Deeper Aquifer (Model Layer 2 in Two-layer Model)

L2.RSI

Scale 1 inch = 1750 feet (1:21000)

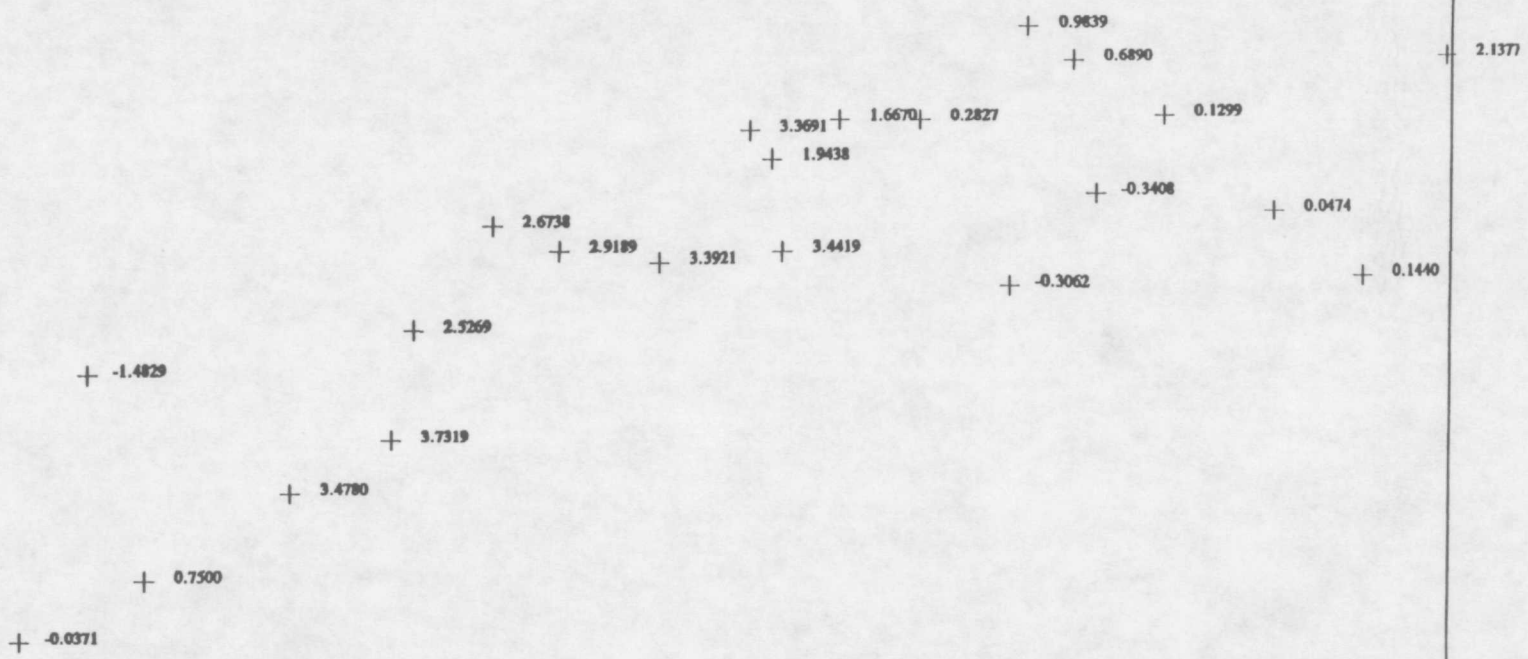


Sensitivity Case #2 - Vertical Head Differentials Between Upper Gravel Zone and Deeper Aquifer (Model Layers 1 and 2 in Two-layer Model)

Scale 1 inch = 1750 feet (1:21000)

E_DW

Input Fi
07/01/9



B.4 SENSITIVITY CASE #3 – INCREASED TRANSMISSIVITY IN LAYER 2 (DEEPER AQUIFER/INTERFLOW SEDIMENTS) – BANNOCK RANGE AREA

Given the complexities associated with modeling groundwater flow through the Bannock Range, this sensitivity run was used to test the model response to higher transmissivity in the deeper zone through the Bannock Range. The T zones assigned a value of 2.83 ft^2/day were changed to 9,940 ft^2/day, a value similar to the transmissivity assigned to the region associated with the sediment-filled valley along the FMC-Simplot fenceline.

Total discharge to the river and springs increased approximately 7 cfs. This change is within the observed range of river and spring discharge. Simulated contour patterns in the upper gravel zone are quite similar to the calibrated model, with the exception of the contour patterns along the easternmost Bannock Range area, where there is an increased mounding. Simulated contour patterns in the deeper aquifer are significantly different in this sensitivity case when compared to the calibrated model. For example, there are no significant capture zones associated with the FMC production wells or the Simplot production wells. In addition, the zone where groundwater flow converges through FMC is no longer apparent in the contours for the deeper aquifer heads. The regional hydraulic sink associated with the Portneuf River and springs is less pronounced in this sensitivity case. Vertical head differentials are well beyond the observed ranges for well pairs located along the Bannock Range/Michaud Flats transition area. In some cases the simulated heads in the deeper aquifer are over 20 feet higher than the heads in the upper gravel zone.

Particle tracks through the upper gravel zone indicate a major shift in groundwater flow patterns from the Michaud Flats to the river and in the area east of the Simplot production wells. The higher flux of groundwater underflowing through the Bannock Range reduces the potential capture zone of the Simplot production wells.

The model is sensitive to increasing the transmissivity through large T zones in the Bannock Range. Increasing the transmissivity by 3 orders of magnitude in the lower layer through the Bannock Range has major impacts on simulated vertical gradients, contour patterns, and particle tracks. There are significant differences between observed data and the simulated heads, contour patterns, flow patterns, and vertical head differentials.

3

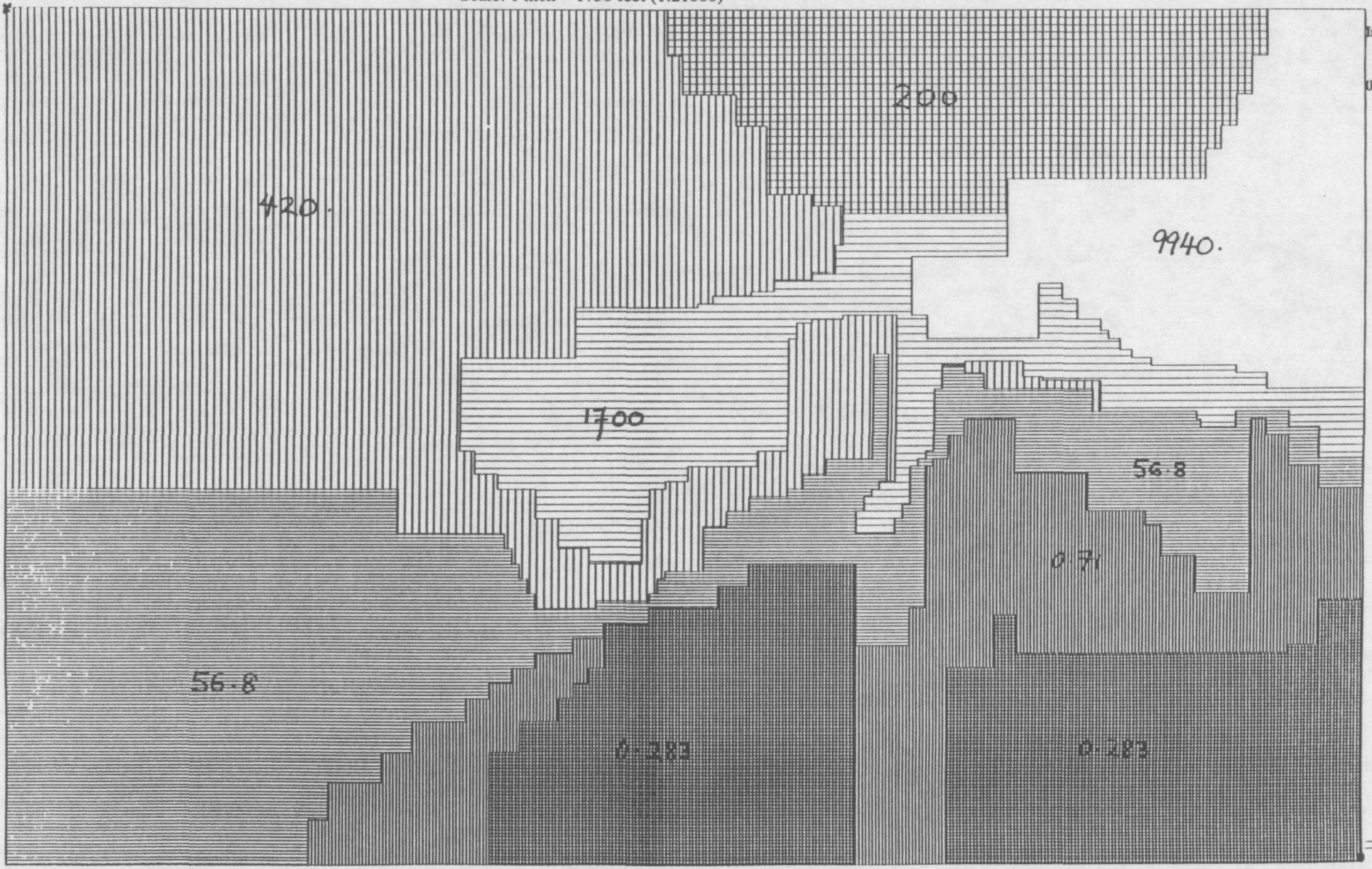
K values - layer-1

[ft/d]

L1.H

Sensitivity Case #3 - Hydraulic Conductivity Zones in Upper Gravel Zone (Model Layer 1 in Two-layer Model)

Scale: 1 inch = 1750 feet (1:21000)



Input

06/30

3

T values - Layer-2.

[ft²/d]

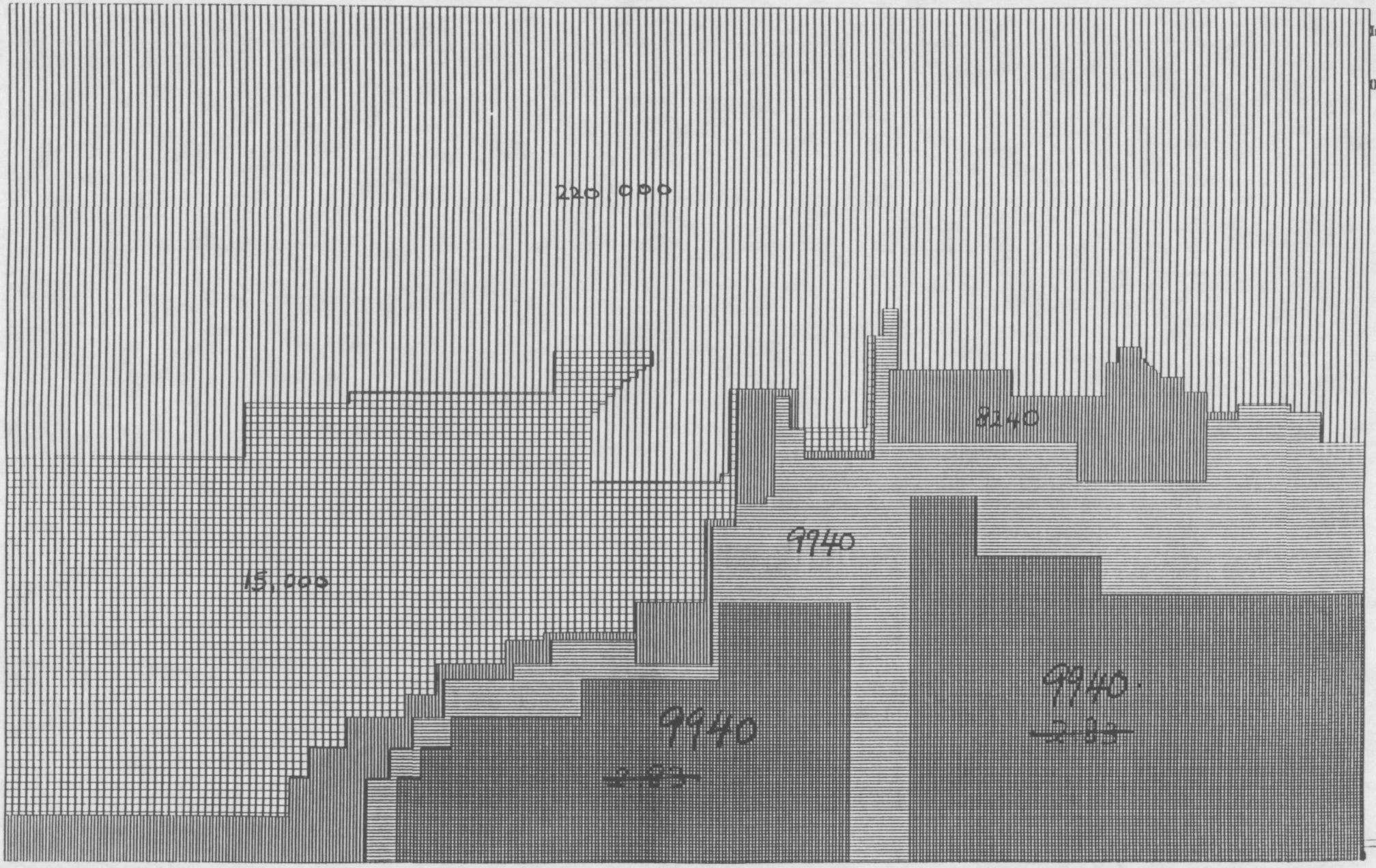
L2.T

Sensitivity Case #3 - Transmissivity (ft²/day) Zones in Deeper Aquifer (Model Layer 2 in Two-layer Model)

Scale: 1 inch = 1750 feet (1:21000)

Input

06/30

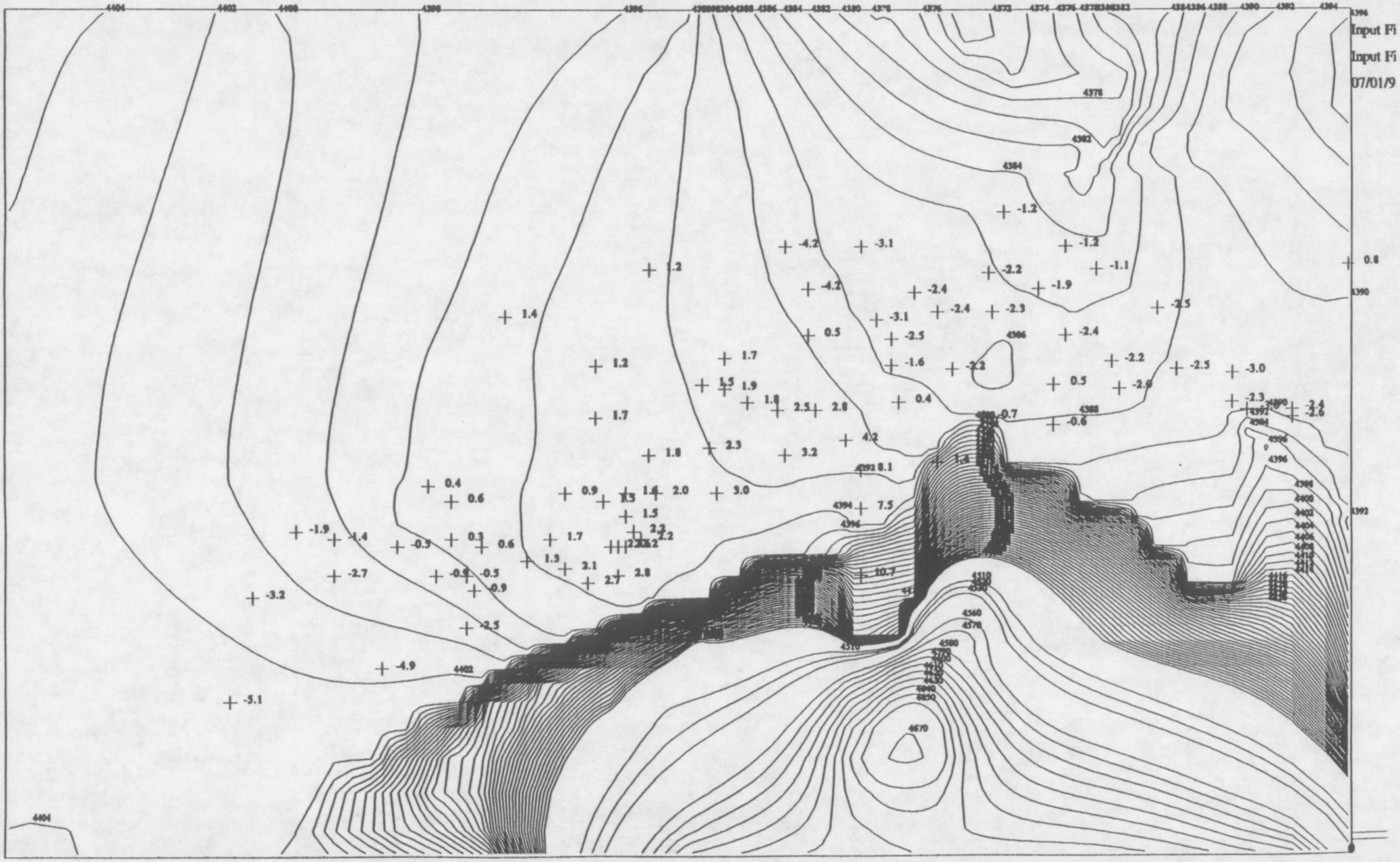


3

Sensitivity Case #3 - Contoured Heads in Upper Gravel Zone (Model Layer 1 in Two-layer Model)

L1.RSI

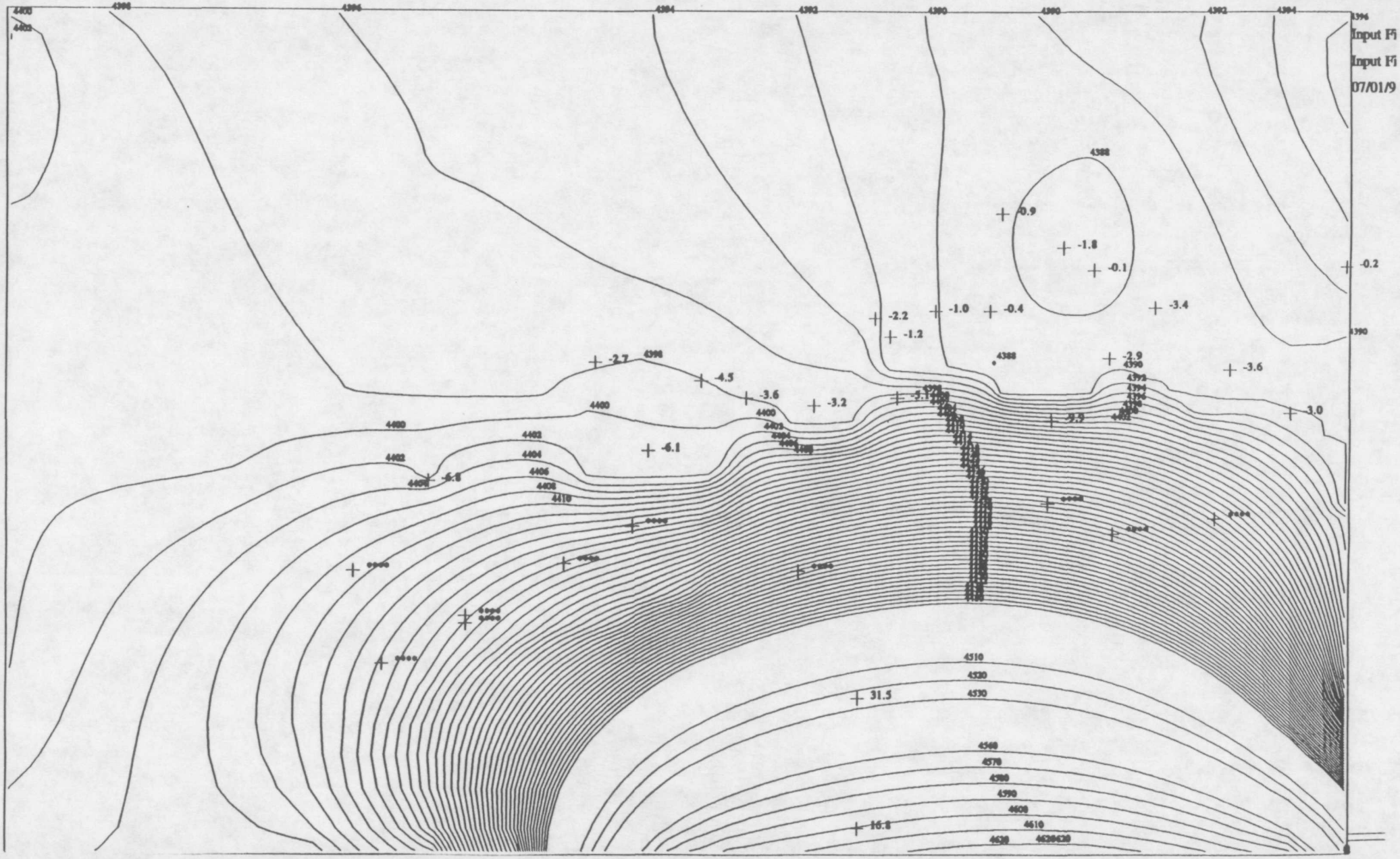
Scale 1 inch = 1750 feet (1:21000)



Sensitivity Case #3 - Contoured Heads in Deeper Aquifer (Model Layer 2 in Two-layer Model)

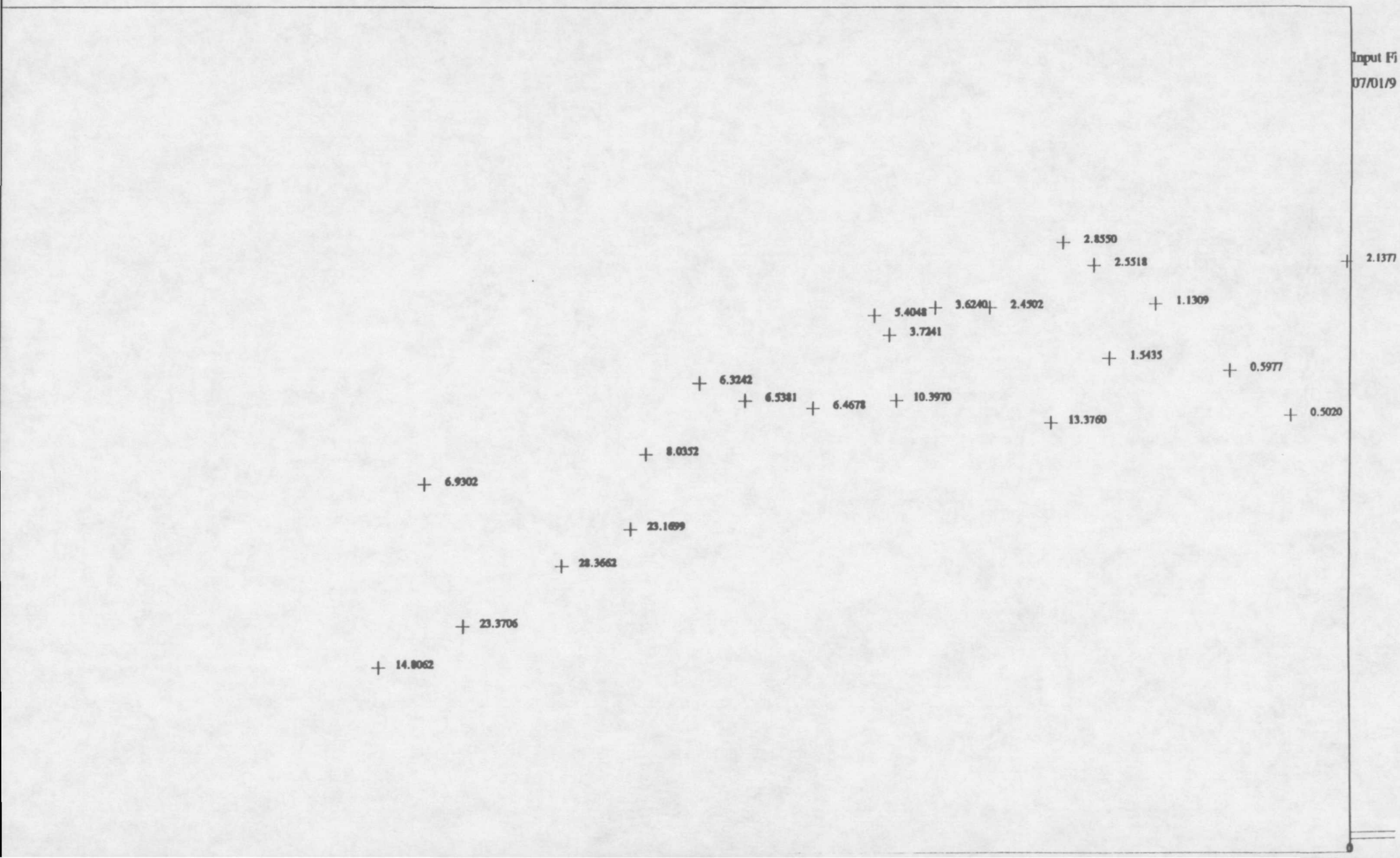
L2.RSI

Scale 1 inch = 1750 feet (1:21000)



Sensitivity Case #3 - Vertical Head Differentials Between Upper Gravel Zone and Deeper Aquifer (Model Layers 1 and 2 in Two-layer Model)

Scale 1 inch = 1750 feet (1:21000)



E_DW

Input Fi

07/01/9

B.5 SENSITIVITY CASE #4 – DECREASED TRANSMISSIVITY IN LAYER 2 (DEEPER AQUIFER/SEDIMENT-FILLED VALLEY) – BANNOCK RANGE AREA

In the conceptual model, the sediment-filled valley along the FMC-Simplot fenceline was identified as a possible preferential migration pathway for constituents emanating from sources in the FMC-Simplot joint fenceline area. Given the uncertainties associated with the areal distribution of T-zones in the Bannock Range, this scenario investigated the model sensitivity to lower transmissivity in the Bannock Range through the sediment-filled valley and along the flanks of the mountains. The calibrated model used a value of 9,940 ft^2/day which was replaced with a value of 2.83 ft^2/day.

Model sensitivity to lower transmissivity in the Bannock Range is minimal in the upper gravel zone. Simulated contour patterns and particle tracks are very similar to the calibration targets. The biggest model response was seen in the contour patterns in the deeper aquifer. By lowering the transmissivity through the sediment-filled valley and along the flanks of the Bannock Range, most of the modeled heads in the deeper aquifer were much lower than the observed heads. Decreasing the transmissivity in the Bannock Range increases the hydraulic sink associated with the Simplot production wells, springs and river. The FMC production wells also have a more pronounced cone of depression. River and spring total discharge is 66 cfs, 8 cfs lower than the calibrated model.

In general, reducing the transmissivity in the deeper aquifer along the Bannock Range and through the sediment-filled valley does not impact the simulated contour patterns or flow paths in the upper gravel; however, large changes were noted in the contour patterns in the deeper aquifer. The reduction in the river and spring discharge (8 cfs) indicates that the amount of water supplied through the southern model boundary is minimal compared to the total amount of water supplied to the model through underflow from other boundaries.

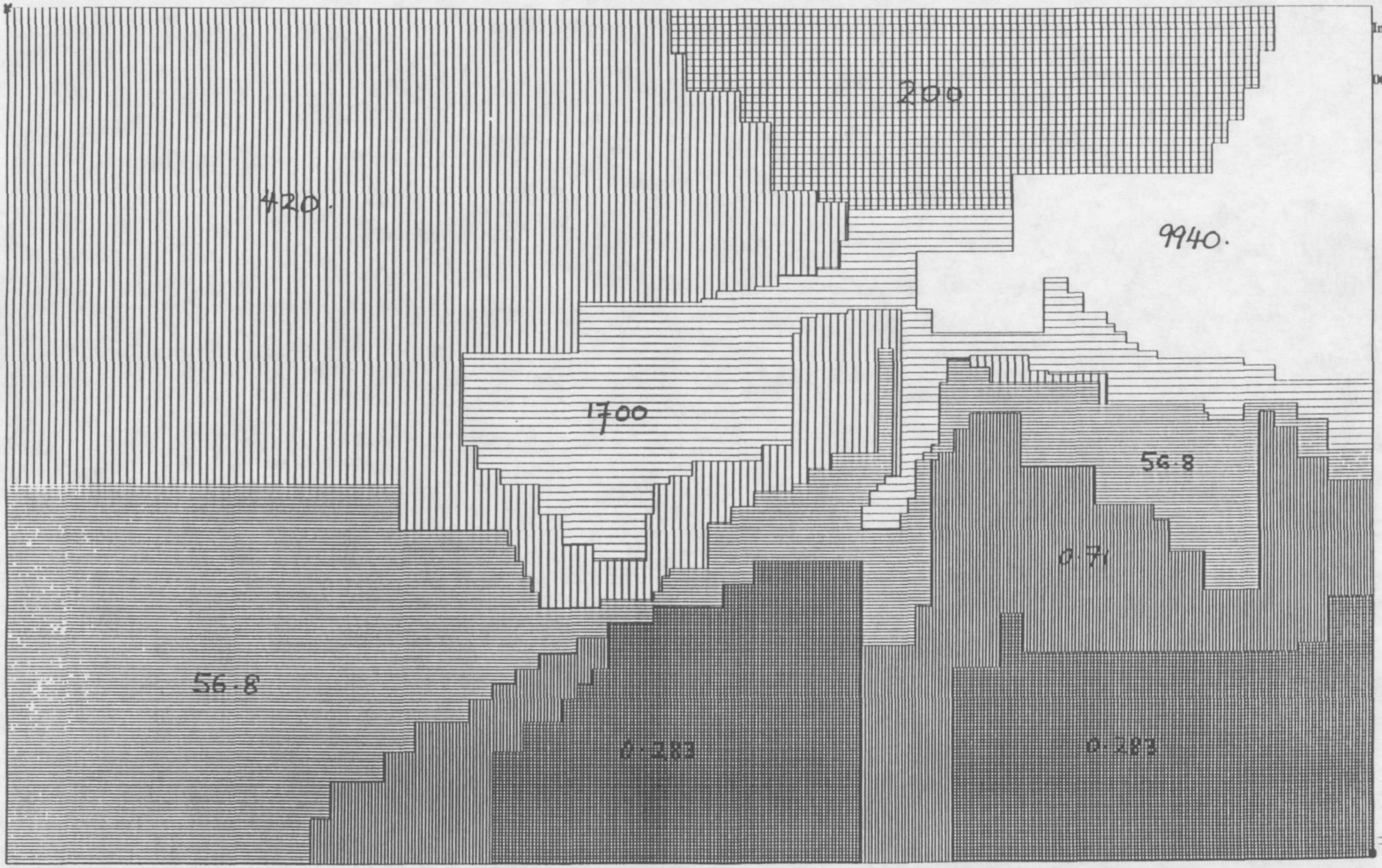
K values - layer-1 4²

[ft/d]

L1.H

Sensitivity Case #4 - Hydraulic Conductivity Zones in Upper Gravel Zone (Model Layer 1 in Two-layer Model)

Scale: 1 inch = 1750 feet (1:21000)



Input

06/30

T values - Layer - 2.
[ft²/d]

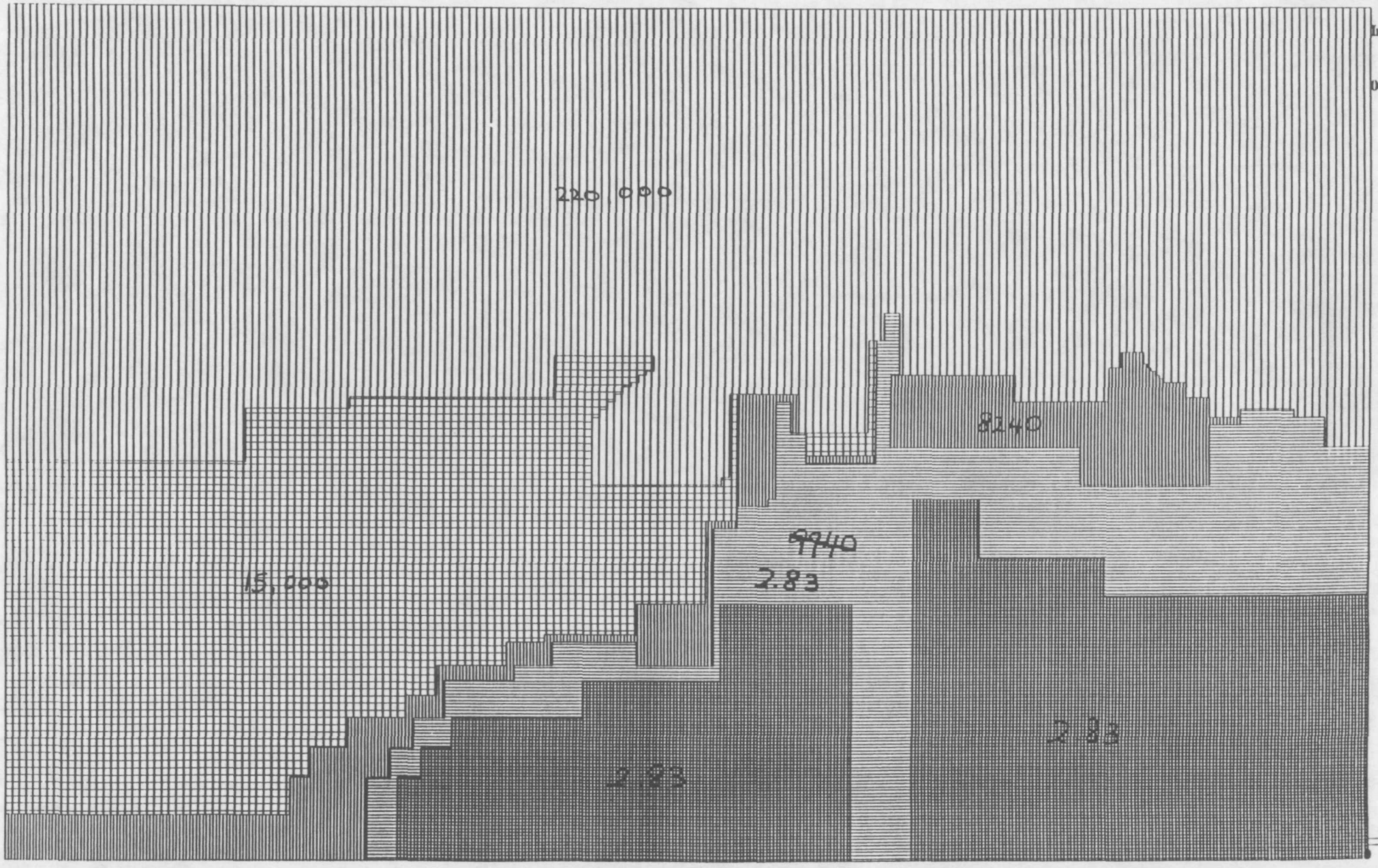
Sensitivity Case #4 - Transmissivity (ft²/day) Zones in Deeper Aquifer (Model Layer 2 in Two-layer Model)

Scale: 1 inch = 1750 feet (1:21000)

L2.T1

Input 1

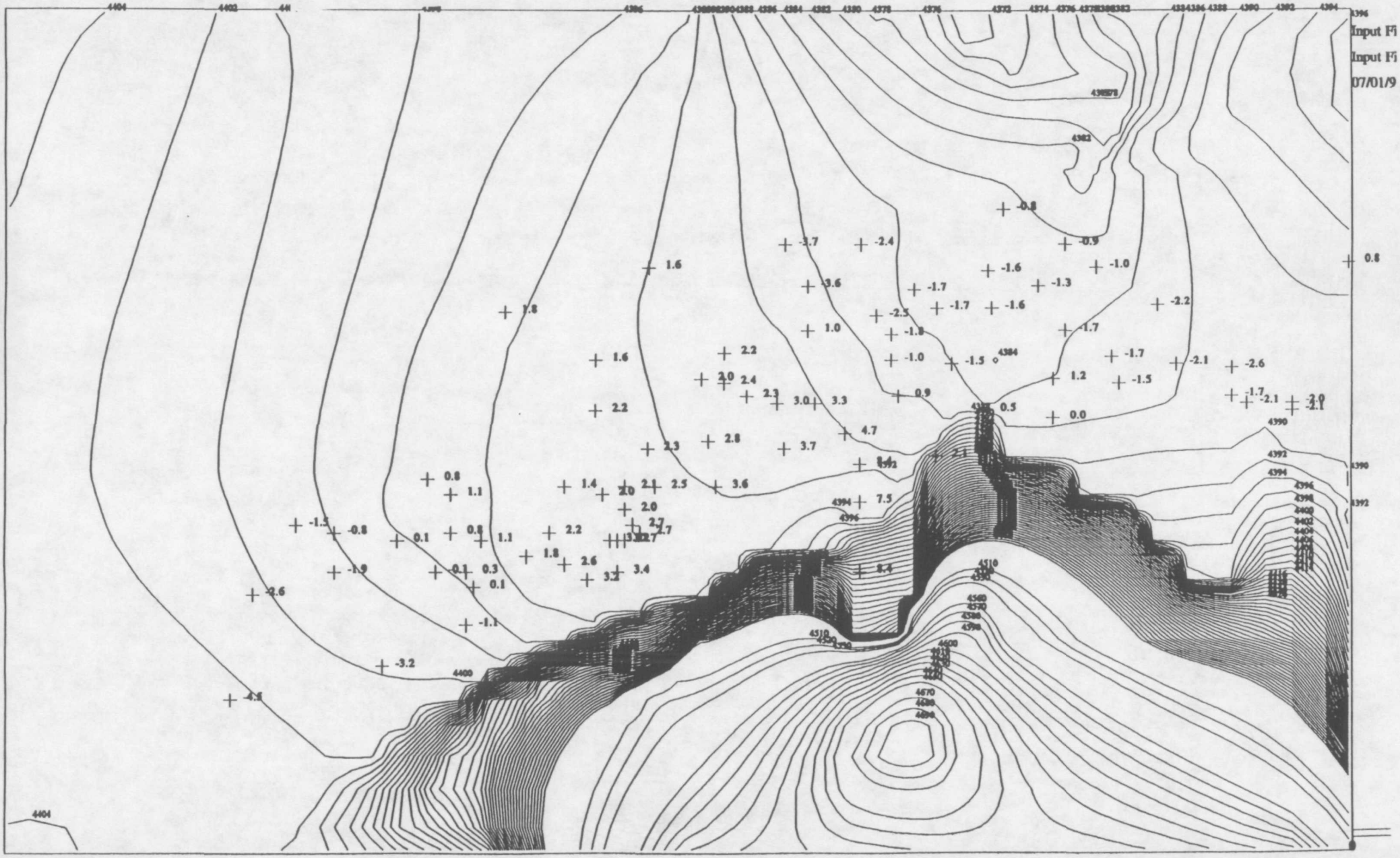
06/30/



Sensitivity Case #4 - Contoured Heads in Upper Gravel Zone (Model Layer 1 in Two-layer Model)

L1.RSI

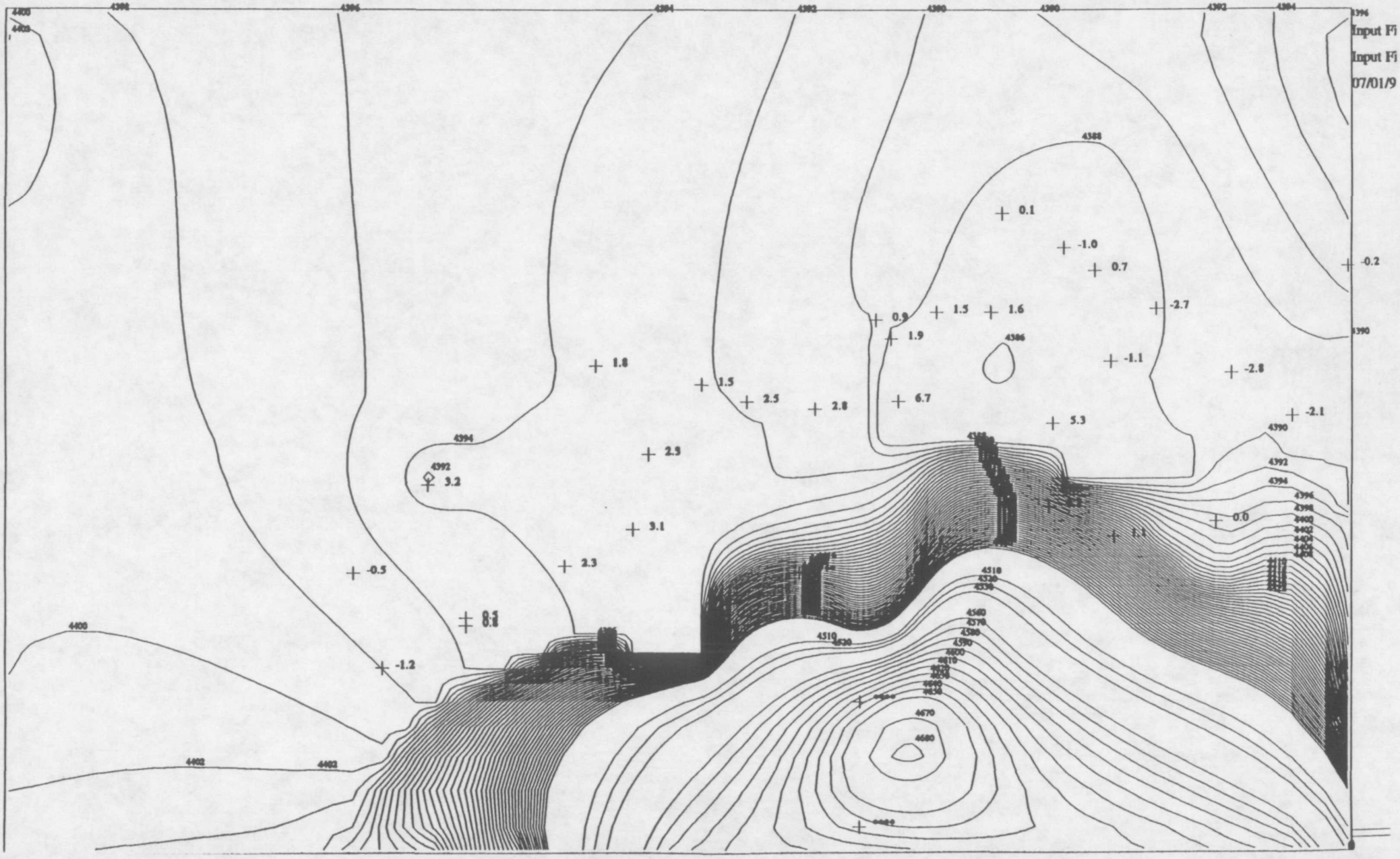
Scale 1 inch = 1750 feet (1:21000)



Sensitivity Case #4 - Contoured Heads in Deeper Aquifer (Model Layer 2 in Two-layer Model)

L2.RSI

Scale 1 inch = 1750 feet (1:21000)

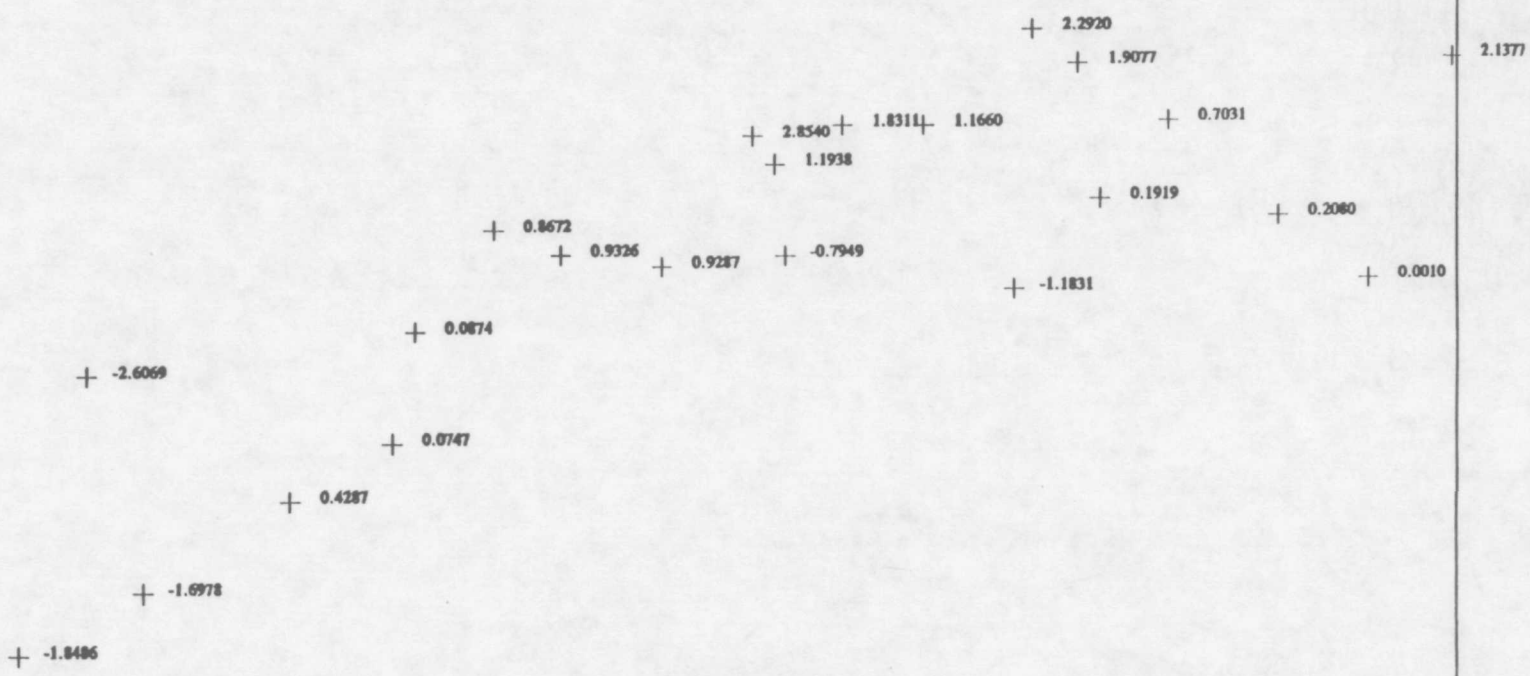


E_DW

Sensitivity Case #4 - Vertical Head Differentials Between Upper Gravel Zone and Deeper Aquifer (Model Layers 1 and 2 in Two-layer Model)

Scale 1 inch = 1750 feet (1:21000)

Input Fi
07/01/9



B.6 SENSITIVITY CASE #5 – NATURAL RECHARGE REDUCED BY A FACTOR OF 10

Natural recharge throughout the model area was estimated to be 10% of the total mean annual precipitation. This estimate was based on other studies performed in the Eastern Snake River Plain (Wood and Low, 1986). In addition, potential recharge from irrigated cropland and the Taghee Canal was not incorporated into the model. Estimates of increased recharge from irrigation range from 2 to 4 times the natural recharge and the Taghee Canal may lose several cfs across the model domain. To assess the model's sensitivity to the recharge term, recharge was reduced by a factor of 10 for those areas that are not affected by the gypsum stack, Pond 8S, the IWW ditch, or the Portneuf River.

The total river and spring discharge decreased by 1 cfs as a result of reduced recharge. Simulated contour patterns, heads at individual wells, and vertical head differentials did not change when compared to the calibrated model. Particle tracks through the upper gravel zone are very close to the particle tracks from the calibrated model.

5

K values - layer-1

[ft/d]

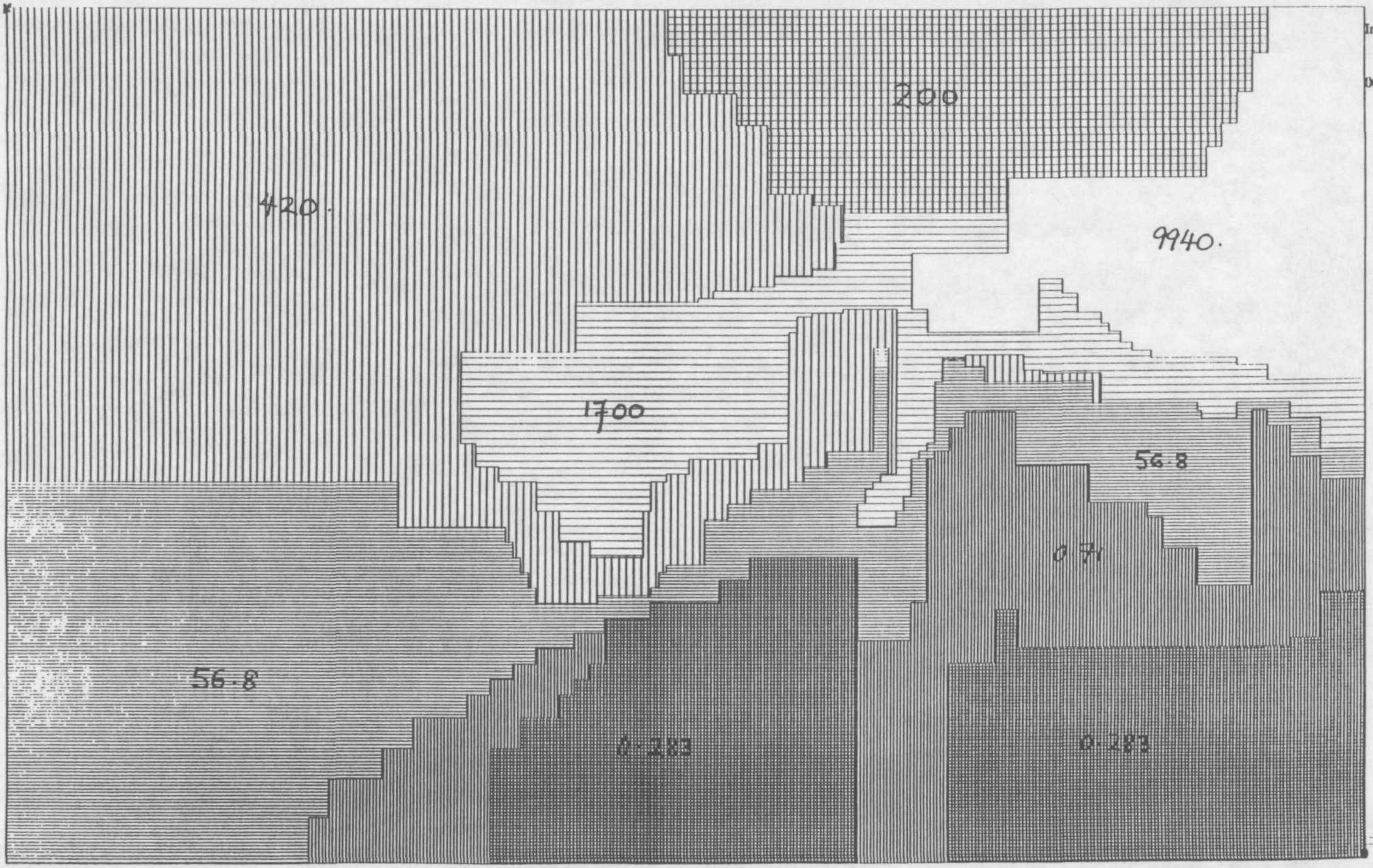
Sensitivity Case #5 - Hydraulic Conductivity Zones in Upper Gravel Zone (Model Layer 1 in Two-layer Model)

Scale: 1 inch = 1750 feet (1:21000)

L1.11

Input

06/30



5

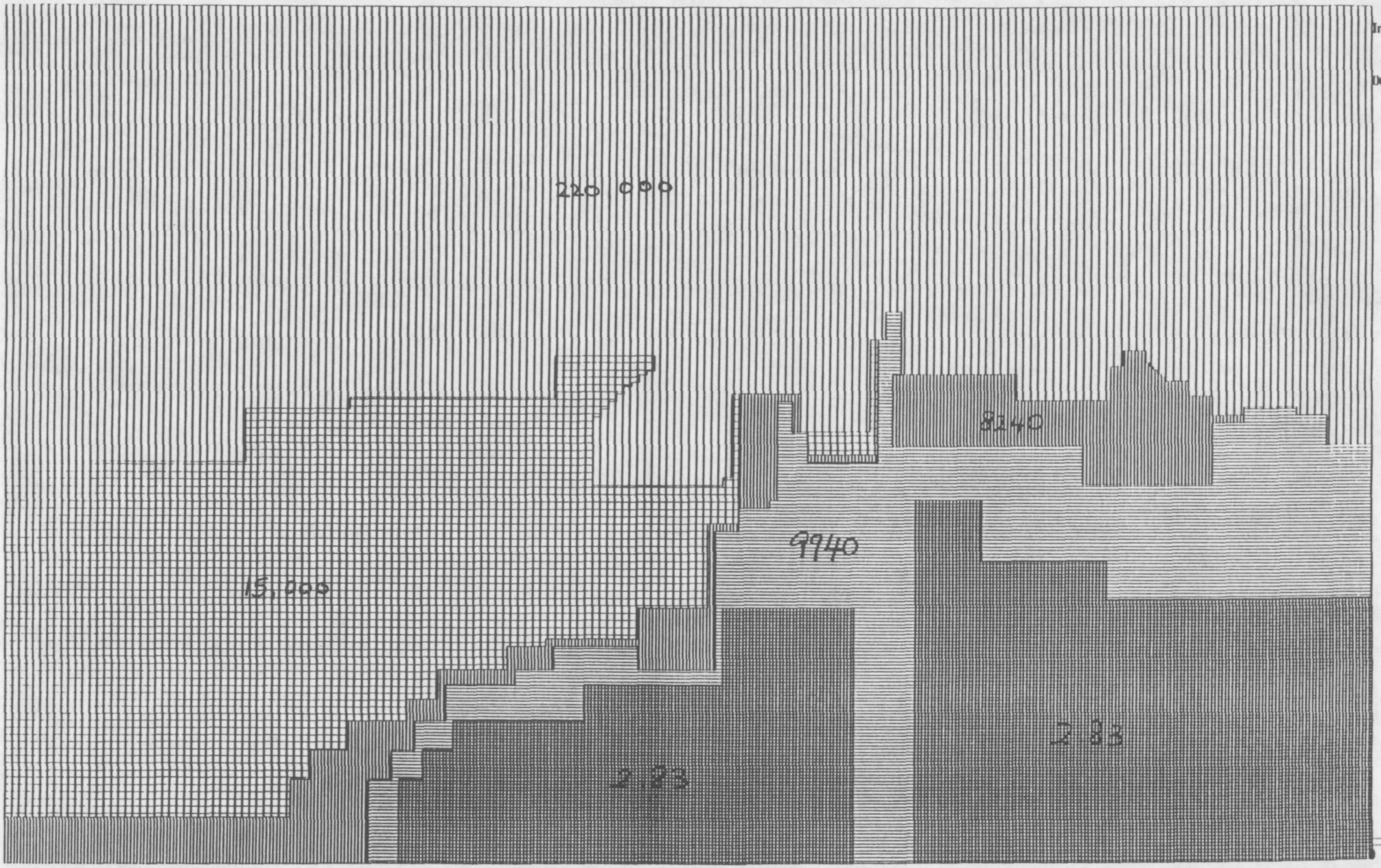
Sensitivity Case #5 - Transmissivity (ft^2/day) Zones in Deeper Aquifer (Model Layer 2 in Two-layer Model)

Scale: 1 inch = 1750 feet (1:21000)

L2.T

Input

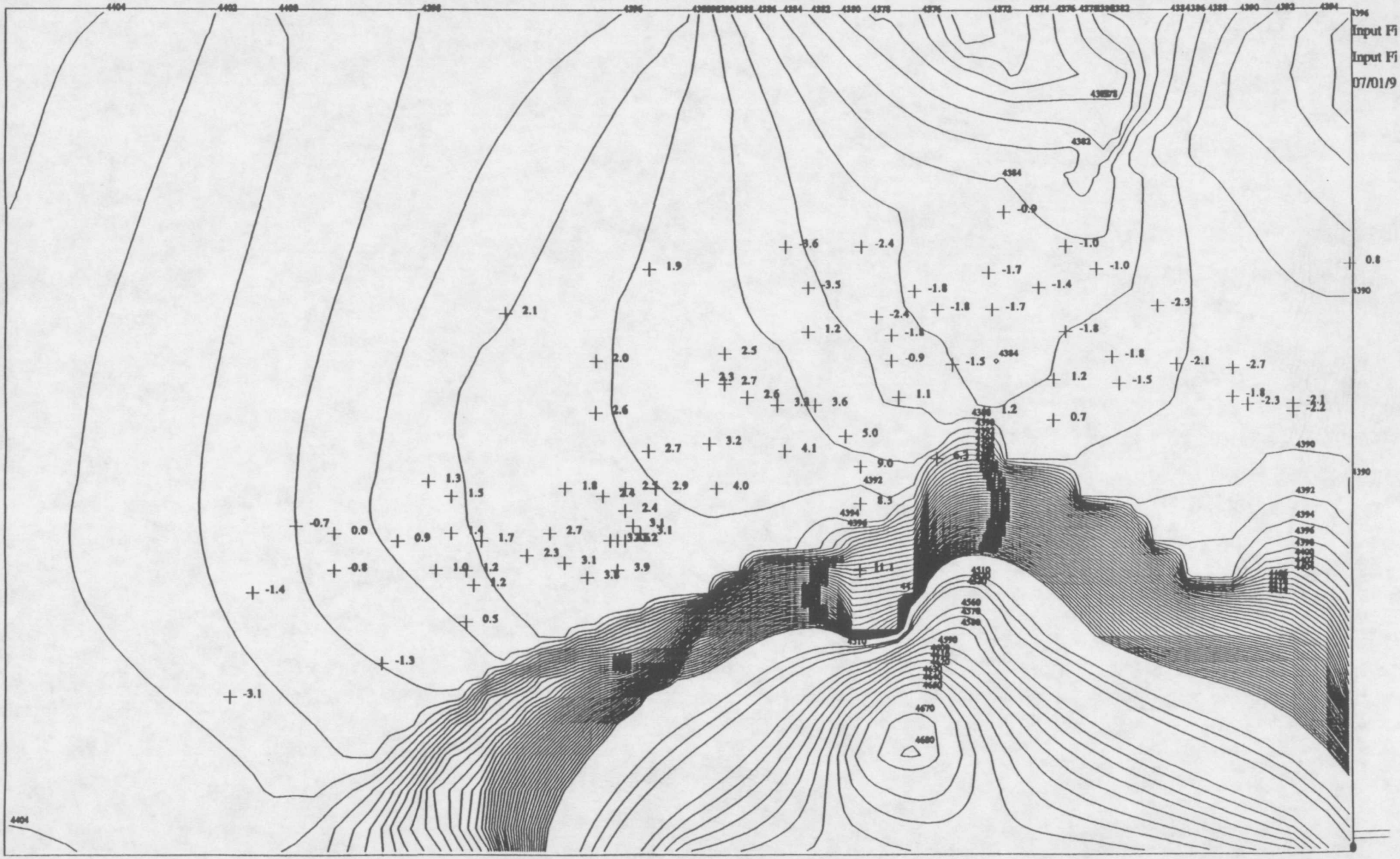
06/30



Sensitivity Case #5 - Contoured Heads in Upper Gravel Zone (Model Layer 1 in Two-layer Model)

L1.RSI

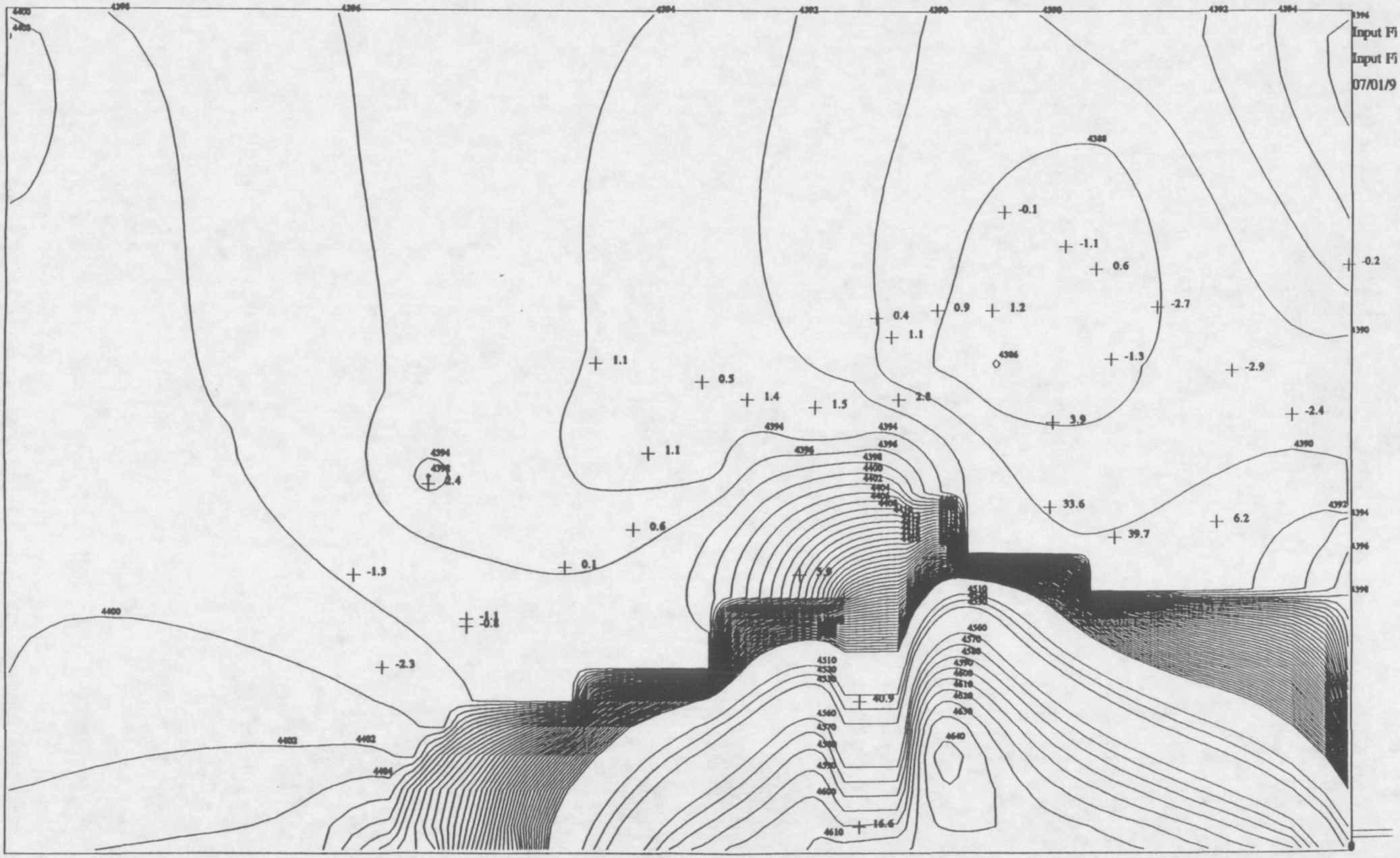
Scale 1 inch = 1750 feet (1:21000)



Sensitivity Case #5 - Contoured Heads in Deeper Aquifer (Model Layer 2 in Two-layer Model)

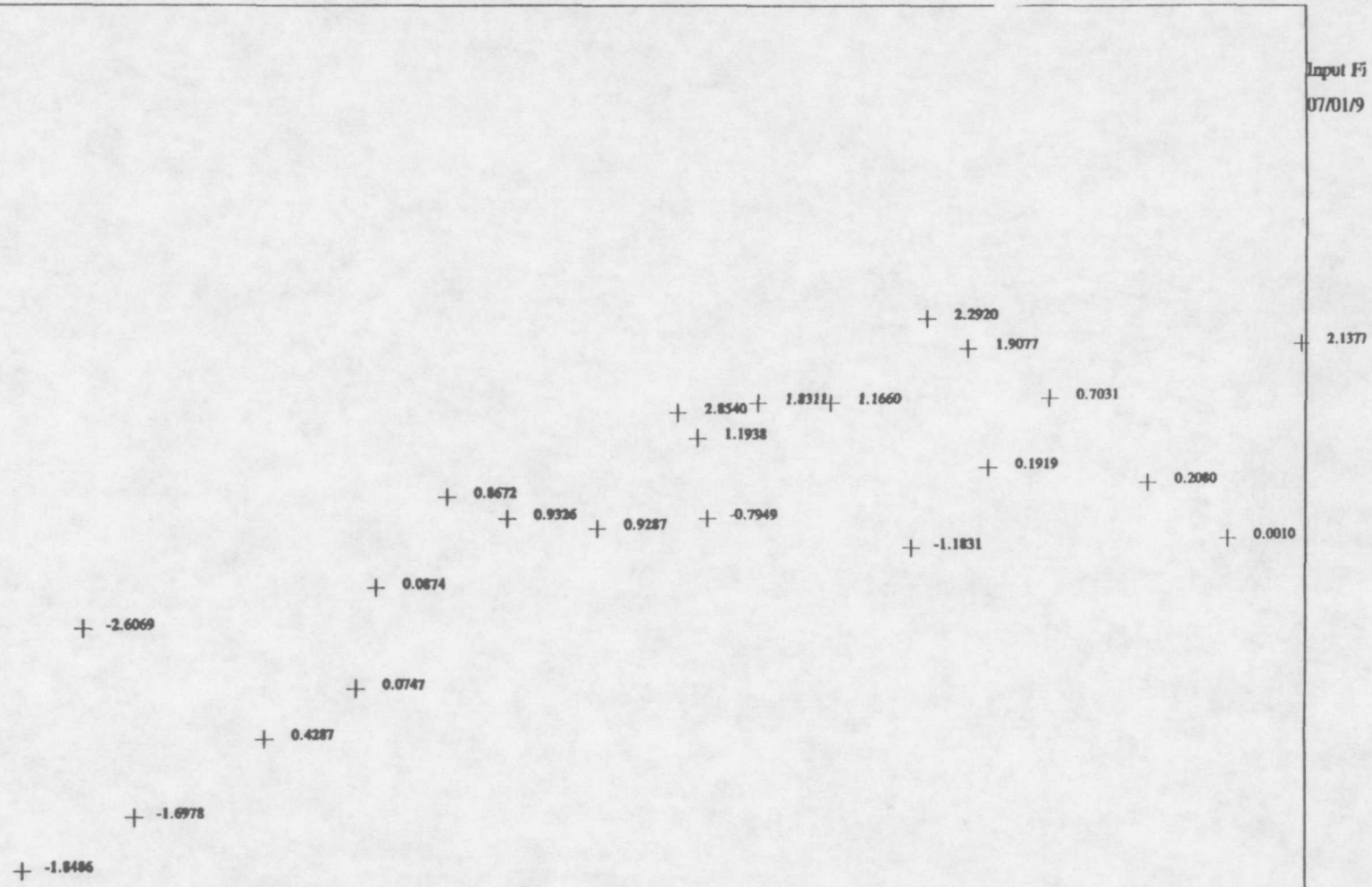
L2.RSI

Scale 1 inch = 1750 feet (1:21000)



Sensitivity Case #5 - Vertical Head Differentials Between Upper Gravel Zone and Deeper Aquifer (Model Layers 1 and 2 in Two-layer Model)

Scale 1 inch = 1750 feet (1:21000)



Input Fi
07/01/9

B.7 SENSITIVITY CASE #6– EASTERN BOUNDARY HEADS LOWERED BY 5 FEET

Eastern model boundary heads were lowered by 5 feet compared to the calibrated model. This was done to investigate the model sensitivity to the boundary heads through the highly transmissive Pocatello aquifer.

Total river and spring discharge decreased by 17 cfs to 57 cfs. Contour patterns in both the upper gravel zone and deeper aquifer showed the most change near the eastern model boundary. These contour patterns show a strong hydraulic sink along the eastern model boundary. This sink causes particle tracks beginning east of the Simplot production wells to flow almost directly east, to this sink. The simulated heads throughout the model domain were within the calibration targets, including those heads in wells along the Portneuf River. No other significant changes to the simulated contour patterns, vertical gradients and flow paths were noted.

This simulation points out the model's sensitivity to changes in the eastern flow model boundary conditions. In general, a five-foot reduction in the eastern boundary heads results in marked changes to simulated contour patterns and flowpaths along the eastern boundary. The simulated flowpaths in this sensitivity case are not supported by the geochemistry data from numerous wells between the Portneuf River and the Simplot lower gypsum stack. The simulated river and spring discharge rates are 17 cfs lower than the calibrated model, indicating that the flux of groundwater through the eastern model boundary is sensitive to the model boundary conditions.

6

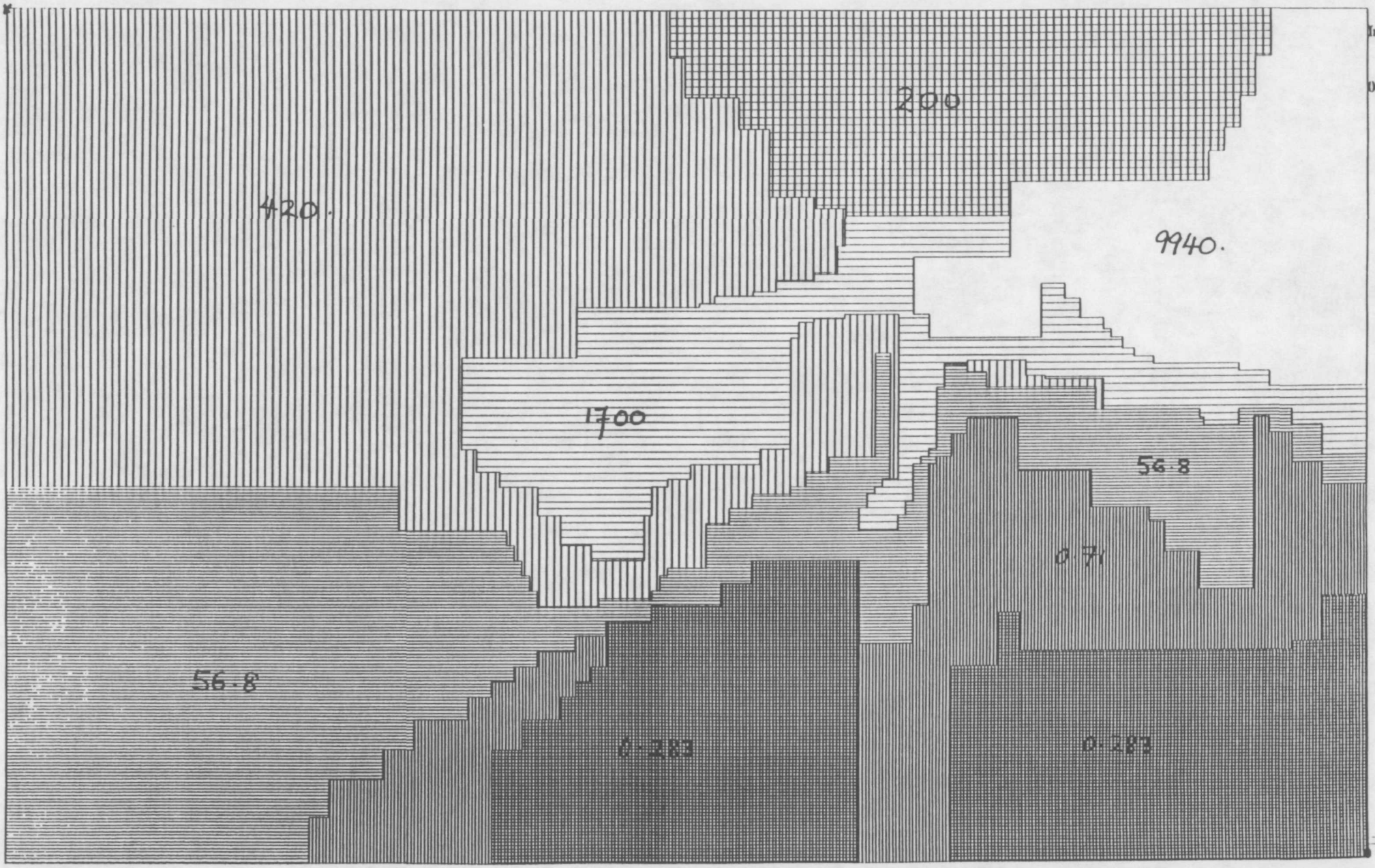
Sensitivity Case #6 - Hydraulic Conductivity Zones in Upper Gravel Zo... (Model Layer 1 in Two-layer Model)

Scale: 1 inch = 1750 feet (1:21000)

L1.H

Input

06/30



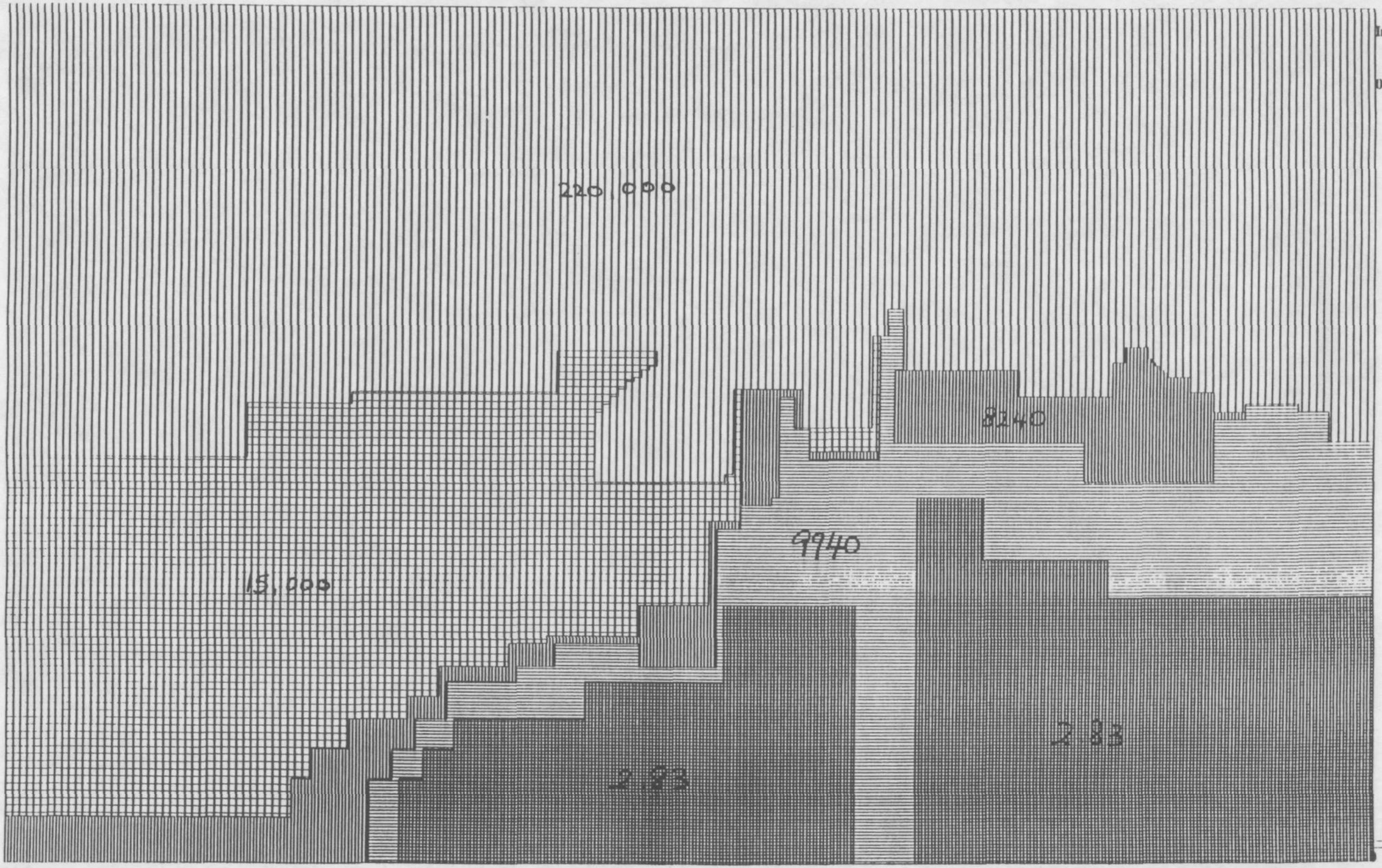
Sensitivity Case #6 - Transmissivity (ft^2/day) Zones in Deeper Aquifer (Model Layer 2 in Two-layer Model)

Scale: 1 inch = 1750 feet (1:21000)

L2.1

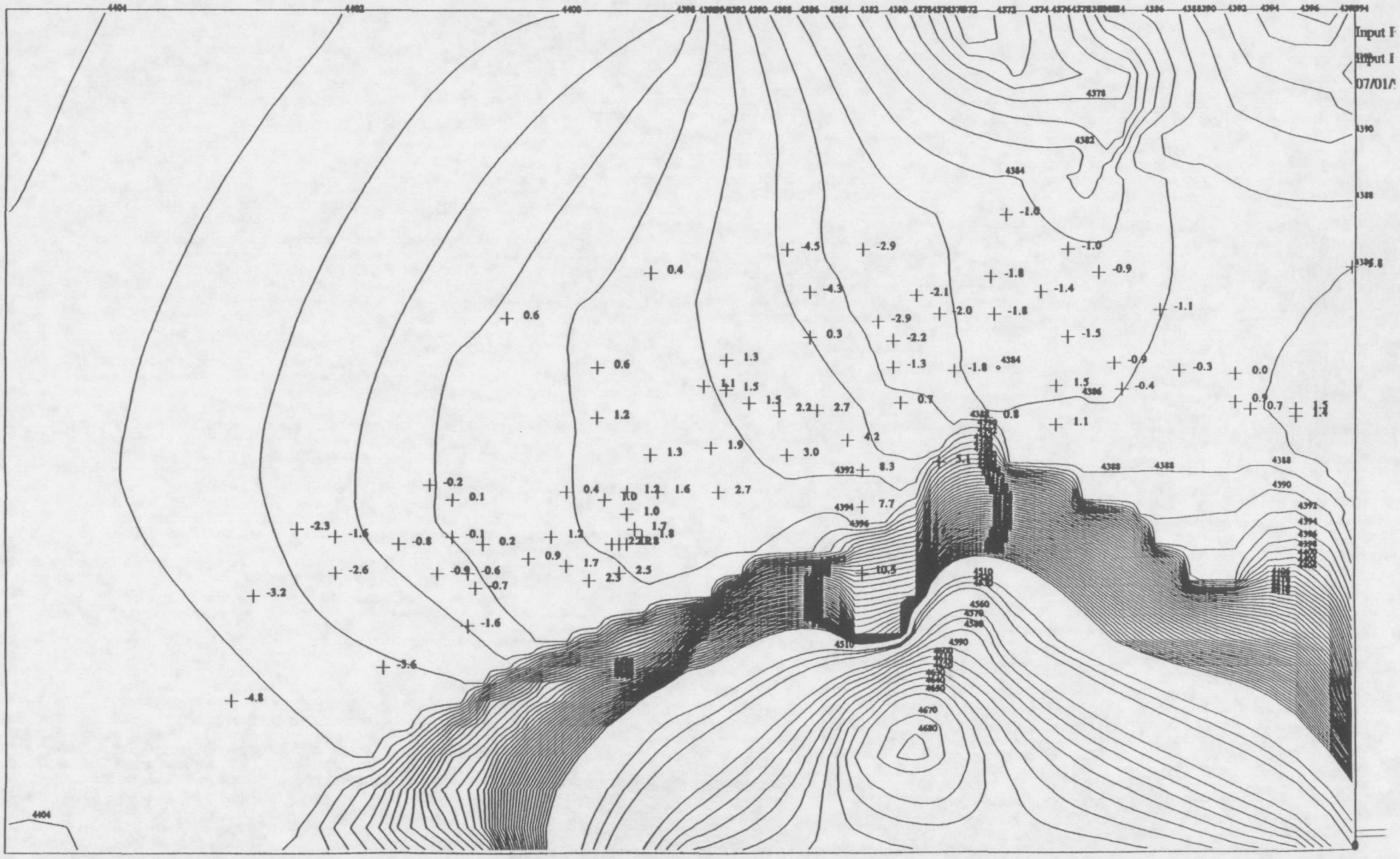
Input

06/30



Sensitivity Case #6 - Contoured Heads in Upper Gravel Zone (Model Layer 1 in Two-layer Model)

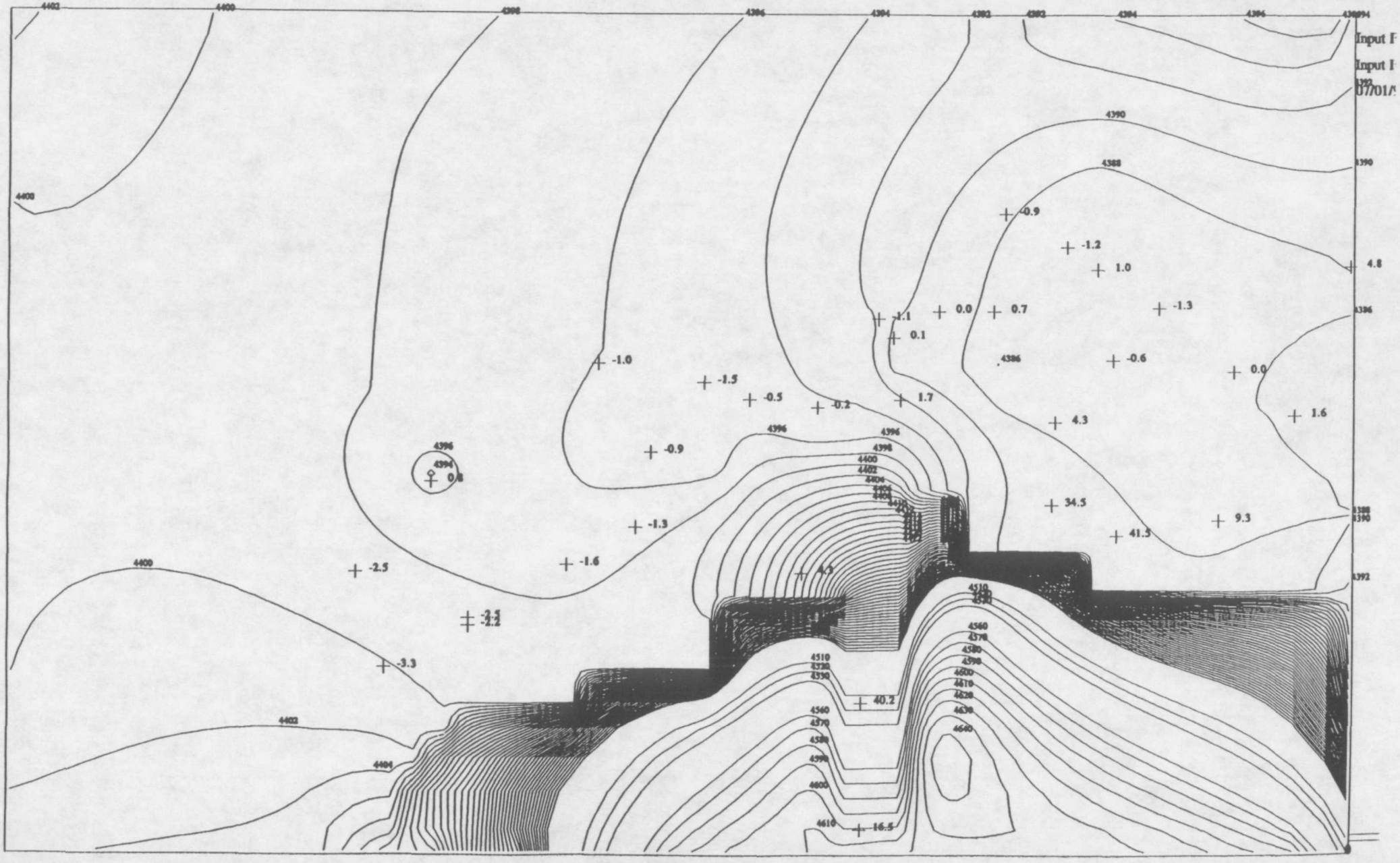
Scale 1 inch = 1750 feet (1:21000) L1.RS



Sensitivity Case #6 - Contoured Heads in Deeper Aquifer (Model Layer 2 in Two-layer Model)

L2.RS

Scale 1 inch = 1750 feet (1:21000)



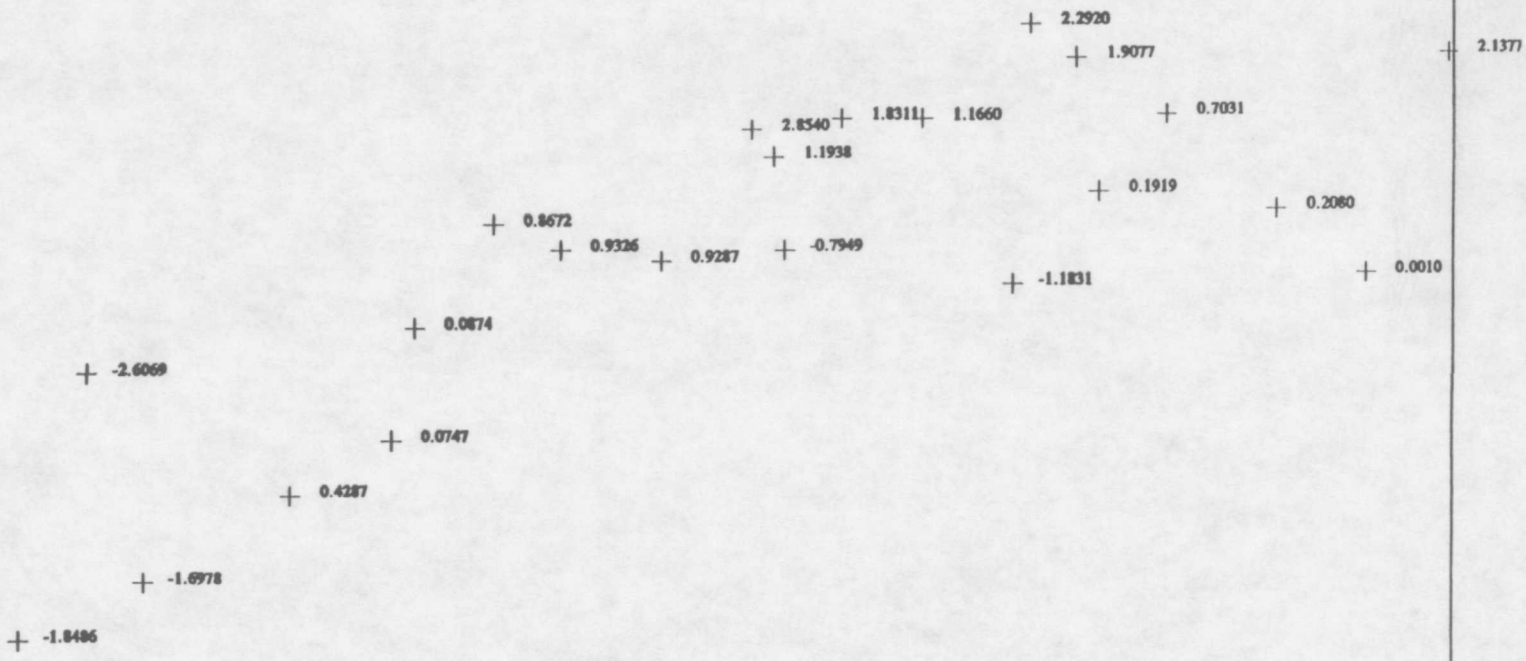
Sensitivity Case #6 - Vertical Head Differentials Between Upper Gravel Zone and Deeper Aquifer (Model Layers 1 and 2 in Two-layer Model)

E DW

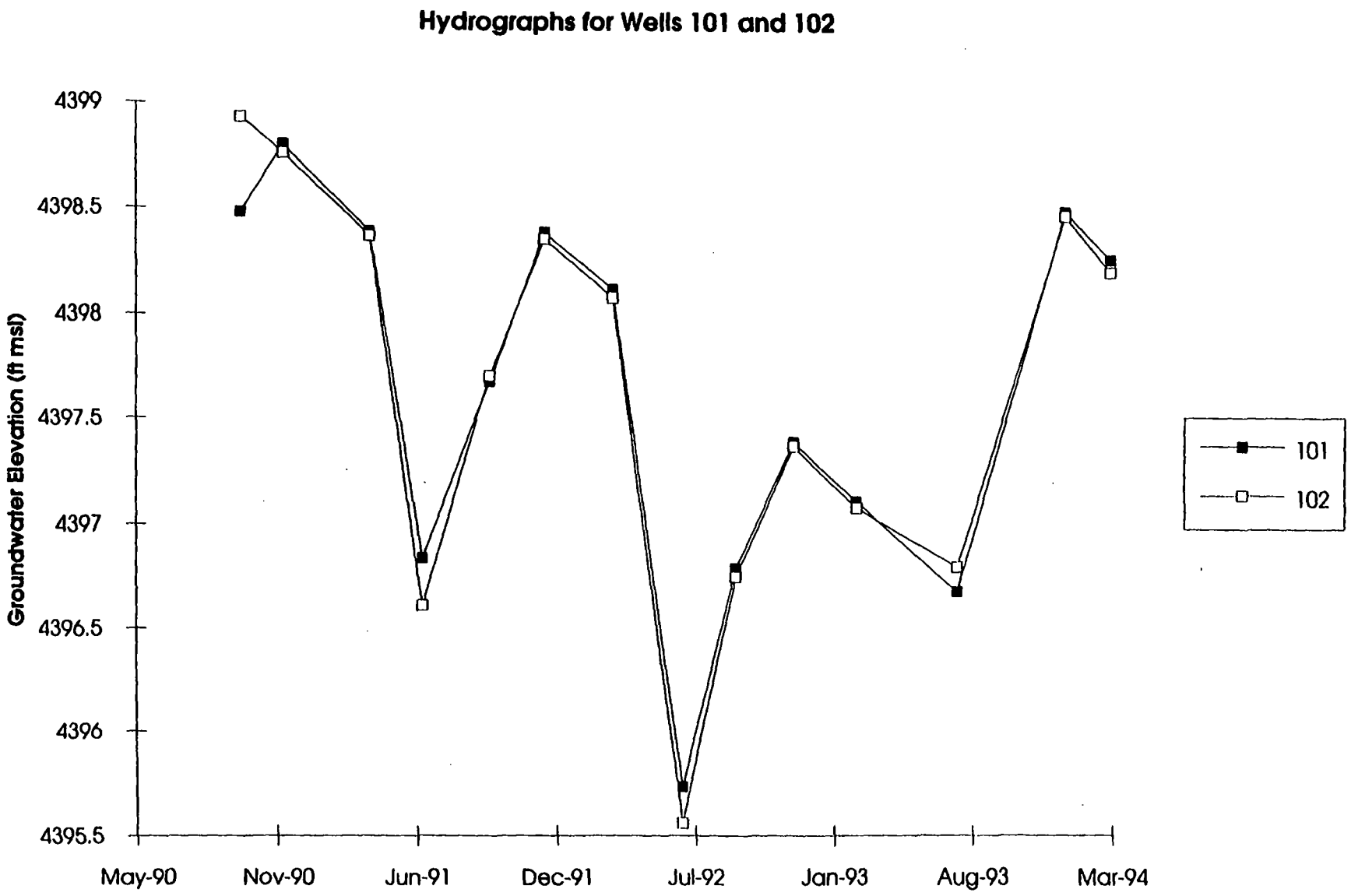
Scale 1 inch = 1750 feet (1:21000)

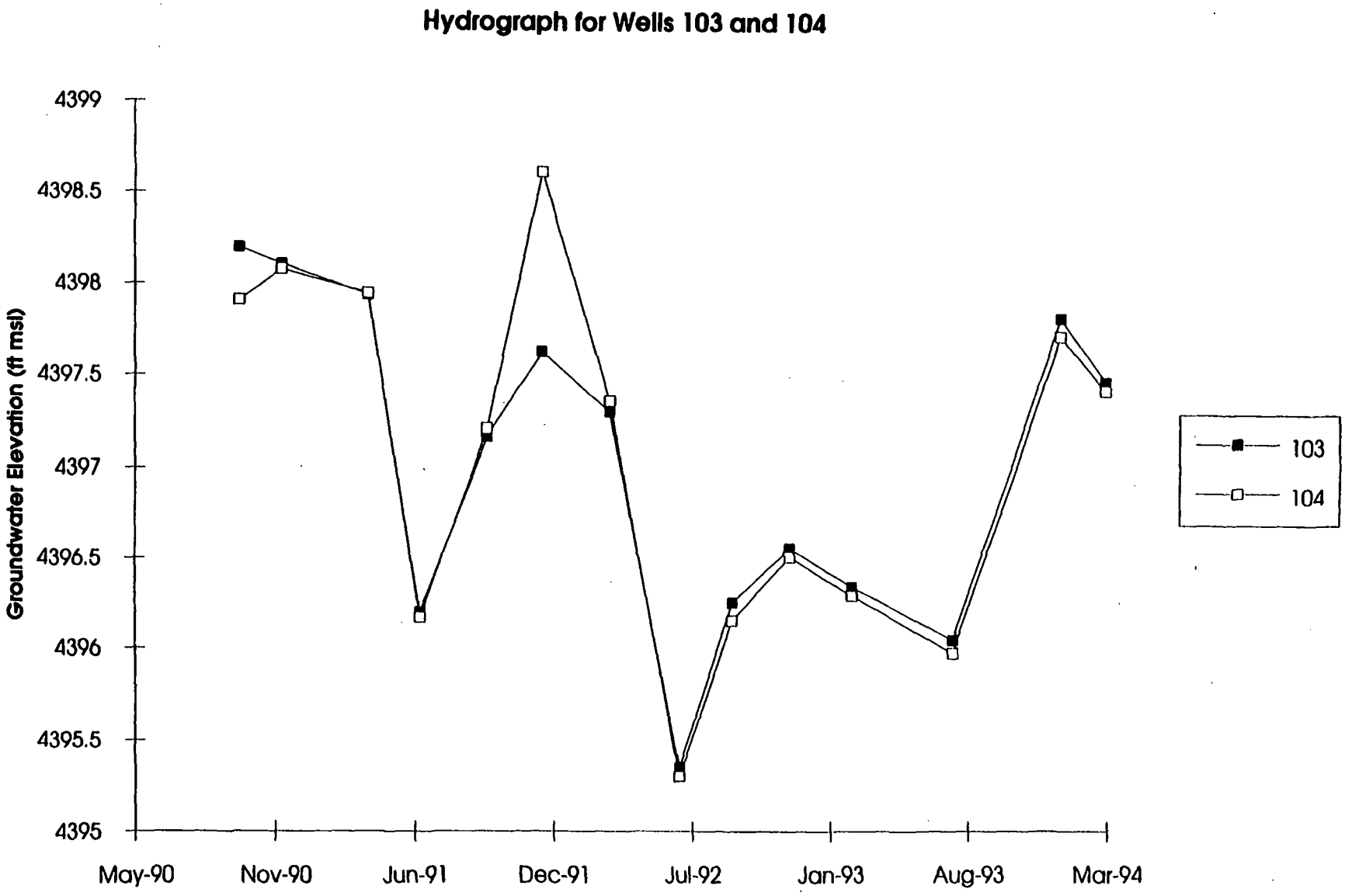
Input Fi

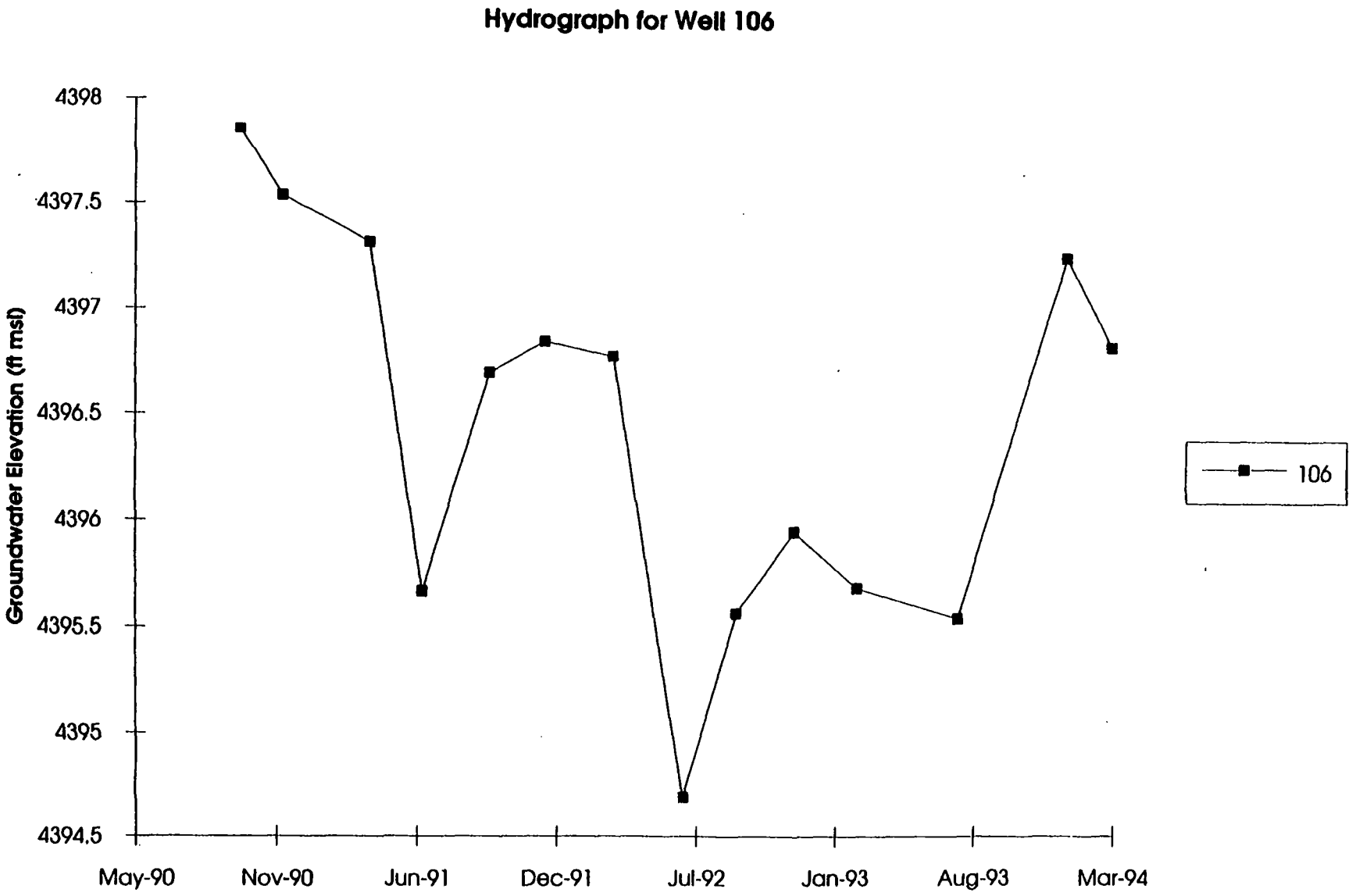
07/01/9

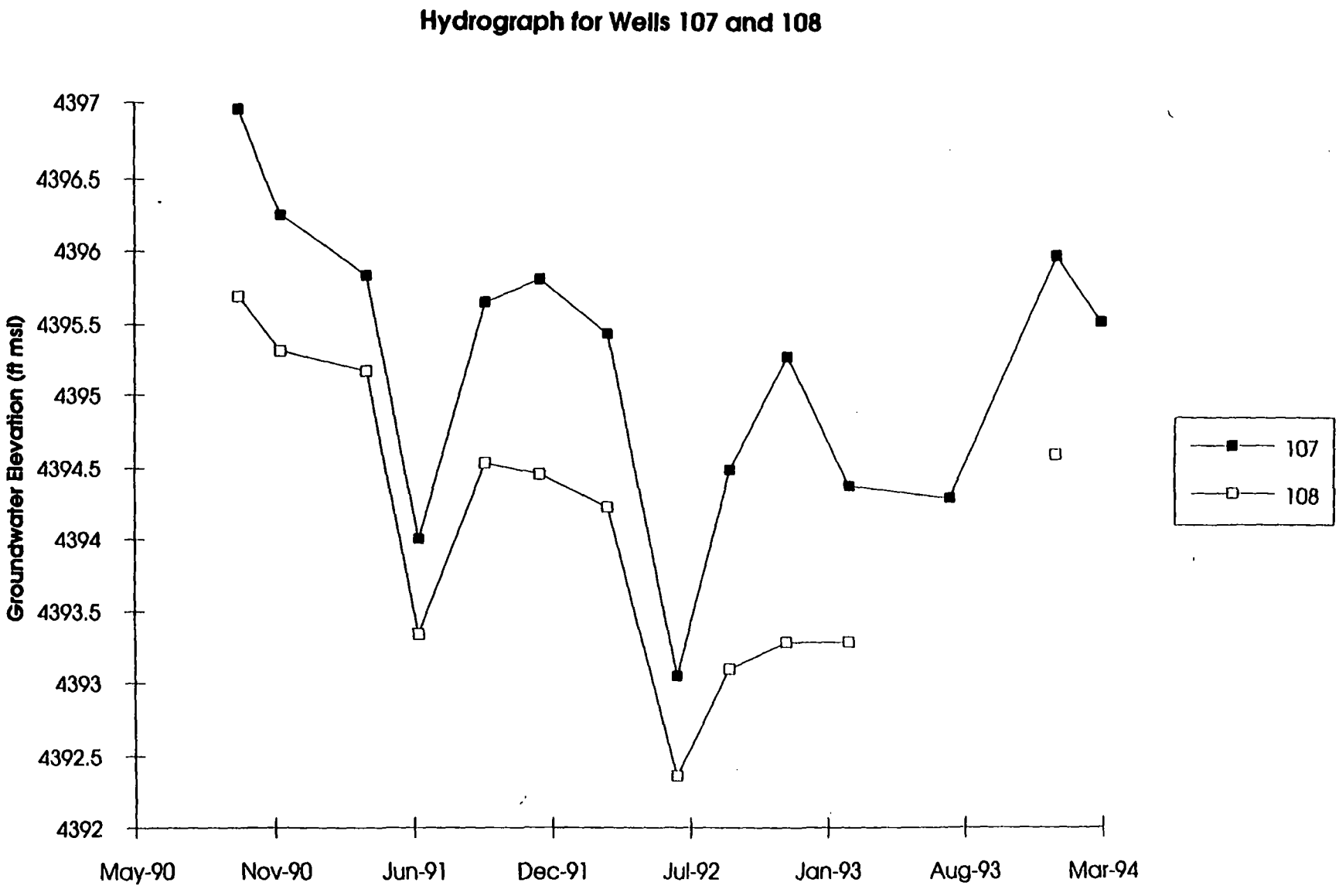


Appendix C
Hydrographs for EMF Wells

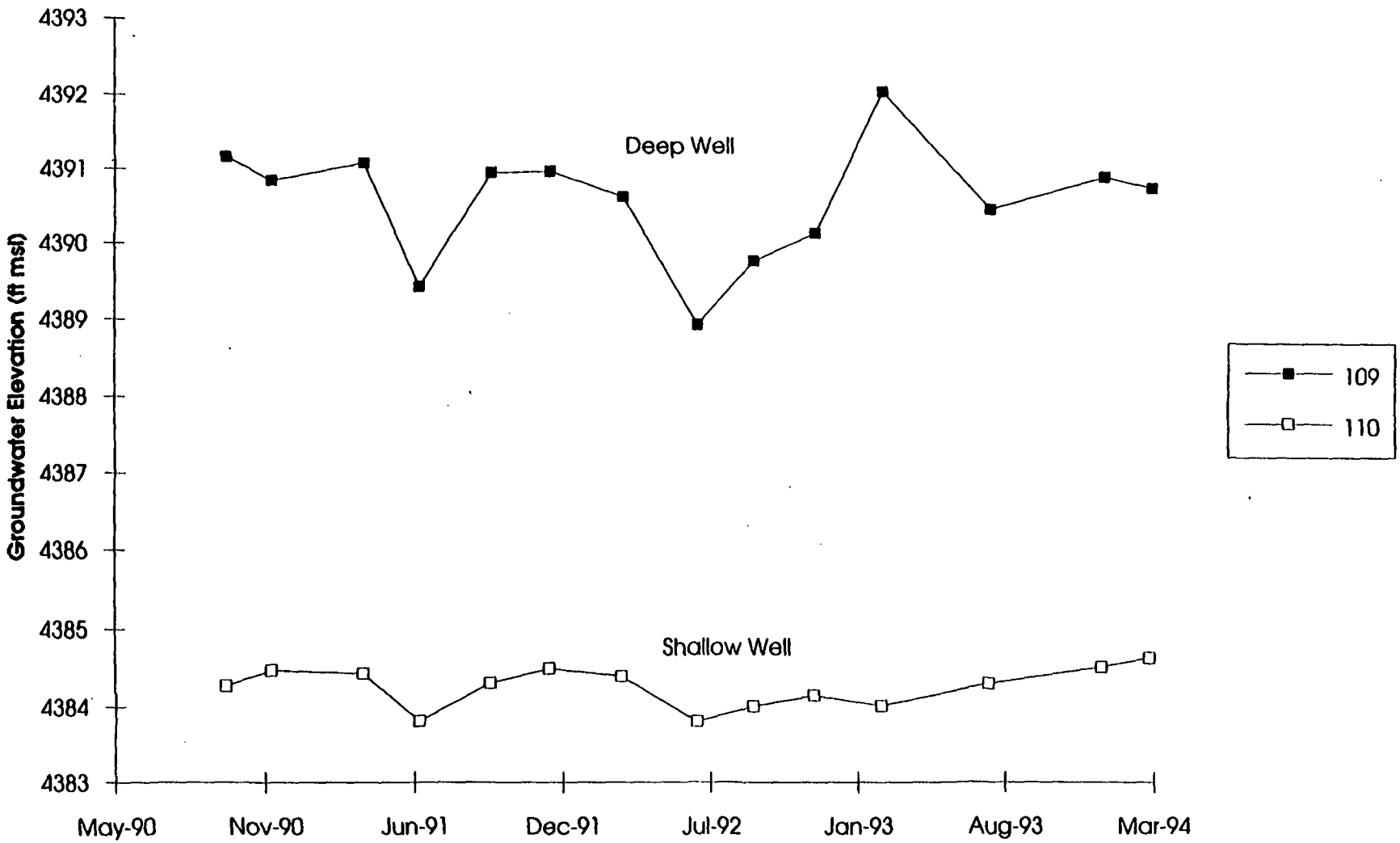

Hydrographs for Wells 101 and 102
Groundwater Elevation (ft msl)
4399
4398.5
4398
4397.5
4397
4396.5
4396
4395.5
May-90
Nov-90
Jun-91
Dec-91
Jul-92
Jan-93
Aug-93
Mar-94
101
102

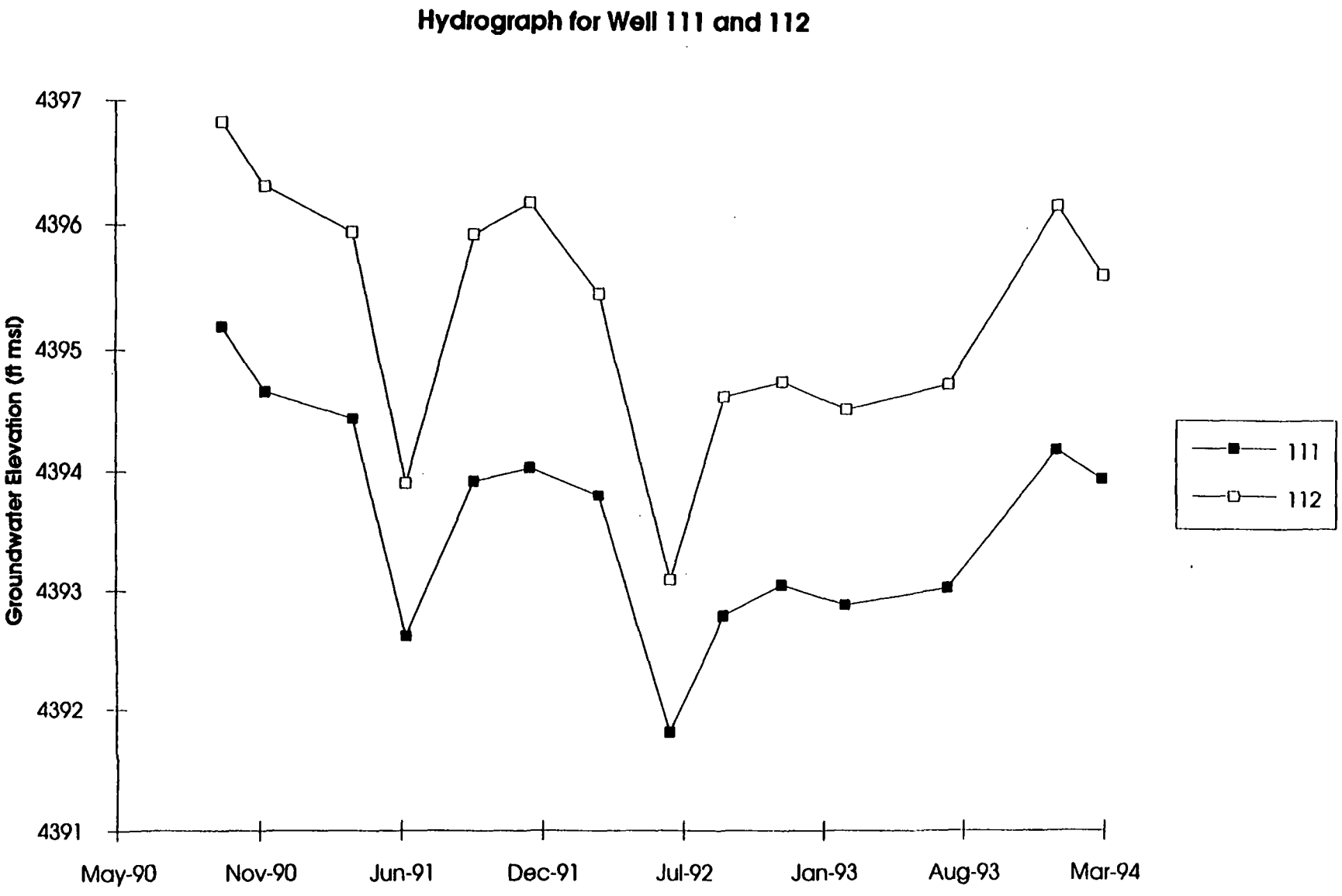

Hydrograph for Wells 103 and 104
Groundwater Elevation (ft msl)
4399
4398.5
4398
4397.5
4397
4396.5
4396
4395.5
4395
May-90
Nov-90
Jun-91
Dec-91
Jul-92
Jan-93
Aug-93
Mar-94
103
104


Hydrograph for Well 106
Groundwater Elevation (ft msl)
4398
4397.5
4397
4396.5
4396
4395.5
4395
4394.5
May-90
Nov-90
Jun-91
Dec-91
Jul-92
Jan-93
Aug-93
Mar-94
106

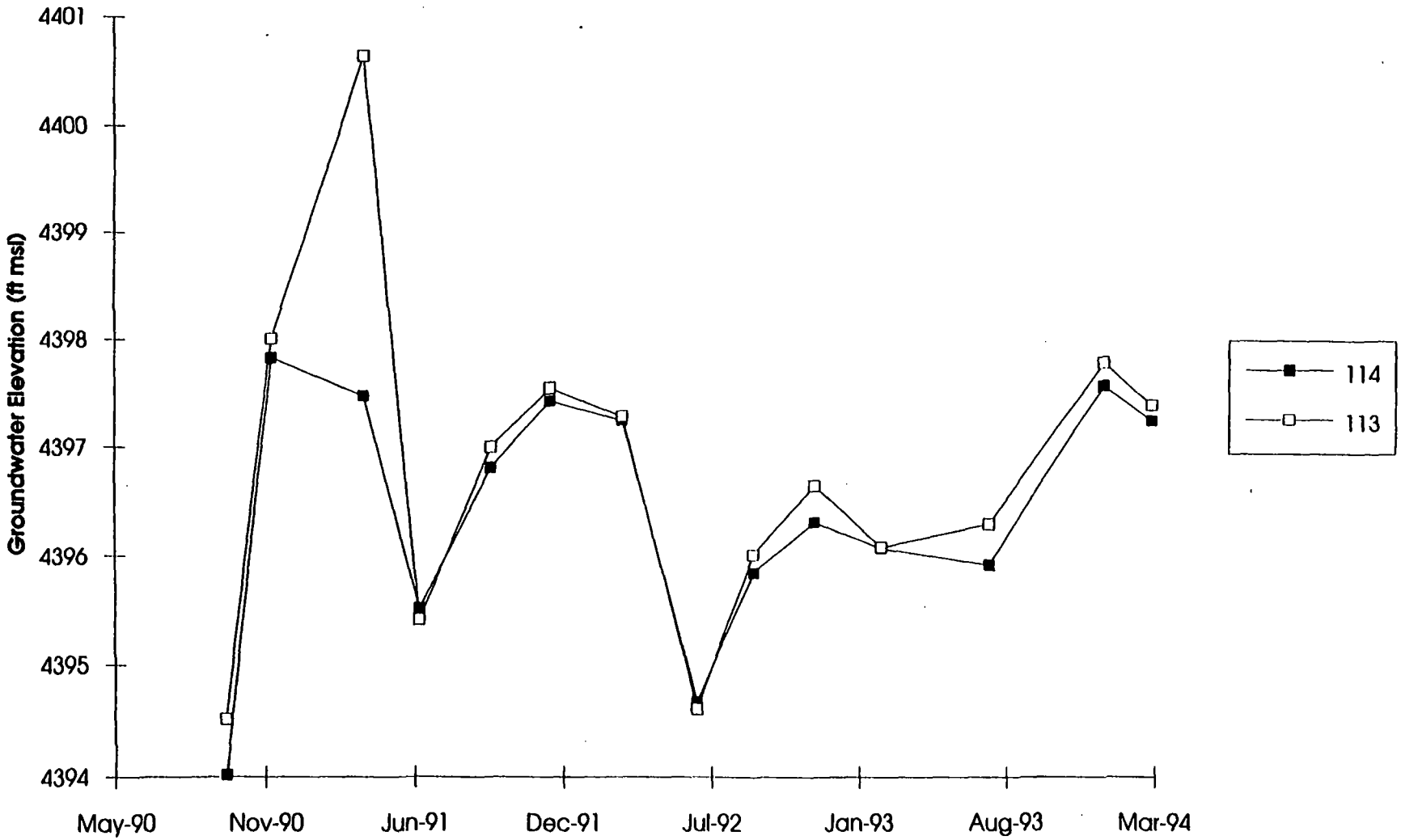

Hydrograph for Wells 107 and 108
Groundwater Elevation (ft msl)
4397
4396.5
4396
4395.5
4395
4394.5
4394
4393.5
4393
4392.5
4392
May-90
Nov-90
Jun-91
Dec-91
Jul-92
Jan-93
Aug-93
Mar-94
107
108

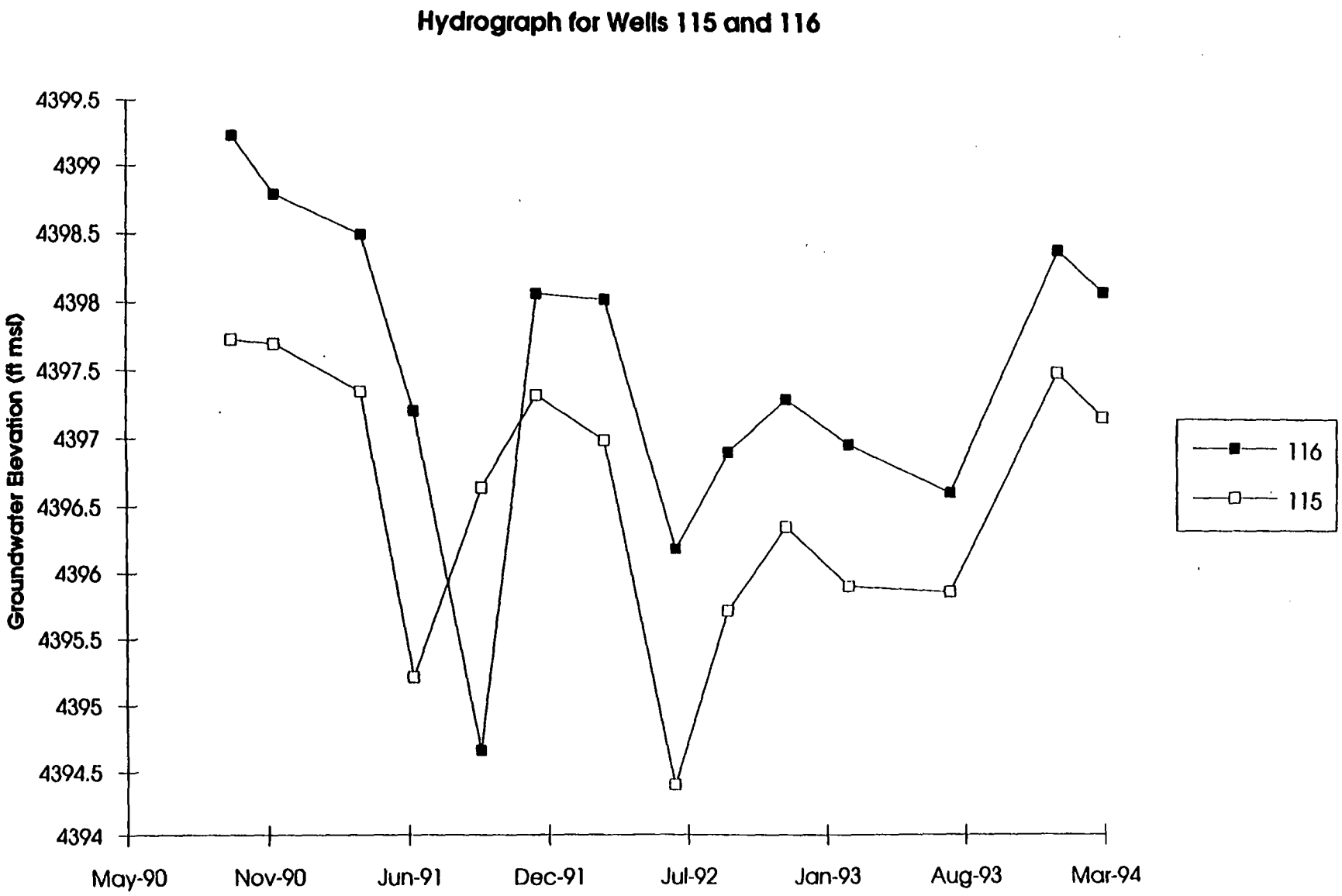
Hydrograph for Well 109 and 110



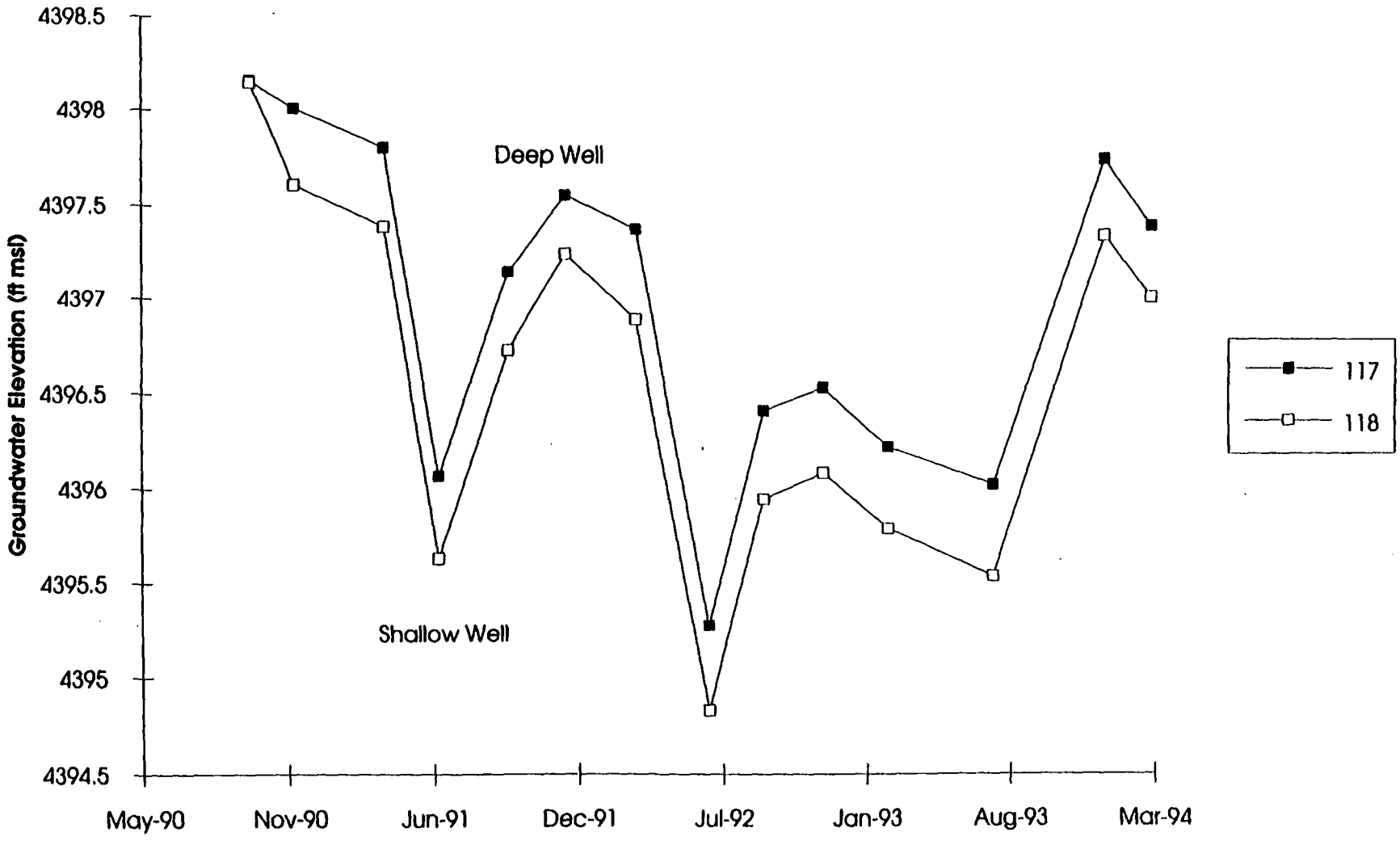

Hydrograph for Well 111 and 112
Groundwater Elevation (ft msl)
4397
4396
4395
4394
4393
4392
4391
May-90
Nov-90
Jun-91
Dec-91
Jul-92
Jan-93
Aug-93
Mar-94
111
112

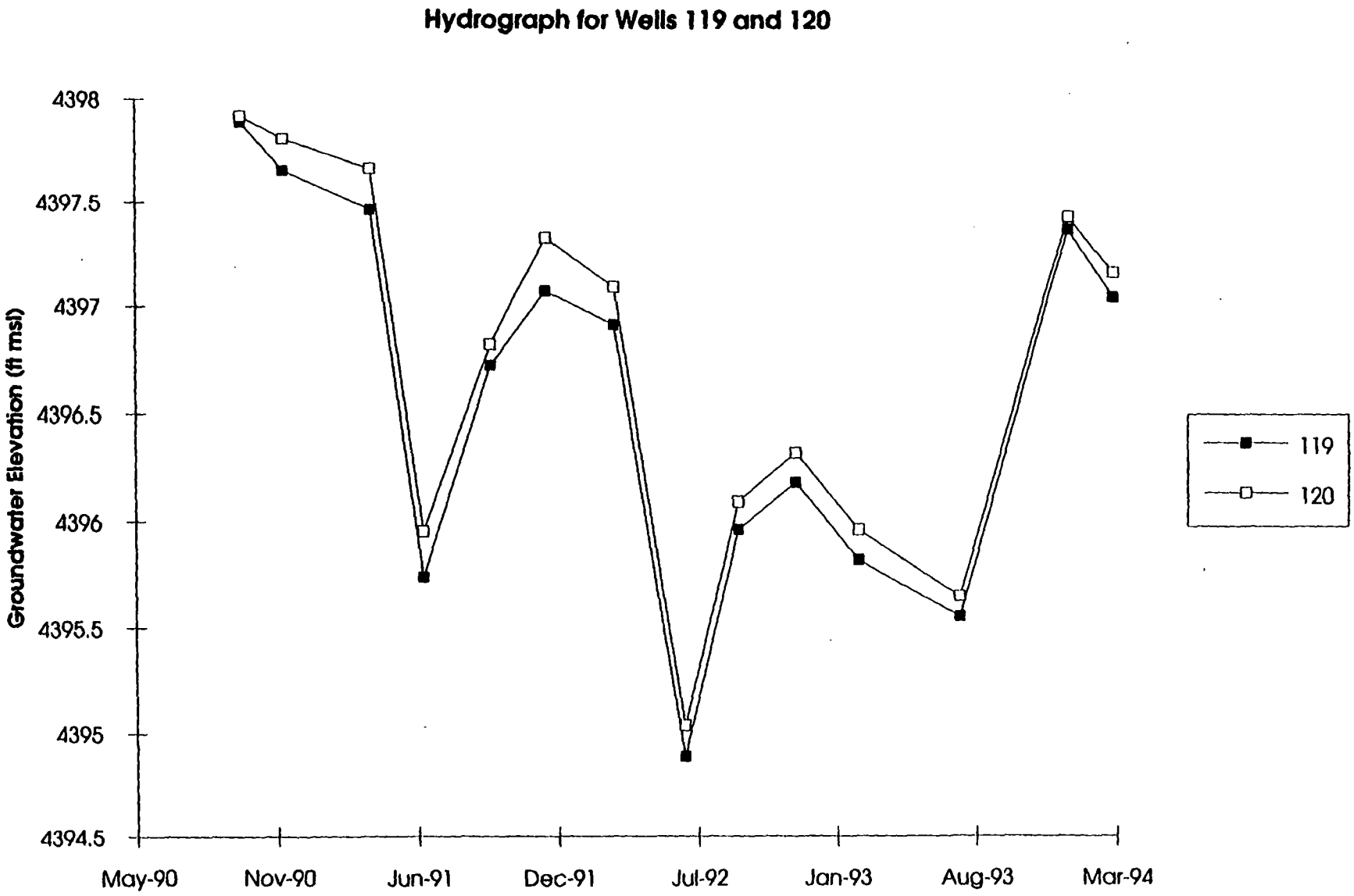
Hydrograph for Wells 113 and 114

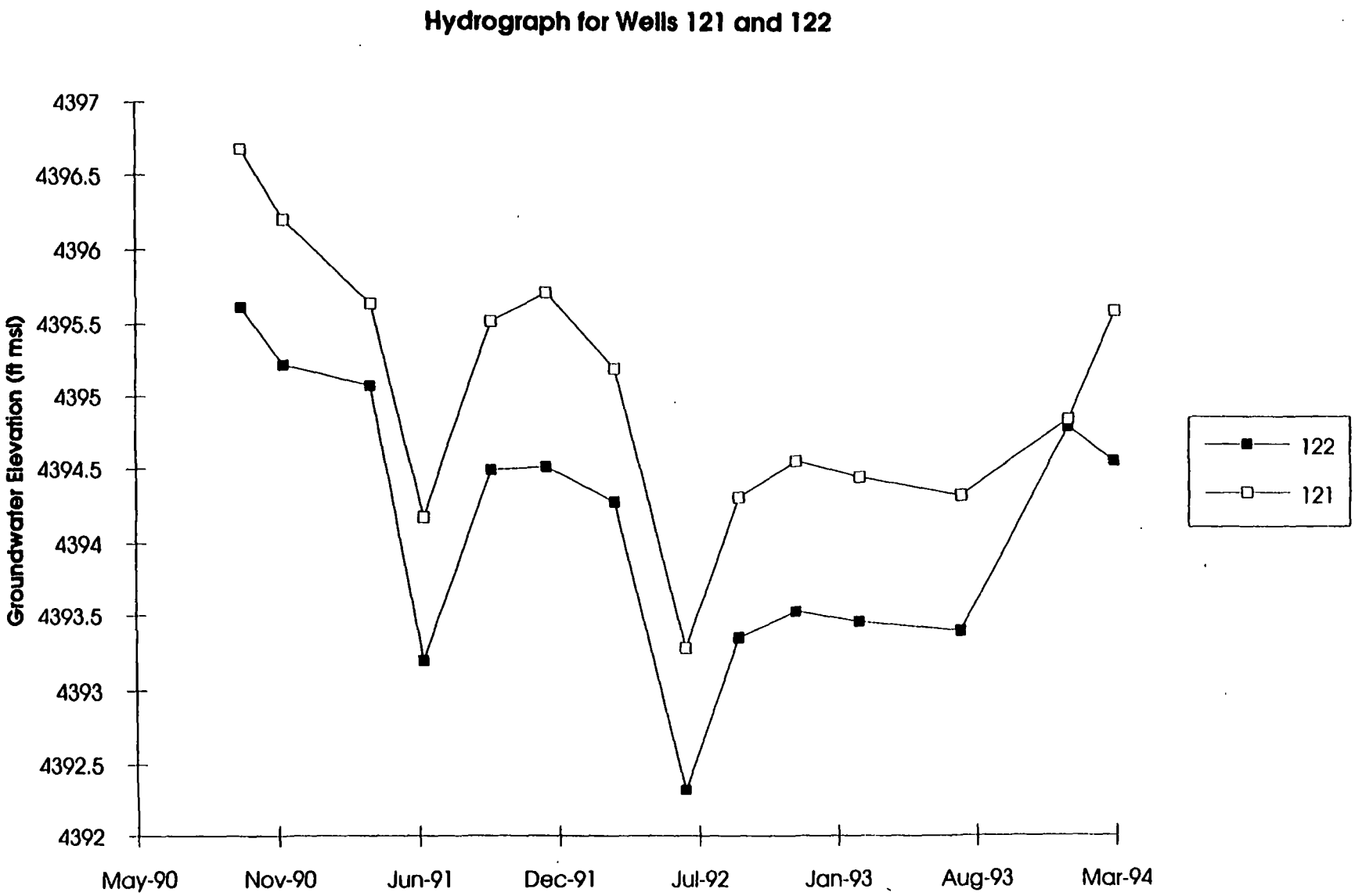


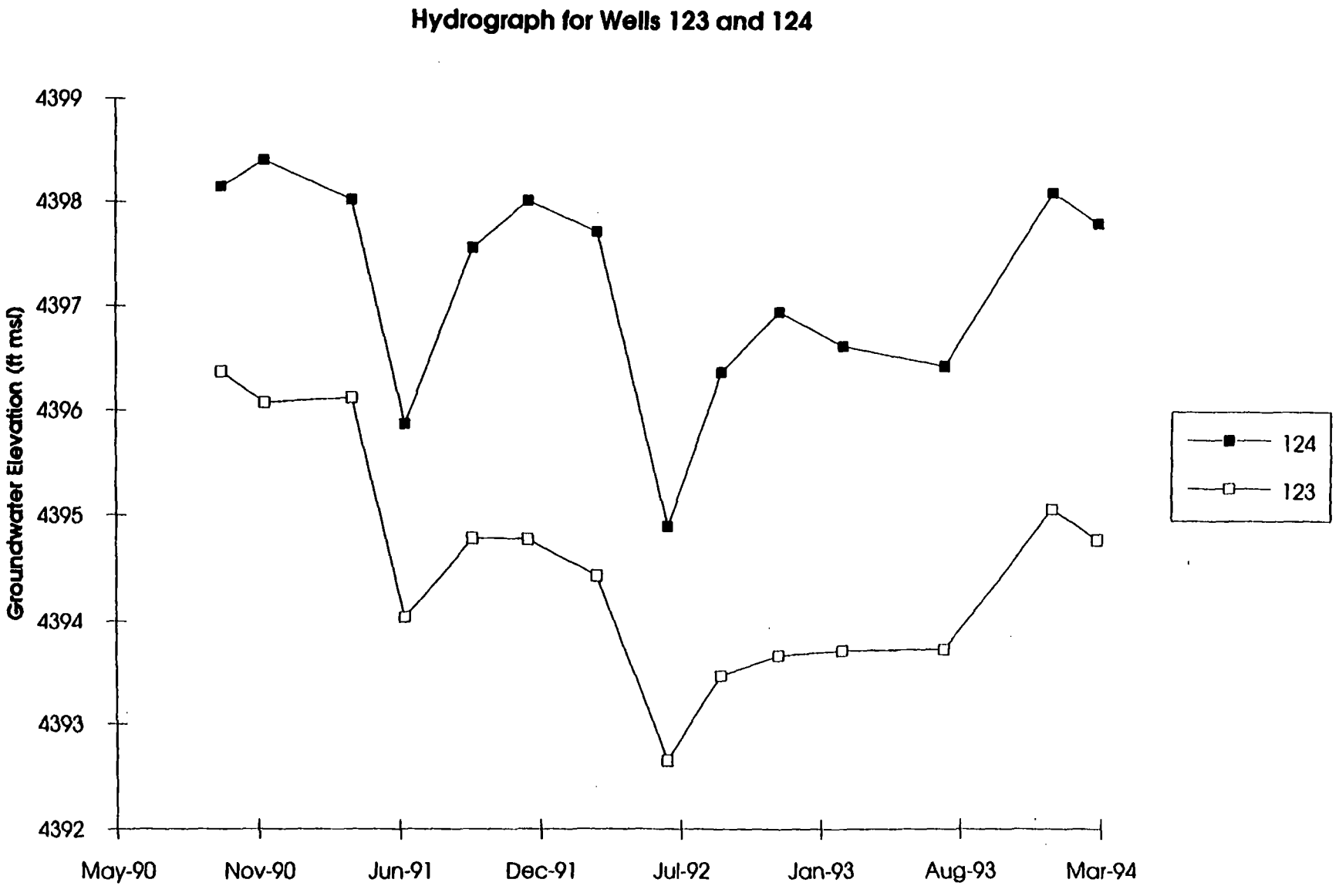

Hydrograph for Wells 115 and 116
Groundwater Elevation (ft msl)
4399.5
4399
4398.5
4398
4397.5
4397
4396.5
4396
4395.5
4395
4394.5
4394
May-90
Nov-90
Jun-91
Dec-91
Jul-92
Jan-93
Aug-93
Mar-94
116
115

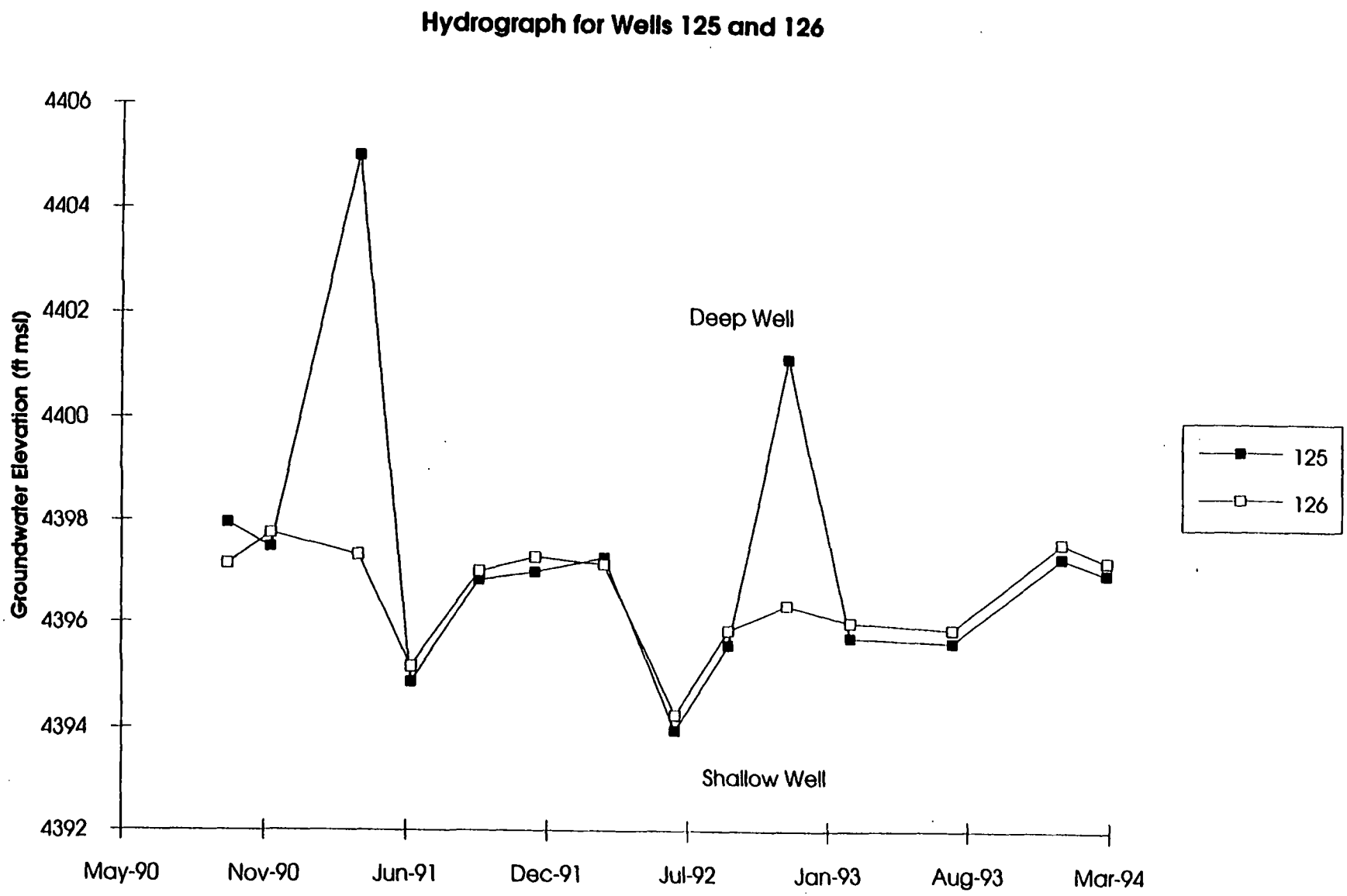
Hydrograph for Wells 117 and 118

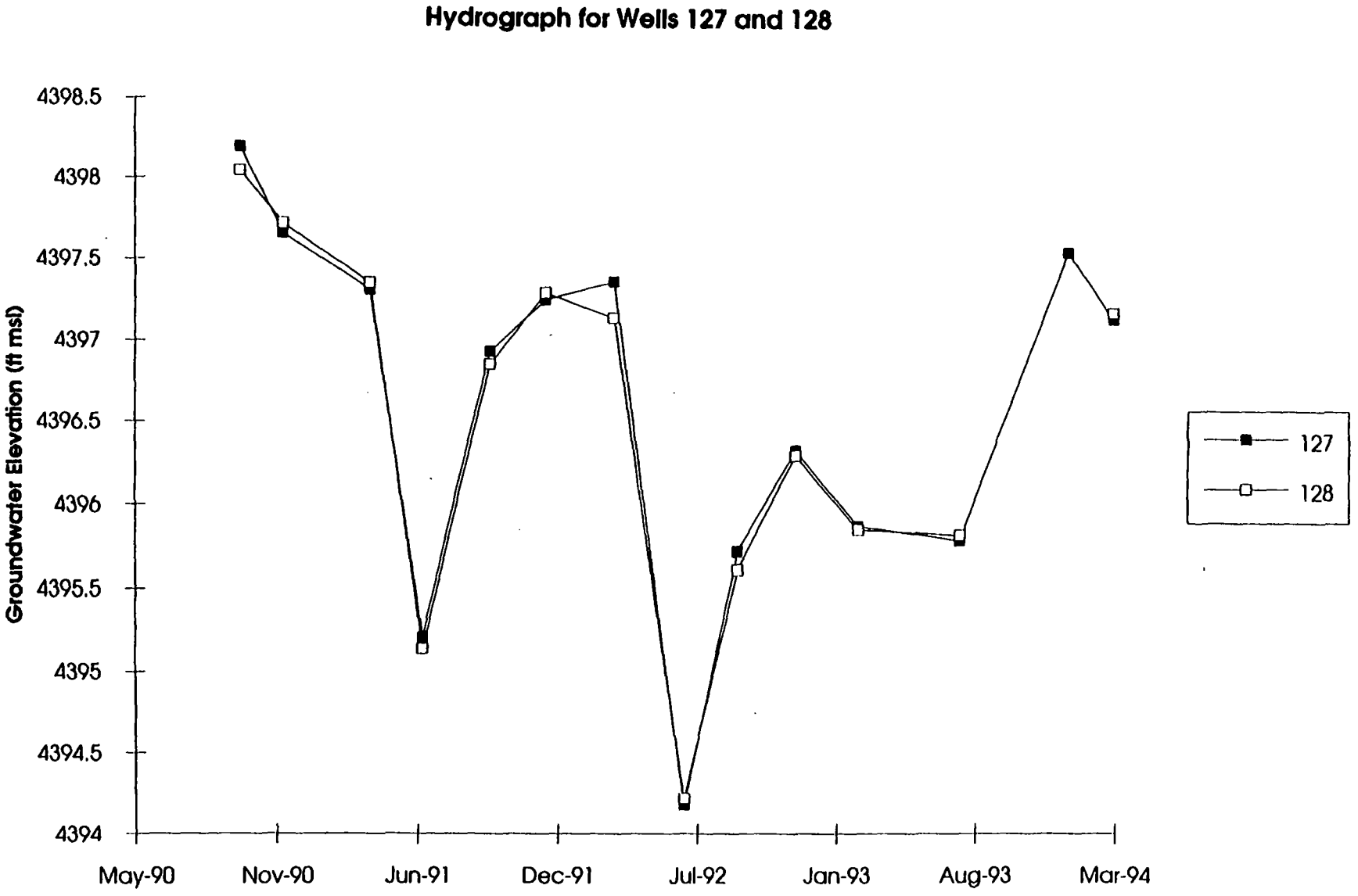


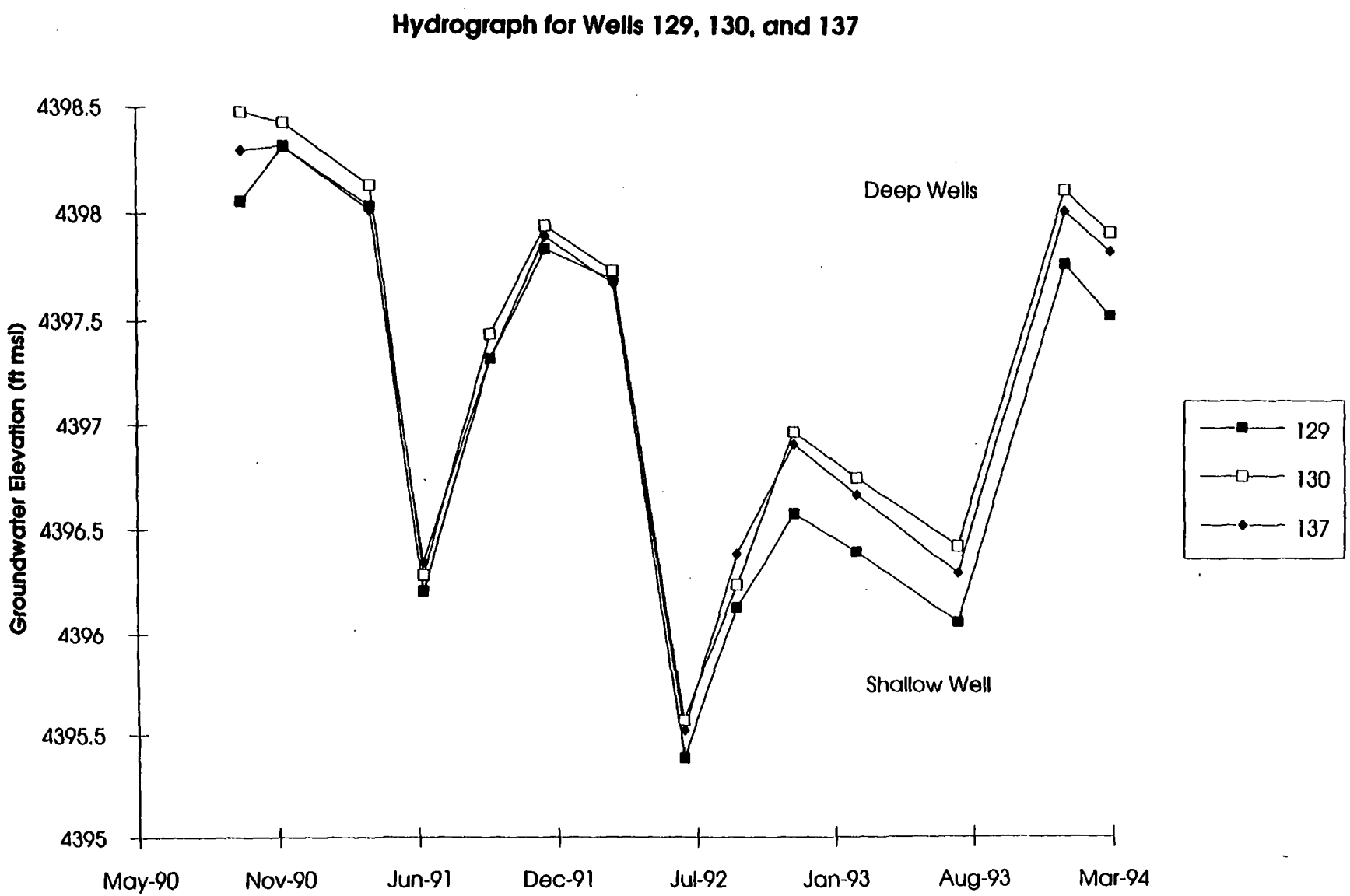

Hydrograph for Wells 119 and 120
Groundwater Elevation (ft msl)
4398
4397.5
4397
4396.5
4396
4395.5
4395
4394.5
May-90
Nov-90
Jun-91
Dec-91
Jul-92
Jan-93
Aug-93
Mar-94
119
120

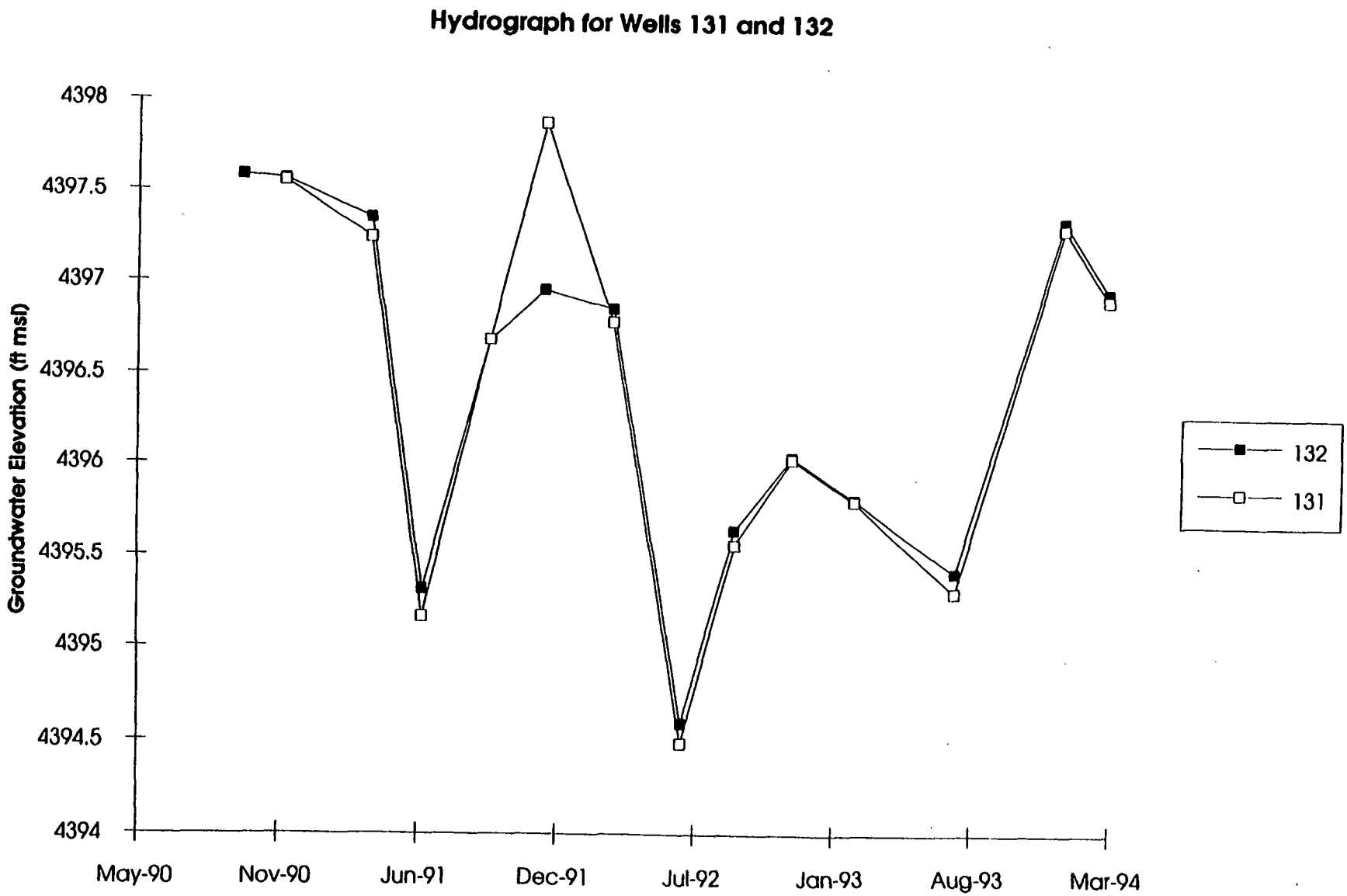

Hydrograph for Wells 121 and 122
Groundwater Elevation (ft msl)
4397
4396.5
4396
4395.5
4395
4394.5
4394
4393.5
4393
4392.5
4392
May-90
Nov-90
Jun-91
Dec-91
Jul-92
Jan-93
Aug-93
Mar-94
122
121

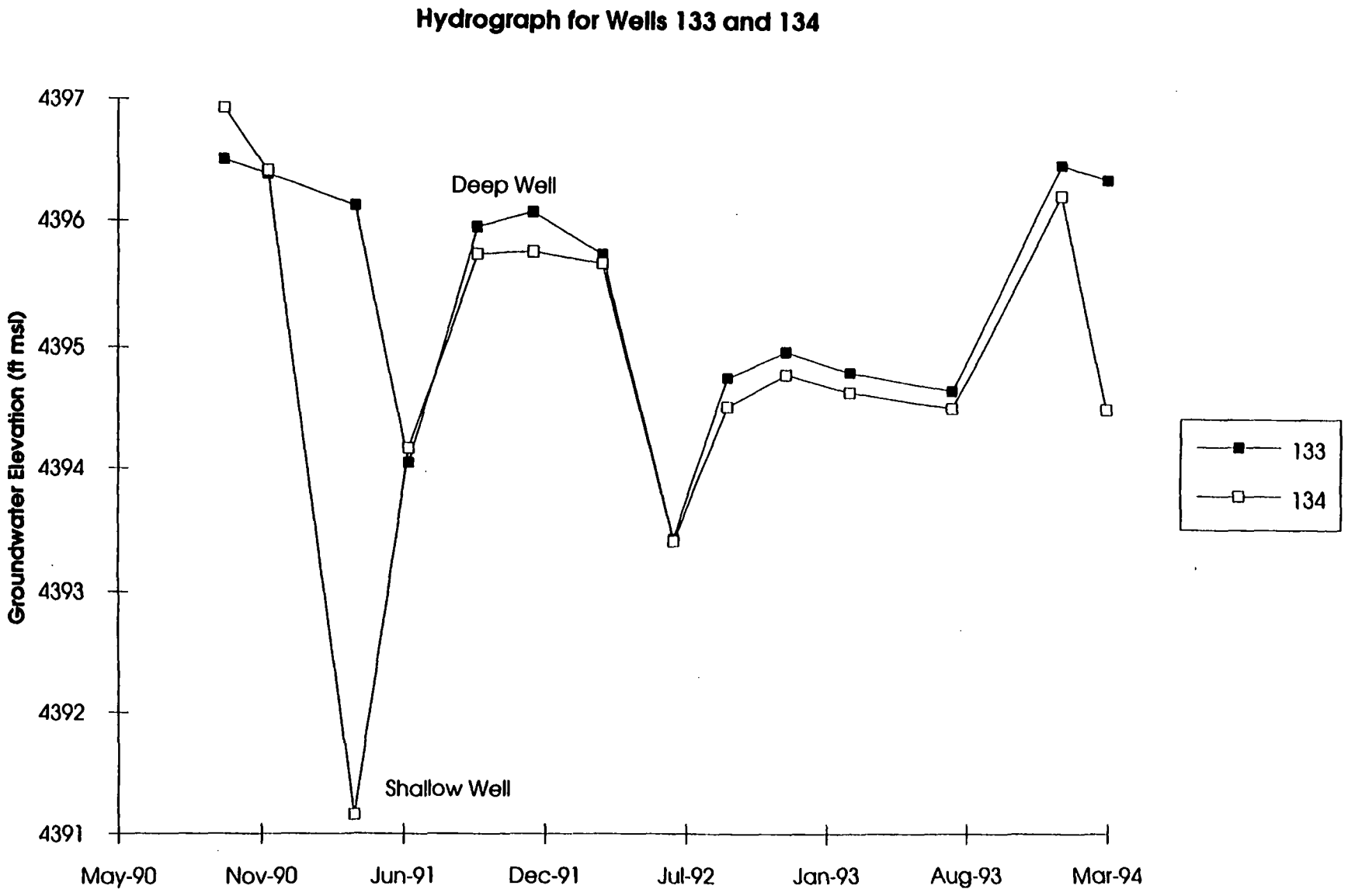

Hydrograph for Wells 123 and 124
Groundwater Elevation (ft msl)
4399
4398
4397
4396
4395
4394
4393
4392
May-90
Nov-90
Jun-91
Dec-91
Jul-92
Jan-93
Aug-93
Mar-94
124
123

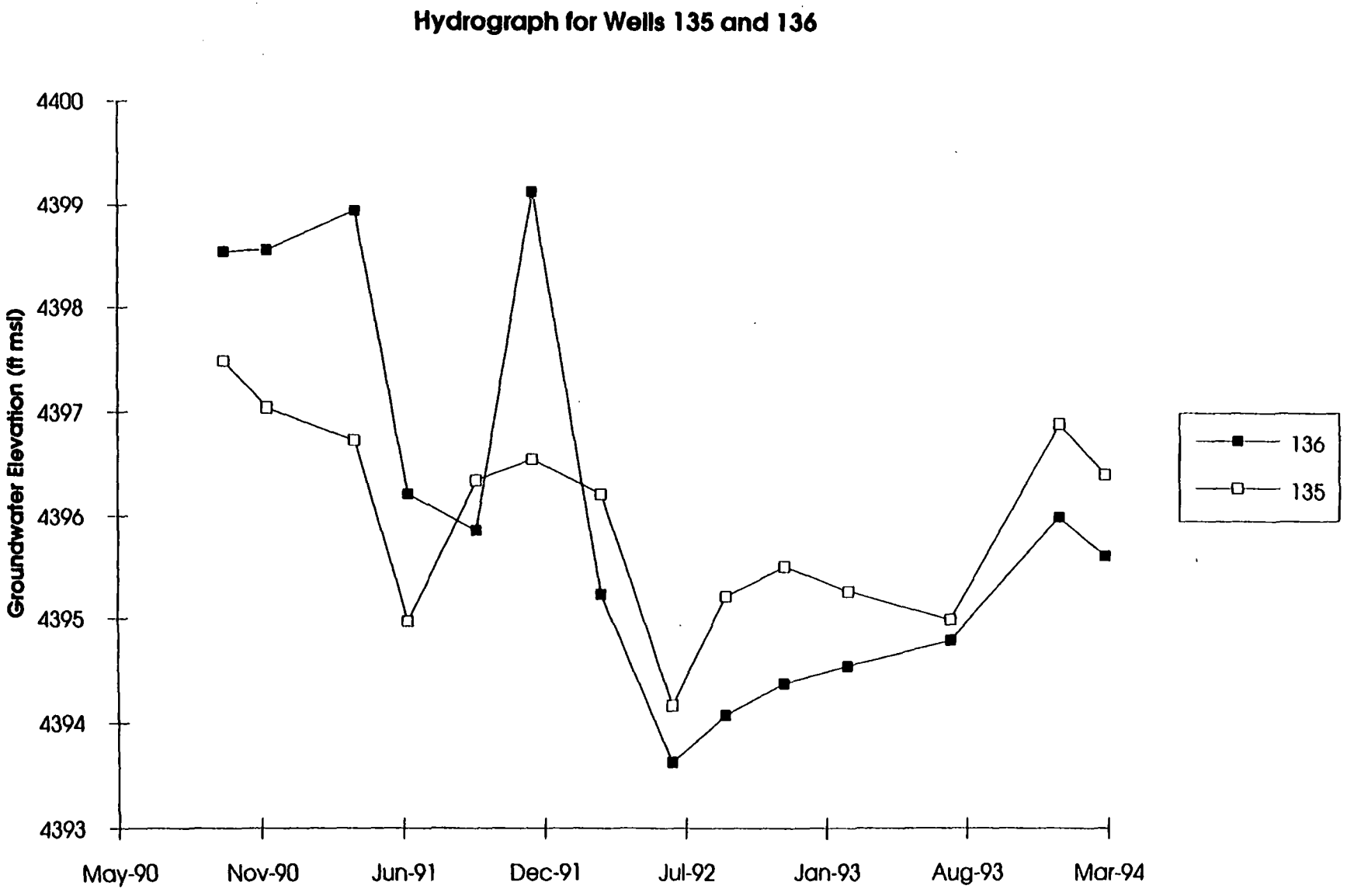

Hydrograph for Wells 125 and 126
Groundwater Elevation (ft msl)
4406
4404
4402
4400
4398
4396
4394
4392
Deep Well
Shallow Well
125
126
May-90
Nov-90
Jun-91
Dec-91
Jul-92
Jan-93
Aug-93
Mar-94

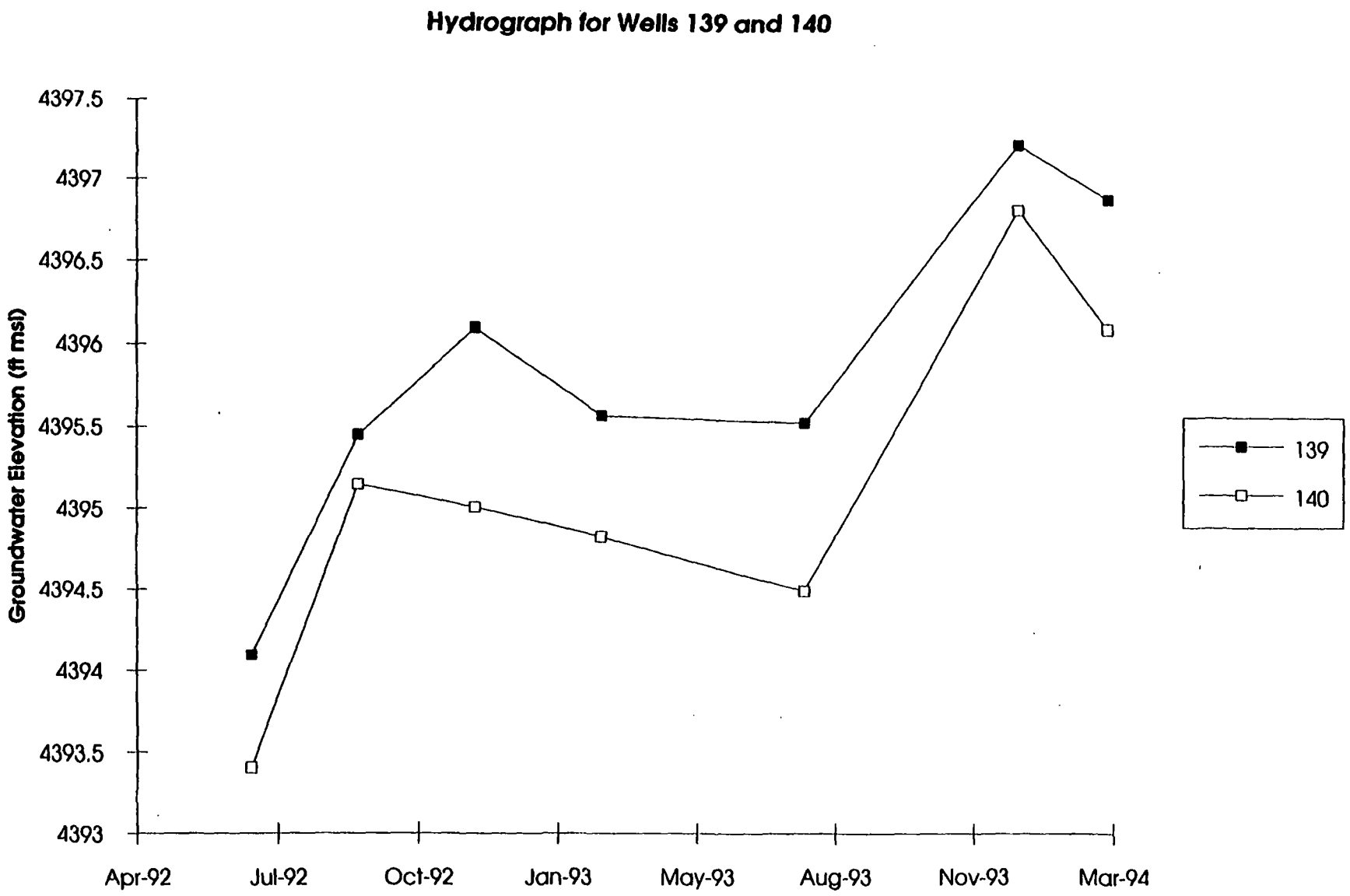

Hydrograph for Wells 127 and 128
Groundwater Elevation (ft msl)
4398.5
4398
4397.5
4397
4396.5
4396
4395.5
4395
4394.5
4394
May-90
Nov-90
Jun-91
Dec-91
Jul-92
Jan-93
Aug-93
Mar-94
127
128

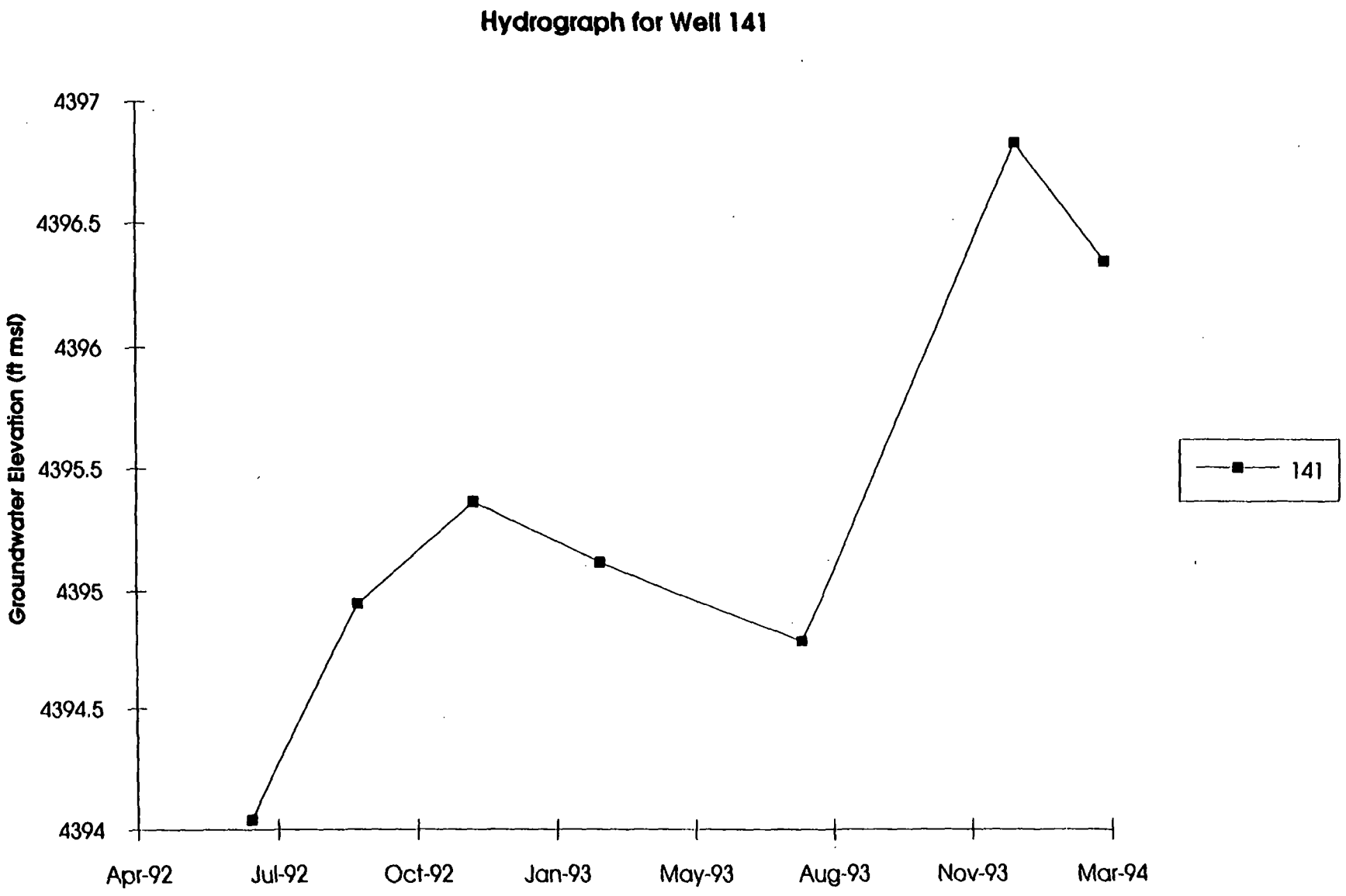

Hydrograph for Wells 129, 130, and 137
Groundwater Elevation (ft msl)
4398.5
4398
4397.5
4397
4396.5
4396
4395.5
4395
May-90
Nov-90
Jun-91
Dec-91
Jul-92
Jan-93
Aug-93
Mar-94
Deep Wells
Shallow Well
129
130
137

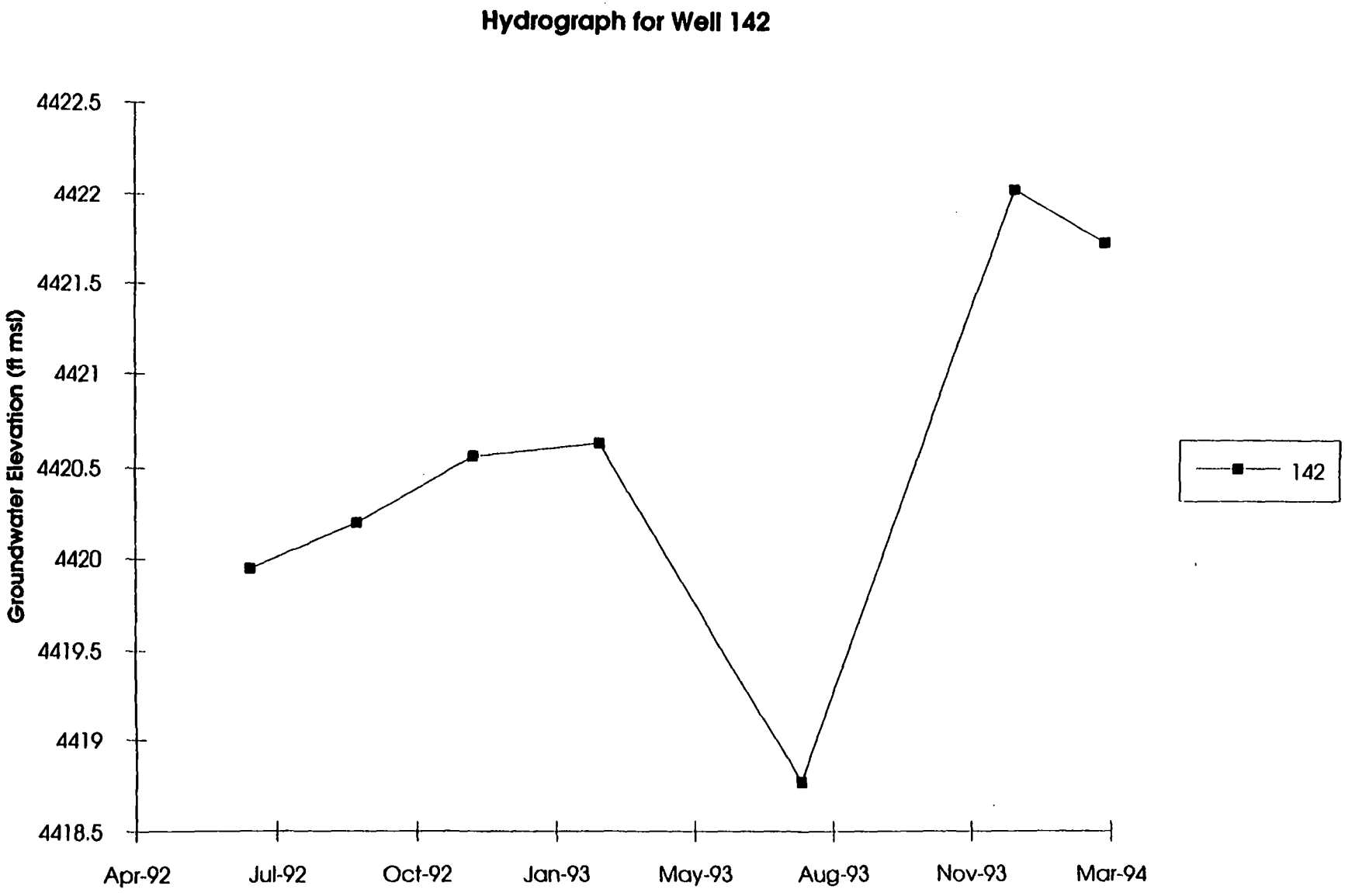

Hydrograph for Wells 131 and 132
Groundwater Elevation (ft msl)
4398
4397.5
4397
4396.5
4396
4395.5
4395
4394.5
4394
May-90
Nov-90
Jun-91
Dec-91
Jul-92
Jan-93
Aug-93
Mar-94
132
131

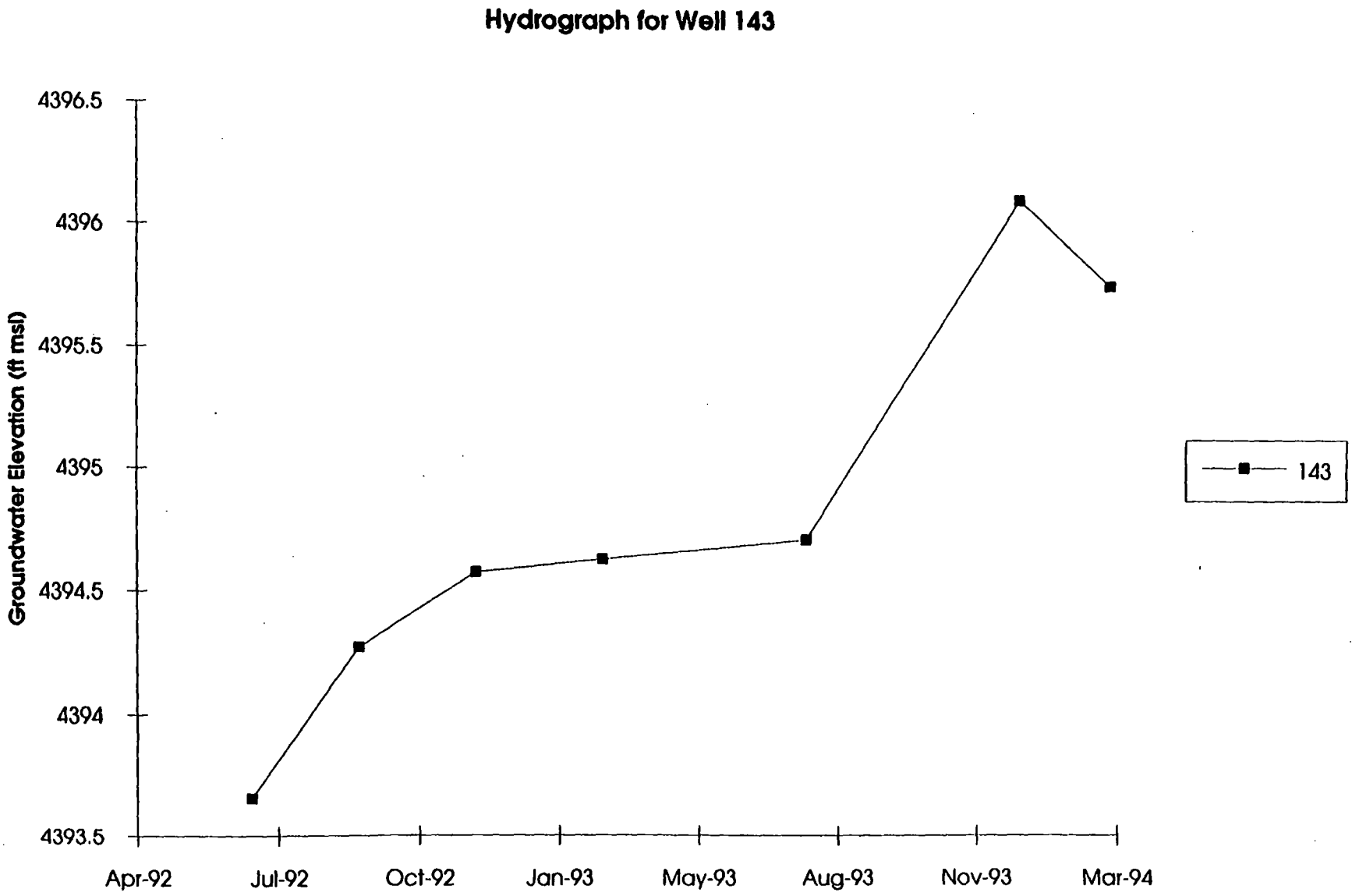

Hydrograph for Wells 133 and 134
Groundwater Elevation (ft msl)
4397
4396
4395
4394
4393
4392
4391
May-90
Nov-90
Jun-91
Dec-91
Jul-92
Jan-93
Aug-93
Mar-94
Deep Well
Shallow Well
133
134

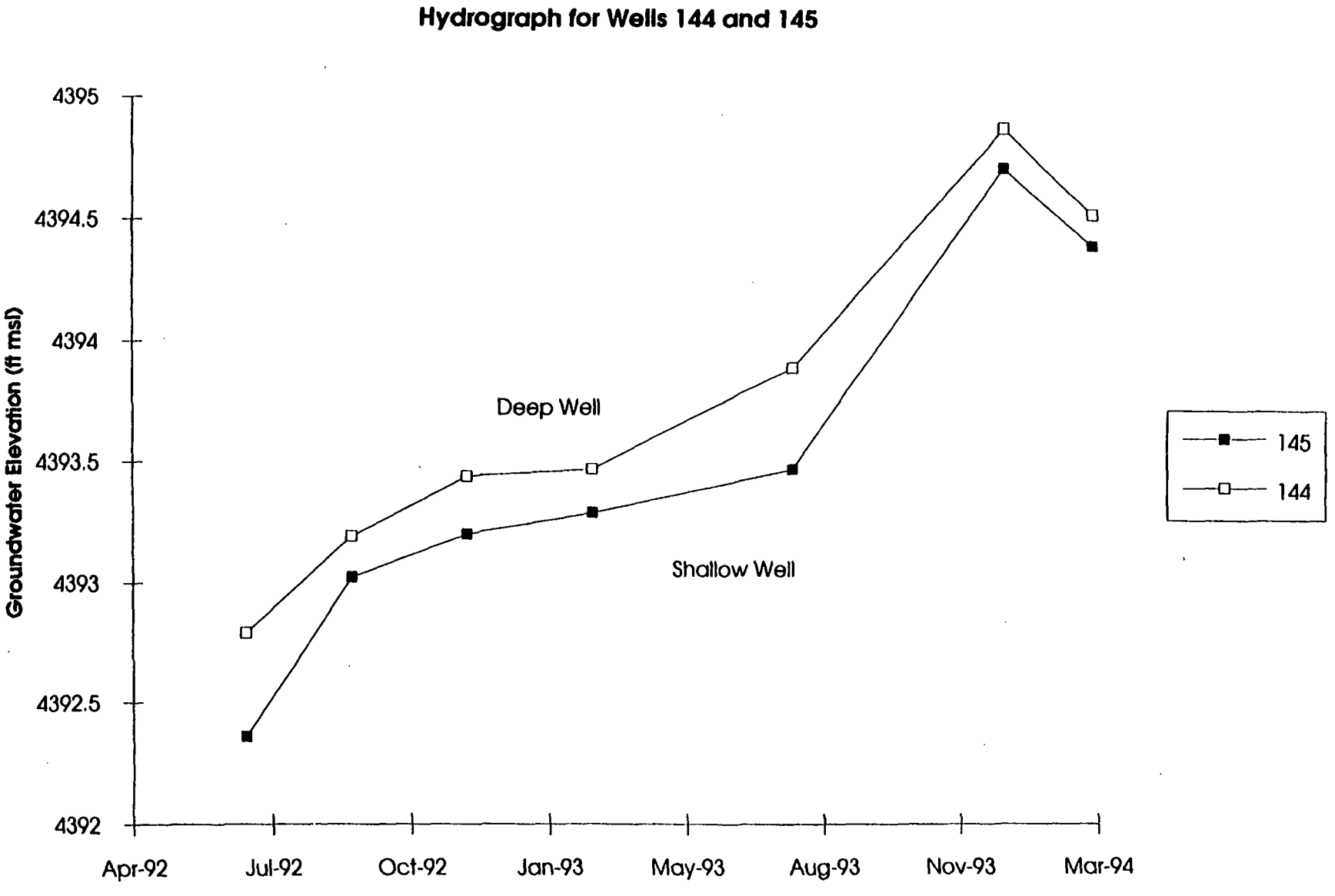

Hydrograph for Wells 135 and 136
Groundwater Elevation (ft msl)
4400
4399
4398
4397
4396
4395
4394
4393
May-90
Nov-90
Jun-91
Dec-91
Jul-92
Jan-93
Aug-93
Mar-94
136
135

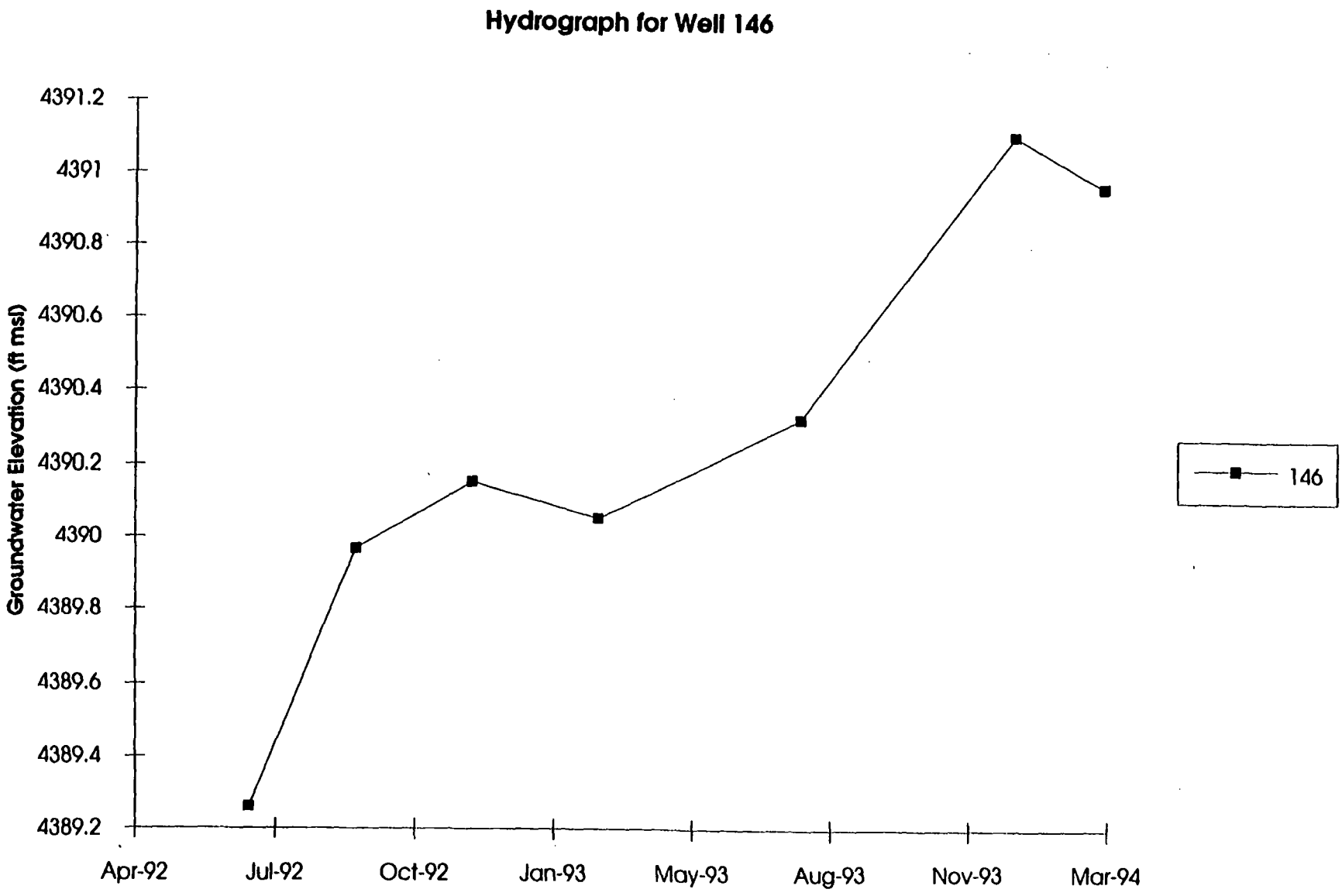

Hydrograph for Wells 139 and 140
Groundwater Elevation (ft msl)
4397.5
4397
4396.5
4396
4395.5
4395
4394.5
4394
4393.5
4393
Apr-92
Jul-92
Oct-92
Jan-93
May-93
Aug-93
Nov-93
Mar-94
139
140


Hydrograph for Well 141
Groundwater Elevation (ft msl)
4397
4396.5
4396
4395.5
4395
4394.5
4394
Apr-92
Jul-92
Oct-92
Jan-93
May-93
Aug-93
Nov-93
Mar-94
141

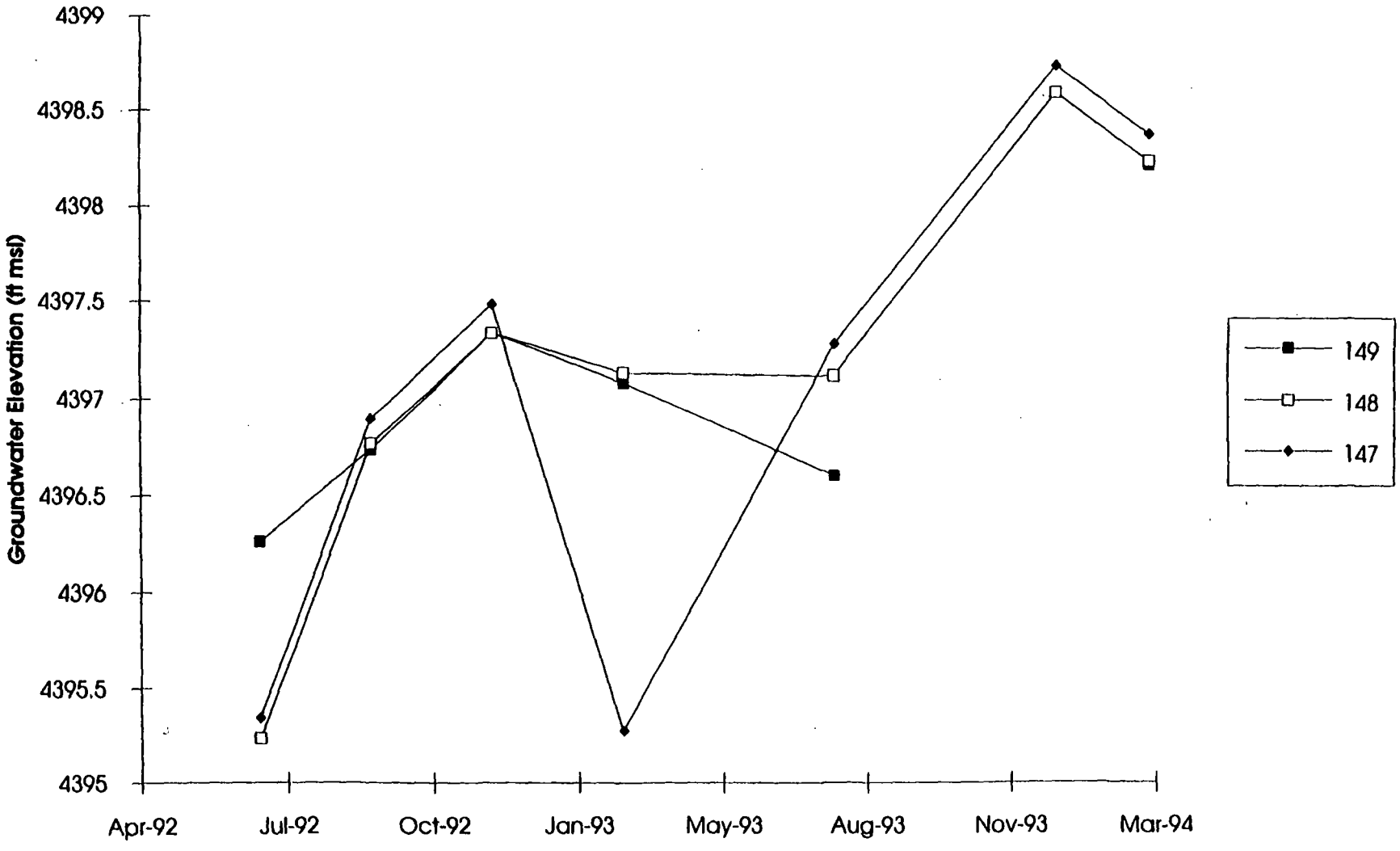

Hydrograph for Well 142
Groundwater Elevation (ft msl)
4422.5
4422
4421.5
4421
4420.5
4420
4419.5
4419
4418.5
Apr-92
Jul-92
Oct-92
Jan-93
May-93
Aug-93
Nov-93
Mar-94
142

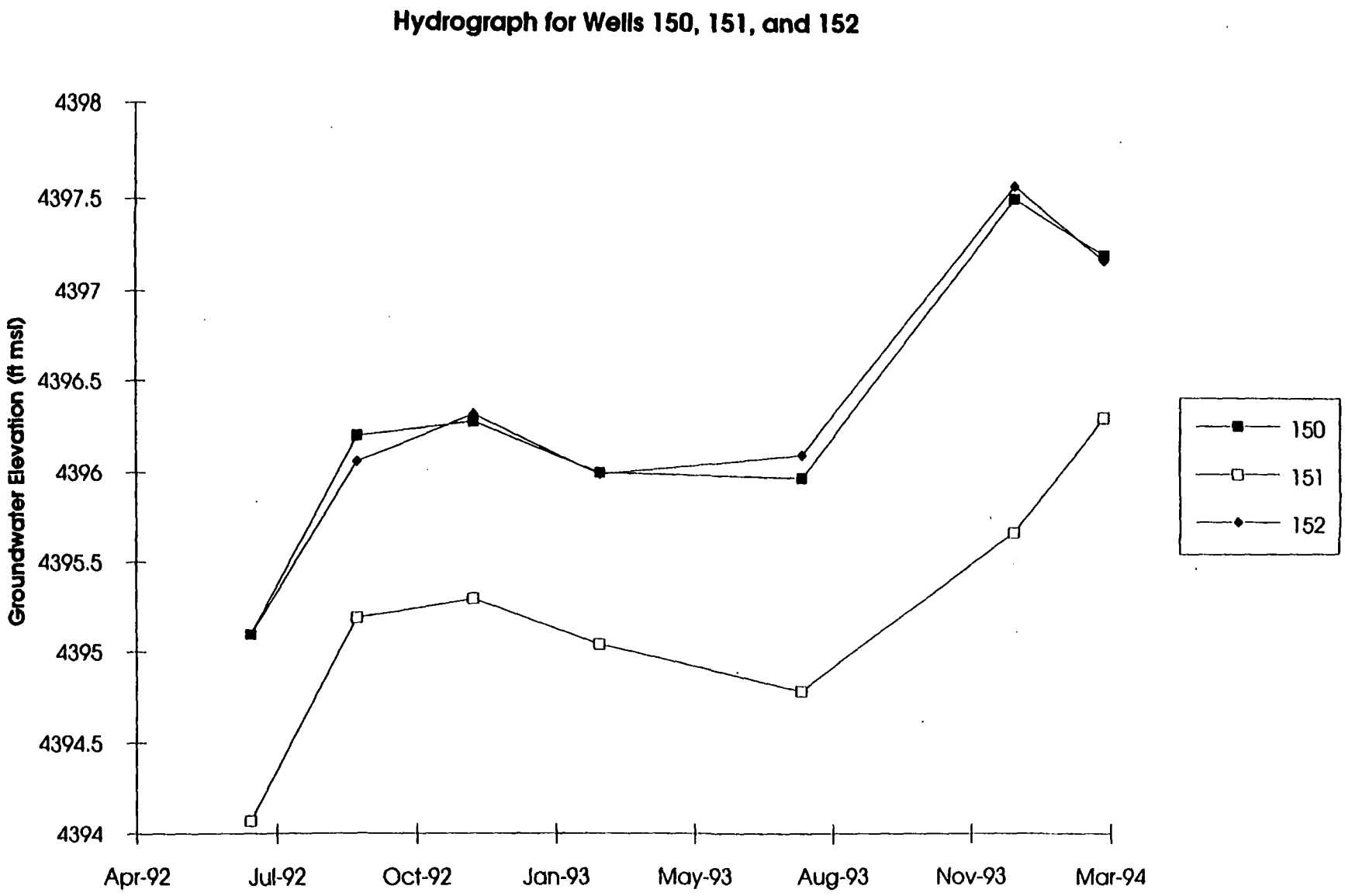

Hydrograph for Well 143
Groundwater Elevation (ft msl)
4396.5
4396
4395.5
4395
4394.5
4394
4393.5
Apr-92
Jul-92
Oct-92
Jan-93
May-93
Aug-93
Nov-93
Mar-94
143


Hydrograph for Wells 144 and 145
Groundwater Elevation (ft msl)
4395
4394.5
4394
4393.5
4393
4392.5
4392
Apr-92
Jul-92
Oct-92
Jan-93
May-93
Aug-93
Nov-93
Mar-94
Deep Well
Shallow Well
145
144

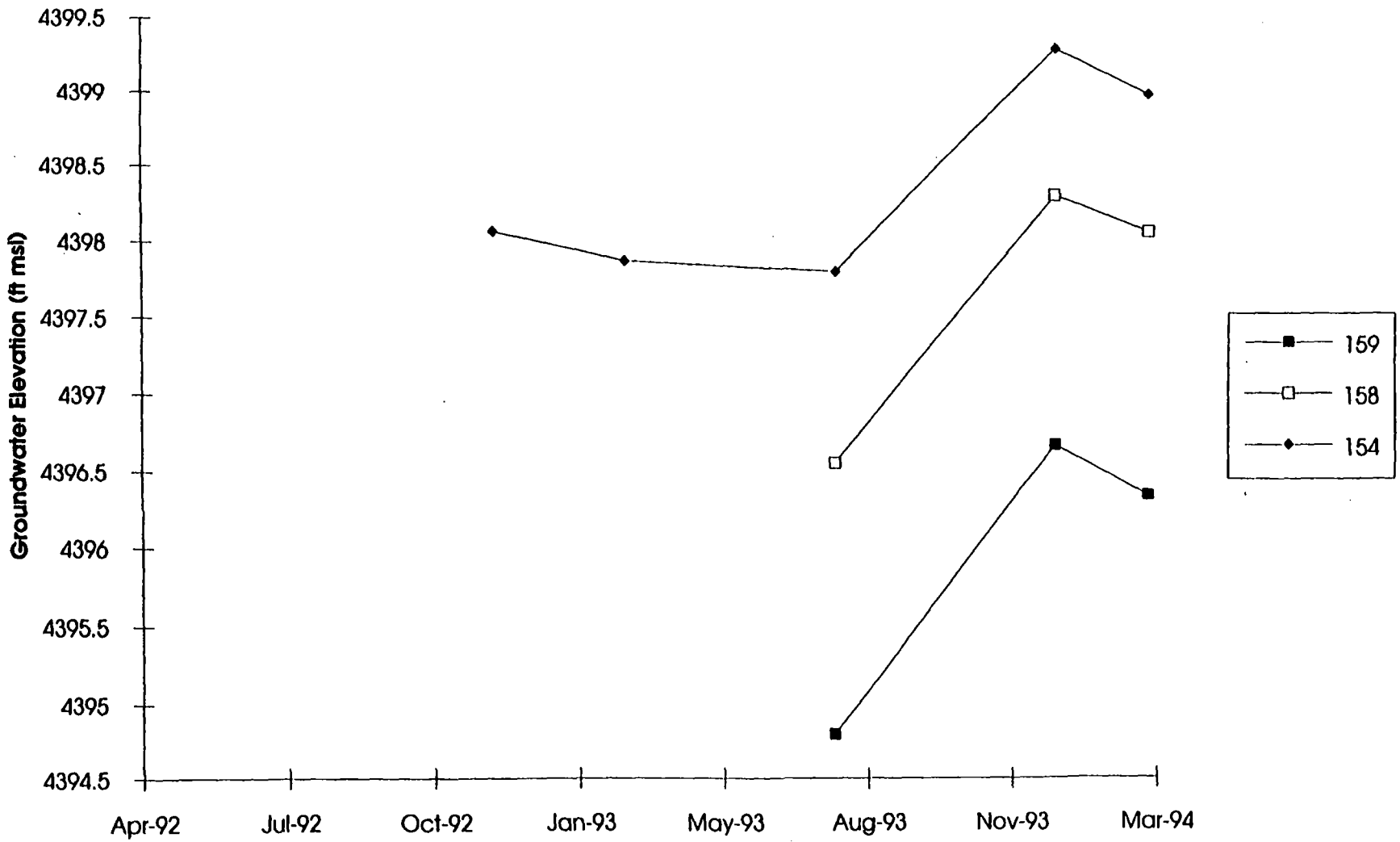

Hydrograph for Well 146
Groundwater Elevation (ft msl)
4391.2
4391
4390.8
4390.6
4390.4
4390.2
4390
4389.8
4389.6
4389.4
4389.2
Apr-92
Jul-92
Oct-92
Jan-93
May-93
Aug-93
Nov-93
Mar-94
146

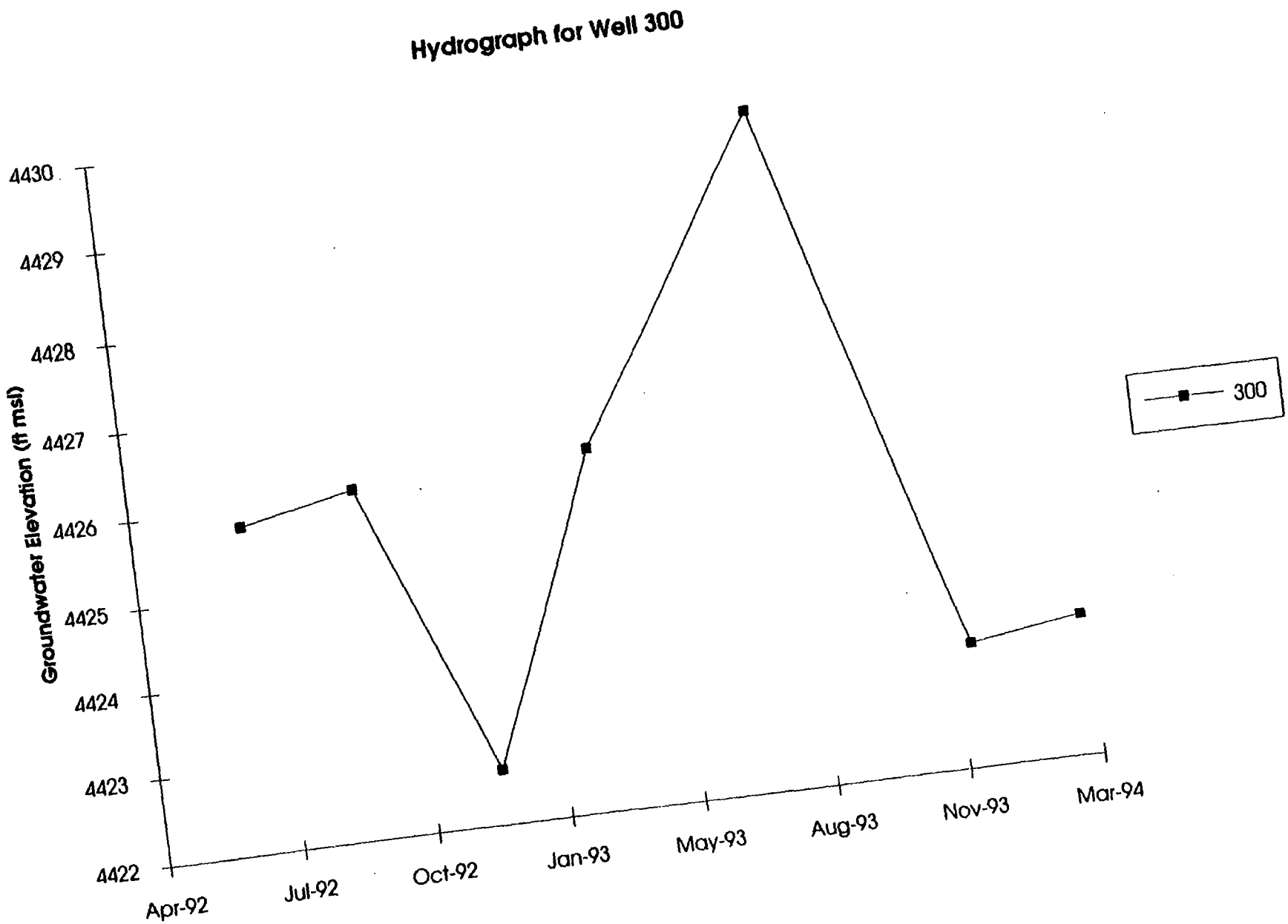
Hydrograph for Wells 147, 148, and 149

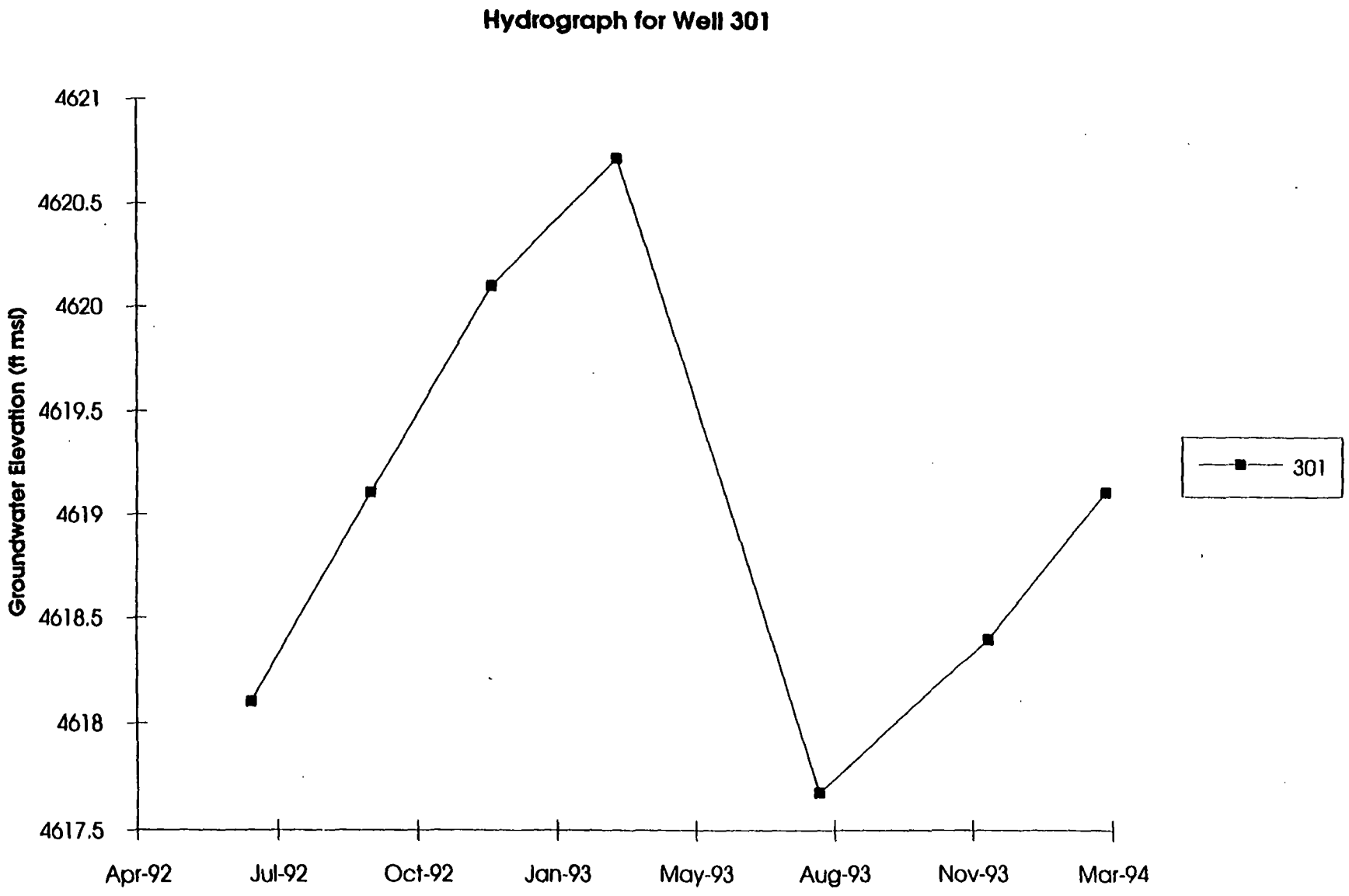


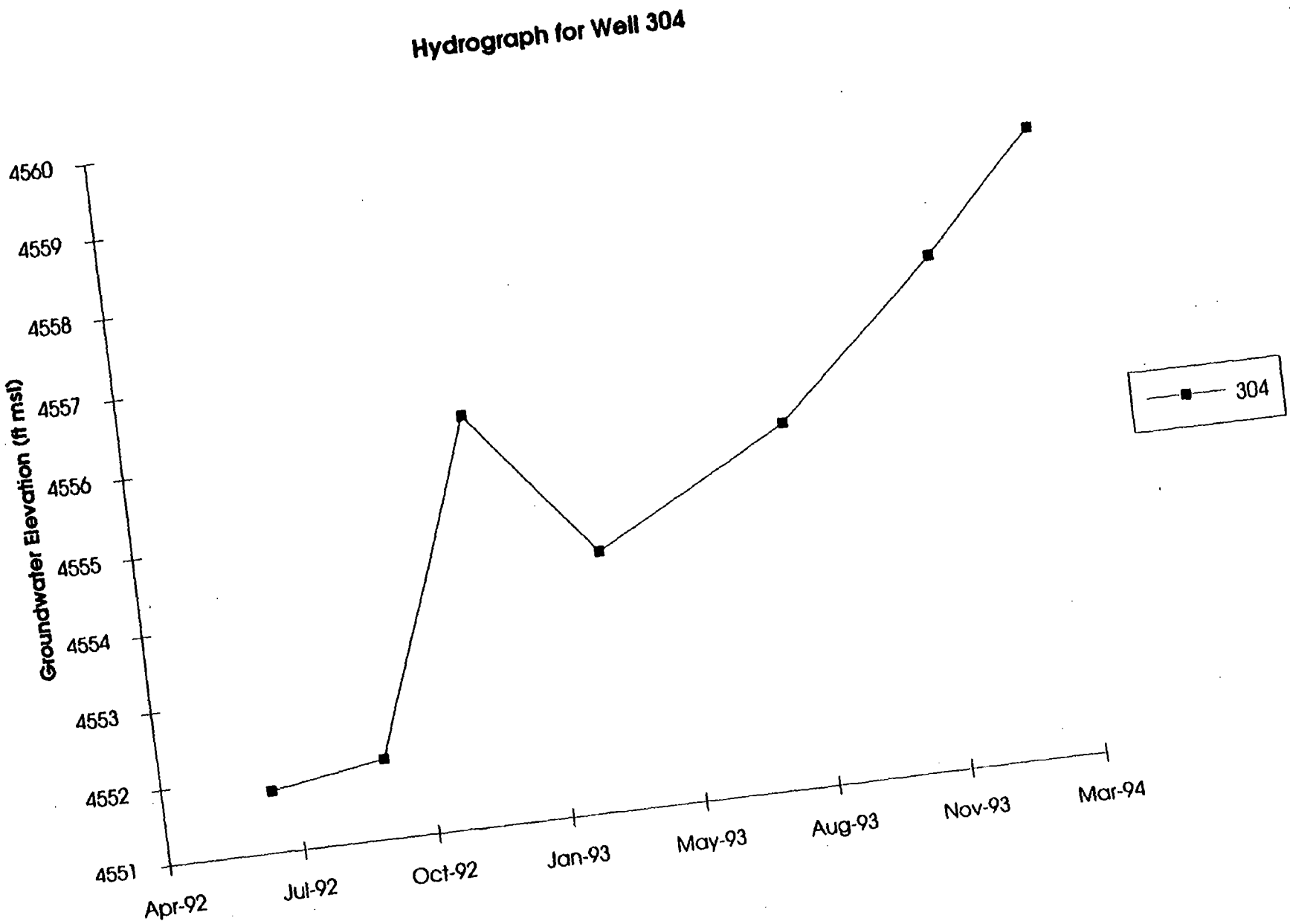

Hydrograph for Wells 150, 151, and 152
Groundwater Elevation (ft msl)
4398
4397.5
4397
4396.5
4396
4395.5
4395
4394.5
4394
Apr-92
Jul-92
Oct-92
Jan-93
May-93
Aug-93
Nov-93
Mar-94
150
151
152

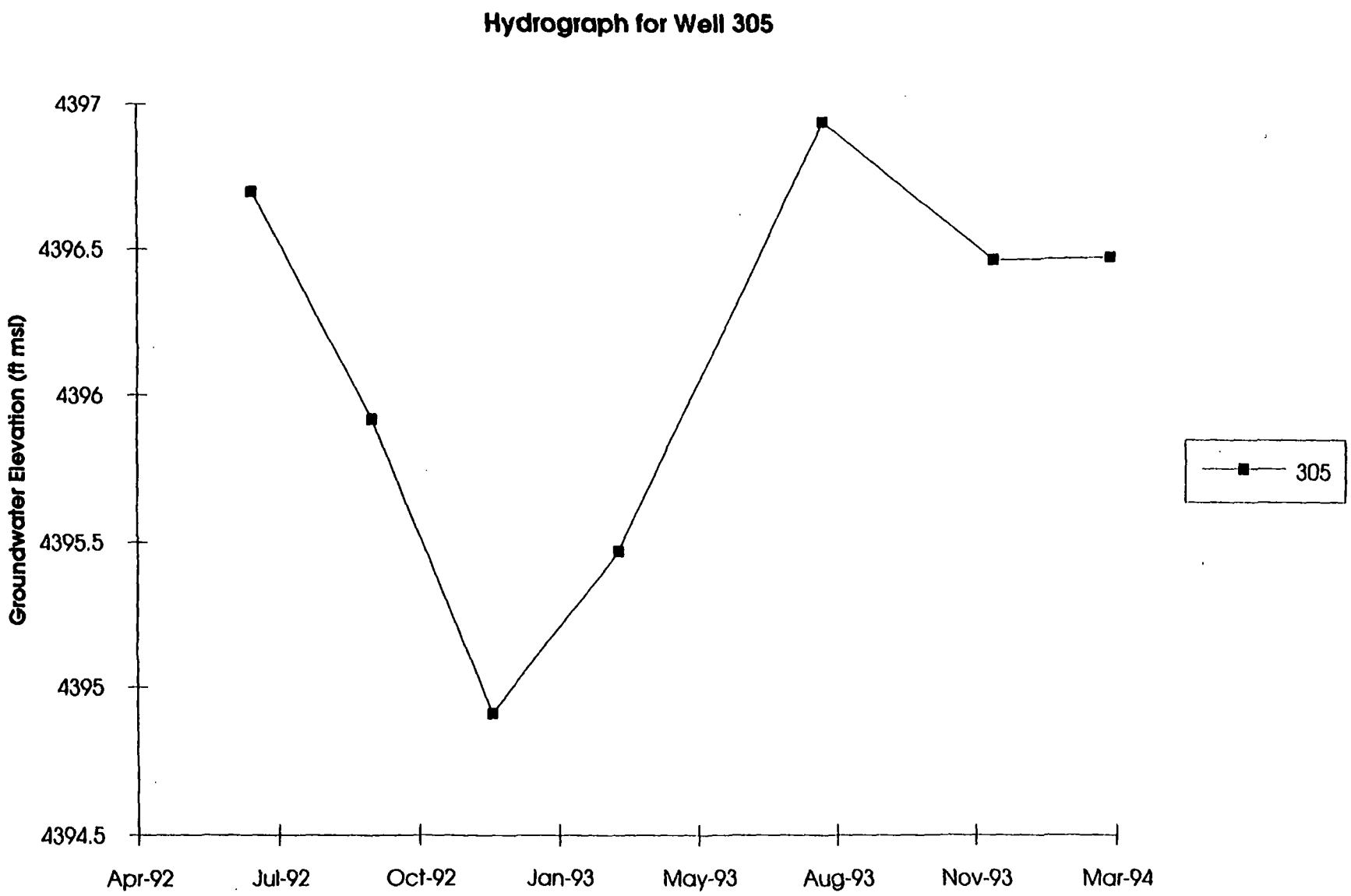
Hydrograph for Wells 154, 158, and 159

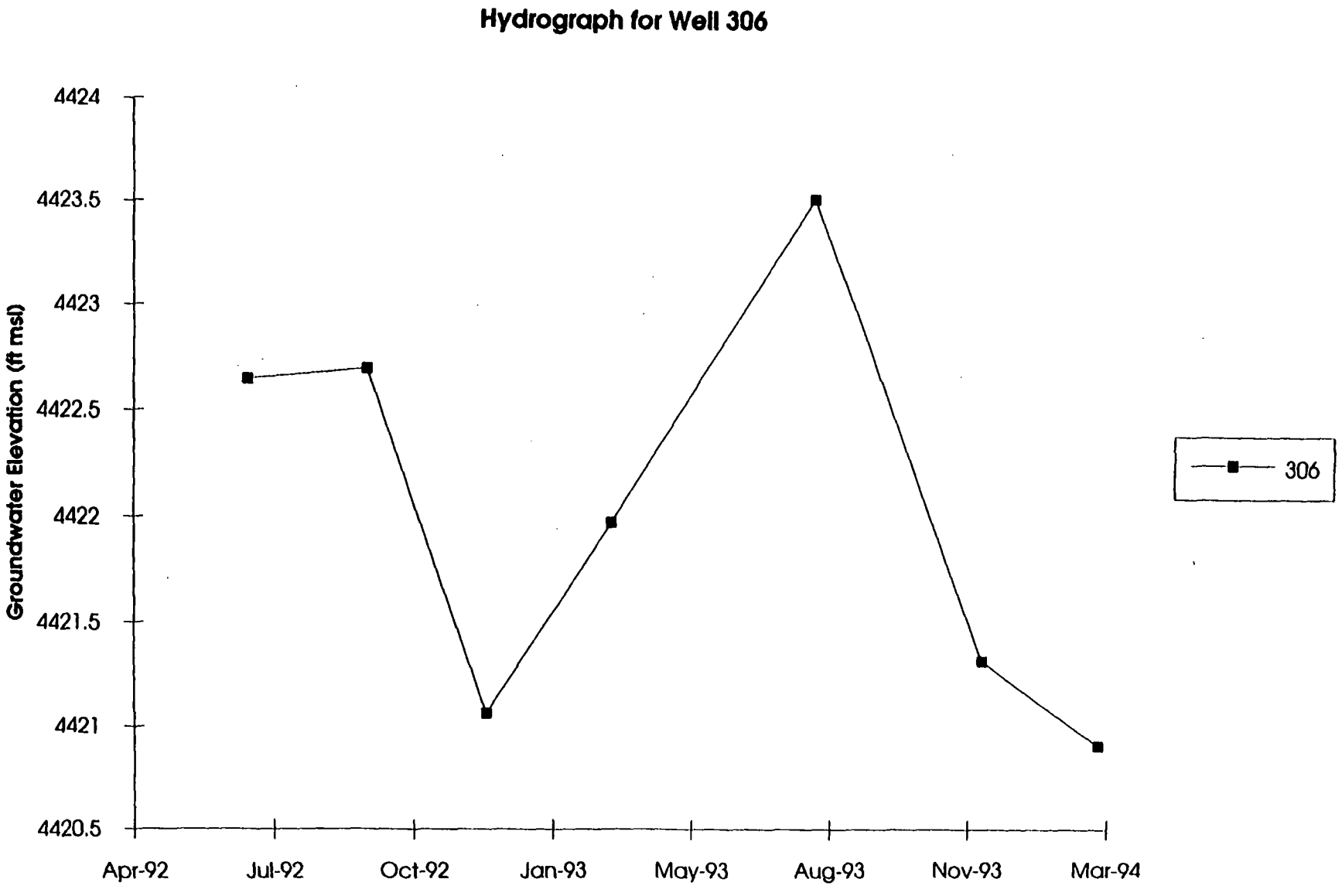


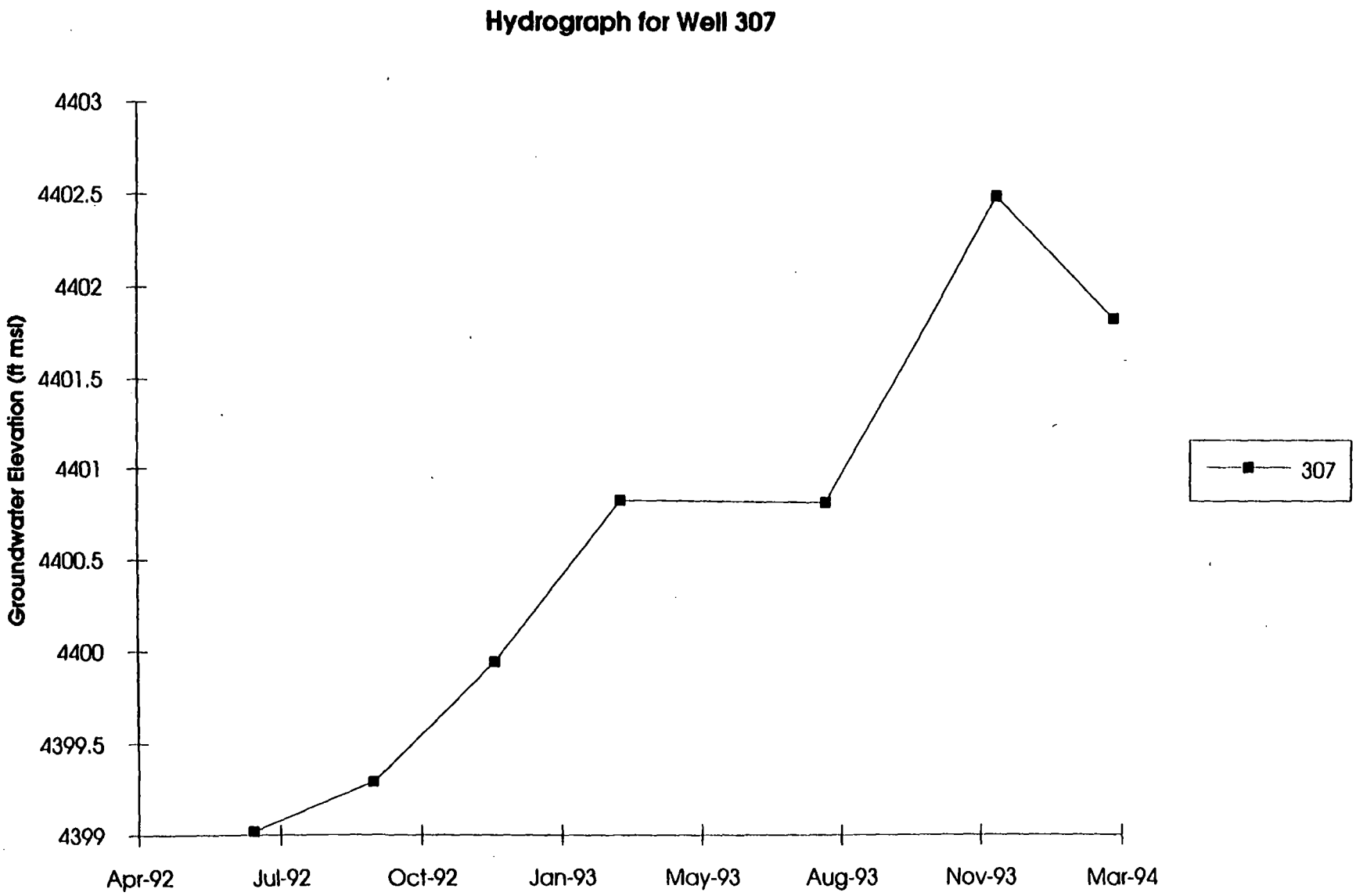

Hydrograph for Well 300
Groundwater Elevation (ft msl)
4430
4429
4428
4427
4426
4425
4424
4423
4422
Apr-92
Jul-92
Oct-92
Jan-93
May-93
Aug-93
Nov-93
Mar-94
300

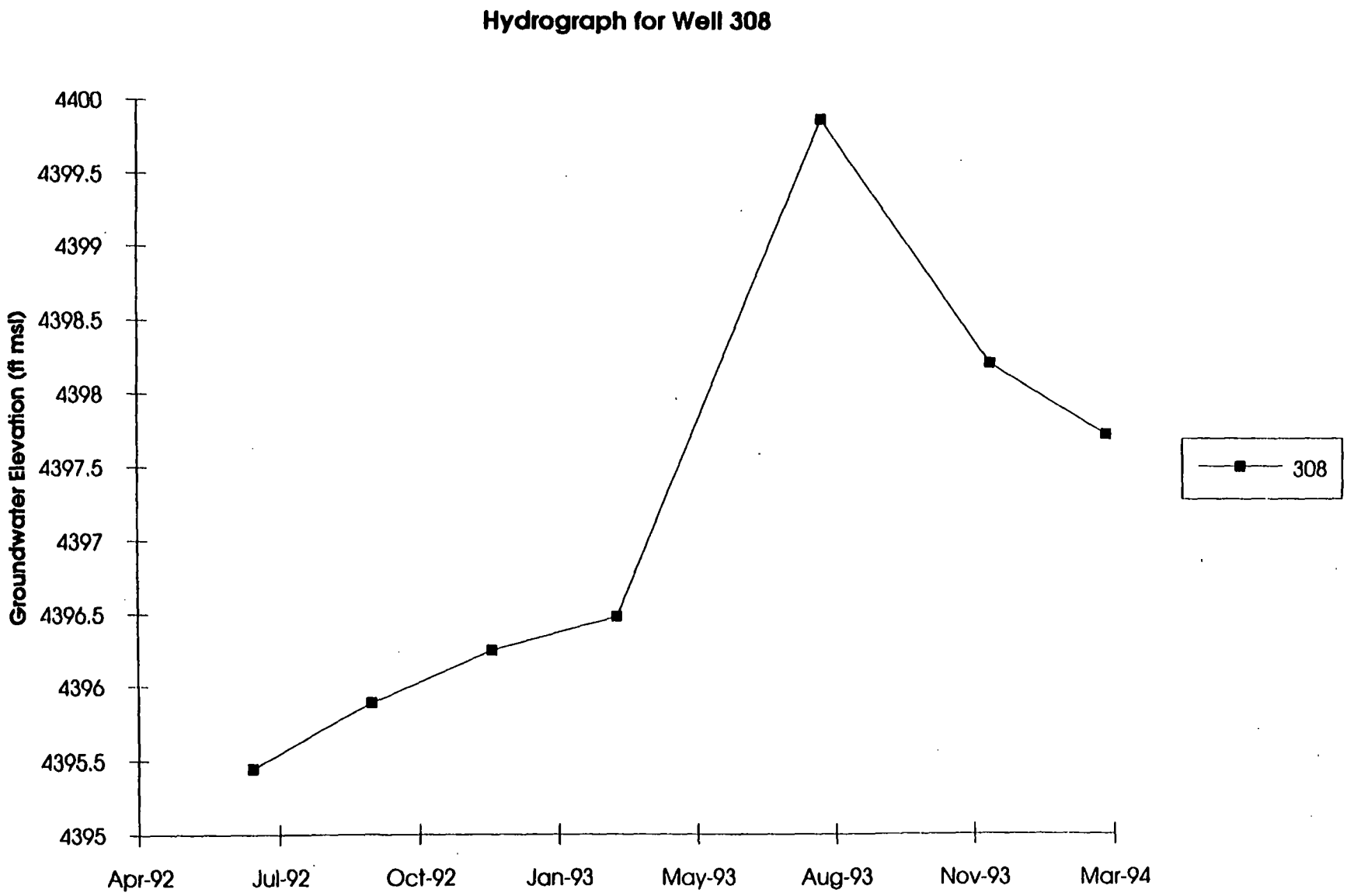

Hydrograph for Well 301
Groundwater Elevation (ft msl)
4621
4620.5
4620
4619.5
4619
4618.5
4618
4617.5
Apr-92
Jul-92
Oct-92
Jan-93
May-93
Aug-93
Nov-93
Mar-94
301

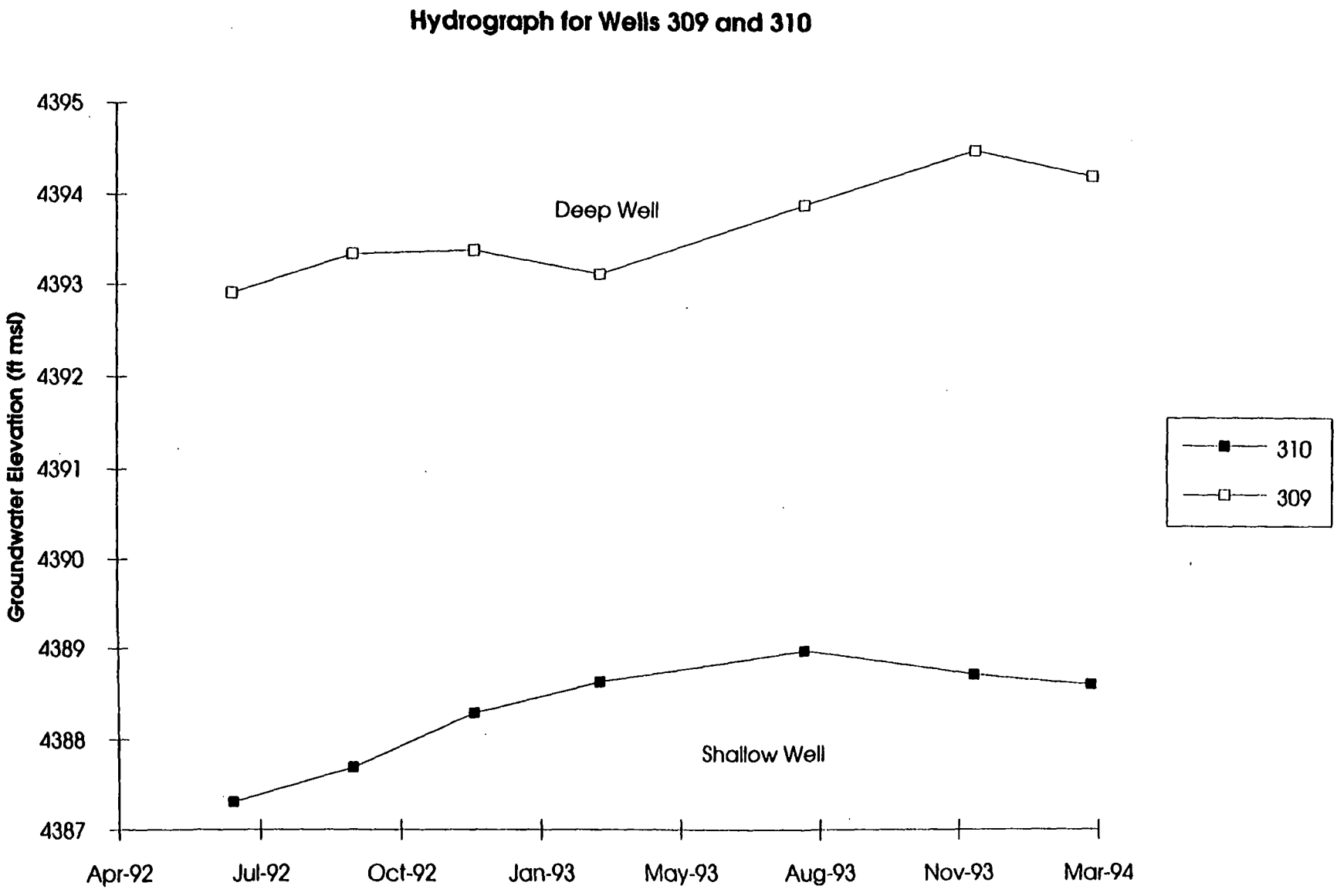

Hydrograph for Well 304
Groundwater Elevation (ft msl)
4560
4559
4558
4557
4556
4555
4554
4553
4552
4551
Apr-92
Jul-92
Oct-92
Jan-93
May-93
Aug-93
Nov-93
Mar-94
304

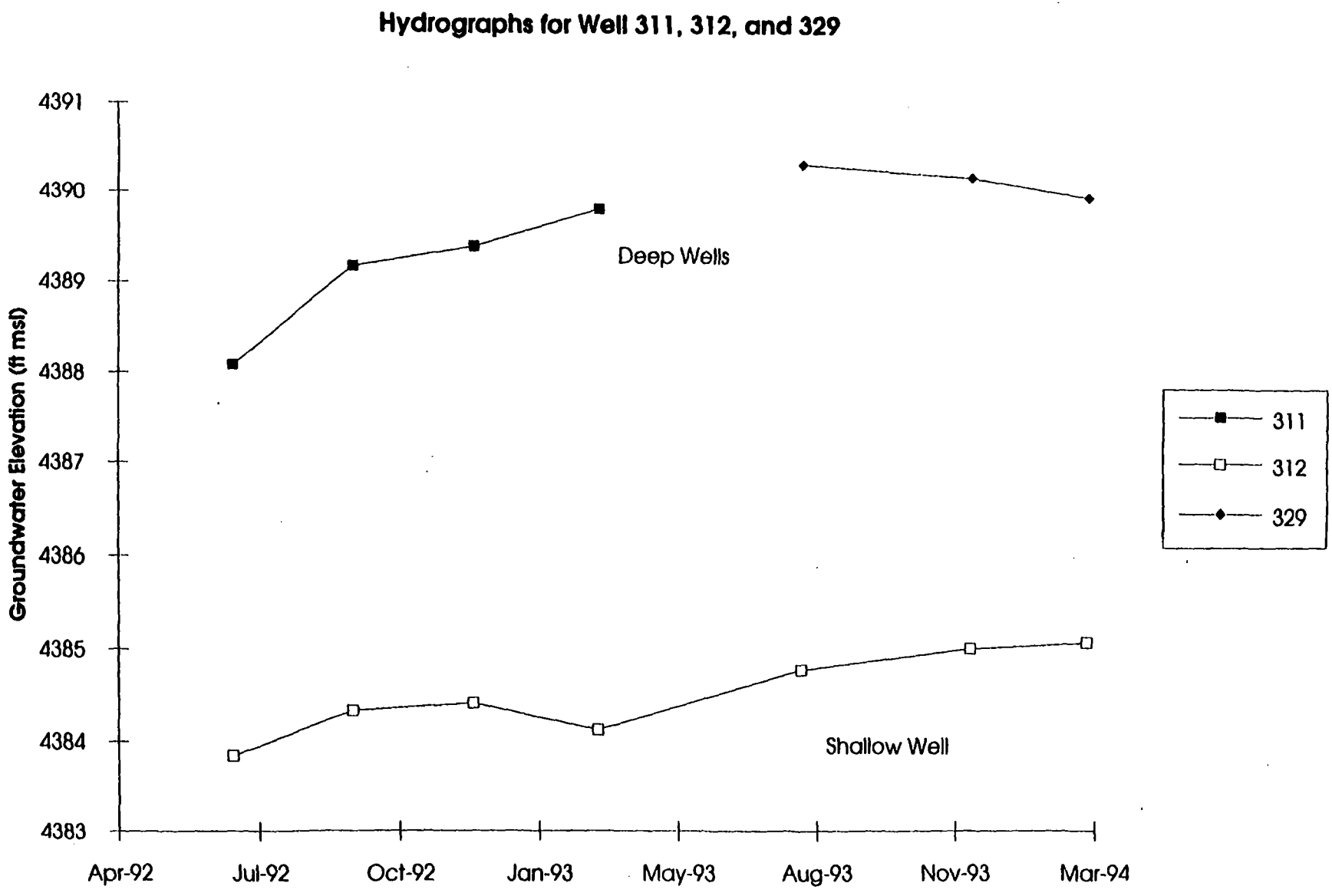

Hydrograph for Well 305
Groundwater Elevation (ft msl)
4397
4396.5
4396
4395.5
4395
4394.5
Apr-92
Jul-92
Oct-92
Jan-93
May-93
Aug-93
Nov-93
Mar-94
305

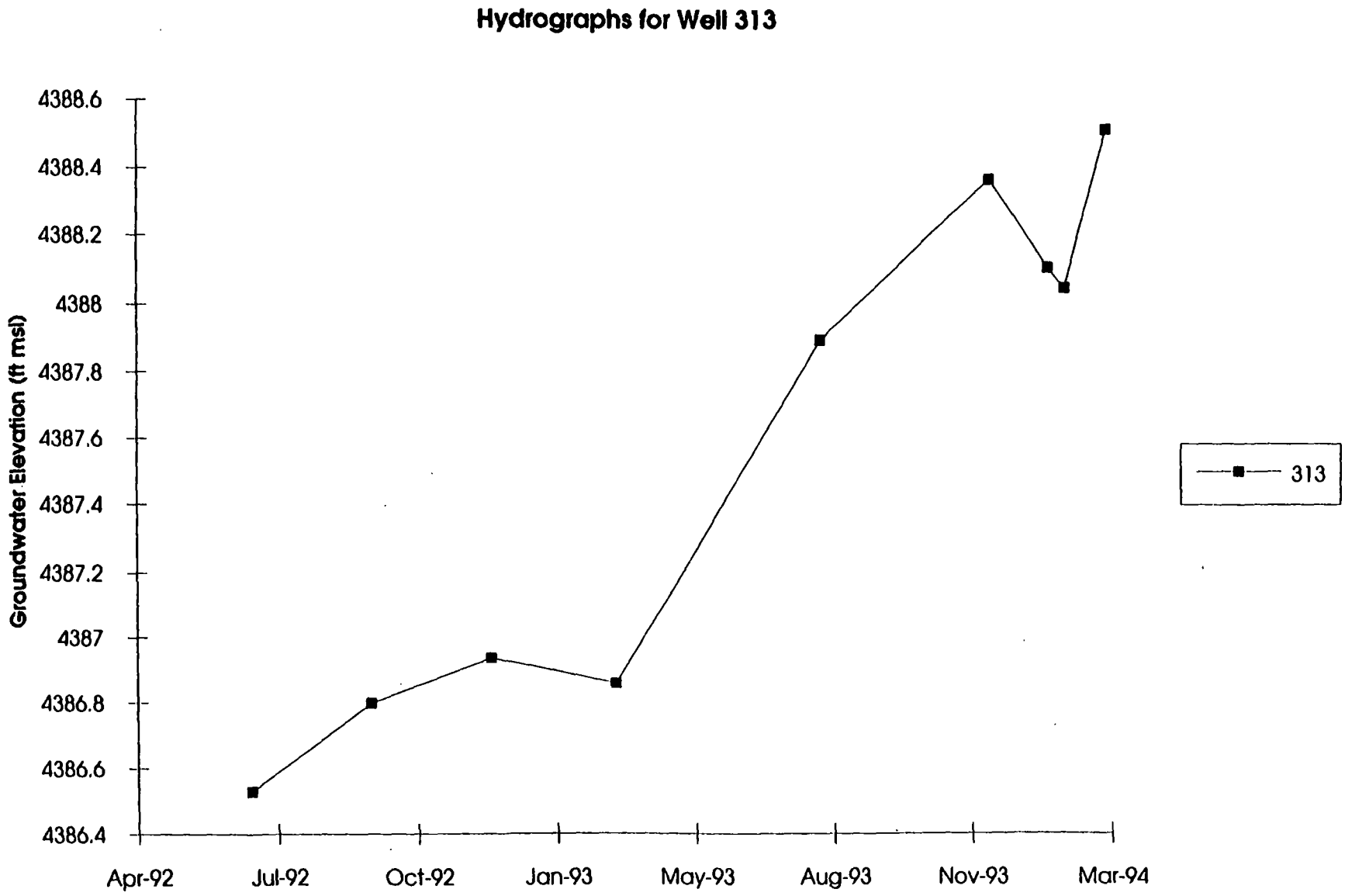

Hydrograph for Well 306
Groundwater Elevation (ft msl)
4424
4423.5
4423
4422.5
4422
4421.5
4421
4420.5
Apr-92
Jul-92
Oct-92
Jan-93
May-93
Aug-93
Nov-93
Mar-94
306


Hydrograph for Well 307
Groundwater Elevation (ft msl)
4403
4402.5
4402
4401.5
4401
4400.5
4400
4399.5
4399
Apr-92
Jul-92
Oct-92
Jan-93
May-93
Aug-93
Nov-93
Mar-94
307

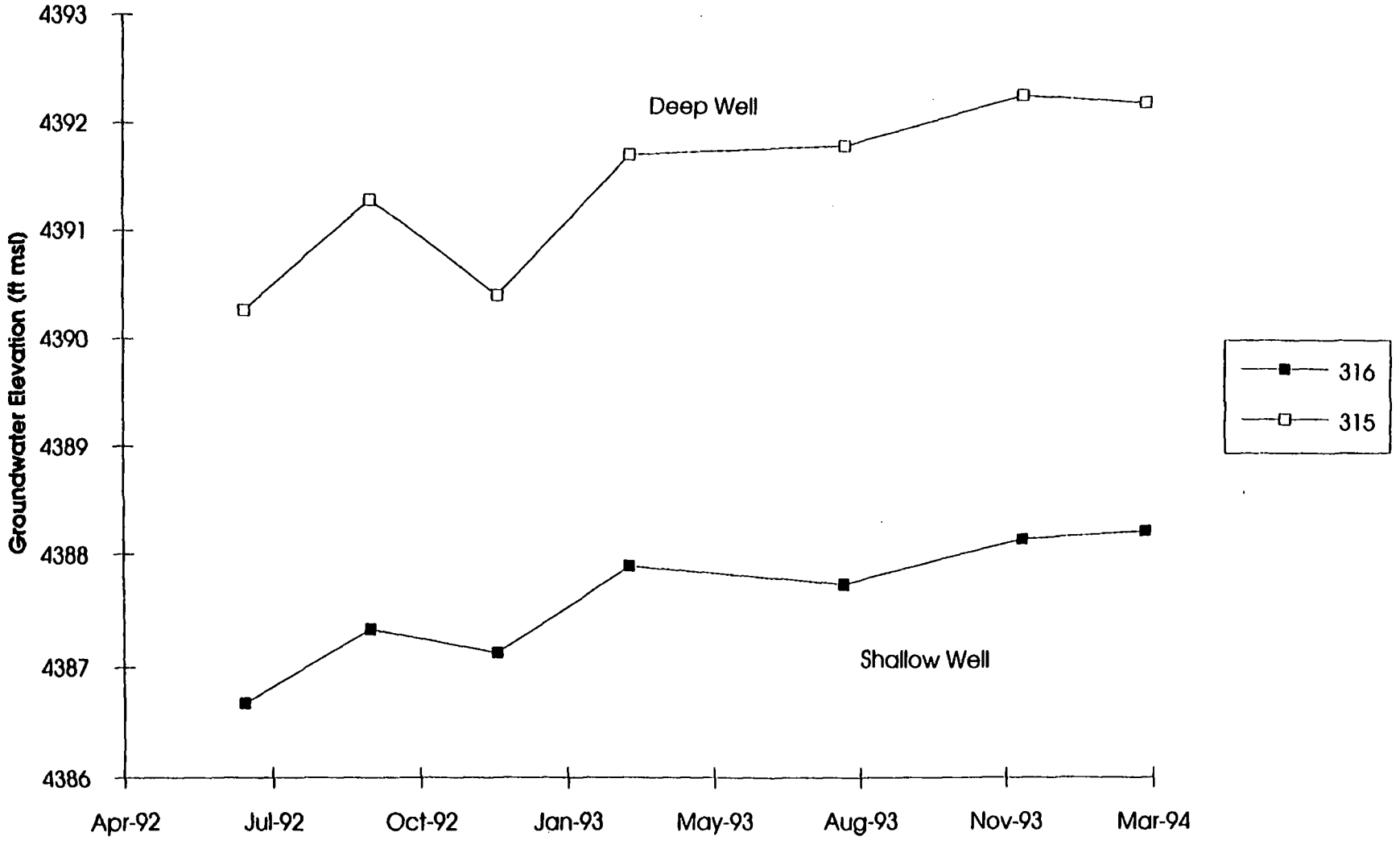

Hydrograph for Well 308
Groundwater Elevation (ft msl)
4400
4399.5
4399
4398.5
4398
4397.5
4397
4396.5
4396
4395.5
4395
Apr-92
Jul-92
Oct-92
Jan-93
May-93
Aug-93
Nov-93
Mar-94
308

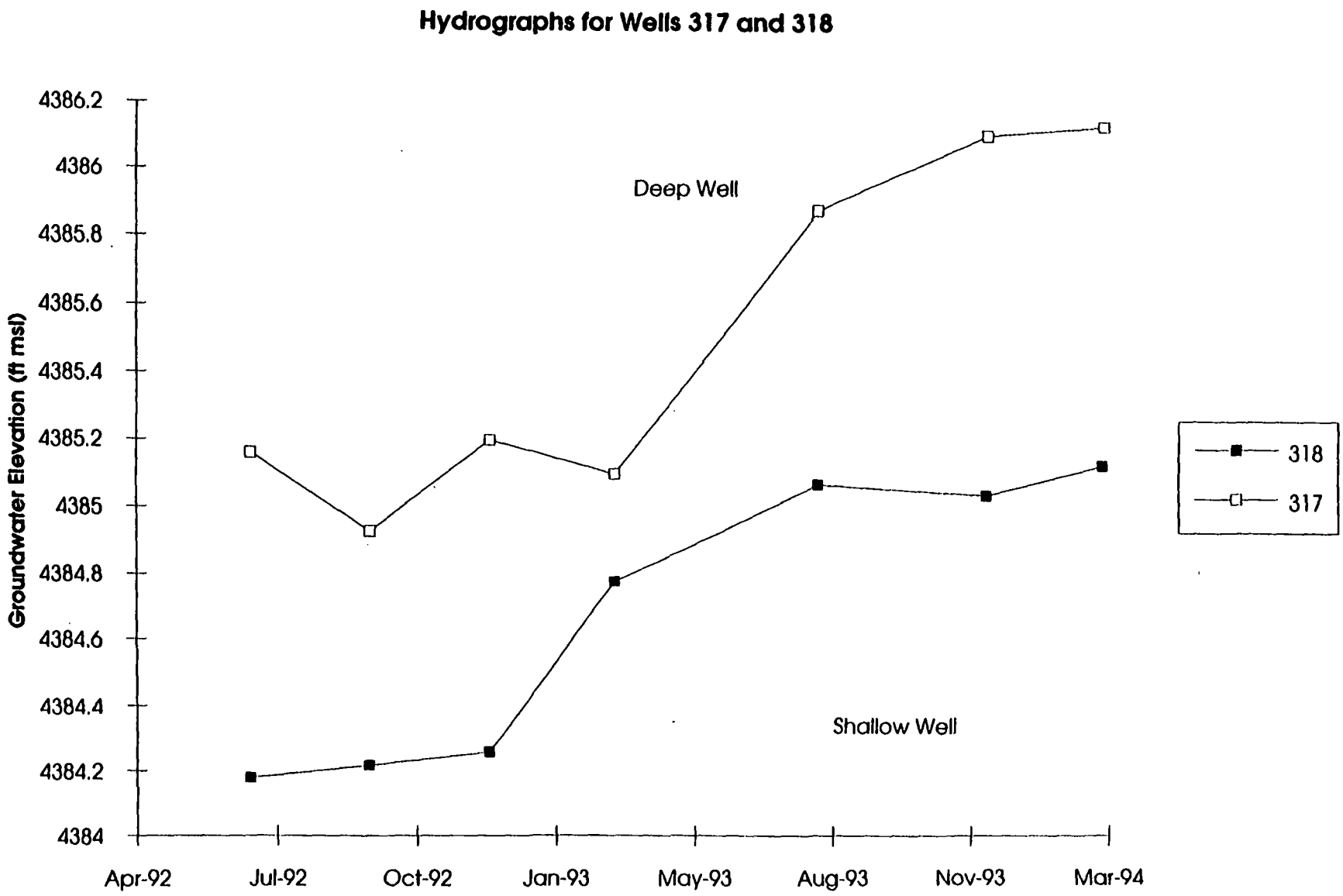

Hydrograph for Wells 309 and 310
Groundwater Elevation (ft msl)
4395
4394
4393
4392
4391
4390
4389
4388
4387
Deep Well
Shallow Well
Apr-92
Jul-92
Oct-92
Jan-93
May-93
Aug-93
Nov-93
Mar-94
310
309

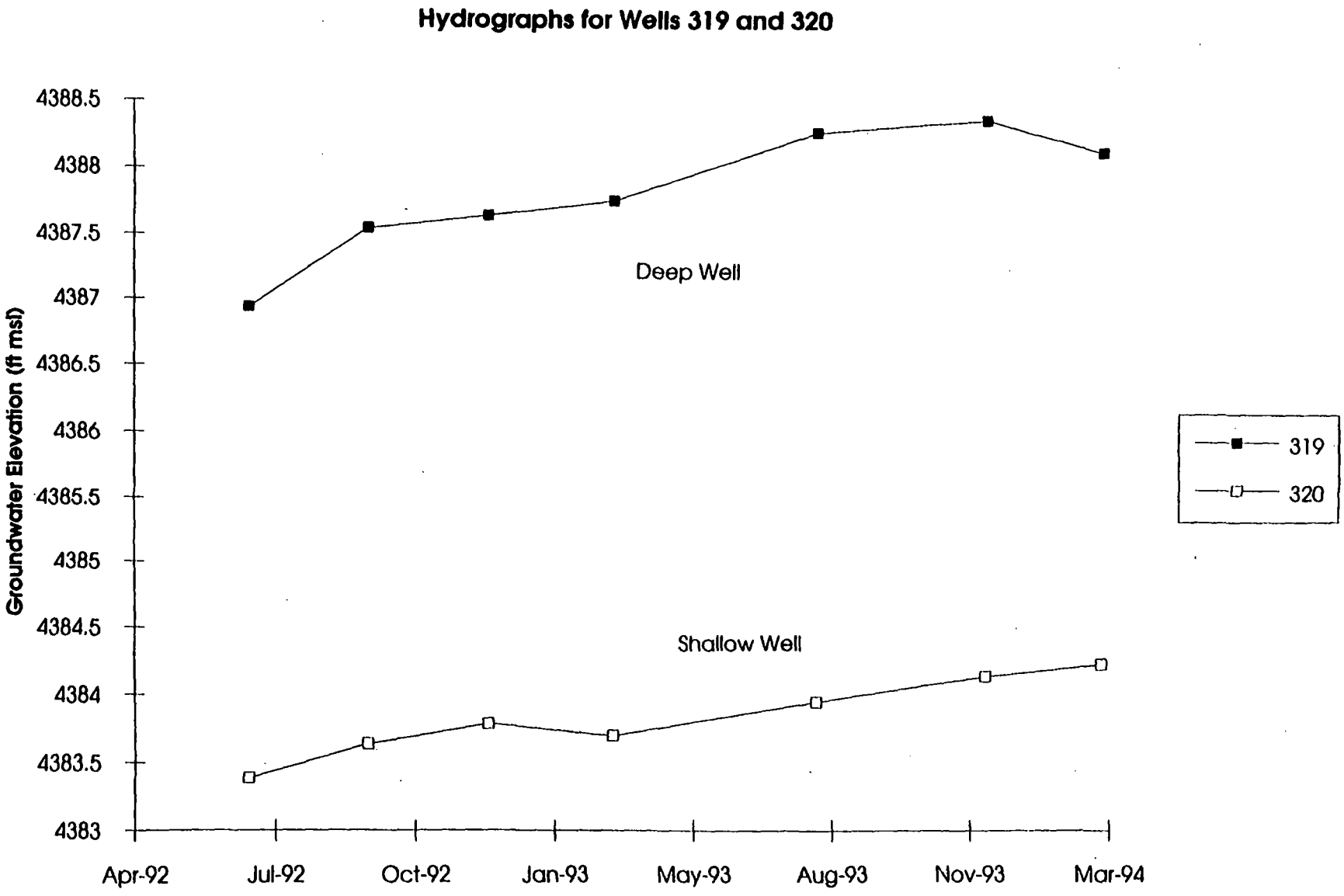

Hydrographs for Well 311, 312, and 329
Groundwater Elevation (ft msl)
4391
4390
4389
4388
4387
4386
4385
4384
4383
Apr-92
Jul-92
Oct-92
Jan-93
May-93
Aug-93
Nov-93
Mar-94
Deep Wells
Shallow Well
311
312
329

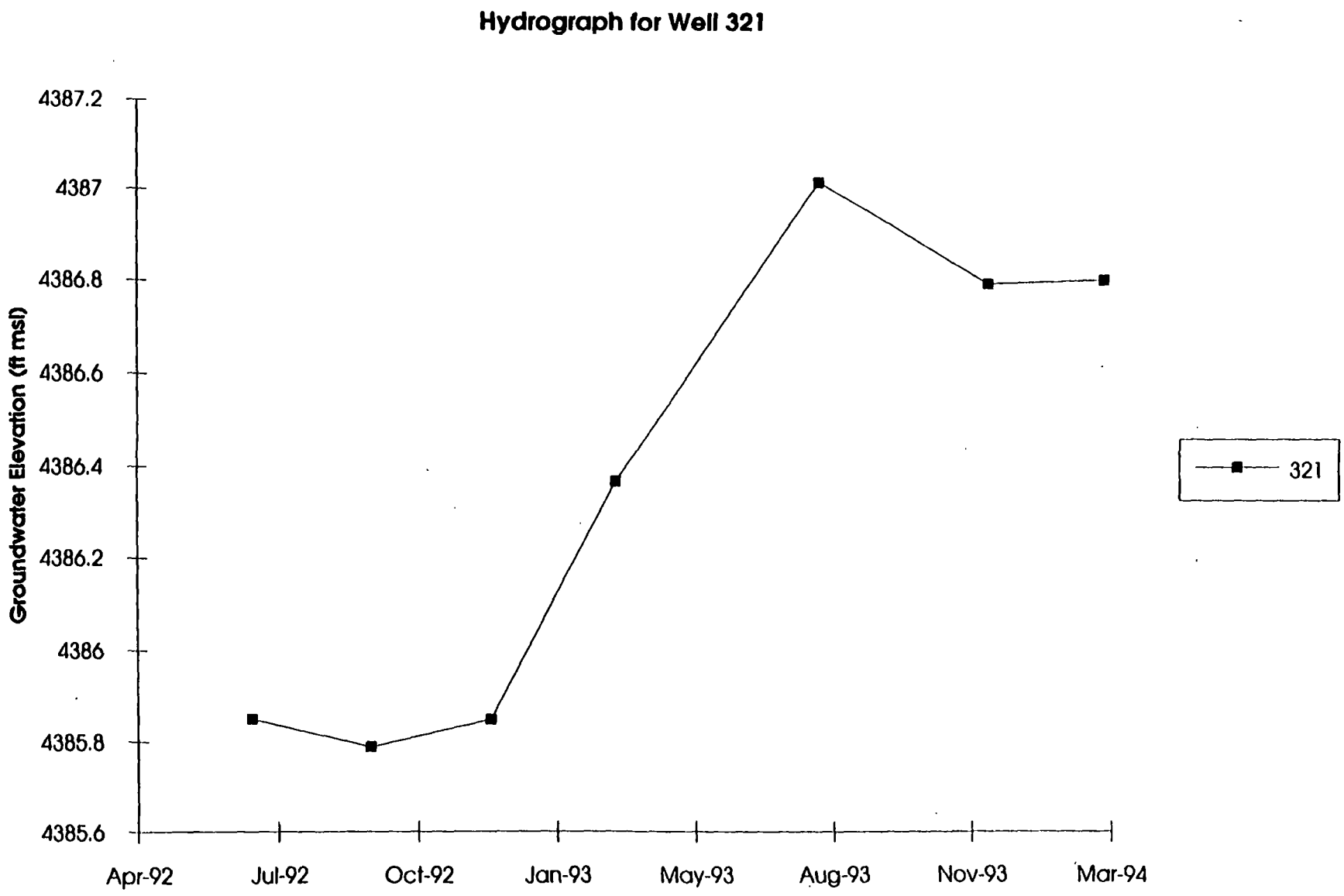

Hydrographs for Well 313
Groundwater Elevation (ft msl)
4388.6
4388.4
4388.2
4388
4387.8
4387.6
4387.4
4387.2
4387
4386.8
4386.6
4386.4
Apr-92
Jul-92
Oct-92
Jan-93
May-93
Aug-93
Nov-93
Mar-94
313

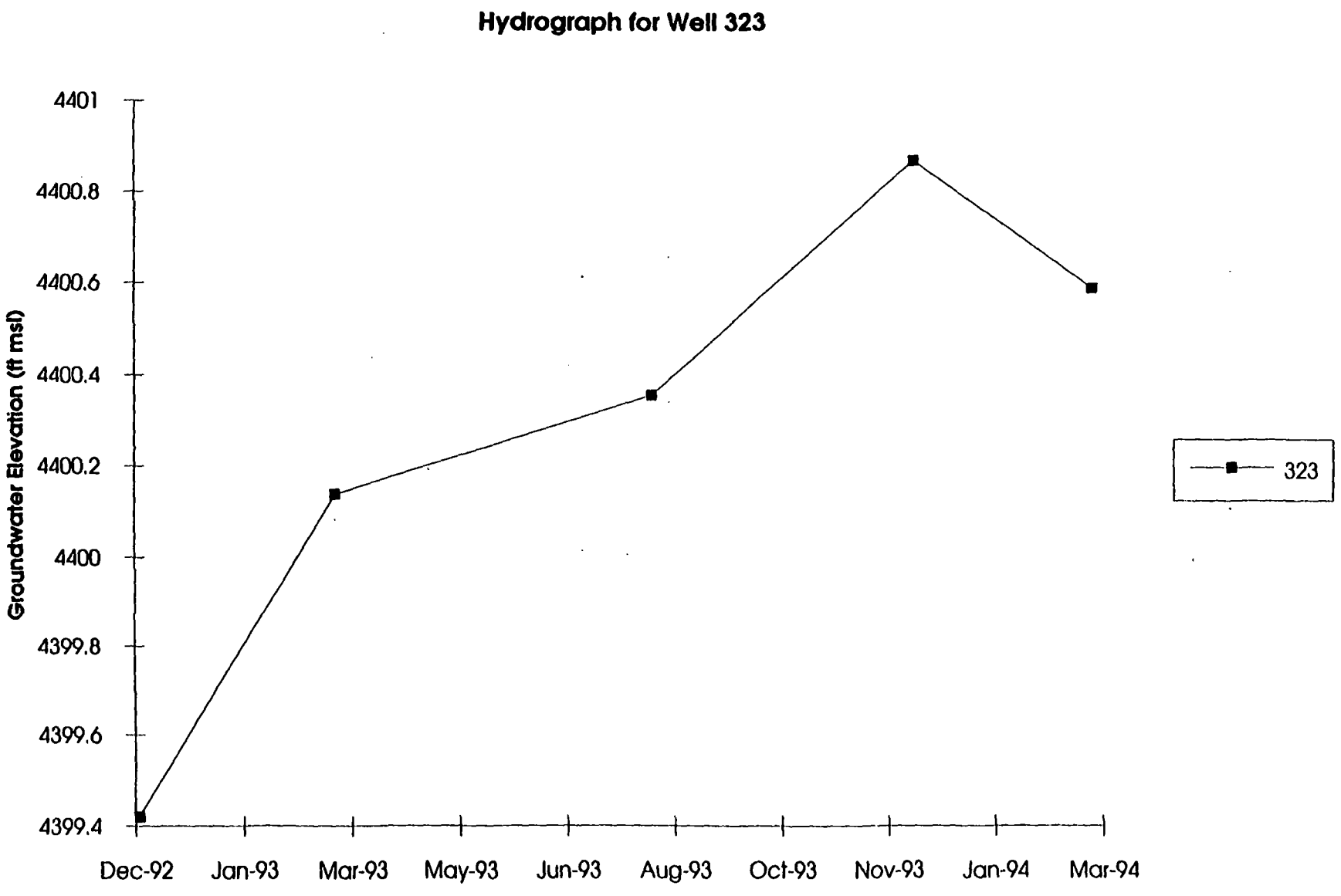
Hydrographs for Wells 315 and 316

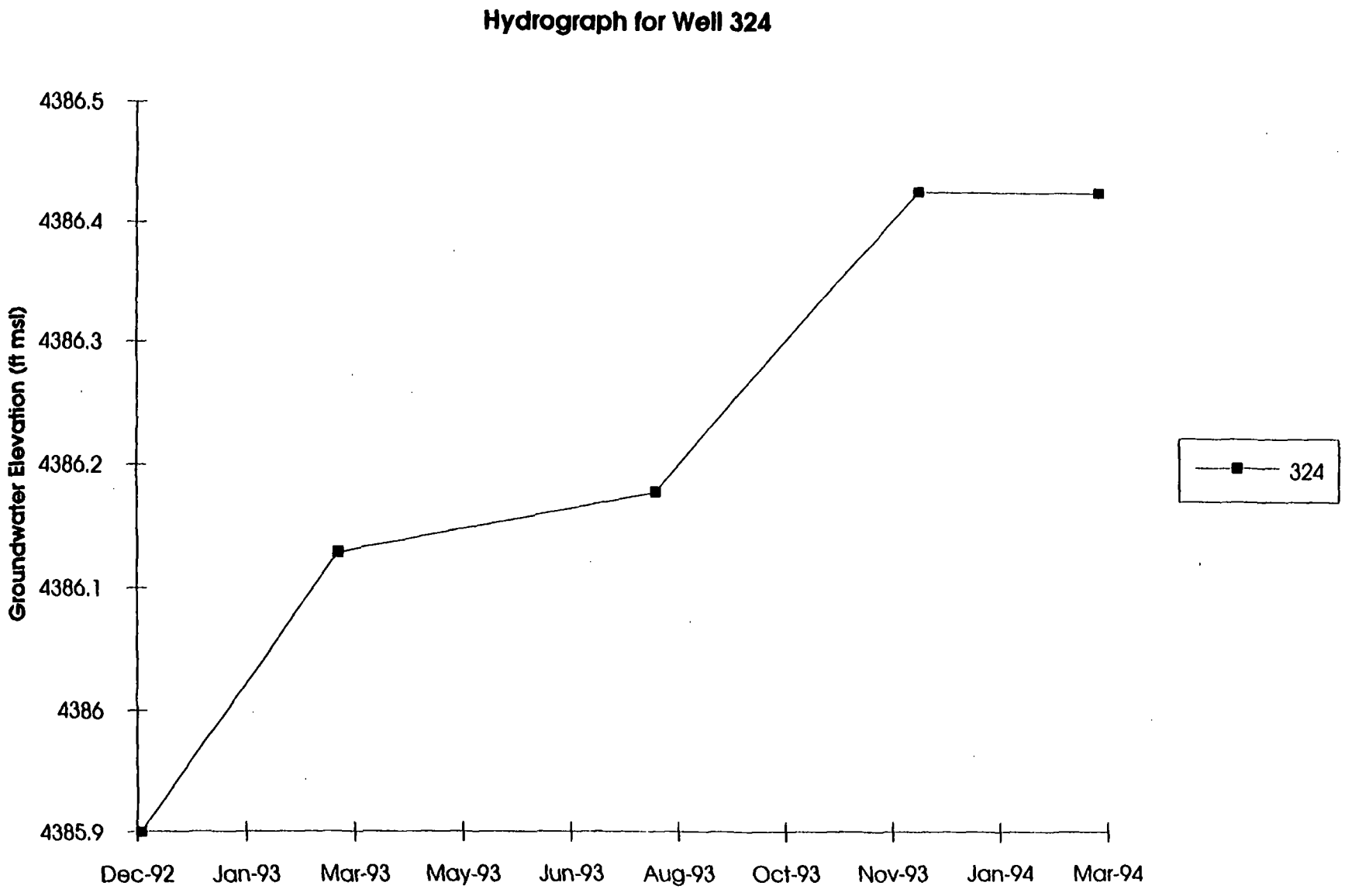


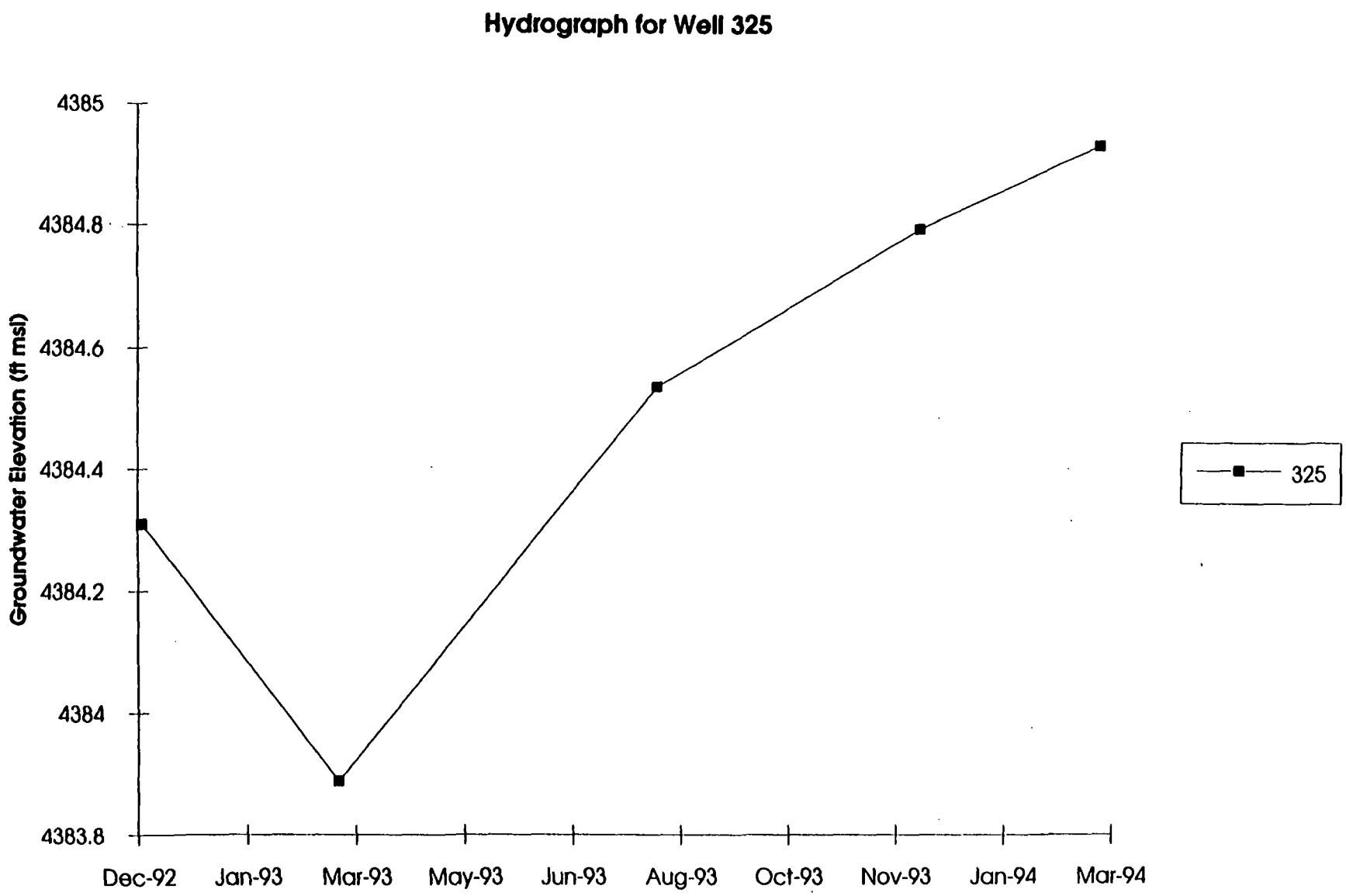

Hydrographs for Wells 317 and 318
Groundwater Elevation (ft msl)
4386.2
4386
4385.8
4385.6
4385.4
4385.2
4385
4384.8
4384.6
4384.4
4384.2
4384
Apr-92
Jul-92
Oct-92
Jan-93
May-93
Aug-93
Nov-93
Mar-94
Deep Well
Shallow Well
318
317

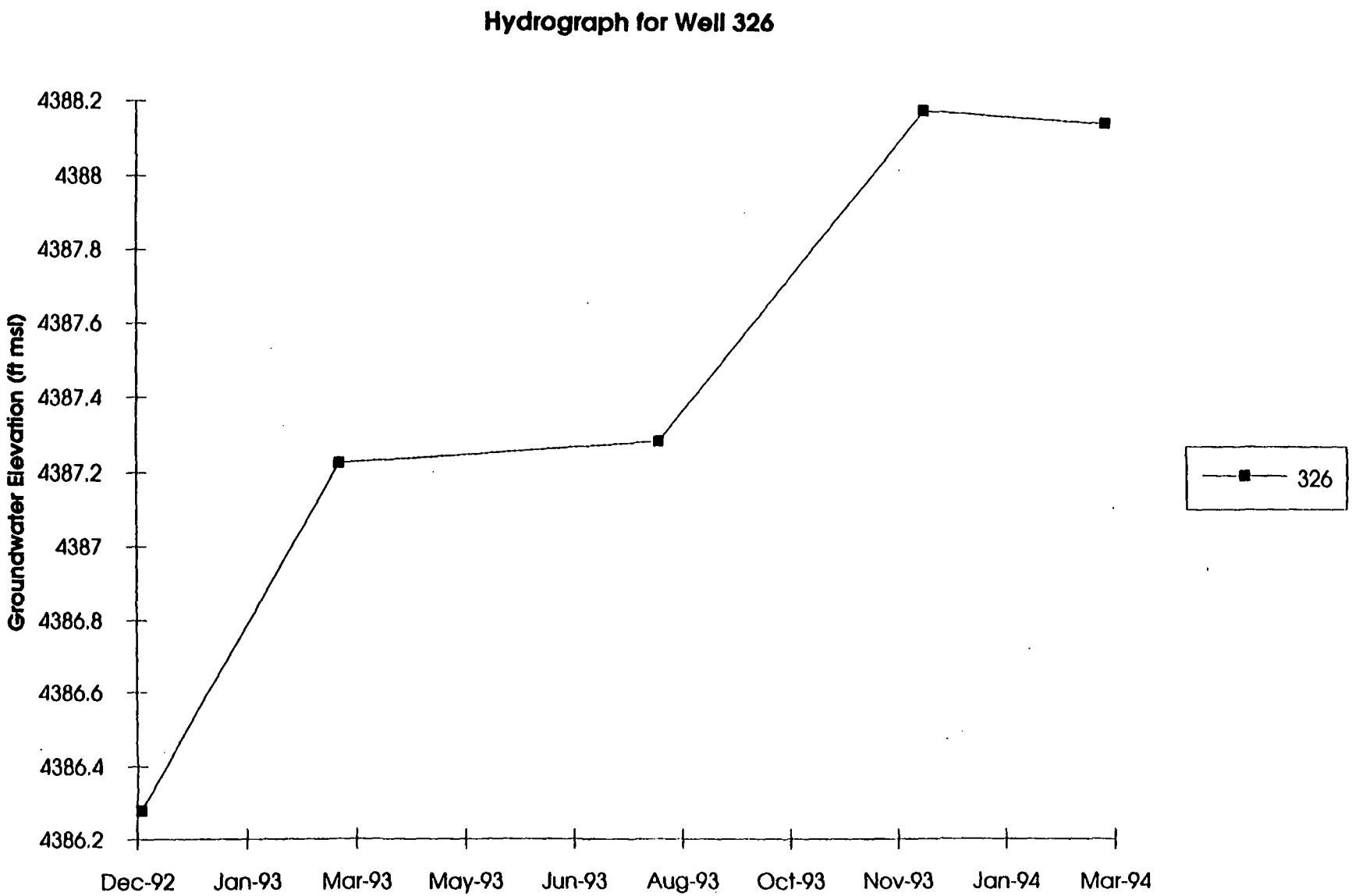

Hydrographs for Wells 319 and 320
Groundwater Elevation (ft msl)
4388.5
4388
4387.5
4387
4386.5
4386
4385.5
4385
4384.5
4384
4383.5
4383
Apr-92
Jul-92
Oct-92
Jan-93
May-93
Aug-93
Nov-93
Mar-94
Deep Well
Shallow Well
319
320

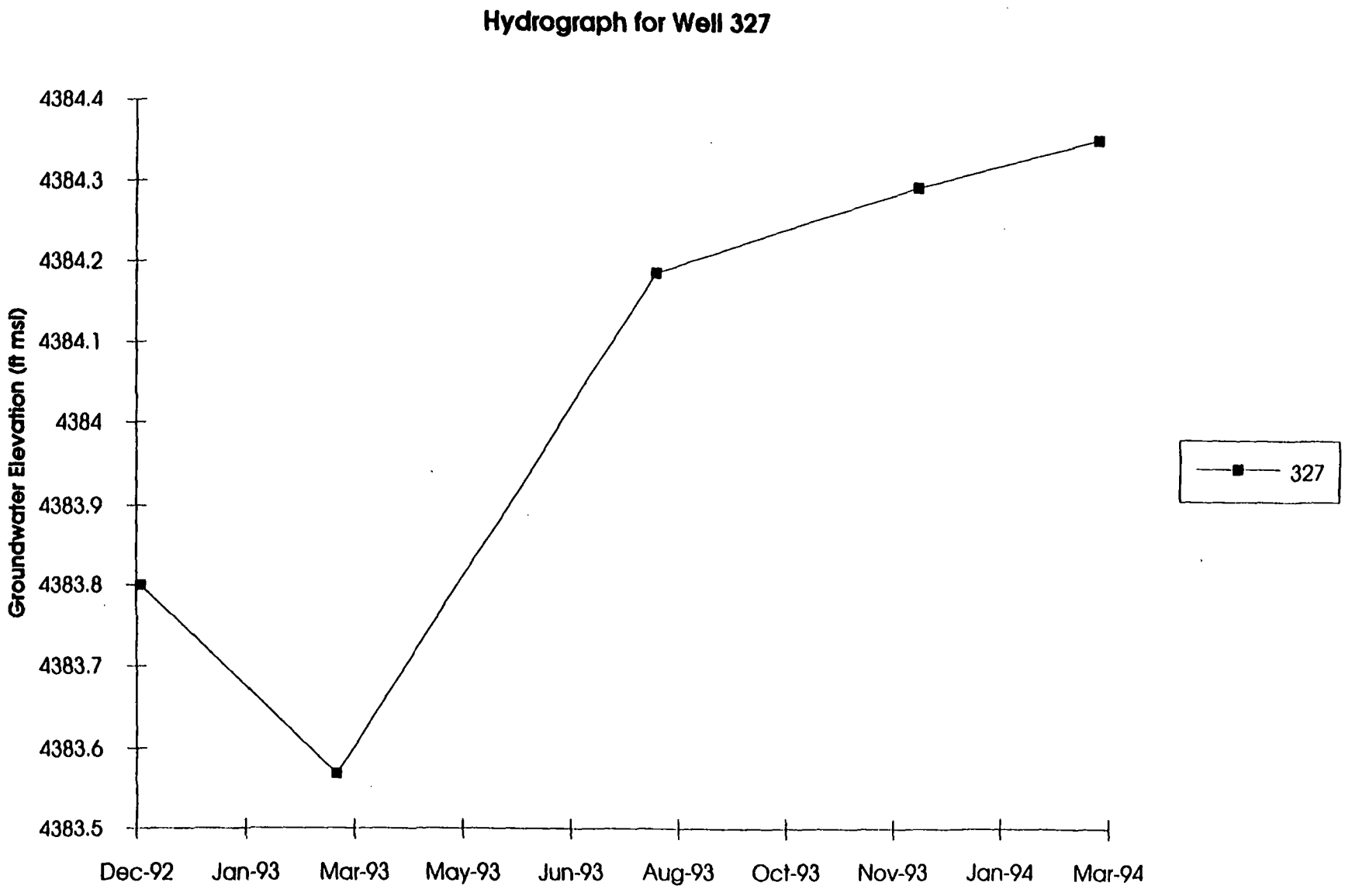

Hydrograph for Well 321
Groundwater Elevation (ft msl)
4387.2
4387
4386.8
4386.6
4386.4
4386.2
4386
4385.8
4385.6
Apr-92
Jul-92
Oct-92
Jan-93
May-93
Aug-93
Nov-93
Mar-94
321

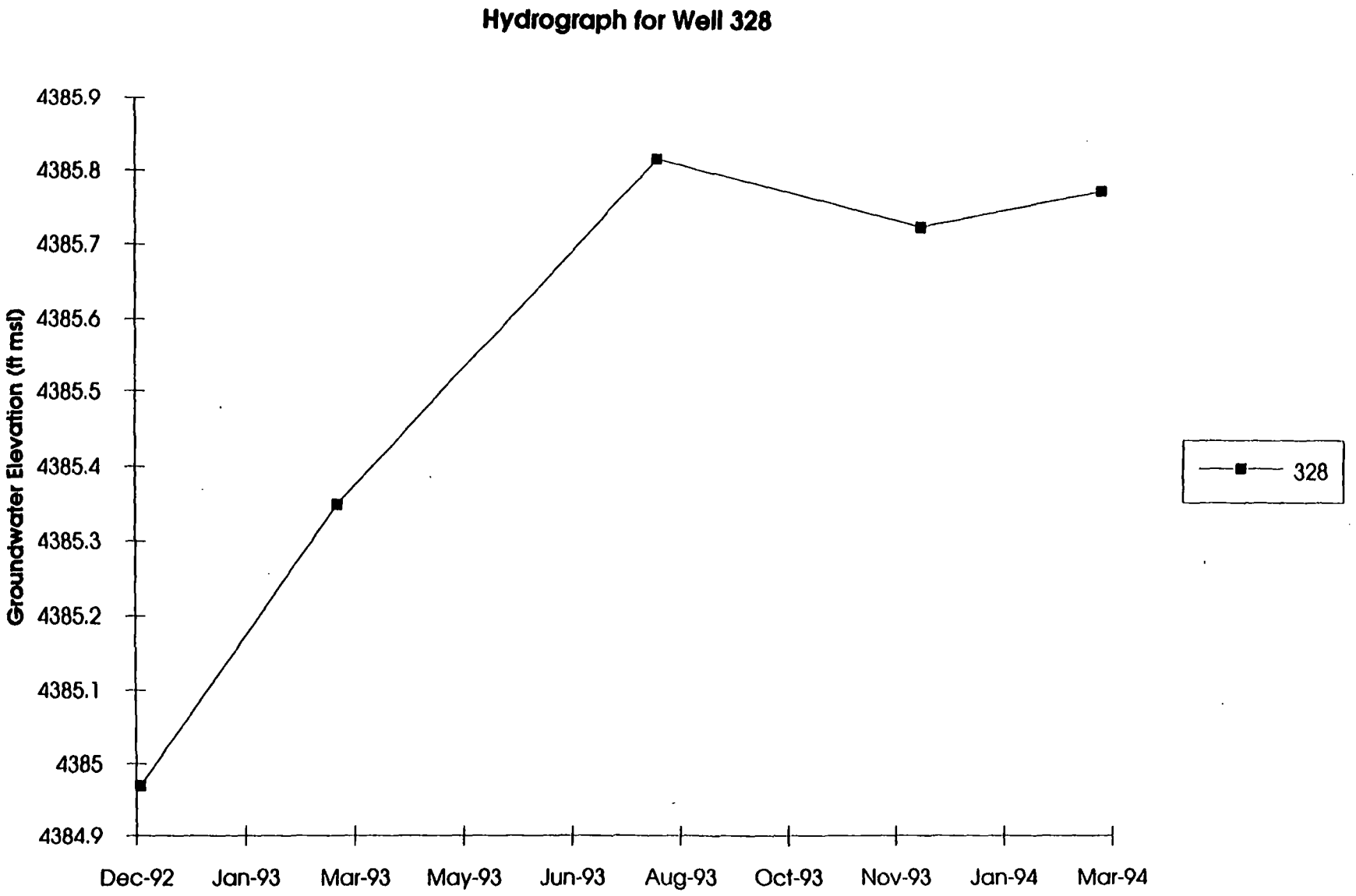

Hydrograph for Well 323
Groundwater Elevation (ft msl)
4401
4400.8
4400.6
4400.4
4400.2
4400
4399.8
4399.6
4399.4
Dec-92
Jan-93
Mar-93
May-93
Jun-93
Aug-93
Oct-93
Nov-93
Jan-94
Mar-94
323

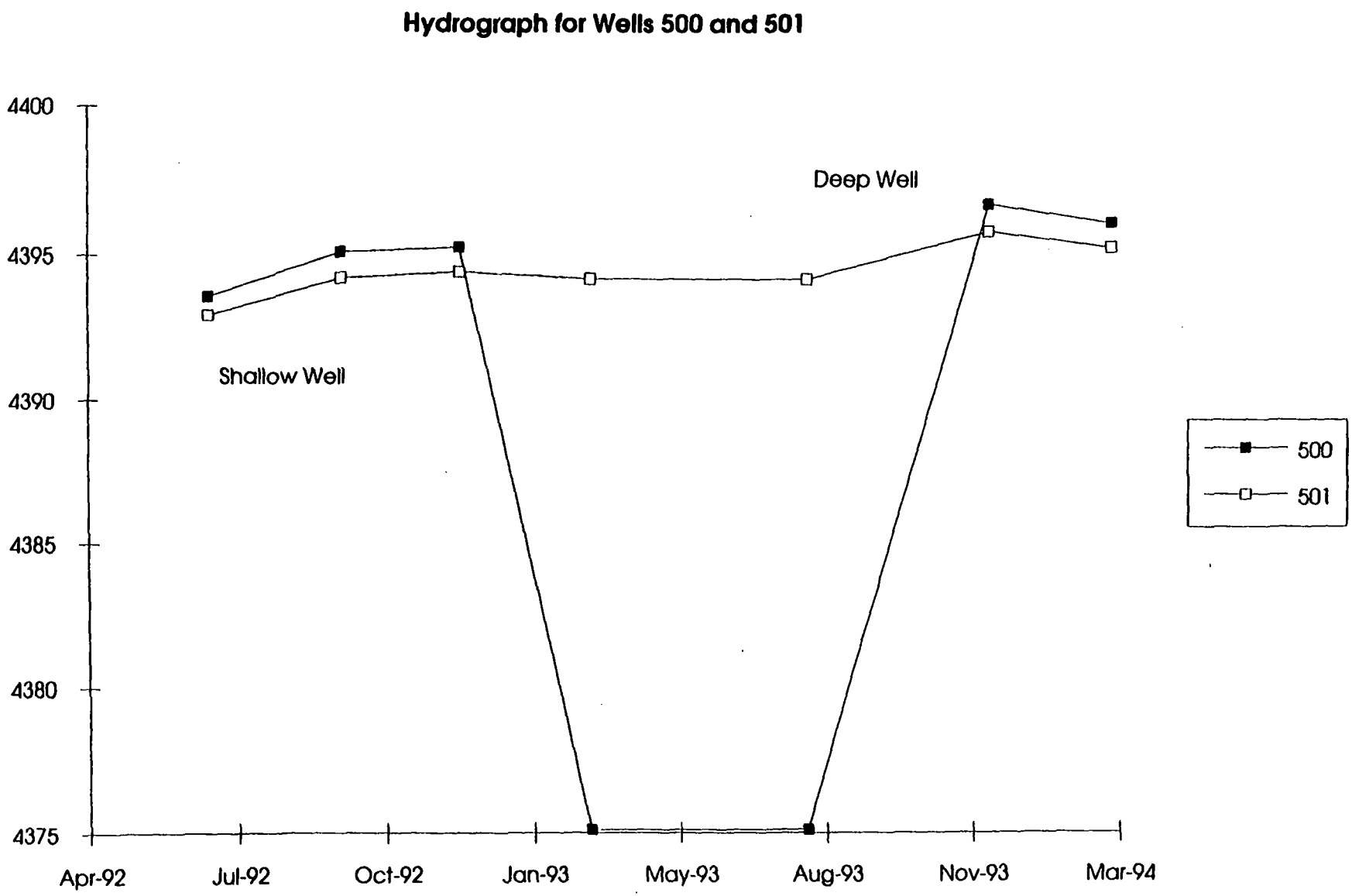

Hydrograph for Well 324
Groundwater Elevation (ft msl)
4386.5
4386.4
4386.3
4386.2
4386.1
4386
4385.9
Dec-92
Jan-93
Mar-93
May-93
Jun-93
Aug-93
Oct-93
Nov-93
Jan-94
Mar-94
324

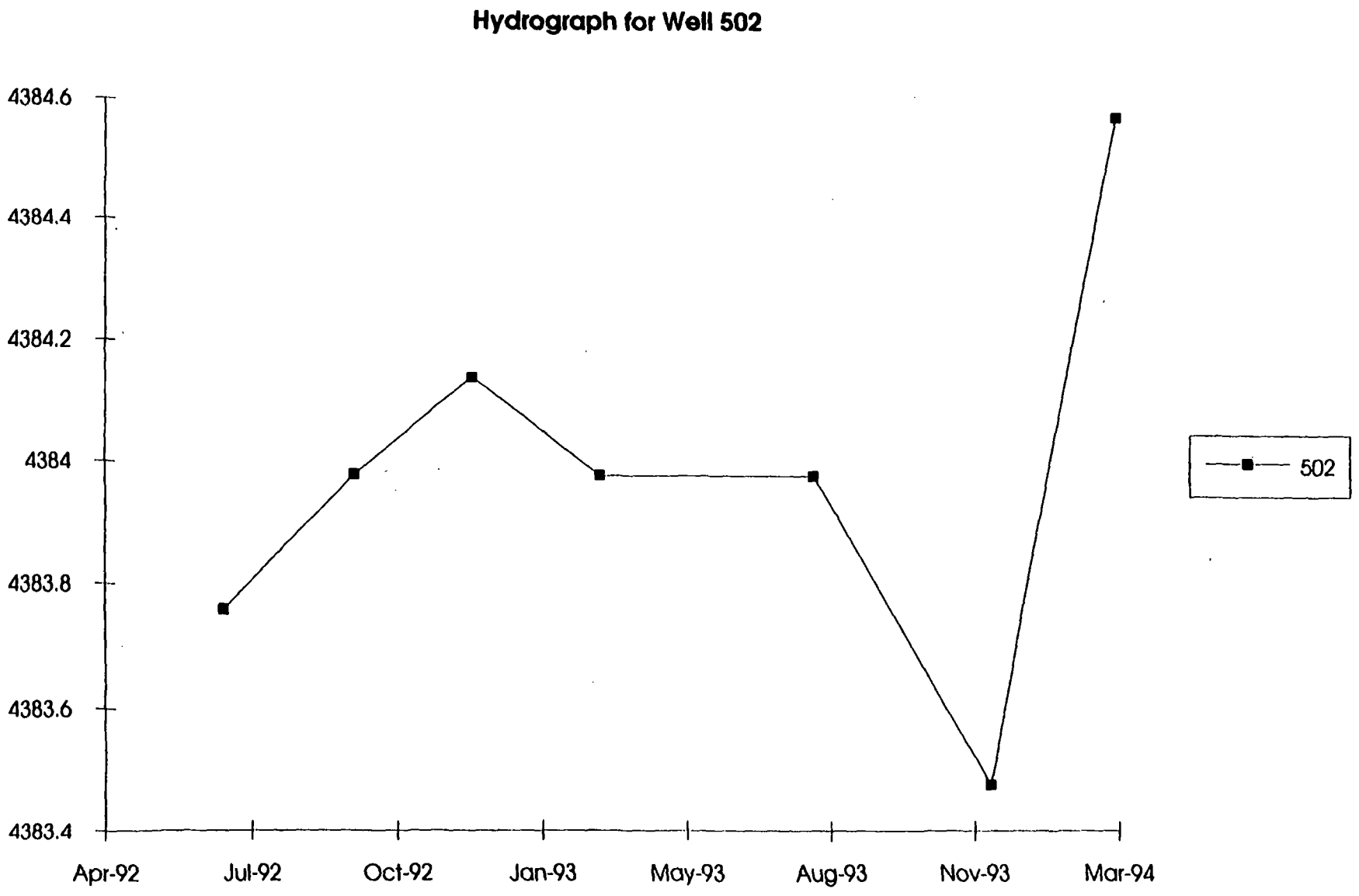

Hydrograph for Well 325
Groundwater Elevation (ft msl)
4385
4384.8
4384.6
4384.4
4384.2
4384
4383.8
Dec-92
Jan-93
Mar-93
May-93
Jun-93
Aug-93
Oct-93
Nov-93
Jan-94
Mar-94
325

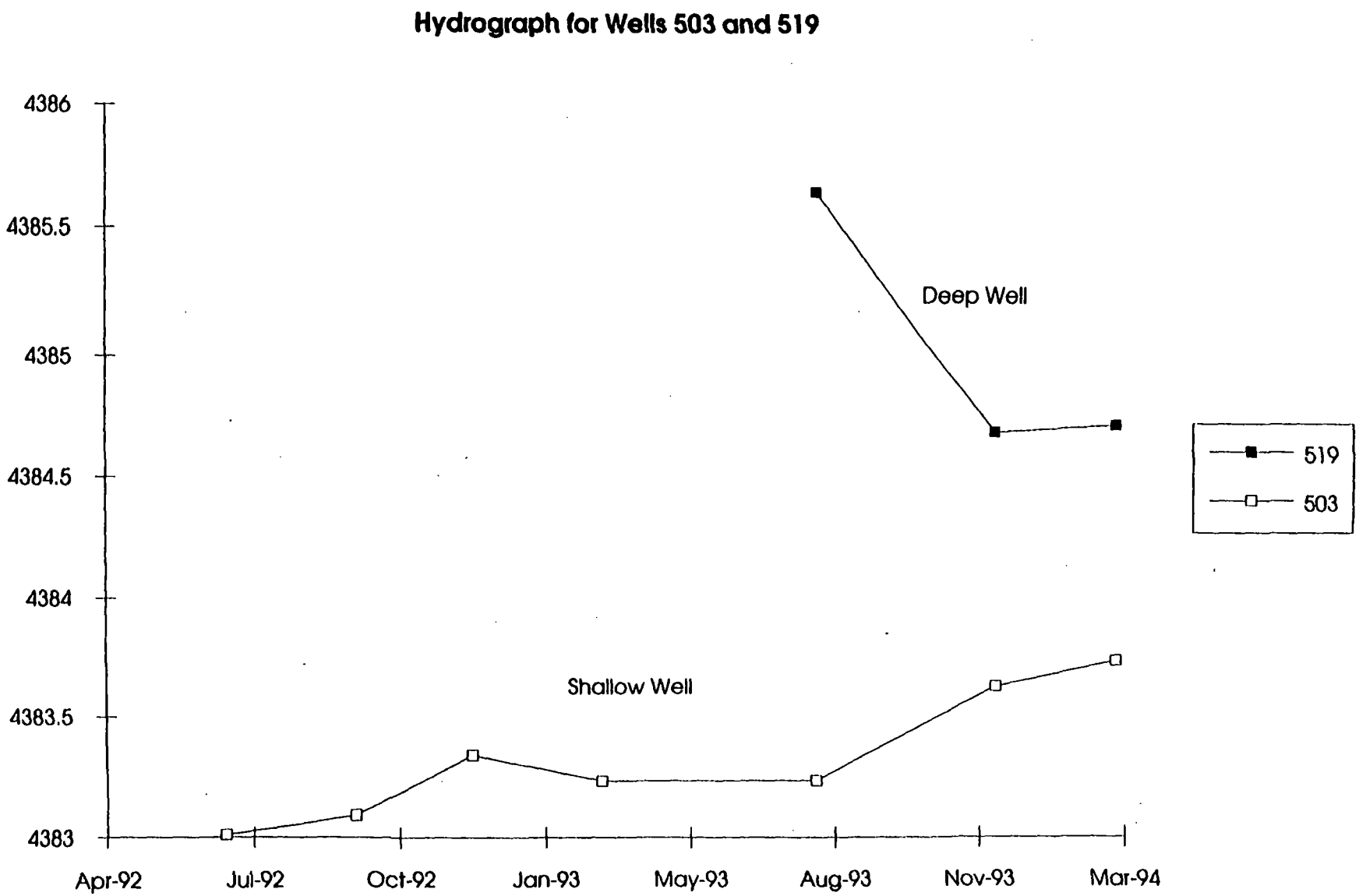

Hydrograph for Well 326
Groundwater Elevation (ft msl)
4388.2
4388
4387.8
4387.6
4387.4
4387.2
4387
4386.8
4386.6
4386.4
4386.2
Dec-92
Jan-93
Mar-93
May-93
Jun-93
Aug-93
Oct-93
Nov-93
Jan-94
Mar-94
326

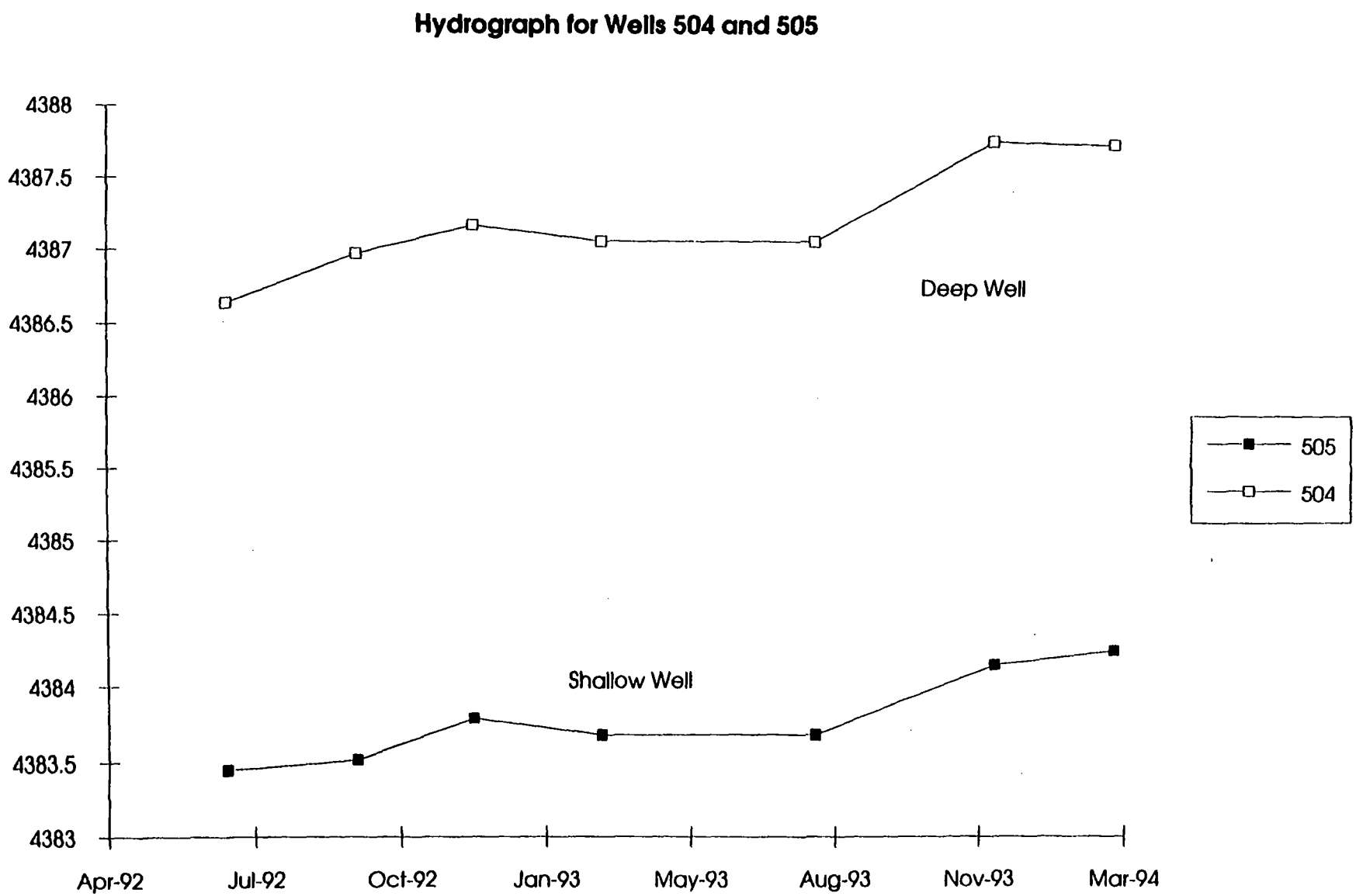

Hydrograph for Well 327
Groundwater Elevation (ft msl)
4384.4
4384.3
4384.2
4384.1
4384
4383.9
4383.8
4383.7
4383.6
4383.5
Dec-92
Jan-93
Mar-93
May-93
Jun-93
Aug-93
Oct-93
Nov-93
Jan-94
Mar-94
327


Hydrograph for Well 328
Groundwater Elevation (ft msl)
4385.9
4385.8
4385.7
4385.6
4385.5
4385.4
4385.3
4385.2
4385.1
4385
4384.9
Dec-92
Jan-93
Mar-93
May-93
Jun-93
Aug-93
Oct-93
Nov-93
Jan-94
Mar-94
328

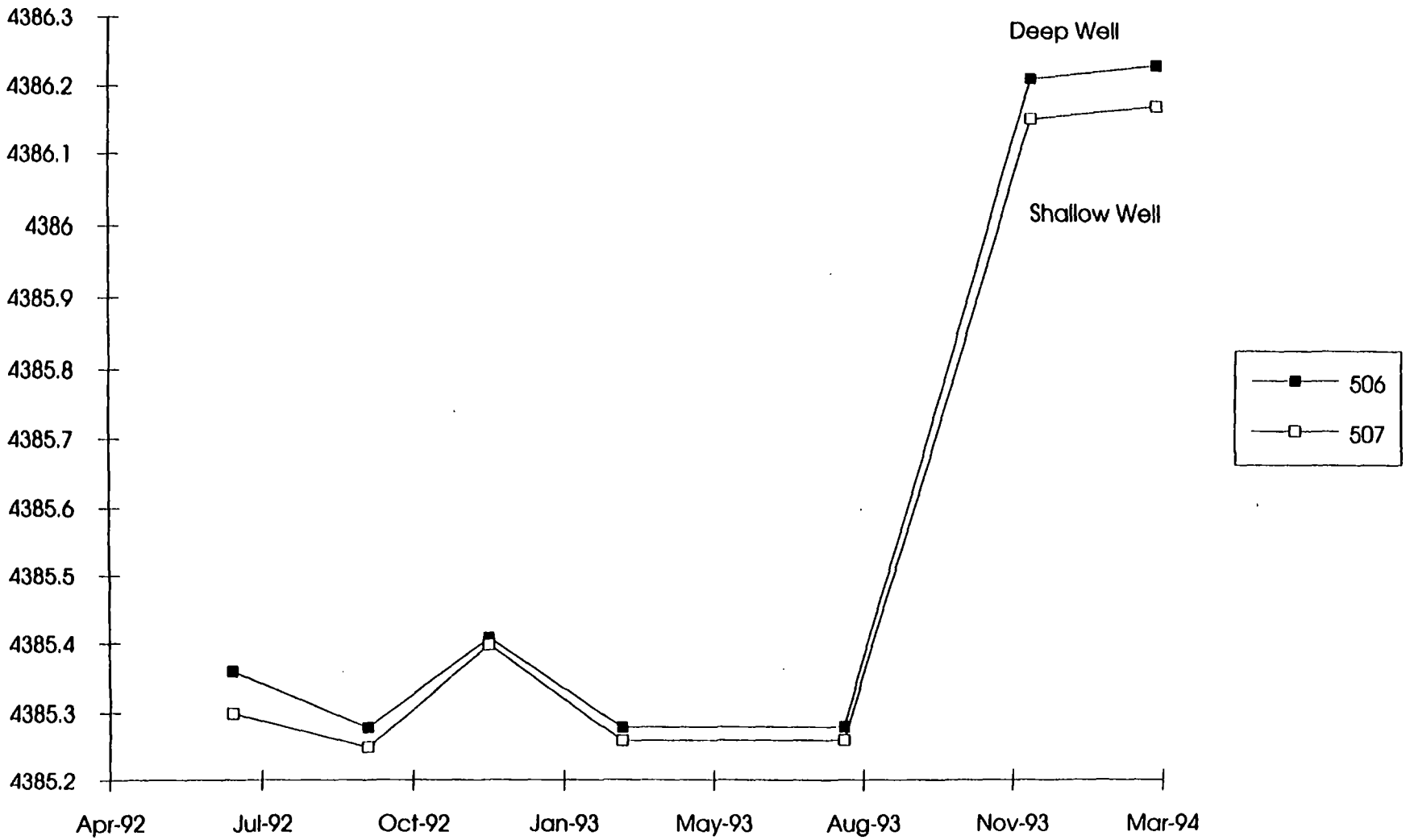

Hydrograph for Wells 500 and 501
4400
4395
4390
4385
4380
4375
Apr-92
Jul-92
Oct-92
Jan-93
May-93
Aug-93
Nov-93
Mar-94
Deep Well
Shallow Well
500
501


Hydrograph for Well 502
4384.6
4384.4
4384.2
4384
4383.8
4383.6
4383.4
Apr-92
Jul-92
Oct-92
Jan-93
May-93
Aug-93
Nov-93
Mar-94
502

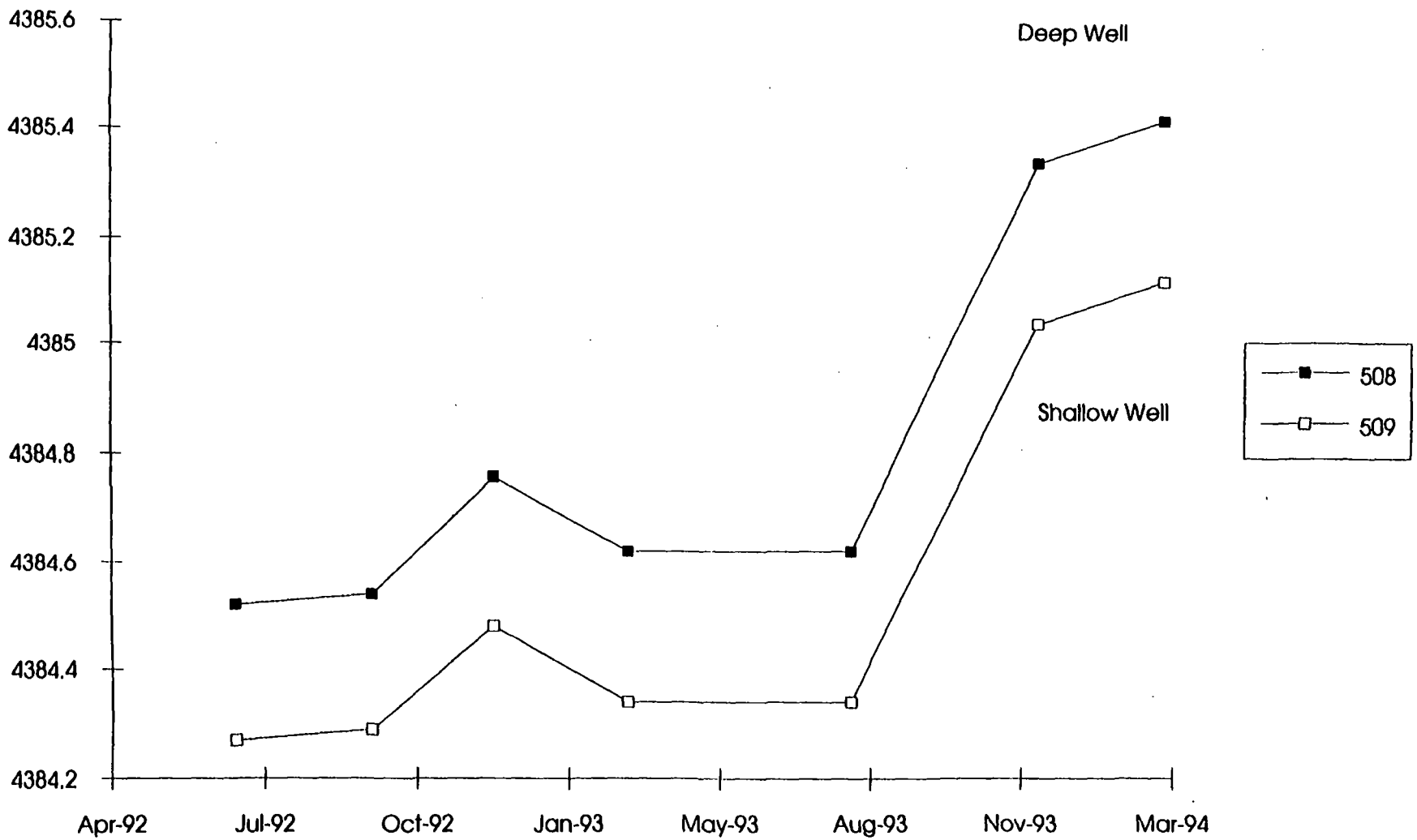

Hydrograph for Wells 503 and 519
4386
4385.5
4385
4384.5
4384
4383.5
4383
Apr-92
Jul-92
Oct-92
Jan-93
May-93
Aug-93
Nov-93
Mar-94
Deep Well
Shallow Well
519
503

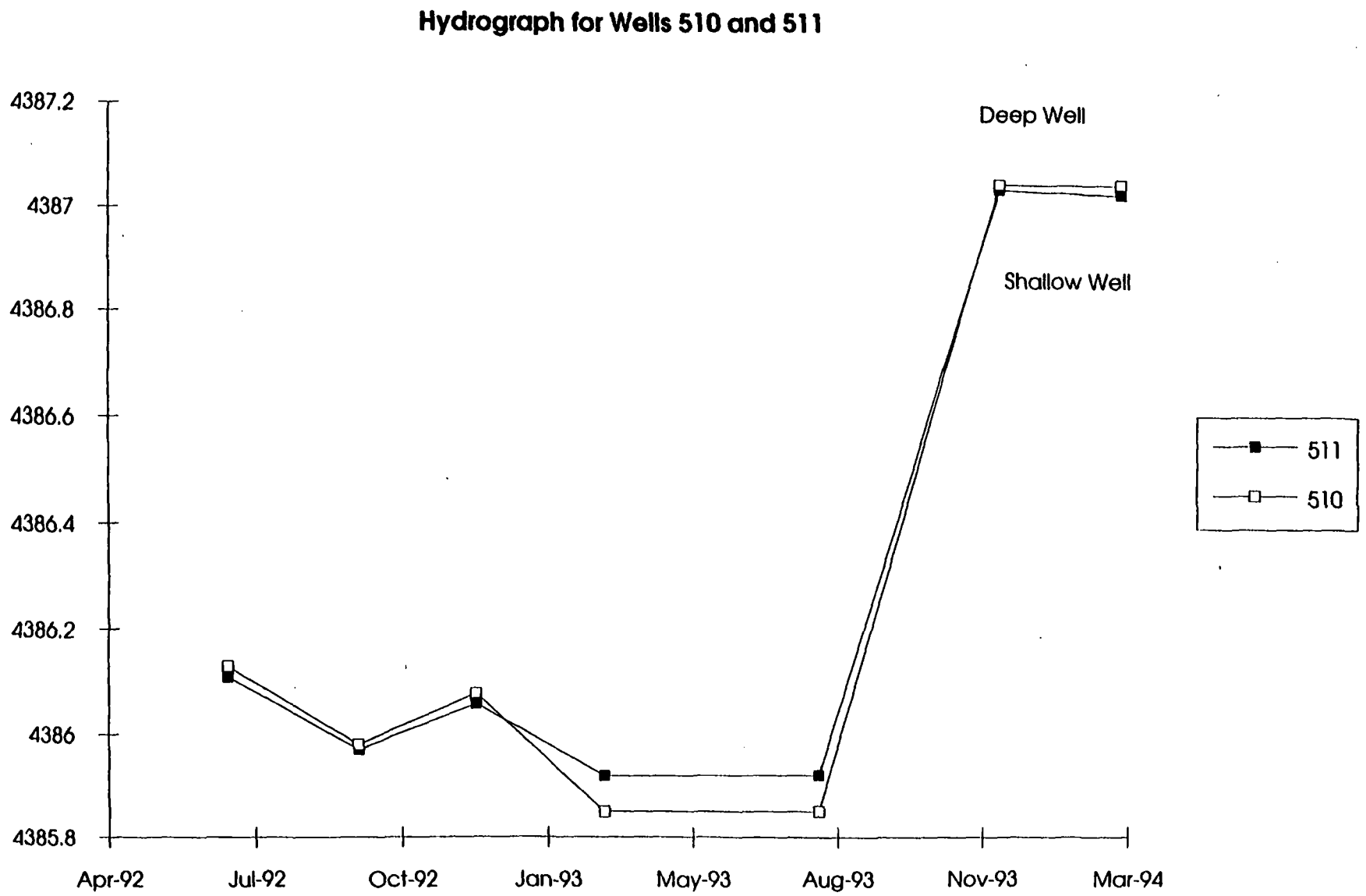

Hydrograph for Wells 504 and 505
4388
4387.5
4387
4386.5
4386
4385.5
4385
4384.5
4384
4383.5
4383
Apr-92
Jul-92
Oct-92
Jan-93
May-93
Aug-93
Nov-93
Mar-94
Deep Well
Shallow Well
505
504

Hydrograph for Wells 506 and 507

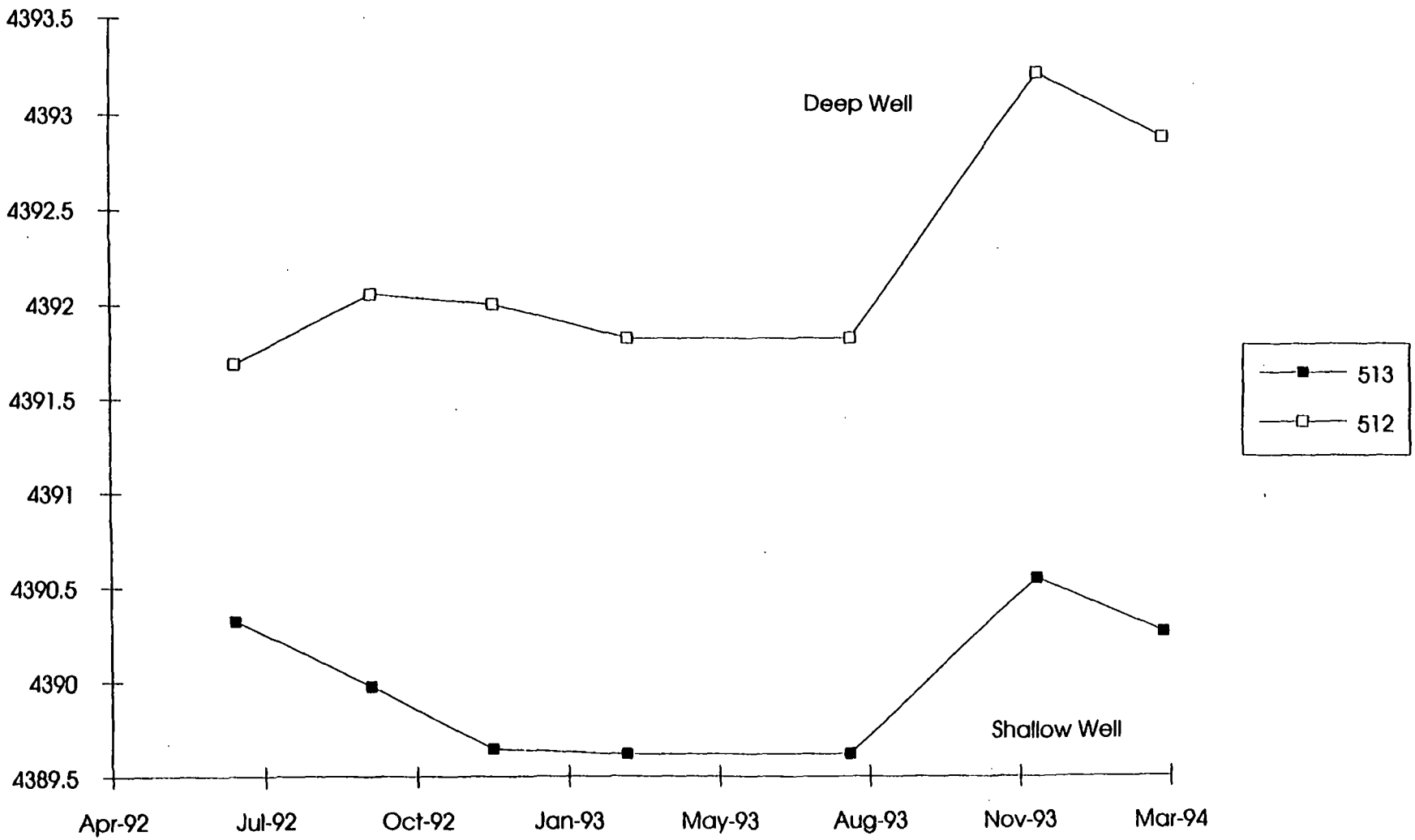


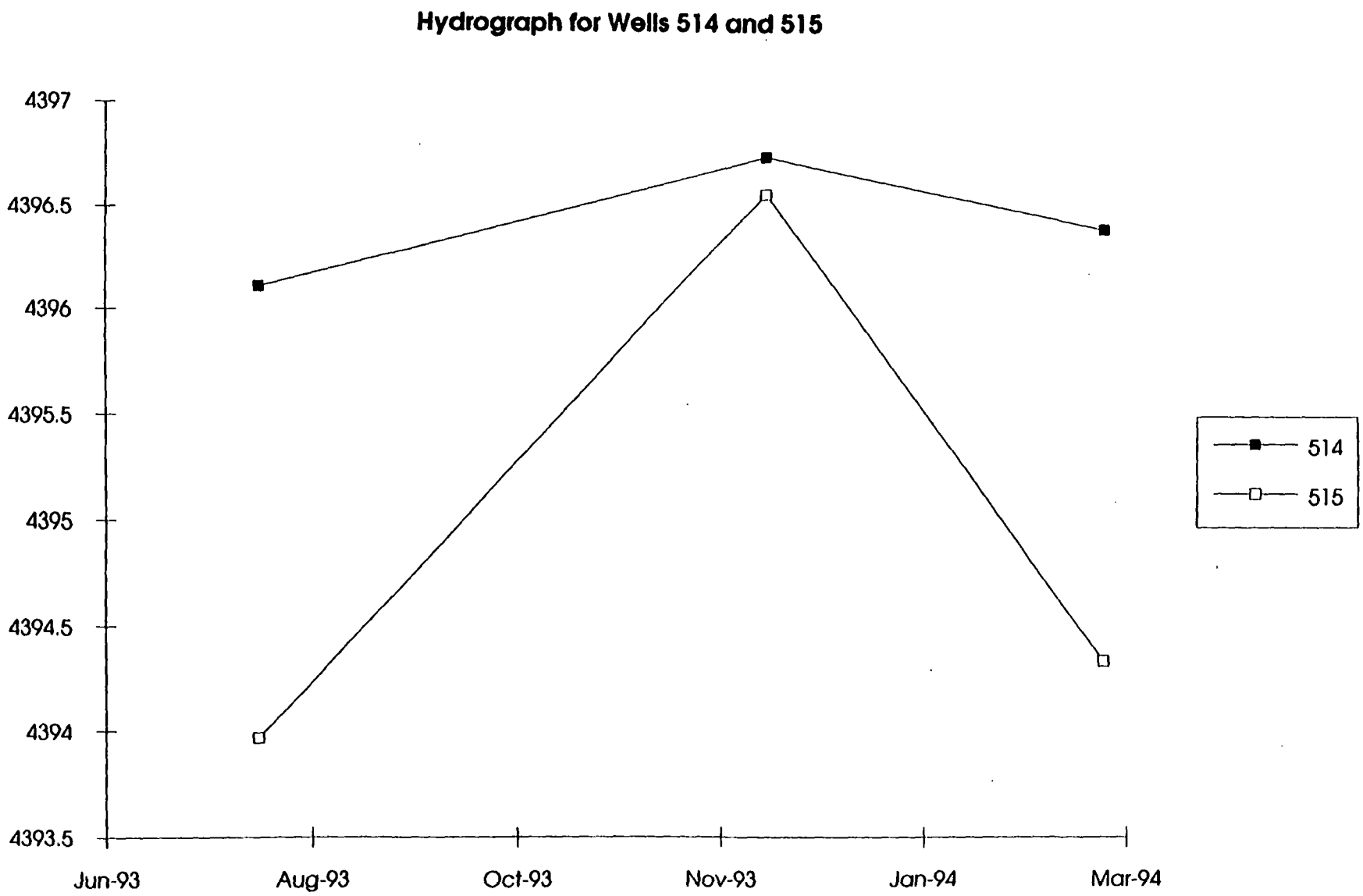
Hydrograph for Wells 508 and 509



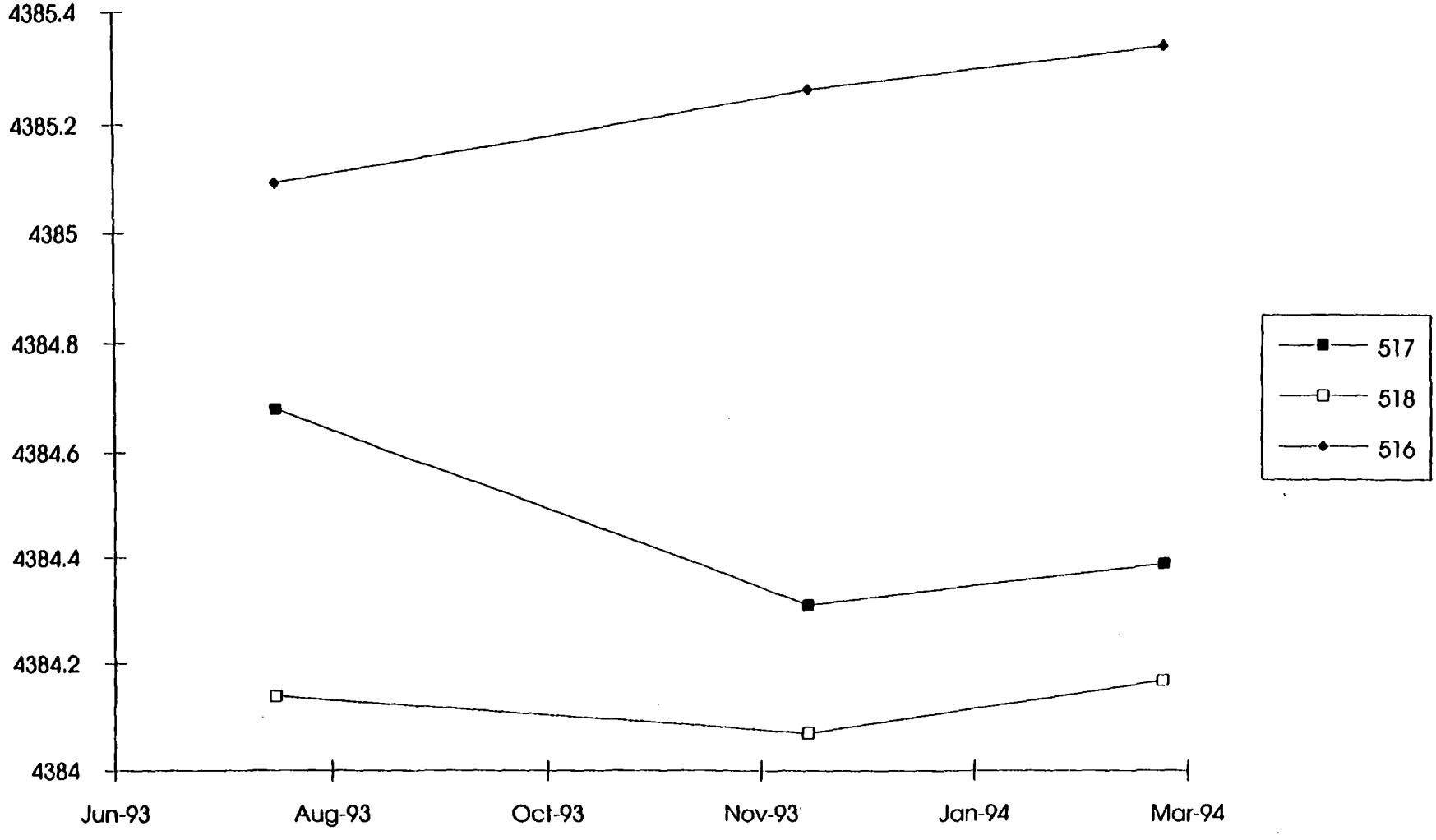

Hydrograph for Wells 510 and 511
4387.2
4387
4386.8
4386.6
4386.4
4386.2
4386
4385.8
Apr-92
Jul-92
Oct-92
Jan-93
May-93
Aug-93
Nov-93
Mar-94
Deep Well
Shallow Well
511
510

Hydrograph for Wells 512 and 513

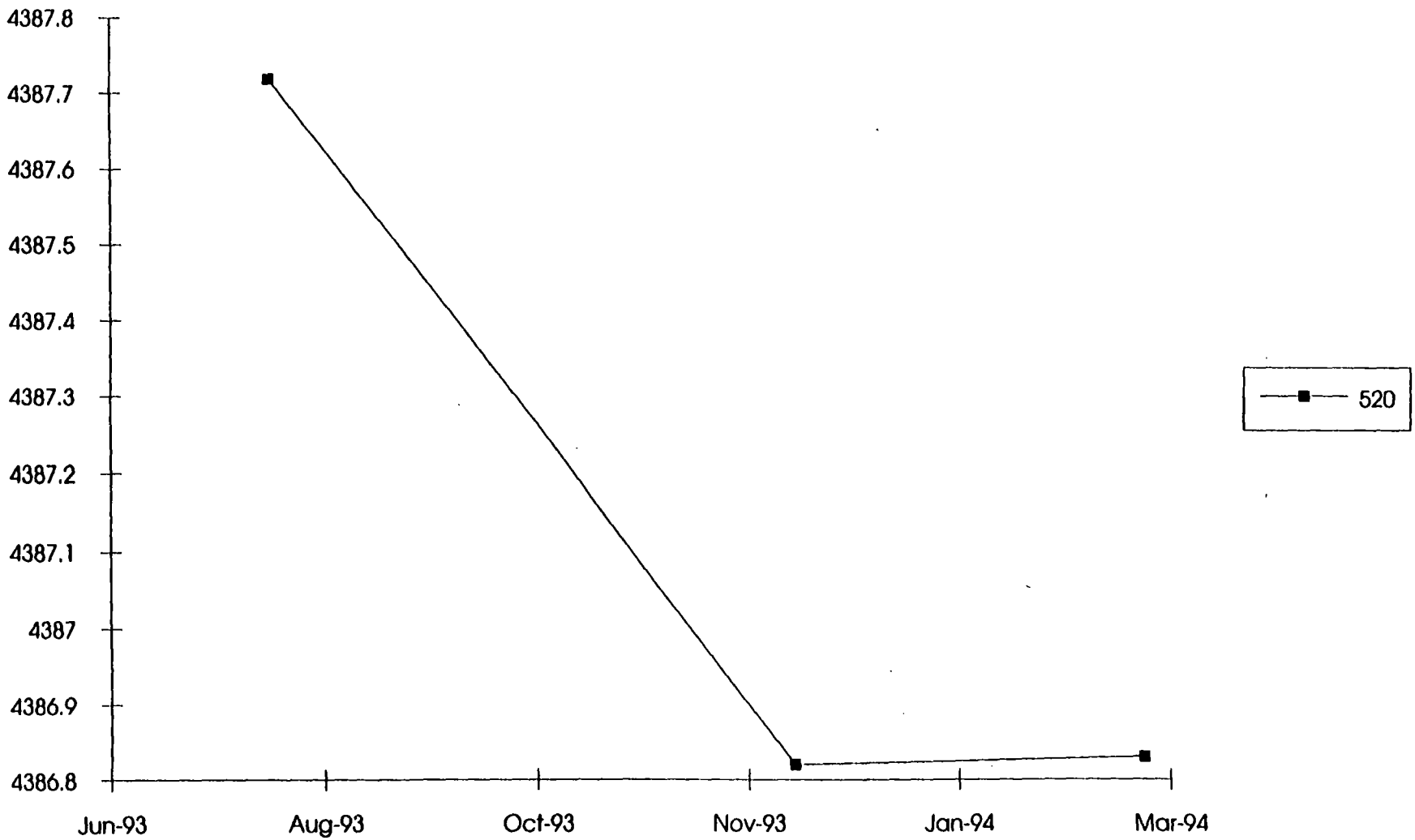


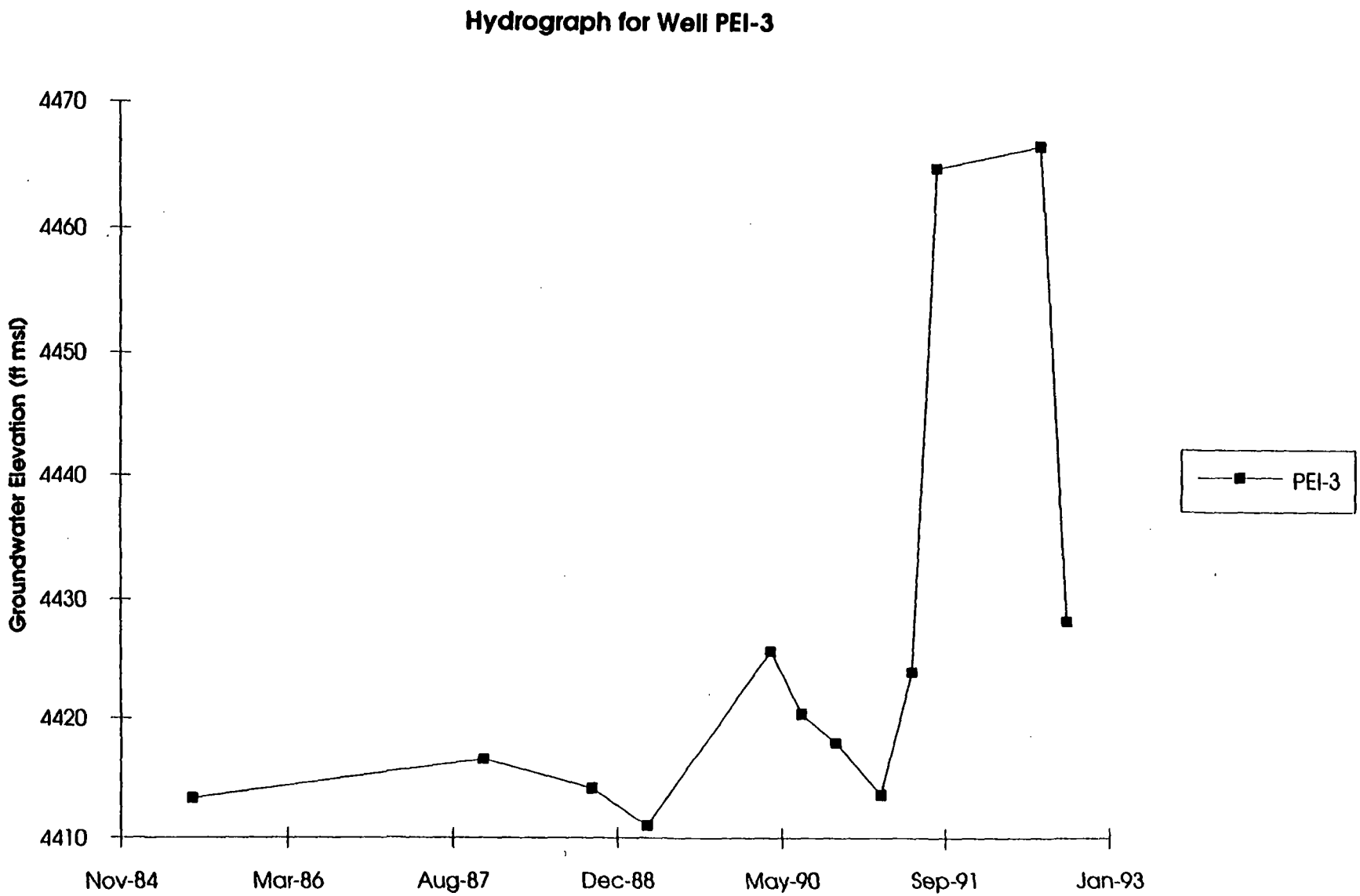

Hydrograph for Wells 514 and 515
4397
4396.5
4396
4395.5
4395
4394.5
4394
4393.5
Jun-93
Aug-93
Oct-93
Nov-93
Jan-94
Mar-94
514
515

Hydrograph for Wells 516, 517 and 518

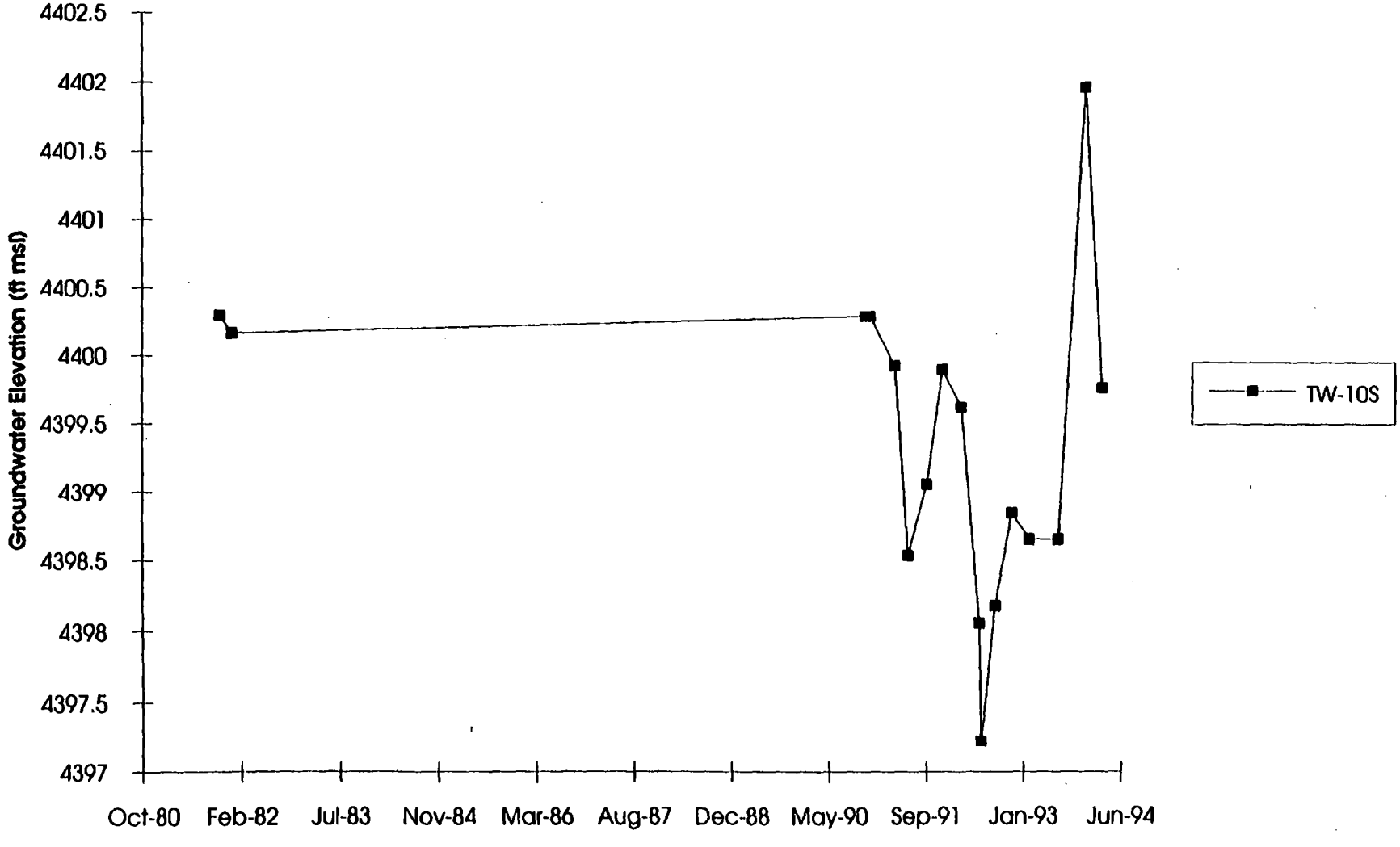


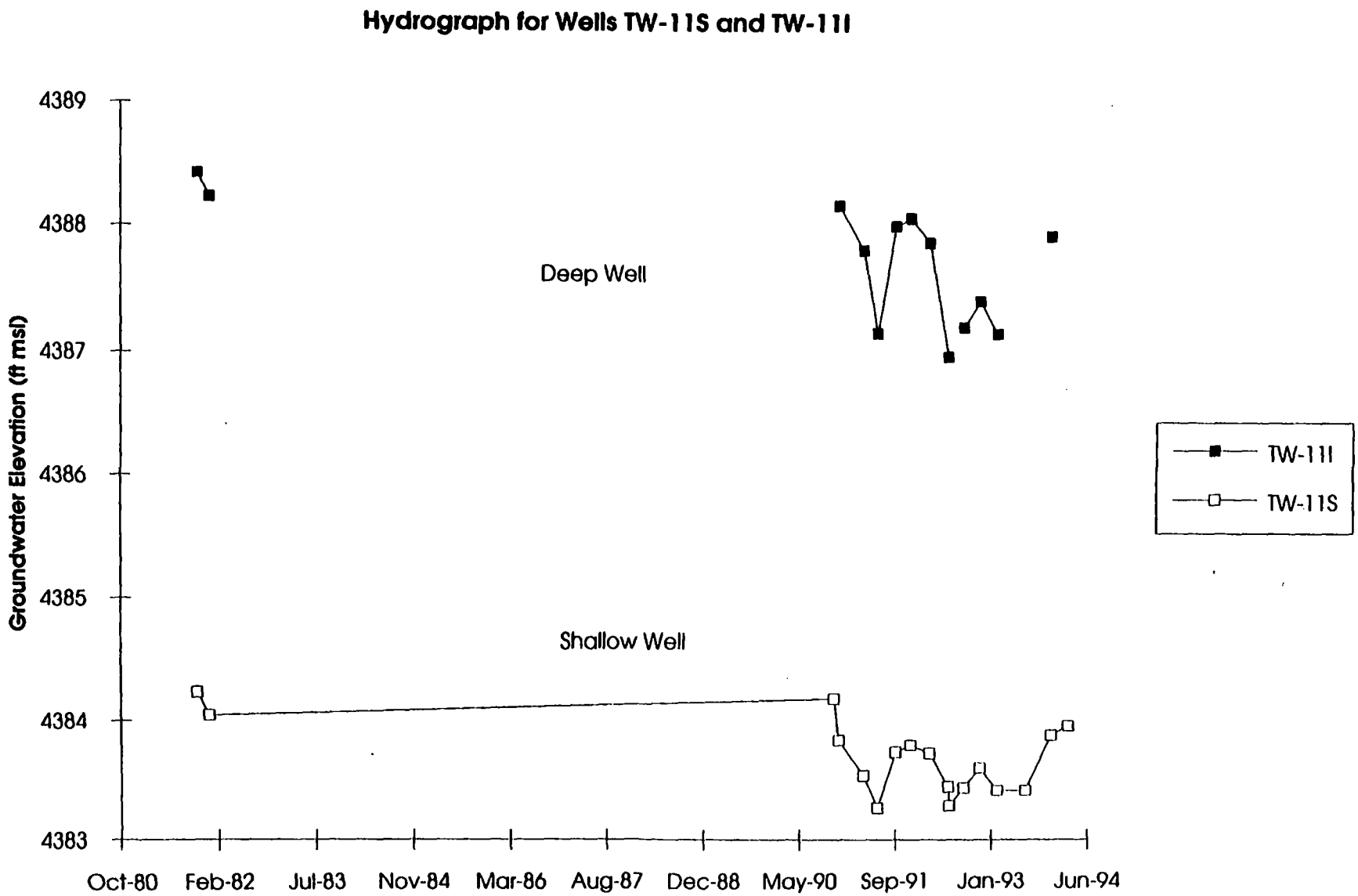
Hydrograph for Well 520

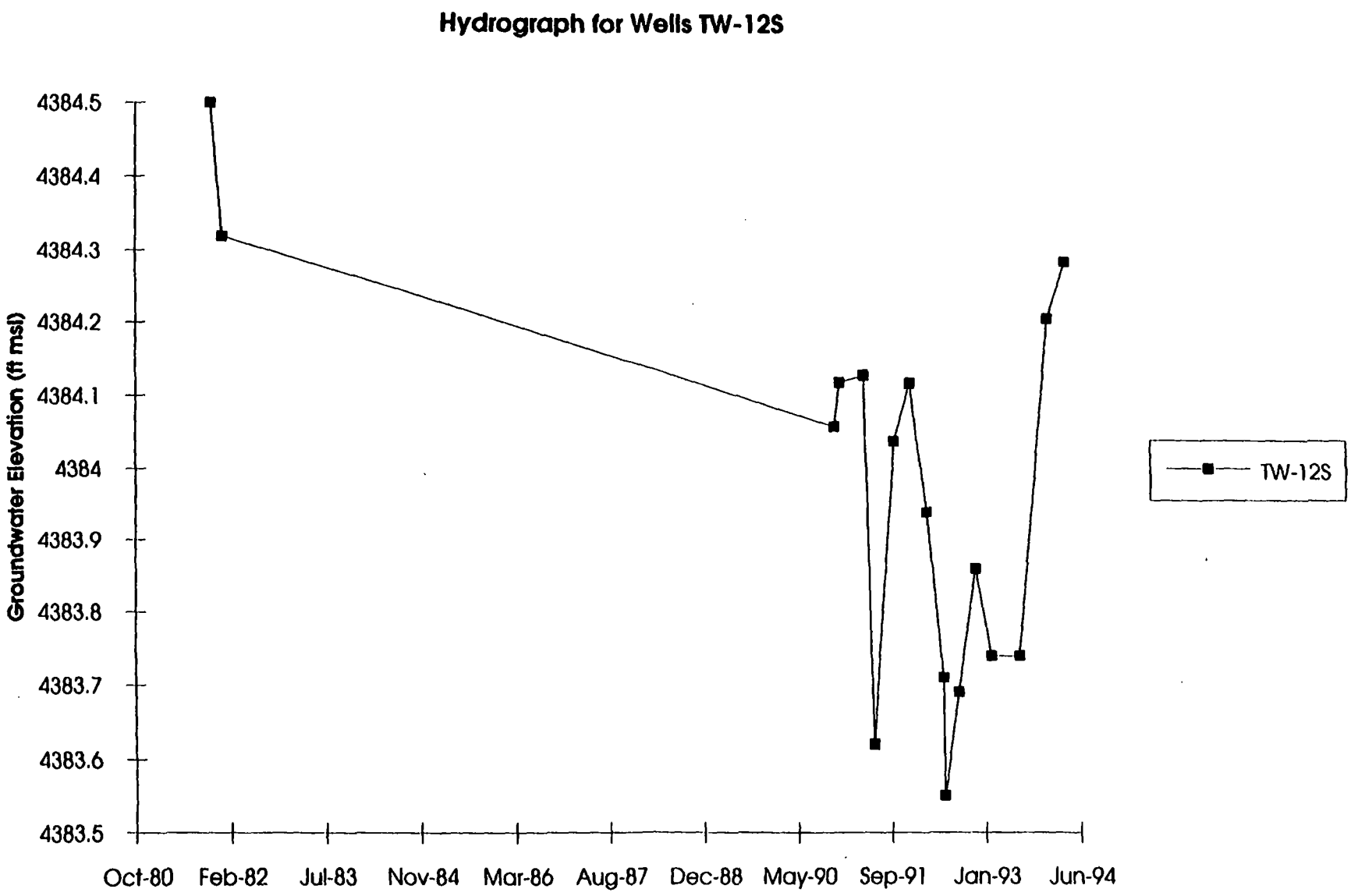



Hydrograph for Well PEI-3
Groundwater Elevation (ft msl)
4470
4460
4450
4440
4430
4420
4410
Nov-84
Mar-86
Aug-87
Dec-88
May-90
Sep-91
Jan-93
PEI-3

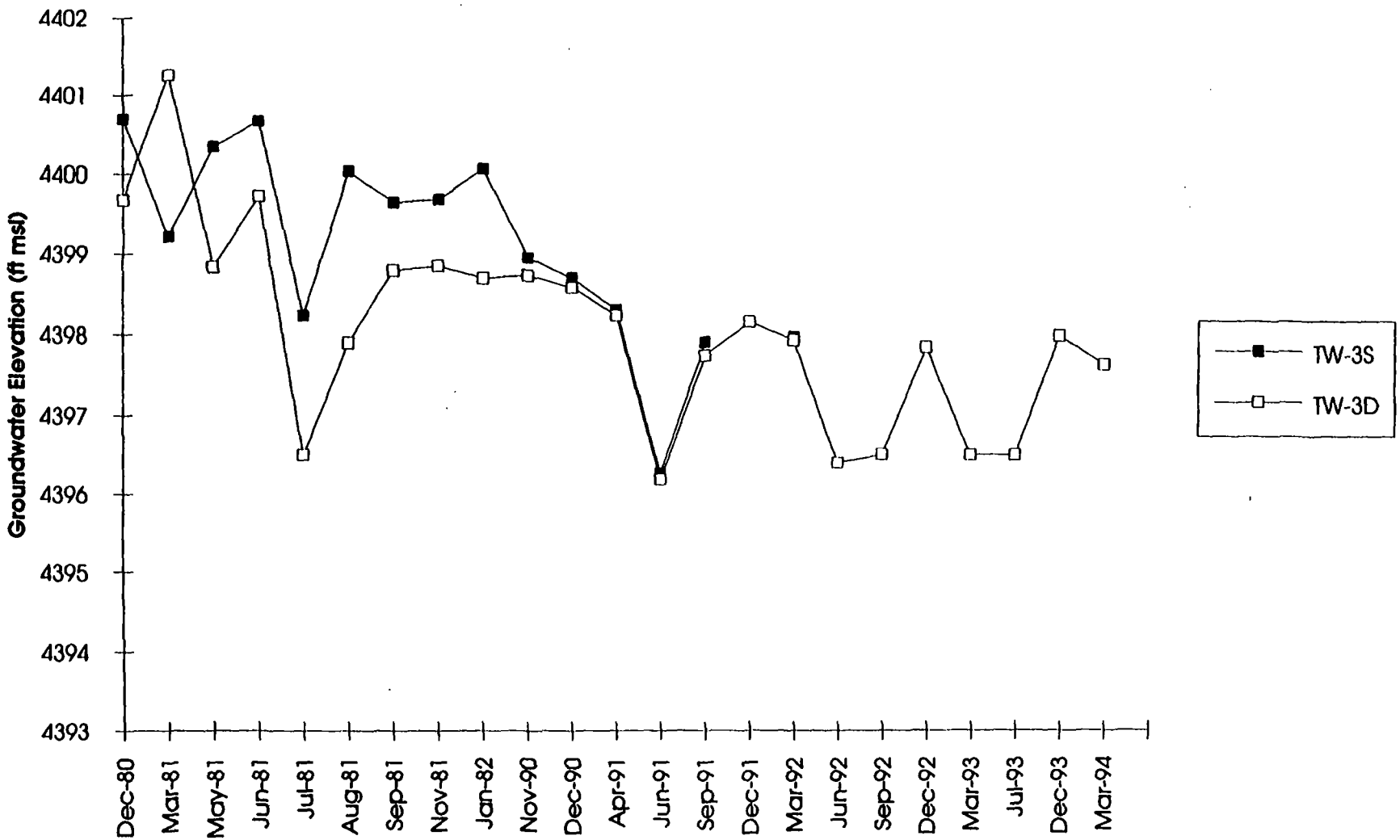
Hydrograph for Well TW-10S



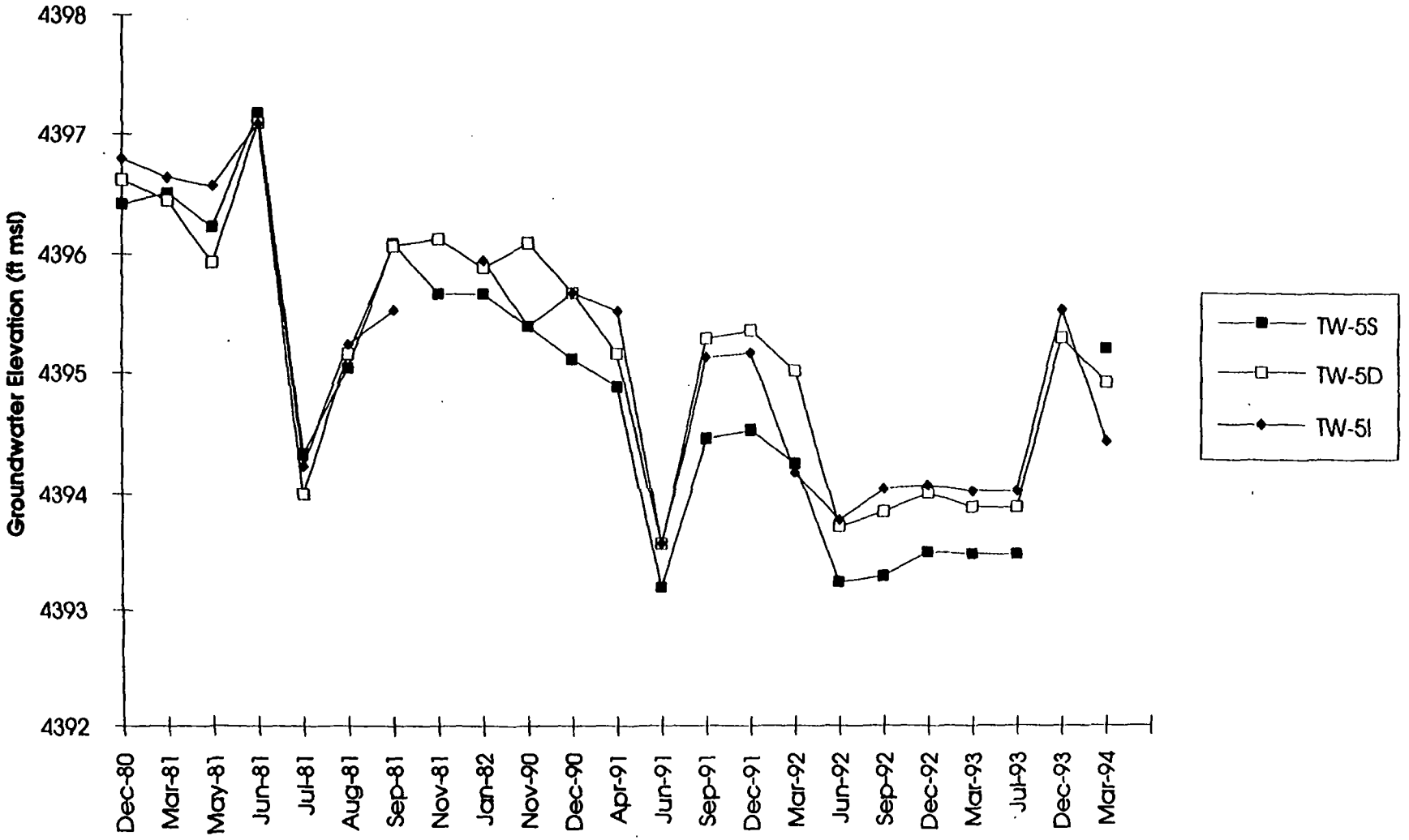

Hydrograph for Wells TW-11S and TW-11I
Groundwater Elevation (ft msl)
4389
4388
4387
4386
4385
4384
4383
Deep Well
Shallow Well
TW-11I
TW-11S
Oct-80
Feb-82
Jul-83
Nov-84
Mar-86
Aug-87
Dec-88
May-90
Sep-91
Jan-93
Jun-94


Hydrograph for Wells TW-12S
Groundwater Elevation (ft msl)
4384.5
4384.4
4384.3
4384.2
4384.1
4384
4383.9
4383.8
4383.7
4383.6
4383.5
Oct-80
Feb-82
Jul-83
Nov-84
Mar-86
Aug-87
Dec-88
May-90
Sep-91
Jan-93
Jun-94
TW-12S

Hydrograph for Wells TW-3D and TW-3S



Hydrograph for Wells TW-5D, TW-5I and TW-5S



Appendix D
Response to EPA's Comments on the Groundwater Flow Modeling Report

Response to EPA's Comments on the Groundwater Flow Modeling Report

Comment #1:

Page 1-1, Page 7-1, and elsewhere, as appropriate. The statement is made that groundwater from beneath the site does not discharge to the Portneuf River. This would be easy to misinterpret. Please reword to clarify the point that the groundwater does not discharge directly to the Portneuf, but first to the springs, which subsequently flow into the river.

Response

The appropriate sections have been revised to indicate that groundwater from beneath the site flows to the Portneuf River via spring discharge and baseflow. The original text stated that groundwater from beneath the site does not discharge to springs or the river *at points north of Batiste Spring* [emp. added]. There was no intent to imply that groundwater originating beneath the facilities did not discharge to the Portneuf River.

Comment #2:

Page 2-8 The Dames and Moore 1975 reference does not appear in the Reference section.

Response

The Dames and Moore reference was incorrect. The appropriate reference is Cochrane, 1980, and this has been added to the reference list.

Comment #3:

A number of borings, well logs, and groundwater elevation measurement points were used in the modeling effort that are not located on available maps (such as Boring 162, page 2-9 and Figure 2). A map showing locations of all borings, wells logs, groundwater elevation measurement points used as stratigraphic and hydrogeologic reference points for the model, should be provided. (Indian Springs Trout Farm is referred to, but not shown on Figure 1).

Response

Maps showing the locations of wells and hydrogeologic reference points used in the modeling study are included as Figures 1 and 2 in the final modeling report (Appendix K of Part II of the

RI Report). The Indian Springs Trout Farm well is shown in Figure 2. Boring 162 was a soil boring, not a monitoring well, and was drilled as part of the Potential Source and Onsite Soils Investigation. Soil borings which were used in the flow model development were included in the PSCS, and the logs and locations of these borings are included in the RI Report (Figures 1.3-3, 1.3-5, 2.1-1, and 2.1-3).

City of Pocatello well logs are included in Appendix B of Part II of the RI Report. Well and boring logs drilled by PEI Associates, and Geraghty and Miller are not included in this document; however, well and boring locations are shown on the appropriate figures. USGS monitoring well logs and locations are included, as are the Chevron Tank Farm monitoring wells and logs.

Although there were no well logs available for the numerous irrigation wells in the Michaud Flats, the USGS reports referenced in the report summarize the hydrostratigraphy, and interpretations were made based on this information. These wells are shown on Figure 1.

Comment #4:

> *Boundary conditions for the model require additional detail in their definition. A map should be included to show exactly where the various types of boundary conditions (i.e., specified head, specified flux, etc.) exist in the model. Also, values for these head or flux nodes should be given.*

Response

Maps illustrating the boundary cell types for each layer are included as Figures 10(b) through 10(e) in the final flow modeling report. Values for the constant head cells can be seen on the simulated groundwater contour plots. There are no constant flux boundary cells.

Comment #5:

> *There is a discussion relative to the rates of water flow at wells, springs and such, but there is no discussion of the water balance for the MODFLOW model. There should be a table and discussion relative to how much water enters and exits the model through recharge and various boundary types. What is the % discrepancy for the water in vs. water out?*

Response:

A water balance for the MODFLOW model will be included as a new Table 9. The percent discrepancy for water in vs. water out is 0.01%, based on total outflow. [Please refer to the response to Comment Number 144 in Attachment A of this communication.]

Comment #6:

It is likely that the Portneuf River forms a good hydraulic boundary for groundwater flow and contaminant transport; however, there appears to be a lack of sufficient data on the northeast side of the river to completely substantiate this claim to the degree that it is stated in the report.

Response

Numerous head and water quality measurements were collected from springs and wells along the eastern side of the river. None of these measurements indicated potential transport of EMF-derived constituents across the river. In addition to these measurements, the head at the FMC Employee Park duck pond spring (see Figure 4.5-1d in Part II of the RI Report) was surveyed by Bithell Engineering (summer 1994). The water elevation in this spring pond was more than 3 feet higher than the river elevation at this point. The head relationships between the springs along the river indicate that the springs (groundwater) have a higher head than the river water elevations. Sufficient data are available to show that the Portneuf River forms a hydraulic barrier for groundwater flow and constituent transport.

Comment #7:

Figures 7 and 8. The area labeled "gravel (silt not present)" along the Portneuf River is fairly large and appear to extend beyond the study area to the east-southeast (upriver). A few thousand feet in that direction, however, are the Union Pacific Railroad and Pacific Hide and Fur NPL sites, which are underlain by the American Falls Lake Beds. At those sites, the Lake Bed silts range in thickness from 18 to 9 feet, and thin to the southwest, toward the river. How sensitive is the model expected to be to the over- or under-estimation of the area where the Lake Beds are not present?

Response

The most critical aspect of the American Falls Lake Beds in terms of their impact on the groundwater flow patterns is their absence where the Portneuf River transitions from a losing to a gaining stream. The extent of the Lake Beds in this area are well defined along the western side of the river, and less well-defined along the eastern side of the river. However, in the area to the southeast of the study area, the presence or absence of the Lake Beds will have much less of an impact on groundwater flow patterns.

The greatest impact of the interpretations made regarding the extent of this formation is on the water budget for the model domain. Specifically, in Model Layer 3, which accommodates most of the AFLB, there are "no-flow" boundary cells where the silt is thought to be present, and

constant-head cells where the gravels are thought to be present. The constant-head cells provide an additional high-permeability cross-sectional area for groundwater to flow into the model domain. If silt were present along this model boundary, the net groundwater flux into the model domain along the southeastern boundary would be lower, thereby, lowering the net simulated groundwater discharge to the river and springs. During model calibration, a higher transmissivity may have been assigned to the shallow and deeper gravel zones to achieve the desired calibration target of net discharge to the river.

Comment #8:

> *One of the stated calibration targets was to have the model simulate the measured hydraulic heads for all wells as closely as possible. The results of these data are appropriately provided in bar graphs. However, this does not easily communicate how well the model simulated heads match the target heads for various areas across the site. Maps showing the differences (residuals) between actual and modeled heads and actual and modeled vertical gradients should be provided in the report.*

Response

Maps illustrating the head residuals are included as Figures 12b, 14b, and 14c in the flow modeling report. The first of these illustrates residuals in the shallow aquifer, the second shows residuals in the deeper aquifer, and the third shows the simulated vs. observed head differentials between the shallow and deeper aquifer.

Comment #9:

> *Page 4-2. There is a very large range of vertical hydraulic conductivity measurements from the silt unit. The statement is made that horizontal hydraulic conductivity values are 10 time greater, but a much narrower range of values is used. Please explain this apparent discrepancy.*

Response

The large range in vertical hydraulic conductivity measurements in the silt unit is noted. However, the reviewer appears to have misunderstood the representations of the hydraulic conductivity zonation maps in the report. The silts in model layers 1 and 3 were assigned horizontal hydraulic conductivity values that were derived by: (1) calibrating the model using a vertical conductance term between layers to meet the calibration targets (primarily vertical head differentials); (2) this vertical conductance term was then used to compute a vertical hydraulic conductivity (based on silt thickness) for the silt units; and (3) the horizontal hydraulic conductivity in the silt were then assigned a value 10 times greater than the computed vertical

hydraulic conductivity. All the computed vertical hydraulic conductivities were compared against the measured values to ensure the computed values did not exceed the range of observed values. There are no discrepancies.

Comment #10:

Page 4-2 and 4-3. Part of the descriptions of Layer 1 and Layer 3 are confusing. "The elevations of layer 1 (or 3) were then contoured from the elevations along the southern boundary to the elevations of the base of the silt (or lower silt in the case of Layer 3) unit farther north." It is not clear to me what is being described.

Response

This section of the report attempted to explain how model layer elevations were assigned through the Bannock Range area, where the geologic units are not readily correlatable, but have rather homogeneous hydraulic properties. The base of Layer 1 was set at an elevation 50 feet below the estimated groundwater table along the southern model boundary. The points establishing the elevations of the base of Layer 1 in the Michaud Flats area were based on the observed silt elevations. These elevations were then contoured through the Bannock Range area to establish the elevations of the base of Layer 1 between the southern model boundary and the Michaud Flats area. A similar procedure was used to establish the elevations of Layers 2 and 3 throughout the Bannock Range area.

Comment #11:

Page 5-9 contains the first mention of Scenario 2. The various scenarios should be defined prior to this point or the reader pointed toward where they are defined.

Response

Reference to Scenario 2 on this page has been deleted. All three scenarios are defined at the beginning of the next section of the Groundwater Flow Modeling Study.

Comment #12:

In Section 7 (Summary) the conclusions drawn from the testing the conceptual model and the calibrated model are not fully supported in this report. Finding number 3 discusses fluxes of water beneath source areas as a minor part of the regional water budget. As stated above, the water balance was not documented in this report as well as the supporting data cited for groundwater geochemistry. Finding number 4 (future groundwater scenarios) is not supported by the particle tracks predicted by the model.

In Scenarios 1 and 2 the particle tracks originating at the gypstack in Layer 1 are captured by the Simplot production wells whereas in Scenario 3 they discharge to the Portneuf River between Swanson Road and Batiste Springs. This indicates that increased contaminant discharge to the river can be expected if the Simplot production wells stop pumping.

Response

Section 5 of Part II of the RI Report provides the support for finding number 3. Finding number 4 is supported by the particle tracks from the revised model (no shallow aquifer pumping at SWP-4 or SWP-5).

Comment #13:

The wording of the key findings in Section 7 gives the impression that they are proven facts rather than model projections or estimates with inherent uncertainties. The wording needs to be modified to keep the model's projections in proper perspective.

Response

The key findings were not based solely on model output or projections. The key findings were based on large amounts of data (geologic, hydrogeologic, geochemical, and hydrologic); however, the reader is made aware that these findings are model projections by appropriate changes to the text of Section 7.

Comment #14:

Provide additional discussion relating to the selection of parameter values in sensitivity analysis.

Response

This discussion is provided in the final text of Appendix B of the flow modeling study.

IWW Ditch Water Quality*

L.1 BACKGROUND

The main use of the IWW system is to cool equipment throughout the plant that is subject to heat buildup. Although there are several source streams to the ditch more than 90% of the water is from cooling the furnace domes and the calciner cooling beams. Water from the IWW cooling pond is partially recycled to the calciners for reuse. This is a closed loop system within the operating area, although the water is eventually discharged in to the Portneuf River.

As part of the Remedial Investigation, FMC's contractor sampled the industrial waste water (IWW) ditch to determine the water quality being discharged into the Portneuf River. This stream is a non-contact cooling water permitted under NPDES. The NPDES presently limits heat loading to the River. During the Phase I sampling in 1992, a one time grab sample was taken near the weir, just prior to the water going into a buried pipeline that conveys the water to the river. This sample contained elevated levels of selenium, gross alpha, orthophosphate, fluoride and several other parameters. (See Table L-1, Comparison of IWW Sample and Calciner Water.)

In order to validate this sample and further characterize the water in the ditch, the water was resampled in July 1993 as part of the Phase II RI work. For fourteen consecutive days, grab samples were taken every eight hours. These samples were then composited into twenty-four hour samples, resulting in a total of fourteen samples. Six of these samples (three during high flow and three during low flow) were sent to the laboratory for analysis. The average of the results of these six samples is presented in Table L-1. The water quality in all six of these samples met drinking water standards.

Upon review of the 1993 data it seemed evident that there was a plant upset condition during the September 1992 sampling which resulted in the elevated levels. In order to understand, and perhaps identify the source of the upset, as well as to provide information concerning sediment deposition in the Portneuf River at the outfall a spectrographic analysis was performed on samples taken at the outfall, ore, precipitator dust, and slag. Calciner fines were not used in the comparison, as FMC could not identify any route, either direct or indirect, for calciner water to enter the ditch.

During late 1993 and 1994, FMC began to look for an upset condition, or other possible pathway that might have caused the 1992 contamination. This included a detailed study of the entire IWW system.

* Source: FMC Corporation

L.2 FMC INVESTIGATION

FMC began an investigation to explain the September 1992 elevated parameters in the ditch, to identify the source if possible, and institute procedures, or corrective measures, if necessary.

Part of the investigation was an intensive sampling of the water discharged into the ditch system, as well as the water discharged into the Portneuf River. Operating records were also examined to determine any plant upset or activity that would result in the elevated parameters.

All known sources of water discharging to the IWW system were inventoried. Sample locations were determined for sources with the potential to contaminate the IWW system. The sampling locations are depicted in Figure L-1.

In order to determine water quality throughout the IWW system, samples were taken from 23 sampling ports, throughout the system, as well as a background location. The background sample is the make-up water sampled prior to the water entering the system. The analytical results of the water samples were compared to the background sample as well as the September 1992 IWW ditch water sample and the July 1993 IWW water samples. As can be seen in Table L-2, the 1994 results most closely resemble the July 1993 IWW water samples.

FMC also compared the September 1992 results with plant waste streams to determine a possible source for the elevated parameters. Based on the selenium and fluoride content and elevated gross alpha, it was concluded that the most likely source was calciner return water from the calciner ponds. However, there is no direct or indirect way for this water to enter the IWW system.

Therefore, it was determined that the September 1992 event was a plant upset condition of some sort. Operating records were examined, and it was determined that during the period of the September 1992 sampling event, a major calciner renovation was in progress. This renovation was a major overhaul of the #1 calciner, involving pallet replacement, hood modifications, and general maintenance. As part of these activities, hood washing, and general cleanup of the area were performed.

There is a manhole located north of the #1 calciner which accesses the IWW system. It is possible that while doing the hood washing, this area was flooded, resulting in infiltration to the IWW system of a waste stream which would emulate the September 1992 sample.

It is also possible that when the washing was being conducted, a hose was connected to the calciner return water to be used in the cleanup. If the hose were placed into one of the funnels at the calciners, the water would also enter the IWW system. FMC personnel think this is the most probable cause for the elevated parameters seen in the September 1992 sample.

L.3 CORRECTIVE MEASURES

FMC will establish a procedure that will easily identify the calciner return water lines, and eliminate it as a source washdown water in the calciner area. We also plan to raise the level of the manhole, to ensure that flooding in the area will not result in contaminated water entering the IWW system at this point.

Table L-1
Comparison of IWW Sample and Calciner Water

(All units mg/l inless otherwise noted)								
Parameter		**IWW Ditch water FSWIWW01, 9/92**			**Calciner Pond Water FSWCPW01, 9/92**			**IWW water Avg. , 7/93**
Alkalinity		324			541			176.5
Calcium		141J			154			64.12
Chloride		1620			3750			81.65
Magnesium		22			14.7J			20.121
Potassium		747J			19330			8.3
Sodium		1450J			3990			58.25
Sulfate		8400			19800			75.14
TDS		7460			64000			616.5
Ammonia		288			268			0.0225
Nitrate		18.4			27.9			1.225
Orthophosphate		2210			3930			0.4
Total Phosphorus		2590			5340			0.48
Fluoride		61.6			134			0.65

Table L-1 (Cont'd)

Parameter		IWW Ditch water			Calciner Pond Water			IWW water
		FSWIWW01, 9/92			FSWCPW01, 9/92			Avg. 7/93
Aluminum		7.66J			9.24			0.25
Antimony		U			1.92J			0.0055
Arsenic		1.759J			3.977J			0.006
Barium		0.27			0.26			0.08
Beryllium		U			0.001			0.0005
Boron		4.53			2.89			0.19
Cadmium		0.0341J			0.818			0.0014
Chromium		U			0.133J			0.003
Cobalt		U			U			0.008
Copper		0.163			0.223			0.006
Iron		4.99J			7.06J			0.03
Lead		U			0.3258			0.05
Lithium		1.599			2.216			0.023
Manganese		0.187			0.211			0.007
Mercury		U			U			5.21E-05
Molybdenium		0.19			0.31			0.007
Nickel		0.17			0.339			0.005
Selenium		4.217J			2.785			0.001
Silver		0.035			0.058			0.002
Thallium		0.318J			0.176			0.0005
Vanadium		0.83			1.14			0.005
Zinc		5.25			10.13			0.009

Table L-1 (Cont'd)

Parameter	IWW Ditch water FSWIWW01, 9/92	Calciner Pond water FSWCPW01, 9/92	IWW Water Avg. 7/93
Gross Alpha *	186.5	642	2-3.7**
Gross Beta	103.58	17700	5.01-10.2
Radium 226	NS	U	1-1.5
Radium 228	NS	U	1-1.7

* Rad units pCi/g

**Ranges for 7/93 sampling

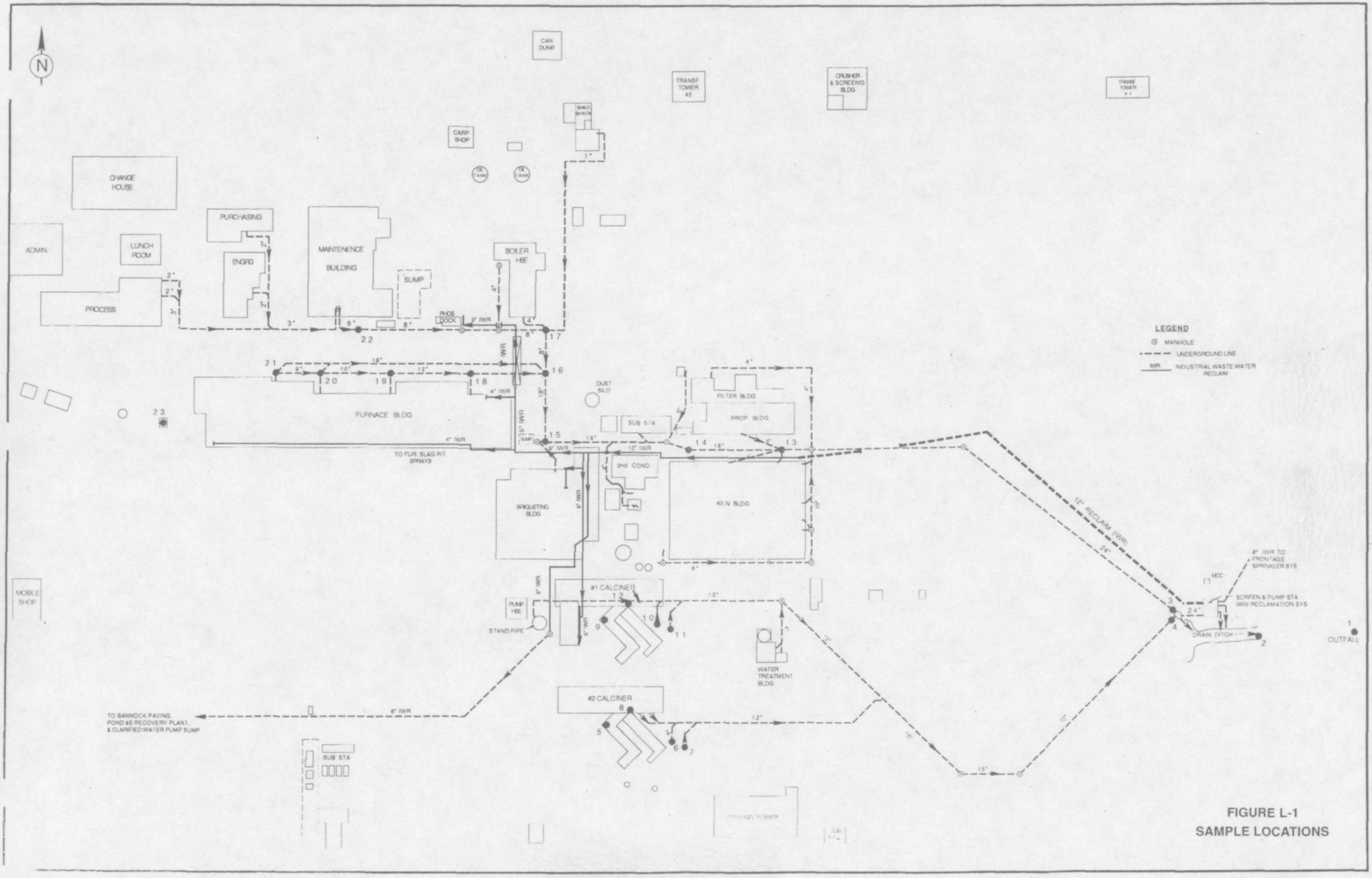


FIGURE L-1
SAMPLE LOCATIONS

Table L-2

Summary of Analytical Results of Samples Collected During Industrial Waste Water Investigation, 1994

Phosphate Analysis
Industrial Waste Water Investigation, 1994

Sample ID Number	Sample Location	Sample Date									Number of Samples	Minumum Concentration Detected	Maximum Concentration Detected	Average of Concentrations Detected
		3/25/94	4/8/94	4/22/94	5/8/94	5/28/94	6/8/94	7/27/94	8/20/94	9/21/94				
01	Outfall	1 60	3 20	12.40	2 20	4 40	4 50	2 20	2 00	1 70	9	1 6	12 4	3 80
02	IWW Composite	1 40	5 00	4 60	2.00	9 90	8.70	2 60	4 90	4 00	9	1 4	9 9	4.79
03	North Ditch	1 60	3 60	1 40	1.60	2 00	7.20	4 60	4 40	2 80	9	1 4	7 2	3 24
04	South Ditch	1 40	3.40	16.00	3.00	22 50	33 40	18 60	4 80	4 20	9	1 4	33 4	11 92
05	Calciner 2 Cooler Fan 2	1.60	3 20	10 90	1.80	3 70	97.80	1 80	2 30	2 40	9	1 6	97 8	13 94
06	Calciner 2 Cooler Fan 1	1 60	3 10	10.40	1.60	3 00	119 00	1 90	2 60	4 00	9	1 6	119	16 36
07	Calciner 2 Primary Air Fan	0 80	2 80	6 90	1.80	0 80	27 60	1 40	1 30	1 90	9	0 8	27 6	5 03
08	Calciner 2 Cooling Beam	1 90	3 30	9.40		2 70	11.70	1 80	2 00	1 80	8	1 8	11 7	4 33
09	Calciner 1 Cooler Fan 2	1 50	3 80	5 60	1 60	2 30	6 80	1 90	2 30	1 60	9	1 5	6 8	3 04
10	Calciner 1 Cooler Fan 1	1 50	3 20	8 20	1 60	2 80	118 00	1 80	2 60	1 50	9	1 5	118	15 69
11	Calciner 1 Primary Fan	1 60	3 80	5 60	1 60	2.40	128.00	1 50	2 10	2 70	9	1 5	128	16 59
12	Calciner 1 Cooling Beam	1 80	3.60		1 50	2 50	5 70	1 90	1 50	8 10	8	1 5	8 1	3 33
13	Kiln Bildg East Manhole	1.30	3.60	1.10	1 20	1.20	0 80	1 40	1 20	1 50	9	0 8	3 6	1 48
14	Kiln Bldg. West Manhole	1.30	3 10	0 30	1.00		0 80	1 60	1 40	1 00	8	0 3	3 1	1 31
15	Pelletizer Bldg Manhole	1 40	2 80	1 00	1 10	1.40	0.80	1 60	1 20	1 40	9	0 8	2 8	1 41
16	Furnaces Composite	0 70	3 50		1 20	1 60	1 00		1 60	1 40	7	0 7	3 5	1 57
17	Boiler House Manhole	3.40	5.40	1 00	3.50	0.80	2.00	1.40	0 70	2 10	9	0 7	5 4	2.26
18	Furnace 1	0 60	2.20	0 80	1 70	0 70	0 70	90 60	0 90	1 00	9	0 6	90 6	11.02
19	Furnace 2	2.10	2.50	1.30	1.60	0 80	1.40	66 00	0 40	1 10	9	0 4	66	8 58
20	Furnace 3	0 80	2 20	1.00	1.00	1.80	2.40	2 40	0 30	2 00	9	0 3	2 4	1 54
21	Furnace 4	0.80	3 30	0 90	1.00	1.90	1.00	2 20	0.20	1 60	9	0 2	3 3	1.43
22	Maintenance Building	2 00	1.80	0.40	0.40	0.80	0.20	0.40	<0 1	1 00	9	0 2	2	0 88
23	Chlorinator Building	0.30	1.40	0.40	nd	nd	nd	ND	0 90	ND	9	0 3	1.4	0.75

Table L-2 (Cont'd)

Sulphate Analysis
Industrial Waste Water Investigation, 1994

Sample ID Number	Sample Location	Sample Date									Number of Samples	Minumum Concentration Detected	Maximum Concentration Detected	Average of Concentrations Detected
		3/25/94	4/8/94	4/22/94	5/8/94	5/28/94	6/8/94	7/27/94	8/20/94	9/21/94				
01	Outfall	81 00	59 90	71.10	10 70	145.30	2.20	73.00	77 00	54 00	9	2 20	145 30	63 80
02	IWW Composite	82.00	60.70	69.60	11.10	60 60	4.20	61.00	80.00	77 00	9	4 20	82 00	56.24
03	North Ditch	78 00	64.30	59.80	23 20	50 60	1.80	77 00	94 00	78 00	9	1 80	94 00	58 52
04	South Ditch	85 00	77 50	63 40	23 90	28 60	1 20	102 00	92 00	76 00	9	1 20	102 00	61 07
05	Calciner 2 Cooler Fan 2	73 00	63 00	52 10	26.20	22.10	nd	72 00	76 00	79 00	9	22 10	79 00	57.93
06	Calciner 2 Cooler Fan 1	75 00	71 00	56 80	23 20	20 30	nd	79 00	68 00	85 00	9	20 30	85 00	59 79
07	Calciner 2 Primary Air Fan	79 00	71 80	69 00	36.00	17.60	7.70	71 00	64 00	47 00	9	7 70	79 00	51 46
08	Calciner 2 Cooling Beam	80 00	73.40	92 80		21 50	3.20	74 00	79 00	56 00	8	3 20	92 80	59 99
09	Calciner 1 Cooler Fan 2	77 00	70 90	78.10	23 90	19 90	5 40	79 00	73 00	57 00	9	5 40	79 00	53 80
10	Calciner 1 Cooler Fan 1	77 00	66 10	76 40	26 80	21 80	5.90	75 00	79 00	53 00	9	5 90	79 00	53 44
11	Calciner 1 Primary Fan	76 00	63.10	71.80	11 30	21.20	nd	79 00	83 00	48 00	9	11 30	83 00	56 68
12	Calciner 1 Cooling Beam	77 00	56 20		27.90	22 90	6 00	81 00	75 00	48 00	8	6 00	81 00	49 25
13	Kiln Bildg East Manhole	70 00	73 40	74.70	21.10	21.50	4 90	65 00	75 00	38 00	9	4 90	75 00	49 29
14	Kiln Bldg. West Manhole	75 00	67.80	66.70	20 00		5.30	70 00	69 00	46 00	8	5 30	75 00	52 48
15	Pelletizer Bldg Manhole	69 00	73.70	64.60	35 20	21 80	5 80	80 00	88 00	50 00	9	5 80	88 00	54 23
16	Furnaces Composite	73.00	64.00		24 30	28.10	5 60		22 00	49 00	7	5 60	73 00	38 00
17	Boiler House Manhole	79.00	96.70	119 00	29.10	33 30	8 80	74 00	61 00	46 00	9	8 80	119 00	60 77
18	Furnace 1	68.00	64 30	74 50	23.70	19 20	4 30	111 00	66 00	38 00	9	4 30	111 00	52 11
19	Furnace 2	70.00	64.80	70.30	21.60	17.70	3 90	99 00	61 00	53 00	9	3 90	99 00	51 26
20	Furnace 3	68.00	57.50	62.60	22.50	26 00	4 10	13 50	49 00	83 00	9	4 10	83 00	42 91
21	Furnace 4	69 00	60 20	74.70	21 60	23.20	3.90	17 00	38 00	72 00	9	3 90	74 70	42.18
22	Maintenance Building	41.00	31.10	51.90	17.80	13 60	3 60	50.00	43 00	33 00	9	3 60	51 90	31.67
23	Chlorinator Building	40.00	32.90	43.00	16.30	11.30	3 00	59 00	70 00	30 00	9	3 00	70 00	33.94

Table L-2 (Cont'd)

Fluoride Analysis
Industrial Waste Water Investigation, 1994

Sample ID Number	Sample Location	Sample Date									Number of Samples	Minumum Concentration Detected	Maximum Concentration Detected	Average of Concentrations Detected
		3/25/94	4/8/94	4/22/94	5/8/94	5/28/94	6/8/94	7/27/94	8/20/94	9/21/94				
01	Outfall	0 66	0 44	1.31	0 06	0.67	1.8	0 85	0 90	0 62	9	0 06	1 8	0 81
02	IWW Composite		0 44	0.91	0.06	0 91	2 9	0 85	1 17	0 66	8	0 06	2 9	0 99
03	North Ditch	0 56	0 41	0.75	0 04	0 54	2 1	1 02	1 05	0 63	9	0 04	2 1	0 79
04	South Ditch	0 65	0.42	1.4	0 07	1.38	3 9	1 78	1 18	0 64	9	0 07	3 9	1 27
05	Calciner 2 Cooler Fan 2	0 51	0.4	1.1	0 04	0 62	18	0 77	0 81	0 55	9	0 04	18	2 53
06	Calciner 2 Cooler Fan 1	0 57	0.4	1.1	0 05	0.53	22 4	0 77	0 85	0 69	9	0 05	22 4	3 04
07	Calciner 2 Primary Air Fan	0 44	0 36	0 9	0 04	0.5	5.3	0 74	0 70	0 55	9	0 04	5 3	1 06
08	Calciner 2 Cooling Beam	0 51	0.38	1.2		0 52	4 8	0 77	1 50	0 52	8	0 38	4 8	1 28
09	Calciner 1 Cooler Fan 2	0 5	0.4	0.95	0 04	0 51	1 7	0 74	0 89	0 5	9	0 04	1 7	0 69
10	Calciner 1 Cooler Fan 1	0.5	0 38	1.1	0 04	0 51	16 3	0 72	0 86	0 48	9	0 04	16 3	2 32
11	Calciner 1 Primary Fan	0.68	0 39	0.96	0 04	0.53	15 9	0 72	0 81	0 53	9	0 04	15 9	2 28
12	Calciner 1 Cooling Beam	0 48	0 41		0 05	0 52	1.7	0 75	0 72	0 93	8	0 05	1 7	0 70
13	Kiln Bldg East Manhole	0 44	0 27	0.069	0 03	0.43	0 83	0 67	0 58	0 55	9	0 03	0 83	0 43
14	Kiln Bldg West Manhole	0 41	0 27	0.41	0 03		0.81	0 62	0 54	0 5	8	0 03	0 81	0 45
15	Pelletizer Bldg. Manhole	0.41	0.25	0.67	0.04	0.43	0.7	0 62	0 55	0 48	9	0 04	0 7	0 46
16	Furnaces Composite	0.4	0.29		0.05	0 38	0.84		0 64	0 4	7	0 05	0 84	0 43
17	Boiler House Manhole	0 56	0.398	1	0 06	0.75	0.89	0 66	0 57	0 57	9	0 06	1	0 61
18	Furnace 1	0.44	0.23	0 68	0 03	0.48	0 78	13 5	0 56	0 46	9	0 03	13 5	1 91
19	Furnace 2	0.41	0 23	0.66	0 04	0 46	0.75	9 5	0 59	0 45	9	0 04	9 5	1 45
20	Furnace 3	0.41	0.22	0.26	0 03	0 35	0 71	0.5	0 59	0 33	9	0 03	0 71	0 38
21	Furnace 4	0.41	0.23	0.65	0.03	0 35	0 74	0 49	0 60	0 34	9	0 03	0 74	0 43
22	Maintenance Building	0.49	0.27	0 78	0.04	0.54	0 68	0.77	0 60	0 46	9	0 04	0 78	0 51
23	Chlorinator Building	0.47	0.26	0.81	0.04	0.5	0.67	0 6	0 59	0 5	9	0 04	0 81	0 49

Table L-2 (Cont'd)

Potassium Analysis
Industrial Waste Water Investigation, 1994

Sample ID Number	Sample Location	Sample Date								Number of Samples	Minumum Concentration Detected	Maximum Concentration Detected	Average of Concentrations Detected
		3/25/94	4/8/94	4/22/94	5/8/94	5/28/94	34493.00	7/27/94	8/20/94				
01	Outfall	9.36	7.50	24.30	9.70	9.20	*9.2	*7.6	9.10	9	7 50	24 30	11.53
02	IWW Composite	8.05	7.20	13.70	10.70	12.60	23.75	5.02	9.92	9	5 02	23.75	11.37
03	North Ditch	9.58	6.80	9.30	8.90	8.90	12.70	7.62	9.64	9	6 80	12.70	9.18
04	South Ditch	8.28	6.60	28.20	10.40	26.60	38.55	8.99	9.92	9	6 60	38.55	17.19
05	Calciner 2 Cooler Fan 2	7.82	6.20	21.20	10.40	8.20	127.00	4.04	7.54	9	4 04	127.00	24.05
06	Calciner 2 Cooler Fan 1	7.55	6.40	17.80	8.40	8.20	15.40	0.74	9.43	9	0 74	17.80	9.24
07	Calciner 2 Primary Air Fan	9.11	7.00	11.50	9.90	5.80	114.00	0.78	8 23	9	0 78	114 00	20 79
08	Calciner 2 Cooling Beam	5.20	7.30	16.80			32.20	3 28	6.54	7	3 28	32 20	11.89
09	Calciner 1 Cooler Fan 2	6.51	6.00	12.40	8.80	7.30	13.30	0.85	8.73	9	0 85	13 30	7.99
10	Calciner 1 Cooler Fan 1	6.54	5.70	15.60	9.10	8.80	96.35	0.40	9 08	9	0 40	96 35	18.95
11	Calciner 1 Primary Fan	6.24	11.00	10.10	7.30	7.20	*132	1.61	6.39	9	1 61	11 00	7 12
12	Calciner 1 Cooling Beam	5.73	10.30		8.20		11.10	4 25	5.04	7	4 25	11 10	7.44
13	Kiln Bildg. East Manhole	5.13	6.90	5.00	7.10	4.70	5.39	0.34	0.55	9	0 34	7 10	4 39
14	Kiln Bldg. West Manhole	4.59	6.60	9.80	6.30		5.60	8.32	1.79	8	1 79	9 80	6.14
15	Pelletizer Bldg. Manhole	8.53	6.50	8.50	4.20	4.89	6.02	7.71	1.79	9	1.79	8.53	6.02
16	Furnaces Composite	9.19	7.30	7.90	11.70	7.00	6.23		8.94	8	6.23	11.70	8.32
17	Boiler House Manhole	7.82	13.50	6.20	7.30	3.80	7.05	48.00	0.48	9	0 48	48 00	11.77
18	Furnace 1	9.01	6.20	7.90	8.40	2.50	6.40	10.10	5.76	9	2 50	10.10	7.03
19	Furnace 2	8.37	6.30	9.10	7.40	1.00	6.83	45.40	2.01	9	1 00	45.40	10.80
20	Furnace 3	10.40	6.10	9.20	8.30	1.58	6.94	7.21	4.44	9	1 58	10.40	6.77
21	Furnace 4	8.52	5.50	11.20	10.10	2.19	6.94	10.30	0.58	9	0 58	11.20	6.92
22	Maintenance Building	8.30	4.00	7.80	9.00	3.56	7.46	2.05	4.17	9	2 05	9.00	5.79
23	Chlorinator Building	7.64	3.90	5.90	5.80	0.33	6.83	2.66	2.77	9	0 33	7.64	4.48

Table L-2 (Cont'd)

Arsenic Analysis
Industrial Waste Water Investigation, 1994

Sample ID Number	Sample Location	Sample Date							Number of Samples	Minumum Concentration Detected	Maximum Concentration Detected	Average of Concentrations Detected
		3/25/94	4/8/94	5/8/94	5/28/94	6/8/94	7/27/94	8/20/94				
01	Outfall	<1.0	<1.0	0.001	0.010	*<0.05	*<0.1	*<0.1	7	0.001	0.010	0.006
02	IWW Composite	<1.0	<1.0	0.001	ND	0.070	ND	ND	7	0.001	0.070	0.036
03	North Ditch	<1.0	<1.0	0.020	ND	ND	ND	ND	7	0.020	0.020	0.020
04	South Ditch	<1.0	<1.0	ND	ND	0.009	ND	ND	7	0.009	0.009	0.009
05	Calciner 2 Cooler Fan 2	<1.0	<1.0	0.040	ND	0.004	ND	ND	7	0.004	0.040	0.022
06	Calciner 2 Cooler Fan 1	<1.0	<1.0	0.050	ND	ND	ND	ND	7	0.050	0.050	0.050
07	Calciner 2 Primary Air Fan	<1.0	<1.0	ND	0.059	ND	ND	ND	7	0.059	0.059	0.059
08	Calciner 2 Cooling Beam	<1.0	<1.0			0.102	ND	ND	6	0.102	0.102	0.102
09	Calciner 1 Cooler Fan 2	<1.0	<1.0	0.030	0.034	0.098	ND	ND	7	0.030	0.098	0.054
10	Calciner 1 Cooler Fan 1	<1.0	<1.0	ND	0.061	0.088	ND	ND	7	0.061	0.088	0.075
11	Calciner 1 Primary Fan	<1.0	<1.0	ND	ND	*<0.50	ND	ND	7			
12	Calciner 1 Cooling Beam	<1.0	<1.0	ND		0.021	ND	ND	7	0.021	0.021	0.021
13	Kiln Bildg. East Manhole	<1.0	<1.0	ND	0.028	0.040	ND	ND	7	0.028	0.040	0.034
14	Kiln Bldg. West Manhole	<1.0	<1.0	ND		0.067	ND	ND	6	0.067	0.067	0.067
15	Pelletizer Bldg. Manhole	<1.0	<1.0	ND	ND	0.004	ND	ND	7	0.004	0.004	0.004
16	Furnaces Composite	<1.0	<1.0	ND	ND	ND		ND	6			
17	Boiler House Manhole	<1.0	<1.0	0.020	ND	0.050	ND	ND	7	0.020	0.050	0.035
18	Furnace 1	<1.0	<1.0	0.006	ND	0.005	ND	ND	7	0.005	0.006	0.006
19	Furnace 2	<1.0	<1.0	0.020	0.022	0.011	ND	ND	7	0.011	0.022	0.018
20	Furnace 3	<1.0	<1.0	ND	0.141	ND	ND	ND	7	0.141	0.141	0.141
21	Furnace 4	<1.0	<1.0	0.010	0.048	ND	ND	ND	7	0.010	0.048	0.029
22	Maintenance Building	<1.0	<1.0	0.030	0.020	ND	ND	ND	7	0.020	0.030	0.025
23	Chlorinator Building	<1.0	<1.0	0.010	0.034	ND	ND	ND	7	0.010	0.034	0.022

Table L-2 (Cont'd)

Barium Analysis
Industrial Waste Water Investigation, 1994

Sample ID Number	Sample Location	Sample Date								Number of Samples	Minumum Concentration Detected	Maximum Concentration Detected	Average of Concentrations Detected
		3/25/94	4/8/94	4/22/94	5/8/94	5/28/94	6/8/94	7/27/94	8/20/94				
01	Outfall	0.100	0.090	<0.01	0.080	0.100	*<0.20	*<0.20	*<0.20	8	0.080	0.100	0.093
02	IWW Composite	0.100	0.100	<0.01	0.090	0.090	0.030	0.032	0.084	8	0.030	0.100	0.075
03	North Ditch	0.090	0.090	<0.01	0.080	0.090	0.065	0.052	0.071	8	0.052	0.090	0.077
04	South Ditch	0.090	0.090	<0.01	0.080	0.070	0.045	0.072	0.078	8	0.045	0.090	0.075
05	Calciner 2 Cooler Fan 2	0.090	0.090	<0.01	0.090	0.080	0.079	0.036	0.073	8	0.036	0.090	0.077
06	Calciner 2 Cooler Fan 1	0.090	0.080	<0.01	0.110	0.080	0.033	0.023	0.066	8	0.023	0.110	0.069
07	Calciner 2 Primary Air Fan	0.100	0.100	<0.01	0.100	0.090	0.071	0.012	0.106	8	0.012	0.106	0.083
08	Calciner 2 Cooling Beam	0.100	0.090	<0.01			0.092	0.025	0.087	8	0.025	0.100	0.079
09	Calciner 1 Cooler Fan 2	0.110	0.100	<0.01	0.080	0.090	0.088	ND	0.082	8	0.080	0.110	0.092
10	Calciner 1 Cooler Fan 1	0.100	0.090	<0.01	0.080	0.090	0.071	0.006	0.086	8	0.006	0.100	0.075
11	Calciner 1 Primary Fan	0.100	0.090	<0.01	0.080	0.100	*<0.20	0.011	0.096	8	0.011	0.100	0.080
12	Calciner 1 Cooling Beam	0.090	0.080		0.070		0.084	0.034	0.054	7	0.034	0.090	0.069
13	Kiln Bldg. East Manhole	0.080	0.900	<0.01	0.070	0.128	0.073	ND	0.000	8	0.000	0.900	0.209
14	Kiln Bldg. West Manhole	0.080	0.090	<0.01	0.050		0.069	ND	0.028	7	0.028	0.090	0.063
15	Pelletizer Bldg. Manhole	0.090	0.070	<0.01	0.060	0.086	0.076	0.056	0.027	8	0.027	0.090	0.066
16	Furnaces Composite	0.080	0.050	<0.01	0.110	0.067	0.081		ND	7	0.050	0.110	0.078
17	Boiler House Manhole	0.080	0.040	<0.01	0.080	0.049	0.085	0.156	0.021	8	0.021	0.156	0.073
18	Furnace 1	0.080	0.060	<0.01	0.090	0.077	0.086	ND	0.031	8	0.031	0.090	0.071
19	Furnace 2	0.080	0.070	<0.01	0.080	0.073	0.083	0.011	0.001	8	0.001	0.083	0.057
20	Furnace 3	0.080	0.060	<0.01	0.090	0.075	0.067	0.043	0.067	8	0.043	0.090	0.069
21	Furnace 4	0.060	0.120	<0.01	0.090	0.071	0.073	0.047	0.028	8	0.028	0.120	0.070
22	Maintenance Building	0.070	0.100	<0.01	0.080	0.057	0.068	0.014	0.063	8	0.014	0.100	0.065
23	Chlorinator Building	0.080	0.080	<0.01	0.070	0.058	0.063	ND	0.068	8	0.058	0.080	0.070

Table L-2 (Cont'd)

Beryllium Analysis
Industrial Waste Water Investigation, 1994

Sample ID Number	Sample Location	Sample Date							Number of Samples	Minumum Concentration Detected	Maximum Concentration Detected	Average of Concentrations Detected
		3/25/94	4/8/94	5/8/94	5/28/94	6/8/94	7/27/94	8/20/94				
01	Outfall	<1.0	<1.0	ND	ND	*<0.005	*<0.005	*<0.005	8			
02	IWW Composite	<1.0	<1.0	ND	ND	0.001	ND	ND	8	0.001	0.001	0.001
03	North Ditch	<1.0	<1.0	ND	ND	0.024	ND	ND	8	0.024	0.024	0.024
04	South Ditch	<1.0	<1.0	ND	ND	ND	ND	ND	8			
05	Calciner 2 Cooler Fan 2	<1.0	<1.0	ND	ND	ND	ND	ND	8			
06	Calciner 2 Cooler Fan 1	<1.0	<1.0	ND	ND	ND	ND	ND	8			
07	Calciner 2 Primary Air Fan	<1.0	<1.0	ND	0.002	ND	0.004	0.032	8	0.002	0.032	0.013
08	Calciner 2 Cooling Beam	<1.0	<1.0			0.001	0.001	0.001	6	0.001	0.001	0.001
09	Calciner 1 Cooler Fan 2	<1.0	<1.0	ND	0.002	ND	ND	ND	8	0.002	0.002	0.002
10	Calciner 1 Cooler Fan 1	<1.0	<1.0	ND	ND	ND	ND	ND	8			
11	Calciner 1 Primary Fan	<1.0	<1.0	ND	ND	*<0.005	ND	ND	8			
12	Calciner 1 Cooling Beam	<1.0	<1.0	ND		ND	ND	ND	6			
13	Kiln Bildg. East Manhole	<1.0	<1.0	ND	0.003	ND	0.004	ND	8	0.003	0.004	0.004
14	Kiln Bldg. West Manhole	<1.0	<1.0	ND		ND	0.001	0.026	7	0.001	0.026	0.014
15	Pelletizer Bldg. Manhole	<1.0	<1.0	ND	0.010	0.001	ND	0.023	8	0.001	0.023	0.011
16	Furnaces Composite	<1.0	<1.0	ND	ND	ND		ND	7			
17	Boiler House Manhole	<1.0	<1.0	ND	ND	ND	ND	ND	8			
18	Furnace 1	<1.0	<1.0	ND	0.001	ND	ND	ND	8	0.001	0.001	0.001
19	Furnace 2	<1.0	<1.0	ND	ND	ND	ND	ND	8			
20	Furnace 3	<1.0	<1.0	ND	ND	ND	0.001	ND	8	0.001	0.001	0.001
21	Furnace 4	<1.0	<1.0	ND	ND	ND	ND	ND	8			
22	Maintenance Building	<1.0	<1.0	ND	ND	ND	ND	ND	8			
23	Chlorinator Building	<1.0	<1.0	ND	ND	ND	ND	ND	8			

Table L-2 (Cont'd)

Cadmium Analysis
Industrial Waste Water Investigation, 1994

Sample ID Number	Sample Location	Sample Date								Number of Samples	Minumum Concentration Detected	Maximum Concentration Detected	Average of Concentrations Detected
		3/25/94	4/8/94	4/22/94	5/8/94	5/28/94	6/8/94	7/27/94	8/20/94				
01	Outfall	<0.01	<0.01	<0.01	ND	0.005	*<0.005	*<0.005	*<0.005	8	0.005	0.005	0.005
02	IWW Composite	<0.01	<0.01	<0.01	ND	0.002	0.011	ND	0.004	8	0.002	0.011	0.006
03	North Ditch	<0.01	<0.01	<0.01	ND	ND	0.005	ND	0.001	8	0.001	0.005	0.003
04	South Ditch	<0.01	<0.01	<0.01	ND	0.002	0.004	0.008	ND	8	0.002	0.008	0.005
05	Calciner 2 Cooler Fan 2	<0.01	<0.01	<0.01	ND	0.003	0.062	ND	ND	8	0.003	0.062	0.033
06	Calciner 2 Cooler Fan 1	<0.01	<0.01	<0.01	0.002	0.001	0.004	ND	ND	8	0.001	0.004	0.002
07	Calciner 2 Primary Air Fan	<0.01	<0.01	<0.01	ND	0.004	0.055	0.001	0.004	8	0.001	0.055	0.016
08	Calciner 2 Cooling Beam	<0.01	<0.01	<0.01			0.020	0.003	0.005	6	0.003	0.020	0.009
09	Calciner 1 Cooler Fan 2	<0.01	<0.01	<0.01	ND	0.004	0.005	ND	0.003	8	0.003	0.005	0.004
10	Calciner 1 Cooler Fan 1	<0.01	<0.01	<0.01	0.001	0.002	0.030	ND	ND	8	0.001	0.030	0.011
11	Calciner 1 Primary Fan	<0.01	<0.01	<0.01	0.003	0.003	*0.065	ND	0.004	8	0.003	0.004	0.003
12	Calciner 1 Cooling Beam	<0.01	<0.01		0.002		0.004	ND	0.003	7	0.002	0.004	0.003
13	Kiln Bldg. East Manhole	<0.01	<0.01	<0.01	0.002	0.003	ND	0.007	ND	8	0.002	0.007	0.004
14	Kiln Bldg. West Manhole	<0.01	<0.01	<0.01	ND		0.001	0.004	0.002	7	0.001	0.004	0.002
15	Pelletizer Bldg. Manhole	<0.01	<0.01	<0.01	ND	0.002	0.004	0.005	ND	8	0.002	0.005	0.004
16	Furnaces Composite	<0.01	<0.01	<0.01	0.003	ND	0.002		ND	7	0.002	0.003	0.003
17	Boiler House Manhole	<0.01	<0.01	<0.01	0.002	ND	0.003	ND	0.001	8	0.001	0.003	0.002
18	Furnace 1	<0.01	<0.01	<0.01	0.002	ND	0.002	0.008	0.005	8	0.002	0.008	0.004
19	Furnace 2	<0.01	<0.01	<0.01	0.001	ND	0.003	0.020	0.002	8	0.001	0.020	0.007
20	Furnace 3	<0.01	<0.01	<0.01	ND	ND	0.007	0.004	0.002	8	0.002	0.007	0.004
21	Furnace 4	<0.01	<0.01	<0.01	ND	ND	0.002	ND	ND	8	0.002	0.002	0.002
22	Maintenance Building	<0.01	<0.01	<0.01	0.001	ND	ND	0.001	0.001	8	0.001	0.001	0.001
23	Chlorinator Building	<0.01	<0.01	<0.01	ND	ND	0.003	ND	0.001	8	0.001	0.003	0.002

Table L-2 (Cont'd)

Chromium Analysis
Industrial Waste Water Investigation, 1994

Sample ID Number	Sample Location	Sample Date								Number of Samples	Minumum Concentration Detected	Maximum Concentration Detected	Average of Concentrations Detected
		3/25/94	4/8/94	4/22/94	5/8/94	5/28/94	6/8/94	7/27/94	8/20/94				
01	Outfall	<1.0	<0.10	<0.10	0.020	ND	*<0.010	*<0.010	*<0.030	8	0.020	0.020	0.020
02	IWW Composite	<1.0	<0.10		0.020	ND	0.028	0.007	0.013	7	0.007	0.028	0.017
03	North Ditch	<1.0	<0.10	<0.10	0.020	ND	0.002	0.004	0.016	8	0.002	0.020	0.011
04	South Ditch	<1.0	<0.10	<0.10	0.020	ND	ND	0.009	0.001	8	0.001	0.020	0.010
05	Calciner 2 Cooler Fan 2	<1.0	<0.10	<0.10	0.030	ND	0.015	0.002	0.006	8	0.002	0.030	0.013
06	Calciner 2 Cooler Fan 1	<1.0	<0.10	<0.10	0.030	ND	ND	0.005	0.001	8	0.001	0.030	0.012
07	Calciner 2 Primary Air Fan	<1.0	<0.10	<0.10	0.020	0.001	0.011	0.004	0.016	8	0.001	0.020	0.010
08	Calciner 2 Cooling Beam	<1.0	<0.10	<0.10			0.006	0.003	0.013	7	0.003	0.013	0.007
09	Calciner 1 Cooler Fan 2	<1.0	<0.10	<0.10	0.020	0.004	ND		ND	7	0.004	0.020	0.012
10	Calciner 1 Cooler Fan 1	<1.0	<0.10	<0.10	0.020	ND	0.006	0.002	ND	8	0.002	0.020	0.009
11	Calciner 1 Primary Fan	<1.0	<0.10	<0.10	0.020	0.003	*0.026	0.002	0.011	8	0.002	0.020	0.009
12	Calciner 1 Cooling Beam	<1.0	<0.10		0.020		ND	0.004	ND	6	0.004	0.020	0.012
13	Kiln Bildg. East Manhole	<1.0	<0.10	<0.10	0.030	ND	ND	ND	ND	8	0.030	0.030	0.030
14	Kiln Bldg. West Manhole	<1.0	<0.10	<0.10	0.020		ND	ND	0.026	7	0.020	0.026	0.023
15	Pelletizer Bldg. Manhole	<1.0	<0.10	<0.10	0.030	ND	0.007	0.003	0.023	8	0.003	0.030	0.016
16	Furnaces Composite	<1.0	<0.10	<0.10	0.030	ND	0.003		ND	7	0.003	0.030	0.017
17	Boiler House Manhole	<1.0	<0.10	<0.10	0.030	ND	0.004	ND	0.016	8	0.004	0.030	0.017
18	Furnace 1	<1.0	<0.10	<0.10	0.020	ND	0.004	ND	0.020	8	0.004	0.020	0.015
19	Furnace 2	<1.0	<0.10	<0.10	0.030	ND	0.002	ND	0.014	8	0.002	0.030	0.015
20	Furnace 3	<1.0	<0.10	<0.10	0.040	0.006	0.006	ND	0.014	8	0.006	0.040	0.017
21	Furnace 4	<1.0	<0.10	<0.10	0.030	ND	ND	0.005	0.049	8	0.005	0.049	0.028
22	Maintenance Building	<1.0	<0.10	<0.10	0.030	0.007	0.007	0.005	0.021	8	0.005	0.030	0.014
23	Chlorinator Building	<1.0	<0.10	<0.10	0.030	0.002	0.003	ND	0.023	8	0.002	0.030	0.015

Table L-2 (Cont'd)

Lead Analysis
Industrial Waste Water Investigation, 1994

Sample ID Number	Sample Location	Sample Date							Number of Samples	Minumum Concentration Detected	Maximum Concentration Detected	Average of Concentrations Detected
		3/25/94	4/8/94	5/8/94	5/28/94	6/8/94	7/27/94	8/20/94				
01	Outfall	<1.0	<1.0	0.030	ND	*<0.050	*<0.20	<*0.20	8	0.030	0.030	0.030
02	IWW Composite	<1.0	<1.0	ND	ND	ND	ND	ND	8			
03	North Ditch	<1.0	<1.0	0.020	ND	ND	ND	ND	8	0.020	0.020	0.020
04	South Ditch	<1.0	<1.0	0.008	ND	0.012	ND	ND	8	0.008	0.012	0.010
05	Calciner 2 Cooler Fan 2	<1.0	<1.0	0.030	ND	0.008	ND	ND	8	0.008	0.030	0.019
06	Calciner 2 Cooler Fan 1	<1.0	<1.0	ND	ND	ND	ND	ND	8			
07	Calciner 2 Primary Air Fan	<1.0	<1.0	ND	0.020	ND	ND	ND	8	0.020	0.020	0.020
08	Calciner 2 Cooling Beam	<1.0	<1.0			0.026	ND	ND	6	0.026	0.026	0.026
09	Calciner 1 Cooler Fan 2	<1.0	<1.0	ND	0.007	ND	ND	ND	8	0.007	0.007	0.007
10	Calciner 1 Cooler Fan 1	<1.0	<1.0	ND	0.030	ND	ND	ND	8	0.030	0.030	0.030
11	Calciner 1 Primary Fan	<1.0	<1.0	ND	0.003	*<0.050	ND	ND	8	0.003	0.003	0.003
12	Calciner 1 Cooling Beam	<1.0	<1.0	ND		ND	ND	ND	6			
13	Kiln Bildg. East Manhole	<1.0	<1.0	ND	0.028	ND	ND	ND	8	0.028	0.028	0.028
14	Kiln Bldg. West Manhole	<1.0	<1.0	ND		0.007	ND	ND	7	0.007	0.007	0.007
15	Pelletizer Bldg. Manhole	<1.0	<1.0	ND	0.040	ND	ND	ND	8	0.040	0.040	0.040
16	Furnaces Composite	<1.0	<1.0	0.007	ND	ND		ND	7	0.007	0.007	0.007
17	Boiler House Manhole	<1.0	<1.0	ND	0.013	ND	ND	ND	8	0.013	0.013	0.013
18	Furnace 1	<1.0	<1.0	ND	ND	0.009	ND	ND	8	0.009	0.009	0.009
19	Furnace 2	<1.0	<1.0	ND	ND	ND	ND	ND	8			
20	Furnace 3	<1.0	<1.0	0.003	ND	ND	ND	ND	8	0.003	0.003	0.003
21	Furnace 4	<1.0	<1.0	ND	ND	0.003	ND	ND	8	0.003	0.003	0.003
22	Maintenance Building	<1.0	<1.0	0.004	ND	ND	ND	ND	8	0.004	0.004	0.004
23	Chlorinator Building	<1.0	<1.0	ND	ND	0.004	ND	ND	8	0.004	0.004	0.004

Table L-2 (Cont'd)

Selenium Analysis
Industrial Waste Water Investigation, 1994

Sample ID Number	Sample Location	Sample Date							Number of Samples	Minumum Concentration Detected	Maximum Concentration Detected	Average of Concentrations Detected
		3/25/94	4/8/94	5/8/94	5/28/94	6/8/94	7/27/94	8/20/94				
01	Outfall	<1.0	<1.0	<0.2	ND	*<0.10	*<0.3	<*0.30	8			
02	IWW Composite	<1.0	<1.0	0.040	ND	ND	ND	ND	8	0 04	0 04	0.04
03	North Ditch	<1.0	<1.0	0.060	ND	ND	ND	ND	8	0 06	0 06	0.06
04	South Ditch	<1.0	<1 0	ND	ND	ND	ND	ND	8			
05	Calciner 2 Cooler Fan 2	<1.0	<1.0	ND	ND	ND	ND	ND	8			
06	Calciner 2 Cooler Fan 1	<1.0	<1.0	ND	ND	ND	ND	ND	8			
07	Calciner 2 Primary Air Fan	<1.0	<1.0	ND	0.060	ND	ND	ND	8	0 06	0 06	0.06
08	Calciner 2 Cooling Beam	<1.0	<1.0			ND	ND	ND	6			
09	Calciner 1 Cooler Fan 2	<1.0	<1.0	ND	0.079	ND	ND	ND	8	0 079	0 079	0.08
10	Calciner 1 Cooler Fan 1	<1.0	<1.0	ND	ND	ND	ND	ND	8			
11	Calciner 1 Primary Fan	<1.0	<1.0	ND	0.108	*<0.10	ND	ND	8	0.108	0.108	0.11
12	Calciner 1 Cooling Beam	<1.0	<1.0	ND		ND	ND	ND	7			
13	Kiln Bildg. East Manhole	<1.0	<1.0	0.250	0.182	ND	ND	ND	8	0 182	0.25	0.22
14	Kiln Bldg. West Manhole	<1.0	<1.0	ND		ND	ND	ND	7			
15	Pelletizer Bldg. Manhole	<1.0	<1.0	ND	0.041	ND	ND	ND	8	0.041	0.041	0.04
16	Furnaces Composite	<1.0	<1.0	ND	0.080	0.185		ND	7	0 08	0.185	0.13
17	Boiler House Manhole	<1.0	<1.0	0.140	0.125	ND	ND	ND	8	0.125	0.14	0.13
18	Furnace 1	<1.0	<1.0	ND	ND	ND	ND	ND	8			
19	Furnace 2	<1.0	<1.0	0.170	ND	ND	ND	ND	8	0 17	0.17	0.17
20	Furnace 3	<1.0	<1.0	0.290	ND	ND	ND	ND	8	0.29	0 29	0.29
21	Furnace 4	<1.0	<1.0	0.070	ND	0.176	ND	ND	8	0.07	0.176	0.12
22	Maintenance Building	<1.0	<1.0	ND	ND	ND	ND	ND	8			
23	Chlorinator Building	<1.0	<1.0	0.030	ND	0.391	ND	ND	8	0 03	0.391	0.21

Table L-2 (Cont'd)

Silver Analysis
Industrial Waste Water Investigation, 1994

Sample ID Number	Sample Location	Sample Date							Number of Samples	Minumum Concentration Detected	Maximum Concentration Detected	Average of Concentrations Detected
		3/25/94	4/8/94	5/8/94	5/28/94	6/8/94	7/27/94	8/20/94				
01	Outfall	<1.0	<1.0	<0.2	ND	*<0.010	*<0.02	<*0.02	7			
02	IWW Composite	<1.0	<1.0	<0.2	ND	ND	ND	ND	7			
03	North Ditch	<1.0	<1.0	<0.2	ND	ND	ND	ND	7			
04	South Ditch	<1.0	<1.0	<0.2	ND	ND	ND	ND	7			
05	Calciner 2 Cooler Fan 2	<1.0	<1.0	<0.2	ND	ND	ND	ND	7			
06	Calciner 2 Cooler Fan 1	<1.0	<1.0	<0.2	ND	ND	ND	ND	7			
07	Calciner 2 Primary Air Fan	<1.0	<1.0	<0.2	ND	ND	ND	ND	7			
08	Calciner 2 Cooling Beam	<1.0	<1.0			0.002	ND	ND	5	0.002	0.002	0.002
09	Calciner 1 Cooler Fan 2	<1.0	<1.0	<0.2	ND	ND	ND	ND	7			
10	Calciner 1 Cooler Fan 1	<1.0	<1.0	<0.2	ND	ND	ND	ND	7			
11	Calciner 1 Primary Fan	<1.0	<1.0	<0.2	ND	*<0.010	ND	ND	7			
12	Calciner 1 Cooling Beam	<1.0	<1.0	<0.2		0.024	ND	ND	6	0.024	0.024	0.024
13	Kiln Bldg. East Manhole	<1.0	<1.0	<0.2	1.360	0.011	ND	ND	7	0.011	1.36	0.686
14	Kiln Bldg. West Manhole	<1.0	<1.0	<0.2		ND	ND	ND	6			
15	Pelletizer Bldg. Manhole	<1.0	<1.0	<0.2	ND	ND	ND	ND	7			
16	Furnaces Composite	<1.0	<1.0	<0.2	ND	ND		ND	6			
17	Boiler House Manhole	<1.0	<1.0	<0.2	ND	ND	ND	ND	7			
18	Furnace 1	<1.0	<1.0	<0.2	ND	ND	ND	ND	7			
19	Furnace 2	<1.0	<1.0	<0.2	ND	ND	ND	0.073	7	0.073	0.073	0.073
20	Furnace 3	<1.0	<1.0	<0.2	ND	ND	ND	0.019	7	0.019	0.019	0.019
21	Furnace 4	<1.0	<1.0	<0.2	ND	ND	ND	ND	7			
22	Maintenance Building	<1.0	<1.0	<0.2	ND	ND	ND	ND	7			
23	Chlorinator Building	<1.0	<1.0	<0.2	ND	ND	ND	ND	7			

Table L-2 (Cont'd)

Vanadium Analysis
Industrial Waste Water Investigation, 1994

Sample ID Number	Sample Location	Sample Date								Number of Samples	Minumum Concentration Detected	Maximum Concentration Detected	Average of Concentrations Detected
		3/25/94	4/8/94	4/22/94	5/8/94	5/28/94	6/8/94	7/27/94	8/20/94				
01	Outfall	<1.0	<0.10	<0.10	0.003	0.006	*<0.050	*<0.02	*<0.02	8	0.003	0.006	0.005
02	IWW Composite	<1.0	<0.10	<0.10	0.009	0.009	0.003	0.011	ND	8	0.003	0.011	0.008
03	North Ditch	<1.0	<0.10	<0.10	0.006	0.005	0.004	0.005	ND	8	0.004	0.006	0.005
04	South Ditch	<1.0	<0.10	<0.10	0.006	0.003	0.003	0.013	ND	8	0.003	0.013	0.006
05	Calciner 2 Cooler Fan 2	<1.0	<0.10	<0.10	0.007	0.004	0.013	0.016	ND	8	0.004	0.016	0.010
06	Calciner 2 Cooler Fan 1	<1.0	<0.10	<0.10	0.007	0.004	ND	ND	ND	8	0.004	0.007	0.006
07	Calciner 2 Primary Air Fan	<1.0	<0.10	<0.10	0.002	0.014	0.011	ND	ND	8	0.002	0.014	0.009
08	Calciner 2 Cooling Beam	<1.0	0.100	<0.10			0.006	ND	0.012	6	0.006	0.100	0.039
09	Calciner 1 Cooler Fan 2	<1.0	0.200	<0.10	ND	0.009	0.003	ND	0.026	8	0.003	0.200	0.060
10	Calciner 1 Cooler Fan 1	<1.0	<0.10	<0.10	0.002	0.009	0.004	ND	0.029	8	0.002	0.029	0.011
11	Calciner 1 Primary Fan	<1.0	0.200	<0.10	0.003	0.004	*<0.050	ND	0.029	8	0.003	0.200	0.059
12	Calciner 1 Cooling Beam	<1.0	0.040		0.003		0.005	ND	ND	6	0.003	0.040	0.016
13	Kiln Bildg. East Manhole	<1.0	0.020	<0.10	0.009	0.038	ND	ND	0.002	8	0.002	0.038	0.017
14	Kiln Bldg. West Manhole	<1.0	0.020	<0.10	ND		ND	ND	ND	7	0.020	0.020	0.020
15	Pelletizer Bldg. Manhole	<1.0	<0.10	<0.10	ND	0.002	0.011	ND	ND	8	0.002	0.011	0.007
16	Furnaces Composite	<1.0	<0.10	<0.10	0.002	0.004	0.008		0.003	7	0.002	0.008	0.004
17	Boiler House Manhole	<1.0	<0.10	<0.10	0.006	0.003	0.001	ND	ND	8	0.001	0.006	0.003
18	Furnace 1	<1.0	<0.10	<0.10	ND	0.001	ND	ND	0.001	8	0.001	0.001	0.001
19	Furnace 2	<1.0	<0.10	<0.10	ND	0.001	ND	ND	ND	8	0.001	0.001	0.001
20	Furnace 3	<1.0	<0.10	<0.10	ND	ND	ND	0.003	ND	8	0.003	0.003	0.003
21	Furnace 4	<1.0	<0.10	<0.10	ND	0.001	0.002	0.001	ND	8	0.001	0.002	0.001
22	Maintenance Building	<1.0	<0.10	<0.10	0.007	0.001	ND	ND	ND	8	0.001	0.007	0.004
23	Chlorinator Building	<1.0	<0.10	<0.10	0.005	ND	ND	ND	ND	8	0.005	0.005	0.005

Table L-2 (Cont'd)

Zinc Analysis
Industrial Waste Water Investigation, 1994

Sample ID Number	Sample Location	Sample Date								Number of Samples	Minumum Concentration Detected	Maximum Concentration Detected	Average of Concentrations Detected
		3/25/94	4/8/94	4/22/94	5/8/94	5/28/94	6/8/94	7/27/94	8/20/94				
01	Outfall	<0.10	<0.10	<0.10	ND	ND	0.078	*<0.04	*0.04	8	0.078	0.078	0.078
02	IWW Composite	<0.10	<0.10	<0.10	ND	0.010	0.030	0.002	0.040	8	0.002	0.040	0.021
03	North Ditch	<0.10	<0.10	<0.10	ND	0.040	0.014	0.036	0.124	8	0.014	0.124	0.054
04	South Ditch	<0.10	<0.10	<0.10	ND	ND	ND	0.075	0.027	8	0.027	0.075	0.051
05	Calciner 2 Cooler Fan 2	<0.10	<0.10	<0.10	ND	0.005	4.220	ND	0.028	8	0.005	4.220	1.418
06	Calciner 2 Cooler Fan 1	<0.10	<0.10	<0.10	ND	ND	0.089	ND	0.050	8	0.050	0.089	0.070
07	Calciner 2 Primary Air Fan	<0.10	<0.10	<0.10	ND	0.013	3.900	0.001	0.058	8	0.001	3.900	0.993
08	Calciner 2 Cooling Beam	<0.10	0.100	<0.10			0.904	0.011	0.012	6	0.011	0.904	0.257
09	Calciner 1 Cooler Fan 2	<0.10	0.200	<0.10	0.004	0.003	0.109	0.001	0.026	8	0.001	0.200	0.057
10	Calciner 1 Cooler Fan 1	<0.10	<0.10	<0.10	ND	ND	1.990	ND	0.029	8	0.029	1.990	1.010
11	Calciner 1 Primary Fan	<0.10	0.200	<0.10	ND	0.010	*3.90	ND	0.029	8	0.010	0.200	0.080
12	Calciner 1 Cooling Beam	<0.10	0.040		0.020		0.063	ND	0.011	7	0.011	0.063	0.034
13	Kiln Bldg. East Manhole	<0.10	0.020	<0.10	ND	ND	ND	ND	0.001	8	0.001	0.020	0.010
14	Kiln Bldg. West Manhole	<0.10	0.020	<0.10	ND		ND	ND	0.000	7	0.000	0.020	0.010
15	Pelletizer Bldg. Manhole	<0.10	<0.10	<0.10	ND	ND	0.002	ND	ND	8	0.002	0.002	0.002
16	Furnaces Composite	<0.10	<0.10	<0.10	ND	ND	ND		ND	7			
17	Boiler House Manhole	<0.10	<0.10	<0.10	ND	ND	ND	ND	0.004	8	0.004	0.004	0.004
18	Furnace 1	<0.10	<0.10	<0.10	ND	ND	ND	0.233	0.005	8	0.005	0.233	0.119
19	Furnace 2	<0.10	<0.10	<0.10	ND	ND	0.015	0.950	ND	8	0.015	0.950	0.483
20	Furnace 3	<0.10	<0.10	<0.10	ND	ND	0.086	ND	ND	8	0.086	0.086	0.086
21	Furnace 4	<0.10	<0.10	<0.10	ND	ND	0.010	ND	ND	8	0.010	0.010	0.010
22	Maintenance Building	<0.10	<0.10	<0.10	ND	ND	ND	0.007	ND	8	0.007	0.007	0.007
23	Chlorinator Building	<0.10	<0.10	<0.10	ND	ND	ND	ND	ND	8			

Evaluation of Volumes and Characteristics of Wastes Potentially Containing Elemental Phosphorus in Former Pond Areas in the Western Portion of the FMC Facility

M.1 PURPOSE

The purpose of this report is to provide sufficient data on the location, character, areal extent and volume of the former unlined ponds at FMC such that intrusive sampling in these areas is not needed to satisfy the requirements of the Remedial Investigations/Feasibility Study (RI/FS). These areas either have a high potential for containing significant amounts of elemental phosphorus which would oxidize when exposed to air, or are located beneath newer, lined ponds which are currently active and managed under RCRA, or are themselves in the process of being closed.

M.2 BACKGROUND

The evaluation of potential source areas as described in the RI/FS Work Plan includes the possible drilling of former pond locations where wastes are likely to contain localized concentrations of elemental phosphorus. Eight such borings were proposed for the Phase II investigations in the summer of 1993, assuming sampling, sample handling and analytical methods which would adequately address health and safety concerns could be developed.

FMC began development of potential drilling and sampling methodologies for characterization of the contents of the former ponds with HOMCO International, Inc. of Casper, Wyoming, and sampling and analytical methods with Mountain States Analytical, Inc. (MSAI) of Salt Lake City, Utah. As method development progressed, it became apparent that there were significant difficulties to overcome in all three areas, and that such a program would be very costly.

During the investigations for planning the closure of existing Pond 8S, an unlined pond similar to those which were formerly used at the facility, it became apparent that these evaluations were pertinent to characterizing the contents of the former pond areas and their significance as sources of chemicals of potential concern.

When the Pond 8S closure plans were completed, the analyses were discussed with the EPA in a meeting in Seattle, Washington in April 1993. The discussion focused on the fact that the former ponds were very similar to the Pond 8S conditions, both physically and chemically, and that the characterization of Pond 8S with respect to the presence and potential migration of chemicals of potential concern was therefore representative of the former ponds. The potential source investigations which were done in the areas of former Ponds 1E, 4E, 5E and 6E indicate similar conditions to those found at Pond 8S (See Preliminary Site Characterization Summary, Section 4.2.3).

FMC reported that both the laboratory analytical work and the drilling and sampling would be potentially hazardous and very expensive to complete, even for a single boring at each pond location. Additionally, while drilling and sampling would provide data on physical and chemical properties at a single location within the former pond areas, it would provide little information not already understood from the Pond 8S analyses. FMC approached the EPA on the subject of developing the volume and aerial extent data for the former ponds on the basis of historical data, without completing the pending drilling in areas where high potential for encountering elemental phosphorus exists. EPA indicated that if FMC could provide reasonable data from historical files, this would be a sufficient characterization of the potential sources constituted by the former ponds.

As part of the characterization of potential sources at the FMC facility, data on history and use of the former unlined phosphorus wastewater ponds were compiled to estimate the areal extent and volume of the material that may be present in the former pond areas. This information was developed through review of various documents and production records, rather than through intrusive sampling methods. The data compiled from this review, combined with the analysis prepared for the Pond 8S closure plan, provides adequate data for the RI/FS evaluations which will lead to the development of remedial alternatives and the proposed plan for site remediation.

This report provides the data for 16 former ponds, with estimates of the volume of material in storage at each location developed on the basis of plant production records, areal extent, and operational life of the ponds. The areal extent of these former ponds has been developed from historical plant drawings and aerial photographs.

Also included in this report are discussions of the development of methods for drilling, sampling, sample handling, and laboratory analyses of materials which contain concentrations of elemental phosphorus. The sample handling and analytical methods developed with MSAI are included in Attachment A. The estimated costs related to performing these activities at the EMF site are also briefly discussed, and the data for development of the costs are included in Attachment B.

M.3 HISTORY OF POND DEVELOPMENT AT THE FMC FACILITY

The FMC facility was built in 1949, and the furnace technology used at that time was the same as that currently employed at the plant. The first electric arc furnace was brought on line in 1950, and had an electrostatic precipitator as an integral part of the process. Between 1950 and 1953, three more furnaces were added to the process. As the facility continued to operate, the furnace capacities were also increased.

Between 1950 and 1962, rotary kilns were used for benefication of the ore, rather than the present day calciners. Calciners were installed in 1960 and 1967. The effluent from the kiln scrubbers was discharged to the kiln ponds (now located

beneath the #2 calciner), and from there to the kiln overflow pond (now located under the calciner fines area). These wastes were deposited in the east-central portion of the facility, away from the locations of the old wastewater ponds. Blowdown from the calciners and the Medusa scrubbers was sent to former Ponds 1C and 2C, which were constructed in 1965 and 1979 respectively. New lined ponds for calciner and the Medusa scrubber blowdown, also designated 1C and 2C, were constructed just north of these ponds. Sludge was removed from the old calciner ponds, and new lined Ponds 3C and 4C now occupy this area as well. These ponds will not be discussed further, as the focus in this report is on the former ponds with a high potential for containing elemental phosphorus.

Between 1949 and 1954, precipitator dust was handled in a dry form. There were a number of operational and safety problems with this method of operation, and in 1954-1955, slurry systems were installed for all the precipitators. To handle the slurry, a series of unlined disposal ponds have been developed throughout the west-central portion of the facility, as shown on Figure M-1. Early ponds were unlined; however, ponds constructed after 1976 (Ponds 8E, 9E, and 10S through 16S) have been lined. These ponds were used to store both the "phossy" water from the phosphorus loading dock (phos dock) area and the precipitator slurry from the furnace operations.

Between 1954 and 1957, precipitator solids were deposited in Ponds 00S and 0S along with the phossy water generated from the phos dock. The exact location of these former ponds is uncertain. In 1957, Pond 1S was brought into service and was operated from 1957 through 1961 (see Table M-1 and Figure M-3). As one pond was filled, another was brought into service. A total of sixteen (16) unlined ponds (1S through 9S and 1E through 7E) were developed for this purpose. This practice continued unchanged until the lined ponds were constructed. The first lined pond constructed was Pond 10S. This pond was constructed in 1976. It managed precipitator slurry from the fluidized bed drier until 1989. All ponds constructed since 1976 were lined. All lined ponds (11S through 16S, 8E and 9E) which currently contain liquids are regulated under RCRA. The only pond currently receiving precipitator slurry and RCRA hazardous phossy water is Pond 16S.

M.4 POTENTIAL SOURCE INVESTIGATIONS

M.4.1 Proposed Investigations for the Former Unlined Ponds

When the Phase II Work Plan for the RI was prepared, it included eight proposed borings in the areas of the old ponds that contained plant wastes and byproducts. The locations of these proposed borings are shown on Figure M-2. Several other old ponds are under newer, lined ponds which currently contain precipitator slurry and phossy water wastes. Therefore, these areas are not accessible for drilling. Prior to drilling in the old pond areas, the drilling and sampling methods were to be tested first in an area where no elemental phosphorus was present, such as the undeveloped westernmost portion of the FMC facility, and then a test sample taken

in an area expected to encounter elemental phosphorus. The purpose of this test program was two-fold; test the method, and to make certain all personnel are familiar with the procedures prior to actual sampling.

Once the methods had been developed sufficiently, estimates of the cost of drilling, sampling, and performing the analyses on the samples was estimated by the three subcontractors (Bechtel, Homco, and Mountain States). The cost of drilling and sampling of the proposed borings was estimated to be about $450,000. A summary of the estimated costs are provided in Attachment B.

M.5 ALTERNATIVE METHODS FOR POND CHARACTERIZATION

The EPA has indicated that there are four data needs for the former ponds; an estimate of the amount of elemental phosphorus in the former ponds, analysis of the waste streams, estimates of the volume of each former pond, and potential for migration of chemicals of concern. The following sections address these concerns, drawing significantly on the work performed for the Pond 8S Closure.

M.5.1 Pond 8S Studies and Estimates of Elemental Phosphorus

At the time the Phase II drilling program was being developed, significant hydrogeological and chemical data were being collected and evaluated for former Pond 8S, as part of preparing the RCRA Closure Plan for this former pond. The Pond 8S Closure Plan included a model of solute transport from the pond developed using numerical modeling techniques. As indicated earlier, all of the former unlined ponds received similar byproducts and wastes, and with the exception of the change from rotary kiln to calciner operations, the plant operations have remained virtually the same since the fourth furnace went on line in 1953.

During the development of the Pond 8S model, all the FMC groundwater wells were sampled (September 1992) and analyzed for P_4. MSAI performed the analyses using analytical procedures developed by FMC. These data were included in the 8S Closure Plan. It should be noted that these analyses have not been validated, as there is no approved method for this analysis. The data indicated that phosphorus was not migrating in the form of elemental phosphorus. Therefore, the elemental phosphorus content of the ponds would not be a concern with respect to migration of elemental phosphorus to the groundwater.

M.5.2 Waste Stream Analysis

As stated earlier, the furnace technology and operation at the plant is essentially the same as it was in 1950 when the first furnace was placed in service. Throughout the years, the efficiency of the recovery of elemental phosphorus has increased through the development of better precipitators, changes in mining technology, and changes in the phos dock equipment.

FMC has tracked efficiency rates since the early 1970's. Therefore, an analysis of current concentrations of constituents other than elemental phosphorus will be conservative with respect to the concentrations of these constituents that would have been present in the waste streams in earlier years. The recent analyses of the waste streams performed as part of the potential source investigations during the RI are sufficient to characterize precipitator slurry and phossy water. The degree of uncertainty in the constituent concentrations within the ponds derived from these analyses is much less than the accuracy of estimates of the volumes of wastes sent to the former ponds. Estimated volumes of waste materials produced and their elemental phosphorus content are shown on Table M-2.

M.5.3 Migration of Chemicals of Potential Concern

The potential source investigations performed at the FMC facility for the RI are discussed in Section 2.1.2 of the Preliminary Site Characterization Summary (PSCS). Borings were drilled in the areas of former ponds 8S, 1E, 4E, 5E and 6E. Additionally, there are many groundwater monitoring wells both upgradient and downgradient from all the former pond areas.

Section 4.2.3 of the PSCS describes the results of the potential source investigations, including descriptions of the physical and chemical characteristics of the waste streams at the FMC Facility. Section 4.4.2 discusses the impact of these former ponds on the groundwater flowing beneath the FMC facilities.

M.5.4 Volumes of the Former Ponds

FMC has determined the approximate operational lifetime of each of the former ponds through interviews with long-term employees. Additionally, the surface area of each pond has been determined from historic aerial photographs. The volumes of the former ponds have been calculated from information obtained from interviews which provide data on the depths of the old ponds, and from some borings in the areas of the old ponds. The following is a discussion of each of the sixteen unlined ponds, describing its history, volume, and current status.

M.6 OPERATION AND HISTORY OF UNLINED PONDS AT THE FMC FACILITY

M.6.1 General

This section describes the history of pond construction and operation as it applies to estimation of pond areas, volumes of materials placed in the ponds, and volumes likely to be present in the former pond locations today.

Table M-2 is a summary of production rates of solids (by dry weight) as an estimated percentage of total elemental phosphorus production. This is based on recovery efficiency rates for those years, and a ratio of precipitator solids and phossy water

solids to the amount of elemental phosphorus produced. The ratio of elemental phosphorus to total solids for the years 1961 through 1970 was derived by taking the average of the first five years of this record (1971 through 1976), and applying it to the solids production estimates for 1961 through 1970. A lower ratio was applied to the estimates for 1954 through 1960, when the rotary kilns were in operation.

These data were applied to the information compiled on the operational life of the former ponds, and volumes were allocated to individual ponds or groups of ponds active during the year. Table M-3 provides data on the operational history of the former ponds, indicating the years and number of months per year that Ponds 1S through 9S and 1E through 7E were in operation for the period from 1954 through 1976. Figure M-3 is a graphic presentation of the operational periods of the various wastewater ponds. It should be noted that at various times, material was removed from the ponds and either blended back with the shale and reprocessed, or dried and sold as a separate product. Therefore, production of phossy water and precipitator slurry wastes in excess of pond capacity should be expected to occur.

Volumes of solids remaining in place in the various former pond locations were calculated from data on the areal extent of the ponds and estimates of the depth of these solids in the former pond areas. The areal extent was determined from historic maps and aerial photographs. The depth of materials in the ponds was estimated from interviews with former employees, and in some instances, data from borings. A summary of the areas and volumes of the former unlined ponds is provided in Table M-4.

The volumes in the ponds could not be estimated from production data. Materials were periodically removed from the ponds and P_4 was reclaimed from these materials. Some material was also blended with the ore processed by either kiln or calciner methods, and sent on to the furnace. Additionally, at various times the dried wastes were reclaimed and sold.

It should also be noted that the volumes estimated from production data are based on the dry weight of the materials. A brief history, and an estimate of the area and volume of each of the former unlined wastewater pond is provided in the following paragraphs.

M.6.2 Former Pond 1S

Former Pond 1S was completed in about 1956, and had a surface area of only about one-half an acre (21,800 ft^2). This pond contained slurry material to a depth of about 11 feet. Some P_4 was reclaimed from this former pond between 1966 and 1972. Residuals from the reclaim operation were placed in Pond 3S. Pond 1S was dried and capped in 1972. The area was disturbed during the excavation of a power line trench in 1976, and the contents oxidized. In 1991, this area was estimated to contain about 2,850 tons (2,400 yd^3) of phossy waste material.

M.6.3 Former Pond 2S

Former Pond 2S was also completed in about 1956, and had a surface area of about 0.8 acre (34,850 ft^2). Depth of slurry material was estimated to be similar to that in pond 1S, or about 11 feet. Some P_4 was reclaimed from this former pond between 1966 and 1972. Residuals from the reclaim operation were placed in Pond 3S. This pond was also dried and capped in 1972. In 1991, this area was estimated to contain about 1,050 tons (875 yd^3) of phossy waste material.

M.6.4 Former Pond 3S

Former Pond 3S was constructed in November 1961. It was used from November 1961 until some time in 1965. It was routinely dug out twice a year during the time it was in operation. Between 1972 and 1976, phosphorus was reclaimed from the eastern 100 feet of this former pond, and the area was backfilled with slag. The rest of the pond area was dried between June and December of 1976, and then covered with dirt and slag. Pond 3S had a surface area of about 1.2 acres (52,300 ft^2), and was about 20 feet deep. It is estimated to contain about 10,600 tons (8,800 yd^3) of phossy wastes, primarily precipitator slurry.

M.6.5 Former Pond 4S

Pond 4S, located south of Pond 3S, was constructed in April 1966. This pond, with an area of 0.8 acre (34,850 ft^2) operated for a period of about one year, receiving precipitator slurry. This pond was estimated to contain about 6.4 feet of slurry, or an estimated 7,800 tons (6,500 yd^3) of phossy waste material (precipitator slurry). It was isolated for drying in June of 1976, and covered with dirt and slag in the latter part of the year.

M.6.6 Former Pond 5S

Pond 5S received primarily phossy water and phossy solids, creating a residual waste with a very high phosphorus content. This pond had an area of about one acre (43,560 ft^2) and contained residual slurry to a depth of about 6.4 feet. This pond was in operation from 1965 through 1967. Closed and dried in 1975-76, it proved difficult to dry due to the high phosphorus content of the waste. It was covered with baghouse dust, dirt, fluid bed drier prills and dust, slag, and a soil cap over the top. It is estimated that about 10,200 tons (8,500 yd^3) of phossy waste material remains in this former pond area.

M.6.7 Former Pond 6S

Pond 6S was about twice the size of any of the earlier ponds, with a surface area of about 2.3 acres (100,200 ft^2), and a depth of about 4 feet. This pond operated from 1967 through 1969 and received primarily precipitator slurry, with some phossy water and phossy solids. The phossy solids were placed in the northeast corner.

This pond was dried in 1976, capped with slag and dirt, and a new haul road was constructed over the south end of the area. It is estimated that about 29,500 tons (24,600 yd^3) of phossy waste material remains in this former pond area.

M.6.8 Former Pond 7S

Constructed in 1969 and in service for about 18 months, Pond 7S, at 3.6 acres (156,800 ft^2), was the largest pond placed in service to that date. This pond received primarily precipitator slurry. When closed in 1980, there were some areas where there were high concentrations of phosphorus. These areas were capped with concrete. The entire area was then capped with 6 to 10 feet of slag and three feet of soil placed over the slag. This area is estimated to contain about 21,800 tons (18,200 yd^3) of residual phossy wastes.

M.6.9 Former Pond 8S

Pond 8S was constructed in October 1970 and received phossy water. This pond was also used in a pilot phosphorus recovery project from 1982 through 1990. Pond 8S has a surface area of about 3.1 acres (135,000 ft^2) and has about 15 feet of phossy wastes in the bottom. The volume of these wastes is difficult to estimate, as they have not been dried and capped as the other ponds have been. The volume after capping will probably be similar to that of Pond 7S, which is of similar size. Pond 7S is estimated to contain about 21,800 tons (18,200 yd^3) of phossy wastes. The wastes in Pond 8S are high in phosphorus content. Pond 8S is currently (summer 1994) in the process of being capped.

M.6.10 Former Pond 9S

The four-acre (174,250 ft^2) Pond 9S was constructed in 1971 to receive precipitator slurry. The pond operated until about 1974. In October of 1980, the material was dried in place without a cover, and the dried material was excavated and sold during the summer of 1981. This area was used as a storage area for dried precipitator dust between 1981 and July 1991. FMC discontinued the sale of precipitator dust as a product in July 1991. Some small local pockets of precipitator slurry may remain in this area, but in general, the material has been removed and sold.

M.6.11 Former Pond 1E

Pond 1E was constructed in April of 1965 and had a variety of uses. This 1.9 acre (82,750 ft^2) pond was used as a drying pond for various wastes, and for temporary storage of dried precipitator slurry. The pond was dried in October of 1980, but was used again as a temporary storage and loadout site for dried precipitator slurry dredged from ponds 8E and 9E. This area is estimated to contain about 10,800 tons (9,000 yd^3) of residual phossy waste materials.

M.6.12 Former Pond 2E

Former Pond 2E was a 3.3 acre (143,750 ft^2) pond established in April 1965. It received phossy water and carryover fine solids from upstream ponds until October 1967. The site was also used for fluid bed drier product storage. This pond was excavated in 1984 for the construction of lined Pond 8E. The residual slurry materials were moved to nearby Pond 4E.

M.6.13 Former Pond 3E

Pond 3E was put into service in May 1967 and received phossy wastes until September 1970. With a surface area of 10.4 acres (453,000 ft^2), this was the largest unlined pond constructed at the facility. The pond received phossy water and carryover fine solids from upstream ponds. Some of this material was removed and sold. This pond was excavated for the construction of the lined Phase IV Ponds (11S, 12S, 13S and 14S) in 1980.

M.6.14 Former Pond 4E

Pond 4E was also put into service in May 1967 and received phossy wastes periodically until 1982. Pond 4E had a surface area of about 1.8 acres (78,400 ft^2). The pond received precipitator slurry overflow, residual solids from Pond 2E modifications, carryover fine solids from upstream ponds, and slag-contaminated dried precipitator dust. The site was also used for fluid bed drier product storage. This pond was dried in 1980 and the dried material was sold. As described above, the area was used occasionally for storage of waste materials between 1980 and 1982. This area, adjacent to the southern boundary of the Phase IV ponds (11S-14S), is estimated to contain about 34,850 tons (29,000 yd^3) of residual phossy waste materials. The area has not been capped.

M.6.15 Former Pond 5E

Former Pond 5E was a 6.6 acre (287,500 ft^2) pond established in April 1968. This pond received wastes until 1972-1973. The pond received phossy water and minor carryover fine solids from upstream ponds. The pond was dried in October 1980, and 4 to 6 inches of dried gray dirt was removed and placed in the area just south of lined Pond 15S. New pond 15S was constructed in 1982 over former Ponds 5E, 6E, and the eastern portion of Pond 7E.

M.6.16 Former Pond 6E

Former Pond 6E was a 6.7 acre (291,800 ft^2) pond established in November 1968. This pond operated in the same manner as Pond 5E, receiving wastes until 1972-1973. The pond received phossy water and minor carryover fine solids from upstream ponds. The pond was dried in 1981 and as described above, new lined Pond 15S was constructed in 1982 over former Ponds 5E and 6E.

M.6.17 Former Pond 7E

Pond 7E was a 4.3 acre (187,300 ft^2) pond constructed in December 1969. This pond received overflow phossy water from upstream ponds. No solids were observed in this pond. In 1982 Pond 7E was partially excavated and the excavated materials were used in the construction of Pond 15S.

M.7 DEVELOPMENT OF POTENTIAL INTRUSIVE SAMPLING METHODS

The materials which were sent to the older ponds included precipitator slurry (a mixture of water and particulate from the precipitators associated with the furnace off gas); and phosphorus-containing water (phossy water), primarily from operations such as product storage, pump-packing purges, and slag quenching. Because elemental phosphorus is the product of the facility, it is present in the waste streams at the facility. Phosphorus burns when exposed to oxygen at levels present in the air, and therefore, it represents a safety hazard during drilling, sampling, sample handling, and laboratory analysis.

In preparing the Work Plan for the remedial investigations, FMC discussed these safety concerns with the EPA, and indicated that if suitable procedures could be developed for drilling, sampling, and laboratory analysis, FMC would obtain samples from the potential source areas which were likely to contain significant concentrations of elemental phosphorus. At the same time, the Companies proceeded with all other potential source investigations at the facilities. During these investigations, elemental phosphorus was occasionally encountered, and some burning of the phosphorus occurred. Where this did occur, the boring was immediately stopped, and a nearby alternative boring location was selected.

FMC began development of potential drilling and sampling methodologies for characterization of the contents of the former ponds with HOMCO International, Inc. of Casper, Wyoming, and sampling and analytical methods with Mountain States Analytical, Inc. (MSAI) of Salt Lake City, Utah. As method development progressed, it became apparent that there were significant difficulties to overcome in all three areas. Drilling would require a special core barrel, and maintaining a "wet" condition at the drill bit, so that any elemental phosphorus encountered would not be directly exposed to air. The water circulation would also have been required to maintain cooler bit temperatures to prevent the heat generated by friction between the bit and the soils from causing the phosphorus to ignite. Homco developed an aluminum core barrel, and a preliminary method of drilling and sample extraction which maintained the core barrel in a submerged condition until opened.

The preliminary operating plan was to obtain a sample from the core barrel while the core barrel was maintained in a water bath by using a special sub-sampling device inserted into the core barrel from the open bottom surface. The excess sample material would then be placed into an existing operating pond on the FMC facility. Once samples were obtained, they would remain submerged, or in an oxygen-free environment (i.e. nitrogen glove box) during sub-sampling. By

sub-sampling at the facility, it would be possible to reduce the volume of the sample to be shipped, thereby reducing the amount of phosphorus-containing materials to be shipped offsite for chemical analysis.

Development of analytical methods for the laboratory had the dual problems of meeting safety requirements, and obtaining representative results for chemicals of concern. Initially, this was considered to include analysis for organic compounds, but this requirement was later eliminated. This removed a serious roadblock, as analysis for organics created a significant subset of safety and analytical problems which would have been very difficult to overcome.

After extensive discussions and evaluations, drilling, sampling, sample handling and laboratory analysis methods were developed which it appeared would provide acceptable samples and representative analytical results, and do so in a safe manner. The analytical procedures developed jointly by FMC and MSAI were submitted to the EPA for review and approval. Approval was granted on August 30, 1993. These procedures are included in Attachment A.

M.8 SUMMARY AND CONCLUSIONS

The history of pond development and operation has been reviewed. The contents of the waste streams have been analyzed as part of the potential source investigations, and the results are presented in Section 4.2.3 of the PSCS. The content of these waste streams have changed little during the life of the facility. The approximate elemental phosphorus content of the wastes has been estimated on the basis of production efficiency records.

The locations and areal extent of the former unlined wastewater ponds have been determined from historical aerial photographs, facility maps, drawings, and sketches and personnel interviews. Volumes have been determined from plant generated estimates, personnel interviews, and from boring logs.

Information on the potential migration of chemicals of potential concern from these former pond areas are discussed in Section 4.4.2 of the PSCS.

Analytical methods developed for drilling, sampling, sample handling, and laboratory analysis are provided in Attachment A. The estimated cost of drilling, sampling, and analyzing samples from 8 exploratory borings in the area of the former unlined ponds is provided in Attachment B.

Data provided in this document and in the Preliminary Site Characterization Summary are sufficient to evaluate the chemicals of potential concern associated with the former unlined wastewater ponds at the FMC facility at the EMF site.

Table M-1
FMC Facility – Unlined Former Ponds
Historical Summary

Pond No.	When Built	When Use Ended	When Dried	Material Received	Cover Material(s)	Other Notes
00S	1954-55	1956	?	Precipitator dust and phossy residuals. Mixed with ore pile and reprocessed.	NA	Site is under Mobile Shop now; Mobile Shop constructed in 1965.
0S	1954-55	1956	Prior to 1965	Precipitator dust and phossy residuals. Some mixed with ore pile and reprocessed.	Slag	Site was a pit only, not a "pond"; site now is a mobile equipment parking lot.
1S	1954	Oct. 1961	1972	Phossy water and phossy solids. Reclaimed to plant twice per year.	Slag, soil.	Initially hauled in slurry truck; pipeline installed in 1957. P_4 was reclaimed to plant from 1966-1972.
2S	1955	Oct. 1961	1972	Phossy water and phossy solids Reclaimed to plant twice per year.	Slag, soil.	P_4 was reclaimed to plant twice a year until September 1965. P_4 continued to be reclaimed to plant from 1966-1972.
3S	Nov. 1961	Jun. 1965	Dec. 1976	Precipitator dust slurry; slag pit water and solids; phossy water and phossy solids; residuals from P_4 reclaim operation on ponds 1S and 2S and east end of 3S	Capped with 3 feet of soil, then covered with crushed slag.	Settled solids were routinely dug out twice a year until 1965. P4 in east end was reclaimed in 1972-1976; approximately 100 feet of east end was filled with slag after reclaiming; this area is not capped as is the rest of the former pond.
4S	Apr. 1966	Mar. 1967	Jul. 1976	Precipitator dust slurry	Capped with 3 to 6 feet of soil.	

Table M-1
FMC Facility – Unlined Former Ponds
Historical Summary (Cont'd)

Pond No.	When Built	When Use Ended	When Dried	Material Received	Cover Material(s)	Other Notes
5S	Jul. 1965	Mar. 1967	Mar. 1976	Phossy water and phossy solids	Capped with baghouse dust; precipitator dust slurry; fluid bed drier product prills and dust; slag; final soil cap on top.	Very difficult to dry because of pyrophoric contents; fine solids would not support cover weight.
6S	Apr. 1967	Feb. 1969	Jul. 1976	Precipitator dust slurry; some phossy water and phossy solids in NE corner.	Capped with soil; south end partially filled with slag and paved with asphalt for use as a new slag haul road.	New slag haul road over south end.
7S	Mar. 1969	Sep. 1970	Jan. 1980	Precipitator dust slurry with phossy hot spots.	Two high - P_4 areas capped with cement; entire area capped with 6 to 10 feet of pit-run slag, then three feet of soil.	New slag haul road over south end; This site is now byproduct ferrophosphorus stockpile, approximately 25 feet high.
8S	Oct. 1970	Sep. 1993	?	Phossy water and phossy solids; some precipitator dust slurry.	Cover design in progress.	Site was raw material source for 8S P_4 recovery plant, built in 1982, closed in 1993.
9S	1971	1974 (?)	Nov. 1980	Precipitator dust slurry; slag pit water and solids. Material dried and sold.	Not capped.	Contents were dried in place and about 20 to 25 feet dug out for outside sales; small quantity remains in place.

Table M-1
FMC Facility – Unlined Former Ponds
Historical Summary (Cont'd)

Pond No.	When Built	When Use Ended	When Dried	Material Received	Cover Material(s)	Other Notes
1E	Apr. 1965	Fall 1982	Oct. 1980	Phossy water and carryover fine solids from upstream ponds; precipitator dust slurry and dried slurry. Material dried and sold.	Not capped.	Filled with dredged precipitator dust slurry from fluid bed drier surge pond in fall of 1982.
2E	Apr. 1965	Oct. 1967	1977	Phossy water and carryover fine solids from upstream ponds. Some material removed and sold.	Site is beneath current Phase IV ponds (8E).	Site was used for storage of precipitator slurry fluid bed drier product, then dug out for lined pond 8E construction in 1984; residual precipitator dust sent to 4E site. Some material was removed and sold.
3E	May 1967	Sep. 1970	1980	Phossy water and carryover fine solids from upstream ponds.	Site is beneath current Phase IV ponds (11S-14S).	Contents dug out for construction of new lined ponds in 1980; this site now occupied by lined ponds 11S, 12S, 13S, and 14S.
4E	May 1967	1980	Oct. 1980	Phossy water and carryover fine solids from upstream ponds; precipitator dust slurry overflow.	Not capped.	Received precipitator slurry from fluid bed drier slurry pond in fall of 1982. Some material removed and sold.

Table M-1
FMC Facility – Unlined Former Ponds
Historical Summary (Cont'd)

Pond No.	When Built	When Use Ended	When Dried	Material Received	Cover Material(s)	Other Notes
5E	Apr. 1968	1972-73 (?)	1981	Phossy water and very minor carryover fine solids from upstream ponds.	Site is beneath current Pond 15S.	Dried gray settled soil (4" to 6") placed in area just south of new 15S lined pond. New lined pond 15S was built on this site in 1982.
6E	Nov. 1968	1980-81	1981	Same as 5E.	Same as 5E.	Same as 5E.
7E	Dec. 1969	1980-81	1981	Received phossy water only a few seasons; no solids observed in 7E.	Not capped.	Eastern ± 150 feet used for construction of lined pond 15S (1982) and 9E (1986).

Table M-2
Estimates of Solids Sent To Former and Current Ponds

YEAR	SOLIDS (DRY TONS)	P4 (DRY TONS)	TOTAL (DRY TONS)	VOLUME (CU/YDS)	VOLUME (ACRE FT.)
1954	2063	971	3,034	2,530	1.57
1955	2174	1023	3,197	2,666	1.65
1956	2198	1034	3,232	2,695	1.67
1957	2366	1113	3,479	2,901	1.80
1958	2491	1172	3,663	3,055	1.89
1959	2545	1198	3,743	3,122	1.93
1960	2524	1188	3,712	3,096	1.92
1961	3088	1453	4,541	3,787	2.35
1962	1918	2738	4,656	3,883	2.41
1963	2054	2932	4,986	4,158	2.58
1964	2112	3014	5,126	4,275	2.65
1965	2729	3895	6,624	5,524	3.42
1966	2687	3835	6,522	5,439	3.37
1967	2881	4111	6,992	5,831	3.61
1968	3553	5071	8,624	7,192	4.46
1969	3359	4795	8,154	6,800	4.22
1970	3432	4898	8,330	6,947	4.31
1971	2,750	2,376	5,126	4,275	2.65
1972	1,000	1,788	2,788	2,325	1.44
1973	1,500	2,723	4,223	3,522	2.18
1974	1,750	1,059	2,809	2,343	1.45
1975	2,136	1,232	3,368	2,809	1.74
1976	1,574	1,295	2,869	2,393	1.48
1977	1,683	694	2,377	1,982	1.23
1978	2,647	1,054	3,701	3,087	1.91
1979	1,902	1,500	3,402	2,837	1.76
1980	3,912	2,266	6,178	5,152	3.19
1981	3,873	2,675	6,548	5,461	3.38
1982	3,362	1,410	4,772	3,980	2.47
1983	3,269	512	3,781	3,153	1.95
1984	4,559	1,685	6,244	5,207	3.23
1985	4,834	1,268	6,102	5,089	3.15
1986	5,110	1,218	6,328	5,277	3.27
1987	9,551	2,188	11,739	9,790	6.07
1988	7,665	1,910	9,575	7,985	4.95
1989	13,200	1,866	15,066	12,565	7.79
1990	17,785	1,679	19,464	16,233	10.06
	138,236	76,839	215,075	179,370	111

Notes: Volumes for 1954 through 1970 were estimated from total production of elemental phosphorus.

Table M-3 History of Unlined Pond Operations by Year

Pond	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1S	12	12	12	12	12	12	12	10											Dried										
2S		12	12	12	12	12	12	10											Dried										
3S								2	12	12	12	6											Dried						
4S													9	3								Dried							
5S												6	12	3								Dried							
6S														9	12	2							Dried						
7S																10	9							Dried					
8S																	3	12	12	12	12	12	12	12	12	12	12	9	
9S																			7	12	12						Dried		
1E												9	12	9	12	12	12	12	12	12	12	12	12	12	12	12	Dried		*
2E												9	12	10										Dried					
3E														8	12	12	9										Dried		
4E														8	12	12	12	12	12	12	12	12	12	12	12	12	Dried		*
5E															9	12	12	12	12	12							Dried		
6E															2	12	12	12	12	12	12	12	12	12	12	12	Dried		
7E																1	12	12	12	12	12	12	12	12	12	12	Dried		

* Received dredged precipitator slurry

Table M-4
Estimated Volumes of Materials
in Former Unlined Wastewater Ponds

Pond No.	Area of Pond (Ft^2)	Estimated Volume (Yd^3) of Wastes in Pond Area
1S	21,800	2,400
2S	34,850	875
3S	52,300	8,800
4S	34,850	6,500
5S	43,560	8,500
6S	100,200	24,600
7S	156,800	18,200
8S	135,000	18,200
9S	174,250	NP
1E	82,750	9,000
2E	143,750	NP
3E	453,000	NP
4E	78,400	29,000
5E	287,500	NP
6E	291,800	NP
7E	187,300	NP

NP indicates the material was excavated, moved to another location or sold, or was never present in quantity at this location (i.e., Pond 7E).

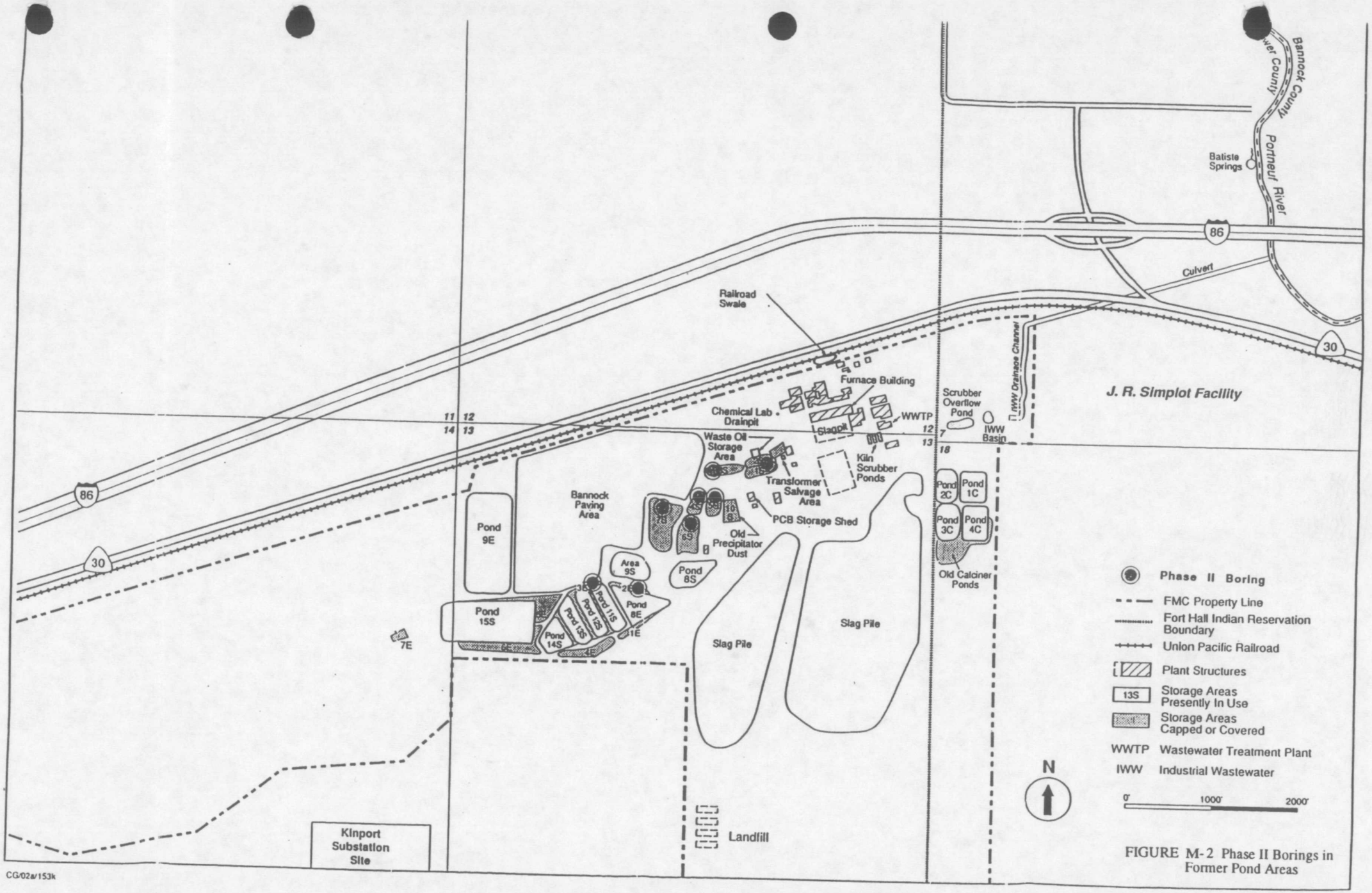


FIGURE M-2 Phase II Borings in Former Pond Areas

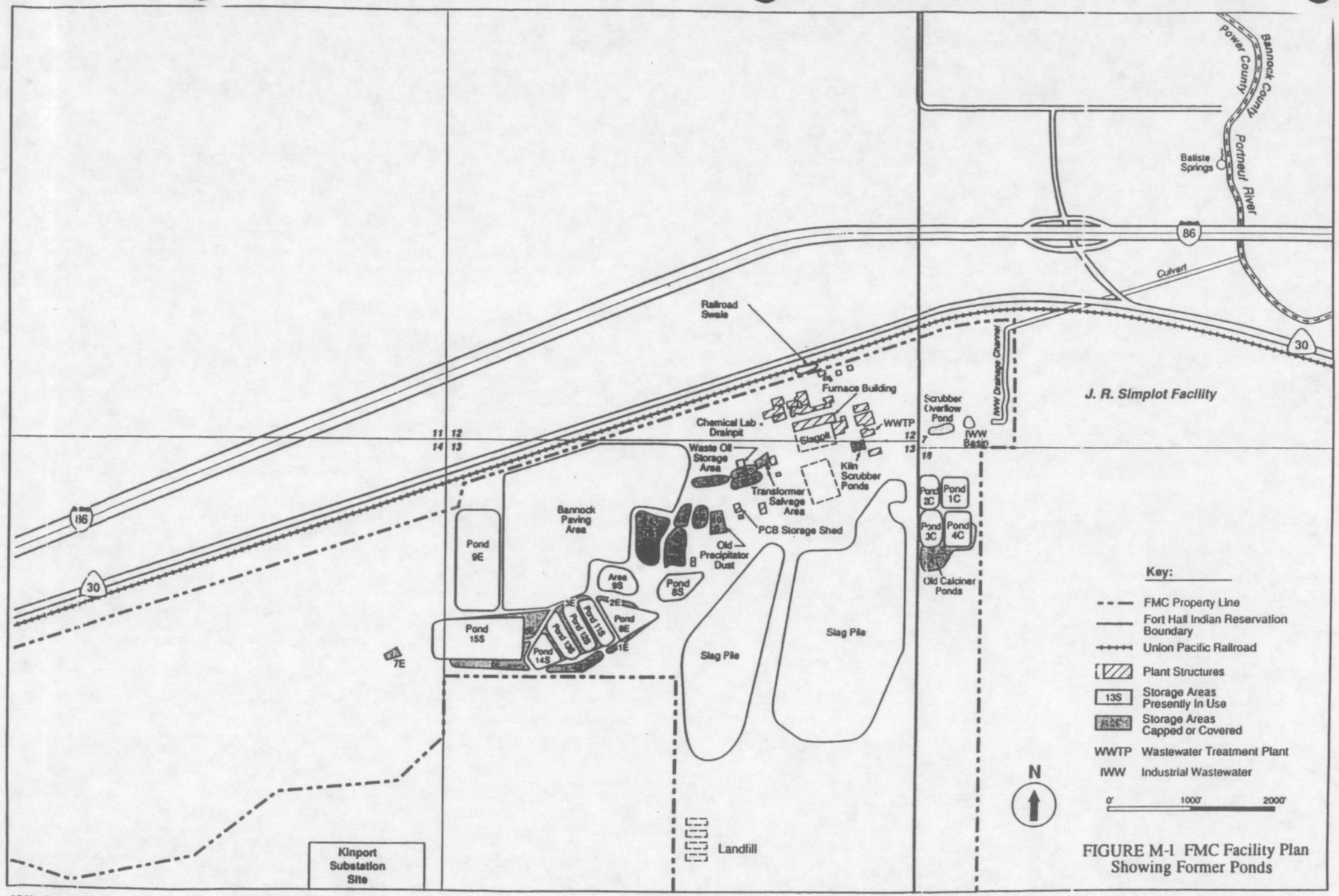
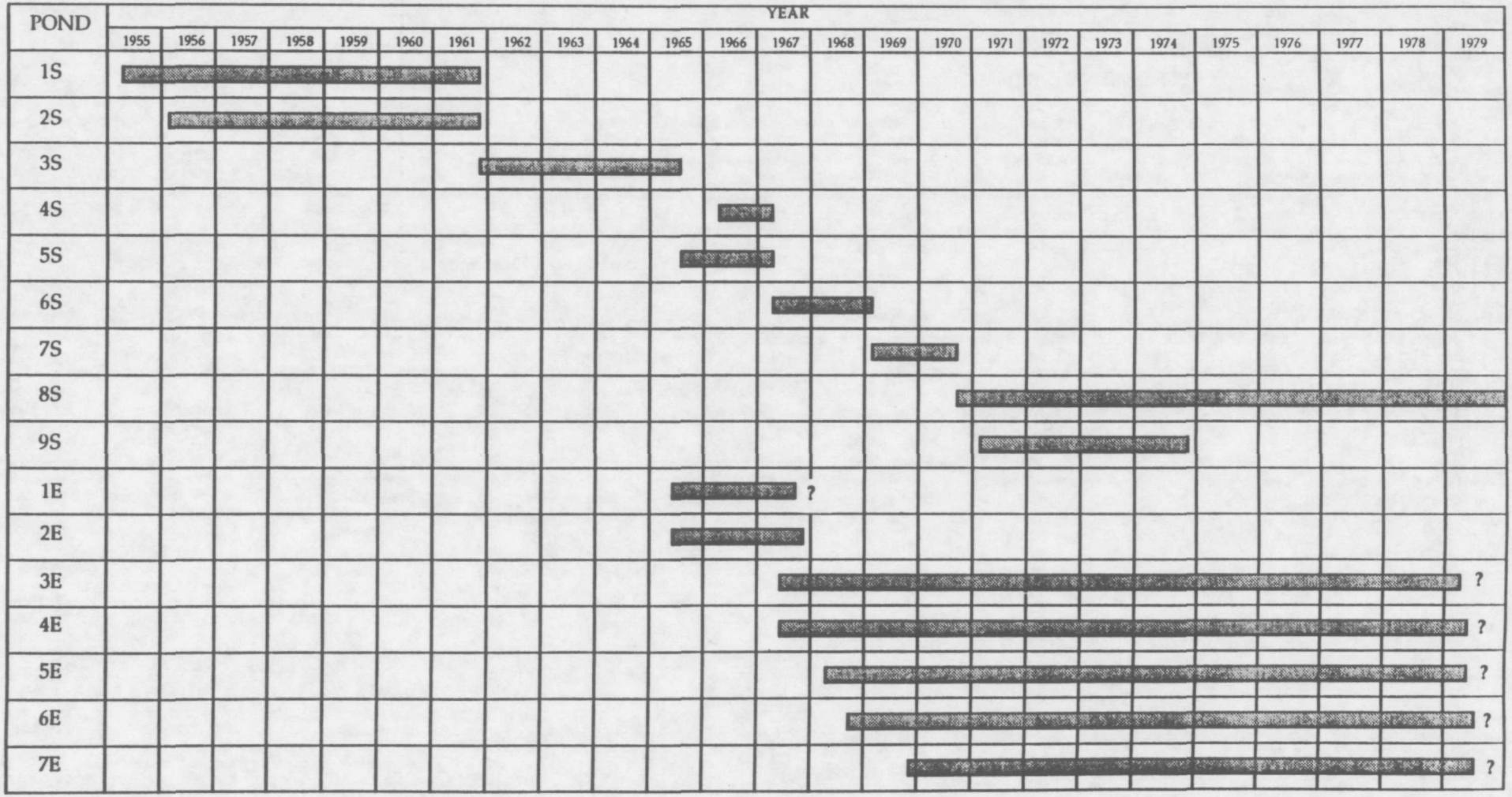


FIGURE M-1 FMC Facility Plan Showing Former Ponds

CG/02a/153k

21372/2a/m/EMF/1:3k
6-10-92 vi/sm : 6

Figure M-3. Estimated Operational Life of Unlined Wastewater Ponds



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Attachment A

Elemental Phosphorus Analyses by Microextraction and Capillary Gas Chromatography

A Status Report

Submitted to

Pamela S. French
FMC Corporation
Phosphorus Chemical Division
Pocatello, ID

Prepared by

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May 1993

Introduction

Few analytical methods exist for the detection and quantitation of elemental phosphorus at low levels. At the request of FMC, Mountain States Analytical, Inc. (MSAI) has performed a detailed study to develop and validate a reliable, accurate method for the determination of elemental phosphorus (P_4) by capillary column gas chromatography (GC) using a selective nitrogen/phosphorus detector (NPD). The P_4 method described in this report was developed with the assistance of FMC's chemistry staff and is based on a similar packed column GC method used by FMC for the past several years. A copy of the FMC method is attached to this report as Appendix A. The capillary GC/NPD method developed by MSAI is capable of detecting P_4 contamination in ground water and soil matrices in the low parts-per-billion (ppb) concentration range.

Experimental

Standards Preparation. The elemental phosphorus used for the calibration standards was purchased from Aldrich Chemicals (Catalog # 30,255-4; Phosphorus, stick yellow, 99+% purity, in water). Small pieces cut under water were rinsed with toluene and placed in toluene (Fisher Scientific, Optima Solvent) in a tared 1000 milliliter (ml) volumetric flask. 3.0 grams (g) of phosphorus was dissolved in a small amount of solvent and the flask brought to volume with toluene. The final concentration of this stock solution was 3000 milligrams/liter (mg/l) and was labeled Phosphorus Stock Solution. The stock solution was diluted to obtain four calibration solutions at the following concentration levels: 0.015 mg/l, 0.150 mg/l, 1.50 mg/l, and 15.0 mg/l.

An elemental P_4 spiking solution was prepared at 450 mg/l in methanol (Burdick and Jackson, purge and trap grade). This solution was then used to spike aqueous samples analyzed in these experiments.

Standards prepared by FMC were also used as a second source check on MSAI solutions. These samples were prepared by FMC chemists and transported (at 4°C) to MSAI by courier.

Instrument Set-up. This initial study for analysis of P_4 in xylene and toluene extracts was performed on a leased (U.S. Analytical, San Carlos, CA) Hewlett-Packard (HP) 5890 Series II GC-NPD with a 7673 autosampler and split/splitless injector. An HP ChemStation data system was used for collection and processing of qualitative and quantitative data. The GC was equipped with a 5 meter (m) x 0.53 millimeter (mm) internal diameter HP-1 fused silica capillary column (2.65 micron film thickness). After several trial runs using the P_4 standards in toluene, the following conditions were established:

Injection Volume:	2 ul
Initial Temperature:	50°C
Initial Time:	1.0 min
Oven Program:	Ramp to 80°C at 6.0°C/min (No Hold)
	Ramp to 180°C at 20.0°C/min (Hold 3 min)
Injector Temperature:	200°C
Detector Temperature:	250°C

In addition to the NPD, an HP 5970 mass selective detector (MSD) coupled to an HP 5890 GC was used to obtain mass spectral identification of P_4 in a toluene solution. An HP 1000 computer data system with RTE software (Rev. F) was used to collect, store, and process the mass spectral data. The capillary column used in this system was a 30 m x 0.25mm i.d. RTx-5 (Restek, Bellefonte, PA).

Calibration. A four point calibration curve based on peak area counts, over a concentration range from 0.015 mg/l to 15.0 mg/l was used. Due to the instability of the NPD, calibration curves were established daily. Quantitation of P_4 in the samples analyzed for this study was achieved using a point-to-point calibration technique (i.e., the two nearest calibration points were used to calculate the sample concentration using a straight line formula). This quantitation method is a standard procedure provided by the HP ChemStation software used with the GC for these experiments.

Sample Extraction. Two different sample preparation procedures were used in this work. The first was a liquid/liquid extraction technique performed using separatory funnel procedure. The basic procedure used by FMC (see Appendix A) was used with minor modifications. The primary difference was the use of toluene in place of xylene as the P_4 extracting solution. Toluene (Fisher Scientific, Optima Solvent) was used because of its higher purity compared to xylene. In addition, the phase separation filtration step described in the FMC procedure was not performed.

A microextraction procedure was developed by MSAI to facilitate handling and to insure immediate extraction of aqueous samples collected in the field. A copy of the procedure used by the field samplers is shown in Appendix B. Briefly, 2.0 ml of toluene was measured into a 40 ml volatile organic analysis (VOA), precleaned-Type 1 vial (ESS, Oakland, CA) and shipped to the field. The samplers were instructed to fill the VOA vial to the bottom of the neck (see diagram in Appendix B) with sample (approximately 37 ml $\pm$ 0.35%), replace the cap, and vigorously shake the water/toluene solution for 30 to 60 seconds. The sample vials were

collected in duplicate for each location, packaged in a cooler with blue ice at 4 °C, and delivered to the laboratory by express courier service. This same procedure was used by MSAI chemists in preparing solutions for comparison of the separatory funnel and microextraction procedures.

Results and Discussion

Several sets of experiments were performed to validate the GC/NPD method for the analysis of P_4 in aqueous and soil samples. First, an appropriate calibration procedure was investigated. Additionally, GC/MS was used to confirm that elemental P_4 was indeed the compound eluting from the capillary column using the developed GC method. A series of standards and sample extracts prepared by FMC and MSAI was also exchanged to validate the performance of the two laboratories and their procedures and instrumental measurements. Next, a comparison study of the separatory funnel and microextraction sample preparation procedures was conducted. These experiments included a stability study of P_4 in the microextraction vials to determine the degradation rate and an acceptable holding time. Finally, this study culminated with analysis of a set of ground water samples collected from the FMC elemental phosphorus plant in Pocatello, ID.

Calibration Studies. The excellent signal to noise ratio obtained by this capillary GC/NPD method is observed in the chromatogram shown in Figure 1 from the analysis of the 0.015 mg/l calibration solution.

A P_4 calibration table using data collected early in the method development phase is shown in Table 1. The P_4 calibration is reasonably linear using the three lower concentrations, but the linearity deteriorates when the highest calibration level is considered. This phenomenon

Table 1. Calibration Table for P_4 Analyses (23 June 92).

Level	Concentration (mg/l)	Response Factor
1	0.015	2.54e-007
2	0.15	2.83e-007
3	1.5	4.11e-007
4	15.0	9.76e-007
Notes: (1) Cal Levels 1-3: Mean = 3.16e-007; Std Dev = 0.68e-007; RSD = 21.6%		
(2) Cal Levels 1-4: Mean = 4.81e-007; Std Dev = 2.92e-007; RSD = 61%		

is probably due to detector overloading and the lower linearity range of the NPD (10^4) compared to other GC detectors, such as the flame ionization detector (10^7).

The linear regression calculation for all four calibration levels results in an R^2 value of 0.987514. If only the three lowest concentration levels are used, then the R^2 value increases to 0.991530. These observations indicate that a calibration range of 0.010 to 1.0 mg/l may provide more acceptable linearity compared to EPA's Contract Laboratory Program (CLP) requirements, which recommend an R^2 value of > 0.995 to quantify organic compounds.

If the procedures prescribed in Section 7.4 of Method 8000, SW-846 (Test Methods for Evaluating Solid Wastes) are considered, either a calibration curve or an average response factor quantitation approach may be selected. As noted in Table 1, the average (mean) response factor (R_f) for the first three calibration levels has a relative standard deviation (RSD) of 21.6%, only

slightly higher than the 20% window allowed by Method 8000. Setting the calibration range from 0.010 to 1.0 mg/l as suggested above could result in meeting the 20% criteria of Method 8000. Because the RSD of the average R_f was greater than 20%, the calibration curve method described in the experimental section was used to quantify P_4 in the samples analyzed in these studies.

Calibration curves obtained subsequent to the early measurements reported in Table 1 have shown average R_f values for multiple point calibration curves with RSD values less than 20% and R_2 values greater than 0.995. For example, a four point calibration curve (0.015 to 15.0 mg/l) performed on 09/03/92 had an average R_f with an RSD of 9.7% and an R^2 value of 0.999930. These data suggest that acceptable linearity can be achieved using this GC/NPD method to provide valid quantitation of P_4 in toluene sample extracts.

<u>GC/MS Confirmation.</u> GC/MS was used to establish that the peak eluting from the capillary column was elemental phosphorus and not an oxide or solvent-derived by-product. The 15 mg/l P_4 standard in toluene was analyzed according to the conditions described in the experimental section. The relevant portion of the chromatogram from this analysis is shown in Figure 2. P_4 eluted at 12.5 minutes and was very symmetrical with no peak tailing, even with the 30 meter column used for GC/MS experiment. The mass spectrum shows the molecular ion or parent ion for the P_4 at 124 atomic mass units (amu). The 124 amu peak is also the base peak for this elemental compound. Fragment ions representing P_3 (93 amu), P_2 (62 amu) and P_1 (31 amu) were also observed due to the ionization voltage of the mass spectrometer (electron impact mode; approximately 70 eV). Higher mass fragments indicative of P_4 oxides, complexes, or

reaction products were not observed. This data confirms that P_4 survives the chromatography conditions used in this GC method and is the elemental compound being quantified.

Comparison Studies. Several sets of P_4 standard solutions and blanks were exchanged between FMC and MSAI's laboratories to correlate and validate both the qualitative and quantitative aspects of the GC/NPD method. First, P_4 quality control samples (blanks and calibration standards) prepared and used by FMC were analyzed by MSAI to verify method development and calibration. All FMC xylene blanks had P_4 levels below the limit of quantitation (BLOQ) when analyzed by MSAI. An FMC calibration standard at a concentration of 0.115 mg/l gave a 104% recovery versus MSAI's calibration. Likewise, a 1.15 mg/l calibration standard gave a 97.4% recovery. In a second round of verification experiments, MSAI's calibration standards for all four levels (0.015 to 15.0 mg/l) were analyzed by FMC's laboratory under their GC conditions for comparison and as a bias check. Results from this comparison experiment are shown in Table 2; raw data as submitted to MSAI is found in Appendix C. FMC quantified

Table 2: FMC's Analysis of MSAI's Calibration Standards

MSAI Calibration Standard (mg/l)	FMC Value (mg/l)	Difference (%)
15.0	16.74	112
1.50	2.01	134
0.150	0.19	127
0.015	0.021	140
Blank	BLOQ	NA

each standard by bracketing the concentration of the MSAI calibration standard with their own calibration standards (see Appendix C). Although biased somewhat high, agreement appears to be within an acceptable range.

Extraction Method Comparison. A series of experiments was performed to demonstrate the acceptability of using both the separatory funnel and microextraction liquid/liquid extraction procedures for sample preparation. First, these two sample preparation procedures were compared by MSAI chemists. A P_4 methanol spike solution was used to prepare three spiked aqueous samples of increasing P_4 concentration that were subsequently extracted by both procedures. This protocol was performed in duplicate. The results from this comparison experiment are shown in Table 3.

Table 3. Comparison of Separatory Funnel and Microextraction Procedures.

		Concentration (mg/l)	Spike Recovery (%)	Duplicate RPD (%)
Separatory Funnel				
High	9.0 mg/l	12.6	140	0.91
Mid	0.45 mg/l	0.263	58.4	1.5
Low	0.045 mg/l	0.0183	40.7	7.9
Microextraction				
High	9.0 mg/l	11.1	124	0.79
Mid	0.45 mg/l	0.186	41.3	4.7
Low	0.045 mg/l	0.0172	38.2	9.8

Data from this comparison experiment suggest a strong correlation between the microextraction and separatory funnel liquid/liquid extraction sample preparation procedures. The results obtained from extracting the spiked aqueous sample by each method agreed well at each concentration level. It is interesting to note, however, that the extraction efficiency significantly decreases at the two concentration levels below 1.0 mg/l for both techniques. Further experimentation at concentrations less than 1.0 mg/l is required to elucidate and confirm this observation.

Next, the microextraction and separatory funnel liquid/liquid extraction procedures were compared with actual samples. For this experiment, FMC collected two aliquots of two different Slag Pit water samples containing both dissolved and microparticulate solid P_4. The first aliquot was collected, diluted (5 ml to 500 ml), and extracted (400 ml) by FMC's procedure at their laboratory. The P_4 concentration was determined by FMC using their GC/NPD method. These sample extracts were then transferred to MSAI for determination of the P_4 concentration by the developed capillary GC/NPD method. The second aliquot was collected (37 ml sample) in a microextraction VOA vial containing toluene (2 ml) according to the instructions in Appendix B. Duplicate VOA vials were collected for each sample. These samples were transferred to MSAI for P_4 analyses. The results of this set of experiments are provided in Table 4.

According to FMC's data, Sample #1 and Sample #2 contained approximately 100 mg/l elemental phosphorus. Concentration data for Sample #1 prepared by each method agree within 5% if MSAI's separatory funnel and microextraction values are compared, and within 16% if FMC's separatory funnel and MSAI's microextraction results are compared. Comparison of Sample #2 data in the same manner results in agreement of 46% and 20%, respectively.

Table 4. Comparison of Extraction Procedures for Two Field Samples.

Sample Description	P_4 Concentration (mg/l)		% Difference
	FMC Value	MSAI Value	
Separatory Funnel/Sample #1	93.0	103	111
Separatory Funnel/Sample #2	118	97.1	82.3
Microextraction/Sample #1	NA	108	NA
Microextraction/Sample #2	NA	142	NA
Note: Duplicates for microextraction of Samples #1 and #2 had RPD values of 2.4% and 4.5%, respectively.			

Interestingly, FMC's separatory funnel and MSAI's values have better agreement than MSAI's values for the two techniques. A possible source of error for the MSAI measurements was the fact that quantitation was reported outside the calibration window (i.e. above the high calibration standard of 15.0 mg/l). Although the curve was extremely linear (R_2= 0.999930), better accuracy may have been obtained if quantitation had been performed within the calibration range. Nonetheless, these data indicate a reasonable level of agreement and support the use of the microextraction technique as a preparation method for aqueous samples.

<u>P_4 Stability Study</u>. The microextraction technique developed by MSAI requires storage (4°C) of the toluene extract in a 40 ml vial in the presence of the aqueous sample for an extended period. Due to this factor, it is essential to determine if P_4 is stable under these storage conditions. An experiment was performed in which a low concentration of P_4 was spiked into several 40 ml VOA vials containing 37 ml of deionized water and 2.0 ml of toluene. An adequate quantity of vials was spiked, shaken, and stored so that triplicate P_4 analyses could be

performed at regular intervals over approximately a one month period. The Day 0 sample was extracted immediately after preparation, analyzed by the GC/NPD method in triplicate, and the average used as 100% recovery. Initially, triplicates were analyzed daily, but as the study continued the analysis frequency was decreased from daily to every 2-7 days. The results from this stability study are summarized in Table 5 and shown graphically in Figure 3.

Table 5: Phosphorus Stability Study Data

Day	Sample. Volume (ml)	Solvent Volume (ml)	Instrument Concentration (mg/l)	P_4 Concentration (mg/l)	P_4 Remaining (%)
0	37	2	0.138	0.00746	100.0
1	37	2	0.132	0.00714	95.7
2	37	2	0.133	0.00719	96.4
3	37	2	0.130	0.00703	94.2
6	37	2	0.133	0.00719	96.4
8	37	2	0.132	0.00714	95.7
10	37	2	0.134	0.00724	97.1
13	37	2	0.132	0.00714	95.7
22	37	2	0.131	0.00708	94.9
24	37	2	0.128	0.00692	92.8
28	37	2	0.132	0.00714	95.7

The results indicate a drop of about 5% in the first 24 hours, followed by a very gradual decrease of 3-4% over the next 27 days. The spiked concentration in the water sample was relatively low at about 0.0075 mg/l. Some variations in the day-to-day results should be expected due to the low concentration of P_4 in the samples and the large number of spiked

samples required for this study. However, the plot in Figure 3 shows a very acceptable overall reproducibility. These results demonstrate the validity of a 28 day holding time for aqueous samples containing elemental phosphorus using the microextraction technique.

Ground Water Samples. A set of eight ground water samples from FMC's elemental phosphorus plant (Pocatello, ID) was collected and extracted using the separatory funnel liquid/liquid extraction technique and analyzed for P_4 using the GC/NPD method. FMC completed the extractions and both FMC and MSAI performed the GC/NPD analyses. Samples were collected and extracted by FMC on June 18, 1992. MSAI received the sample extracts on June 19, 1992 and analyzed them on June 25, 1992. Elemental phosphorus data for these ground water samples are summarized in Table 6. Table 7 provides results for the quality control samples submitted by FMC with the ground water samples. Finally, copies of the chain of custody forms and MSAI's analysis log are attached in Appendix D.

All eight ground water sample extracts were found to have P_4 concentrations less than the limit of quantitation (0.001 mg/l). However, Sample #9206-219 had a P_4 concentration of 0.017 mg/l, just above the low standard of 0.015 mg/l. A duplicate vial for Sample #9206-221 was prepared and analyzed as batch QC. The RPD based on peak area counts for these duplicate analyses was only 5.63%, even though the area counts were below the limit of quantitation. An FMC check standard at 1.15 mg/l was analyzed as a calibration check just prior to analyzing the ground water sample. The percent recovery for the check standard was 105%. All toluene and xylene solvent blanks analyzed during the sequence showed no detectable P_4 contamination or carry-over in the system.

Table 6. Ground Water Sample Results.

MSAI Lab Number	Sample Description	Instrument Concentration (mg/l)	MSAI Sample Concentration (mg/l)	FMC Sample Concentration (mg/l)
28472	GW-9206-219	0.017	<0.001	<0.001
28473	GW-9206-220	<0.015	<0.001	<0.001
28474	GW-9206-223	<0.015	<0.001	<0.001
28475	GW-9206-221	<0.015	<0.001	<0.001
28476	GW-9206-224	<0.015	<0.001	<0.001
28477	GW-9206-225	<0.015	<0.001	<0.001
28478	GW-9206-226	<0.015	<0.001	<0.001
28479	GW-9206-227	<0.015	<0.001	No Data

Table 7. Ground Water Quality Control Samples.

MSAI Lab Number	Sample Description	Instrument Concentration (mg/l)	MSAI Sample Concentration (mg/l)	FMC Sample Concentration (mg/l)
QC Standard	10-FMC	0.243	NA	0.248
QC Standard	11-FMC	1.35	NA	2.067
QC Sample	12-1A Xylene Extract	13.5	no data	250
QC Sample	13-4A Xylene Extract	23.3	no data	16

The agreement on the 0.248 mg/l FMC standard (Sample #11, Table 7) was excellent with the FMC value slightly higher than MSAI's reported value. Poorer agreement for the 2.067 mg/l sample was observed, with the MSAI reported value only 65.3% of FMC's declared true value. The last two samples (#12-1A and #13-4A) were blind samples submitted by FMC.

After completion of these analyses, FMC reported P_4 concentrations for the 12-1A xylene extract of 250 mg/l and 16 mg/l for the 13-4A xylene extract. To date, FMC has not provided calculation information so that the P_4 concentrations in these two xylene extracts can be compared.

Summary

This report summarizes the development work performed at MSAI in order to provide independent analytical capability for analyzing P_4 contamination in aqueous and soil samples by microextraction and GC/NPD. Standards preparation and calibration procedures are in place that comply with EPA SW-846 method requirements. The application of capillary columns to the analysis of P_4 by GC/NPD have resulted in lower detection limits and better resolution compared to similar packed column techniques. Reproducible detection limits for aqueous extracts of 0.0005 mg/l, or better, should be obtainable with this method.

MSAI has also developed a liquid/liquid microextraction sample preparation method for collecting ground water samples that greatly simplifies field handling, provides immediate extraction of elemental phosphorus upon sampling, and facilitates transport and storage. The studies presented in this report document that the microextraction procedure provides comparable result to the separatory funnel technique. In addition, the stability of P_4 in the microextraction vial has been shown to be at least 28 days.

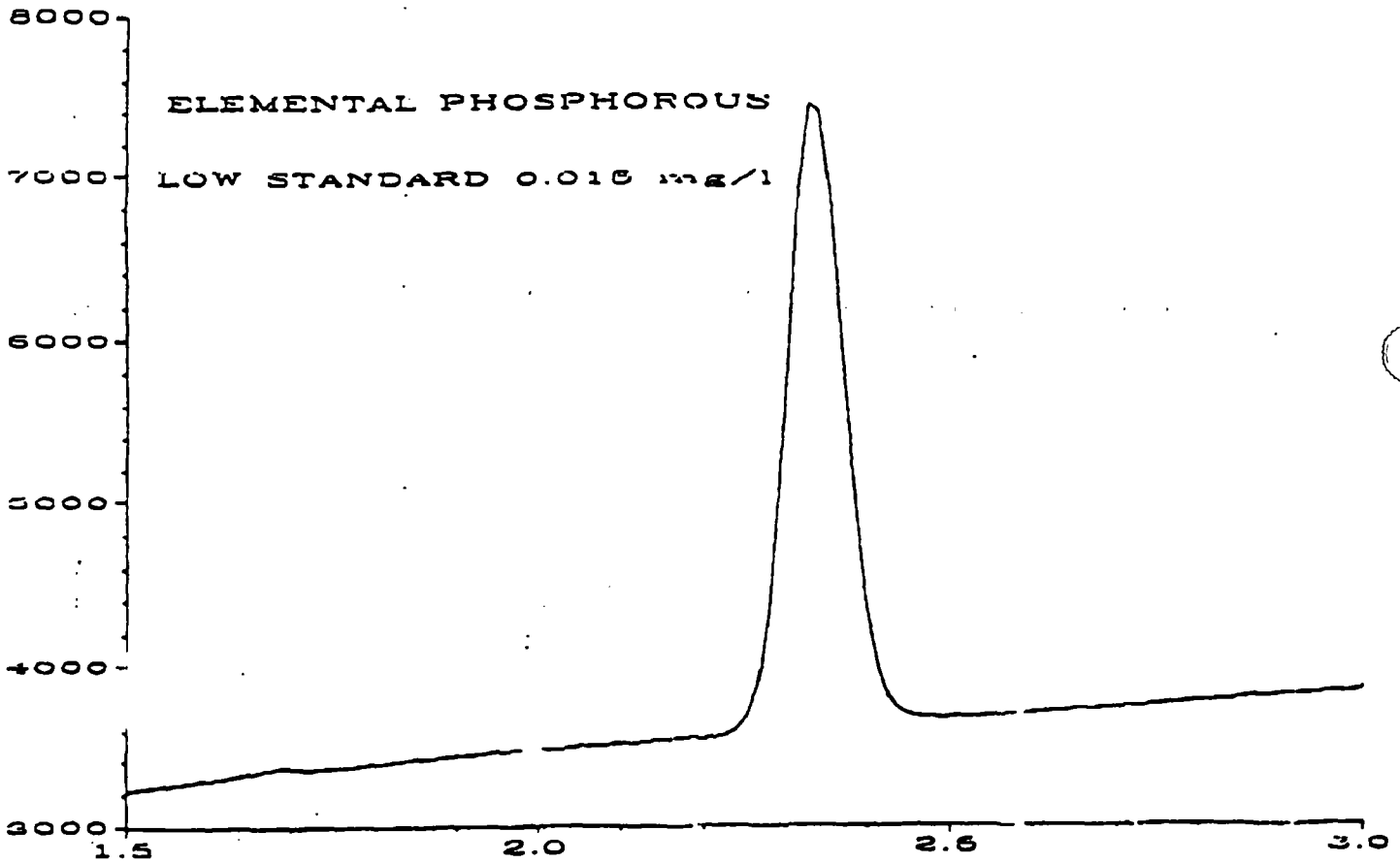


Figure 1. GC/NPD chromatogram of elemental phosphorus (0.015 mg/l).

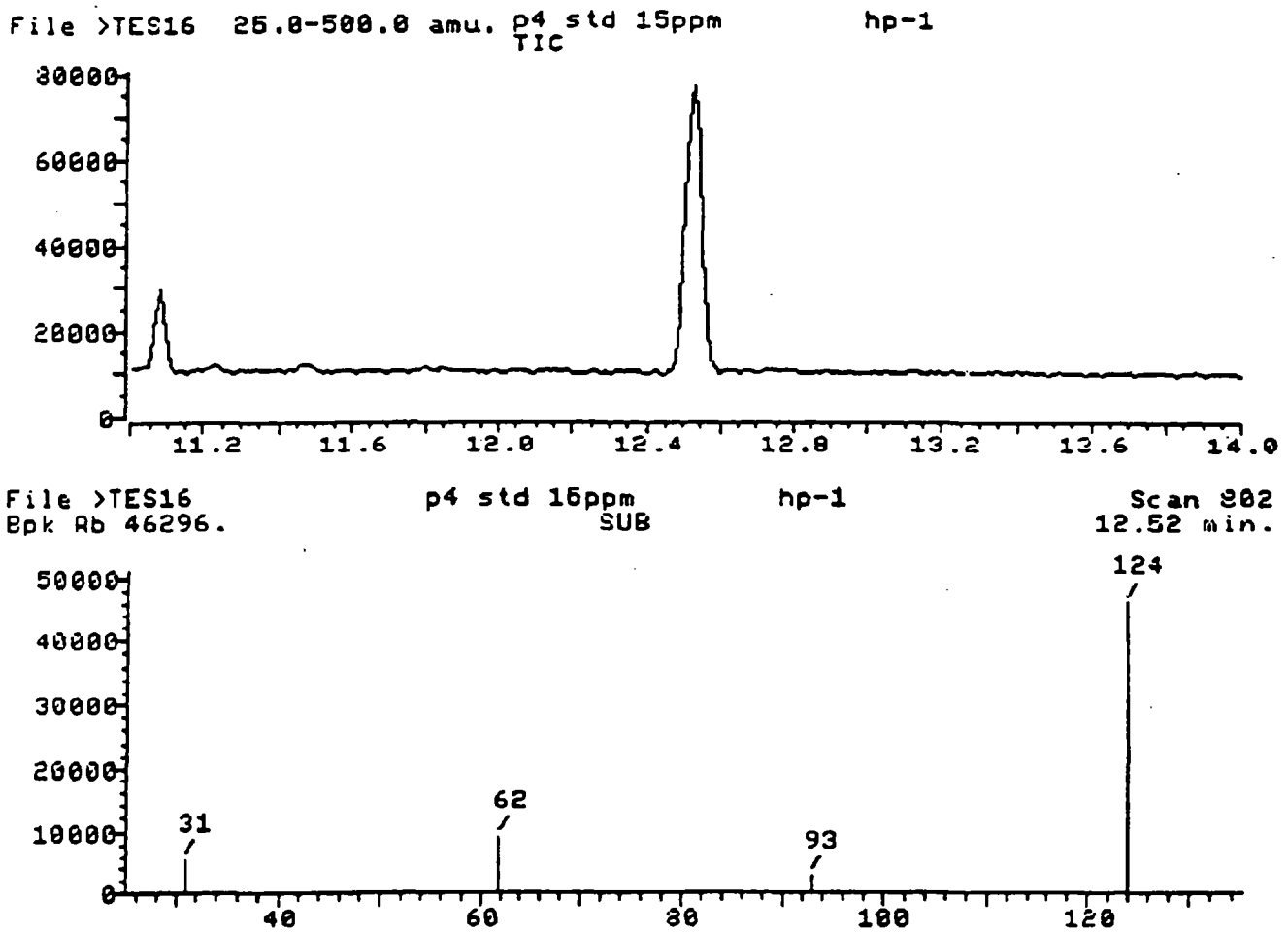


Figure 2. GCMS total ion chromatogram (top) and mass spectra (bottom) of elemental phosphorus (15.0 mg/l).

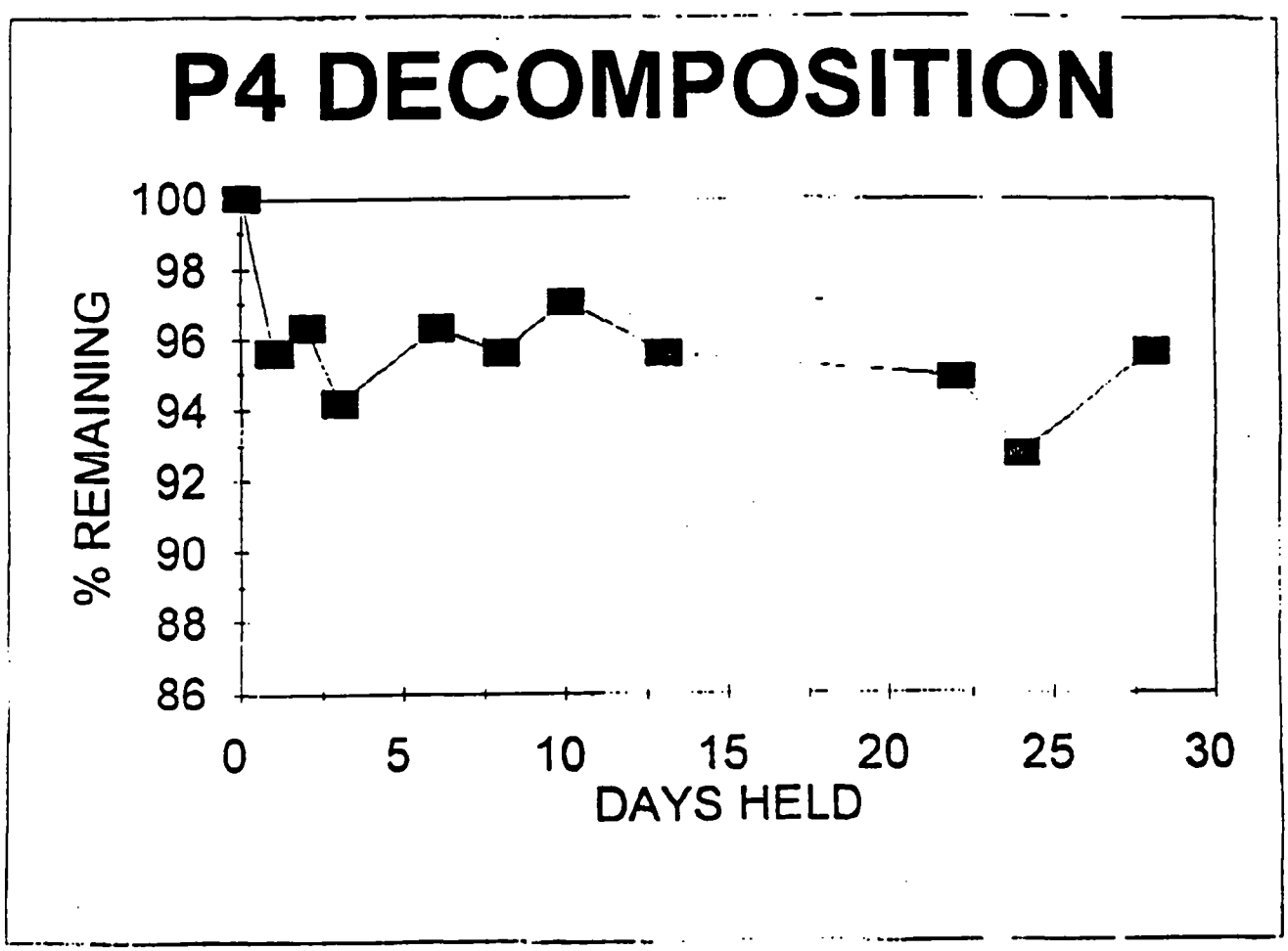


Figure 3. Elemental phosphorus stability curve.

Appendix A: FMC GC/NPD Phosphorus Method

FMC CORPORATION
PHOSPHORUS CHEMICALS DIVISION
POCATELLO PROCESS CONTROL LABORATORY

Analytical Method K-9A
Water
Method for Elemental Phosphorus
By Gas Chromatography

February 6, 1973
Revised June 24, 1976
Revised November 12, 1991

Based On

D. E. Rushing, "A Tentative Method for the Determination of Elemental Phosphorus in Air", American Industrial Hygiene Journal, September-October, 1962, p. 383.

E. R. Kaelble, "Gas Chromatographic Determination of Elemental Phosphorus in Air", Special Report No. 7781, Monsanto Company, Research and Development, St. Louis, Missouri.

Development work at the Pocatello Control Laboratory.

Principle

Elemental white phosphorus is almost insoluble in water (one part in 300,000 parts of water); and soluble in xylene (>1000 ug/ml). Therefore, elemental phosphorus both dissolved and suspended may be extracted from water using xylene. The xylene solution is injected into gas chromatograph equipped with a flame ionization detector with nitrogen-phosphorus accessory. Phosphorus elutes as a sharp peak in less than 1 minute. Peak height is linearly proportional to phosphorus concentration.

Safety

Xylene is considered a moderate health hazard and a severe flammability hazard. This material should be handled in a hood or in adequate ventilation and proper gloves, safety glasses and lab coat should be used to minimize exposure.

Elemental phosphorus is rated as a severe health and flammability hazard. Use safety glasses, face shield, rubber gloves and apron when handling the solid phosphorus in preparing the standards.

Precision and Accuracy

The detector has been checked for specificity using phosphine and various phosphate salts which gave no response.

Procedure

Low part per million solutions of elemental phosphorus in water are unstable and rapidly oxidize. The following extraction must be done in the field immediately after the sample is taken. Transfer a measured volume of the water sample, <400 ml, to a 500 ml separatory funnel. Add 20 ml xylene and shake for 5 minutes, relieving the pressure periodically. Allow the layers to separate and drain off the water layer, and discard. Filter the xylene layer through phase separation paper. Collect the xylene into a glass vial and cap. This solution will be stable for at least two weeks.

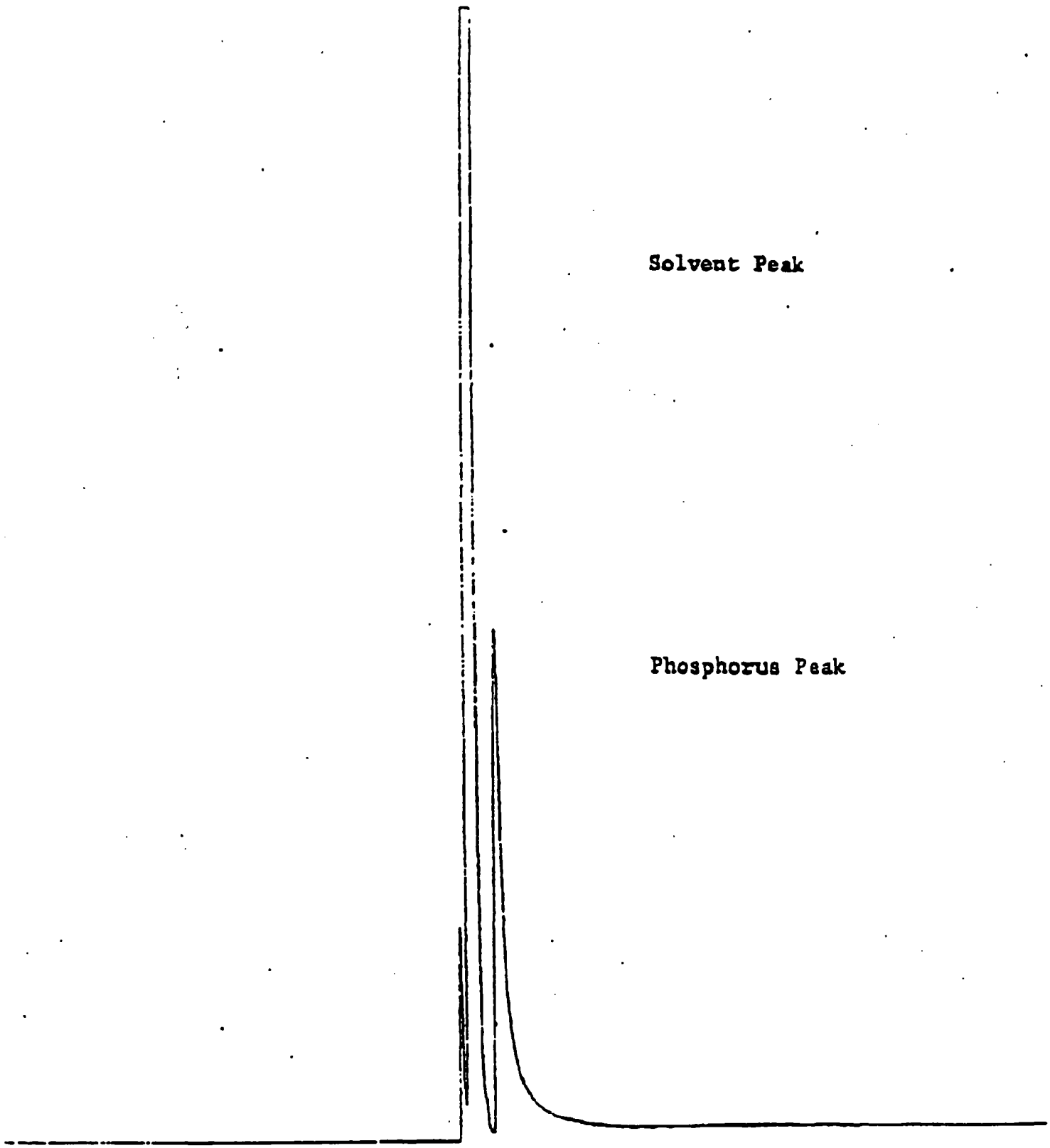
Condition the detector by injecting 0.5µl of the 15 µg/l standard twice into the chromatograph. The phosphorus peak elutes after the solvent peak at approximately 40 seconds. A typical chromatogram is seen in Figure I. Standards must always be run with the samples as detector response varies from day to day. The attentuation and amplifier range setting will influence the peak heights. By varying these settings, the response of the detector can be kept within the scale of the recorder. The standard run will have to correspond to the concentration of the samples. Measure the peak heights and prepare a calibration curve. Inject the sample solution and read the concentration from the calibration curve.

Calculations

$$\text{ppm P} = \frac{\text{Micrograms P from Calibration Curve} \times 20}{\text{mL sample}}$$

CDH:nm

Figure 1 A Typical Phosphorus Chromatogram



Repeated runs on the same xylene extract gave the following results.

Average	Standard Deviation
0.49 ppb	±0.06
0.135 ppm	±0.0045
8.13 ppm	±0.19

Reagents

Xylene: Reagent grade.

Standard Phosphorus Solutions: Carefully prepare a stock solution of phosphorus in xylene as follows: Place an approximately 1.5 gram piece of phosphorus in acetone to dissolve the water. Dry off the acetone and quickly weight the phosphorus in a nitrogen filled container. Quickly transfer the sample to a 1000 ml volumetric flask containing xylene. Dissolve and dilute to volume. From the stock solution, prepare standards covering the range of interest by making quantitative dilutions from xylene. Our standards covered the range 0.02 to 15 mg/l. Standards, if stored in the dark, are stable for over 4 months.

Special Apparatus

A Perkin-Elmer Model 990 Gas Chromatograph equipped with a flame ionization detector with nitrogen-phosphorus accessory was used for the elemental phosphorus determinations. The conditions are listed below.

Column	Alltech C-5000 668899L 6 ft. x 1/8" x 0.085" stainless steel packed with Ultrabond 20M 100-120 mesh. Precondition the column @ 115°C overnight
Column temperature	100°C
Injector temperature	210°C
Manifold temperature	300°C
Detector power supply	Detector Engineering & Technology 12-1403 operating setting 3420
Recorder	Kipp & Zoner BD40
Helium flow	15 ml/min
Hydrogen flow	4.2 ml/min
Air Flow	50 ml/min

Hamilton one microliter syringe #7001SN
Whatman IPS phase separating paper 12.5 cm diameter
Glass vials 20 ml with foil lined lids

Appendix B: Microextraction Field Sampling Method

Mountain States Analytical

The Quality Solution

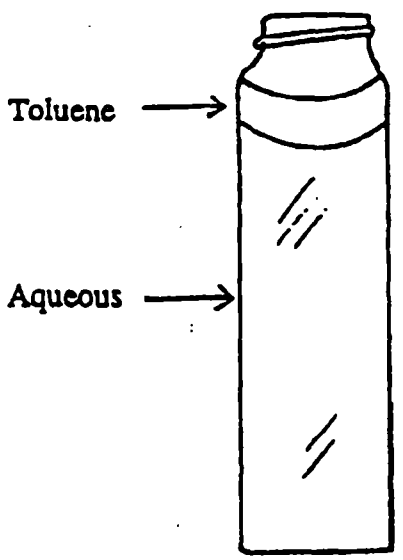
A Field Method for collecting groundwater samples for elemental phosphorus analysis

for Jeff Cross - Hydrometrics
September 9, 1992

Obtain duplicate 40 ml amber vials which have been prepreserved with exactly 2 ml toluene for groundwater well samples which will be analyzed for elemental phosphorus (P_4).

Fill the vial with sample to the approximate center (or halfway through the curvature) of the neck of the vial according to the illustration below. This allows for a small air space for agitation (microextraction). Two liquid layers should be observed as the aqueous sample is introduced into the vial. The toluene solvent will be the top layer. It is important to avoid loss of the solvent during the sample collection step, i.e. don't overfill the vial. If this occurs, obtain another vial and repeat the collection step correctly. MSAI has determined there to be a maximum of 0.7% difference in volume by filling the vials in this manner. Each vial will contain approximately 37 ml of sample and exactly 2 ml of toluene.

Cap the vial tightly and agitate by inverting and shaking rapidly for 30 seconds to one minute. Wrap vial in protective material (such as bubble wrap) and pack in cooler at 4°C for shipment to MSAI. **Each sample source shall be collected in duplicate.**



Microextraction sample vial w/o cap
(3/4 actual size)

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Appendix C: Raw Data for FMC's Analysis of MSAI's Calibration Standards

Mountain States Analytical

'OCATELLO TECHNICAL DEPARTMENT | FMC CORPORATION | PHOSPHORUS CHEMICALS DIVISION

REQUEST FOR ANALYSIS

Date Submitted Aug. 1, 92 Date Wanted _____ Submitted by C D Holmes

Comments Bias check between FMC LAB AND MOUNTAIN STATES ANA. LAB.

General Description EPA STANDARD CHECK By Gas Chromatograph

ANALYZE FOR

NEIGHBORS NUMBER	LAB NUMBER	SPECIFIC DESCRIPTION OF EACH SAMPLE	FMC	MSAL								
	026494	STD 15.0 ppm	15.01	16.74		STANDARDS USED FOR DETERMINATION 16.53/8.27						
	026495	1.5 ppm	1.78	2.01		2.07/1.16						
	026496	0.15 ppm	0.15	0.19		.248/.115						
	026497	TOLUENE BLANK	NO DETECTION									
	026498	.015	.016	.021		.0248/.0103						

Date Reported 8-4-92 Analyst AH Approved CDH

A-27

Attachment A

Appendix D: 9206 Ground Water Chains of Custody and Analyses Log

Mountain States Analytical

The Quality Solution

Sample Chain of Custody

W.O.No.:

Project Name: FMC G.W. 9206

Sampler: C.P.H

Sample Number	Date	Time	COMP	GRAB	Station Location	Number of Containers	EPA						Remarks
1	6-18-92	0910		X	FMC G.W. 9206 - 219	1							
2	" "	1040		X	" " " 220	1							
3	" "	1345		X	" " " 223	1							
4	" "	1515		X	" " " 221	1							
5	" "	1755		X	" " " 224	1							
6	" "	1850		X	" " " 225	1							
7	" "	2000		X	" " " 226	1							
8	" "	2050		X	" " " 227	1							
9	" "				XYLENE BLANK	1							

Sample Relinquished by:	Date	Time	Sample Received by:	Date	Time	Reason for Transfer
[illegible]	6-19-92	1420				

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Attachment A

Mountain States Analytical

The Quality Solution

Sample Chain of Custody

W.O.No.:

Project Name: FMC GW 92-6

Sampler: C.D.H

Sample Number	Date	Time	COMP	GRAB	Station Location	Number of Containers	EPA							Remarks
10	6-1992	1400			Fmc Standard .248 ppm	1								
11					" " 2.067 ppm	1								
12					1-A XYLENE Extract	1								
13					4-A XYLENE Extract	1								
14					XYLENE Blank	1								

Sample Relinquished by:	Date	Time	Sample Received by:	Date	Time	Reason for Transfer
C.D. Holmes	6-19-92	1425				

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Attachment A

25 Jun 92 11:54 AM

Sequence: C:\HPCHEM\1\SEQUENCE\PHOSTEMP.SEQ

Operator: KAR

Sequence preparation date: 25 Jun 92 11:54 AM

Data File Subdirectory: 25JUNPHS

Part of methods to run: full method

On a barcode mismatch: inject anyway

Comment:
P4 SAMPLE ANALYSIS ON NPD SYSTEM

Sample Table

Vial Num.	Sample Name	Sample Amount	Multiplier	ISTD Amount
1	TOLUENE			
2	P4 0.015			
3	P4 0.15			
4	P4 1.5			
5	P4 15			
6	TOLUENE			
[illegible]	OCS 1.15 P4			
[illegible]	TOLUENE			
9	1-9206-219			
10	2-9206-220			
11	3-9206-223			
12	4-9206-221			
13	4-9206-221 DUP			
14	TOLUENE			
15	5-9206224			
16	6-9206-225			
17	7-9206-226			
18	8-9206-227			
19	9-XYLENE BLANK			
20	10-FMC 0.248 PPM			
21	11-FMC 2.067 PPM			
22	12-1A XYLENE EXT			
23	13-4A XYLENE EXT			
24	14-XYLENE BLANK			

Attachment B

ATTACHMENT B
Estimated Costs

This attachment contains information used to develop the cost of an exploratory program for eight borings to be sampled in the areas of the former unlined wastewater ponds which have a high probability of containing concentrations of elemental phosphorus in the subsurface. The extent of the proposed program is described in detail in the Phase II Site Investigation Plan issued in March, 1993.

Costs developed are for drilling, sampling, sample handling, and laboratory analysis. Cost of development of the specialized drilling, sampling, and laboratory equipment and methodologies is not included. Additionally, analysis of the data obtained from the program is not included in the costs.

Table B-1 summarizes the estimated cost of the program. Information from HOMCO and Mountain States Analytical Services from which these cost data were compiled is provided following the table.

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TABLE B-1
DRILLING AND SAMPLING OLD POND AREAS AT THE FMC FACILITY
ESTIMATED COSTS

Bechtel Environmental, Inc.	$51,000
HOMCO International, Inc.	$242,000
Mountain States Analytical	$139,000
SUBTOTAL	$432,000
Contingency (10%)	$43,000
TOTAL	$475,000

Notes:

1. Costs based on estimates obtained from Bechtel Environmental, Inc., Mountain States Analytical, Inc., and HOMCO International, Inc.

2. These costs do not include any of FMC's costs for equipment and personnel.

HOMCO

HOMCO INTERNATIONAL, INC.

DATE : March 25, 1993

FAXED TO: Mr. John Ross
Bechtel Environmental, Inc.

FROM: Bob Richardsonson
Homco International

TOTAL PAGES: 6 including cover page

HOMCO

HOMCO INTERNATIONAL, INC.

Especially Prepared For:

Mr. John H. Ross
Project Manager
Bechtel Environmental, Inc.

by

Bob Richardson
Sales Representative
Homco International
P.O. Box 2755
Casper, Wyoming 82602

March 25, 1993

Ms. Pamela French
FMC Corporation
Phosphorus Chemicals Division
PO Box 4111
Pocatello Idaho 83202

RE: Proposed costs for trial sampling procedure in Casper yard and sampling of phosphorus in Pocatello facility.

Dear Pam,

Homco Internationals cost to run the pilot test here in the yard will consist of the following charges:

Drilling Rig RATE: $225.00 per Hr. x 8 hour minimum	$ 1,800.00
Lubricator RATE: $150.00 per Day	150.00
Core Bit *** SALE: $10,250.00	10,250.00
Core Barrel RATE: $200.00 per Day	200.00
Homco Engineer RATE: $550.00 per Day	550.00
Troughs (for handling inner barrel) SALE: $1000.00 Each	2,000.00

Exhibition of Phosphorus Sampling Procedure Cost..$ 14,950.00

A large portion of the initial start up cost for the actual sampling process will be covered in the trial run ie;core bit cost.

- -

Cost estimates for the actual sampling process is broken down into start up cost, daily operating cost and speculative total sample well cost.

Cont...

Start up charge will be $28,000.00 from which the following items and rates will be deducted to this amount. There after, rates and items needed will be billed out as outlined below.

Items and services that will be deducted from start up charge are as follows:

Safety Training & Equipment

21 Aluminum Inner Barrels

Center Plug for Core Bit

5-7/8" Tri-Cone Bit

Machine Shop Work on Casing Advancement System

Mileage Charge for Equipment and Personal to Pocatello

Sand Blasting and Cleaning Equipment of Contaminates

Mileage Charges and Permits on Vehicles

Listing of daily service and equipment rates for sampling phosphorus ponds as follows:

A) DRILLING RIG/CASING ADVANCE SYSTEM
Rental @ $300.00 per hour (8 hr. minimum per day)
Complete with pumps,tanks,mud pan,tubulars,handling tools and 3 man crew

B) WATER VAC TRUCKS
Rental @ $45.00 per hour per truck
2 trucks will be utilized

C) STEAM CLEANER
Rental @ $100.00 per day

D) LUBRICATOR
Rental @ $150.00 per day

E) CORE BARREL
Rental @ $200.00 per day

Cont...

F) HOMCO ENGINEER
Service @ $550.00 per day

G) PERDIEM
Charge @ $50.00 per person per day

Assuming three 8 hour days of rental and service per well including rig up, sampling, plugging, rig down and clean up. Estimated cost totals per well, per 8 wells, per 24 wells as follows:

Per Day Cost

DRILLING RIG	$ 2,400.00
WATER TRUCKS	720.00
STEAM CLEANER	100.00
LUBRICATOR	150.00
CORE BARREL	200.00
HOMCO ENGINEER	550.00
PERDIEM	200.00

Estimated Total Daily Cost..... $ 4,320.00

Estimated Cost Total Per Well..... $ 12,960.00

Estimated Cost Total On 8 Wells..... $ 103,680.00

Estimated Cost Total On 24 Wells..... $ 311,040.00

Mileage on vehicles will be charged out @ $1.00 per mile on light trucks and $1.30 per mile plus permits on heavy trucks and drilling rig.

Fishing tools and caseing jack prices have not been listed. If they should be needed the operator is responsible for the cost of these as well as any other equipment lost or destroyed. Plugging material and possibly some drilling fluid additives will be needed on the wells. We can provide them at cost plus 10%.

With the method we are going to utilize, quality of the samples should be excellent and hole problems will be minimized to the greatest extent possible. Every phase of the sampling will be carried out with safety being the prime concern.

Cont...

If there is an area on this cost estimate you feel I have over looked or is not covered to your satisfaction, please give me a call @ (307) 473-1250.

Respectfully Submitted;

Bob Richardson

Bob Richardson
Sales Representative
Homco International Inc.

cc: John Ross
Sam Roberts
Pat Evans

ROBERTS DRILLING INC.
1150 CHAMBERLAIN RD. • P.O. BOX 1197 • MILLS, WY 82644 • (307) 234-4081

August 17, 1992

FMC Corporation
Phosphorus Chemicals Division
P.O. Box 4111
Pocatello, ID 83202
ATTN: Pamela French

Dear Pam;

The following is our equipment and price list that we propose for your phosphorus sampling project in Pocatello, Idaho.

If you should have questions, please don't hesitate to call me, at (307) 234-4081.

Sincerely,

S.E. Roberts
Roberts Drilling Inc.

MONITOR WELLS • URANIUM • COAL • SHALLOW PRODUCTION • TRONA

HOMCO INTERNATIONAL, INC.

August 17, 1992

Ms. Pamela French
FMC CORPORATION
Phosphorus Chemical Division
P.O. Box 4111
Pocatello, Idaho 83202

Reference: Phosphorus Lake Beds

Dear Ms. French,

Homco Coring Services submits the following proposal to core your phosphorus lake beds located at the FMC facility in Pocatello, Idaho. We recommend the following equipment and services.

A. Core Barrel
   4 3/4" x 1 3/4" x 5'
   Rental: $200.00/DAY

B. Aluminum Inner Barrel
   2 1/2" x 2" x 2.5'
   Sale: $85.00 Each/Joint

C. Core Bit:
   5 7/8" x 1 3/4" PDC
   Sale: $11,450.00

D. Service Engineer/Mileage
   Charge: $550.00/Day...plus $1.00/business mile

E. Plastic End Caps
   Sale: $2.00/Each

F. Transportation
   Equipment will be shipped by company vehicle and mileage charge is consolidated.

G. Equipment and Services not listed above will be provided by Roberts Drilling at proposed rates. (ATTACHED)

Continue..

Intial set up charge will be $60,000.00 in which above charges are to be deducted up to this amount. There after, rates will be assessed as listed above.

Operator shall be liable for damages or loss of coring equipment while on location.

Equipment and services will be provided by this district office in Casper, Wyoming. If I can be further assistance to you, please call me at (307) 472-6657.

Sincerely,

Bob Richardson

Bob Richardson
HOMCO INTERNATIONAL, INC.

August 17, 1992
Equipment & Prices

GARDNER-DENVER, MODEL 1500, DRILLING RIG MOUNTED ON A 1980 PETERBILT MODEL 353 TRUCK CHASSIS. EQUIPPED WITH THE FOLLOWING: 5½ x 8 GARDNER-DENVER MUD PUMP, LEROI COMPRESSOR MODEL 256 SDS-B 600 CFM @ 250 PSI, BEAM WATER INJECTION, FOAM INJECTION, OIL INJECTION PUMP, HAMMER DRILLING, FOUR HYDRAULIC LEVELING JACKS, 2 7/8" x 20' DRILL PIPE.
ONE 1975 PETERBILT WITH A 4000 GALLON VACUUM TANK
ONE 1988 FORD ONE TON CREW CAB PICKUP
A UNIT CONSIST OF ONE RIG, ONE WATER TRUCK,AND ONE PICKUP

	UNIT/HOUR	$	225.00
1975 PETERBILT WITH A 4000 GALLON VACUUM TANK	PER/HOUR	$	40.00
STEAM CLEANER	PER/DAY	$	100.00
CREW PER DIEM (3)	PER/DAY	$	150.00
LUBRICATOR	PER/DAY	$	150.00
TROUGHS (2) approx. 15' x 3" x 8"	EACH	$	1,000.00
MOBIL & DEMOBIL (UNIT) PLUS THE COST OF ANY PERMITS REQUIRED	PER/MI.	$	2.50
PICTHER SAMPLER (if needed)	PER/DAY	$	200.00

ROBERTS DRILLING'S CORE BARRELS, H.Q. WIRE LINE PIPE, CEMENT MIXING TANK WILL BE OF NO CHARGE TO FMC CORPORATION.

A MINIMUM OF SIX HOURS WILL BE BILLED DAILY.

SUPPLIES PROVIDED WILL BE CHARGED AT COST PLUS 10%.

Mountain States Analytical

The Quality Solution

Bechtel Environmental
Attn: John Ross
50 Beale Street
San Francisco, CA 94105
Telephone: (415)768-7911
Telefax: (415)768-4898

Effective Date: 04/05/93
Expiration Date: 12/05/93
Reference Number: Q040593A

The following quotation is for the analysis of precipitator pond soils from the FMC facility at the EMF/Pocatello, Idaho. This is a budgetary quotation only; prices are subject to change based on results of method development currently under way at MSAI. This quotation is divided into three sections that address both analytical and field pricing. The pricing for soil analyses is divided into two sections based on the probability of certain soils containing high levels of elemental phosphorus that will require special handling and safety precautions.

NO.	PARAMETER	EPA METHOD	VOLUME	QUOTED PRICE($)	EXTENDED PRICE($)
A.	Analysis of P4-containing Soils				
1.	Metals Analysis				
a.	Aluminum, ICP	6010	88	14.00	1,232.00
b.	Antimony, ICP	6010	88	14.00	1,232.00
c.	Arsenic, HAA	7061	88	35.00	3,080.00
d.	Barium, ICP	6010	88	14.00	1,232.00
e.	Beryllium, ICP	6010	88	14.00	1,232.00
f.	Boron, ICP	6010	88	14.00	1,232.00
g.	Cadmium, ICP	6010	88	14.00	1,232.00
h.	Chromium, ICP	6010	88	14.00	1,232.00
i.	Cobalt, ICP	6010	88	14.00	1,232.00
j.	Copper, ICP	6010	88	14.00	1,232.00
k.	Iron, ICP	6010	88	14.00	1,232.00
l.	Lead, GFAA	7421	88	40.00	3,520.00
m.	Lithium, ICP	6010	88	14.00	1,232.00
n.	Manganese, ICP	6010	88	14.00	1,232.00
o.	Mercury, CVAA	7471	88	35.00	3,080.00
p.	Molybdenum, ICP	6010	88	14.00	1,232.00
q.	Nickel, ICP	6010	88	14.00	1,232.00
r.	Selenium, HAA	7741	88	35.00	3,080.00
s.	Silver, ICP	6010	88	14.00	1,232.00
t.	Thallium, GFAA	7841	88	40.00	3,520.00
u.	Vanadium, ICP	6010	88	14.00	1,232.00
v.	Zinc, ICP	6010	88	14.00	1,232.00

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NO.	PARAMETER	EPA METHOD	VOLUME	QUOTED PRICE ($)	EXTENDED PRICE ($)
	w. Preparation/digestion, sw	3005	88	35.00	3,080.00
		Summary:		458.00	40,304.00
		Add 12% QA:		54.96	4,836.48
		Subtotal:		512.96	45,140.48
2.	Wet Chemistry Parameters				
	a. Fluoride, sw	340.2	88	68.00	5,984.00
	b. Phosphorus, total, sw	365.3	88	22.00	1,936.00
	c. Phosphorus, orthophosphate, sw	365.3	88	25.00	2,200.00
	d. pH, sw	9045	88	10.00	880.00
		Summary:		125.00	11,000.00
		Add 12% QA:		15.00	1,320.00
		Subtotal:		140.00	12,320.00
3.	Moisture				
	a. Cupric sulfate method	160.3 mod	88	18.00	1,584.00
	b. Karl-Fischer	E-203	88	55.00	4,840.00
		Summary (3.a. only):		18.00	1,584.00
		Add 12% QA:		2.16	190.08
		Subtotal:		20.16	1,774.08
4.	Elemental Phosphorus Analysis		88	120.00	10,560.00
		Add 12% QA:		14.40	1,267.20
		Subtotal:		134.40	11,827.20
		Total Section A.:		807.52	71,061.76

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NO.	PARAMETER	EPA METHOD	VOLUME	QUOTED PRICE($)	EXTENDED PRICE($)
B.	Soils Not containing P4				
1.	Metals Analysis				
	a. Aluminum, ICP	6010	56	9.55	534.80
	b. Antimony, ICP	6010	56	9.55	534.80
	c. Arsenic, HAA	7061	56	23.89	1,337.84
	d. Barium, ICP	6010	56	9.55	534.80
	e. Beryllium, ICP	6010	56	9.55	534.80
	f. Boron, ICP	6010	56	9.55	534.80
	g. Cadmium, ICP	6010	56	9.55	534.80
	h. Chromium, ICP	6010	56	9.55	534.80
	i. Cobalt, ICP	6010	56	9.55	534.80
	j. Copper, ICP	6010	56	9.55	534.80
	k. Iron, ICP	6010	56	9.55	534.80
	l. Lead, GFAA	7421	56	27.30	1,528.80
	m. Lithium, ICP	6010	56	9.55	534.80
	n. Manganese, ICP	6010	56	9.55	534.80
	o. Mercury, CVAA	7471	56	23.89	1,337.84
	p. Molybdenum, ICP	6010	56	9.55	534.80
	q. Nickel, ICP	6010	56	9.55	534.80
	r. Selenium, HAA	7741	56	23.89	1,337.84
	s. Silver, ICP	6010	56	9.55	534.80
	t. Thallium, GFAA	7841	56	27.30	1,528.80
	u. Vanadium, ICP	6010	56	9.55	534.80
	v. Zinc, ICP	6010	56	9.55	534.80
	w. Preparation/digestion, sw	3005	56	17.06	955.36
		Summary:		305.68	17,118.08
		Add 12% QA:		36.68	2,054.17
		Subtotal:		342.36	19,172.25
2.	Wet Chemistry Parameters				
	a. Fluoride, sw	340.2	56	46.40	2,598.40
	b. Phosphorus, total, sw	365.3	56	15.00	840.00
	c. Phosphorus, orthophosphate, sw	365.3	56	17.00	952.00
	d. pH, sw	9045	56	10.50	588.00
		Summary:		88.90	4,978.40

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NO.	PARAMETER	EPA METHOD	VOLUME	QUOTED PRICE($)	EXTENDED PRICE($)
		Add 12% QA:		10.67	597.41
		Subtotal:		99.57	5,575.81
3.	Moisture				
	a. Moisture	160.3 mod	56	10.08	564.48
		Summary:		10.08	459.20
		Add 12% QA:		1.21	55.10
		Subtotal:		11.29	514.30
		Total Section B.:		453.22	25,262.36
C.	Water Analyses				
1.	Metals Analysis				
	a. Aluminum, ICP	6010	8	9.85	78.80
	b. Antimony, ICP	6010	8	9.85	78.80
	c. Arsenic, HAA	7061	8	21.10	168.80
	d. Barium, ICP	6010	8	9.85	78.80
	e. Beryllium, ICP	6010	8	9.85	78.80
	f. Boron, ICP	6010	8	9.85	78.80
	g. Cadmium, GFAA	6010	8	21.10	168.80
	h. Chromium, GFAA	6010	8	21.10	168.80
	i. Cobalt, ICP	6010	8	9.85	78.80
	j. Copper, ICP	6010	8	9.85	78.80
	k. Iron, ICP	6010	8	9.85	78.80
	l. Lead, GFAA	7421	8	21.10	168.80
	m. Lithium, ICP	6010	8	9.85	78.80
	n. Manganese, ICP	6010	8	9.85	78.80
	o. Mercury, CVAA	7471	8	17.59	140.72
	p. Molybdenum, ICP	6010	8	9.85	78.80
	q. Nickel, ICP	6010	8	9.85	78.80
	r. Selenium, HAA	7741	8	21.10	168.80
	s. Silver, ICP	6010	8	9.85	78.80
	t. Thallium, GFAA	7841	8	21.10	168.80

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The Quality Solution

NO.	PARAMETER	EPA METHOD	VOLUME	QUOTED PRICE($)	EXTENDED PRICE($)
	u. Vanadium, ICP	6010	8	9.85	78.80
	v. Zinc, ICP	6010	8	9.85	78.80
	w. Preparation/digestion, w/ww	3005	8	10.55	84.40
		Summary:		302.49	2,419.92
		Add 12% QA:		36.30	290.39
		Subtotal:		338.79	2,710.31
2.	Wet Chemistry Parameters				
	a. Fluoride, w/ww	340.2	8	12.66	101.28
	b. Phosphorus, total, w/ww	365.3	8	15.48	123.84
	c. Phosphorus, orthophosphate, w	365.3	8	10.55	84.40
	d. pH, w/ww	150.1	8	5.88	47.04
		Summary:		44.57	356.56
		Add 12% QA:		5.35	42.79
		Subtotal:		49.92	399.35
		Total Section C.:		388.71	3,109.66
D.	Field Sampling & Miscellaneous				
1.	Field Labor (hours)				
	a. Field Supervisor		96	70.00	6,720.00
	b. Field Sampler		192	50.00	9,600.00
	c. Field Technician		192	35.00	6,720.00
		Subtotal:			23,040.00

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Mountain States Analytical

The Quality Solution

NO.	PARAMETER	EPA METHOD	VOLUME	QUOTED PRICE($)	EXTENDED PRICE($)
2.	Miscellaneous				
	a. Sampling Equipment		1	1,500.00	1,500.00
	b. Sampling Supplies/Materials		1	2,000.00	2,000.00
	c. Lodging, per day/person		60	70.00	4,200.00
	d. Meals, per day/person		60	30.00	1,800.00
	e. Travel, per vehicle/mile		1200	0.29	348.00
		Subtotal:			9,848.00
		Total Section D:			32,888.00
		Grand Total:			132,321.78

NOTES:

1. Safety equipment and clothing will be provided by FMC Corp.
2. Quantities and pricing in Item D are estimated; actual will be billed.

TERMS AND CONDITIONS:

Sampling containers will be prepared and provided as part of the quoted service.

Parameters not listed in this quotation may be found in the Mountain States Analytical's Schedule of Services and Fees.

Purchase Orders: Please be sure to enclose your company's P.O. number with the sample submission.

Please sign and return a copy of this quotation as your authorization.

Approved by: _____ Date: _____

Please contact me with any questions you may have at (801)973-0050.

Douglas W. Later

Douglas W. Later, Ph.D.
Mountain States Analytical, Inc.

1645 West 2200 South, Salt Lake City, Utah 84119 (801) 973-0050 FAX (801) 972-6278

Member: American Council of

Ecology Data Validation Summary

This appendix contains copies of data validation summaries extracted from the following Remedial Investigation/Feasibility Study reports:

- Attachment N-1 Bechtel, 1995. "Data Validation Report, Ecological Sampling (Vegetation, Soils, and Sediment),"Volume I, September 1994.
- Attachment N-2 Bechtel, 1995. "Data Validation Report, Ecological Sampling (Phase I Delta Sediment), "October 1994.
- Attachment N-3 Bechtel, 1995. "Data Validation Report, Ecological Sampling, Small Mammals (deer mice)," March 1995.

Ecology Data Validation Summary

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Attachment N-1
Data Validation Report, Ecological Sampling (Vegetation, Soils, and Sediment)

Remedial Investigation/Feasibility Study

Data Validation Report

September 1994
Ecological Sampling
(Vegetation, Soils, and Sediment)

Metals, Simultaneously Extracted Metals, General Chemistry, and Sediment Bioassays Analyses

Prepared for:
FMC Corporation
J.R. Simplot Company

for the
Eastern Michaud Flats Site

Volume I

January 1995

Bechtel
Bechtel Environmental, Inc.

DATA VALIDATION SUMMARY

Date: December 19, 1994
Project Number: T10869
WP file: C:\WP51\ECO\T10869.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: T10869	VALIDATOR: JDJ	DATE: 01/19/95

COMMENTS: Data was of acceptable quality.

Sample analysis was by SW-846, and data validation was by CLP requirements. This was done for the purpose of keeping new data and historical data compatible.

The field sampling plan detection limits were checked for sample T10869, all required detections limits were meet by EA Laboratories.

The COCs have samples listed with a VR prefix as being the EPA sample numbers associated with this SDG. However, the cover page and forms associated with this SDG have the lab sample number listed as the EPA sample number, and the EPA sample number is being refired to as the lab sample number. The data was validated using the nomenclature of the FORMs 1, that is, the lab sample number appears in the EPA sample block and the EPA sample number is listed as the lab sample ID.

ANALYTE	QUALIFIER	SAMPLES AFFECTED	REASON
Acceptable	NONE	NONE	N/A

Data Package reviewed by:

Signature	Date:
[signature]	1/19/95

Date: December 20, 1994
Project Number: T10842
WP file: C:\WP51\ECO\T10842.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: T10842	VALIDATOR: JDJ	DATE: 01/20/95

COMMENTS: Data was of acceptable quality.

Sample analysis was by SW-846, and data validation was by CLP requirements. This was done for the purpose of keeping new data and historical data compatible.

The field sampling plan detection limits were checked for sample T10842, all required detections limits were meet by EA Laboratories.

The COCs have samples listed with a R prefix as being the EPA sample numbers associated with this SDG. However, the cover page and forms associated with this SDG have the lab sample number listed as the EPA sample number, and the EPA sample number is being refired to as the lab sample number. The data was validated using the nomenclature of the FORMs 1, that is, the lab sample number appears in the EPA sample block and the EPA sample number is listed as the lab sample ID.

ANALYTE	QUALIFIER	SAMPLES AFFECTED	REASON
Acceptable	NONE	NONE	N/A

Data Package reviewed by:

Signature	Date:
Jerry D. Johnson	1/20/95

Date: December 19, 1994
Project Number: T10909
WP file: C:\WP51\ECO\T10909.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: T10909	VALIDATOR: JDJ	DATE: 01/20/95

COMMENTS: Data was of acceptable quality.

Sample analysis was by SW-846, and data validation was by CLP requirements. This was done for the purpose of keeping new data and historical data compatible.

The field sampling plan detection limits were checked for sample T10909, all required detections limits were meet by EA Laboratories.

The COCs have samples listed with a VG prefix as being the EPA sample numbers associated with this SDG. However, the cover page and forms associated with this SDG have the lab sample number listed as the EPA sample number, and the EPA sample number is being refired to as the lab sample number. The data was validated using the nomenclature of the FORMs 1, that is, the lab sample number appears in the EPA sample block and the EPA sample number is listed as the lab sample ID.

ANALYTE	QUALIFIER	SAMPLES AFFECTED	REASON
Acceptable	NONE	NONE	N/A

Data Package reviewed by:

Signature	Date:
Jimmy L. Johnson	1/20/95

Date: January 18, 1995
Project Number: T10889
WP file: C:\WP51\BECH\T10889.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: T10889	VALIDATOR: SLC	DATE: 01/18/95	

COMMENTS:
Data was of acceptable quality.

EA Lab sample IDs and EPA sample IDs were switched on CLP cover page. EA Lab Sample IDs were reported in Form I (in box) instead of EPA sample IDs.

Holding time for prep and analysis were met. There were no blank detects reported. Matrix spike, duplicate and LCS results were all within QC limits. ICP serial dilution results were also acceptable.

The results were reported on wet weight basis.

No unusual problems were seen with the data.

PARAMETER	QUALIFIER	SAMPLES AFFECTED	REASON
Accept			

Date:
Project Number:
WP file:

DATA QUALIFICATION SUMMARY-FORM

SDG: U10849	VALIDATOR: RJH	DATE: 1.22.95	PAGE
COMMENTS: No qualification of results necessary. See overall comments.			
ANALYTE	QUALIFIER	SAMPLES AFFECTED	REASON

Data Package reviewed by:

Signature	Date:
RJHaesworth	1.22.95

Date:
Project Number:
WP file:

DATA QUALIFICATION SUMMARY-FORM

SDG: W10849	VALIDATOR: RJH	DATE: 1.22.95	PAGE
COMMENTS: No qualification of results necessary. See overall comments.			
ANALYTE	QUALIFIER	SAMPLES AFFECTED	REASON

Data Package reviewed by:

Signature	Date:
RJ Holdsworth	1.22.95

Date: December 21, 1994
Project Number: U10930
WP file: C:\WP51\ECO\U10930.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: U10930	VALIDATOR: JDJ	DATE: 01/21/95

COMMENTS: Data was of acceptable quality.

Sample analysis was by SW-846, and data validation was by CLP requirements. This was done for the purpose of keeping new data and historical data compatible.

The field sampling plan detection limits were checked for sample U10930, all required detections limits were meet by EA Laboratories.

The COCs have samples listed with a VS prefix as being the EPA sample numbers associated with this SDG. However, the cover page and forms associated with this SDG have the lab sample number listed as the EPA sample number, and the EPA sample number is being refired to as the lab sample number. The data was validated using the nomenclature of the FORMs 1, that is, the lab sample number appears in the EPA sample block and the EPA sample number is listed as the lab sample ID.

ANALYTE	QUALIFIER	SAMPLES AFFECTED	REASON
Acceptable	NONE	NONE	N/A

Data Package reviewed by:

Signature	Date:
[signature]	1/21/95

Date: December 21, 1994
Project Number: W10930
WP file: C:\WP51\ECO\W10930.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: W10930	VALIDATOR: JDJ	DATE: 01/21/95	

COMMENTS: Data was of acceptable quality.

Sample analysis was by SW-846, and data validation was by CLP requirements. This was done for the purpose of keeping new data and historical data compatible.

The field sampling plan detection limits were checked for sample T10909, all required detections limits were meet by EA Laboratories.

The COCs have samples listed with a VS prefix as being the EPA sample numbers associated with this SDG. However, the cover page and forms associated with this SDG have the lab sample number listed as the EPA sample number, and the EPA sample number is being refired to as the lab sample number. The data was validated using the nomenclature of the FORMs 1, that is, the lab sample number appears in the EPA sample block and the EPA sample number is listed as the lab sample ID.

The calculated concentration of zinc in sample W10930 agreed with that of the value reported by EA labs. The concentration of cadmium could not be verified, this was due to the lack of raw data which was lost on the analytical instrument's (7P) printer due to a paper jam. Data was not backed up on a computer, nor was the sample reran.

ANALYTE	QUALIFIER	SAMPLES AFFECTED	REASON
Acceptable	NONE	NONE	N/A

Data Package reviewed by:

Signature	Date:
Erin D. Johnson	1/21/95

Date: January 16, 1995
Project Number: BECH-355
WP file: C:\WP51\BECH\BECH355.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: BECH-355	VALIDATOR: SLC	DATE: 01/16/95

COMMENTS: Data was of generally acceptable quality.

PH holding time was not met for rinsate blank and no PH was determined. PH for soil samples was measured 19 days after collection and conservatively "J1" qualified.

There were blank detects for Ca, Fe, Mg and Na. Those analytes were "U7" qualified. Insignificant Cd and Zn detects in calibration and prep blanks have no impact on the sample results.

Matrix spike outliers for sodium led to "J8" qualification; otherwise MS results for all other analytes were judged to be acceptable. No sodium in rinsate blank required "N" and "E" qualifiers because rinsate blank should not be qualified against soil QC. Duplicate results were all acceptable. Sodium was qualified with "J16" because ICP serial dilution result was outside QC limit. LCS recoveries were all acceptable.

Wet chemistry Form I reported sample matrix as water. However result units were reported as mg/kg. The resubmital of corrected form was requested.

No other problems were seen with the data.

PARAMETER	QUALIFIER	SAMPLES AFFECTED	REASON
Calcium	U7	R70101	Contaminant in the calibration and prep blanks (CCB1,2,3,4, PBS1 & PBS2).
Iron	U7	R70101	Contaminant in the calibration and prep blanks (ICB, CCB4, and PBS1).
Magnesium	U7	R70101	Contaminant in the calibration and prep blanks (CCB4, and PBS1).
Sodium	U7	R70101	Contaminant in the prep blanks (PBS1).
Sodium	J8	All soil samples	Matrix spike recovery was outside QC limit
Sodium	J16	All soil samples	ICP serial dilution recovery was outside QC limit.
PH	J1	All soil samples	Holding time was not met

Date: January 20, 1994
Project Number: 9410930
WP file: C:\WP61\ECO\9410930.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: 9410930	VALIDATOR: RJW	DATE: 1.19.95	
COMMENTS: Data best regarded as of uncertain quality.			
ANALYTE	QUALIFIER	SAMPLES AFFECTED	REASON
Fluoride	J14	all samples	See overall comments
	U7	all washed sage samples	See overall comments

Data Package reviewed by:

Signature	Date:
R Hollesworth	1.20.96

Date:
Project Number:
WP file:

DATA QUALIFICATI... SUMMARY-FORM

SDG: BECH 357	VALIDATOR: R.J. HOLDSWORTH	DATE: 1.18.94	PAGE
COMMENTS: All detects for rinsate sample R70301 with the exception of K were given U7 qualification because of prep. blank contamination.			
ANALYTE	QUALIFIER	SAMPLES AFFECTED	REASON
Sodium	U7	24941E 24942E 4945E 4946E 24948E 24949E 24950E	Prep. blank contamination
Potassium	J8	All solid samples	Low MS recovery

Data Package reviewed by:

Signature	Date:
RJ Holdsworth	1.23 95

Date: January 14, 1995
Project Number: BECH-356
WP file: C:\WP51\BECH\BECH356.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: BECH-356	VALIDATOR: SLC	DATE: 01/14/95

COMMENTS: Data was of generally acceptable quality.

PH holding time was not met for rinsate blank and no PH was determined. PH for soil samples was measured 20 days after collection and conservatively "J1" qualified.

There were blank detects for Fe and Zn. Those analytes were "U7" qualified. There were insignificant Cd, Ca, Mg, K and Na detects in calibration and prep blanks and they have no impact on the sample results.

Matrix spike outliers for TOC led to "J8" qualification; otherwise MS results for all other analytes were acceptable. No TOC and sodium in rinsate blank required "N" and "E" qualifier, respectively, because rinsate should not be qualified against soil QC. Duplicate results were all acceptable. Sodium was qualified with "J16" because ICP serial dilution result was outside QC limit. LCS recoveries were all acceptable.

No other problems were seen with the data.

PARAMETER	QUALIFIER	SAMPLES AFFECTED	REASON
Zinc	U7	R70201	Contaminant in the prep blanks (PBS1 & PBS2).
Iron	U7	R70201	Contaminant in the calibration and prep blanks (CCB3, PBS1 and PBS2).
Sodium	J16	All soil samples	ICP serial dilution recovery was outside QC limit.
PH	J1	All soil samples	Holding time was not met
Total Organic Carbon	J8	All soil samples	Matrix spike recovery was outside QC limit.

Date: January 13, 1995
Project Number: BECH-359
WP file: C:\WP51\BECH\BECH359.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: BECH-359	VALIDATOR: SLC	DATE: 01/13/95	

COMMENTS: Data was of generally acceptable quality.

PH holding time was not met for water samples (rinsate and water blanks) and no PH was determined. PH for soil samples was measured 18 days after collection and conservatively "J1" qualified.

One rinsate blank (R70502) and a water blank (B50201) were not preserved with sulfuric acid for TOC and were "J2" qualified.

There were blank detects for Cd, Zn, Ca, Fe, Mg, K and Na. Those analytes were "U7" qualified. Matrix spike outliers for Fe, Mg and K led to "J8" qualification; otherwise other metal's MS results were all acceptable. Matrix spike recoveries for Fluoride and TOC were also acceptable. Duplicate results were all within QC limits. LCS recoveries were all acceptable.

No other problems were seen with the data.

PARAMETER	QUALIFIER	SAMPLES AFFECTED	REASON
Cadmium	U7	DOCU0505 DOCU0509	Contaminant in the calibration and prep blanks (CCB3,4, PBS1, PBS2)
Zinc	U7	R70501 R70502 B50201	Contaminant in the calibration and prep blanks (ICB, PBS1, PBS2)
Calcium	U7	R70501 R70502 B50201	Contaminant in the calibration and prep blanks (ICB, CCB1,2,3,4, PBS1, PBS2)
Iron	U7	B50201	Contaminant in the prep blanks (PBS1, PBS2)
Magnesium	U7	B50201	Contaminant in the calibration blanks (CCB1,2,4)
Potassium	U7	R70501 R70502 B50201	Contaminant in the prep blanks (PBS1, PBS2)
Sodium	U7	R70501 R70502 B50201	Contaminant in the prep blanks (PBS1, PBS2)

Date: January 13, 1995
Project Number: BECH-358
WP file: C:\WP51\BECH\BECH358.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: BECH-358	VALIDATOR: SLC	DATE: 01/14/95

COMMENTS: Data was of generally acceptable quality.

PH holding time was not met for rinsate blank and no PH was determined. PH for soil samples was measured 20 and 21 days after collection and conservatively "J1" qualified.

There were blank detects for Ca, Fe and Mg. Those analytes were "U7" qualified. A slight Zn contamination in rinsate blank and prep blank did not have impact on sample data due to high Zn in the samples. There were insignificant Ca and Na detects in calibration and prep blanks, respectively. A considerable amount Na contamination was detected in rinsate blank. The soil data were not qualified against this rinsate blank.

Matrix spike outliers for K led to "J8" qualification; otherwise other metal's MS results were all acceptable. Matrix spike recoveries for Fluoride and TOC were also acceptable. No potassium in rinsate blank required "N" qualifier because rinsate should not be qualified against soil QC.

Duplicate results were all within QC limits. Slightly low LCS recovery for cation-exchange capacity was observed. The CEC method does not require a LCS and there is no control limit available. No qualification was given for CEC. Otherwise all other LCS recoveries were acceptable.

No other problems were seen with the data.

PARAMETER	QUALIFIER	SAMPLES AFFECTED	REASON
Calcium	U7	R70401	Contaminant in the prep blank (PBS1 and PBS2)
Iron	U7	R70401	Contaminant in the prep blank (PBS1 and PBS2)
Magnesium	U7	R70401	Contaminant in the calibration blanks (ICB, CCB1,3)
Potassium	J8	All	Matrix spike recovery was outside QC limit

Date: January 11, 1995
Project Number: BECH-361
WP file: C:\WP51\BECH\BECH361.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: BECH-361	VALIDATOR: SLC	DATE: 01/11/95	

COMMENTS: Data was of generally acceptable quality.

This data package represents the reanalysis of previously-reported soil samples for cadmium by graphite furnace atomic absorption spectroscopy. The cadmium was originally reported using ICP analysis. All non-detects were reanalyzed.

The MSA analysis was performed on samples which did not meet post digestion spike QC limits. This was performed using different instrument (PE 4100Z). The original analysis was done by Varian 400Z. The results reported from MSA analysis were about 3 to 4 times higher than original results. Post-digestion spike recoveries in original results on those samples were either marginally low or slightly high which indicate that MSA data should not be too far from the original results. MSA data reported were all above 10 µg/l (except one, 6.7 µg/l) which were about 5x ICP detection limit and could be detected by ICP. However, there were no detects in ICP data for all those samples except one (3.1 µg/l). Therefore it was judged that MSA results were rejected and original furnace results were taken with "J". qualification.

Since MSA results were reported in this package, Data Base Change Request Form was generated.

There was no blank detects. Matrix spike and duplicate results calculated using the original furnace data. Duplicate results were all within QC limits. Matrix spike outlier led to "J" qualification. No MS/DUP analyses were performed for water samples. Therefore "N" qualifier was removed from water sample data. LCS recovery was acceptable.

Cadmium detection limit reported was 1.0 µg/l which was mistake of 0.1 µg/l. This was confirmed by Mr. Rolf Larsen at Mountain State Analytical, Inc. Therefore all water sample results were changed from 0.001 mg/l U to 0.0001 mg/l U. Data Base Change Request Form was generated.

All sample results were below CRDL and were within calibration range with highest standard of 5.0 µg/l. The linearity of lower calibration curve was verified using 0.5 µg/l. The data were judged to be generally acceptable.

PARAMETER	QUALIFIER	SAMPLES AFFECTED	REASON
Cadmium	J15	DOCU0503 DOCU0504 DOCU0509 DOCU0510	Post-digestion spikes were outside QC limits
Cadmium	J8	All	Matrix spike recoveries were outside QC limits

Date: January 10, 1995
Project Number: BECH-360
WP file: C:\WP51\BECH\BECH360.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: BECH-360	VALIDATOR: SLC	DATE: 01/10/95

COMMENTS: Data was of acceptable quality.

This data package represents the reanalysis of previously-reported soil samples for cadmium by graphite furnace atomic absorption spectroscopy. The cadmium was originally reported using ICP analysis. All non-detects were reanalyzed.

There was no blank detects. Matrix spike and duplicate results were all within QC limits. LCS recovery was acceptable.

Soil samples were diluted below CRDL and did not meet EPA CLP requirement. However, the data were within standard curve calibration range with highest standard of 5.0 µg/l and the linearity of lower calibration curve was verified using 0.5 µg/l. Therefore the data was judged to be acceptable.

PARAMETER	QUALIFIER	SAMPLES AFFECTED	REASON
All Acceptable			

Date: January 21, 1995
Project Number: 10837.SEM
WP file: C:\WP51\ECO\10837.SEM

DATA QUALIFICATION SUMMARY-FORM

SDG: 10837.SEM	VALIDATOR: JDJ	DATE: 01/23/95	

COMMENTS:

Sample analysis was by SW-846, and data validation was by CLP requirements. This was done for the purpose of keeping new data and historical data compatible.

Blank analysis for the associated metals reveled blank contamination in some of the method blanks as well as initial and continuing blanks (see table in section III. Blank Analysis Results).

According to the case narrative, the metals associated with the SEM analysis were not given a matrix spike, however, a post digestion spike was analyzed for all analytes of interest. This however does not provide information about the effects of the digestion process and its affect on analyte recovery, therefore all analytes other than sulfide will be flagged "J14" on the report.

Sample 10837 was used for laboratory duplicate for the purpose of gathering precision data. All RPD values were acceptable.

An SEM Laboratory Control Sample (LCS) was not submitted for cadmium, copper, nickel, zinc, and lead, therefore the aforementioned metals will be flagged "J10" on the report forms.

The copy quality of this data package was illegible in many cases, this included pages that were missing portions of the print on the edge of a page as a result of misalignment in the copier while printing.

ANALYTE	QUALIFIER	SAMPLES AFFECTED	REASON
See section III.	U7		Blank contamination.
See section V.	J14		No matrix spike.
See section VII.	J10		LCS not submitted for cadmium, copper, nickel, zinc, and lead.
See section IX.	J16		Serial dilution recovery greater than 10%.

Date: November 17, 1994
Project Number: T10837
WP file: C:\WP51\ECO\T10837.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: T10837	VALIDATOR: JDJ	DATE: 11/17/94	

COMMENTS: Data was of acceptable quality.

Sample analysis was by SW-846, and data validation was by CLP requirements. This was done for the purpose of keeping new data and historical data compatible.

The CRDL recoveries for lead (furnace) and mercury (cold vapor) were within the ±20% acceptable range, however, the CRDL for thallium was not reported.

Sample T10837S was used for the matrix spike, several analytes had recoveries
that were less than 75% but greater than 30%, these analytes were flagged "J8" or "UJ8" as appropriate on the FORMS 1.

Sample number T10839 (T10839L) was used to meet the ICP serial dilution requirement. Magnesium (Mg) and manganese (Mn) both had percent differences (%D) greater that 10% in T10839, also the concentrations of Mg and Mn in sample T10839 was greater than fifty (50) times their IDLs. Mg and Mn were given a "J16" qualifier on the FORMS 1.

ANALYTE	QUALIFIER	SAMPLES AFFECTED	REASON
Boron	U7	T10937 T10838 T10839	Preparation blank contamination.
Antimony Cadmium Chromium Lead Selenium Silver Vanadium	J8/UJ8	All	Matrix spike recoveries were low.
Magnesium Manganese	J16	All	Serial dilution recovery greater than 10%.

Date: 20th January 1995
Project Number: 9410837
WP file: 9410837.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: 9410837	VALIDATOR: RJH	DATE: 1.21.95	PAGE
COMMENTS: Results for sulfide given R qualification			
ANALYTE	QUALIFIER	SAMPLES AFFECTED	REASON
Fluoride	J8,5, 1, 10	see validation package	see validation package
TOC	J8	All sediments	see validation package
Sulfide	R8	All sediments	MS % recovery <30%
Ammonia	UJ8	All liquid samples	See validation package

Data Package reviewed by:

Signature	Date:
RJ Holdsworth	1. 21. 95

Date: January 20, 1995
Project Number: T10840
WP file: C:\WP51\ECO\T10840.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: T10840	VALIDATOR: JDJ	DATE: 01/20/95	
COMMENTS: Data was of acceptable quality. Sample analysis was by SW-846, and data validation was by CLP requirements. This was done for the purpose of keeping new data and historical data compatible.			
ANALYTE	QUALIFIER	SAMPLES AFFECTED	REASON
Iron	U7	T10840	Preparation blank contamination.

Data Package reviewed by:

Signature	Date:
Jim D. Johnson	1/20/95

Attachment N-2
Data Validation Report, Ecological Sampling (Phase I Delta Sediment)

Remedial Investigation/Feasibility Study

Data Validation Report

October 1994
Ecological Sampling
(Phase I Delta Sediment)
Metals, Simultaneously Extracted Metals, General Chemistry, and Particle Size Analyses

Prepared for:
FMC Corporation
J.R. Simplot Company

for the
Eastern Michaud Flats Site

January 1995

Bechtel
Bechtel Environmental, Inc.

DATA VALIDATION SUMMARY

Date: December 13, 1994
Project Number: T12236
WP file: C:\WP51\ECO\T12236.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: T12236	VALIDATOR: JDJ	DATE: 12/13/94	

COMMENTS: Data was of acceptable quality.

Sample analysis was by SW-846, and data validation was by CLP requirements. This was done for the purpose of keeping new data and historical data compatible.

The CRDL recovery for mercury (cold vapor) was outside the ±20% acceptable range. No action is required for CRDL recoveries that exceeded the ±20% acceptable range.

ANALYTE	QUALIFIER	SAMPLES AFFECTED	REASON
Arsenic	U7	T12236	Contamination of Continuing Calibration Blank 8
Mercury	U7	T12216 T12243 T12244	Preparation blank contamination.

Data Package reviewed by:

Signature	Date:
[signature]	1/18/95

Date: December 8, 1994
Project Number: T12216
WP file: C:\WP51\ECO\T12216.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: T12216	VALIDATOR: JDJ	DATE: 12/08/94

COMMENTS: Data was of acceptable quality.

Sample analysis was by SW-846, and data validation was by CLP requirements. This was done for the purpose of keeping new data and historical data compatible.

The CRDL recovery for mercury (cold vapor) was outside the ±20% acceptable range. No action is required for CRDL recoveries that exceeded the ±20% acceptable range.

The concentration of zinc in sample T12216 was 31.9 mg/kg, which is greater than the lab's Quantitation limit of 2.83 mg/kg for zinc in sample T12216, therefore this will be acceptable.

The COCs have samples listed with a CC or SDC prefix as being the EPA sample numbers associated with this SDG. However, the cover page and forms associated with this SDG have the lab sample number listed as the EPA sample number, and the EPA sample number is being refired to as the lab sample number. Also, the case narrative has sample numbers that are not correct, this is the only place where the sample numbers appear to be wrong.

ANALYTE	QUALIFIER	SAMPLES AFFECTED	REASON
Mercury	U7	T12216	Contamination of Continuing Calibration Blank 1
Mercury	U7	T12217 T12218 T12219 T12220 T12221 T12222 T12223 T12225 T12226 T12227 T12228 T12229 T12230 T12231 T12232	Preparation blank contamination.

Date: December 13, 1994
Project Number: T12249
WP file: C:\WP51\ECC T12249.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: T12249	VALIDATOR: JDJ	DATE: 12/13/94	
COMMENTS: Data was of acceptable quality. Sample analysis was by SW-846, and data validation was by CLP requirements. This was done for the purpose of keeping new data and historical data compatible. The CRDL recovery for mercury (cold vapor) was outside the ±20% acceptable range. No action is required for CRDL recoveries that exceeded the ±20% acceptable range.			
ANALYTE	QUALIFIER	SAMPLES AFFECTED	REASON
Mercury	U7	T12251 T12255 T12256	Preparation blank contamination.

Data Package reviewed by:

Signature	Date:
[signature]	1/18/95

Date: December 14, 1994
Project Number: T12239
WP file: C:\WP51\ECO\T12239.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: T12239	VALIDATOR: JDJ	DATE: 12/14/94	
COMMENTS: Data was of acceptable quality. Sample analysis was by SW-846, and data validation was by CLP requirements. This was done for the purpose of keeping new data and historical data compatible.			
ANALYTE	QUALIFIER	SAMPLES AFFECTED	REASON
Arsenic	U7	T12239	Contamination in Continuing Calibration Blank no.2 (CCB2)
Iron	U7	T12239	Preparation blank contamination.

Data Package reviewed by:

Signature	Date:
Jerry D. Johnson	1/18/95

Date: December 20, 1994
Project Number: 9412216
WP file: C:\WP51\ECO\9412216.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: 9412216	VALIDATOR: JDJ	DATE: 12/21/94	
COMMENTS: Data was of acceptable quality. Sample analysis was by SW-846, and data validation was by CLP requirements. This was done for the purpose of keeping new data and historical data compatible.			
ANALYTE	QUALIFIER	SAMPLES AFFECTED	REASON
Fluoride	J8	SDCPDB05 SDCPDC06 SDCPDB06 SDCPDB07 SDCPDC07 SDCPDC08 SDCPDB08 SDCPDC09 SDCPDB09 SDCPDC10 SDCPDB10 CC02 RF01 SDCSDC06 SDCSDB07 SDCSDC07 SDCSDB08 SDCSDC08 SDCSDB09 SDCSDC09	Matrix spike recovery was less than 75%.
Fluoride	UJ1	R75002 R75006 R75008 R76002 R76004	Samples were analyzed for fluoride outside the twenty-eight (28) day holding time for waters.

Data Package reviewed by:

Signature	Date:
Jimmy D Johnson	12/21/94

Date: December 15, 1994
Project Number: T12260
WP file: C:\WP51\ECO\T12260.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: T12260	VALIDATOR: JDJ	DATE: 12/15/94	
COMMENTS: Data was of acceptable quality. Sample analysis was by SW-846, and data validation was by CLP requirements. This was done for the purpose of keeping new data and historical data compatible.			
ANALYTE	QUALIFIER	SAMPLES AFFECTED	REASON
Arsenic	U7	T12264	Contamination in Continuing Calibration Blank no. 7 (CCB7)

Data Package reviewed by:

Signature	Date:
	1/18/95

Date: December 20, 1994
Project Number: SEM
WP file: C:\WP51\ECO\SEM.RPT

Sulfide	J1	CC01 SDCPDB01 SDCPDC01 SDCPDC02 SDCPDB02 SDCPDC03 SDCPDB03 SDCPDC04 SDCPDB04 SDCPDC05 SDCPDB05 SDCPDC06 SDCPDB06 SDCSDC01 SDCSDB02 SDCSDC02 SDCSDB03 SDCSDC03	Exceeded holding time.
See section III.	U7		Blank contamination.
See section V.	J8 J14		Low recovery for matrix or no matrix spike.
See section VII.	J10		LCS not submitted for cadmium, copper, nickel, zinc, and lead.
See section IX.	J16		Serial dilution recovery greater than 10%.

Data Package reviewed by:

Signature	Date:
Jim D. Johnson	1/18/95

Date: December 20, 1994
Project Number: SEM
WP file: C:\WP51\ECO\SEM.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: SEM	VALIDATOR: JDJ	DATE: 01/16/95	

COMMENTS:

Sample analysis was by SW-846, and data validation was by CLP requirements. This was done for the purpose of keeping new data and historical data compatible.

The AVS analysis for sulfides were analyzed outside the seven (7) day holding time. Although the 7 day holding time was intended for use as guidance for holding times related to water samples (solid samples do not have a clear holding time established) all samples listed above are sediments, several AVS results will be flagged "J1" on the report forms based on the 7 day holding time established for sulfide analysis associated with water samples
(see table in section I.).

Blank analysis for the associated metals reveled blank contamination in some of the method blanks as well as initial and continuing blanks (see table in section III. Blank Analysis Results).

According to the case narrative, the metals associated with the SEM analysis were not given a matrix spike, however, a post digestion spike was analyzed for all analytes of interest. This however does not provide information about the effects of the digestion process and its affect on analyte recovery, therefore all analytes other than sulfide will be flagged "J14" on the report. In addition to the "J14" flag, any flags listed in section V. (Matrix Spike Results) will also be applied to the appropriate samples and their report forms. This is due to the low recoveries of the post digestion spike mentioned above.

Sample 12220, 12228, and 12240 were used for laboratory duplicates for the purpose of gathering precision data. All RPD values were <35% soil sample
criteria and therefore acceptable.

An SEM Laboratory Control Sample (LCS) was not submitted for cadmium, copper, nickel, zinc, and lead, therefore the aforementioned metals will be flagged "J10" on the report forms.

The copy quality of this data package was illegible in many cases, this included pages that were missing portions of the print on the edge of a page as a result of misalignment in the copier while printing.

ANALYTE	QUALIFIER	SAMPLES AFFECTED	REASON

Date: January 19, 1995
Project Number: 9412216
WP file: C:\WP51\ECO\9412216.TOC

DATA QUALIFICATION SUMMARY-FORM

SDG: 9412216 (TOC)	VALIDATOR: JDJ	DATE: 01/19/95	

COMMENTS: Sample analysis was by SW-846 method 9060, and data validation was by CLP requirements. This was done for the purpose of keeping new data and historical data compatible.

Sample number 9412216 (CC01) was used as the matrix spike for the samples listed in the table above (See section IV.). The low recovery for the matrix spike (MS) was most likely due to the spike not being added to the MS sample and/or poor homogeneity of the original sample and the MS sample.

The copy quality of this data package was illegible in many cases, this included pages that were missing portions of the print on the edge of a page as a result of misalignment in the copier while printing.

ANALYTE	QUALIFIER	SAMPLES AFFECTED	REASON
TOC	J8	9412216 9412217 9412218 9412219 9412220 9412221 9412222 9412223 9412224 9412225 9412226 9412227 9412228 9412229 9412230 9412231 9412232	The matrix spike was not recovered.

Data Package reviewed by:

Signature	Date:
Jimmy D. Johnson	1/19/95

Attachment N-3
Data Validation Report, Ecological Sampling, Small Mammals (deer mice)

Remedial Investigation/Feasibility Study

Data Validation Report

September 1994
Ecological Sampling
Small Mammals (deer mice)

Fluoride, Cadmium and Zinc Analyses

Prepared for:
FMC Corporation
J.R. Simplot Company

for the
Eastern Michaud Flats Site

March 1995

Bechtel
Bechtel Environmental, Inc.

Date: February 21, 1995
Project Number: T11006
WP file: C:\WP51\ECO\T11006.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: T11006	VALIDATOR: JDJ	DATE: 02/21/95	

COMMENTS: Data was of acceptable quality.

Sample analysis was by EPA method 200.3 preparation, 200.9 for cadmium and 200.7 for zinc, and data validation was by CLP requirements. This was done for the purpose of keeping new data and historical data compatible.

The field sampling plan detection limits were checked for sample T11012, all required detections limits were meet by EA Laboratories.

The COCs have samples listed with a MWBU0 prefix as being the EPA sample numbers associated with this SDG. However, the cover page and forms associated with this SDG have the lab sample number listed as the EPA sample number, and the EPA sample number is being refired to as the lab sample number. The data was validated using the nomenclature of the FORMs 1, that is, the lab sample number appears in the EPA sample block and the EPA sample number is listed as the lab sample ID.

The LCS recovery for cadmium was 76.2% which was outside the ±20% QC limit. Therefore, all cadmium results were flagged "J10" on the report forms.

ANALYTE	QUALIFIER	SAMPLES AFFECTED	REASON
Cadmium	J10	T11006 T11007 T11008 T11009 T11010 T11011 T11012 T11013 T11014 T11015 T11016 T11017 T11018 T11019 T11020 T11021 T11022 T11023 T11024 T11025	Solid LCS recovery was less than 80%.

Data Package reviewed by:

Date: February 21, 1995
Project Number: T11006
WP file: C:\WP51\ECO\T11006.RPT

Signature	Date:
Jimmy D. Johnson	2/22/95

Date: February 22, 1995
Project Number: T11026
WP file: C:\WP51\ECO\T11026.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: T11026	VALIDATOR: JDJ	DATE: 02/23/95	

COMMENTS: Data was of acceptable quality.

Sample analysis was by EPA method 200.3 preparation, 200.9 for cadmium and 200.7 for zinc, and data validation was by CLP requirements. This was done for the purpose of keeping new data and historical data compatible.

The field sampling plan detection limits were checked for sample T11027, all required detections limits were meet by EA Laboratories.

The COCs have samples listed with a MWBU0 prefix as being the EPA sample numbers associated with this SDG. However, the cover page and forms associated with this SDG have the lab sample number listed as the EPA sample number, and the EPA sample number is being refired to as the lab sample number. The data was validated using the nomenclature of the FORMs 1, that is, the lab sample number appears in the EPA sample block and the EPA sample number is listed as the lab sample ID.

Continuing Calibration Verification (CCV) number two (2) had 6.47 listed on FORM 2A as the found concentration of cadmium with a %R of 107.8, this could not be confirmed by the raw data which indicated the found concentration to be 6.16 with a %R of 102.7%.

ANALYTE	QUALIFIER	SAMPLES AFFECTED	REASON
Cadmium	J5B	T11026	CCV5 recovery greater than 10%.
Cadmium	J5B	T11027	
Cadmium	J5B	T11028	
Cadmium	J5B	T11030	
Cadmium	J5B	T11031	

Data Package reviewed by:

Signature	Date:
[signature]	2/23/95

Date: February 28, 1995
Project Number: 9411006
WP file: C:\WP51\ECO\9411006F.RPT

DATA QUALIFICATION SUMMARY-FORM

SDG: 9411006	VALIDATOR: JDJ	DATE: 02/[illegible]/95	

COMMENTS:
Data is acceptable with qualifications.

Sample analysis was by AOAC method 3.08 for fluoride in tissue, sample preparation was by AOAC method 3.08, and data validation was by CLP requirements. This was done for the purpose of keeping new data and historical data compatible.

The technical specification for this project required a minimum detection limit of 1 μg/g for the analysis of fluoride in mouse samples. EA Laboratories submitted 7.5 μg/g as being their minimum detection limit for fluoride in mouse samples.

The matrix spike recoveries for fluoride in mouse bodies were lower than the minimum acceptable QC limit of 75%, this will cause all samples associated with this matrix to be flagged "J8" on the report FORMs 1. EA laboratory did not analyze a matrix spike for any of the mouse femur samples, therefore all samples associated with the mouse femurs will be flagged "J14" on the report FORMs 1.

One (1) out of four (4) LCS recoveries was outside the ±20% QC limit. All samples associated with this LCS will be flagged "J10" on the FORMs 1.

ANALYTE	QUALIFIER	SAMPLES AFFECTED	REASON
Fluoride	J8	All samples associated with mouse body tissue.	Low recovery of the matrix spike.
Fluoride	J14	All samples associated with mouse femurs.	No matrix spike.

Date: February 28, 1995
Project Number: 9411006
WP file: C:\WP51\ECO\9411006F.RPT

Fluoride	J10	MWBU0110 MWBU0201 MWBU0202 MWBU0203 MWBU0204 MWBU0205 MWBU0206 MWBU0207 MWBU0208 MWBU0209 MWBU0210 MWBU0301 MWBU0302 MWBU0303 MWBU0304 MWBU0305 MWBU0306 MWBU0307 MWBU0308 MWBU0309 MWBU0310	Low recovery of the LCS.

Data Package reviewed by:

Signature	Date:
Jim D Johnson	2/28/95

Appendix O

Radiation Studies

This appendix contains copies of the following reports:

- Attachment O-1 Simplot Gamma Radiation Survey
- Attachment O-2 FMC Gamma Radiation Survey
- Attachment O-3 Simplot Radon Studies Summary
- Attachment O-4 Simplot Radon Emission Estimates

Attachment O-1
Simplot Gamma Radiation Survey

Bechtel Environmental, Inc.
50 Beale Street (94105)
P.O. Box 193965 (94119)
San Francisco, CA

Facsimile Cover Sheet

To:	Carl Stineman	Date:	1/31/95
Company:	E&E	FAX:	716-684-0844
Location:	Lancaster, NY	Verify:	716-684-8060
From:	Art Day	Phone:	415-768-2066
Company:	Bechtel Environmental, Inc.	FAX:	415-768-0412
Location	EMF Project - San Francisco, CA		

Number of Pages (including cover sheet): 10

Carl,

I understand that you spoke with Steve Curreri and Linda Hanna earlier today and that you were interested in reviewing the gamma exposure measurements obtained in the vicinity of the gypstack at Simplot.

The enclosed report from Dr. Joe Alvarez of IT (Englewood, CO; 303-793-5265) dated January 24, 1995 provides these data. It includes a map showing the locations of the measurement stations; this map will be refined for publication with the report.

Please call me if you have any difficulty in reading the map; I suspect that faxing might make it difficult to read.

cc: Steve Curreri
Linda Hanna
Joe Alvarez

Simplot Employee Exposures

J. L. Alvarez
IT Corporation

Introduction

The Simplot Pocatello Phosphate Plant in Pocatello, ID produces phosphate fertilizers from ore. The ore and resultant phosphogypsum contain ^{226}Ra and progeny in concentrations higher than local background soil. The ore and phosphogypsum consequently emit more gamma radiation than the local soil, thus exposing the workers to higher levels of ionizing radiation than the local background. The levels of radiation generally measured within the plant boundary and at specific locations directly above the phosphogypsum and ore were found not to be sufficient to require a radiation protection program under 40 CFR 1910.96.

Because EPA raised the possibility of excess worker risk under provisions of CERCLA Simplot had an extensive survey performed that would allow evaluation of risk, rather than the need for a radiation protection program. This survey included evaluation of specific job sites under working conditions and time of exposure estimates at the job sites.

Equipment and Methods

Worker activities include transporting and mixing of ores, controlling ore preparation operations, ore processing to extract phosphate, removal, transport, and general maintenance on equipment or the condition of phosphogypsum stack. These activities are usually conducted from the cab of earth moving equipment or from control rooms. Some of these activities are performed while standing directly on the phosphogypsum, but workers are typically transported to the location of the activity by light vehicles such as pick-up trucks.

Exposure rate to the workers was measured on 9-8-94 in the usual worker geometry, e.g., in the cab, control room, or standing on phosphogypsum. When measurements were made in a shielded geometry, a corresponding measurement was made, when possible, standing at the same or nearly the same location well removed from any shielding device. The shielded and unshielded measurements were compared to obtain shielding factors for the various activities.

The measurements were performed with a Bicron µrem meter (B846M), which is tissue equivalent for exposure measurements. The meter was calibrated 5-12-94 and was due for calibration 11-12-94. The meter was performance checked against several locations that were established in a previous study using a pressurized ionization chamber (IT 1994). See Table 1. The exposure rate measurements are given in Table 2.

Development of Shielding Factors

The usual quantity for radiation risk assessment is excess risk above background. Excess exposure rate, E_E, is obtained from the total exposure rate, E_T, by subtraction of the background exposure rate, E_{BG}, or

$$E_E = E_T - E_{BG}. \qquad 1.$$

The background exposure rate is considered to be inescapable, although this may not be strictly true in all cases. If a shield is sufficiently thick and completely surrounds a point, then the shield becomes the terrestrial radiation background for the point. The cosmic radiation portion of the background cannot be easily shielded and is generally considered to be undiminished except for extremely thick shields. For most outdoor situations a shielding factor, F_S, is obtained as the ratio of the excess exposure rate in the shielded configuration to excess exposure rate of the unshielded configuration. If the exposure rate in the shield is E_S, then F_S is found by

$$\frac{E_S - E_{BG}}{E_E} = F_S. \qquad 2.$$

That this is the correct expression can be seen from the following:

Outside a shield, the gamma radiation comprises cosmic radiation, γ_c, and terrestrial radiation, γ_t. The cosmic radiation is unshieldable so that

$$(\gamma_c)_u = (\gamma_c)_s. \qquad 3.$$

The subscripts, u and s, refer to the shielded and unshielded cases. The terrestrial radiation is shieldable, but since the terrestrial radionuclides are found in all materials, the total shield comprising steel, plastics, fabrics, and other materials is assumed have approximately the same concentrations of terrestrial radionuclides,

$$(\gamma_t)_u \cong (\gamma_t)_s. \qquad 4.$$

The total background radiation (cosmic and terrestrial), γ_{bkg}, is, therefore, approximately the same for the shielded and unshielded cases,

$$\gamma_{bkg,u} \cong \gamma_{bkg,s}. \qquad 5.$$

It is assumed that phosphorus slag also contains similar amounts of terrestrial radionuclides with the exception that the concentration of ^{226}Ra is higher. It is the above background ^{226}Ra that can be shielded. The above background radiation from phosphorus slag is found by

$$\gamma_{p,a} = \gamma_{p,t} - \gamma_{bkg,u}. \qquad 6.$$

The subscript, p, refers to phosphorus slag, a, refers to above background, and t, to the total radiation from slag. The exposure reduction factor, f_{er}, for the radiation due to slag is obtained from

$$f_{ar} = \frac{(\gamma_{p,t})_s - \gamma_{bkg,s}}{\gamma_{p,t} - \gamma_{bkg,u}} \qquad 7.$$

Substitution of equations 5 and 6 into equation 7 results in

$$f_{ar} = \frac{(\gamma_{p,t})_s - \gamma_{bkg,u}}{\gamma_{p,a}} \qquad 8.$$

Equation 8 shows that the exposure reduction is properly considered for the above-background exposure from slag if a reduction in background is not effected by the shield.

The total exposure rate, E_S, at a given, shielded location, is obtained from (EPA 1979)

$$E_E \cdot F_S + E_{BG} = E_S . \qquad 9.$$

The excess, shielded exposure rate, E_{ES}, at any location, using the same shield can be determined using the shielding factor and the total unshielded exposure rate E_T

$$E_{ES} = E_S - E_{BG} = E_E \cdot F_S = (E_T - E_{BG}) \cdot F_S . \qquad 10.$$

Use of the Shielding Factors in Worker Risk Assessment

Risk is estimated based on the total excess effective dose to the workers. Exposure at a location, S_i, is obtained as the product of the excess exposure rate, E_{Ei}, and the time at the location, t_i. The total exposure, S_T, is the summation of exposures at the i locations

$$S_T = \sum_i E_{Ei} \cdot t_i . \qquad 11.$$

The total exposure must be converted to effective dose before risk can be assessed.

Conversion of Exposure to Effective Dose

For external radiation of any given energy flux, effective dose to any point within an organism depends on the type and energy of the radiation, the depth within the organism of the point at which the effective dose is required, and the elementary constitution of the absorbing medium at that point. The relationship between exposure and effective dose for external radiation is given by (Zankl 1992)

$$H_E = \sum w_T H_T . \qquad 12.$$

H_E is the effective dose, w_T is the tissue weighting factor, and H_T is the tissue equivalent dose. The spatial distribution of exposure requires modeling of the effective dose in tissue, based on the distribution of the sources of radiation. H_E for several source

distributions and energies has been calculated by the ICRP and presented in ICRP 51 (ICRP 1987), Table 3a. H_E has also been calculated for a planar source in Federal Guidance Report No. 12 (EPA 1993).

Environmental terrestrial radiation comprises a spectrum of gamma energies ranging from 0 to 3000 keV of both discrete primary energies and degraded energies. These energies are strongly to moderately attenuated in tissue, so there is a large variation in H_E with energy for equal amount of exposure at these energies. Cosmic radiation, also a part of environmental radiation, is usually of much higher energies, which are mildly attenuated by tissue. H_E is nearly 1 for cosmic radiation.

It is necessary to integrate over H_E for all energies of terrestrial radiation in order to obtain an average H_E for calculating effective dose. A typical background radiation spectrum for the area of the Simplot Plant was used to integrate over the conversion factors. For a planar geometry the result was $H_E = 0.65$ of the exposure. For a room having walls and floor as a source, the typical background spectrum yielded $H_E = 0.67$ of the exposure using a combination of conversion factors for planar and rotationally symmetric sources.

The typical background spectrum includes contributions from uranium, thorium, and potassium. Phosphogypsum has contributions from essentially ^{226}Ra and progeny only. Radium has a lower average energy than the background spectrum, which will cause a slight lowering in the average H_E. The lowering is small enough that it is practical to use H_E of the typical background spectrum.

The quantity of interest for assignment of effective dose is the above background effective dose. It is necessary to convert exposure to effective dose for this quantity only. Calculation of above-background, shielded, effective dose is performed by first calculating the above-background total exposure by equation 11 then multiplying the result by 0.65,

$$H_E = 0.65\ S_T. \qquad 13.$$

This manner of converting to the dose equivalent after subtraction of the background exposure eliminates the need for a conversion that includes the cosmic component.

References

EPA 1979 Indoor Radiation Exposure Due to Radium-226 in Florida Phosphate Lands, EPA 520/4-/8-013, February 1979

EPA 1993 External Exposure to Radionuclides in Air, Water, and Soil, K. F. Eckerman and J. C. Ryman, Federal Guidance Report No. 12, U. S. EPA, Washington, DC, 1993.

ICRP 1987 Data for Use in Protection Against External Radiation, International Commission on Radiation Protection, Report 51, 1987.

IT 1994 Methods Development Study Report, September 1994 .

Zankl 1992 Effective Dose and Effective Dose Equivalent--The Impact of the New ICRP Definition for External Photon Irradiation, M. Zankl, N. Petoussi, and G. Drexler, Health Physics, Vol. 62, No. 5, May 1992.

Locations of Measurements and Background

The locations are shown in numerical order on the map.

Background of the plant site is varied, because of the highly variable geology. The hills south, southwest and southeast of the plant site are rhyolitic. General locations on the hills are from 15 to 25 µrem/h but locations directly south of the plant range from 20 to 40 µrem/h. Between the plant and the Portneuf River, river deposites from upstream tend to dominate. Background exposure rates of 12-15 µrem/h are found. On the plant site, in the production area, concrete tends to dominate and the exposure rate is usually 10 µrem/h or lower than the average background which can be assumed to be nearer 15 µrem/h. The background in the absence of the plant and the gypstack can only be inferred from the surrounding areas.

Table 1.
Bicron µrem meter performance check.

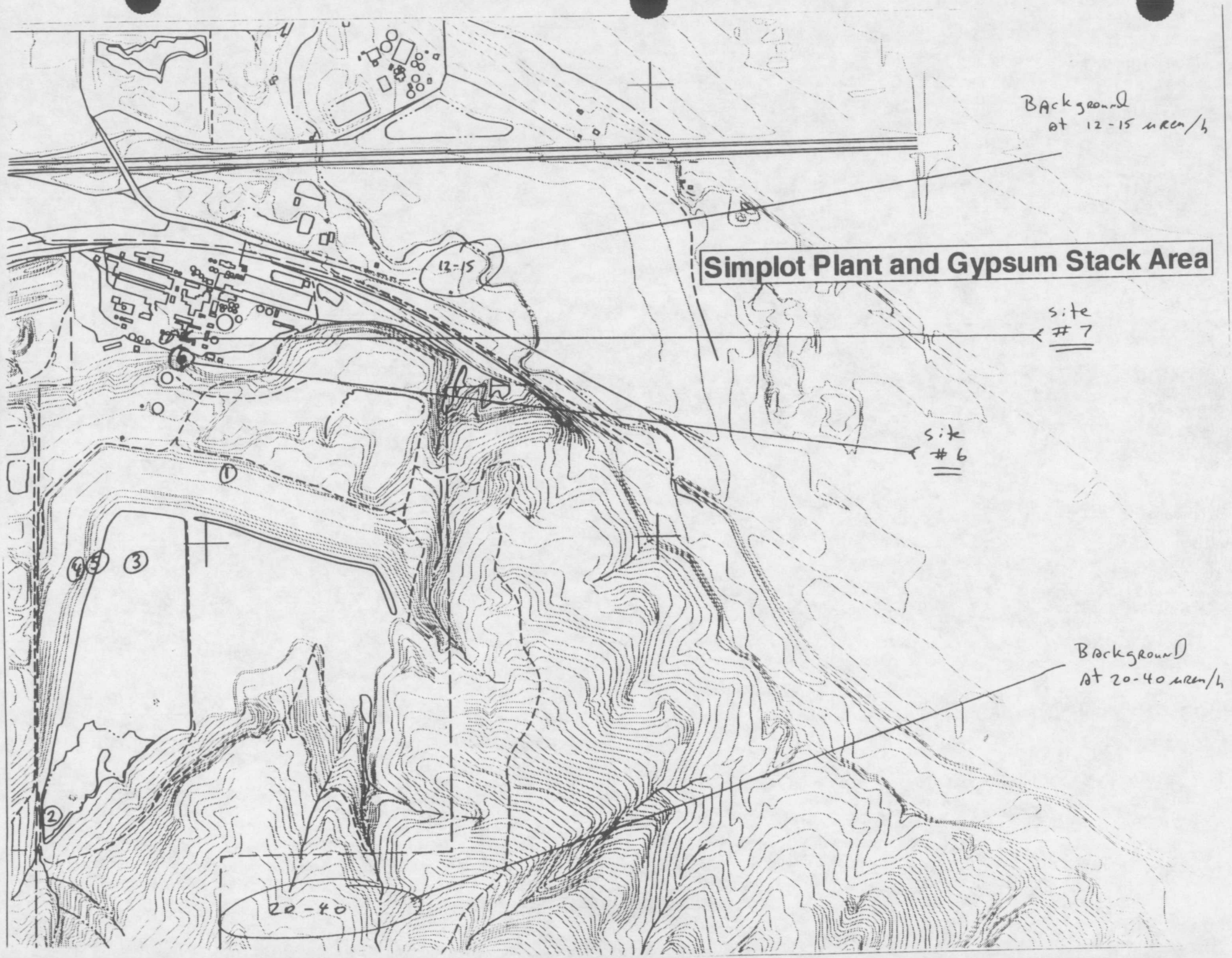
Location	PIC* (µR)	µrem** (µrem)
1	16.4	15
2	10.8	10
3	21.0	20
4	55.0	53

*Pressurized Ionization Chamber (does not include conversion of µR to µrem).
**All values within 3 standard deviations of PIC.

Table 2.
Exposure rate measurements.
Bicron µrem meter
September 8, 1994

	Location	Shielding	Exposure rate (µrem/h)
1	Lower dike	.....	23
		backhoe	12
		cat	9
		pick up	15
2	SW Boundary	.....	10
		pick up	10
3	Upper dike (fill area)	.....	10; water logged
		cat	10; water logged
4	Upper dike (road)	.....	20; several locations
5	Upper dike (on slope)	.....	25; non-working location
		.....	30; non-working location
		.....	25; non-working location
6	Underflow pumps	.....	25
		truck	11
7	Old control room	.....	15-25; general region
		inside	10
	Phos acid control	.....	10
	Evaporator	.....	10
	TSP	.....	10
	Main slurry recovery tank	.....	10
	Liquid process	.....	10
	Lead filters	.....	10
	Tank wash area	.....	10
	Laboratory building	.....	10

not shown on MAP


Simplot Plant and Gypsum Stack Area
Background at 12-15 uRem/h
12-15
site #7
site #6
Background at 20-40 uRem/h
20-40
1
2
3
4
5
6

Attachment O-2
FMC Gamma Radiation Survey

FMC Corporation

Phosphorus Chemicals Division
Box 4111
Pocatello, Idaho 83205
(208) 236-8200
FAX (208) 236-8396

003400

FMC

June 23, 1995

Mr. Bill Adams
U.S. EPA - Region 10
CERCLA Section, HW-113
1200 Sixth Avenue
Seattle, WA 98101

Re: Radiation Exposure Survey for FMC
Eastern Michaud Flats CERCLA Project

Dear Mr. Adams:

I have attached a report entitled "Gamma Radiation Survey, FMC-Pocatello, Idaho" conducted by J. L. Alvarez of IT Corporation. This report supplies site-specific information pertaining to gamma radiation exposures and the shielding factors afforded FMC workers by mobile equipment cabs.

As you know, the PRPs objected to the use of EPA's 1986 aerial gamma survey to characterize potential worker exposures to gamma radiation and resultant risk. FMC and our consultants feel that the IT Survey data are more appropriate for the Risk Assessment. The joint PRP letter commenting on EPA's draft risk assessment (dated June 20) indicated that FMC would be supplying the attached site-specific gamma radiation survey (Comment #7) to EPA.

Sincerely,

Jim Sieverson

J. P. Sieverson
FMC CERCLA Site Manager

Gamma Radiation Survey
FMC - Pocatello, Idaho

J. L. Alvarez
IT Corporation

Introduction

The FMC Plant in Pocatello, Idaho produces elemental phosphorus from phosphate shale. The shale and resultant slag contain naturally-occurring ^{238}U and progeny in concentrations higher than local background soil. Consequently both shale and slag emit more gamma radiation than local soil, thus exposing the workers to higher levels of ionizing radiation than the local background. The levels of radiation generally measured within the plant boundary and at specific locations directly above the slag were found not to be sufficient to require a radiation protection program under 29 CFR 1910.96. Nevertheless, FMC performs radiation measurements on an annual basis to ensure that the radiation environment has not changed sufficiently to require re-evaluation.

Because EPA raised the possibility of excess worker risk under provisions of CERCLA, FMC had a more extensive survey performed that would allow evaluation of risk, rather than the need for a radiation protection program. Key to that risk evaluation is the radiation shielding provided by equipment cabs and buildings. This survey presents gamma radiation measurements and calculated shielding factors for equipment cabs and structures around the FMC Plant.

Equipment and Methods

Worker activities include unloading and storage of phosphate shale; preparation of shale; furnace operations; handling of furnace products and byproducts, including slag; and general maintenance operations. Worker activities are usually conducted from inside the cab of mobile equipment or from indoor control rooms/activity areas. Some activities are performed outdoors while standing directly on phosphate shale or slag, but workers are typically transported to outdoor activities by light vehicles, such as pick-up trucks.

Most of the dose rates to FMC workers were measured in August, 1994 by IT personnel. Subsequent measurements were made by the FMC Radiation Safety Officer using identical methods and equipment. Sampling location descriptions and measurements can be found in Table 2. Sampling locations are shown on a map (FMC Drawing #399176) attached. All measurements were made in the usual worker geometry, e.g., inside equipment cabs or control room, or standing outdoors. When measurements were made in a shielded geometry, a corresponding measurement was made, when possible, standing at the same location well removed from any shielding device. The shielded and unshielded measurements were compared to obtain shielding factors for the various activities. Table 3 of this report summarizes the shielding factors.

IT measurements were performed with a Bicron µrem meter (B846M), which is tissue equivalent for exposure measurements. The meter was calibrated 5-12-94 and was due for calibration 11-12-94. FMC measurements were also performed with a Bicron µrem

meter (B645R). This meter was calibrated 1/31/95 and is due for calibration 1/31/96. These meters were performance checked against several locations that were established in a previous study using a pressurized ionization chamber (IT 1994).

Table 1. Comparison of IT PIC and µrem Meters

Location	PIC* (µR)	µrem** (µrem)
1	16.4	15
2	10.8	10
3	21.0	20
4	55.0	53

*Pressurized Ionization Chamber (does not include conversion of 0.95 µR = µrem).
**All values within 3 standard deviations of PIC (PIC ± 0.7 µR; µrem ± 2 µrem).

Development of Shielding Factors

The usual quantity for radiation risk assessment is excess risk above background. Excess exposure rate, E_E, is obtained from the total exposure rate, E_T, by subtraction of the background exposure rate, E_{BG}, or

$$E_E = E_T - E_{BG}. \qquad 1.$$

The background exposure rate is considered to be inescapable, although this may not be strictly true in all cases. If a shield is sufficiently thick and completely surrounds a point, then the shield becomes the terrestrial radiation background for the point. The cosmic radiation portion of the background cannot be easily shielded and is generally considered to be undiminished except for extremely thick shields. For most outdoor situations, a shielding factor, F_S, is obtained as the ratio of the excess exposure rate in the shielded configuration to excess exposure rate of the unshielded configuration. If the exposure rate in the shield is E_S, then F_S is found by

$$\frac{E_S - E_{BG}}{E_E} = F_S. \qquad 2.$$

That this is the correct expression can be seen from the following:

Outside a shield, the gamma radiation comprises cosmic radiation, γ_c, and terrestrial radiation, γ_t. The cosmic radiation is unshieldable so that

$$(\gamma_c)_u = (\gamma_c)_s. \qquad 3.$$

The subscripts, *u* and *s*, refer to the shielded and unshielded cases. The terrestrial radiation is shieldable, but since the terrestrial radionuclides are found in all materials, the

total shield (typically comprised steel, plastics, fabrics, and other materials) is assumed have approximately the same concentrations of terrestrial radionuclides, so

$$(\gamma_t)_u \equiv (\gamma_t)_s . \qquad 4.$$

The total background radiation (cosmic and terrestrial), γ_{bkg}, is, therefore, approximately the same for the shielded and unshielded cases,

$$\gamma_{bkg,u} \equiv \gamma_{bkg,s} . \qquad 5.$$

It is assumed that phosphorus slag also contains similar amounts of terrestrial radionuclides with the exception that the concentration of ^{226}Ra is higher. It is the ^{226}Ra above background that can be shielded. The above background radiation from phosphorus slag is found by

$$\gamma_{p,a} = \gamma_{p,t} - \gamma_{bkg,u} . \qquad 6.$$

The subscript, *p*, refers to phosphorus slag; *a*, refers to above background; and *t*, to the total radiation from slag.

The exposure reduction factor, f_{er}, for the radiation due to slag is obtained from

$$f_{er} = \frac{(\gamma_{p,t})_s - \gamma_{bkg,s}}{\gamma_{p,t} - \gamma_{bkg,u}} \qquad 7.$$

Substitution of equations 5 and 6 into equation 7 results in

$$f_{er} = \frac{(\gamma_{p,t})_s - \gamma_{bkg,u}}{\gamma_{p,a}} . \qquad 8.$$

Equation 8 shows that the exposure reduction is properly considered for the above-background exposure from slag if a reduction in background is not effected by the shield.

The exposure rate, E_S, at a given, shielded location, is obtained from (EPA 1979)

$$E_E \cdot F_S + E_{BG} = E_S . \qquad 9.$$

The excess, shielded exposure rate, E_{ES}, at any location, using the same shield can be determined using the shielding factor and the total unshielded exposure rate E_T

$$E_{ES} = E_S - E_{BG} = E_E \cdot F_S = (E_T - E_{BG}) \cdot F_S . \qquad 10.$$

Dose at a location, S_i, is obtained as the product of the excess exposure rate, E_{Ei}, and the time at the location, t_i. The total dose, S_T, is the summation of doses at the i locations

$$S_T = \sum_i E_{Ei} \cdot t_i \,. \qquad 11.$$

The total dose must be converted to effective dose before risk can be assessed.

Conversion of Exposure to Effective Dose

For external radiation of any given energy flux, effective dose to any point within an organism depends on the type and energy of the radiation, the depth within the organism of the point at which the effective dose is required, and the elementary constitution of the absorbing medium at that point. The relationship between exposure and effective dose for external radiation is given by:

$$H_E = \Sigma\, w_T H_T. \qquad \text{(Zankl 1992)} \qquad 12.$$

H_E is the effective dose, w_T is the tissue weighting factor, and H_T is the tissue equivalent dose. The spatial distribution of exposure requires modeling of the effective dose in tissue, based on the distribution of the sources of radiation. H_E for several source distributions and energies has been calculated by the ICRP and presented in ICRP 51 Table 3a (ICRP 1987). H_E has also been calculated for a planar source in Federal Guidance Report No. 12 (EPA 1993).

Environmental terrestrial radiation comprises a spectrum of gamma energies ranging from 0 to 3000 keV of both discrete primary energies and degraded energies. These energies are strongly to moderately attenuated in tissue, so there is a large variation in H_E with energy for equal amount of exposure at these energies. Cosmic radiation, also a part of environmental radiation, is usually of much higher energies, which are mildly attenuated by tissue. H_E is nearly 1 for cosmic radiation.

It is necessary to integrate over H_E for all energies of terrestrial radiation in order to obtain an average H_E for calculating effective dose. A typical background radiation spectrum for the area of the FMC Plant was used to integrate over the conversion factors. For a planar geometry the result was $H_E = 0.65$ of the exposure. For a room having walls and a floor as a source, the typical background spectrum yielded $H_E = 0.67$ of the exposure, using a combination of conversion factors for planar and rotationally symmetric sources.

The typical background spectrum includes contributions from uranium, thorium, and potassium. Phosphogypsum has contributions from essentially ^{226}Ra and progeny only. Radium has a lower average energy than the background spectrum, which will cause a slight lowering in the average H_E. The lowering is small enough that it is practical to use H_E of the typical background spectrum.

The portion of effective dose of interest to this study is the above background effective dose. It is necessary to convert exposure to effective dose for this portion only. Calculation of above-background, shielded, effective dose is performed by first calculating the above-background total exposure by equation 11 then multiplying the result by 0.65,

$$H_E = 0.65\ S_T. \qquad 13.$$

This manner of converting to the dose equivalent after subtraction of the background exposure eliminates the need for a conversion that includes the cosmic component.

Conclusions

Based on the data in Table 2, there is no need for a radiation program under 29 CFR 1910.96. A radiation protection program is required where external radiation doses have a potential for exceeding 500 mrem/y. The highest dose rates observed were near 55 µrem/h which, after subtracting a background of 13 µrem/h, yields an excess dose rate of 42 µrem/h. Full-time exposure at this rate for 2000 hrs results in 84 mrem/y. This dose is far below the requirement for a radiation protection program.

The actual doses will be much lower than this maximum dose because full-time is not spent at the highest exposure rates and shielding is present for most outdoor activities. The actual doses should be calculated by equation 11 and a single location annual dose can be calculated by

$$\mathbf{DA_i = (GDR - BG) \times ET \times EF \times SF}$$

DA = annual dose
GDR = total gamma dose rate at a location
BG = background dose rate
ET = exposure time in hours per day
EF = exposure frequency in days per year
SF = shielding factor

The shielding factors must be calculated only for outdoor locations where personnel may be shielded by vehicles. When unshielded, the shielding factor is 1. Shielding factors calculateds from Table 2 are shown in Table 3. The shielding factors are corrected for background.

References

EPA 1979 **Indoor Radiation Exposure Due to Radium-226 in Florida Phosphate Lands**, EPA 520/4-/8-013, February 1979

EPA 1993 **External Exposure to Radionuclides in Air, Water, and Soil**, K. F. Eckerman and J. C. Ryman, Federal Guidance Report No. 12, U. S. EPA, Washington, DC, 1993.

ICRP 1987 **Data for Use in Protection Against External Radiation**, International Commission on Radiation Protection, Report 51, 1987.

IT 1994 **Methods Development Study Report**, September 1994 .

Zankl 1992 **Effective Dose and Effective Dose Equivalent -- The Impact of the New ICRP Definition for External Photon Irradiation**, M. Zankl, N. Petoussi, and G. Drexler, Health Physics, Vol. 62, No. 5, May 1992.

Table 2
Gamma Radiation Measurements
FMC Pocatello, Idaho

(All measurements made with a Bicron µrem meter)

Location (#) = Map Reference	**Shielding**	**Exposure rate** (µrem/h) (Includes background)
(1) Main Entrance Security Office	None - outside	12-15
(2) Burden Business Building	None - outside	25
	Inside pickup cab	18
(3) Shale Stacker	None - outside	45
	Inside pickup cab	32
	None - outside	50
	Inside operator area	30
(4) North of Kiln Bldg.	Inside pickup cab	25
(5) Silica Pile Area	None - outside	10
	Inside pickup cab	10
(6) Dry Valley shale pile	None - outside	35
	Inside pickup cab	25
(7) Reclaim wheel	None - outside	45
(8) Crusher Bldg.	None - outside	38
	Inside pickup cab	22
	None - outside	45
	On steps outside control room	25
	Inside control room	14
(9) Car Dumper, no shale dumping	None - outside	20
	Inside control room	15
(9) Car Dumper, with shale dumping	None - outside	35
	Inside control room	20

Table 2 (continued)

Location (#) Map Reference	Shielding	Exposure rate (µrem/h) (Includes background)
(10) Briqueting building	None - outside	10-15
(11) Walkway	None - outside	30-45
(12) Kiln building (break area)	None - outside	10
(13) Calciners	None - outside	10-15
	Inside control room	10
	None - outside, near a pallet	20
	None - outside cat walk	15-18
(14) Pallet shop	Inside	10
(15) South side calciner	None - outside - Fines pile	38-45
	None - outside - Fan area	10
(16) Cooling towers	None - outside	15-40
(17) Nodule reclaim	None - outside	45
(18) East end of furnace	None - outside bldg.	10
(19) Tapper cool down	None - outside bldg.	10
(20) Near slag pit	None - outside	20
(21) Furnace Control Rm. 1&2	Inside control room	10
(22) Furnace Control Rm. 3&4	Inside control room	10
(23) Furnace 3&4	Inside-Near tapper break structure	15
	Inside break structure	15
	Inside-Furnace area	25

Table 2 (continued)

Location (#) = Map Reference	Shielding	Exposure rate (µrem/h) (Includes background)
(24) Tapper Area	Inside-Near tapper break structure	15-20
	Inside tapper break structure	15
25) Slag pit, west side	None - outside	35
	Inside #1 Link Belt cab	22
	None - outside	30
	Inside #2 Link Belt cab	20
	None - outside	43 (45-48*)
	Inside slag truck cab	15 (15-17*)
	None - outside	40 (44-47*)
	Inside Cat FEL cab	15 (15-20*)
(26) Slag pile, various locations	None - outside	52
	Inside pickup cab	22
	Inside slag truck cab	15
(27) Outdoor fabrication area	None - outside	25-30
(28) Phos tank cleaning area	None - outside	35
	None - outside on platform	20
	Inside control room	10
(29) Contractor Gate	None - outside	33*
	Inside guard shack	23*
(30) Ponds	Inside shack	20*
(31) Ponds	None - outdoors, near pump station	37*

* These measurements were taken by the FMC Radiation Safety Officer with a Bicron µrem meter (B645R. The meter was performance checked at several locations where levels were established by IT using a pressurized ionization chamber (IT 1994).

Table 3
Calculated Gamma Radiation Shielding Factors
FMC- Pocatello, Idaho

Shield	Shielding Factor (1)	Work Area	Map Location
Pickup cab	0.58	Burden Business	(2)
Pickup cab	0.41	Shale stacker area	(3)
Pickup cab	0.54	Silica pile area	(5)
Pickup cab	0.45	Dry Valley shale	(6)
Pickup cab	0.64	Crusher building area	(8)
#1 Link Belt cab	0.59	Slag pit	(25)
#2 Link Belt cab	0.59	Slag pit	(25)
Slag truck cab	0.93	Slag pit	(25)
Cat FEL cab	0.93	Slag pit	(25)
Pickup cab	0.77	Slag pile area	(26)
Slag truck cab	0.95	Slag pile area	(26)
Average	0.77		
SD	0.26		

(1) The factor reported above is $1-E_{ES}$, where E_{ES} is the excess, shielded exposure rate calculated from Equation 10 (given earlier in this report).

Attachment O-3
Simplot Radon Studies Summary

FMC Corporation
J.R. Simplot Co.

November 19, 1993

Mr. Bill Adams
M/S HW-113
U. S. Environmental Protection Agency, Region 10
1200 Sixth Avenue
Seattle, WA 98101

Subject: Eastern Michaud Flats RI/FS
Summary of EPA and Simplot Radon Studies

Dear Mr. Adams:

Enclosed is a summary of radon studies performed by EPA and Simplot in connection with Simplot's phosphoric acid plant in Pocatello, Idaho. We plan to incorporate the summary into the EMF site Preliminary Site Characterization Summary.

For your convenience, we are also enclosing copies of two key references cited in the summary: "Radiological Surveys of Idaho Phosphate Ore Processing - The Wet Process Plant", prepared by EPA's Office of Radiation Programs in 1978, and Chapter 13 of EPA's 1989 "Draft Environmental Impact Statement for Proposed NESHAPS for Radionuclides".

Please contact Andy Phelps of Bechtel (415/768-1111) or me if you have any questions about the enclosed materials.

Sincerely yours,

for

Earl C. Mapes
J. R. Simplot Company

cc: Mike Thomas, ID Dept. of Health and Welfare, Div. of Envir. Qual.
Gordon Brown, ID Dept. of Health and Welfare, Pocatello Field Office
Gary Fenwick, Shoshone-Bannock Tribes
Andy Hafferty, Ecology and Environment

SUMMARY OF RADON STUDIES PERFORMED AT THE J. R. SIMPLOT PHOSPHORIC ACID PLANT POCATELLO, IDAHO

Introduction. Several studies of radon concentrations associated with Simplot's phosphoric acid production plant have been conducted by both EPA and Simplot. These studies indicate that radon concentrations at the plant are within ranges measured in homes in southeast Idaho and/or are insignificant relative to normal household exposures.

Radon is of interest at phosphoric acid production plants such as Simplot's Pocatello plant because it is a decay product of radium-226 which is concentrated during the production of phosphoric acid in the primary process byproduct, phosphogypsum (calcium sulfate). Phosphate rock, the primary feed material in the production of phosphoric acid, contains uranium at concentrations of 20 to 200 parts per million (ppm), 10 to 100 times higher than than those present in typical rocks (1 to 2 ppm). When the phosphate rock is reacted with sulfuric acid to produce phosphoric acid, uranium and its decay products, which include Ra-226, are selectively separated and concentrated. Approximately 80 percent of the radium-226 is transferred to the phosphogypsum (Guimond, 1975).

EPA Studies. EPA has conducted two principal studies of radon emissions from the Simplot facility. The first study was conducted as part of a larger radiological survey of Idaho phosphate ore processing (EPA, 1978). The second was conducted in support of an Environmental Impact Statement for proposed radionuclide NESHAPS (EPA, 1989).

In the first study, EPA measured ambient radon-22 concentrations in several buildings within the Simplot plant and in several outdoor areas, specifically the phosphate ore loading/unloading area and the gypsum stacks. Concentrations were measured with a continuous, low-volume sampling system which drew filtered air through a small, low-volume air pump into a Mylar bag. The intake was about one meter above the ground surface. Various sampling time periods were used. Radon analysis was performed at EPA's Environmental Monitoring and Support Laboratory in Las Vegas, Nevada.

Indoor ambient radon-222 concentrations ranged from a low of 0.14 pCi/l to a high of 1.9 pCi/l. Outdoor concentrations were lower, ranging from 0.23 pCi/l to 0.31 pCi/l in the ore loading/unloading area and gypsum stacks, respectively. These concentrations were deemed within ranges expected as a result of natural terrestrial background sources alone. Radon levels inside structures were cited as generally between 0.6 an 1.2 pCi/l for ventilation rates below four air changes per hour. Radon concentrations in the general environment were cited as ranging form 0.03 to 0.4 pCi/l.

As part of the second EPA study, EPA measured radon flux from each of the two Simplot gypsum stacks. Radon-222 flux is the amount of radon-222 (picocuries) that escapes from a given area of stack surface (square meters) in a given time (seconds). The flux measurements were made with large area activated carbon canisters. The results are summarized in Table 1. All measurements were below the radon NESHAP of 20 pCi/square meter/second. Since the measurements were made during warm, dry summer months and moisture is known to decrease radon flux, EPA acknowledged the measurements were not likely representative of annual average fluxes and likely overestimate annual average flux values (Attachment 1).

Table 1
RADON FLUX MEASUREMENTS ($pCi/m^2/s$)

DESCRIPTION	DATE	AVERAGE	STD. DEV.	# SAMPLES
Upper Stack: Top	July 1987	2.58	2.05	28
Upper Stack: Slope	July 1987	9.08	2.60	6
Lower Stack: Top	July 1987	3.26	2.44	14
Upper Stack: Top	May 1988	4.74	4.46	39
Upper Stack: Slope	May 1988	16.56	10.50	17
Lower Stack: Top	May 1988	7.26	6.88	22
Lower Stack: Slope	May 1988	11.44	6.09	4

Using its radon flux measurements and established models, EPA estimated the radon concentration increases caused by the Simplot gypsum stacks to which the individual residing nearest the stacks is exposed, arriving at concentration increases of 0.0061 pCi/l and 0.002 pCi/l for the upper (southernmost) and lower (northernmost) gypsum stacks, respectively. Maximum lifetime fatal cancer risks were also estimated and are presented in Table 2. The estimates are conservative and overestimate the true concentration increases, not only because of the conservative flux measurements used, but because of conservative assumptions used to simplify the modeling effort (e.g., 1-meter stack heights).

Table 2

ESTIMATED LIFETIME FATAL CANCER RISKS TO NEARBY INDIVIDUALS CAUSED BY RADON-222 EMISSIONS FROM SIMPLOT PHOSPHOGYPSUM STACKS

Location	Radon Concentration (pCi/1)	Maximum Lifetime Fatal Cancer Risk to Individual	Distance [a] (meters)
Lower Stack	2.0E-3	9E-6	1,200
Upper Stack	6.1E-3	3E-5	2,000

(a) Distance from the center of the stack

To put the estimated radon concentration increases in perspective, a University of Pittsburgh study estimates that a household radon concentration of 1 pCi/l reduces the life expectancy of a person spending 75% of his time in his house by 25 days, or that the same person will have a 1 in 300 chance of dying from lung cancer as a result of this exposure (Attachment 2).

Simplot Study. In 1990, Simplot measured ambient radon concentrations at various locations throughout the plant. Measurements were also made across Highway 30 from the plant in a Simplot research building. Measurements were made with detector kits purchased from Key Technologies, Inc. The detector kits were returned to Key Technologies for analysis.

Measurements ranged from a low of 0.2 pCi/l to a high of 19.7 pCi/l (Attachment 3). The two highest concentrations, 12.2 and 19.7 pCi/l, were not measured at the plant, but rather in the research building across the highway from the production area. These measurements are all within the 0 to 38 pCi/l range of measurements made in 160 southeastern Idaho homes in 1987, for which 50% of the measurements were above 3 pCi/l (Idaho State Journal, 1991). EPA recommends reducing radon in homes to levels below 4 pCi/l (EPA, 1986). Thirty four percent of the Simplot plant measurements were above 3 pCi/l; 22 percent exceeded 4 pCi/l.

Conclusion. In summary, indoor radon concentrations measured by EPA and Simplot for worker exposure were similar, but slightly lower, than concentrations measured in homes in southeastern Idaho. Outdoor ambient concentrations measured by EPA were within ranges expected as a result of natural terrestrial background sources alone. In addition, EPA estimates of radon concentration increases due to the gypsum stacks are insignificant for nearby residents compared to normal household exposures despite conservative measurements and assumptions used in EPA's analysis.

References

Office of Radiation Programs, Las Vegas, Nevada USEPA, "Radiological Surveys of Idaho Ore Processing - The Wet Process Plant", April 1978.

USEPA, Office of Air and Radiation, "A Citizen's Guide to Radon", August 1986.

USEPA, Office of Radiation Programs, EPA 520/1-89-006-1, Risk Assessments, Environmental Impact Statement for NESHAPS Radionuclides, Volume 2, Background Information Document.

Guimond, R. J., & Winham, S. T., "Radioactivity Distribution in Phosphate Products, By-products, Effluents, and Wastes," USEPA, Technical Note ORP/CSD-75-3, Washington, D.C., August 1975.

ATTACHMENT 1

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RADIATION PROGRAMS-LAS VEGAS FACILITY
P.O. BOX 98517
LAS VEGAS, NEVADA 89193-8517
(702/798-2476 · FTS 545-2476)

MAR 8 1990

John F. Cochrane, Director
Environmental Affairs Department
J. R. Simplot Company
P.O. Box 912
Pocatello, Idaho 83201

Dear Mr. Cochrane:

Enclosed is a brief report of the radon flux measurement data which EPA collected on your phosphogypsum stacks in July 1987 and May 1988.

We decided during the course of the Idaho Radionuclide Exposure Study that radon flux measurements would be of relatively little benefit in our reaching our objective. Sampling was not sufficient to meet the criteria currently expressed in 40 CFR Part 61, Subpart R, National Emission Standards for Radon Emissions from Phosphogypsum Stacks, specifically Method 115, Part 2.

If you have any further questions, please call me or Gregg Dempsey at 702-798-2476.

Sincerely yours,

Wayne A. Bliss
Director

Enclosure

cc: Richard Guimond (ANR-458)
J. William Gunter (ANR-460)
Jerry Leitch, Region 10
Mark Masarik, ID Ops Office, Boise

INTRODUCTION

Radon flux measurements were made at the two JR Simplot phosphogypsum stacks in Pocatello, Idaho during July of 1987 and May of 1988. The measurement results for the two stacks, (designated "old" and "new") are listed in Tables 1 and 2. These measurements may not be representative of the annual average flux, which can vary considerably with time. Since the measurements were all made during warm dry periods, they are expected to give an upper limit to the annual average radon flux.

A more intensive sampling program is needed to characterize the annual radon flux. EPA 520/5-88-021, "A Long-Term Study of Radon and Airborne Particulates at Phosphogypsum Stacks in Central Florida" concludes that approximately 100 measurements at 10 or more sites, irrespective of sampling period, is needed to provide a representative radon source term for phosphogypsum stacks in Florida.

METHOD

Large area activated carbon canisters were used to make the radon flux measurements. This technique uses a 0.052 m^2 PVC cap containing 200 grams of charcoal evenly distributed over the surface of the canister. The charcoal is held in place with a screened pad secured with a metal retainer spring. The open end of the canister is sealed to the surface by pressing the lip into the material or placing other material around the edges of the canister to prevent wind currents under the canister.

The canister is typically deployed for 24 hours and collected. It is assumed that 100% of the radon released during the exposure period is adsorbed on the activated carbon. The charcoal is removed from the canister and sealed in a 10 centimeter diameter polyethylene "cottage cheese" container. The containers are left for a minimum of 4 hours to allow the radon decay products to reach equilibrium.

The amount of radon adsorbed on the activated carbon is determined by measuring the intensity of the 609 keV gamma emission from Bi-214 using a sodium iodide scintillation crystal and multichannel analyzer.

REPLICATE AND DUPLICATE SAMPLES

Fourteen sets of replicate samples and four sets of duplicate samples were made during the May 1988 sampling period. The results are listed in Table 3. Replicate samples were taken in the same location as the original sample on the following day, and duplicate samples were taken beside the original sample during the same time period.

Replicate samples are designated with an "R" and duplicate samples with a "DU" at the end of the ID number.

EXPERIMENTAL MEASUREMENTS

Some of the measurements made were of an experimental nature and should not be considered as representative of the true flux. These measurements are listed in Table 4. Sample number SM-44-3 was made ten inches off the ground surface to note the variation of radon concentration with height. Sample number SM-44-5 was made in an area that was intentionally disturbed to see the dependence of flux on excavation. Samples number SM-88, SM-92-2, SM-93, SM-95, SM-97, SM-98 and SM-99 were experimental measurements made over fissures.

CONCLUSIONS

While the data collected during this study may not be representative of the annual average radon flux, the errors are conservative and most likely overestimate the actual flux values. The measured flux indicates that the annual average is probably less than 10 pCi/m^2-sec.

TABLE 1: JR Simplot July 1987

New Gypsum Pile (Top)

ID No.	Date	Flux pCi/m²-s
SG-01	14-Jul87	2.0
SG-02	14-Jul87	1.1
SG-03	14-Jul87	0.8
SG-04	14-Jul87	0.5
SG-05	14-Jul87	0.4
SG-06	14-Jul87	6.2
SG-07	14-Jul87	9.0
SG-08	14-Jul87	4.5
SG-09	14 Jul87	1.2
SG-10	14-Jul87	1.0
SG-11	14-Jul87	2.8
SG-12	14-Jul87	0.9
SG-13	14-Jul87	4.1
SG-14	14-Jul87	1.7
SG-15	14-Jul87	0.5
SG-16	14-Jul87	4.3
SG-16R	15-Jul87	0.9
SG-17	14-Jul87	4.5
SG-17R	15-Jul87	1.0
SG-18	14-Jul87	2.7
SG-18R	15-Jul87	1.2
SG-19	14-Jul87	2.9
SG-19R	15-Jul87	2.1
SG-20	14-Jul87	3.6
SG-21	14-Jul87	2.4
SG-22	14-Jul87	2.1
SG-23	14-Jul87	2.0
SG-24	14-Jul87	5.8

New Gypsum Pile (Slope)

SG-25	14-Jul87	10.3
SG-26	14-Jul87	12.2
SG-27	14-Jul87	11.6
SG-28	14-Jul87	8.4
SG-29	14-Jul87	6.0
SG-30	14-Jul87	6.3

Old Gypsum Pile (Top)

ID No.	Date	Flux pCi/m²-s
SG-31	14-Jul87	3.9
SG-31R	15-Jul87	2.0
SG-32	14-Jul87	6.1
SG-33	14-Jul87	8.3
SG-33R	15-Jul87	3.6
SG-34	14-Jul87	2.0
SG-34R	15-Jul87	1.5
SG-35	14-Jul87	3.7
SG-35R	15-Jul87	0.6
SG-36	15-Jul87	2.1
SG-37	15-Jul87	0.8
SG-38	15-Jul87	3.5
SG-39	15-Jul87	7.1
SG-40	15-Jul87	0.5

* R = Replicate Sample

TABLE 2: JR Simplot May 1988

New Gypsum Pile (Top)

ID No.	Date	Flux pCi/m²-s
SM-01	11-May88	2.67
SM-02	11-May88	0.40
SM-04	11-May88	6.57
SM-05	11-May88	0.89
SM-06	11-May88	9.36
SM-06R	12-May88	9.79
SM-07	11-May88	3.04
SM-08	11-May88	6.72
SM-09	11-May88	5.56
SM-10	11-May88	8.22
SM-11	11-May88	LOST
SM-12	11-May88	5.06
SM-13	11-May88	7.18
SM-14	11-May88	9.70
SM-14R	12-May88	11.35
SM-15	11-May88	8.34
SM-16	11-May88	5.12
SM-17	11-May88	0.67
SM-18	11-May88	0.04
SM-20	11-May88	0.28
SM-20DU	11-May88	0.24
SM-33	12-May88	1.78
SM-34	12-May88	0.14
SM-36	12-May88	1.44
SM-37	12-May88	1.45
SM-38	12-May88	1.48
SM-39	12-May88	19.90
SM-40	12-May88	7.33
SM-41	12-May88	4.48
SM-42	12-May88	3.73
SM-43	12-May88	15.29
SM-44-1	12-May88	1.04
SM-44-2	18-May88	5.80
SM-44-4	18-May88	5.60
SM-45	12-May88	4.26
SM-46	12-May88	0.37
SM-47	12-May88	0.00
SM-48	12-May88	4.71
SM-48DU	12-May88	0.66
SM-51	12-May88	0.74
SM-52	12-May88	3.42

New Gypsum Pile (Slope)

ID No.	Date	Flux pCi/m²-s
SM-03	11-May88	19.62
SM-19	11-May88	15.99
SM-19DU	11-May88	4.10
SM-21	11-May88	31.15
SM-22	11-May88	8.34
SM-23	11-May88	15.78
SM-23R	12-May88	7.72
SM-35	12-May88	2.34
SM-49	12-May88	4.48
SM-50	12-May88	26.08
SM-53	12-May88	6.47
SM-89	18-May88	32.83
SM-90	18-May88	33.64
SM-91	18-May88	22.32
SM-92-1	18-May88	9.78
SM-94	18-May88	24.60
SM-96	18-May88	16.22

* R = Replicate Sample
*DU = Duplicate Sample

TABLE 2: JR Simplot May 1988 (continued)

Old Gypsum Pile (Top)

ID No.	Date	Flux pCi/m²-s
SM-25	11-May88	3.57
SM-26	11-May88	4.43
SM-26R	12-May88	0.35
SM-27	11-May88	13.43
SM-28	11-May88	2.01
SM-29	11-May88	1.77
SM-30	11-May88	9.06
SM-31	11-May88	6.52
SM-31R	12-May88	3.94
SM-32	11-May88	29.77
SM-32DU	11-May88	7.78
SM-32R	12-May88	6.72
SM-54	12-May88	3.67
SM-55	12-May88	0.97
SM-56	12-May88	5.97
SM-57	12-May88	1.04
SM-58	12-May88	5.35
SM-59	12-May88	17.53
SM-60	12-May88	4.54
SM-85	18-May88	4.39
SM-86	18-May88	11.23
SM-87	18-May88	15.81

Old Gypsum Pile (Slope)

ID No.	Date	Flux pCi/m²-s
SM-81	18-May88	10.09
SM-82	18-May88	17.83
SM-83	18-May88	14.22
SM-84	18-May88	3.63

* R = Replicate Sample
*DU = Duplicate Sample

TABLE 3: Replicate and Duplicate Samples

Replicate Samples

ID No.	Date	Flux pCi/m²-s
SG-16	14-Jul87	4.3
SG-16R	15-Jul87	0.9
SG-17	14-Jul87	4.5
SG-17R	15-Jul87	1.0
SG-18	14-Jul87	2.7
SG-18R	15-Jul87	1.2
SG-19	14-Jul87	2.9
SG-19R	15-Jul87	2.1
SG-31	14-Jul87	3.9
SG-31R	15-Jul87	2.0
SG-33	14-Jul87	8.3
SG-33R	15-Jul87	3.6
SG-34	14-Jul87	2.0
SG-34R	15-Jul87	1.5
SG-35	14-Jul87	3.7
SG-35R	15-Jul87	0.6
SM-06	11-May88	9.36
SM-06R	12-May88	9.79
SM-14	11-May88	9.70
SM-14R	12-May88	11.35
SM-23	11-May88	15.78
SM-23R	12-May88	7.72
SM-26	11-May88	4.43
SM-26R	12-May88	0.35
SN-31	11-May88	6.52
SM-31R	12-May88	3.94
SM-32	11-May88	29.77
SM-32R	12-May88	6.72

Duplicate Samples

ID No.	Date	Flux pCi/m²-s
SM-20	11-May88	0.28
SM-20DU	11-May88	0.24
SM-48	12-May88	4.71
SM-48DU	12-May88	0.66
SM-19	11-May88	15.99
SM-19DU	11-May88	4.10
SM-32	11-May88	29.77
SM-32DU	11-May88	7.78

TABLE 4: Experimental Measurements

ID No.	Date	Flux pCi/m²-s	
SM-44-3	18-May88	-0.02	(Top of New Gypsum Pile, Ten Inches Off Surface)
SM-44-5	18-May88	11.48	(Top of New Gypsum Pile, Simulation of Excavation)
Fissures, Top of New Gypsum Pile			
SM-88	18-May88	8.90	
SM-93	18-May88	4.44	
SM-95	18-May88	58.33	
SM-97	18-May88	7.71	
SM-98	18-May88	0.92	(sample was found flooded by water after placement).
SM-99	18-May88	2.54	
Fissures, Slope of New Gypsum File			
SM-92-2	18-May88	35.75	
Native Soil Sample			
SM-100	18-May88	1.76	

REPORT ON RADON MEASUREMENT IN YOUR HOME

Radon Project, University of Pittsburgh

The measured radon level in picocuries per liter (pCi/ℓ), from the radon collector kept in your house, is shown by the encircled number above your name on the mailing label of the envelope containing this letter. The following information is to help you understand this result.

It is estimated that the average radon level in European and North American homes is about 1 pCi/liter. This average varies substantially with geography. There are indications that the U.S. average is about 1.4 pCi/liter. In Finland and Sweden, the average is 2.6 pCi/liter. In Pittsburgh we found an average of 2.2 pCi/liter. In most studies, about 15% of all houses have over twice the average level, 4% have over 4 times the average, and about 1% have over 10 times the average.

Exposures to radon decay products are often expressed in "working level", WL. A rough conversion is 1 pCi/liter = 0.005 WL, or 1 WL = 200 pCi/liter.

A typical estimate is that a person spending 75% of his lifetime in a house with a level of 1 pCi/liter will have one chance in 300 of dying from lung cancer as a result of this exposure. The risk is directly proportional to the radon level; e.g. if your reading was 10 pCi/ℓ, your risk is 10 times higher, or one chance in 30.

In terms of loss of life expectancy, a reading of 1 pCi/liter is estimated to reduce one' life expectancy by about 25 days; 15 pCi/liter reduces it by 1 year. By comparison, smoking a pack of cigarettes per day reduces life expectancy by 6 years, being poor reduces it by 4 years, being 25 lb overweight reduces it by 2 years, and automobile accidents reduce it by 200 days. It is reduced 50 days by the risk of falling and 30 days each by the risks of drowning and of fire and burns. Air pollution reduces it by 20 days, and our use of nuclear power will reduce it by 1.5 days according to anti-nuclear activists or by 0.04 days according to most scientists.

One way to reduce radon levels is to improve ventilation; doubling the rate of air exchange roughly cuts the radon level in half. An easy way to eliminate radon almost completely is to open two windows in the basement and install a large fan in one of them, but this is not practical in cold weather. Radon normally enters basements from the grou through cracks in the floor and around pipe entries or through cinder block walls which are often quite porous. Sealing these entry routes may be helpful, but usually is not. Exhausting air from under the basement floor or from "weeping tiles" that surround the exterior has frequently solved the problem. Exhausting air from the hollow spaces inside cinder blocks should also be effective.

For more information about remedial action or about radon in general, you should contact public health officials in your state. If the level in your house is high, they will frequently provide further measurements free of charge.

<u>LIMITATION OF LIABILITY</u>:

The results of any radon tast are obtained exclusively for research purposes. While we make every effort to maintain quality control and include several checks and verification steps in our procedures, we make <u>NO WARRANTY OF ANY KIND, EXPRESS OR IMPLIED</u> for the consequences of erroneous test results. Before expressive action is taken on the basis of the result reported, we recommend that further measurements be made. Neither the University of Pittsburgh nor any of its employees or agents shall be liable under any claim, charge or demand whether in contract, tort or otherwise, for any and all loss, cost, charge, claim, demand, fee, expense or damage of any nature or kind arising out of, connected with, or sustained as a result of any radon test requested.

PLANT RADON SURVEY

January 16, 1990

LOCATION	LOCATION #	SERIAL #	PCi/L
TECH. BLDG.	1.Analytical lab	203351	3.5
	2.Process lab	199765	2.7
	3.Medical Dept.	199780	5.8
FOREMANS OFFICE	4.Lobby area	203361	7.9
	5.Del Butlers Office	203460	8.3
MAINT. OFFICE	6.C.Hirschi Office	199775	4.6
	7.L.McLean Office	203461	1.8
PHOS ACID PLANT	8.Control room	203451	4.4
	9.Digester floor	203491	2.0
T.S.P. PLANT	10.Control room	203482	0.3
	11.Elect. control cntr.	203380	0.6
WATER RECLAIM	12.Control room	203381	3.3
	13.Hydrolic pump room	203452	0.5
ROCK UNLOADING	14.Control room	203377	missing
	15.Elect. control cntr.	203470	missing
CALCINERS	16.Control room	199751	4.9
	17.Elect. control cntr.	203458	4.7
STORES	18.Safety equip area	203382	1.5
	19.Upstairs storage	203373	1.5
MOBILE SHOP	20.Lunch area	203362	1.8
	21.Mechanics garage	203397	0.5
CENTRAL MAINT. SHOP	22.Kirks Office	203486	0.2
	23.Welding area	199785	1.4
MAIN OFFICE	24.Secretary	202720	2.6
	25.Engineering (downstairs)	203476	2.3
GUARDS OFFICE	26.Office area	203391	missing
SHIPPING OFFICE	27.Secretary	203489	3.2
BOILER BLDG.	28.Lab Prep area	203467	0.7
	29.Treater room	203379	1.2
300 SULFURIC	30.Control room	203493	1.8
LIQUID PLANT	31.Control room	203394	0.6
100 AMMO PHOS	32.Control room	199767	1.0
	33.Granulation area	203356	missing
200 AMMO PHOS	34.Control room	203485	0.5
	35.Granulation area	203497	1.2

PLANT RADON SURVEY

January 16, 1990

LOCATION	LOCATION #	SERIAL #	PCi/L
SULFATE	36.Control room	203395	0.3
MILLS	37.Control room	199789	missing
SOLUTIONS	38.Control room	199784	1.4
AMMONIA PLANT	39.Control room	197271	1.7
LABOR POOL	40.Shaffers Office	203376	1.1
SALVAGE SHOP	41.Main shop	203363	1.8
ELECTRICAL SHOP	42.Sengbusch Office	199799	3.3
INSULATORS SHOP	43.Smiths Office	203498	1.3
FRONTIER BLDG.	44.Reception area	199793	19.7
	45.Basement area	203464	12.2
RESEARCH & DEVELOPMENT	46.Lab area	203495	3.8

Attachment O-4
Simplot Radon Emission Estimates

Eastern Michaud Flats Site
Corporate Superfund Offices

FMC Corporation
J.R. Simplot Co

February 8, 1995

Mr. Bill Adams
M/S HW-113
U. S. Environmental Protection Agency, Region 10
1200 Sixth Avenue
Seattle, WA 98101

Subject: Eastern Michaud Flats RI/FS
Radon Emission Estimates

Dear Mr. Adams:

Pursuant to your interest in radon emissions from the J. R. Simplot gypsum stacks, we have estimated radon-222 emission rates and activities in ambient air using three different methods: EPA's Risk Assessment Guidance for Superfund, Part B (RAGS) (EPA,1991); DOE's Manual for Implementing Residual Radioactive Material Guidelines (RESRAD code) (DOE, 1989); and NRC's Regulatory Guide 3.64 (NRC,1989).

In summary, all methods used to estimate radon emissions from the stacks yielded ambient air activities below EPA's ambient indoor radon limit for the home of 4 pCi/L and far below EPA's annual occupational intake limit of 4 WLM (working level months) which corresponds to an ambient air activity of 34 pCi/L.

EPA RAGS Method

The J. R. Simplot plant in Pocatello, Idaho processes phosphate rock to produce phosphoric acid. The process generates phosphogypsum, a calcium sulfate byproduct, which is stacked at the facility. The gypsum stack is approximately 340 acres in area and ranges in thickness from 40 to 100 ft. Radium-226, a radioactive decay product of uranium-238 which is naturally-occurring in the phosphate rock, is concentrated in the gypsum byproduct. The average radium-226 activity is approximately 31 pCi/g. Radon-222, a gaseous progeny of radium-226, is emitted from the stack.

The RAGS (Volume 1, Part B) method for estimating radon-222 activity in ambient air due to radium-226 in soil is the same as that recommended by NCRP (1976) and UNSCEAR (1982). This method applies the general assumption that an average activity of 1 pCi/g of radium-226 in soil generates a radon-222 activity of 120 pCi/m^3 in ambient air. The radon-222 gas activity over the Simplot gypsum stack was estimated by this method using the following additional assumptions:

- Soil and gypsum stacks behave similarly in emanating radon gas.

- Radium-226 is distributed uniformly throughout the gypsum stack.

The radon-222 concentration in ambient air due to radium-226 in the stack was estimated by simply multiplying the gypsum stack radium-226 activity by 120 to convert pCi/g in soil to pCi/m^3 in air. A gypsum stack radium-226 activity of 31 pCi/g yields a radon-222 activity of 3.72E+03 pCi/m^3 (3.72 pCi/L) in air.

DOE RESRAD Code Method

The DOE's RESRAD code (Version 4.6) was used to model the outdoor radon-222 flux and concentration in ambient air immediately above the gypsum stack surface using the following assumptions:

- The stack area is approximately 1.38E+06 m^2 (340 acres).
- The stack geometry is a square with approximately 1173 m sides.
- The stack density is 2.5 g/cm^3.
- Default parameters for sandy material (e.g., total porosity, effective porosity, hydraulic conductivity, retardation factor) listed in the RESRAD manual adequately describe the gypsum stack for the input file. (See Table 1.)
- The gypsum stack has an estimated erosion rate of 2.32E-06 m/year, based on the loss of 8 metric tons of gypsum per year.
- The average radium-226 activity is 31 pCi/g.
- Soil underlying the stack is adequately described by RESRAD default values for soil.

The RESRAD model, designed to assess the maximally exposed individual (conservative approach), predicts a maximum activity of outdoor radon above the gypsum stack surface of approximately 1.89E+03 pCi/m^3 (1.89 pCi/L) in ambient air at time = 0. This result is very close to the result predicted by the RAGS (Part B) methodology.

NRC Regulatory Guide 3.64 Method

The method designed by NRC to estimate radon flux from contaminated piles (e.g., uranium mill tailings) with or without covers can be applied to a gypsum stack, provided that gypsum-stack-specific parameters are used in the model. Radon flux for the Simplot gypsum stack was calculated as prescribed by NRC Regulatory Guide 3.64 (NRC, 1989) using the following formalism:

$$\Phi = 10^4 R \rho E \sqrt{(\lambda D)} \operatorname{Tanh}[T \sqrt{(\lambda + D)}]$$

where

Φ	=	radon flux ($pCi/m^2 \bullet s$)
10^4	=	conversion factor from cm^2 to m^2
R	=	average radium-226 activity in the gypsum stack (31 pCi/g)
ρ	=	dry bulk density of the gypsum stack (2.5 g/cm^3)
E	=	radon emanation coefficient for gypsum (0.28) (Cothern and Smith, 1987)
λ	=	radon-222 decay constant ($2.1 \times 10^{-6}\ s^{-1}$) (NRC 1989)
D	=	radon diffusion coefficient for sand-like material (3×10^{-2} cm/s) (Cothern and Smith, 1987)
T	=	average thickness of gypsum pile [approximately 15 m (40–50 ft)]

Flux calculation results were then used to calculate the radon activity over the coverless gypsum stack, as prescribed by RESRAD (ANL, 1989), using the following formalism:

$$C = (\Phi F) + (\lambda H) \times \{1 - e^{-[(\lambda X) + (2 u)]}\}$$

where

Φ	=	radon flux ($pCi/m^2 \bullet s$)
F	=	outdoor area (A) factor (A/100 for $0 \leq A \leq 100\ m^2$ and 1 for $A \geq 100\ m^2$)
λ	=	radon-222 decay constant ($2.1 \times 10^{-6}\ s^{-1}$) (NRC, 1989)
H	=	mixing height of radon (2 m) (ANL, 1989)
X	=	effective length of gypsum pile ($\sqrt{A}$) (1173 m, based on a square with an area equal to 340 acres)
u	=	average wind speed (4.58 m/s based on 10 mph)

The radon activity calculated using this formalism was approximately 3.5 pCi/L. This value is similar to the results generated with the other two methods.

EPA Study of Simplot Gypsum Stack

As indicated in an earlier letter to you regarding radon emissions (E. C. Mapes to B. Adams, November 19, 1993), EPA conducted a study of radon emissions from the Simplot facility as part of a larger radiological survey of phosphate ore processing in Idaho (EPA. 1978); radon-222 activities in ambient air were measured at the gypsum stack with a continuous, low-volume sampling system that drew air through a filter into a Mylar bag at an intake about 1 m

above the ground surface. The average outdoor activity of radon-222 in the gypsum stack area was approximately 0.31 pCi/L.

Conclusion

The EPA limit for ambient indoor radon in the home is 4 pCi/L. Federal Guidance Report No. 11 (EPA, 1988) specifies an occupational annual radon-222 limit of intake of 4 WLM (working level months), which corresponds to an air activity of approximately 34 pCi/L. (WLM is defined as working in an area with a radon concentration of 1 WL for 1 working month, which is equal to approximately 170 hours; each working year is approximately equal to 2000 hours. One WL corresponds to a radon-222 activity of 100 pCi/L.) All estimates show radon activities in ambient air at Simplot to be less than the 4 pCi/L EPA indoor household limit and the 34 pCi/L Federal Guidance Report No. 11 recommendation for control of occupational exposure. In addition, the results of the EPA study described above (0.31 pCi/L) lend support to the estimates, which are, by design, more conservative than measured results.

Please direct any comments you may have about the contents of this letter to Art Day at Bechtel (415/768-2066).

S. Curreri
J. R. Simplot Company

cc: Mike Thomas, ID Dept. of Health and Welfare, Div. of Envir. Qual.
Gordon Brown, ID Dept. of Health and Welfare, Pocatello Field Office
Tribal Superfund Project Officer, Shoshone-Bannock Tribes
Andy Hafferty, Ecology and Environment
Carl Stineman, Ecology and Environment

Table 1

SITE-SPECIFIC PARAMETERS USED FOR RESRAD MODEL

Parameter	Value	Comment
Contaminated area	1.38E+06 m^2	
Contaminated zone erosion rate	1.32E-06 m/y	
Thickness of contaminated zone	15 m	
Total porosity	0.43	ANL 1989; sandy-like material
Effective porosity	0.33	ANL 1989; sandy-like material
Hydraulic conductivity	5550 m/y	ANL 1989; sandy-like material
Zone b parameter	4.02	ANL 1989; sandy-like material
Runoff coefficient	0.4	ANL 1989; sandy-like material
K_d of Ra-226	7	ANL 1989; sandy-like material
Radon diffusion coefficient	Code calculated	ANL 1989; sandy-like material
Average area wind speed	4.58 m/s	
Radon emanation coefficient	0.2	Default (ANL 1989)
Ra-226 activity	31 pCi/g	

References

ANL, 1989. *A Manual for Implementing Residual Radioactive Material Guidelines*, Energy and Environmental Systems Division, ANL/ES-160, DOE/CH/8901.

Cothern, C. R. and J. E. Smith, Jr. (editors) 1987. *Environmental Radon*, Plenum Press, New York and London.

EPA, 1978. Office of Radiation Programs, Las Vegas, Nevada USEPA, *Radiological Surveys of Idaho Ore Processing - The Wet Process Plant*, April 1978.

EPA, 1988. *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*, EPA/520/1-88.

EPA, 1991. *Risk Assessment Guidance for Superfund: Volume I—Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals)*, Interim, Office of Emergency and Remedial Response, Publication 9285.7-01B.

NCRP, 1976. *Environmental Radiation Measurements*, NCRP Report No. 50.

NRC, 1989. *Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailings Covers*, Office of Nuclear Regulatory Research, Regulatory Guide 3.64.

UNSCEAR, 1982. *Ionizing Radiation Sources and Effects*, UN, N.Y., N.Y.

Appendix P

Radionuclides in On-Site Soils

Source: August 4, 1994 FMC/Simplot letter to EPA, Attachment 2a

RADIONUCLIDES IN ON-SITE SOILS

GENERAL APPROACH AND CONCLUSIONS

To identify and estimate the activities of specific radionuclides in on-site soils, facility feed stocks, products or waste materials, hereinafter referred to as "site-related materials", which are most likely to have impacted the soils were identified for each on-site soil sample. The radionuclide ratios for a given "site-related material" were then used, together with the gross alpha and beta measurements for on-site soils, to estimate the activities of specific radionuclides in each soil sample. This latter step was performed only for soil samples collected at or above 10 feet below ground surface and in which gross alpha or beta measurements plus the associated measurement accuracy exceeded representative levels. The latter step assumes that the "site-related materials" and on-site soil samples are uniform and homogeneous.

The approach described above yields estimates of radium-226 activities in on-site soils ranging from less than 4% to 24% of corresponding soil gross alpha measurements. These percentages are significantly less than 100% radium-226, an assumption under consideration by EPA and its risk assessment contractor without the benefit of the data provided in this attachment.

SPECIFIC APPROACH AND CONCLUSIONS

"Site-related materials" were associated with individual on-site soil samples on the basis of soil sample location, appearance and chemistry. The resulting associations are indicated in Table 2a-1 for soil samples less than or equal to 10 feet deep and/or in which gross alpha or beta measurements exceeded representative levels. For some samples, the specific material which impacted the soil could not be identified, despite the fact that evidence of fill material and/or facility impact was clear. For these soils, the designation "N", indicating no clear association, appears in the "associated site-related material" column of Table 2a-1. For those samples for which "N" appears in the "associated site-related material" column of Table 2a-1, the site-related material most often associated with other soil samples in the same general area was assumed to have impacted the sample. If no site-related material was associated with other samples in the same general area, the site-related material which might most logically have impacted the sample was assumed (e.g., slag for samples from FMC and for road samples at both facilities, and gypsum for the remaining samples at Simplot, given the prevalence of slag and gypsum at the respective facilities).

Radionuclide speciation data for the "site-related materials" are presented in Table 2a-2. Some of these data were collected as part of the EMF Remedial Investigation, and some

were extracted from published literature. Note that activities for radionuclides in the thorium and actinium series are an order of magnitude or more below the activities of radionuclides in the uranium series and are, therefore, negligible in this exercise.

Estimates of specific radionuclide activities in the on-site soils of concern are provided, along with the formulae used to generate the estimates, in Table 2a-3. Derivation of the formulas for each of the "site-related materials" is described below.

Ore and Calciner Fines. Uranium series radionuclides in soils associated with either ore or calciner fines were assumed to be in secular equilibrium. This assumption is supported by the fact that the ore is unprocessed, and that calciner fines are largely unprocessed, the latter, therefore, expected to have a radiochemical composition similar to the ore. This assumption is generally supported by the ore and calciner fine data presented in Table 2a-2, particularly when the accuracy of the radionuclide measurements is taken into consideration.

Based on the assumption of secular equilibrium, the activities of the first four alpha emitters in the uranium series (uranium-238, uranium-234, thorium-230 and radium-226) were summed, multiplying the radium-226 activity by a factor of (3) to account for radium-226 and its three relatively short-lived alpha-emitting daughters for which actual measurements are not available (radon-222, polonium-218 and polonium-214). The activity of each of the first four alpha emitters was then estimated at one seventh (the first <u>four</u> alpha emitters <u>plus</u> the <u>three</u> radium-226 daughters in secular equilibrium) the gross alpha activity in the soil samples for which either ore or calciner fines were identified as the associated site-related material. Lead-210 and polonium-210 activities were set equal to the activities of radium-226 based on the secular equilibrium assumption. Lead-210 was not included in the sum because it is a beta emitter; polonium-210 was not included in the sum because it is largely volatilized in the gross alpha measurement process.

Note in Table 2a-3, that estimated lead-210 concentrations are consistently less than measured gross beta. The difference can be attributed to other beta emitters in the uranium series and to potassium of which potassium-40, a naturally-occurring beta emitter, is a part. (Conversion factor for total potassium in mg/kg to potassium-40 in pCi/g equals 0.0009.)

Ammonium Phosphate and Gypsum. The gypsum data presented in Table 2a-2 indicate enrichment of radium-226 and its daughters, an observation which is consistent with the fact that radium-226 is largely unacidulated in the phosphoric acid production process.

The ammonium phosphate data presented in Table 2a-2 indicate some depletion of thorium-230, radium-226 and other radionuclides below them in the uranium decay series. This observation is consistent with the fact that radium-226 is largely unacidulated in the production of phosphoric acid, one of the primary feed stocks for the production of ammonium phosphate.

To estimate the activities of specific radionuclides in soils associated with ammonium phosphate and gypsum, the alpha emitters activities were summed as described above for ore and calciner fines. (For convenience, the activities measured for the ammonium phosphate sample in Table 2a-2 labeled "various grades" and for the gypsum sample data taken from the Draft EIS for Proposed NESHAPS for Radionuclides were used.) The sums of the alpha emitter activities were used as the denominators in fractions multiplied by the gross alpha measurements in the soils to arrive at estimates of specific radionuclide activities. The individual isotope activities were used as the numerators. (See radioisotope speciation formulae on Table 2a-3.) In the case of ammonium phosphate, lead-210 and polonium-210 were assumed to be in secular equilibrium with radium-226, and their activities were set equal to that that of radium-226. In the case of gypsum, lead-210 and polonium-210 activities were estimated by assuming these radionculides were present in the soils in the same proportion to radium-226 that they are in the gypsum sample used to derive the alpha-emitter fractions described above. (See ammonium phosphate and gypsum radioisotope speciation formulae on Table 2a-3.)

Slag. The slag data presented in Table 2a-2 indicate depletion of lead-210 and polonium-210. This observation is consistent with the fact that these two radionuclides are largely volatilized in the manufacture of elemental phosphorus. The phossy waste/ precipitator slurry data indicate varying degrees of depletion of thorium-230 and its daughters.

To estimate the activities of specific radionuclides in soils associated with slag, the alpha emitters activities were summed as described above for ore and calciner fines. (For convenience, the activities measured for the slag sample data in Table 2a-2 taken from the Idaho Radionuclide Exposure Study were used.) The sum of the alpha emitter activities was used as the denominator in fractions multiplied by the gross alpha measurements in the soils to arrive at estimates of specific radionuclide activities. The individual isotope activities were used as the numerators. (See radioisotope speciation formulae on Table 2a-3.) Lead-210 and polonium-210 activities were estimated by assuming these radionculides were present in the soils in the same proportion to radium-226 that they are in the slag sample used to derive the alpha-emitter fractions described above. (See slag radioisotope speciation formula on Table 2a-2.)

Phossy Wastes/Precipitator Slurry . The phossy waste/precipitator slurry data presented in Table 2a-2 indicate enrichment of lead-210 and polonium-210.

To estimate the activities of specific radionuclides in soils associated with this "site-related material", the alpha emitters activities were summed as described above for ore and calciner fines. The sum of the alpha emitter activities was used as the denominator in fractions multiplied by the gross alpha measurements in the soils to arrive at estimates of specific radionuclide activities. The individual isotope activities were used as the numerators. (See radioisotope speciation formulae on Table 2a-3.) Lead-210 and polonium-210 activities were estimated by assuming these radionculides were present in the soils in the same proportion to radium-226 that they are in the precipitator slurry

sample used to derive the alpha-emitter fractions described above. (See phossy water/solids or precipitator slurry radioisotope speciation formula on Table 2a-2.)

Table 2a-1

Sample ID	Gross Alpha (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Alpha plus Accuracy (pCi/g)	> Representative Level (26.9 pCi/g)	Gross Beta (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Beta plus Accuracy	> Representative Level (31.4 pCi/g)	Associated Site-Related Material (a)	Basis for Association (b)	Comments
Calciner Ponds and Sediments													
F023B000	53.1	11.86	J	64.96	Y	38.8	6.08		44.88	Y	CF	L,C	
F023B010	14.1	5.44	J	19.54		20.3	4.54		24.84				>10'
F023B020	15.6	6.2	J	21.8		27.3	5.78		33.08	Y			>10'
F023B030	15	6.06	J	21.06		20.9	4.62		25.52				>10'
F023B040	26.2	7.78	J	33.98	Y	31.9	5.52		37.42	Y			>10'
F023B050	40.8	12.8	J	53.6	Y	33.1	5.62		38.72	Y			>10'
F023B060	34.8	8.94	J	43.74	Y	42.5	6.54		49.04	Y			>10'
Former Pond 4E													
F024B000	95.3	22.2		117.5	Y	113	13.32		126.32	Y	P	C	
F024B010	16.1	9.44		25.54		25	7.24		32.24	Y	P	C	
F024B020	18.5	9.64		28.14	Y	26.2	7.02		33.22	Y			>10'
F024B030	13.7	8.44		22.14		21.1	6.82		27.92				>10'
F024B040	13.1	10.12		23.22		20.2	7.2		27.4				>10'
F024B050	17.2	10.4		27.6	Y	23.9	7.38		31.28				>10'
F024B060	28.9	11.98		40.88	Y	34.1	7.66		41.76	Y			>10'
F024B070	24.1	12.62		36.72	Y	31.5	8.42		39.92	Y			>10'
F024B080	11.7	6.98		18.68		20.1	6.54		26.64				>10'
Former Pond 5E													
F025B000	86.6	10.94		97.54	Y	119	9.4		128.4	Y	P	A,C	
F025B010	191	17.78		208.78	Y	282	14.44		296.44	Y	P	A,C	
F025B020	19.3	5.94		25.24		29	5.1		34.1	Y			>10'
F025B030	9.37	3.7		13.07		17.2	3.86		21.06				>10'
F025B060	13.6	4.72		18.32		26.9	4.6		31.5	Y			>10'
F025B070	11.8	4.58		16.38		30	5.08		35.08	Y			>10'
Former Pond 6E													
F026B010	12.8	4.42		17.22		24.4	4.9		29.3				< rep levels
F026B060	14.3	4.8		19.1		27.2	5.06		32.26	Y			>10'
Active Landfill													
F027B000	21.1	10.7	J	31.8	Y	20	7.44		27.44				>10'
F027B010	11.6	4.32		15.92		20.3	4.3		24.6				>10'
F027B020	14.6	4.8		19.4		27.6	4.98		32.58	Y			>10'
F027B030	12.6	8.96	J	21.56		29.4	9.14		38.54	Y			>10'
F027B040	11.6	8.68	J	20.28		24	8.48		32.48	Y			>10'
F027B050	26.9	12.32	J	39.22	Y	31.1	8.04		39.14	Y			>10'
F027B060	15	8.2	J	23.2		19.6	6.84		26.44				>10'
F027B070	14.3	8.68	J	22.98		20.9	7.12	J	28.02				>10'
F027B080	12.2	8.84	J	21.04		21.7	7.88	J	29.58				>10'
F027B090	18.8	9.86	J	28.66	Y	21.5	7.02		28.52				>10'
F027B100	16.5	9.56	J	26.06		20.9	6.78	J	27.68				>10'
F027B110	21.2	10.52	J	31.72	Y	24.1	8		32.1	Y			>10'

Table 2a-1

Sample ID	Gross Alpha (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Alpha plus Accuracy (pCi/g)	> Representative Level (26.9 pCi/g)	Gross Beta (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Beta plus Accuracy	> Representative Level (31.4 pCi/g)	Associated Site-Related Material (a)	Basis for Association (b)	Comments
F027B120	14.2	9.02	J	23.22		20.3	7.56		27.86				>10'
Chemical Laboratory Seepage Pit													
F028B000	55	9.72		64.72	Y	48.3	6.52		54.82	Y	S	A,C	
F028B010	14	5		19		26.1	5.28		31.38		S	A,C	
F028B020	14	4.82		18.82		26.1	5.14		31.24				>10'
F028B030	14.8	4.88		19.68		22.7	4.76		27.46				>10'
F028B070	14.3	4.96		19.26		26.1	5.24		31.34				>10'
F029B000	25.7	6.72		32.42	Y	35.1	6.08		41.18	Y			>10'
F029B020	15.1	5.48		20.58		25.9	5.32		31.22				>10'
F029B030	12.8	4.62		17.42		19.8	4.32		24.12				>10'
F029B060	14.8	5.06		19.86		21.8	4.6		26.4				>10'
F029B070	9.07	7.86	J	16.93		21.2	7.52	J	28.72				>10'
IWW Basin and Ditch													
F030B000	171	24.6	J	195.6	Y	67.3	7.8		75.1	Y	O	C	
F030B010	13.9	5.68	J	19.58		21.2	5.14		26.34				< rep levels
F030B020	13.6	5.44	J	19.04		22.6	4.9		27.5				>10'
F030B030	97	12.5	J	109.5	Y	18.4	4.32		22.72				>10'
F030B040	16.2	5.82	J	22.02		27	5.26		32.26	Y			>10'
F030B050	15.6	6.26	J	21.86		26.3	5.54		31.84	Y			>10'
F030B065	25.2	7.44	J	32.64	Y	35.1	5.6		40.7	Y			>10'
F030B075	20.4	7.18	J	27.58	Y	23.9	5.46		29.36				>10'
Former Pond 1E													
F033B000	23.9	10.04	J	33.94	Y	34.6	7.74		42.34	Y	P	L	
F033B005	19.8	8.88	J	28.68	Y	37.5	8.54		46.04	Y	P	L	
F033B010	114	22.4		136.4	Y	152	15.2		167.2	Y			>10'
F033B015	20	9.86		29.86	Y	30.9	7.52		38.42	Y			>10'
9S Storage Area													
F034B000	32.1	11.54		43.64	Y	47.3	9.36		56.66	Y	P	L,C	
F034B005	11.6	7.36		18.96		25	7.04		32.04	Y	P	L,C	
F034B010	31.8	10.52		42.32	Y	42.9	8.96		51.86	Y			>10'
F034B015	7.72	5.52		13.24		18	6.52		24.52				>10'
Former Transformer Salvage Area													
F035B002	15.6	10.86	J	26.46		28.8	9.08		37.88	Y	P	C	
F035B005	19.3	11.86	J	31.16	Y	25.2	6.9		32.1	Y	P	C	
F035B007	16.2	8.72		24.92		30.5	7.84		38.34	Y	P	C	
F035B010	11.5	7.02	J	18.52		18	5.8		23.8				< rep levels
F036B000	31.7	10.9	J	42.6	Y	39.3	8.34		47.64	Y	P	C	
F036B002	13.2	7.74	J	20.94		23.3	7		30.3				< rep levels
F036B005	20.4	9.92	J	30.32	Y	26.2	6.84		33.04	Y	P	C	
F036B007	13	7.74	J	20.74		22.8	6.76		29.56				< rep levels
F036B010	5.37	4.88	J	10.25		14	5.96		19.96				< rep levels

Table 2a-1

Sample ID	Gross Alpha (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Alpha plus Accuracy (pCi/g)	> Representative Level (26.9 pCi/g)	Gross Beta (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Beta plus Accuracy	> Representative Level (31.4 pCi/g)	Associated Site-Related Material (a)	Basis for Association (b)	Comments
Waste Oil Storage Area													
F037B000	32.6	14.96	J	47.56	Y	62.7	10.12		72.82	Y			>10'
Railroad Swale													
F039B000	216	45.2		261.2	Y	76.1	12.44		88.54	Y	O	C	
F039B002	280	57		337	Y	82.2	12.92		95.12	Y	O	C	
F039B005	16.6	7.84		24.44		22.2	6.56		28.76				< rep levels
F039B007	21.6	9.82		31.42	Y	28.5	7.36		35.86	Y	O	C	
F039B010	17.7	9.32		27.02	Y	24.8	7.04		31.84	Y	O	C	
F040B000	18.5	9.18		27.68	Y	22.5	6.66		29.16				>10'
F041B000	96.9	22	J	118.9	Y	62.6	11.7		74.3	Y	S,O	A (slag), C	
F041B002	7.23	5.76	J	12.99		17.6	6.32	J	23.92				< rep levels
F041B005	10.9	6.94	J	17.84		20.9	7		27.9				>10'
F042B000	7.3	6.34	J	13.64		20.9	7.28	J	28.18				< rep levels
F042B002	12.6	8.74	J	21.34		23.3	8.1	J	31.4				< rep levels
F042B005	12	7.32	J	19.32		19.2	6.88	J	26.08				>10'
Former PCB Storage Shed													
F043B000	11.6	7.12		18.72		25.2	6.94		32.14	Y			>10'
F043B002	19.4	10.2		29.6	Y	25.3	7.6		32.9	Y			>10'
F043B005	19.5	9.68		29.18	Y	27.8	7.5		35.3	Y			>10'
F043B007	16.9	10.08		26.98	Y	19.7	7.12		26.82				>10'
F043B010	25.3	10.76		36.06	Y	25.7	6.9		32.6	Y			>10'
F044B000	236	47.4		283.4	Y	79.5	12.36		91.86	Y	N		
F044B002	287	49.6		336.6	Y	130	16.7		146.7	Y	N		
F044B005	103	27.2		130.2	Y	53	10.08		63.08	Y			>10'
F044B007	81.6	23.4		105	Y	45	10.1		55.1	Y			>10'
F044B010	19.9	10.72		30.62	Y	26.1	8.34		34.44	Y			>10'
F045B000	24.1	13.34	J	37.44	Y	26.7	8.16		34.86	Y	N		
F045B002	22.5	10.22	J	32.72	Y	32.6	8.52		41.12	Y	N		
F045B005	17.9	11.98	J	29.88	Y	25.3	7.82		33.12	Y	N		
F045B007	20.4	10.7	J	31.1	Y	25.6	8.28		33.88	Y			>10'
F045B010	14.6	9.72	J	24.32		19.7	7.76		27.46				>10'
Septic Drain Fields													
F046B000	18.5	9.54		28.04	Y	30.5	7.98		38.48	Y	S	A	
F046B007	17.8	9.58		27.38	Y	23.1	6.36		29.46		S	A	
F046B010	13.9	7.94		21.84		23.8	6.82		30.62				< rep levels
F047B000	22.1	9.52		31.62	Y	26.4	7.1		33.5	Y	N		
F047B002	18.4	9.38		27.78	Y	28.1	6.9		35	Y	N		
F047B005	14.5	7.74		22.24		25.6	7.42		33.02	Y	N		
F047B007	12.8	8.28		21.08		28.3	7.48		35.78	Y	N		
F047B010	10.3	7.1		17.4		30.4	7.46		37.86	Y	N		
F048B000	85.8	25.6		111.4	Y	36.5	8.26		44.76	Y	N		
F048B002	18.6	9.76		28.36	Y	24	6.92		30.92		N		
F048B005	19.8	10.36		30.16	Y	23.5	7.1		30.6		N		
F048B007	18.7	9.3		28	Y	29.9	8.28		38.18	Y	N		

Table 2a-1

Sample ID	Gross Alpha (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Alpha plus Accuracy (pCi/g)	> Representative Level (26.9 pCi/g)	Gross Beta (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Beta plus Accuracy	> Representative Level (31.4 pCi/g)	Associated Site-Related Material (a)	Basis for Association (b)	Comments
F048B010	17.2	9.48		26.68		28.2	7.62		35.82	Y	N		
F049B000	54.8	19.38	R	74.18	Y	37	8.3		45.3	Y	N		
F049B002	11.1	7.24	J	18.34		21.8	7.22	J	29.02				< rep levels
F049B005	21.3	10.64	J	31.94	Y	25.6	7.82	J	33.42	Y	N		
F049B007	14.9	9.02	J	23.92		25.8	7.48		33.28	Y	N		
F049B010	15.5	10.46		25.96		26.2	7.82		34.02	Y	N		
Calciner Pond Sediment Storage Area A													
F050B000	137	45		182	Y	133	21		154	Y	CF	A,C	
F050B002	232	61		293	Y	170	23.6		193.6	Y	CF	A,C	
F050B005	352	79.8		431.8	Y	199	25.4		224.4	Y	CF	A,C	
F050B007	241	61.4		302.4	Y	157	28		185	Y	CF	A,C	
F050B010	186	52		238	Y	131	25.8		156.8	Y	CF	A,C	
Calciner Pond Sediment Storage Area B													
F051B000	185	58.4		243.4	Y	94.9	23.2		118.1	Y	CF	A,C	
F051B002	115	37.6		152.6	Y	56.1	14.64		70.74	Y	CF	A	
F051B005	22.3	14.62		36.92	Y	29.3	11.54		40.84	Y	CF	A	
F051B007	39.5	19.3		58.8	Y	42.4	12.84		55.24	Y			>10'
F051B010	62.6	27		89.6	Y	41.1	12.92		54.02	Y			>10'
Secondary Condenser Area													
F052B000	32	13.14		45.14	Y	27.4	7.5		34.9	Y			>10'
F052B002	48.1	16.08	J	64.18	Y	35.4	8.96	J	44.36	Y			>10'
F052B005	18.6	9.9		28.5	Y	31.4	8.4	R	39.8	Y			>10'
F052B007	9.08	6.68	J	15.76		20.8	6.58		27.38				>10'
F052B010	12.3	9.06	R	21.36		21.1	6.9	J	28				>10'
F053B000	43.4	15.68		59.08	Y	43.5	9.74	R	53.24	Y			>10'
F053B002	28.3	11.18	J	39.48	Y	26.5	7.52		34.02	Y			>10'
F053B005	15.9	9.66		25.56		24.9	7.7		32.6	Y			>10'
F053B007	25.8	11.78	J	37.58	Y	26.2	7.78	J	33.98	Y			>10'
F053B010	20.4	10.64	J	31.04	Y	23.7	7.62	J	31.32				>10'
Former Kiln Scrubber Overflow Pond													
F054B000	15.9	8.56		24.46		26	7.32		33.32	Y			>10'
F054B002	14.5	7.98		22.48		26.4	7.16		33.56	Y			>10'
F054B005	12.6	7.52		20.12		21	6.7		27.7				>10'
F054B007	29.3	15.32		44.62	Y	41	11.6		52.6	Y			>10'
F054B010	15.9	8.82		24.72		22.2	6.58		28.78				>10'
Tree-Lined Area Adjacent to Former Pond 7S													
F055B000	16.6	12.7		29.3	Y	22.6	10.4		33	Y	P	L,C	
F055B002	46	19		65	Y	42	11.56		53.56	Y	P	L,C	
F056B000	25.4	16.08		41.48	Y	32.5	11.66		44.16	Y	P	L,C	
F056B002	1530	199.8		1729.8	Y	1070	77		1147	Y	P	L,C	
F057B000	31.4	17.28		48.68	Y	28.1	10.94		39.04	Y	P	L,C	
F057B002	47.4	31		78.4	Y	34.9	17.04		51.94	Y	P	L,C	

Table 2a-1

Sample ID	Gross Alpha (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Alpha plus Accuracy (pCi/g)	> Representative Level (26.9 pCi/g)	Gross Beta (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Beta plus Accuracy	> Representative Level (31.4 pCi/g)	Associated Site-Related Material (a)	Basis for Association (b)	Comments
8S Recovery Process													
F058B000	161	57.2		218.2	Y	546	50.6		596.6	Y	P	C	
F058B002	143	49.2		192.2	Y	81.7	21.6		103.3	Y	P	C	
F059B000	1660	149		1809	Y	1220	59.6		1279.6	Y	P	C	
Area West of the Mobile Shop													
F060B000	130	30.2		160.2	Y	56.7	11.54		68.24	Y	S w/P	C	
F060B002	135	35		170	Y	79.1	13.48		92.58	Y	S w/P	C	
F061B000	159	32.6		191.6	Y	116	16.08		132.08	Y	S w/P	C	
F061B002	192	41.2		233.2	Y	145	19.5		164.5	Y	S w/P	C	
Long-Term Phosphorus Storage Area													
F062B000	17.7	13.94		31.64	Y	27.6	11.44		39.04	Y	N		
F062B002	17.3	15.66		32.96	Y	29.2	13.36		42.56	Y	N		
F063B000	22.2	14.98		37.18	Y	22.2	10.42		32.62	Y	N		
F063B002	40.4	39.8		80.2	Y	29.3	17.96		47.26	Y	N		
Phos Dock Area													
F064B000	13.9	10.5	J	24.4		30.4	10.36	J	40.76	Y	N		
F064B002	38.8	15.04		53.84	Y	31.4	7.94		39.34	Y	N		
Paved Area North of the Furnace Building													
F066B002	23.2	15.14		38.34	Y	27.8	11.26		39.06	Y	S	A,C	
F067B000	32	11.12		43.12	Y	36.6	7.64		44.24	Y	S	A,C	
F067B002	17.1	8.3		25.4		25.7	6.54		32.24	Y	S	A	
F068B000	14.2	12.16		26.36		19.3	9.8		29.1				< rep levels
F068B002	24.6	15.66		40.26	Y	27.6	11.18		38.78	Y	N		
F069B000	16.4	12.94		29.34	Y	24.9	10.44		35.34	Y	N		
F069B002	24.1	13.94		38.04	Y	32.1	10.62		42.72	Y	N		
Phossy Waste/Precipitator Slurry Pipeline Cleanout Areas													
F070B000	27.3	19.04		46.34	Y	28	13.04		41.04	Y	N		
F070B002	31.9	18.28		50.18	Y	36.5	12.44		48.94	Y	N		
F071B000	19.5	9.18		28.68	Y	27.9	6.94		34.84	Y	S	A	
F071B002	17.5	8.36		25.86		25.6	6.66		32.26	Y	S	A	
F072B000	33.3	11.52		44.82	Y	33.7	7.36		41.06	Y	S	A	
F072B002	17.9	7.64		25.54		26.2	6.6		32.8	Y	S	A	
F073B000	16.7	8.52		25.22		28.1	6.96		35.06	Y			>10'
F073B002	11.3	7.24		18.54		25.6	6.52		32.12	Y			>10'
F074B000	14	8.2		22.2		31.2	7.18		38.38	Y	S	A, C	
F074B002	71.8	16.04		87.84	Y	77.8	10.2		88	Y			>10'
F075B000	14.7	10.3		25		23.6	8.28		31.88	Y	N		
F075B002	31.1	17.56		48.66	Y	30.1	11.54		41.64	Y	N		
F076B000	16.5	13.64		30.14	Y	29	11.52		40.52	Y			>10'
F076B002	9.26	11.1	UJ	20.36		27.9	11.12		39.02	Y			>10'
F077B000	94.1	32.2		126.3	Y	53	14.42		67.42	Y	S, P	A (slag), C	

Table 2a-1

Sample ID	Gross Alpha (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Alpha plus Accuracy (pCi/g)	> Representative Level (26.9 pCi/g)	Gross Beta (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Beta plus Accuracy	> Representative Level (31.4 pCi/g)	Associated Site-Related Material (a)	Basis for Association (b)	Comments
F077B002	18.5	13.9		32.4	Y	28.5	11.24		39.74	Y			>10'
F078B000	14.3	12.48		26.78		21.2	10.26		31.46	Y	N		
F078B002	14	12.24		26.24		20.7	10.14		30.84				>10'
F079B000	42.6	20		62.6	Y	40	12.78		52.78	Y	P	C	
F079B002	57.3	22.8		80.1	Y	69	15.96		84.96	Y	P	C	
Bannock Paving Area													
F080B000	14.6	10.18		24.78		23	8.2		31.2				< rep levels
F080B002	9.31	9.66	UJ	18.97		19.8	8.76		28.56				< rep levels
F081B000	21.5	15.24		36.74	Y	25.2	11		36.2	Y	N		
F081B002	21.8	14.56		36.36	Y	19.9	10.1		30		N		
F082B000	12.1	9.46		21.56		21.4	8.08		29.48				< rep levels
F082B002	12.4	12.42	UJ	24.82		18.5	9.76		28.26				< rep levels
Railcar Loading and Unloading Area at Bannock Paving													
F083B002	18.6	13.9		32.5	Y	20.4	10.4		30.8		S	L,A	
F084B000	14.8	12.22		27.02	Y	23.3	10.6		33.9	Y	S	L,A	
F084B002	20.9	14.46		35.36	Y	21.9	10.5		32.4	Y	S	L,A	
Shale Ore Handling Area													
F090B000	207	40.8		247.8	Y	84	12.32		96.32	Y	O	C	
F090B002	262	58.4		320.4	Y	75.3	11.7		87	Y	O	C	
F091B000	186	40.6		226.6	Y	65.1	11.18		76.28	Y	O	L	
F091B002	23.3	10.4		33.7	Y	30.8	8.02		38.82	Y	O	L	
F092B000	35.9	12.26		48.16	Y	28.7	7.12		35.82	Y	O	C	
F092B002	22.1	10.44		32.54	Y	31	7.92		38.92	Y	O	C	
F093B000	222	61		283	Y	92.4	19.16		111.56	Y	O	L	
F093B002	95.7	32.8		128.5	Y	46	13.18		59.18	Y	O	L	
F094B000	20.3	13.54		33.84	Y	25.3	10.82		36.12	Y	O	L	
F094B002	42.2	19.4		61.6	Y	38.4	12.42		50.82	Y	O	L	
Roads													
F101B000	94.1	27		121.1	Y	47.5	11.86		59.36	Y	S	A	
F101B002	22.8	14.3		37.1	Y	26	10.74		36.74	Y	S	A	
F101R000	88.8	33.2		122	Y	77.1	18.74		95.84	Y	P	C	
F101R002	182	65		247	Y	81	19.52		100.52	Y	P,S	C	
F102B000	17.4	10.68		28.08	Y	23.3	8.2		31.5	Y	N		
F102B002	13.3	10.86		24.16		21.2	8.76		29.96				< rep levels
F103B000	19.6	11.66		31.26	Y	24.9	8.64		33.54	Y	N		
F103B002	17.1	10.42		27.52	Y	26.5	8.56		35.06	Y	N		
F104R000	177	63		240	Y	82.4	24.8		107.2	Y	S,FP	A (slag),C	
F104R002	102	55.4		157.4	Y	79.9	29.4		109.3	Y	S,FP	A (slag),C	
F105B000	281	52.2	J	333.2	Y	108	13.88		121.88	Y	S	C	
F105B002	206	37.2	J	243.2	Y	99.3	13.32		112.62	Y	S	C	
F106B000	15.5	11.18		26.68		23	8.86		31.86	Y	S	L,C	
F106B002	10.3	8.26		18.56		23.3	7.92		31.22				< rep levels
F107R000	234	71.6		305.6	Y	[illegible]	[illegible]6		114	Y	S	A,C	

Table 2a-1

Sample ID	Gross Alpha (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Alpha plus Accuracy (pCi/g)	> Representative Level (26.9 pCi/g)	Gross Beta (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Beta plus Accuracy	> Representative Level (31.4 pCi/g)	Associated Site-Related Material (a)	Basis for Association (b)	Comments
F107R002	99.9	37.8		137.7	Y	53.1	16.5		69.6	Y	S	A,C	
F108B000	41	16.1		57.1	Y	27.8	7.78		35.58	Y	S	C	
F108B002	57.2	18.2		75.4	Y	38.5	9.14		47.64	Y	S	C	
F109B000	30.2	11.44		41.64	Y	32.4	8.08		40.48	Y	G,S	A,C (gypsum)	
F109B002	19.3	10.12		29.42	Y	20.8	6.62		27.42		G,S	C	
F110B000	28.5	14.36	J	42.86	Y	28.4	10.54	J	38.94	Y	S,O	C	
F110B002	90.3	22.8	J	113.1	Y	53.3	10.62	J	63.92	Y	S,O	C	
F111R000	334	94.2		428.2	Y	125	26.2		151.2	Y	S	A,C	
F111R002	162	31.2		193.2	Y	79.9	10.98		90.88	Y	S	A,C	
F112R000	149	28.8		177.8	Y	76.8	10.2		87	Y	S	A	
F112R002	188	33.4		221.4	Y	107	12.92		119.92	Y	S	A	
F113R000	145	27.8		172.8	Y	79.8	10.52		90.32	Y	S,O	C	
F113R002	28.6	19.26		47.86	Y	33.5	13.8		47.3	Y	S,O	C	
F114R000	177	31.4		208.4	Y	78.8	10.24		89.04	Y	S,O	C	
F114R002	17.4	8.88		26.28		37.8	7.72		45.52	Y	S,O	C	
F115R000	151	27		178	Y	81.4	10.72		92.12	Y	O	C	
F115R002	27.6	16.14		43.74	Y	25.2	10.88		36.08	Y	O	C	
F119R000	226	77.8		303.8	Y	96	26.6		122.6	Y	O	A,C	
F119R002	153	89		242	Y	85.1	38.4		123.5	Y	O	A,C	
F121R000	129	26.6		155.6	Y	65.6	9.78		75.38	Y	S	A,C	
F121R002	126	22.8		148.8	Y	69.6	9.82		79.42	Y	S	A,C	
F122R000	38.2	17.34		55.54	Y	34.1	10.28		44.38	Y	N		
F122R002	9.38	8.14		17.52		25.1	8.32		33.42	Y	N		
F123B000	25.8	15.78		41.58	Y	27.1	11.26		38.36	Y	N		
F123B002	22.9	14.9		37.8	Y	25.7	10.9		36.6	Y	N		
F124B000	61.8	28		89.8	Y	37.8	14.56		52.36	Y	S	A,C	
F124B002	26.2	17.04		43.24	Y	32.4	11.9		44.3	Y	P	C	
F125B000	29.9	19.34		49.24	Y	23.9	12.5		36.4	Y	N		
F125B002	16	14.76		30.76	Y	18.7	11.68		30.38		N		
F126B000	19.2	14.58		33.78	Y	33.2	11.42		44.62	Y	N		
F126B002	22.9	15.06		37.96	Y	29.8	11		40.8	Y	N		
Storage Area B (Phase II)													
F127B000	84.2	13.1		97.3	Y	81.5	6.36		87.86	Y	CF	A,C	
F127B005	2.24	2.37	UJ	4.61		3.49	2.49	UJ	5.98				< rep levels
F127B015	17.4	5.95		23.35		20.7	3.93		24.63				>10'
F127B025	11.9	5.15		17.05		20.6	3.92		24.52				>10'
F127B035	20.7	6.14		26.84		21.1	3.95		25.05				>10'
Storage Area A (Phase II)													
F128B010	13.7	5.29		18.99		33.2	4.66		37.86	Y	CF	L,C	
F128B020	17.3	6		23.3		27	4.33		31.33				>10'
F128B030	20.4	6.68		27.08	Y	25.8	4.26		30.06				>10'
F128B040	15.9	5.98		21.88		20.6	3.9		24.5				>10'
F128B060	16	5.69		21.69		24.1	4.15		28.25				>10'
F128B070	23.3	6.92		30.22	Y	36.2	4.88		41.08	Y			>10'
F128B080	26.1	6.77		32.87	Y	26.9	4.32		31.22				>10'

Table 2a-1

Sample ID	Gross Alpha (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Alpha plus Accuracy (pCi/g)	> Representative Level (26.9 pCi/g)	Gross Beta (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Beta plus Accuracy	> Representative Level (31.4 pCi/g)	Associated Site-Related Material (a)	Basis for Association (b)	Comments
F128B100	11.4	5.54		16.94		17.9	3.76		21.66				>10'
Roads (Phase II)													
F129B000	62.4	11.6		74	Y	35.3	5.29		40.59	Y	S	C	
F129B005	10.9	4.09		14.99		23.4	4.32		27.72				< rep levels
F129B010	18.7	5.56		24.26		20.2	4.17		24.37				< rep levels
F129B015	11.4	4.18		15.58		19.4	4.07		23.47				>10'
F129B020	15.9	4.63		20.53		25.8	4.49		30.29				>10'
F129B025	14	4.92		18.92		23	4.34		27.34				>10'
Former Kiln Scrubber Overflow Pond (Phase II)													
F130B000	126	19.6		145.6	Y	59.5	8.36		67.86	Y			>10'
F130B010	22.3	6.01		28.31	Y	23.1	4.21		27.31				>10'
F130B020	7.35	3.27		10.62		13.6	3.62		17.22				>10'
F130B040	4.99	2.64	U	7.63		10	3.25		13.25				>10'
F130B050	4.78	2.66	U	7.44		16.2	3.74		19.94				>10'
F130B070	12.9	3.92		16.82		21.3	4.1		25.4				>10'
F130B090	11.6	4		15.6		22.1	4.2		26.3				>10'
Railroad Swale (Phase II)													
F131B040	5.71	2.76		8.47		13.2	3.51		16.71				>10'
F131B060	16	5.02		21.02		23.7	4.28		27.98				>10'
F131B070	17.9	8.61		26.51		21.6	4.41		26.01				>10'
Gypsum Stacks													
S001B000	68.8	29.6		98.4	Y	43.4	13.04		56.44	Y			>10'
S001B010	9.25	10.52	UJ	19.77		21.8	10.14		31.94	Y			>10'
S001B030	10.2	9.64		19.84		20.7	9.48		30.18				>10'
S001B040	2.73	6.7	UJ	9.43		18.1	9.18		27.28				>10'
S001B050	7.61	9.7	UJ	17.31		17.5	9.24		26.74				>10'
S001B060	11.2	10.88		22.08		22.1	10		32.1	Y			>10'
S001B070	[illegible]	18.58		43.26	Y	18.5	12.06		30.56				>10'
S001B080	[illegible]	16	UJ	30.8	Y	20.9	12.46		33.36	Y			>10'
S002B000	150	39.8		189.8	Y	31.5	7.3		38.8	Y			>10'
S002B010	20.1	8.82		28.92	Y	11.5	4.84		16.34				>10'
S002B020	5.73	4.5		10.23		13.8	5.48		19.28				>10'
S002B030	9.65	6		15.65		16.9	6		22.9				>10'
S002B040	10.6	6.52		17.12		23.4	7.1		30.5				>10'
S002B050	13.2	11.86		25.06		20.5	9.98		30.48				>10'
S002B060	6.94	8.5	UJ	15.44		18.6	9.34		27.94				>10'
S002B070	12.3	11.62		23.92		22.2	[illegible]		32.3	Y			>10'
S003B010	10.8	10.16		20.96		18.8	9.5		28.3				>10'
S003B020	15.3	12.8		28.1	Y	20.1	9.86		29.96				>10'
S003B030	9.6	11.02	UJ	20.62		23.8	10.04		33.84	Y			>10'
S003B060	26.4	15.78		42.18	Y	33.9	11.6		45.5	Y			>10'
S003B070	34	18.5		52.5	Y	32.9	11.44		44.34	Y			>10'
S004B000	11.3	13.2	UJ	24.5		27.7	13.68		41.38	Y			>10'

Table 2a-1

Sample ID	Gross Alpha (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Alpha plus Accuracy (pCi/g)	> Representative Level (26.9 pCi/g)	Gross Beta (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Beta plus Accuracy	> Representative Level (31.4 pCi/g)	Associated Site-Related Material (a)	Basis for Association (b)	Comments
S004B010	11.5	14.5	UJ	26		12.9	11.36		24.26				>10'
S004B020	52.5	26.4		78.9	Y	60.1	18.02		78.12	Y			>10'
S004B030	34.2	21		55.2	Y	48.9	16.38		65.28	Y			>10'
S004B040	10.2	11.78	UJ	21.98		14.4	11.52		25.92				>10'
S004B050	4.36	8.2	UJ	12.56		13	10.72		23.72				>10'
S004B060	15.2	15.16		30.36	Y	47.4	16.84		64.24	Y			>10'
S004B070	55.7	32.4		88.1	Y	46.4	16.8		63.2	Y			>10'
S004B080	9.25	13.2	UJ	22.45		17.8	12.3		30.1				>10'
S004B090	19.4	17.72		37.12	Y	21.1	12.94		34.04	Y			>10'
S004B100	17.1	10.48	J	27.58	Y	27.1	9.1	J	36.2	Y			>10'
S004B110	17.9	11.14	J	29.04	Y	24	8.84	J	32.84	Y			>10'
S005B000	15.3	17.22	UJ	32.52	Y	15.7	13.36		29.06				>10'
S005B010	17.2	18.68	UJ	35.88	Y	29.1	15.4		44.5	Y			>10'
S005B020	10.5	14.94	UJ	25.44		27.1	15.48		42.58	Y			>10'
S005B030	14.1	15.9	UJ	30	Y	15.4	12.86		28.26				>10'
S005B040	9.64	14.04	UJ	23.68		17.8	13.34		31.14				>10'
S005B050	6.33	11.84	UJ	18.17		20.9	13.8		34.7	Y			>10'
S005B060	16	18.2	UJ	34.2	Y	18.6	13.96		32.56	Y			>10'
S005B070	8.88	9.86	UJ	18.74		26.2	10.68		36.88	Y			>10'
S005B080	8.8	8.66		17.46		20	8.32		28.32				>10'
S005B090	11.2	11.22	UJ	22.42		21.4	10.02		31.42	Y			>10'
S005B100	12.9	11.56		24.46		18.9	9.38		28.28				>10'
S005B110	12.1	12.98	UJ	25.08		29.6	12.78		42.38	Y			>10'
S005B120	9.88	10.48	UJ	20.36		20.9	9.76		30.66				>10'
S005B130	12.8	9.96		22.76		24.7	9.14		33.84	Y			>10'
S005B140	8.36	9.9	UJ	18.26		21.5	9.88		31.38				>10'
S005B150	14.3	13.1		27.4	Y	33.1	11.8		44.9	Y			>10'
S005B160	8.47	9.62	UJ	18.09		19.9	9.54		29.44				>10'
S005B180	13.3	11.64		24.94		32.7	11.24		43.94	Y			>10'
S006B000	23.9	14.78		38.68	Y	23.9	10.34		34.24	Y			>10'
S006B010	69.4	28.4		97.8	Y	44.4	12.88		57.28	Y			>10'
S006B020	24.9	14.9		39.8	Y	27.7	10.88		38.58	Y			>10'
S006B030	15.6	12.42		28.02	Y	22.1	10.02		32.12	Y			>10'
S006B040	40.2	19.32		59.52	Y	40.2	12.44		52.64	Y			>10'
S006B060	17.1	12.5		29.6	Y	33.8	11.76		45.56	Y			>10'
S006B070	11.7	11.6		23.3		17.8	9.58		27.38				>10'
S006B080	24.6	14.58		39.18	Y	35.1	11.82		46.92	Y			>10'
S006B090	25.3	15.36		40.66	Y	28	10.92		38.92	Y			>10'
S006B100	26	15.4		41.4	Y	50.3	13.44		63.74	Y			>10'
S006B120	13.1	10.92		24.02		29.9	11.08		40.98	Y			>10'
S006B130	25.4	15.04		40.44	Y	39.4	12.3		51.7	Y			>10'
Former Water Treatment Settling Pond													
S007B000	17.3	11.48		28.78	Y	21	9.8		30.8		N		
S007B010	18	11.46		29.46	Y	19.5	9.54		29.04				>10'
S007B020	5.94	7.2	UJ	13.14		6.62	7.8	UJ	14.42				>10'

Table 2a-1

Sample ID	Gross Alpha (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Alpha plus Accuracy (pCi/g)	> Representative Level (26.9 pCi/g)	Gross Beta (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Beta plus Accuracy	> Representative Level (31.4 pCi/g)	Associated Site-Related Material (a)	Basis for Association (b)	Comments
Dewatering Pit													
S008B000	406	81.2		487.2	Y	138	21		159	Y	O	L	
S008B001	14.5	10.68		25.18		20.9	9.96		30.86				< rep levels
S008B010	3.46	6.16	UJ	9.62		6.01	7.82	UJ	13.83				< rep levels
S008B020	11.1	9.8		20.9		13.7	8.86		22.56				< rep levels
S008B030	5.1	7.36	UJ	12.46		13	8.94		21.94				< rep levels
Former Pillow Tank Area													
S010B000	10.4	11.44	UJ	21.84		23.2	10.34		33.54	Y			>10'
S010B002	6.35	9.52	UJ	15.87		20.3	9.52		29.82				>10'
S010B005	17.3	13.38		30.68	Y	20.9	9.74		30.64				>10'
S010B007	18.6	13.44		32.04	Y	23	10.02		33.02	Y			>10'
S010B010	13.6	12.54		26.14		21	9.92		30.92				>10'
S011B000	20.4	15.6		36	Y	19.7	11.14		30.84				>10'
S011B002	15.9	14.54		30.44	Y	21.7	11.5		33.2	Y			>10'
S011B005	14	12.28		26.28		20.6	10.12		30.72				>10'
S011B007	12.7	13	UJ	25.7		22.1	11.64		33.74	Y			>10'
S011B010	18.7	15.24		33.94	Y	24.1	11.98		36.08	Y			>10'
Ammonium Phosphate Plant #1													
S030B000	34.4	23.8		58.2	Y	21	14.5		35.5	Y	G	A,C	
S031B000	29.4	19.78		49.18	Y	10.3	11.56	UJ	21.86		AP	L,C	
S032B000	242	87.2		329.2	Y	91	25		116	Y	AP	L,C	
S032B002	18.5	18.14		36.64	Y	15.8	13		28.8		AP	A,C	
S033B000	54.7	30.2		84.9	Y	33.4	16.52		49.92	Y	N		
S033B002	31.8	14.6		46.4	Y	32.3	10.08		42.38	Y	N		
S034B000	27.2	12.1		39.3	Y	34.8	9.62		44.42	Y	AP	L,C	
S034B002	15.1	8		23.1		20.4	6.44		26.84				< rep levels
S035B000	57	14.9		71.9	Y	43.8	8.52		52.32	Y	AP	L,C	
S035B002	14.9	8.96		23.86		17.4	5.7		23.1				< rep levels
S036B000	11.3	7.12		18.42		21.7	6.48		28.18				< rep levels
S036B002	44.5	14.08		58.58	Y	41.1	[illegible]		49.78	Y	AP	L,C	
S037B000	64.5	17.18		81.68	Y	37.4	[illegible]		45.54	Y	N		
S037B002	16.1	8.52		24.62		23.8	[illegible]		30.18				< rep levels
Ammonium Phosphate Plant #2													
S038B000	12.5	14.04	UJ	26.54		13.6	12.48		26.08				< rep levels
S038B002	14.2	16.86	UJ	31.06	Y	19.2	13.46		32.66	Y	AP	L,C	
S040B000	11.6	14.4	UJ	26		19.8	13.68		33.48	Y	N		
S041B000	6.52	10.58	UJ	17.1		11.1	11.8	UJ	22.9				< rep levels
S042B000	9.46	10.86	UJ	20.32		12.9	10.3		23.2				< rep levels
S042B002	13.1	15.8	UJ	28.9	Y	23.5	14.24		37.74	Y	AP	L,C	
S043B000	51.8	21.6		73.4	Y	33.4	11.48		44.88	Y	AP	L,C	
S043B002	10.3	10.96	UJ	21.26		16.4	9.48		25.88				< rep levels
S044B000	17.7	11.58		29.28	Y	15.3	9.3		24.6		N		
S045B000	13.2	10.4		23.6		18.6	9.7		28.3				< rep levels
S045B002	3.01	8.04	UJ	11.05		17	9.52		26.52				< rep levels

Table 2a-1

Sample ID	Gross Alpha (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Alpha plus Accuracy (pCi/g)	> Representative Level (26.9 pCi/g)	Gross Beta (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Beta plus Accuracy	> Representative Level (31.4 pCi/g)	Associated Site-Related Material (a)	Basis for Association (b)	Comments
Ammonium Sulfate Paint													
S046B000	94.5	33.4		127.9	Y	55.3	14.62		69.92	Y	N		
S046B002	11	10.62		21.62		17.6	9.46		27.06				< rep levels
S047B000	80.7	28.8		109.5	Y	40.9	12.78		53.68	Y	N		
S047B002	12.6	9.9		22.5		16.6	9.2		25.8				< rep levels
S048B000	133	32		165	Y	55.1	10.7		65.8	Y	O	A,C	
S048B002	16	8		24		28.4	7.58		35.98	Y	O	A,C	
S049B000	22.5	10.2		32.7	Y	31.2	7.42		38.62	Y	N		
S049B002	47.2	15.06		62.26	Y	40.1	8.96		49.06	Y	N		
Triple Superphosphate Area													
S050B000	49.1	25.8		74.9	Y	34	15.14		49.14	Y	N		
S050B002	11.2	15.3	UJ	26.5		21.1	12.9		34	Y	N		
S051B000	136	35.6	J	171.6	Y	57.7	12.12	J	69.82	Y	G	C	
S051B002	27.2	17.02		44.22	Y	26.3	12.2		38.5	Y	G	C	
S052B000	133	31.4	J	164.4	Y	52.3	11.44	J	63.74	Y	G	C	
S052B002	49.1	20.6	J	69.7	Y	29.7	9.38	J	39.08	Y	G	C	
S053B000	107	29.6	J	136.6	Y	54.6	11.7	J	66.3	Y	N		
S053B002	17.7	12.4	J	30.1	Y	15.2	7.84	J	23.04		N		
Phosphoric Acid Tank Containment Area													
S054B000	8.07	8.42	UJ	16.49		13	8.48		21.48				< rep levels
S055B000	21.3	13.92		35.22	Y	26	10.82		36.82	Y	G	C	
S055B002	10.6	9.44		20.04		13.5	8.46		21.96				< rep levels
S055B005	12.6	11.38		23.98		22.5	10.06		32.56	Y	N		
Former Phosphoric Acid Loading Area/Railcar Cleaning Area													
S056B000	86.7	26.8		113.5	Y	55.1	14.52		69.62	Y	N		
Sulfuric Acid Loading Dock													
S058B000	24.7	13.94		38.64	Y	25.9	10.34		36.24	Y	N		
S058B002	6.45	9.24	UJ	15.69		24.5	10.42		34.92	Y	N		
S058B005	11.7	11.74	UJ	23.44		23.4	10.4		33.8	Y	N		
S058B007	15.3	12.88		28.18	Y	23.9	10.26		34.16	Y	N		
S059B000	41.1	19.14		60.24	Y	25.9	10.5		36.4	Y	N		
S059B002	7.51	10.1	UJ	17.61		19.6	9.48		29.08			< rep levels	
S059B005	15.5	10.98		26.48		20.7	8.7		29.4			< rep levels	
S059B007	10.9	10.86		21.76		21.2	9.78		30.98			< rep levels	
S059B010	14.3	10.28		24.58		17	8.04		25.04			< rep levels	
S060B000	51	28.8		79.8	Y	39	15.04		54.04	Y	N		
S060B002	11	9.82		20.82		21	8.44		29.44			< rep levels	
S060B005	14.4	10.78		25.18		19.7	9.3		29			< rep levels	
S061B000	100	42.2		142.2	Y	51.1	19.1		70.2	Y	N		
S061B002	13.3	16.56	UJ	29.86	Y	20.2	13.98		34.18	Y	N		
S061B005	22.7	22.2		44.9	Y	13.2	12.88		26.08		N		

Table 2a-1

Sample ID	Gross Alpha (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Alpha plus Accuracy (pCi/g)	> Representative Level (26.9 pCi/g)	Gross Beta (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Beta plus Accuracy	> Representative Level (31.4 pCi/g)	Associated Site-Related Material (a)	Basis for Association (b)	Comments
Sulfuric Acid Plant #1													
S062B000	60.8	23.6		84.4	Y	37.9	12.2		50.1	Y	N		
S062B002	7.8	12.1	UJ	19.9		19.3	12.32		31.62	Y	N		
S062B005	35.6	19.18		54.78	Y	33	11.76		44.76	Y	N		
S062B007	8.32	9.32	UJ	17.64		14.2	8.6		22.8			< rep levels	
S063B000	46.7	26.6		73.3	Y	38	16.82		54.82	Y	N		
S063B002	12.6	15.24	UJ	27.84	Y	11.9	12.06	UJ	23.96		N		
S063B005	13.5	17.42	UJ	30.92	Y	15.2	12.9		28.1		N		
Sulfuric Acid Plant #2													
S064B000	7.64	11.9	UJ	19.54		17.6	13.22		30.82				< rep levels
S064B002	7.99	14.06	UJ	22.05		11.3	12.34	UJ	23.64				< rep levels
S064B005	11.3	15.92	UJ	27.22	Y	23.5	14.36		37.86	Y	N		
S065B000	20.3	19.04		39.34	Y	21.6	14.1		35.7	Y	N		
S065B002	4.27	12.74	UJ	17.01		10.7	12.28	UJ	22.98				< rep levels
S065B005	19.7	20.2	UJ	39.9	Y	21.4	13.92		35.32	Y	N		
S065B007	14.9	15.06	UJ	29.96	Y	15.8	12.82		28.42		N		
Phosphoric Acid Loading Dock													
S066B000	43.9	26.2		70.1	Y	31.1	15.34		46.44	Y	N		
S066B002	14.7	18.12	UJ	32.82	Y	17.8	13.74		31.54	Y	N		
S067B000	43	26.2		69.2	Y	29.1	15.24		44.34	Y	N		
Cooling Tower Area													
S068B000	146	34.6	J	180.6	Y	55.9	11.98	J	67.88	Y	N		
S068B005	42.5	15.86	J	58.36	Y	30.8	9.54	J	40.34	Y	N		
S068B007	13	9.04	J	22.04		15.7	7.64	J	23.34				< rep levels
S069B000	160	36.6	J	196.6	Y	67.7	12.84	J	80.54	Y	N		
S069B001	205	46.8	J	251.8	Y	77	15.04	J	92.04	Y	N		
Former Cooling Pond													
S070B000	174	51.8		225.8	Y	69.3	19.08		88.38	Y	N		
S070B002	11.8	12.16	UJ	23.96		21.8	12.3		34.1	Y	N		
S070B007	50.1	23.6		73.7	Y	34.2	14.68		48.88	Y	N		
S070B010	32.1	22		54.1	Y	35	15.04		50.04	Y	N		
S071B000	83.7	32.4		116.1	Y	39.9	15.52		55.42	Y	N		
S071B002	364	71.2		435.2	Y	111	23.2		134.2	Y	N		
S071B005	160	30.2	J	190.2	Y	71.7	12.96	J	84.66	Y	N		
S071B007	16.2	8.84	J	25.04		13.6	7.38	J	20.98				< rep levels
Water Reclaim Area													
S072B000	38	25.6		63.6	Y	26.3	15.28		41.58	Y	N		
S072B002	7.69	12.32	UJ	20.01		23.4	14.3		37.7	Y	N		
S073B000	57.9	23.8		81.7	Y	40.7	12.84		53.54	Y	N		
S073B002	7.02	10.3	UJ	17.32		14.9	9.04		23.94				< rep levels
Former Ore Pile													

Table 2a-1

Sample ID	Gross Alpha (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Alpha plus Accuracy (pCi/g)	> Representative Level (26.9 pCi/g)	Gross Beta (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Beta plus Accuracy	> Representative Level (31.4 pCi/g)	Associated Site-Related Material (a)	Basis for Association (b)	Comments
S074B000	65	22	J	87	Y	43.7	10.7	J	54.4	Y	O	L,C	
S074B002	12.9	10.36	J	23.26		20.3	8.36	J	28.66				< rep levels
S075B000	61.5	19.54	J	81.04	Y	43.1	10.64	J	53.74	Y	O	L,C	
S075B002	20	12.88	J	32.88	Y	22.7	8.78	J	31.48	Y	O	L,C	
S076B000	123	47.6		170.6	Y	79.7	24.4		104.1	Y	O	L,C	
S076B002	9.65	10.94	UJ	20.59		19.1	9.38		28.48				< rep levels
S077B000	100	55.8		155.8	Y	61.5	26.8		88.3	Y	O	L,C	
S077B002	18.1	19	UJ	37.1	Y	16.1	13.26		29.36		O	L,C	
S078B000	143	70.4		213.4	Y	65.1	27		92.1	Y	O	L,C	
S078B002	12.9	17.44	UJ	30.34	Y	14.4	12.68		27.08		O	L,C	
Bone Yard													
S079B000	29.5	16.18		45.68	Y	30.8	11.24		42.04	Y	N		
S079B002	8.97	10.64	UJ	19.61		21.9	9.9		31.8	Y	N		
S080B000	21.2	13.76		34.96	Y	31	11.48		42.48	Y	N		
S080B002	10.5	10.66	UJ	21.16		14.1	8.52		22.62				< rep levels
S081B000	25.5	15.52		41.02	Y	29	10.92		39.92	Y	N		
S081B002	13	11.74		24.74		23.3	10.34		33.64	Y	N		
Roads													
S082B000	34.3	17.82		52.12	Y	22.1	10		32.1	Y	N		
S082B002	23.4	15.52		38.92	Y	21.2	9.94		31.14		N		
S083B000	20.4	14.36		34.76	Y	28.6	11.1		39.7	Y	N		
S083B002	14.2	13.6		27.8	Y	18.1	11.28		29.38		N		
S084B000	23.5	16.62		40.12	Y	24.5	12.22		36.72	Y	N		
S084B002	14.4	11.8		26.2		17.6	9.26		26.86				< rep levels
S085B000	42.4	20.2		62.6	Y	37.5	11.78		49.28	Y	N		
S085B002	6.96	9.26	UJ	16.22		16.3	8.88		25.18				< rep levels
S086B000	20.4	13.94		34.34	Y	26.8	10.6		37.4	Y	N		
S086B002	11.7	12.42	UJ	24.12		19.3	9.54		28.84				< rep levels
S088B000	19.8	12.72		32.52	Y	21.3	9.82		31.12		AP	C	
S088B002	6.31	8.42	UJ	14.73		16.8	9.08		25.88				< rep levels
S089B000	14.9	11.56		26.46		23.4	10		33.4	Y	N		
S090B000	25.6	15.02		40.62	Y	27	10.7		37.7	Y	N		
S090B002	11.9	11.28		23.18		24.3	10.36		34.66	Y	N		
S093B000	12	13.9	UJ	25.9		17.8	12.36		30.16				< rep levels
S093B002	6.23	7.16	UJ	13.39		19.7	7.12		26.82				< rep levels
S094B000	139	30.6	J	169.6	Y	54.2	11.68	J	65.88	Y	G	A	
S094B002	25.3	13.96	J	39.26	Y	22.3	8.74	J	31.04		G	A	
S095B000	115	36		151	Y	64.7	15.34		80.04	Y	N		
S095B002	12.5	12.48		24.98		20.9	10.02		30.92				< rep levels
S096B000	18.4	12.86		31.26	Y	24.1	10.38		34.48	Y	N		
S096B002	21.1	13.4		34.5	Y	26.2	10.88		37.08	Y	N		
Unlined Ditch to Water Treatment Ponds													
S097B000	18.8	6.62		25.42		20.6	5.25		25.85				< rep levels
S097B002	7.08	4.66		11.74		23.1	5.56		28.66				< rep levels

Table 2a-1

Sample ID	Gross Alpha (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Alpha plus Accuracy (pCi/g)	> Representative Level (26.9 pCi/g)	Gross Beta (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Beta plus Accuracy	> Representative Level (31.4 pCi/g)	Associated Site-Related Material (a)	Basis for Association (b)	Comments
S097B010	4.64	3.63	U	8.27		12.6	4.53		17.13				< rep levels
S097B015	9.37	4.72		14.09		17	4.83		21.83				< rep levels
S097B020	2.33	3.12	U	5.45		35.7	6.75		42.45	Y	O	L	
S097B025	11.1	5.14		16.24		19.7	5.13		24.83				< rep levels
Triple Superphosphate Area (Phase II)													
S098B000	14.2	5.71		19.91		23.2	4.53		27.73				< rep levels
S098B002	18.6	7.41		26.01		24.2	4.76		28.96				< rep levels
S098B005	17.7	6.47		24.17		24.6	4.74		29.34				< rep levels
S098B010	6.94	3.1		10.04		17.1	3.48		20.58				< rep levels
East Overflow Pond													
S099B000	49.8	11.9		61.7	Y	9.82	3.99		13.81		G	A,C	
S099B010	12.9	5.04		17.94		13.7	4.45		18.15				< rep levels
S099B050	13	6.19		19.19		11.8	4.89		16.69				< rep levels
Former Cooling Pond (Phase II)													
S100B000	133	16.6		149.6	Y	66.8	6.89		73.69	Y	N		
S100B002	178	15.7		193.7	Y	57.3	6.46		63.76	Y	N		
S100B005	155	20.7		175.7	Y	53.9	7.43		61.33	Y	N		
S100B007	60.5	9.2		69.7	Y	37.9	5.59		43.49	Y	N		
S100B010	90.1	11.1		101.2	Y	43.1	5.63		48.73	Y	N		
S100B012	16.6	5.22		21.82		18.7	4.39		23.09				> 10'
S100B015	11.1	4.24		15.34		14.6	3.62		18.22				> 10'
S100B025	15.5	5.04		20.54		21.6	4.71		26.31				> 10'
S100B045	8.54	3.67		12.21		16.6	3.84		20.44				> 10'
S100B055	7.27	3.9		11.17		17.2	4.03		21.23				> 10'
S100B065	9.47	3.8		13.27		16.6	3.82		20.42				> 10'
S100B080	15.9	4.6		20.5		26.8	4.01		30.81				> 10'
Cooling Tower Area (Phase II)													
S101B000	74.6	9.07		83.67	Y	37	4.29		41.29	Y	N		
S101B002	72.2	10.1		82.3	Y	43.2	4.91		48.11	Y	N		
S101B007	11	4.74		15.74		24.4	4.97		29.37				< rep levels
S101B010	14.3	5.5		19.8		27.1	4.84		31.94	Y	N		
S101B012	16.2	5.95		22.15		26.3	5.08		31.38				>10'
S101B015	14.3	5.1		19.4		21.6	4.36		25.96				>10'
Water Reclaim Area (Phase II)													
S102B000	218	40.4		258.4	Y	86.7	14.7		101.4	Y	N		
S102B002	9.11	3.83		12.94		11.2	3.29		14.49				< rep levels
S102B007	11.1	3.88		14.98		17.7	3.39		21.09				< rep levels
S102B010	6.54	3		9.54		13.2	3.56		16.76				< rep levels
S102B015	13	4.13		17.13		23	3.8		26.8				> 10'
S102B020	7.94	3.57		11.51		14.8	3.27		18.07				>10'
Former Phosphoric Acid Loading Area/Railcar Cleaning Area (Phase II0													

Table 2a-1

Sample ID	Gross Alpha (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Alpha plus Accuracy (pCi/g)	> Representative Level (26.9 pCi/g)	Gross Beta (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Beta plus Accuracy	> Representative Level (31.4 pCi/g)	Associated Site-Related Material (a)	Basis for Association (b)	Comments
S103B000	31.1	9.23		40.33	Y	39.1	7.32		46.42	Y	N		
S103B002	27	8.51		35.51	Y	37.8	6.84		44.64	Y	N		
S103B005	20.8	7.27		28.07	Y	32.7	6.91		39.61	Y	N		
S103B007	156	14.5		170.5	Y	107	7.18		114.18	Y	N		
Sulfuric Acid Plant #1 (Phase II)													
S104B000	79.1	12		91.1	Y	41.5	4.76		46.26	Y	N		
S104B005	18.2	6.12		24.32		18.2	3.49		21.69				< rep levels
S104B010	8.59	3.8		12.39		19.6	3.54		23.14				>10'
S104B015	10	4.05		14.05		18.8	3.49		22.29				>10'
Phosphoric Acid Loading Dock (Phase II)													
S105B000	25	6.18		31.18	Y	21.8	3.71		25.51		N		
S105B002	15.4	5.29		20.69		25.2	3.9		29.1				< rep levels
S105B005	21.6	6.24		27.84	Y	21.8	3.71		25.51		N		
S105B007	18.6	5.53		24.13		23.5	3.79		27.29				< rep levels
S105B010	12.8	4.47		17.27		17.2	3.39		20.59				< rep levels
Ammonium Phosphate Plant #1 (Phase II)													
S106B000	20.4	6.49		26.89		24.8	4.83		29.63				< rep levels
S106B002	10.7	4.4		15.1		24.1	4.6		28.7				< rep levels
S106B005	8.88	4.13		13.01		21.9	4.53		26.43				< rep levels
S106B010	8.89	3.92		12.81		23	4.84		27.84				< rep.levels
S107B000	20	5.72		25.72		22.7	4.9		27.6				< rep levels
S107B002	10.2	4.35		14.55		19.6	4.54		24.14				< rep levels
S107B007	2.7	2.45	U	5.15		13.6	3.64		17.24				< rep levels
S107B010	9.2	3.8		13		16.8	3.97		20.77				< rep levels
Ammonium Phosphate Plant #2 (Phase II)													
S108B000	15.1	5.38		20.48		26.9	4.58		31.48	Y			< rep levels
S108B002	10.2	3.92		14.12		19.2	3.68		22.88				< rep levels
S108B005	5.31	2.64		7.95		10.6	3.45	UJ	14.05				< rep levels
S108B007	0.46	1.52	U	1.98		11.4	3.56		14.96				< rep levels
S109B000	44.8	11.4		56.2	Y	30.7	6.48		37.18	Y	N		
S109B002	6.46	4.98		11.44		17.7	5.54		23.24				< rep levels
S109B005	3.6	3.07	U	6.67		11.6	4.54		16.14				< rep levels
S109B010	5.36	3.59		8.95		18.7	4.93		23.63				< rep levels
Unlined Ditch to Water Treatment Ponds													
SSSUDP01	421	38.8	J	459.8	Y	142	11.4		153.4	Y	O	L	
SSSUDP02	245	23.8	J	268.8	Y	113	10.34		123.34	Y	O	L	
SSSUDP03	108	14.66	J	122.66	Y	66.5	8.6		75.1	Y	O	L	
SSSUDP04	262	24.8	J	286.8	Y	123	11.02		134.02	Y	O	L	
SSSUDP05	139	16.44	J	155.44	Y	80	9.28		89.28	Y	O	L	
SSSUDP06	251	25	J	276	Y	107	10.42		117.42	Y	O	L	

Table 2a-1

Sample ID	Gross Alpha (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Alpha plus Accuracy (pCi/g)	> Representative Level (26.9 pCi/g)	Gross Beta (pCi/g)	Accuracy (pCi/g)	Qualifier	Gross Beta plus Accuracy	> Representative Level (31.4 pCi/g)	Associated Site-Related Material (a)	Basis for Association (b)	Comments
NOTES:													
(a)	AP = ammonium phosphate				(b)	L = location							
	CF = calciner fines, sediment, sludge												
	FP = ferrophos												
	G = gypsum					A = appearance							
	N = no clear association; generally non-specific fill												
	O = ore					C = chemistry							
	P = phossy water/solids or precipitator slurry												
	S = slag												
(b)	A = appearance												
	C = chemistry												
	L = location												
(c)	"< rep levels" indicates both gross alpha and beta measurements plus uncertainty are less than respective representative levels.												
	" >10'" indicates sample was collected more than 10' below grade and will, therefore, not be considered in on-site risk assessment scenarios.												

Table 2a-2

Isotope	Simplot Ore/ Conda	Simplot Ore/ Gay	FMC Ore/ Gay	FMC Ore/ Gay	FMC Ore FOSFPO01	FMC Ore ST"T"	FMC Ore ST"P"	FMC Ore SN"T"
	(a)	(a)	(a)	(a)	(b)	(b)	(b)	(b)
Uranium Series								
U238	<20	26	22	21	24+/-14	39 (f)	52 (f)	26 (f)
U234	39	28	22	NA	NA	NA	NA	NA
Th230	45	44	22	NA	NA	23+/-4	24+/-4	18+/-4
Ra226	28	28	26	NA	NA	18+/-8	27+/-15	<21
Pb210	12	7.9	27	26	<5	<10	<15	<12
Po210	32	35	22	21	NA	27+/-11.0	26+/-5	15+/-10
Thorium/Actinium Series								
U235	<9	<2	1	NA	NA	NA	NA	NA
Th232	<1	3	0.4	NA	NA	0.73+/-0.59	<0.42	0.94+/-0.85
Ra228	<1	1.1	1	NA	NA	<88	<144	<114

Table 2a-2

Isotope	FMC Ore SN"P" (b)	FMC Ore Composite SC"T" (b)	FMC Ore Composite SC"P" (b)
Uranium Series			
U238	31 (f)	29 (f)	37 (f)
U234	NA	NA	NA
Th230	21+/-5	11+/-5	20+/-9
Ra226	<22	<16	<26
Pb210	<17	<13	<17
Po210	39+/-21	16+/-10	65+/-39
Thorium/Actinium Series			
U235	NA	NA	NA
Th232	<1.4	<1.7	<6.4
Ra228	<175	<137	<223

Table 2a-2

Isotope	Gypsum Slurry SGSSGS01 (b)	Gypsum Pile Composite (d)	Gypsum Slurry from Reactor/ suspended (d)	Gypsum Thickner Overflow/ suspended (d)	Gypsum (e)
Uranium Series					
U238	42+/-10	<14	2.9+/-0.32	3.3+/-0.24	3.2
U234	NA	24+/-20	2.7+/-0.32	3.3+/-0.24	3.3
Th230	NA	26+/-7.1	5.7+/-0.33	13+/-0.40	5.1
Ra226	NA	23+/-0.87	43+/-1.2	48+/-1.8	31
Pb210	<5	1.1+/-0.96	3.3+/-0.41	4.3+/-0.31	36
Po210	NA	26+/-3.0	5.7+/-0.68	14+/-1.5	27
Thorium/Actinium Series					
U235	NA	<6.8	0.09+/-0.04	0.15+/-0.03	NA
Th232	NA	<1.3	0.08+/-0.04	0.17+/-0.05	NA
Ra228	NA	<1.0	1.7+/-0.91	<1.8	NA

Table 2a-2

Isotope	Ammonium Phosphate/ various grades (a)	Ammonium Phosphate/ 11-54-0 (d)	Ammonium Phosphate/ 18-46-0 (d)	Ammonium Phosphate/ 16-20-0 (d)
Uranium Series				
U238	21-27	27+/-25	21+/-3.5	<24
U234	<20	<20	20+/-3.5	<19
Th230	6.2-6.3	63+/-9.7	6.2+/-0.32	29+/-6.4
Ra226	0.65-1.6	0.85+/-0.18	0.65+/-0.16	1.6+/-0.23
Pb210	0.62-1.8	0.62+/-0.54	1.8+/-0.6	1.2+/-0.58
Po210	2.1-4.6	4.6+/-0.70	2.1+/-0.86	3.7+/-0.69
Thorium/Actinium Series				
U235	<13	<11	0.76+/-0.24	<13
Th232	0.08-2.0	2.0+/-1.9	0.079+/-0.038	<1.4
Ra228	<0.92-1.8	<0.96	1.8+/-1.0	<0.92

Table 2a-2

Isotope	FMC Slag	FMC Slag	FMC Slag	FMC Slag	FMC Slag	FMC Slag FWSSSA01	FMC Slag FWSSSA02	FMC Slag FWSSSA03	FMC Slag FWSSSA04
	(a)	(a)	(a)	(a)	(a)	(b)	(b)	(b)	(b)
Uranium Series									
U238	25	NA	NA	NA	29	24+/-14	28+/-14	26+/-15	22+/-13
U234	25	NA	NA	NA	38	NA	NA	NA	NA
Th230	26	NA	NA	NA	42	NA	NA	NA	NA
Ra226	32	15.2	39	41	50	NA	NA	NA	NA
Pb210	11	NA	NA	NA	NA	<5	<5	<5	<5
Po210	<16	NA	NA	NA	NA	NA	NA	NA	NA
Thorium/Actinium Series									
U235		NA	NA	NA	NA	NA	NA	NA	NA
Th232	0.6	NA	NA	NA	0.5	NA	NA	NA	NA
Ra228	0.96	NA	NA	NA	NA	NA	NA	NA	NA

Table 2a-2

Isotope	FMC Slag FWSSSA05 (b)	FMC Slag FWSSSA06 (b)
Uranium Series		
U238	30+/-18	27+/-17
U234	NA	NA
Th230	NA	NA
Ra226	NA	NA
Pb210	<5	<5
Po210	NA	NA
Thorium/Actinium Series		
U235	NA	NA
Th232	NA	NA
Ra228	NA	NA

Table 2a-2

Isotope	FMC Ferrophos FWSFSA01 (b)	FMC Ferrophos FWSFSA02 (b)	FMC Ferrophos FWSFSA03 (b)	FMC Ferrophos (c)
Uranium Series				
U238	<5	9.69	12.3	19
U234	NA	NA	NA	NA
Th230	NA	NA	NA	0.4
Ra226	NA	NA	NA	0.3
Pb210	<5	<5	<5	1.1
Po210	NA	NA	NA	0.5
Thorium/Actinium Series				
U235	NA	NA	NA	NA
Th232	NA	NA	NA	NA
Ra228	NA	NA	NA	NA

Table 2a-2

Isotope	FMC Precipitator Dust (c)	FMC Calciner Fines CF"T" (b)	FMC Calciner Fines CF"P" (b)
Uranium Series			
U238	71	39 (f)	46 (f)
U234	NA	NA	NA
Th230	24	14+/-3.4	22+/-4.7
Ra226	13	<6	26+/-11
Pb210	52	<11	<15
Po210	440	25+/-12	24+/-13
Thorium/Actinium Series			
U235	NA	NA	NA
Th232	NA	0.28+/-0.52	<1.1
Ra228	NA	<102	<151
	Notes:		
	All concentrations pCi/g unless otherwise noted.		
	"NA" indicates no analysis		
	(a) Idaho Radionuclide Exposure Study - Literature Review, Batelle, October 1987		
	(b) EMF RI/FS		
	(c) FMC		
	(d) Radiological Surveys of Idaho Phosphate Ore Processing - The Wet Process Plant, EPA, April 1978		
	(e) Draft Environmental Impact Statement for Proposed NESHAPS for Radionuclides, Chapter 13, EPA, Feb. 1989		
	(f) U-238 activity calcuated from total uranium concentration		

Table 2a-3

Sample ID	Associated Site-Related Material (a)	Basis for Association (b)	Gross Alpha (measured) (pCi/g)	U-238 (estimated) (pCi/g)	U-234 (estimated) (pCi/g)	Th-230 (estimated) (pCi/g)	Ra-226 (estimated) (pCi/g)	Pb-210 (estimated) (pCi/g)	Po-210 (estimated) (pCi/g)	Gross Beta (measured) (pCi/g)	Accuracy (pCi/g)
Radioisotope Speciation Formulas (a) (b)											
AP				20/54 x alpha	20/54 x alpha	6/54 x alpha	2/54 x alpha	Ra-226	Ra-226		
AP			1.00	0.37	0.37	0.11	0.04	0.04	0.04		
CF				alpha/7	alpha/7	alpha/7	alpha/7	Ra-226	Ra-226		
CF			1.00	0.14	0.14	0.14	0.14	0.14	0.14		
G				3/135 x alpha	3/135 x alpha	5/135 x alpha	31/135 x alpha	Ra-226	Ra-226		
G			1.00	0.02	0.02	0.04	0.23	0.23	0.23		
O				alpha/7	alpha/7	alpha/7	alpha/7	Ra-226	Ra-226		
O			1.00	0.14	0.14	0.14	0.14	0.14	0.14		
P				71/218 x alpha	71/218 x alpha	24/218 x alpha	13/218 x alpha	52/13 x Ra-226	440/13 x Ra-226		
P			1.00	0.33	0.33	0.11	0.06	0.24	2.02		
S				alpha/7	alpha/7	alpha/7	alpha/7	11/25 x Ra-226	11/25 x Ra-226		
S			1.00	0.14	0.14	0.14	0.14	0.06	0.06		
Calciner Ponds and Sediments											
F023B000	CF	L,C	53.1	7.59	7.59	7.59	7.59	7.59	7.59	38.8	6.08
Former Pond 4E											
F024B000	P	C	95.3	31.04	31.04	10.49	5.68	22.73	192.35	113	13.32
F024B010	P	C	16.1	5.24	5.24	1.77	0.96	3.84	32.50	25	7.24
Former Pond 5E											
F025B000	P	A,C	86.6	28.20	28.20	9.53	5.16	20.66	174.79	119	9.4
F025B010	P	A,C	191	62.21	62.21	21.03	11.39	45.56	385.50	282	14.44
Chemical Laboratory Seepage Pit											
F028B000	S	A,C	55	7.86	7.86	7.86	7.86	3.46	3.46	48.3	6.52
F028B010	S	A,C	14	2.00	2.00	2.00	2.00	0.88	0.88	26.1	5.28
IWW Basin and Ditch											
F030B000	O	C	171	24.43	24.43	24.43	24.43	24.43	24.43	67.3	7.8
Former Pond 1E											
F033B000	P	L	23.9	7.78	7.78	2.63	1.43	5.70	48.24	34.6	7.74
F033B005	P	L	19.8	6.45	6.45	2.18	1.18	4.72	39.96	37.5	8.54
9S Storage Area											
F034B000	P	L,C	32.1	10.45	10.45	3.53	1.91	7.66	64.79	47.3	9.36
F034B005	P	L,C	11.6	3.78	3.78	1.28	0.69	2.77	23.41	25	7.04

Table 2a-3

Sample ID	Associated Site-Related Material (a)	Basis for Association (b)	Gross Alpha (measured) (pCi/g)	U-238 (estimated) (pCi/g)	U-234 (estimated) (pCi/g)	Th-230 (estimated) (pCi/g)	Ra-226 (estimated) (pCi/g)	Pb-210 (estimated) (pCi/g)	Po-210 (estimated) (pCi/g)	Gross Beta (measured) (pCi/g)	Accuracy (pCi/g)
Former Transformer Salvage Area											
F035B002	P	C	15.6	5.08	5.08	1.72	0.93	3.72	31.49	28.8	9.08
F035B005	P	C	19.3	6.29	6.29	2.12	1.15	4.60	38.95	25.2	6.9
F035B007	P	C	16.2	5.28	5.28	1.78	0.97	3.86	32.70	30.5	7.84
F036B000	P	C	31.7	10.32	10.32	3.49	1.89	7.56	63.98	39.3	8.34
F036B005	P	C	20.4	6.64	6.64	2.25	1.22	4.87	41.17	26.2	6.84
Railroad Swale											
F039B000	O	C	216	30.86	30.86	[illegible]	30.86	30.86	30.86	76.1	12.44
F039B002	O	C	280	40.00	40.00	40.00	40.00	40.00	40.00	82.2	12.92
F039B007	O	C	21.6	3.09	3.09	3.09	3.09	3.09	3.09	28.5	7.36
F039B010	O	C	17.7	2.53	2.53	2.53	2.53	2.53	2.53	24.8	7.04
F041B000	S,O (Assume O)	A (slag), C	96.9	13.84	13.84	13.84	13.84	13.84	13.84	62.6	11.7
Former PCB Storage Shed											
F044B000	N (Assume S)		236	33.71	33.71	33.71	33.71	14.83	14.83	79.5	12.36
F044B002	N (Assume S)		287	41.00	41.00	41.00	41.00	18.04	18.04	130	16.7
F045B000	N (Assume S)		24.1	3.44	3.44	3.44	3.44	1.51	1.51	26.7	8.16
F045B002	N (Assume S)		22.5	3.21	3.21	3.21	3.21	1.41	1.41	32.6	8.52
F045B005	N (Assume S)		17.9	2.56	2.56	2.56	2.56	1.13	1.13	25.3	7.82
Septic Drain Fields											
F046B000	S	A	18.5	2.64	2.64	2.64	2.64	1.16	1.16	30.5	7.98
F046B007	S	A	17.8	2.54	2.54	2.54	2.54	1.12	1.12	23.1	6.36
F047B000	N (Assume S)		22.1	3.16	3.16	3.16	3.16	1.39	1.39	26.4	7.1
F047B002	N (Assume S)		18.4	2.63	2.63	2.63	2.63	1.16	1.16	28.1	6.9
F047B005	N (Assume S)		14.5	2.07	2.07	2.07	2.07	0.91	0.91	25.6	7.42
F047B007	N (Assume S)		12.8	1.83	1.83	1.83	1.83	0.80	0.80	28.3	7.48
F047B010	N (Assume S)		10.3	1.47	1.47	1.47	1.47	0.65	0.65	30.4	7.46
F048B000	N (Assume S)		85.8	12.26	12.26	12.26	12.26	5.39	5.39	36.5	8.26
F048B002	N (Assume S)		18.6	2.66	2.66	2.66	2.66	1.17	1.17	24	6.92
F048B005	N (Assume S)		19.8	2.83	2.83	2.83	2.83	1.24	1.24	23.5	7.1
F048B007	N (Assume S)		18.7	2.67	2.67	2.67	2.67	1.18	1.18	29.9	8.28
F048B010	N (Assume S)		17.2	2.46	2.46	2.46	2.46	1.08	1.08	28.2	7.62
F049B000	N (Assume S)		54.8	7.83	7.83	7.83	7.83	3.44	3.44	37	8.3
F049B005	N (Assume S)		21.3	3.04	3.04	3.04	3.04	1.34	1.34	25.6	7.82
F049B007	N (Assume S)		14.9	2.13	2.13	2.13	2.13	0.94	0.94	25.8	7.48
F049B010	N (Assume S)		15.5	2.21	2.21	2.21	2.21	0.97	0.97	26.2	7.82
Calciner Pond Sediment Storage Area A											
F050B000	CF	A,C	137	19.57	19.57	19.57	19.57	19.57	19.57	133	21
F050B002	CF	A,C	232	33.14	33.14	33.14	33.14	33.14	33.14	170	23.6
F050B005	CF	A,C	352	50.29	50.29	50.29	50.29	50.29	50.29	199	25.4
F050B007	CF	A,C	241	34.43	34.43	34.43	34.43	34.43	34.43	157	28
F050B010	CF	A,C	186	26.57	26.57	26.57	26.57	26.57	26.57	131	25.8
Calciner Pond Sediment Storage Area B											

Table 2a-3

Sample ID	Associated Site-Related Material (a)	Basis for Association (b)	Gross Alpha (measured) (pCi/g)	U-238 (estimated) (pCi/g)	U-234 (estimated) (pCi/g)	Th-230 (estimated) (pCi/g)	Ra-226 (estimated) (pCi/g)	Pb-210 (estimated) (pCi/g)	Po-210 (estimated) (pCi/g)	Gross Beta (measured) (pCi/g)	Accuracy (pCi/g)
F051B000	CF	A,C	185	26.43	26.43	26.43	26.43	26.43	26.43	94.9	23.2
F051B002	CF	A	115	16.43	16.43	16.43	16.43	16.43	16.43	56.1	14.64
F051B005	CF	A	22.3	3.19	3.19	3.19	3.19	3.19	3.19	29.3	11.54
Tree-Lined Area Adjacent to Former Pond 7S											
F055B000	P	L,C	16.6	5.41	5.41	1.83	0.99	3.96	33.50	22.6	10.4
F055B002	P	L,C	46	14.98	14.98	5.06	2.74	10.97	92.84	42	11.56
F056B000	P	L,C	25.4	8.27	8.27	2.80	1.51	6.06	51.27	32.5	11.66
F056B002	P	L,C	1530	498.30	498.30	168.44	91.24	364.95	3088.07	1070	77
F057B000	P	L,C	31.4	10.23	10.23	3.46	1.87	7.49	63.38	28.1	10.94
F057B002	P	L,C	47.4	15.44	15.44	5.22	2.83	11.31	95.67	34.9	17.04
8S Recovery Process											
F058B000	P	C	161	52.44	52.44	17.72	9.60	38.40	324.95	546	50.6
F058B002	P	C	143	46.57	46.57	15.74	8.53	34.11	288.62	81.7	21.6
F059B000	P	C	1660	540.64	540.64	182.75	98.99	395.96	3350.46	1220	59.6
Area West of the Mobile Shop											
F060B000	S w/P (Assume S)	C	130	18.57	18.57	18.57	18.57	8.17	8.17	56.7	11.54
F060B002	S w/P (Assume S)	C	135	19.29	19.29	19.29	19.29	8.49	8.49	79.1	13.48
F061B000	S w/P (Assume S)	C	159	22.71	22.71	22.71	22.71	9.99	9.99	116	16.08
F061B002	S w/P (Assume S)	C	192	27.43	27.43	27.43	27.43	12.07	12.07	145	19.5
Long-Term Phosphorus Storage Area											
F062B000	N (Assume S)		17.7	2.53	2.53	2.53	2.53	1.11	1.11	27.6	11.44
F062B002	N (Assume S)		17.3	2.47	2.47	2.47	2.47	1.09	1.09	29.2	13.36
F063B000	N (Assume S)		22.2	3.17	3.17	3.17	3.17	1.40	1.40	22.2	10.42
F063B002	N (Assume S)		40.4	5.77	5.77	5.77	5.77	2.54	2.54	29.3	17.96
Phos Dock Area											
F064B000	N (Assume S)		13.9	1.99	1.99	1.99	1.99	0.87	0.87	30.4	10.36
F064B002	N (Assume S)		38.8	5.54	5.54	5.54	5.54	2.44	2.44	31.4	7.94
Paved Area North of the Furnace Building											
F066B002	S	A,C	23.2	3.31	3.31	3.31	3.31	1.46	1.46	27.8	11.26
F067B000	S	A,C	32	4.57	4.57	4.57	4.57	2.01	2.01	36.6	7.64
F067B002	S	A	17.1	2.44	2.44	2.44	2.44	1.07	1.07	25.7	6.54
F068B002	N (Assume S)		24.6	3.51	3.51	3.51	3.51	1.55	1.55	27.6	11.18
F069B000	N (Assume S)		16.4	2.34	2.34	2.34	2.34	1.03	1.03	24.9	10.44
F069B002	N (Assume S)		24.1	3.44	3.44	3.44	3.44	1.51	1.51	32.1	10.62
Phossy Waste/Precipitator Slurry Pipeline Cleanout Areas											
F070B000	N (Assume S)		27.3	3.90	3.90	3.90	3.90	1.72	1.72	28	13.04
F070B002	N (Assume S)		31.9	4.56	4.56	4.56	4.56	2.01	2.01	36.5	12.44
F071B000	S	A	19.5	2.79	2.79	2.79	2.79	1.23	1.23	27.9	6.94
F071B002	S	A	17.5	2.50	2.50	2.50	2.50	1.10	1.10	25.6	6.66
F072B000	S	A	33.3	4.76	4.76	4.76	4.76	2.09	2.09	33.7	7.36

Table 2a-3

Sample ID	Associated Site-Related Material (a)	Basis for Association (b)	Gross Alpha (measured) (pCi/g)	U-238 (estimated) (pCi/g)	U-234 (estimated) (pCi/g)	Th-230 (estimated) (pCi/g)	Ra-226 (estimated) (pCi/g)	Pb-210 (estimated) (pCi/g)	Po-210 (estimated) (pCi/g)	Gross Beta (measured) (pCi/g)	Accuracy (pCi/g)
F072B002	S	A	17.9	2.56	2.56	2.56	2.56	1.13	1.13	26.2	6.6
F074B000	S	A, C	14	2.00	2.00	2.00	2.00	0.88	0.88	31.2	7.18
F075B000	N (Assume S)		14.7	2.10	2.10	2.10	2.10	0.92	0.92	23.6	8.28
F075B002	N (Assume S)		31.1	4.44	4.44	4.44	4.44	1.95	1.95	30.1	11.54
F077B000	S, P (Assume S)	A (slag), C	94.1	13.44	13.44	13.44	13.44	5.91	5.91	53	14.42
F078B000	N (Assume S)		14.3	2.04	2.04	2.04	2.04	0.90	0.90	21.2	10.26
F079B000	P	C	42.6	13.87	13.87	4.69	2.54	10.16	85.98	40	12.78
F079B002	P	C	57.3	18.66	18.66	6.31	3.42	13.67	115.65	69	15.96
Bannock Paving Area											
F081B000	N (Assume S)		21.5	3.07	3.07	3.07	3.07	1.35	1.35	25.2	11
F081B002	N (Assume S)		21.8	3.11	3.11	3.11	3.11	1.37	1.37	19.9	10.1
Railcar Loading and Unloading Area at Bannock Paving											
F083B002	S	L,A	18.6	2.66	2.66	2.66	2.66	1.17	1.17	20.4	10.4
F084B000	S	L,A	14.8	2.11	2.11	2.11	2.11	0.93	0.93	23.3	10.6
F084B002	S	L,A	20.9	2.99	2.99	2.99	2.99	1.31	1.31	21.9	10.5
Shale Ore Handling Area											
F090B000	O	C	207	29.57	29.57	29.57	29.57	29.57	29.57	84	12.32
F090B002	O	C	262	37.43	37.43	37.43	37.43	37.43	37.43	75.3	11.7
F091B000	O	L	186	26.57	26.57	26.57	26.57	26.57	26.57	65.1	11.18
F091B002	O	L	23.3	3.33	3.33	3.33	3.33	3.33	3.33	30.8	8.02
F092B000	O	C	35.9	5.13	5.13	5.13	5.13	5.13	5.13	28.7	7.12
F092B002	O	C	22.1	3.16	3.16	3.16	3.16	3.16	3.16	31	7.92
F093B000	O	L	222	31.71	31.71	31.71	31.71	31.71	31.71	92.4	19.16
F093B002	O	L	95.7	13.67	13.67	13.67	13.67	13.67	13.67	46	13.18
F094B000	O	L	20.3	2.90	2.90	2.90	2.90	2.90	2.90	25.3	10.82
F094B002	O	L	42.2	6.03	6.03	6.03	6.03	6.03	6.03	38.4	12.42
Roads											
F101B000	S	A	94.1	13.44	13.44	13.44	13.44	5.91	5.91	47.5	11.86
F101B002	S	A	22.8	3.26	3.26	3.26	3.26	1.43	1.43	26	10.74
F101R000	P	C	88.8	6.06	6.06	2.05	1.11	4.44	37.54	77.1	18.74
F101R002	P,S (Assume P)	C	182	59.28	59.28	20.04	10.85	43.41	367.34	81	19.52
F102B000	N (Assume S)		17.4	2.49	2.49	2.49	2.49	1.09	1.09	23.3	8.2
F103B000	N (Assume S)		19.6	2.80	2.80	2.80	2.80	1.23	1.23	24.9	8.64
F103B002	N (Assume S)		17.1	2.44	2.44	2.44	2.44	1.07	1.07	26.5	8.56
F104R000	S,FP (Assume S)	A (slag),C	177	25.29	25.29	25.29	25.29	11.13	11.13	82.4	24.8
F104R002	S,FP (Assume S)	A (slag),C	102	14.57	14.57	14.57	14.57	6.41	6.41	79.9	29.4
F105B000	S	C	281	40.14	40.14	40.14	40.14	17.66	17.66	108	13.88
F105B002	S	C	206	29.43	29.43	29.43	29.43	12.95	12.95	99.3	13.32
F106B000	S	L,C	15.5	2.21	2.21	2.21	2.21	0.97	0.97	23	8.86
F107R000	S	A,C	234	33.43	33.43	33.43	33.43	14.71	14.71	88.4	25.6
F107R002	S	A,C	99.9	14.27	14.27	14.27	14.27	6.28	6.28	53.1	16.5
F108B000	S	C	41	5.86	5.86	5.86	5.86	2.58	2.58	27.8	7.78
F108B002	S	C	57.2	8.17	8.17	8.17	8.17	3.60	3.60	38.5	9.14

Table 2a-3

Sample ID	Associated Site-Related Material (a)	Basis for Association (b)	Gross Alpha (measured) (pCi/g)	U-238 (estimated) (pCi/g)	U-234 (estimated) (pCi/g)	Th-230 (estimated) (pCi/g)	Ra-226 (estimated) (pCi/g)	Pb-210 (estimated) (pCi/g)	Po-210 (estimated) (pCi/g)	Gross Beta (measured) (pCi/g)	Accuracy (pCi/g)
F109B000	G,S (Assume G)	A,C (gypsum)	30.2	0.67	0.67	1.12	6.93	6.93	6.93	32.4	8.08
F109B002	G,S (Assume G)	C	19.3	0.43	0.43	0.71	4.43	4.43	4.43	20.8	6.62
F110B000	S,O (Assume O)	C	28.5	4.07	4.07	4.07	4.07	4.07	4.07	28.4	10.54
F110B002	S,O (Assume O)	C	90.3	12.90	12.90	12.90	12.90	12.90	12.90	53.3	10.62
F111R000	S	A,C	334	47.71	47.71	47.71	47.71	20.99	20.99	125	26.2
F111R002	S	A,C	162	23.14	23.14	23.14	23.14	10.18	10.18	79.9	10.98
F112R000	S	A	149	21.29	21.29	21.29	21.29	9.37	9.37	76.8	10.2
F112R002	S	A	188	26.86	26.86	26.86	26.86	11.82	11.82	107	12.92
F113R000	S,O (Assume O)	C	145	20.71	20.71	20.71	20.71	20.71	20.71	79.8	10.52
F113R002	S,O (Assume O)	C	28.6	4.09	4.09	4.09	4.09	4.09	4.09	33.5	13.8
F114R000	S,O (Assume O)	C	177	25.29	25.29	25.29	25.29	25.29	25.29	78.8	10.24
F114R002	S,O (Assume O)	C	17.4	2.49	2.49	2.49	2.49	2.49	2.49	37.8	7.72
F115R000	O	C	151	21.57	21.57	21.57	21.57	21.57	21.57	81.4	10.72
F115R002	O	C	27.6	3.94	3.94	3.94	3.94	3.94	3.94	25.2	10.88
F119R000	O	A,C	226	32.29	32.29	32.29	32.29	32.29	32.29	96	26.6
F119R002	O	A,C	153	21.86	21.86	21.86	21.86	21.86	21.86	85.1	38.4
F121R000	S	A,C	129	18.43	18.43	18.43	18.43	8.11	8.11	65.6	9.78
F121R002	S	A,C	126	18.00	18.00	18.00	18.00	7.92	7.92	69.6	9.82
F122R000	N (Assume S)		38.2	5.46	5.46	5.46	5.46	2.40	2.40	34.1	10.28
F122R002	N (Assume S)		9.38	1.34	1.34	1.34	1.34	0.59	0.59	25.1	8.32
F123B000	N (Assume S)		25.8	3.69	3.69	3.69	3.69	1.62	1.62	27.1	11.26
F123B002	N (Assume S)		22.9	3.27	3.27	3.27	3.27	1.44	1.44	25.7	10.9
F124B000	S	A,C	61.8	8.83	8.83	8.83	8.83	3.88	3.88	37.8	14.56
F124B002	P	C	26.2	8.53	8.53	2.88	1.56	6.25	52.88	32.4	11.9
F125B000	N (Assume S)		29.9	4.27	4.27	4.27	4.27	1.88	1.88	23.9	12.5
F125B002	N (Assume S)		16	2.29	2.29	2.29	2.29	1.01	1.01	18.7	11.68
F126B000	N (Assume S)		19.2	2.74	2.74	2.74	2.74	1.21	1.21	33.2	11.42
F126B002	N (Assume S)		22.9	3.27	3.27	3.27	3.27	1.44	1.44	29.8	11
Storage Area B (Phase II)											
F127B000	CF	A,C	84.2	12.03	12.03	12.03	12.03	12.03	12.03	81.5	6.36
Storage Area A (Phase II)											
F128B010	CF	L,C	13.7	1.96	1.96	1.96	1.96	1.96	1.96	33.2	4.66
Roads (Phase II)											
F129B000	S	C	62.4	8.91	8.91	8.91	8.91	3.92	3.92	35.3	5.29
Former Water Treatment Settling Pond											
S007B000	N (Assume G)		17.3	0.38	0.38	0.64	3.97	3.97	3.97	21	9.8
Dewatering Pit											
S008B000	O	L	406	58.00	58.00	58.00	58.00	58.00	58.00	138	21
Ammonium Phosphate Plant #1											
S030B000	G	A,C	34.4	0.76	0.76	1.27	7.90	7.90	7.90	21	14.5
S031B000	AP	L,C	29.4	10.89	10.89	3.27	1.09	1.09	1.09	10.3	11.56

Table 2a-3

Sample ID	Associated Site-Related Material (a)	Basis for Association (b)	Gross Alpha (measured) (pCi/g)	U-238 (estimated) (pCi/g)	U-234 (estimated) (pCi/g)	Th-230 (estimated) (pCi/g)	Ra-226 (estimated) (pCi/g)	Pb-210 (estimated) (pCi/g)	Po-210 (estimated) (pCi/g)	Gross Beta (measured) (pCi/g)	Accuracy (pCi/g)
S032B000	AP	L,C	242	89.63	89.63	26.89	8.96	8.96	8.96	91	25
S032B002	AP	A,C	18.5	6.85	6.85	2.06	0.69	0.69	0.69	15.8	13
S033B000	N (Assume AP)		54.7	20.26	20.26	6.08	2.03	2.03	2.03	33.4	16.52
S033B002	N (Assume AP)		31.8	11.78	11.78	3.53	1.18	1.18	1.18	32.3	10.08
S034B000	AP	L,C	27.2	10.07	10.07	3.02	1.01	1.01	1.01	34.8	9.62
S035B000	AP	L,C	57	21.11	21.11	6.33	2.11	2.11	2.11	43.8	8.52
S036B002	N (Assume AP)	L,C	44.5	16.48	16.48	4.94	1.65	1.65	1.65	41.1	8.68
S037B000	N (Assume AP)		64.5	23.89	23.89	7.17	2.39	2.39	2.39	37.4	8.14
Ammonium Phosphate Plant #2											
S038B002	AP	L,C	14.2	5.26	5.26	1.58	0.53	0.53	0.53	19.2	13.46
S040B000	N (Assume AP)		11.6	4.30	4.30	1.29	0.43	0.43	0.43	19.8	13.68
S042B002	AP	L,C	13.1	4.85	4.85	1.46	0.49	0.49	0.49	23.5	14.24
S043B000	AP	L,C	51.8	19.19	19.19	5.76	1.92	1.92	1.92	33.4	11.48
S044B000	N (Assume AP)		17.7	6.56	6.56	1.97	0.66	0.66	0.66	15.3	9.3
Ammonium Sulfate Plant											
S046B000	N (Assume O)		94.5	13.50	13.50	13.50	13.50	13.50	13.50	55.3	14.62
S047B000	N (Assume O)		80.7	11.53	11.53	11.53	11.53	11.53	11.53	40.9	12.78
S048B000	O	A,C	133	19.00	19.00	19.00	19.00	19.00	19.00	55.1	10.7
S048B002	O	A,C	16	2.29	2.29	2.29	2.29	2.29	2.29	28.4	7.58
S049B000	N (Assume O)		22.5	3.21	3.21	3.21	3.21	3.21	3.21	31.2	7.42
S049B002	N (Assume O)		47.2	6.74	6.74	6.74	6.74	6.74	6.74	40.1	8.96
Triple Superphosphate Area											
S050B000	N (Assume G)		49.1	1.09	1.09	1.82	11.27	11.27	11.27	34	15.14
S050B002	N (Assume G)		11.2	0.25	0.25	0.41	2.57	2.57	2.57	21.1	12.9
S051B000	G	C	136	3.02	3.02	5.04	31.23	31.23	31.23	57.7	12.12
S051B002	G	C	27.2	0.60	0.60	1.01	6.25	6.25	6.25	26.3	12.2
S052B000	G	C	133	2.96	2.96	4.93	30.54	30.54	30.54	52.3	11.44
S052B002	G	C	49.1	1.09	1.09	1.82	11.27	11.27	11.27	29.7	9.38
S053B000	N (Assume G)		107	2.38	2.38	3.96	24.57	24.57	24.57	54.6	11.7
S053B002	N (Assume G)		17.7	0.39	0.39	0.66	4.06	4.06	4.06	15.2	7.84
Phosphoric Acid Tank Containment Area											
S055B00[illegible]	[illegible]	C	21.3	0.47	0.47	0.79	4.89	4.89	4.89	26	10.82
S055B00[illegible]	[illegible]		12.6	0.28	0.28	0.47	2.89	2.89	2.89	22.5	10.06
Former Phosphoric Acid Loading Area/Railcar Cleaning Area											
S056B000	N (Assume G)		86.7	1.93	1.93	3.21	19.91	19.91	19.91	55.1	14.52
Sulfuric Acid Loading Dock											
S058B000	N (Assume G)		24.7	0.55	0.55	0.91	5.67	5.67	5.67	25.9	10.34
S058B002	N (Assume G)		6.45	0.14	0.14	0.24	1.48	1.48	1.48	24.5	10.42
S058B005	N (Assume G)		11.7	0.26	0.26	0.43	2.69	2.69	2.69	23.4	10.4
S058B007	N (Assume G)		15.3	0.34	0.34	0.57	3.51	3.51	3.51	23.9	10.26
S059B000	N (Assume G)		41.1	0.91	0.91	1.52	9.44	9.44	9.44	25.9	10.5

Table 2a-3

Sample ID	Associated Site-Related Material (a)	Basis for Association (b)	Gross Alpha (measured) (pCi/g)	U-238 (estimated) (pCi/g)	U-234 (estimated) (pCi/g)	Th-230 (estimated) (pCi/g)	Ra-226 (estimated) (pCi/g)	Pb-210 (estimated) (pCi/g)	Po-210 (estimated) (pCi/g)	Gross Beta (measured) (pCi/g)	Accuracy (pCi/g)
S060B000	N (Assume G)		51	1.13	1.13	1.89	11.71	11.71	11.71	39	15.04
S061B000	N (Assume G)		100	2.22	2.22	3.70	22.96	22.96	22.96	51.1	19.1
S061B002	N (Assume G)		13.3	0.30	0.30	0.49	3.05	3.05	3.05	20.2	13.98
S061B005	N (Assume G)		22.7	0.50	0.50	0.84	5.21	5.21	5.21	13.2	12.88
Sulfuric Acid Plant #1											
S062B000	N (Assume G)		60.8	1.35	1.35	2.25	13.96	13.96	13.96	37.9	12.2
S062B002	N (Assume G)		7.8	0.17	0.17	0.29	1.79	1.79	1.79	19.3	12.32
S062B005	N (Assume G)		35.6	0.79	0.79	1.32	8.17	8.17	8.17	33	11.76
S063B000	N (Assume G)		46.7	1.04	1.04	1.73	10.72	10.72	10.72	38	16.82
S063B002	N (Assume G)		12.6	0.28	0.28	0.47	2.89	2.89	2.89	11.9	12.06
S063B005	N (Assume G)		13.5	0.30	0.30	0.50	3.10	3.10	3.10	15.2	12.9
Sulfuric Acid Plant #2											
S064B005	N (Assume G)		11.3	0.25	0.25	0.42	2.59	2.59	2.59	23.5	14.36
S065B000	N (Assume G)		20.3	0.45	0.45	0.75	4.66	4.66	4.66	21.6	14.1
S065B005	N (Assume G)		19.7	0.44	0.44	0.73	4.52	4.52	4.52	21.4	13.92
S065B007	N (Assume G)		14.9	0.33	0.33	0.55	3.42	3.42	3.42	15.6	12.82
Phosphoric Acid Loading Dock											
S066B000	N (Assume G)		43.9	0.98	0.98	1.63	10.08	10.08	10.08	31.1	15.34
S066B002	N (Assume G)		14.7	0.33	0.33	0.54	3.38	3.38	3.38	17.8	13.74
S067B000	N (Assume G)		43	0.96	0.96	1.59	9.87	9.87	9.87	29.1	15.24
Cooling Tower Area											
S068B000	N (Assume G)		146	3.24	3.24	5.41	33.53	33.53	33.53	55.9	11.98
S068B005	N (Assume G)		42.5	0.94	0.94	1.57	9.76	9.76	9.76	30.8	9.54
S069B000	N (Assume G)		160	3.56	3.56	5.93	36.74	36.74	36.74	67.7	12.84
S069B001	N (Assume G)		205	4.56	4.56	7.59	47.07	47.07	47.07	77	15.04
Former Cooling Pond											
S070B000	N (Assume G)		174	3.87	3.87	6.44	39.96	39.96	39.96	69.3	19.08
S070B002	N (Assume G)		11.8	0.26	0.26	0.44	2.71	2.71	2.71	21.8	12.3
S070B007	N (Assume G)		50.1	1.11	1.11	1.86	11.50	11.50	11.50	34.2	14.68
S070B010	N (Assume G)		32.1	0.71	0.71	1.19	7.37	7.37	7.37	35	15.04
S071B000	N (Assume G)		83.7	1.86	1.86	3.10	19.22	19.22	19.22	39.9	15.52
S071B002	N (Assume G)		364	8.09	8.09	13.48	83.59	83.59	83.59	111	23.2
S071B005	N (Assume G)		160	3.56	3.56	5.93	36.74	36.74	36.74	71.7	12.96
Water Reclaim Area											
S072B000	N (Assume G)		38	0.84	0.84	1.41	8.73	8.73	8.73	26.3	15.28
S072B002	N (Assume G)		7.69	0.17	0.17	0.28	1.77	1.77	1.77	23.4	14.3
S073B000	N (Assume G)		57.9	1.29	1.29	2.14	13.30	13.30	13.30	40.7	12.84
Former Ore Pile											
S074B000	O	L,C	65	9.29	9.29	9.29	9.29	9.29	9.29	43.7	10.7
S075B000	O	L,C	61.5	8.79	8.79	8.79	8.79	8.79	8.79	43.1	10.64

Table 2a-3

Sample ID	Associated Site-Related Material (a)	Basis for Association (b)	Gross Alpha (measured) (pCi/g)	U-238 (estimated) (pCi/g)	U-234 (estimated) (pCi/g)	Th-230 (estimated) (pCi/g)	Ra-226 (estimated) (pCi/g)	Pb-210 (estimated) (pCi/g)	Po-210 (estimated) (pCi/g)	Gross Beta (measured) (pCi/g)	Accuracy (pCi/g)
S075B002	O	L,C	20	2.86	2.86	2.86	2.86	2.86	2.86	22.7	8.78
S076B000	O	L,C	123	17.57	17.57	17.57	17.57	17.57	17.57	79.7	24.4
S077B000	O	L,C	100	14.29	14.29	14.29	14.29	14.29	14.29	61.5	26.8
S077B002	O	L,C	18.1	2.59	2.59	2.59	2.59	2.59	2.59	16.1	13.26
S078B000	O	L,C	143	20.43	20.43	20.43	20.43	20.43	20.43	65.1	27
S078B002	O	L,C	12.9	1.84	1.84	1.84	1.84	1.84	1.84	14.4	12.68
Bone Yard											
S079B000	N (Assume G)		29.5	0.66	0.66	1.09	6.77	6.77	6.77	30.8	11.24
S079B002	N (Assume G)		8.97	0.20	0.20	0.33	2.06	2.06	2.06	21.9	9.9
S080B000	N (Assume G)		21.2	0.47	0.47	0.79	4.87	4.87	4.87	31	11.48
S081B000	N (Assume G)		25.5	0.57	0.57	0.94	5.86	5.86	5.86	29	10.92
S081B002	N (Assume G)		13	0.29	0.29	0.48	2.99	2.99	2.99	23.3	10.34
Roads											
S082B000	N (Assume S)		34.3	4.90	4.90	4.90	4.90	2.16	2.16	22.1	10
S082B002	N (Assume S)		23.4	3.34	3.34	3.34	3.34	1.47	1.47	21.2	9.94
S083B000	N (Assume S)		20.4	2.91	2.91	2.91	2.91	1.28	1.28	28.6	11.1
S083B002	N (Assume S)		14.2	2.03	2.03	2.03	2.03	0.89	0.89	18.1	11.28
S084B000	N (Assume S)		23.5	3.36	3.36	3.36	3.36	1.48	1.48	24.5	12.22
S085B000	N (Assume S)		42.4	6.06	6.06	6.06	6.06	2.67	2.67	37.5	11.78
S086B000	N (Assume S)		20.4	2.91	2.91	2.91	2.91	1.28	1.28	26.8	10.6
S088B000	AP	C	19.8	7.33	7.33	2.20	0.73	0.73	0.73	21.3	9.82
S089B000	N (Assume S)		14.9	2.13	2.13	2.13	2.13	0.94	0.94	23.4	10
S090B000	N (Assume S)		25.6	3.66	3.66	3.66	3.66	1.61	1.61	27	10.7
S090B002	N (Assume S)		11.9	1.70	1.70	1.70	1.70	0.75	0.75	24.3	10.36
S094B000	G	A	139	3.09	3.09	5.15	31.92	31.92	31.92	54.2	11.68
S094B002	G	A	25.3	0.56	0.56	0.94	5.81	5.81	5.81	22.3	8.74
S095B000	N (Assume S)		115	16.43	16.43	16.43	16.43	7.23	7.23	64.7	15.34
S096B000	N (Assume S)		18.4	2.63	2.63	2.63	2.63	1.16	1.16	24.1	10.38
S096B002	N (Assume S)		21.1	3.01	3.01	3.01	3.01	1.33	1.33	26.2	10.88
Unlined Ditch to Water Treatment Ponds											
S097B020	O	L	2.33	0.33	0.33	0.33	0.33	0.33	0.33	35.7	6.75
East Overflow Pond											
S099B000	G	A,C	49.8	1.11	1.11	1.84	11.44	11.44	11.44	9.82	3.99
Former Cooling Pond (Phase II)											
S100B000	N (Assume G)		133	2.96	2.96	4.93	30.54	30.54	30.54	66.8	6.89
S100B002	N (Assume G)		178	3.96	3.96	6.59	40.87	40.87	40.87	57.3	6.46
S100B005	N (Assume G)		155	3.44	3.44	5.74	35.59	35.59	35.59	53.9	7.43
S100B007	N (Assume G)		60.5	1.34	1.34	2.24	13.89	13.89	13.89	37.9	5.59
S100B010	N (Assume G)		90.1	2.00	2.00	3.34	20.69	20.69	20.69	43.1	5.63
Cooling Tower Area (Phase II)											
S101B000	N (Assume G)		74.6	1.66	1.66	2.76	17.13	17.13	17.13	37	4.29

Table 2a-3

Sample ID	Associated Site-Related Material (a)	Basis for Association (b)	Gross Alpha (measured) (pCi/g)	U-238 (estimated) (pCi/g)	U-234 (estimated) (pCi/g)	Th-230 (estimated) (pCi/g)	Ra-226 (estimated) (pCi/g)	Pb-210 (estimated) (pCi/g)	Po-210 (estimated) (pCi/g)	Gross Beta (measured) (pCi/g)	Accuracy (pCi/g)
S101B002	N (Assume G)		72.2	1.60	1.60	2.67	16.58	16.58	16.58	43.2	4.91
S101B010	N (Assume G)		14.3	0.32	0.32	0.53	3.28	3.28	3.28	27.1	4.84
Water Reclaim Area (Phase II)											
S102B000	N (Assume G)		218	4.84	4.84	8.07	50.06	50.06	50.06	86.7	14.7
Former Phosphoric Acid Loading Area/Railcar Cleaning Area (Phase II0											
S103B000	N (Assume G)		31.1	0.69	0.69	1.15	7.14	7.14	7.14	39.1	7.32
S103B002	N (Assume G)		27	0.60	0.60	1.00	6.20	6.20	6.20	37.8	6.84
S103B005	N (Assume G)		20.8	0.46	0.46	0.77	4.78	4.78	4.78	32.7	6.91
S103B007	N (Assume G)		156	3.47	3.47	5.78	35.82	35.82	35.82	107	7.18
Sulfuric Acid Plant #1 (Phase II)											
S104B000	N (Assume G)		79.1	1.76	1.76	2.93	18.16	18.16	18.16	41.5	4.76
Phosphoric Acid Loading Dock (Phase II)											
S105B000	N (Assume G)		25	0.56	0.56	0.93	5.74	5.74	5.74	21.8	3.71
S105B005	N (Assume G)		21.6	0.48	0.48	0.80	4.96	4.96	4.96	21.8	3.71
Ammonium Phosphate Plant #2 (Phase II)											
S109B000	N (Assume G)		44.8	1.00	1.00	1.66	10.29	10.29	10.29	30.7	6.48
Unlined Ditch to Water Treatment Ponds											
SSSUDP01	O	L	421	60.14	60.14	60.14	60.14	60.14	60.14	142	11.4
SSSUDP02	O	L	245	35.00	35.00	35.00	35.00	35.00	35.00	113	10.34
SSSUDP03	O	L	108	15.43	15.43	15.43	15.43	15.43	15.43	66.5	8.6
SSSUDP04	O	L	262	37.43	37.43	37.43	37.43	37.43	37.43	123	11.02
SSSUDP05	O	L	139	19.86	19.86	19.86	19.86	19.86	19.86	80	9.28
SSSUDP06	O	L	251	35.86	35.86	35.86	35.86	35.86	35.86	107	10.42
NOTES:											
(a)			AP = ammonium phosphate								
			CF = calciner fines, sediment, sludge								
			FP = ferrophos								
			G = gypsum								
			N = no clear association; generally non-specific fill								
			O = ore								
			P = phossy water/solids or precipitator slurry								
			S = slag								
(b)			A = appearance								
			C = chemistry								
			L = location								

Appendix Q

Naturally Occurring Mercury in the EMF Study Area

Mercury is a naturally occurring element. The average composition of mercury in igneous and sedimentary rocks ranges from 0.046 to 0.33 milligrams per kilogram (mg/kg) (Hem, 1970). Mercury has a tendency to react with a variety of inorganic and organic compounds to form simple and complex molecules. The most common ore mineral is cinnabar, a mercury sulfide. Mercury also forms many strong organic complexes and is generally much more soluble in organic liquids than in water. The following paragraphs summarize the findings of a literature survey that shows the presence of naturally occurring mercury in soils in the southeastern part of Idaho.

Q.1 EVIDENCE OF NATURALLY OCCURRING LEVELS OF MERCURY IN THE SOILS IN SOUTHEASTERN IDAHO

As described in the following paragraphs, several studies performed by the USGS on economic mineral deposits in the Pocatello and Fort Hall Bottoms area provide sufficient information to demonstrate that mercury is a naturally occurring element in the Fort Hall Gravels and that the bulk of the mercury occurs as very fine-grained minerals (and mercury coatings on very fine-grained gold grains). This information further suggests that natural "winnowing" of the gravels may further concentrate the mercury-bearing grains into the fine-grained sediments found in the Fort Hall Bottoms and Portneuf River delta in the American Falls Reservoir (AFR).

The U.S. Geological Survey (USGS) (Desborough et al. 1988) did extensive sampling and analysis of bulk samples of gravel obtained from a site between Blackfoot and Pocatello, Idaho. One of the samples collected was analyzed for its mineral content. Minerals identified by ore microscopy methods and quantitative electron microprobe analysis indicated the presence of several minerals, including native mercury. The analysis also identified petzite and hessite grains that contained 0.2 - 0.4 percent by weight of mercury. Grains that were considered to be hydrothermal amalgam were found to be the most mercury-rich grains.

The USGS (Desborough, 1992) also reported free mercury, as tiny spheres, in gravels explored by drilling to depths of 12 meters in areas on the Fort Hall Indian Reservation, in the southeastern part of Idaho. In addition, between 1985-1987, the USGS investigated low-grade deposits of placer gold in Holocene and Pleistocene gravel and sand along the Snake River, near Blackfoot, Idaho. A gold-mercury mineral that occurs in grains and grain aggregates was recognized in these deposits.

As presented in Section 4.2, the Environmental Protection Agency (EPA) Region X has determined that the background level of mercury in soil in the EMF study area is 0.16 mg/kg. This level corresponds to the 95 percentile of those subsurface soils (2 feet bgs) collected in areas outside the facilities fence line that did not, in EPA's judgment, display any characteristic of EMF-related impact.

Q.2 MERCURY IN A HYDROTHERMAL ENVIRONMENT

Thermal springs contain readily detectable mercury. Precipitates and bottom sediments in many hot springs, even where no mercury mineral is evident, contain quantities of mercury much above the average content for crystalline rocks. For example, the fine-grained muds of the mudpots and mud volcanoes of Yellowstone National Park are products of hydrothermal alteration of adjacent rocks. Sediments associated with these springs and muds are rich in mercury, containing about 50 to 5,000 times the mercury content of ordinary rocks. Cinnabar and metacinnabar are known to have precipitated from Boiling Springs, Idaho (Shacklette et al. 1971).

As part of a study conducted by the USGS (Desborough, 1988), soil samples were collected from the Fort Hall Bottoms, between Welch placer and Bonanza Bar, in the southeastern part of Idaho. The mineral composition of these samples was studied by electron microprobe analysis. The study noted hydrothermal amalgam on one grain recovered from the reference sample. The very small crystals of amalgam on the grain margins and the high content of mercury were believed to indicate an origin in a hydrothermal environment. Most of the low-temperature amalgam found in the placer environment, which apparently formed from incidental contact of free mercury and native gold, had less than 10 atomic percent of mercury.

Q.3 BIOACCUMULATION OF MERCURY IN RESERVOIRS AND APPLICABILITY TO THE AMERICAN FALLS RESERVOIR

Numerous occurrences of elevated mercury levels in tissues of fish in regions remote from sources of mercury have been documented. Stokes and Wren (1987) summarized studies of mercury levels in fish from reservoirs in the United States and Canada during the late 1970s and early 1980s. The studies indicated that the source of mercury in fish was provided by background levels of mercury present in topsoil which formed the sediments of reservoirs after filling.

The inundation of soils/sediments results in increased bacterial methylation of naturally occurring mercury, with the primary source of mercury being the organic rich upper soil horizon. In addition, increased bacterial production occurs when terrestrial vegetation, moss, peat, and humus are inundated. Shoreline erosion determines the amount of organic content in flooded sediments and, hence, is another factor that enhances the mercury methylation process. In man-made Lake Powell, NM, mercury was released by natural weathering of the basin; the authors estimated that up to 800 kg/year of mercury could accumulate in the reservoir. In a separate study, fluctuations in the water levels of the Elephant Butte Reservoir in New Mexico have contributed to variability in the mercury levels in the water. Reservoirs constructed on the La Grande River in Quebec were studied between 1978-1982, and mercury levels in fish were compared for both pre-impoundment and post-impoundment conditions. It was noticed that post-impoundment mercury levels in fish were two to three times the mercury levels of pre-impoundment conditions.

The AFR is known to show great fluctuations in its water level (4,307 feet msl to 4,354 feet msl), as illustrated in Figures Q-1 and Q-2. This has led to repeated cycles of inundation of the soil horizons and terrestrial vegetation, contributing to an enhanced mercury methylation process. Given the presence of naturally occurring mercury in the soils impounding the AFR, increased levels of mercury in the water and sediments of the AFR are to be expected.

Mercury is also introduced into the AFR through the discharge of naturally occurring mercury in regional groundwater. Groundwater and springs contribute as much as 22 percent of the reservoir inflow. Background levels of mercury in groundwater are estimated at 0.8 micrograms per liter (µg/l) in the Michaud Flats regime and 0.4 µg/l in the Portneuf River Valley regime. Based on these background levels and the rate of groundwater inflow to the AFR, the potential flux of mercury from background groundwater to the Portneuf River may be 200 kg/year. In addition, the flux of mercury from background Portneuf River Valley groundwater is estimated to be 55 kg/year.

As part of a study conducted in the early 1970s by a research team from the Idaho Water Resources Institute, mercury levels in fish, water, and sediment in the AFR were evaluated (Kent and Johnson, 1979). Mean mercury levels in water ranged from 0.25-1.78 µg/l and in sediment from 0.32-0.53 mg/kg. The mean value of mercury for all fish from the AFR reported in this study was 0.30 mg/kg; 30 percent of fish taken from the AFR had mercury levels exceeding 0.50 mg/kg. The presence of methylmercury in water and sediments of a reservoir results in higher levels of uptake into fish. The presence of impoundments contributes to an enhanced methylation process, increasing mercury levels in the water and sediments.

Q.4 MERCURY IS NOT A SITE-RELATED CONSTITUENT IMPACTING THE PORTNEUF RIVER

The primary pathway by which mercury could hypothetically reach the Portneuf River from the EMF facilities is groundwater. As discussed below, this hypothetical pathway from the facilities to the river is not present. However, if mercury is present in sediments along the Portneuf River and the AFR, it may be explained by the presence of naturally occurring mercury in background soils and background groundwater.

As stated in Section 4.4 , mercury is not an element of concern in groundwater in the EMF study area. Mercury reported in a few wells along the Portneuf River is believed to be naturally occurring. USGS studies indicate the presence of naturally occurring mercury in the Snake River alluvial deposits; these gravels underlie the EMF site (Desborough et al., 1988) Other possible sources of mercury *and* selenium include a battery reclaimer upriver of the EMF site and irrigation drainage.

Background levels of mercury in groundwater are estimated at 0.7 µg/l in the Bannock Range groundwater regime; 0.8 µg/l in the Michaud Flats regime; and 0.4

µg/l in the Portneuf River Valley regime. Of interest are the Portneuf River Valley background wells (510 and 511) and the Michaud Flats regime wells (514 and 515). Both sets of wells are, of course, hydraulically upgradient from the EMF groundwater impact area. Both sets of wells may reflect the naturally occurring sources of mercury identified in the USGS studies.

Because mercury appears to be present in background groundwater, it could also be present in surface waters and surface water sediments due to the significant recharge of groundwater to the Portneuf River. The estimated potential flux of mercury from background groundwater to the Portneuf River along the gaining reach north of Swanson Road is as high as 200 kg/year. Additionally, a conservatively estimated flux of mercury from background Portneuf River Valley groundwater is 55 kg/year. EMF site-related groundwater impact has been determined to be present only along the river reach between Swanson Road Spring and Batiste Spring. (See both Sections 4.4 and 4.5.)

Q.5 SUMMARY

A major source of mercury in the water and sediments of the AFR is the naturally occurring mercury from gold-mercury mineral deposits known to be existing in the project area. Inundation of soils and vegetation from fluctuations in the water levels of the AFR has enhanced methylation, and so detection of mercury in water and sediments of the AFR is to be expected. The presence of decaying vegetation and organic matter has also contributed to enhanced methylation and increased levels of mercury in the AFR. In addition, the increase in mercury levels from groundwater inflow is yet another reason for the presence of mercury in the water and sediments of the AFR.

Because of natural and biological factors stated above, mercury levels in the water and sediments are to be expected. Mercury is not a site-related constituent in surface waters and sediments.

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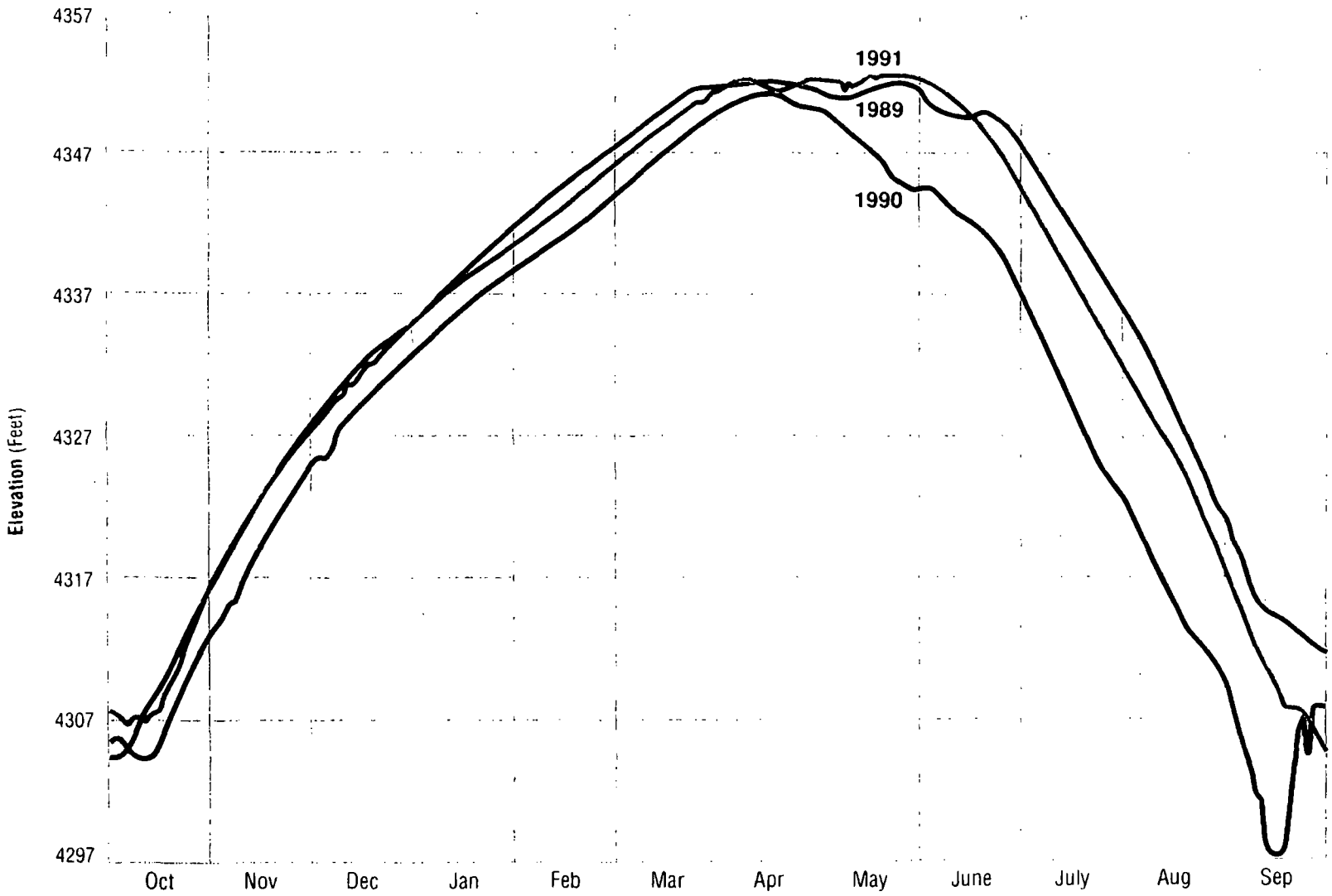
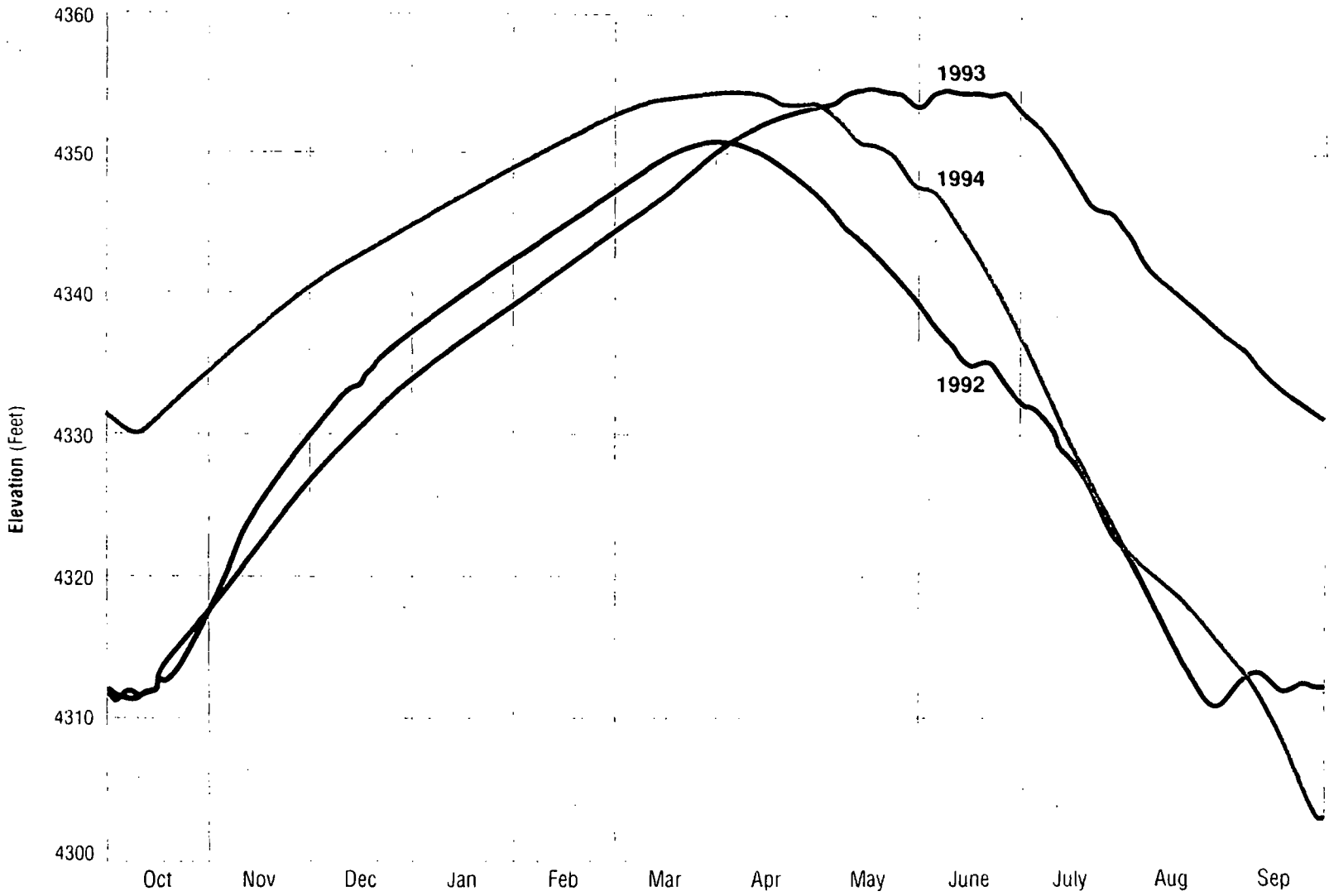


Source: U.S. Bureau of Reclamation, Mike Beus

Figure Q-1: American Falls Reservoir Water Elevations 1989-1990

95-2204 001
8-30-95 rs 0



Source: U.S. Bureau of Reclamation, Mike Beus

Figure Q-2: American Falls Reservoir Water Elevations 1992-1994

95-2204.002
8-30-95 rs 0

Appendix R

Ecological Assessment Field Sampling Plan

ECOLOGICAL ASSESSMENT FIELD SAMPLING PLAN EASTERN MICHAUD FLATS SITE POCATELLO, IDAHO

October 1994

Revised by:

Sciences International, Inc.
Bechtel

DISCLAIMER

Portions of this sampling plan were developed by Sciences International, Inc. (King Street Station, 1800 Diagonal Road, Suite 500, Alexandria, VA 22314-2808) and Bechtel Environmental, Inc. (50 Beale Street, P.O. Box 193965, San Francisco, CA 94119-3965) for FMC Corporation and J.R. Simplot Company. The material provided by Sciences International, Inc. and Bechtel Environmental, Inc. was reviewed and edited by Ecology and Environment, Inc., (E & E) and incorporated into the sampling plan, at the direction of the United States Environmental Protection Agency.

ECOLOGICAL ASSESSMENT FIELD SAMPLING PLAN
EASTERN MICHAUD FLATS SITE
POCATELLO, IDAHO

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ECOLOGICAL ASSESSMENT FIELD SAMPLING PLAN
EASTERN MICHAUD FLATS SITE
POCATELLO, IDAHO

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ECOLOGICAL ASSESSMENT FIELD SAMPLING PLAN
EASTERN MICHAUD FLATS SITE
POCATELLO, IDAHO

REVISION PAGE

Revision Date	Revision Number	Revised Sections and/or Page Numbers

1. INTRODUCTION AND OBJECTIVES

This Field Sampling Plan (FSP) describes the sampling strategy and field methods to be used to gather data in support of the ecological risk assessment at the Eastern Michaud Flats Superfund Site (EMF site) in Pocatello, Idaho. An introduction to the FSP and the objectives of the study are provided in this section.

1.1 INTRODUCTION

This FSP is a component of the Sampling and Analysis Plan (SAP), which provides guidelines for field and laboratory investigations to be conducted in this ecological assessment. In addition to the FSP, the Sampling and Analysis Plan consists of a Quality Assurance Project Plan (QAPjP) and a Health and Safety Plan (HSP). The FSP is based on the *Ecological Assessment Work Plan, Eastern Michaud Flats Site, Pocatello, Idaho* (E & E 1994). The FSP also incorporates decisions regarding specific sampling locations and target species for the assessment based on a field reconnaissance surveys of the terrestrial and riparian areas conducted July 6-8, 1994, and of the Portneuf River delta conducted September 22-23, 1994. The FSP was prepared through the joint efforts of the Potentially Responsible Parties (PRPs), the United States Environmental Protection Agency (EPA), and their respective consultants.

1.2 OBJECTIVES

Field investigations for this ecological assessment were developed to obtain sufficient site-specific data to evaluate potential site impacts to principal ecosystems in the vicinity of the site, including upland sagebrush steppe habitats of the Michaud Flats and Bannock Hills, and riparian and aquatic habitats of the Portneuf River. Vegetation, small mammals, and soils are to be collected from sagebrush steppe habitats for evaluation. Vegetation and soils (but not

small mammals) will be collected from the riparian zone bordering the Portneuf River. Sediments from the Portneuf River and its delta at American Falls Reservoir will be evaluated as indicators of possible site impacts to aquatic habitats. If sediment levels in the delta area are significantly elevated above reference values and levels of ecological concern, fish and benthos will be analyzed in a Phase II study of the Portneuf River delta (Delta Study) as described in Section 2.2.

The sampling plan is designed to derive site-specific data in order to more accurately assess the extent to which ecosystems exposed to site contaminants may have been affected. It is not the intent of these studies to characterize the spatial extent of contamination of soils and plants. However, an objective of this study is to delineate the nature and spatial extent of inorganic contaminants in sediments of the Portneuf River delta, and to estimate the threat of this contamination to aquatic biota and wildlife.

The specific objectives of these studies, including the Phase II assessment of the Portneuf River delta if necessary, are to collect data that will allow comparison of contaminant levels to levels at reference locations and to provide site-specific estimates of bioavailability, uptake, food-chain transfer, and media toxicity of contaminants of potential concern (COPCs) where necessary. The studies, including the Phase II Delta Study, are designed to fill several data gaps including:

- Concentrations at reference site locations;
- Concentration, forms and bioavailability of COPCs in soil, and sediment;
- COPC concentrations in vegetation, small mammals, fish, and benthic macroinvertebrates; and
- Toxicity to aquatic biota of sediment from the Portneuf River and its delta at American Falls Reservoir.

A variety of contaminant investigations are to be performed in this ecological assessment. In order to assess site impacts, samples will be collected from reference locations for comparative purposes. Mineralogical studies will attempt to determine the mineral form and oxidation state of inorganic contaminants in site soils, which determine their bioavailability. Vegetation and soil sampling will provide site-specific data for evaluation of potential for contaminant uptake by terrestrial plants from air and soil. Small mammal

sampling will provide data for evaluation of potential exposure of organisms higher in the food chain to site contaminants. Sediment samples taken adjacent to the site at the outfall of the industrial wastewater (IWW) ditch and at other downstream locations in the Portneuf River delta will be used to evaluate the toxicity of sediments to aquatic biota.

Data collected in these investigations will be presented to the EPA in data summary reports, to be prepared by the PRPs. The data will be evaluated in an ecological risk assessment report, to be prepared by E & E for the EPA.

2. RATIONALE FOR SAMPLE LOCATIONS, ANALYTICAL PARAMETERS, AND NUMBERS OF SAMPLES

The EMF site is located in the intermountain sagebrush ecoregion (USDA 1980), which is characterized as a semiarid desert with hot summers and moderately cold winters. Ecosystem types at the EMF site include sagebrush steppe; juniper woodland; agricultural areas; cliffs, caves, and canyons; wetlands at springs; riverine/riparian; and reservoir (open water and mudflats). Additional background information on the site and its ecology is provided in Bechtel (1994) and E & E (1994).

Because of the variety of potentially impacted ecosystems and species, the field investigations for the ecological assessment will focus only on ecosystems and species considered to be of greatest concern at the site. Ecosystems to be considered are sagebrush steppe, the dominant native upland terrestrial ecosystem in the vicinity of the site; the riparian habitat bordering the Portneuf River; and the aquatic habitat within the Portneuf River and in the delta of the Portneuf River at the American Falls Reservoir.

Ecological risks posed by contaminants in the environment cannot be evaluated simply on the basis of total concentration; physical and chemical properties strongly determine bioavailability of contaminants and their potential toxicity to target species. For example, soil-to-plant uptake factors are available but have generally been determined on agricultural crops grown in typical agricultural soils (e.g., Baes *et al.* 1984). These factors do not provide reliable estimates of plant concentrations in natural ecosystems, particularly at the EMF site where soils are alkaline, unlike many agricultural soils, and native vegetation differs considerably from agricultural crops.

The proposed studies are intended to provide direct evidence of bioavailability and toxicity in the natural ecosystem where exposure is likely to be greatest. Thus, COPC concentrations in soil, vegetation, and small mammals will be used as indicators for effects in terrestrial ecosystems, while the potential for effects in aquatic ecosystems will be indicated by

COPC concentrations in sediment, and, where necessary, bioassays of sediment toxicity combined with analysis of the bioavailable fraction of COPCs in sediment.

The COPCs and sample media to be investigated in the ecological assessment are shown in Table 2-1 which includes the sample media of the Phase II Delta Study. COPCs were identified on the basis of the extent of their spatial distribution in media surrounding the facility, their potential toxicity to ecological receptors, their tendency to mobilize and/or biomagnify in the food chain, evidence of contamination from previous investigations, and the need to resolve data gaps (Bechtel 1994; Ecology and Environment 1993). COPCs include fluoride (F), cadmium (Cd), and zinc (Zn) in soil, vegetation and small mammals; F, Cd, Zn, As, Se, and Hg (even though Hg levels are consistent with background) in sediment; and F, Cd, Zn, Hg, and Se in fish and benthic macroinvertebrates (see Table 2-1). Sample media and target species include surface soils; vegetation (Russian olive fruit, sagebrush foliage, western wheatgrass foliage); small mammals (whole organisms and skeletons of deer mice); surface sediment; fish (Utah sucker); and benthic macroinvertebrates (midge larvae).

An overview of habitats where these sample media and target species will be collected for chemical analyses is provided in Table 2-2. Sampling will be conducted in both terrestrial and aquatic habitats. The terrestrial habitats include sagebrush steppe habitat and riparian habitat. Soil, sagebrush foliage, western wheatgrass, and deer mice will be sampled in the sagebrush steppe habitat. Soil and Russian olive fruit will be sampled in the riparian habitat. The aquatic habitats include riverine habitat and river delta/reservoir habitat. In the riverine habitat, sediment will be sampled and sediment toxicity testing will be conducted. In the river delta/reservoir habitat, sediment, Utah sucker, and midge larvae will be sampled. In the event that Phase II of the Delta Study is triggered (Section 2.2), sediment toxicity testing will be conducted which will necessitate additional sediment sampling.

Potential sampling locations were identified based on evaluation of contaminant levels indicated from previous investigations (Bechtel 1994; E & E 1993). A terrestrial reconnaissance survey was completed July 6 through 8, 1994, in order to verify the suitability of these sampling areas and to locate access points. In addition, the reconnaissance served to familiarize project biologists with site characteristics, and determine appropriate biota target species to be collected. The terrestrial reconnaissance survey was conducted by representatives of the PRPs, Idaho Department of Environmental Quality, U.S. Fish and Wildlife Service, EPA, and an E & E field team. Locations were verified in the field by the PRPs'

representatives using a global positioning system (GPS) calibrated to known benchmarks near the EMF site. The GPS provides three-dimensional locations with an error of less than 2.0 seconds latitude and longitude and less than 500 feet in elevation, provided enough GPS satellites are in position to be acquired. Benchmarks used for reference to known locations are shown on Figure 2-1. The first benchmark is located near the County Fairgrounds (42°55'00.0" north; 112°26'07.7" west; 4,658 feet AMSL). The second benchmark is located near Pocatello Creek Road and Parks Road (42°53'12.9" north; 112°23'45.8" west; 4,880 feet AMSL).

The terrestrial and river sample locations were then selected from sites which were reviewed during the reconnaissance survey, with some revision of the selection during follow-up meetings and discussions between the PRPs, EPA and their representatives. The river delta/reservoir sample locations were selected based on field notes taken during a reconnaissance survey of the Portneuf River delta on September 22-23, 1994.

Numbers of samples to be collected for each media or target species were determined by establishing data quality objectives that permit meaningful statistical comparisons to be made with reference areas. The approach for establishing data quality objectives was in accordance with EPA guidance (EPA 1989, EPA 1992), and was applied to the site using representative data from published literature to estimate the expected degree of variability in study populations. A description of the approach and the data used to determine sample size is presented in Appendix A.

In the discussion that follows, the rationale for sample locations, media and target species, numbers of samples, and analytical parameters is provided. Terrestrial habitat investigations are described in Section 2.1. Aquatic studies are described in Section 2.2.

2.1 TERRESTRIAL STUDIES

2.1.1 Sample Locations, Media, and Target Species

2.1.1.1 Sagebrush Steppe Habitat

Two potentially impacted locations representing likely exposed areas (see Figure 2-2), and one reference location presumed to be unaffected by the EMF site (see Figure 2-3), were selected for sampling from the sagebrush steppe habitat (see Table 2-3). One of the potentially impacted locations is in Michaud Flats, approximately 1 mile north-northeast of the facilities in the direction of the prevailing winds (identified in the reconnaissance survey as Flats #3). During the reconnaissance survey, this area was determined to have suitable habitat, sufficient vegetation for sampling, and easy access. A second area in the foothills of the Bannock Range was identified during a subsequent meeting between the consultants for the PRPs and EPA. This area is approximately 1 to 2 miles southwest of the EMF facilities near a substation. Because access and suitability of this area were not examined during the reconnaissance survey, the decision to include this area as the second potentially impacted location will be made in the field at the time the plan is implemented. If either of these areas has an insufficient quantity of target species at the time of sampling, an alternative site in the foothills of the Bannock Range, approximately 1/2 to 1 miles southeast of the EMF facilities (identified in the reconnaissance survey as Bannock #4) will be used.

A reference sagebrush steppe location to serve as background is included in the study. This habitat location is located at Ferry Butte approximately 15 miles north-northeast of the EMF site, near Blackfoot, ID (identified in the reconnaissance survey as Blackfoot #1).

Within each of the two potentially impacted areas and the reference area, a 1-hectare sample plot will be established for sample collection. Each sample plot will be subdivided into 25 subplots, of which only 10 to 20 subplots will be sampled (see Section 4.1). Samples of soil and vegetation within each subplot will be composited.

The sagebrush steppe habitat is dominated by shrubs and grasses. The most prevalent communities in the area are characterized by codominance of sagebrush (*Artemisia* spp.) and perennial bunch grasses (*Agropyron* spp.). Therefore, the following are the target species and plant tissue types from which vegetation are to be sampled from several plants within each subplot and composited:

- Big sagebrush, *Artemisia tridentata*, leaves and petioles (washed);
- Big sagebrush, *Artemisia tridentata*, leaves and petioles (unwashed);
- Western wheatgrass, *Agropyron smithii* leaves and stems (unwashed).

Since contaminant accumulation in vegetation may be due to either deposition of airborne particulates or soil uptake, half of the sagebrush vegetation mass obtained during sampling will be washed to remove loosely adhering contaminant particles; the remaining half of the sagebrush sample and all of the grass foliage samples will be analyzed unwashed. If sufficient plant material of western wheatgrass is unavailable, cheat grass, *Bromus tectorum*, will be substituted and will become the target grass species at all three sagebrush steppe habitat locations.

To assess the potential for bioaccumulation through higher trophic levels, concentrations of COPCs in deer mice, *Peromyscus maniculatus*, will be determined. Deer mice are widespread throughout the area and potentially may ingest COPCs through soil, seeds, and foliage, or through consumption of invertebrates, e.g., grasshoppers and beetles. Since these mice serve as prey for raptors and other species of potential interest, they are an important link in local food webs. Deer mice will be trapped from each of the three 1-hectare sample plots representative of sagebrush steppe habitat. Deer mice carcasses will be assayed individually. Femurs will be removed from deer mice and analyzed for fluoride, as the skeleton is the primary site of fluoride accumulation.

Mineralogical studies will be conducted on soil samples collected from each sagebrush steppe sampling location, provided the feasibility of these studies can be demonstrated. The feasibility of mineralogical analyses will be tested on a sample of fresh ore, taken from the ore pile, and a sample of soil taken from the Michaud Flats study site. Studies will then be conducted on soil from all three sagebrush steppe locations, as well as on source materials such as ore, slag, gypsum tailings, ferrophos, and airborne particulates. Details of sampling locations and other aspects of the mineralogical analyses will be provided.

2.1.1.2 Riparian Habitat

Two riparian habitat locations, one potentially impacted (see Figure 2-2) and one reference location (see Figure 2-3), will be sampled for soil and vegetation (see Table 2-3).

The potentially impacted location will be along the Portneuf River, approximately 1 mile north-northeast of the EMF facilities (identified in the reconnaissance survey as Flats #4). The reference site will be along the Snake River just below the mouth of the Blackfoot River, approximately 15 miles north-northeast of the EMF site (identified in the reconnaissance survey as Blackfoot # 2).

At each habitat location, a sample plot will be established encompassing both sides of the Portneuf River along a 500 m reach. The sample plot will be divided into 20 subplots from which composited soil samples and vegetation will be obtained (see Section 4.1). Vegetation samples will consist of the current year's fruit of Russian olive, *Elaeagnus angustifolia*. As an alternative to Russian olive, red osier dogwood, *Cornus stolonifera*, may be substituted at both target and reference locations. Small mammals will not be collected in the riparian habitat.

2.1.2 Analytical Parameters and Numbers of Samples

2.1.2.1 Soil and Vegetation

Composited surface soil and vegetation samples will be collected at each of five locations (three sagebrush steppe and two riparian locations). Both soil and vegetation will be analyzed for cadmium, fluoride, and zinc. Additional soil parameters to be determined are the following: pH, cation exchange capacity (CEC), soluble cation concentrations, total organic carbon (TOC), and redox potential. The rationale for these parameters is provided in Table 2-4. Soil and vegetation analytical methods, and associated detection limits, are provided in Section 3 and in the Quality Assurance Project Plan (QAPjP) portion of this SAP.

The number of soil samples to be collected are summarized in Table 2-5. Composited soil samples will be collected from 10 subplots at each of the three sagebrush steppe study locations, for a total of 30 soil samples, and from 10 subplots at each of two riparian study locations, for a total of 20 soil samples. Hence, a total of 50 soil samples will be collected. Ten soil samples from each study site is considered an adequate number to statistically distinguish potentially impacted areas from reference areas (see Appendix A).

The number of vegetation samples to be collected are also summarized in Table 2-5. Composited samples of big sagebrush foliage will be collected from 20 subplots at each of three sagebrush steppe study locations, for a total of 60 sagebrush foliage samples. (Each sample will be divided into washed and unwashed fractions in the laboratory, to provide a total

of 120 samples for analysis). Composited samples of western wheatgrass foliage will be collected from 10 subplots at each of the three sagebrush steppe study locations, for a total of 30 western wheatgrass foliage samples. Composited samples of Russian olive fruit will be collected from 10 subplots at each of the two riparian study locations, for a total of 20 Russian olive fruit samples. Hence, a total of 110 vegetation samples will be collected; and 60 additional sagebrush samples will be obtained in the laboratory for comparison of washed and unwashed fractions. With the exception of sagebrush, 10 vegetation samples from each study site is considered adequate to distinguish the site from reference areas. Twenty sagebrush samples from each study site will be required for fluoride analysis, whereas only 10 sagebrush samples from each study site are required for the other analyses (see Appendix A).

The total number of analyses to be performed on soil and vegetation samples are summarized in Table 2-6.

In addition, a preliminary test of the mineralogical analyses will be performed on a fractionated samples of ore and soil from the Michaud Flats sagebrush steppe sample site. Mineralogical analyses will utilize x-ray fluorometry, x-ray diffractometry, or electron microprobe analysis to determine whether the methods can be expanded to composited soil samples from each of the remaining sagebrush steppe habitat locations, and a variety of source materials.

2.1.2.2 Small Mammals

Deer mice will be collected from the three sagebrush steppe locations and will be analyzed for cadmium, fluoride, and zinc in whole body preparations, as well as fluoride concentrations in skeletal tissue. The rationale for these parameters is provided in Table 2-4. Analyses and associated detection limits are provided in Section 3 and the QAPjP. Whole carcasses of individual mice will be analyzed for cadmium, fluoride, and zinc. Mouse skeletons will be analyzed separately for fluoride. Compositing of mouse skeletons will be done only if necessary to provide sufficient tissue mass for analysis.

The numbers of deer mouse samples to be collected are summarized in Table 2-5. Ten individual mice will be collected from each of the three sagebrush steppe study locations, for a total of 30 deer mouse samples. Femurs will be removed from the deer mice in the laboratory and analyzed separately for fluoride. Ten small mammal samples from each study site is considered an adequate number to statistically distinguish potentially impacted areas

from the reference area (see Appendix A). The total number of analyses to be performed on deer mice are summarized in Table 2-6.

2.2 AQUATIC STUDIES

2.2.1 Sample Locations, Media, and Target Species

Two distinct aquatic investigations will be conducted in the Portneuf River and its delta at the American Falls Reservoir. The first investigation will involve sediment sampling for chemical analysis and toxicity testing, and will take place in riverine habitat in the vicinity of the IWW ditch outfall (see Section 2.2.1.1). The second investigation, i.e. the Delta Study, will occur several miles downriver from the operational site facilities in depositional areas of the Portneuf River delta. This investigation will be based on a two-phase approach (see Section 2.2.1.2). In Phase I, sediment will be sampled for chemical analysis while fish and benthic macroinvertebrates will be collected and frozen for analysis in Phase II. Phase II, if triggered, will involve additional sediment sampling for toxicity testing. Analysis of fish and macroinvertebrate concentrations will also be performed if Phase II proceeds. However, the analysis will be performed only for those analytes determined to be significantly elevated thereby triggering the Phase II study. The trigger for initiating Phase II is discussed in Section 2.2.1.2.

2.2.1.1 IWW Ditch Outfall

An IWW ditch exists which may have discharged COPCs to the Portneuf River. This is a small drainage ditch transporting noncontact cooling waters above ground about 500 m from the FMC facility aeration device to an underground pipe. After water enters the pipe, it is eventually discharged into the Portneuf River. Maximum water flow in the IWW ditch is less than 10 cubic feet per second. Seasonally, the IWW ditch has lush annual and perennial vegetation growing along its margins and a significant freshwater algae component.

In sediment sampling conducted for the Phase I RI/FS, a variety of sediment COPCs were found with their highest concentrations at this outfall location, including cadmium, fluoride, and zinc. Levels of these COPCs were not found to be as elevated at other Portneuf River locations upstream, or downstream of the outfall to River Mile 10 (E & E 1993). Therefore, these investigations are intended to determine the bioavailability and toxicity of sediment near this outfall.

The potential localized impact of the IWW ditch outfall and other facility outfalls that historically discharged at this location will be assessed by sampling sediment within 20 m downstream from where water from the pipe enters the river (identified as sampling station #17 [Bechtel, 1992]). Two other sites on the Portneuf River in the vicinity of the outfall will also be sampled for sediment, one upstream of the IWW ditch outfall to serve as a reference location (identified as sampling station #21 [Bechtel 1992]), and one downstream of the outfall (identified as sampling station #16 [Bechtel 1992]). Sampling locations are described in Table 2-7 and shown on Figure 2-4. Assays of COPCs in composited sediment samples at each location will be performed, as will laboratory bioassays to determine potential sediment toxicity to benthic organisms.

2.2.1.2 Portneuf River Delta

There are three reasons for conducting studies in the delta region of the Portneuf River. First, no samples for water, sediment, or avian food items (benthic invertebrates and fish) have been collected previously from the Portneuf River delta in the remedial investigation, and thus, levels of site contaminants in environmental media and biota in this area are available only from previous investigations (e.g., Low and Mullins 1990). Second, the Portneuf River delta is an important breeding and feeding area for game waterfowl, piscivorous birds, and shorebirds, and is considered to have high ecological value. Third, sediment in the Portneuf River delta may potentially have higher contaminant levels than sediment from upstream locations because suspended particles that adsorb contaminants are deposited in the delta area.

The Portneuf River Delta Study will proceed in two phases whereby Phase II, consisting of the biological analyses, will be performed only if necessary based on a three-tier decision tree. In Phase I, sediment, and avian food items (benthic invertebrates and fish) will be collected from the Portneuf River delta and the reference area, the Snake River delta. Data obtained from the Snake River delta will be used in the Delta Study to provide a comparison for determining the significance of contaminant levels obtained from Portneuf River delta samples. In Phase I, only the sediment concentrations will be analyzed; the biota which is to be used in the Phase II study will be frozen following collection. In Phase II, sediments will

again be collected for laboratory bioassays of sediment toxicity. Ammonia will be measured at this time. The benthic invertebrates and fish collected in Phase I will also be analyzed in Phase II.

Phase II biological analyses will be performed if sediment chemical analyses show that all of the following criteria are met: 1) the COPCs levels in the Portneuf River delta sediment are statistically greater than the Snake River delta sediment, 2) The COPCs levels of the Portneuf River delta sediments are statistically greater than COPC levels in sediment from upstream of the EMF site, and 3) the COPCs levels in the Portneuf River delta sediments are above a level of ecological concern. Biological analyses will be performed only for those chemicals triggered by the above criteria. Details of the statistical analysis and sediment levels of ecological concern will be provided in a separate document.

The Snake River delta was selected as a reference ecosystem for the Portneuf River delta because the two rivers are similarly impacted by human activities. For example, both rivers receive irrigation drainage and flow through urban areas and into American Falls Reservoir (Low and Mullins 1990). In addition, the deltas of both rivers provide similar aquatic habitat and are used by the same species of benthic invertebrates, fish, and waterfowl.

One purpose of Phase I and Phase II sampling in the Portneuf River delta area is to estimate wildlife exposure to site contaminants. Therefore, sediment and avian food items (benthic invertebrates and fish) are targeted for collection from areas where birds concentrate and/or feed. Two main types of aquatic habitats in both delta areas will be sampled: (1) open water habitats within the river channel, which are likely to support fish eating birds and dabbling ducks, and (2) shallow water or exposed mudflat habitats adjacent to the river channel, which would support wading birds. Mudflat locations (even if dry) will be selected from level areas, not from river banks. During the reconnaissance surveys, waterfowl and shorebirds were observed to be concentrated in these habitats.

Sample collection sites in the delta areas are described in Table 2-7 and illustrated in Figures 2-5 and 2-6. The sediment sampling program was configured such that in each delta, 5 samples will be obtained which are clearly above the confluence of the rivers and the American Falls Reservoir (high water line) and 5 below this confluence.

In the Portneuf River delta (see Figure 2-5), the two most upstream sample sites are located approximately 0.5 km and 1.0 km upstream of the furthest downstream site sampled thus far (identified as sampling station "C" [Bechtel 1994]). Subsequent sites are located at

approximately 1-km intervals along the channel for 10 km. Thus, there are 10 sampling sites in the Portneuf River delta. At each site during Phase I, sediment and benthic invertebrates will be collected from the river channel, and sediment will be collected from the mudflats or shallow water habitat adjacent to the channel. Because fish can readily move upstream or downstream, they will be collected from where they are available in the 10-km section of the river, not at each sampling site.

For comparison with samples from the Portneuf River delta, samples will be collected from 10 sample sites in the Snake River delta (see Figure 2-6). The most upstream site is located on the Snake River near the eastern side of Mc Tucker Island; subsequent sites are located at approximately 1-km intervals along the channel for 10 km. Thus, there are 10 channel sites in the Snake River delta (the two furthest upstream sites are not shown in Figure 2-6). At each site during Phase I, sediment, and benthic invertebrates will be collected from the river channel, and sediment will be collected from the exposed mudflats or shallow water habitat adjacent to the channel. Because fish readily move upstream and downstream, they will be collected from where they are available in the 10-km section of the river, not at each sampling site.

In both the Snake River and Portneuf River deltas, the target benthic invertebrate for collection will be midge larvae (*Chironomidae*). Amphipods (i.e., freshwater shrimp) will be collected if midge larvae are not available during sampling. Both midge larvae and amphipods are consumed by fish and shorebirds and were observed to be abundant in both deltas during the reconnaissance survey.

The target fish species for collection in the deltas will be the Utah sucker (*Catostomus ardeus*). The Utah chub (*Gila atraria*) will be the alternate species if sufficient numbers of Utah suckers are not found. Both species are consumed by piscivorous birds, such as the American white pelican, great blue heron, and the bald eagle, and have been collected from American Falls Reservoir in previous investigations (Low and Mullins 1990).

2.2.2 Analytical Parameters and Numbers of Samples

2.2.2.1 IWW Ditch Outfall

For the investigation of sediment toxicity at the IWW ditch outfall, one composited sediment sample will be collected from each of three locations in the Portneuf River: (1) at the IWW ditch outfall (at sampling station #17); (2) upstream of the IWW ditch outfall at

sampling station #21; and (3) downstream of the IWW ditch outfall at sampling station #16. Each of the three composited sediment samples will be analyzed for fluoride, ammonia, TAL inorganic analytes, pH, total organic carbon, Acid-Volatile Sulfide/Simultaneously Extracted Metals (AVS/SEM), particle-size distribution, and percent solids. The rationale for these parameters is provided in Table 2-8. Analyses and associated detection limits are provided in Section 3 and the QAPjP. In addition, a subsample of the three sediment samples will be used in toxicity tests with the amphipod (*Hyallela azteca*) and the midge (*Chironomus tentans*) (ASTM 1993). The number of samples are included in Table 2-9, and the sediment analyses are summarized in Table 2-10.

2.2.2.2 Portneuf River Delta

For Phase I of the Portneuf River Delta Study, the analytical parameters for sediment and the rationale for their measurement are listed in Table 2-8. Sediment samples from river channel and mudflat sites in the Portneuf and Snake River deltas will be measured for fluoride, cadmium, selenium, zinc, arsenic, mercury, aluminum, iron and additional parameters (dissolved oxygen, salinity, temperature, conductivity, turbidity, pH) that play a role in metal speciation and bioavailability in sediment.

If triggered by the results of chemical analyses, Phase II will consist of resampling of three channel sediment samples and three mudflat samples from each delta which will be used in toxicity tests with the midge *Chironomus tentans* and the amphipod *Hyallela azteca* (ASTM 1993). Ammonia will be measured in sediments during this phase of the investigation. Whole fish and benthic invertebrate samples collected during Phase I will be analyzed for fluoride and a subset of TAL inorganic analytes (Cd, Zn, Hg, Se, As) that are known site contaminants and/or which may biomagnify in aquatic food chains.

For sediment, and biota the total number of samples to be collected from the Portneuf River and Snake River deltas are summarized in Table 2-9. The numbers were selected using professional judgement based on data from previous investigations, as discussed below.

For sediment from the Portneuf River delta, 20 sediment samples (10 channel locations, 10 adjacent mudflats) were judged to be the minimum needed to characterize the ~10 km of river channel in the delta area. For comparison, the same number of water and sediment samples will be collected from a 10 km length of the Snake River delta.

The target number of fish for collection (10), was determined as described in Appendix A. Unfortunately, no data could be found on contaminant levels in midge larvae from American Falls Reservoir or its tributaries. Ten composite samples from each delta were judged to be adequate to compare the areas.

Table 2-1

OVERVIEW OF COPCs AND SAMPLE MATRICES

Potentially Affected Media	Sample Matrices	COPCs
Soil	Surface soils	F, Cd, Zn
Vegetation	Big Sagebrush - foliage (washed and unwashed)	F, Cd, Zn
	Western Wheatgrass - foliage	
	Russian Olive - fruit	
Small mammals	Deer Mouse - whole organism	F, Cd, Zn
	Deer Mouse - skeleton	F
Sediment	Surface sediment	F, Cd, Zn, Se, Hg, and As
Fish (Phase II)	Utah Sucker - whole organism	F, Cd, Zn, Hg, Se, As
Benthic macroinvertebrates (Phase II)	Midge larvae - whole organism	F, Cd, Zn, Hg, Se, As

Key:

As = Arsenic
Cd = Cadmium.
F = Fluoride.
Hg = Mercury
Se = Selenium.
Zn = Zinc
Al = Aluminum
Fe = Iron.

Table 2-2

OVERVIEW OF HABITATS AND SAMPLE MATRICES

Habitats	Sample Matrices
Terrestrial - Sagebrush steppe	Surface soil
	Big Sagebrush - foliage (washed and unwashed)
	Western Wheatgrass - foliage
	Deer Mouse - whole organism and skeleton
Terrestrial - Riparian	Surface soil
	Russian Olive - fruit
Aquatic - River Delta	Surface sediment
	Utah Sucker - whole organism (Phase II)
	Midge larvae - whole organism (Phase II)
Aquatic - Riverine	Surface sediment

Table 2-3

LOCATIONS OF TERRESTRIAL STUDY SITES

Habitats	Study Sites	Location
Sagebrush Steppe	Michaud Flats	Approximately 1 mile NNE of the FMC/Simplot facility on Michaud Flats, near the Portneuf River. 42° 55' 23.9" North; 112° 31' 37.2" West; 4,096 feet AMSL.
	Bannock Hills SW	Approximately 1-2 miles SW of the FMC/Simplot facility near electrical substation.
	Ferry Butte[a]	Approximately 15 miles NNE of the FMC/Simplot facility near the Blackfoot River. 43° 07' 29.4" North; 112° 29' 0.06" West; 4,358 feet AMSL.
Riparian	Portneuf River	Approximately 1 mile NNE of the FMC/Simplot facility on the Portneuf River. 42° 55' 16.0" North; 112° 31' 34.8" West; 4,208 feet AMSL.
	Snake River[a]	Approximately 15 miles NNE of the FMC/Simplot facility near the confluence of the Blackfoot and Snake rivers. 43° 07' 35.3" North; 112° 30' 44.8" West; 4,493 feet AMSL.

[a] Reference areas.

Table 2-4

TERRESTRIAL STUDIES
RATIONALE FOR SAMPLE MATRICES AND ANALYTICAL PARAMETERS

Analytical Parameter	*Matrix*	*Rationale*	*References*
Cadmium, fluoride, zinc	Sagebrush foliage, crested wheatgrass foliage, Russian olive fruit, small mammal carcass and femur (fluoride only), and soil	These elements are elevated in soil and vegetation at the EMF site. Other contaminants also occur at the site, but these three chemicals appear to have the widest distribution in soils at levels significantly above background.	E & E 1993 Severson and Gough 1979
pH, total organic carbon, CEC, redox potential, and soluble cations	Soil	These parameters can be used as site-specific variables in geochemical models for estimating pore-water concentrations of site contaminants.	Sposito and Page 1984
Fluoride-, cadmium-, and zinc-containing minerals	Soil, ore, slag, gypsum tailings, ferrophos, airborne particles	Mineralogical analyses will provide information on the chemical form of F, Cd, and Zn in soil and source materials to help estimate their bioavailability and potential toxicity.	Davis *et al.* 1993 Clevenger *et al.* 1991

Table 2-5

TOTAL NUMBER OF INVESTIGATIVE SAMPLES FOR SOIL, VEGETATION, AND SMALL MAMMALS

Sample Matrices	Sagebrush Steppe Locations			Riparian Locations		Total Number of Samples
	Michaud Flats	Bannock Hills SW	Ferry Butte	Portneuf River	Snake River	
Surface soil[a]	10	10	10	10	10	50
Big sagebrush-foliage[b]	20	20	20	—	—	60
Western wheatgrass - foliage	10	10	10	—	—	30
Russian olive - fruit	—	—	—	10	10	20
Deer mouse - whole organism[c]	10	10	10	—	—	30
Total number of samples	50	50	50	20	20	190

a Does not include samples for mineralogical analysis.
b Sagebrush foliage samples will be divided into washed and unwashed fractions in the laboratory to provide a total of 120 samples.
c Deer mouse femurs will be removed in the laboratory and analyzed separately for fluoride.

Table 2-6

TOTAL NUMBER OF INVESTIGATIVE ANALYSES FOR SOIL, VEGETATION, AND SMALL MAMMALS

Parameter	Sagebrush Steppe Locations						Riparian Locations		Total Number of Analyses
	Surface Soil	Sagebrush Foliage - Washed	Sagebrush Foliage - Unwashed	Western Wheatgrass - Foliage	Deer Mouse - Whole	Deer Mouse - Femurs	Surface Soil	Russian Olive - Fruit	
Cadmium and zinc	30	30	30	30	30	—	20	20	190
Fluoride	30	60	60	30	30	30	20	20	280
pH, total organic carbon (TOC), CEC, redox potential, and soluble cations	30	—	—	—	—	—	20	—	50

Table 2-7

LOCATIONS OF AQUATIC STUDY SITES

Habitats	Study Sites	Location
IWW Ditch Outfall	Portneuf River upstream of the IWW ditch outfall[a]	Previously identified as Sampling Station #21.
	Portneuf River at the IWW ditch outfall	Within 20 meters downstream of the confluence of the IWW ditch outfall and the Portneuf River. Previously identified as Sampling Station #17.
	Portneuf River downstream of the IWW ditch outfall	Previously identified as Sampling Station #16.
Portneuf River Delta at American Falls Reservoir	Portneuf River delta clearly above the high water line.	Five stations at approximately 1 km intervals (the two most upstream stations located 0.5 km and 1.0 km from location previously identified as Station "C")
	Portneuf River Delta at American Falls Reservoir	5 locations at approximately 1 km intervals to a distance of 10 km downstream from Station 1 .
	Snake River Delta[a]	Ten locations at approximately 1 km intervals for a distance of 10 km above and below the high water line.

[a] Reference areas.

Table 2-8

AQUATIC STUDIES
RATIONALE FOR SAMPLE MATRICES AND ANALYTICAL PARAMETERS

Analytical Parameter	Matrix	Rationale	Reference
Fluoride	Sediment, fish, and benthic invertebrates	Fluoride has been found at high levels in media on the FMC and Simplot facilities and may have been transported to American Falls Reservoir by the Portneuf River. Birds may be exposed by consumption of contaminated fish and invertebrates and/or by direct contact and ingestion of sediment and surface water. Exposure may cause loss of bone mass and adverse reproductive effects.	E & E 1993 Shupe *et al.* 1979 Hoffman *et al.* 1985
Cd, Zn, Se, Hg, As, Al, Fe	Sediment	Several target analyte list (TAL) metals (e.g., Cd, Hg, Se, Zn) are highly elevated in media on the FMC and Simplot facilities and may have been transported to American Falls Reservoir by the Portneuf River. Elevated metal levels in water and sediment may be toxic to aquatic organisms.	E & E 1993 Eisler 1985, 1993
Cd, Zn, Se, Hg, As	Fish and benthic invertebrates	High levels in benthic invertebrates and fish may be toxic to piscivorous birds, waterfowl, and wading birds that consume them. Mercury and selenium biomagnify in food chains in surface waters of the western United States.	Eisler 1985, 1993 Hallock and Hadlock 1993
Acid-volatile sulfide (AVS)	Sediment	A measure of the ability of sediment to bind toxic metals.	Allen *et al.* 1993
Simultaneously-extracted metals (SEM)	Sediment	A measure of the heavy metals bound with sulfide.	Allen *et al.* 1993
Total organic carbon (TOC)	Sediment	Used to determine organic matter content in sediment. Certain trace metals, such as mercury, are positively correlated with the organic matter content of sediment.	Häkanson and Jansson 1983 Rada *et al.* 1993

Table 2-8

AQUATIC STUDIES
RATIONALE FOR SAMPLE MATRICES AND ANALYTICAL PARAMETERS

Analytical Parameter	Matrix	Rationale	Reference
Particle-size distribution	Sediment	Used to determine clay, silt, and sand fractions. Finer grained sediments often have greater concentrations of trace metals.	Häkanson and Jansson 1983 Forstner and Whitmann 1979
Ammonia (Phase II)	Sediment	Ammonia could be present at toxic levels due to high pH and/or reducing conditions at the site.	Stumm and Morgan 1981
Toxicity to *Hyallela azteca* and *Chiroromus tentans*	Sediment	Sediment toxicity tests can provide direct evidence on the toxicity, or lack of toxicity, of contaminated sediments.	ASTM 1993

Table 2-9

TOTAL NUMBER OF INVESTIGATIVE SAMPLES FOR SEDIMENT, AND AQUATIC BIOTA

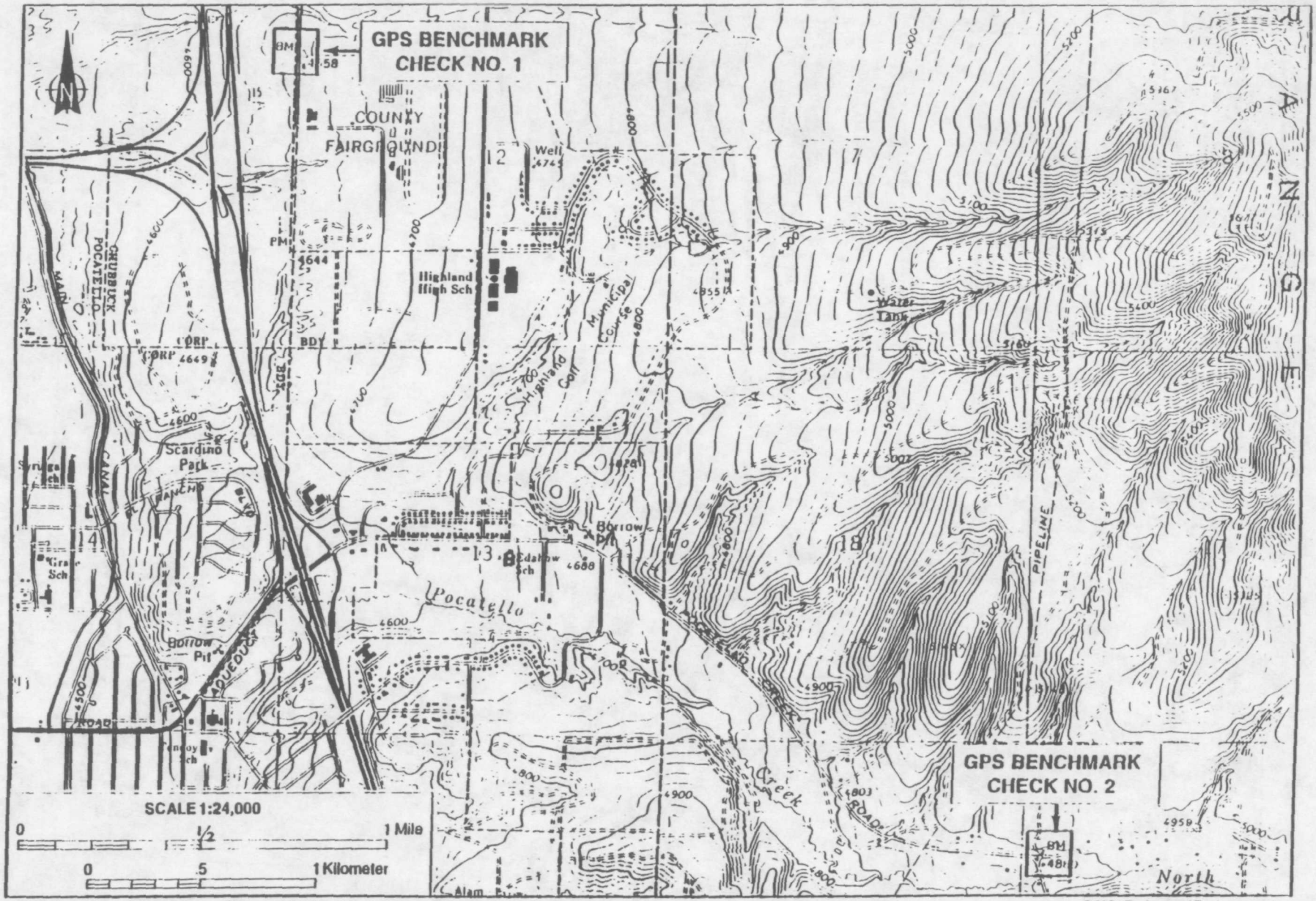
Sample Matrices	IWW Ditch Outfall	Portneuf River Delta		Snake River Delta		Other Portneuf River Locations	Total Number of Samples
		River Channel	Mudflats	River Channel	Mudflats		
Sediment - chemical analysis	1	10	10	10	10	2	43
Sediment - toxicity testing	1	3 (Phase II)	3 (Phase II)	3 (Phase II)	3 (Phase II)	2	15
Utah sucker (Phase II)	—	10	—	10	—	—	20
Midge larvae (Phase II)	—	10	—	10	—	—	20
Total Number of Samples	2	33	13	33	13	4	98

Table 2-10

TOTAL NUMBER OF INVESTIGATIVE ANALYSES FOR SEDIMENT, AND BIOTA

Parameter	IWW	Portneuf River			Snake River			Other Portneuf River Locations	Total Number of Analyses
	Sediment	Sediment	Utah Sucker	Midge Larvae	Sediment	Utah Sucker	Midge Larvae		
Mercury and selenium[a]	1	—	—	—	—	—	—	5	5
Fluoride	1	20	10	10	20	10	10	2	83
Se, Hg, Cd, Zn, As, Fe, Al	1	20	—	—	20	—	—	2	43
Se, Hg, Cd, Zn, As	—	—	10	10	—	10	10	—	40
Ammonia (Phase II)	1	3	—	—	3	—	—	2	9
Acid-volatile sulfide (AVS) and Simultaneously-extracted metals (SEM)	1	20	—	—	20	—	—	2	43
Total organic carbon (TOC)	1	20	—	—	20	—	—	2	43
Particle-size distribution	1	20	—	—	20	—	—	2	43
Toxicity to *Hyallela Azteca* and Chironomus tentans	1	6	—	—	6	—	—	2	15

a Samples collected using ultra-clean protocols and analyzed after Bloom (1990) for mercury and Liang (1994) for selenium.
b Using USEPA CLP methods for collection and analysis.



SOURCE: USGS 7.5 Minute Series (Topographic) Quadrangle: Pocatello North, ID 1971

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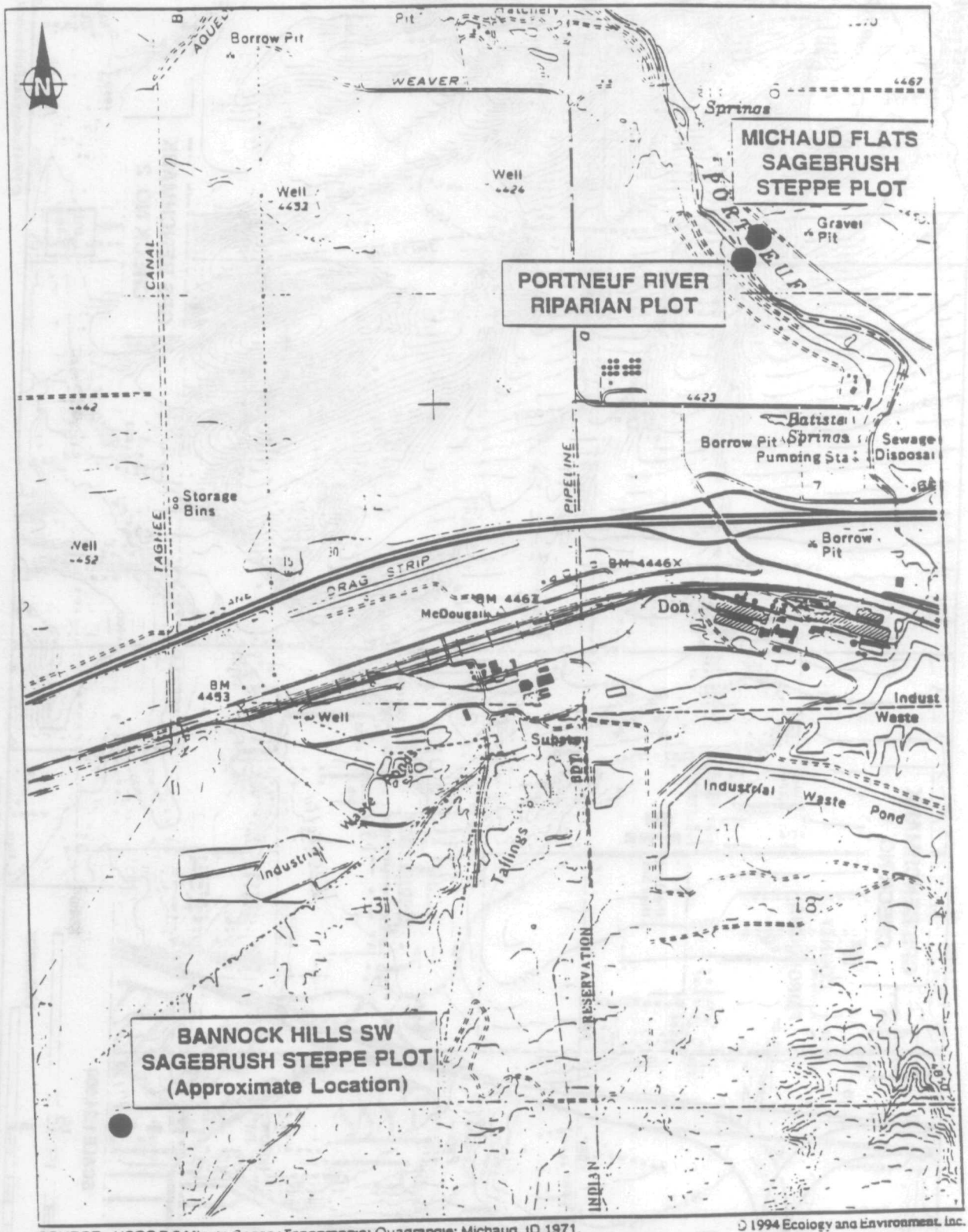
Figure 2-1 GPS BENCHMARK CHECK POINTS



SOURCE: USGS 7.5 Minute Series (Topographic) Quadrangle: Michaud, ID 1971. Photoinspected 1974.

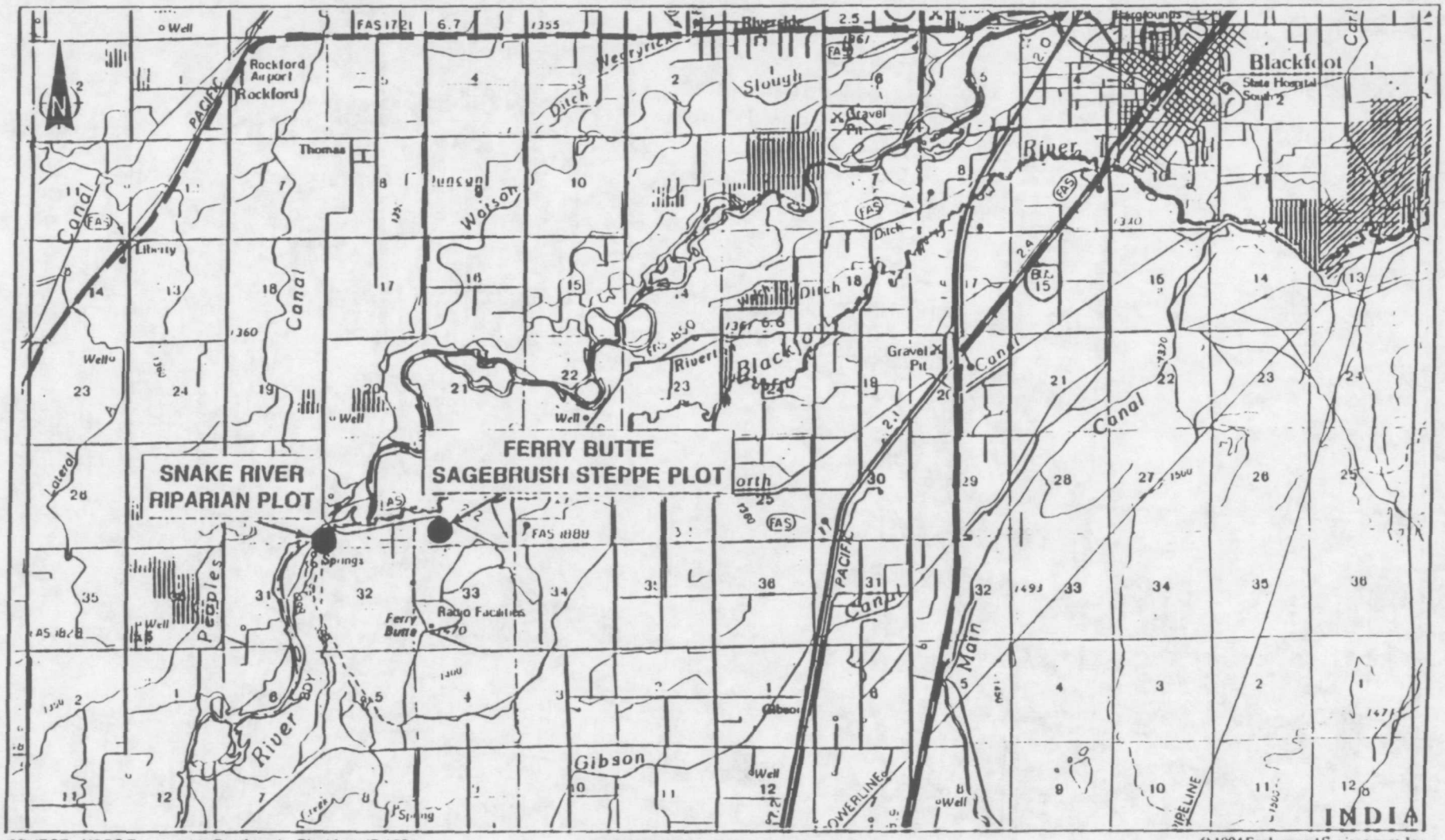
© 1994 Ecology and Environment, Inc.

SCALE 1:24,000

0 ½ 1 Mile

0 .5 1 Kilometer

Figure 2-2 IMPACT TERRESTRIAL SAMPLING POINTS



SOURCE: USGS Topographic Quadrangle: Blackfoot, ID 1991

SCALE 1:100,000

0 1 2 3 4 Miles

0 1 2 3 4 Kilometers

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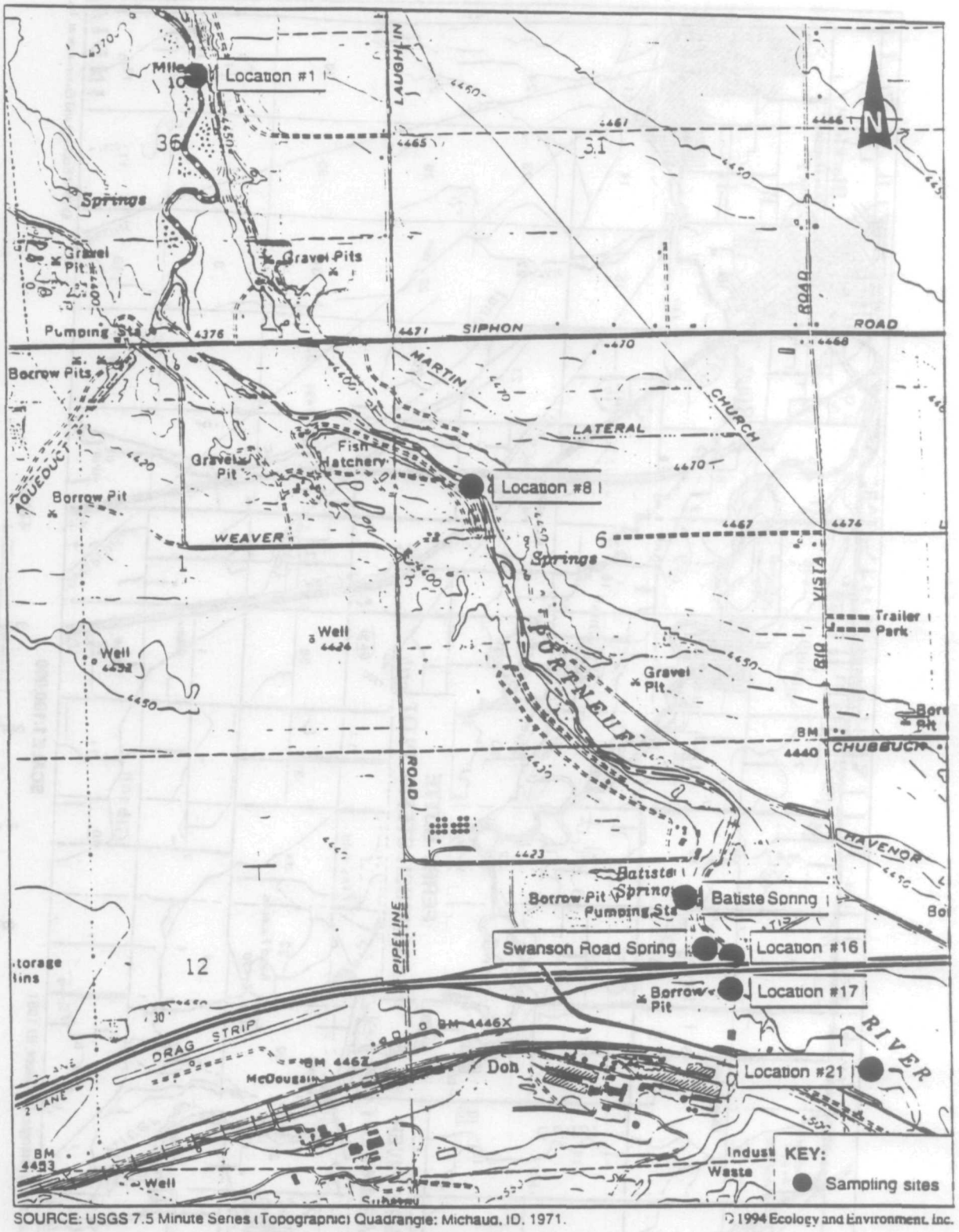
Figure 2-3 TERRESTRIAL SAMPLING REFERENCE PLOTS



SOURCE: USGS 7.5 Minute Series (Topographic) Quadrangle: Michaud, ID. 1971.

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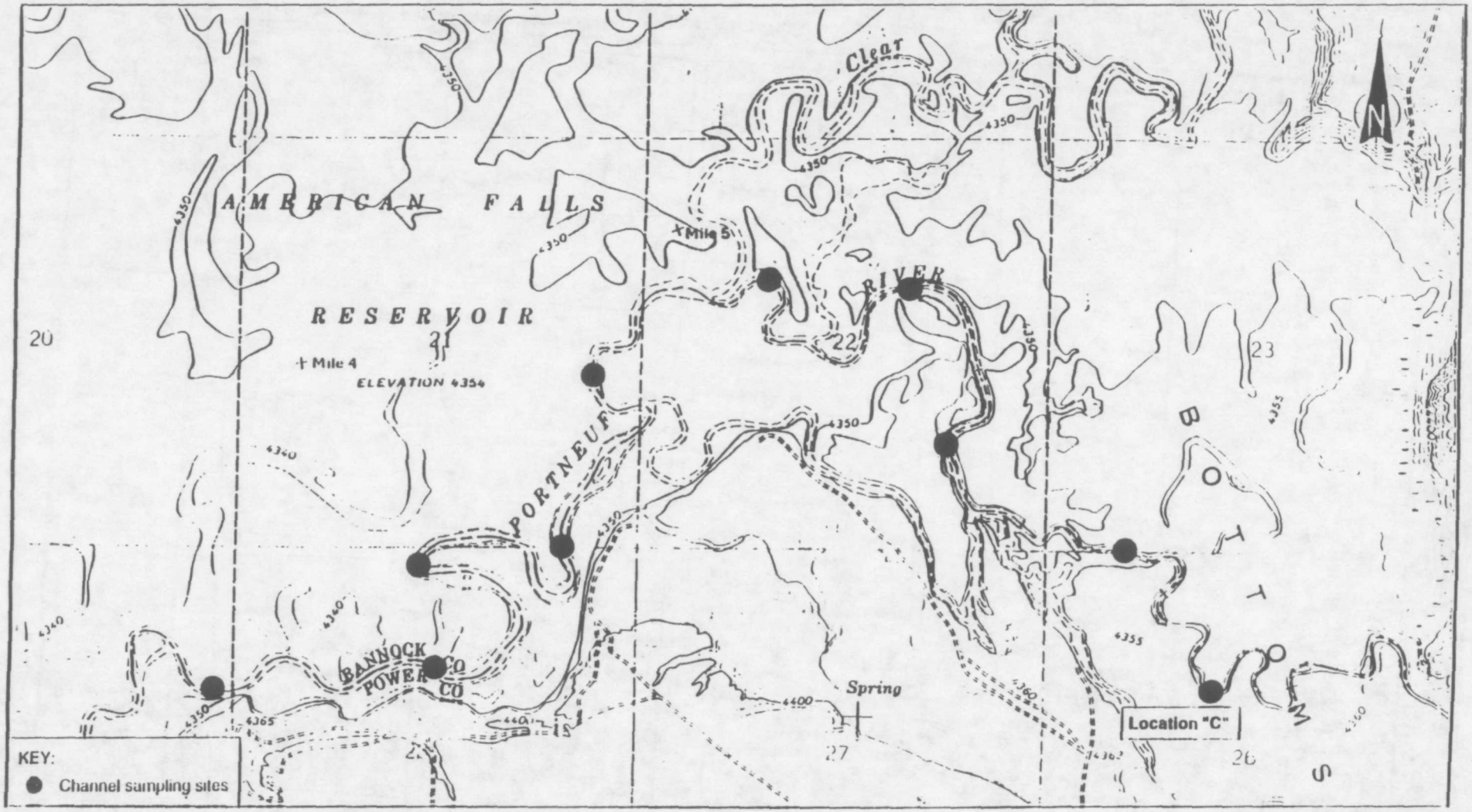
SCALE 1:24,000

0 ½ 1 Mile

0 .5 1 Kilometer

Figure 2-4 PORTNEUF RIVER SAMPLING SITES



SOURCE: USGS 7 5 Minute Series (Topographic) Quadrangle: Michaud, ID 1971.

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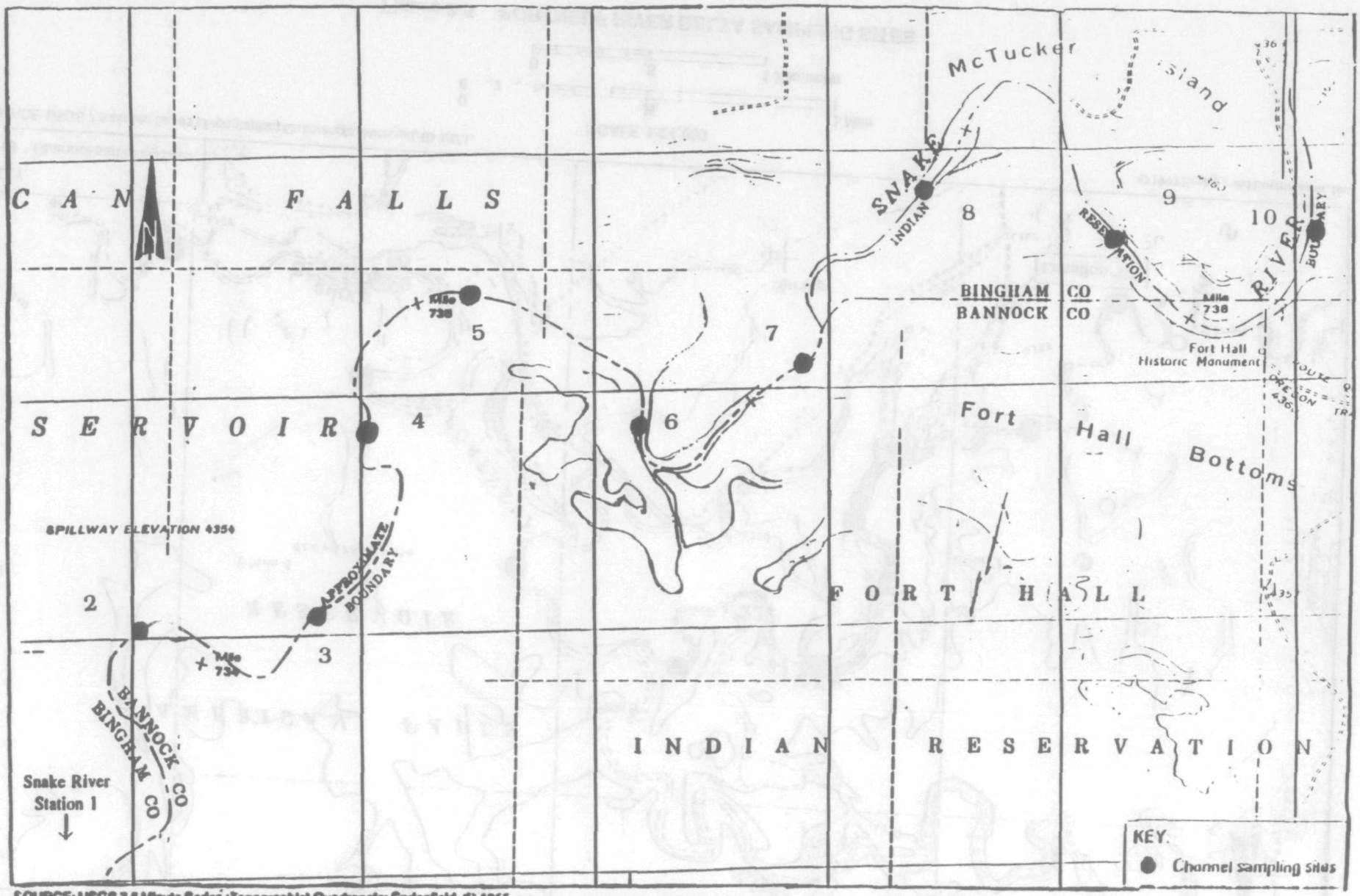
SCALE 1:24,000

0 ½ 1 Mile

0 .5 1 Kilometer

Figure 2-5 PORTNEUF RIVER DELTA SAMPLING SITES



SOURCE: USGS 7.5 Minute Series (Topographic) Quadrangle: Springfield, ID 1955

SCALE 1:24 000

1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

Figure 2-6 SNAKE RIVER DELTA SAMPLING SITES

3. ANALYTICAL AND TOXICITY TEST METHODS

This section provides a summary of the analytical methods for the ecological assessment. Further detailed information on analytical procedures is provided in the QAPjP.

3.1 TERRESTRIAL STUDIES

3.1.1 Analytical Methods

Analyses of soil, vegetation, and deer mice for COPCs will be performed by a subcontract laboratory. The laboratory will use analytical methods as described in the QAPjP Section 5.0. A summary of the methods and the QA objectives for soil, vegetation, and deer mice is provided in Table 3-1, which lists the analytes for each matrix and the suggested analytical method, requested quantitation limit, accuracy,and total precision.

The mineralogical analyses will be performed on fractionated samples of ore, taken from the ore pile, and of soil from the Michaud Flats sagebrush steppe sample site. The analyses will utilize standard laboratory methods for x-ray fluorometry, x-ray diffractometry, and electron microprobe analysis. More detailed methods will be provided.

3.1.2 Quality Control Samples

In addition to the investigative analyses, laboratory QA/QC analyses and field duplicate analyses are required for soil. Laboratory QA/QC samples for matrix spiking and field duplicate samples will be collected at a rate of one per week per parameter, or one per 10 investigative samples, whichever is greater. Field blanks and duplicates will not be collected for terrestrial biota. One equipment blank per day will be collected for soil sampling equipment such as the trowel or shovel.

3.2 AQUATIC STUDIES

3.2.1 Analytical and Toxicity Test Methods

For the aquatic studies, a summary of the methods and QA objectives is provided in Table 3-2, which lists the analytes for each matrix and the suggested analytical method, requested quantitation limit, accuracy, and total precision. Sediment from the Portneuf and Snake River deltas will be analyzed for F, Cd, Hg, Se, and As, Zn, Al, and Fe, in accordance with EPA's Contract Laboratory Program (CLP) routine analytical services (RAS) program. Table 3-3 lists the contract required detection limits for laboratories analyzing TAL metals in sediment in this program.

Toxicity bioassays on sediment samples will follow American Society for Testing and Materials (ASTM) guidance (1993) using an amphipod *(Hyallela azteca)* and a larval dipteran (*Chironomus tenans*).

3.2.2 Quality Control Samples

In addition to the investigative analyses, laboratory QA/QC analyses and field duplicate analyses are required for sediment. Laboratory QA/QC samples for matrix spiking and field duplicate samples will be collected at a rate of one per 10 investigative samples, whichever is greater. Field blanks and duplicates will not be collected for aquatic biota. One equipment blank per day will be collected for sediment sampling equipment such as the Ekman dredge.

Table 3-1

TERRESTRIAL STUDIES
QUALITY ASSURANCE OBJECTIVES

Parameter	Method[a]	Matrix	Requested Quantitation Limit[b]	Accuracy	Total Precision
Fluoride	ASA 26-4.3.4 for digestion and distillation and EPA 340.2 for analysis	Soil	10 µg/g	75 - 125%	±35%
Cadmium	EPA SW846-3050A for digestion and EPA SW846-7131 for analysis	Soil	0.1 µg/g	75 - 125%	±35%
Zinc	EPA SW846-3050A for digestion and EPA SW846-7951 for analysis	Soil	1.0 µg/g	75 - 125%	±35%
Soluble cations (Ca, Mg, Na, K)	Cold-water extraction and EPA SW846-6010A for analysis	Soil	1.0 µg/g	75 - 125%	±35%
pH	ASA 12-2.6	Soil	± 0.1	75 - 125%	±35%
Total organic carbon	EPA SW846-9060	Soil	0.1%	75 - 125%	±35%
Cation exchange capacity	EPA SW846-9081	Soil	0.5 mg/100g	75 - 125%	±35%
Fluoride[c]	ASA 26-4.3.4 for digestion and distillation and EPA 340.2 for analysis	Vegetation	10 µg/g	75 - 125%	±35%
Cadmium	AOAC 986.15	Vegetation	0.005 µg/g	75 - 125%	±35%
Zinc	AOAC 986.15	Vegetation	1 µg/g	75 - 125%	±35%
Fluoride[c]	ASA 26-4.3.4 and digestion and distillation and EPA 340.2 for analysis	Small mammals	1 µg/g	75 - 125%	±35%

Table 3-1

TERRESTRIAL STUDIES
QUALITY ASSURANCE OBJECTIVES

Parameter	Method[a]	Matrix	Requested Quantitation Limit[b]	Accuracy	Total Precision
Cadmium	AOAC 986.15	Small mammals	0.005 µg/g	75 - 125%	±35%
Zinc	AOAC 986.15	Small mammals	1 µg/g	75 - 125%	±35%

[a] Methods: ASA methods are from ASA (1982); AOAC methods are from AOAC (1990); EPA SW methods are from EPA (1986); and other EPA methods are from EPA (1983).
[b] The requested quantitation limits were set below the known or suspected analyte concentrations in the matrices being analyzed and are within the capabilities of the listed methods.
[c] Methods to be verified.

Key:

Ca = Calcium.
Mg = Magnesium.
Na = Sodium.
K = Potassium.

Table 3-2

AQUATIC STUDIES
QUALITY ASSURANCE OBJECTIVES

Parameter	Method[a]	Matrix	Requested Quantitation Limit[b]	Accuracy	Total Precision
Total organic carbon (TOC)	EPA SW846-9060	Sediment	1% DW	75% - 125%	±35%
Particle size distribution	ASTM D 422-63	Sediment	NA	NA	NA
AVS/SEM[c]	Draft EPA Method	Sediment	0.01 µmoles/g	75% - 125%	±35%
Cd, Zn, Hg, Se, As, Al, Fe	EPA SW846-3050A for digestion and GFAA or ICP for analysis	Sediment	See Table 3-3	75% - 125%	±35%
Fluoride[g]	ASA 26-4.3.4 for digestion and distillation and EPA 340.2 for analysis	Sediment	10 µg/g	75% - 125%	±35%
Arsenic	EPA Method 7060. Graphite Furnace Technique	Biota	1 µg/g	75% - 125%	±35%
Ammonia	EPA 350.2 with modification	Sediment	0.1 mg N/L	75 - 125%	±35%
Toxicity	ASTM E 1383-93[d]	Sediment	NA	NA	NA
Cadmium (Phase II)	AOAC 986.15	Aquatic biota	0.01 µg/g	75% - 125%	±35%
Mercury (Phase II)	AOAC 971.21	Fish	0.1 µg/g	75% - 125%	±35%
Mercury (Phase II)	Watras and Bloom (1992)	Benthic Organisms	0.005 µg/g	75 - 125%	±35%
Selenium (Phase II)	AOAC 986.15	Aquatic biota	0.5 µg/g	75% - 125%	±35%

Table 3-2

AQUATIC STUDIES
QUALITY ASSURANCE OBJECTIVES

Parameter	Method[a]	Matrix	Requested Quantitation Limit[b]	Accuracy	Total Precision
Zinc (Phase II)	AOAC 986.15	Aquatic biota	5 µg/g	75% - 125%	±35%
Fluoride[g] (Phase II)	ASA 26-4.3.4 for digestion and distillation and EPA 340.2 for analysis	Aquatic biota	10 µg/g	75% - 125%	±35%

a Methods: ASTM methods are from ASTM (1990) or ASTM (1993); AOAC methods are from AOAC (1990); EPA SW methods are from USEPA (1986); and other EPA methods are from USEPA (1983).

b The requested quantitation limits were set below the known or suspected analyte concentrations in the matrices being analyzed and are within the capabilities of the listed methods.

c AVS/SEM = Acid volatile sulfide and simultaneously extracted metals.

d 10-day test with the midge *Chironomus tentans* and 28-day test with the amphipod *Hyalella azteca*.

e The laboratory should use the analysis method (ICP or GFAA) that will achieve the requested quantitation limits for water listed in Table 3-3; EPA 200.7 for ICP or EPA 200 series for GFAA.

f The laboratory should use the analysis method (ICP or GFAA) that will achieve the requested quantitation limits for sediment listed in Table 3-3; EPA SW846-7000 series for GFAA or EPA SW846-6010A for ICP. Mercury should be measured using the cold vapor method.

g To be verified.

Key:

GFAA = Graphite furnace atomic absorption
ICP = Inductively coupled plasma.
NA = Not applicable.
DW = Dry weight.

Table 3-3

REQUESTED QUANTITATION LIMITS (RQL) FOR TARGET ANALYTE LIST (TAL) METALS IN SEDIMENT

Analyte	Sediment RQL(µg/g)	Water RQL (µg/L)
Aluminum	20	20
Arsenic	1	3
Cadmium	0.5	2
Iron	10	20
Mercury	0.1	NA[a]
Selenium	0.5	NA[a]
Zinc	2	5

[a] NA = Not applicable, measured separately in water.

4. FIELD METHODS AND PROCEDURES

This section of the Field Sampling Plan describes the methods for field collection of terrestrial and aquatic samples. Terrestrial investigations are described in Section 4.1, and aquatic investigations are described in Section 4.2.

4.1 TERRESTRIAL STUDIES

Five study plots will be established for sagebrush steppe and riparian habitat investigations. Locations of each field plot will be plotted on topographic maps and recorded in field logbooks. The locations will be marked in the field with permanent markers or through photos and field notes recording the position relative to permanent identifying physical features. In addition, plot locations will be verified using a global positioning system (GPS) calibrated to known benchmarks near the EMF site (see Figure 2-1).

Each sagebrush steppe habitat sample site will consist of a permanently marked 100 m x 100 m (1-hectare) sample plot. The plot will be subdivided into 25 subplots (each 20 m X 20 m) from which 10 sampling subplots (20 subplots for sagebrush foliage) will be randomly selected for soil and vegetation composite sampling. Traps for deer mice will be dispersed at suitable habitat locations throughout the plot. Figure 4-1 shows an idealized subplot map for sampling within each sagebrush steppe habitat location. Actual sampling will be adjusted to match field plot characteristics and to ensure collection of representative samples. If a subplot is deemed unsuitable for any reason, such as a lack of target vegetation, an alternative subplot will be randomly selected to provide the necessary subplots for sampling. Sketches or maps of the plot layout showing prominent features, subplot locations, and mouse trap locations will be completed during field sampling. Soil, vegetation, and small mammal samples will be collected for analysis as described in Section 2 and below.

Within the riparian habitat locations, a transect 500 m in length parallel to the river along both sides of the river banks will be established. Each transect will be divided into 50 m sectors for a total of 20 subplots that could potentially be sampled. An idealized randomized subplot location chart will be used to pick 10 subplots for vegetation and soil sampling (Figure 4-2). A subplot will be sampled if it has greater than two Russian olive trees within 10 m of the river bank. If a chosen subplot is deemed to have insufficient vegetation, an adjacent subplot will be identified for sampling.

4.1.1 Soil Sampling

Surface samples of soil will be collected from a depth of zero to 2 inches from at least two locations within each subplot using stainless steel garden trowels or shovels. The sampling locations should coincide with the sampled vegetation. The soil samples should be taken within 1 meter outside of the plant canopy. Soil samples taken from each subplot will be composited. Composited soil samples of approximately 16 ounces will be collected. Each sample will be transferred into a precleaned glass jar and packaged for shipment to the laboratory. The sampling trowel or shovel will be cleaned prior to sample collection in accordance with the procedures described in Section 5. All sample locations will be noted in the appropriate log book and sample location map. Sample custody procedures will be followed as described in the QAPjP. Duplicates, matrix spike, and rinsate blanks will be collected as described in Section 3.

Each of the 10 subplot composited soil samples for each habitat location will be analyzed separately for COPCs. Initially, one soil sample from Michaud Flats will have mineralogical analyses performed to determine the feasibility of the technique by establishing the adequacy of the method for assessing the mineral forms of COPCs at the remaining locations.

4.1.2 Vegetation Sampling

Vegetation sampling will be conducted before the first killing frost. The following guidelines will be used for selecting the specific plants to be sampled. The judgement of the field investigators will determine specimens which have morphology and other characteristics representative of each site.

4.1.2.1 Big Sagebrush

A composite sample of the current year's growth of sagebrush vegetation will be collected from at least two of the sagebrush plants on each of the 10 subplots. Up to five individual plants in each subplot will be sampled. The sagebrush plants will be a random sample of all shrubs in the subplot. Vegetative growth from big sagebrush will be plucked by hand. Samplers will wear latex gloves to prevent sample contamination. Inflorescences will be excluded from the sample. A voucher collection will be made from a shrub at each plot and pressed to confirm taxonomy of the samples.

Sampled vegetation within the subplot will be composited in a plastic Ziploc bag, labeled, and stored in a chilled ice chest for transport to the laboratory.

4.1.2.2 Western Wheatgrass

Similar to the sampling of sagebrush, composited samples of the current year's growth of western wheatgrass foliage will be collected from each subplot. Each composited sample should represent a total of at least five plants. Grass foliage samples should be excised at least 1 inch above the soil line, optimally 3-to-4 inches, and soil contamination of foliage should be avoided. Grass samples will be placed in plastic Ziploc bags, labeled, and stored in a chilled ice chest for transport to the laboratory. To confirm grass taxonomy, a voucher specimen will be collected at each sample plot.

4.1.2.3 Russian Olive

At least 50 fruits, determined by field investigators to be well developed and characteristic of the current year's crop, will be collected from trees (at least 2 m tall and 3 cm in diameter at ground level) within each 50 m transect and within 10 m of the river. At least two trees should be sampled within each subplot. Up to five trees will be sampled from each subplot. The fruits will be placed in a plastic Ziploc bag, labeled, and stored on ice for shipment to the laboratory.

4.1.3 Small Mammal Sampling

Adult deer mice will be snap-trapped using standard procedures (Weston 1991). Consecutively numbered traps will be dispersed at suitable habitat locations throughout each of the three 1-hectare sagebrush habitat sample plots. An idealized rectangular trapping grid is shown in Figure 4-1. Trap lines, approximately 100 to 150 traps per plot, will be placed in a square

trapping grid at approximately 10-m spacings. Trap sites may be adjusted slightly to ensure placement in preferred habitat, namely, areas with low shrubs or a thin-to-moderate layer of leaf litter. Trapping will occur before vegetation and soil sampling to avoid excessive disturbance that could reduce trap success. Traps will be baited with standard oat/peanut butter baits and set at dusk. Traps will be checked each morning, and reset each evening until adequate numbers of specimens are obtained. Small mammals will not be trapped during daylight hours.

Mice will be removed from traps, and the trap number will be identified. Deer mice kept for analysis will be sexed, weighed, and measured. Any specimens which are not intact will be discarded. Mice smaller than approximately 15 grams will not be kept, as these are likely to be juveniles. Adult mice still living will be sacrificed by cervical dislocation, with adherence to procedures for protection against hantavirus (see below). Individual specimens will then be placed in a plastic Ziploc bag, labeled, stored in a cold ice chest (4°C), and shipped to the analytical laboratory. The precise location where mice are captured will be noted on sample plot diagrams. Identification of deer mice will be performed by a qualified biologist and representative photographs taken of some mice to confirm taxonomy.

Mouse traps will be decontaminated as described in Section 5.

Sampling Precautions

Hantavirus has been reported in Idaho from neighboring Bingham and Franklin counties. Precautions to protect staff from infection with hantavirus or other rodent-borne diseases will be taken. Complete procedures are specified in the Health and Safety Plan.

4.2 AQUATIC STUDIES

4.2.1 Sediment Sampling

4.2.1.1 IWW Ditch Outfall

The following procedures will be applied to sediment collected from the Portneuf River near the IWW ditch outfall. Sediment samples will be collected using a Ponar or Ekman dredge or a decontaminated stainless steel shovel. At each of the sampling locations, three to five samples will be collected on a transect across the river and homogenized in a stainless steel or plastic container. A stainless steel spoon will be used to transfer the homogenized sediment to a sample jar. Sediment samples will consist of finer material; large stones, pebbles, and rocks will not be sent to the laboratory. Sediment samples will be labeled noting the sampling location,

depth, time, and sampler's initials. Sediment samples for toxicity testing will be handled and stored following ASTM (1993) guidelines, and samples for chemical analyses will be handled according to EPA Contract Laboratory Program (CLP) specifications as described in Bechtel (1992). A rinsate and field blank will be prepared as described in Section 3.

4.2.1.2 Portneuf River Delta

In Phase I, sediment samples will be collected from 10 sites in the Portneuf River delta (see Figure 2-5) and 10 sites in the Snake River delta (see Figure 2-6). At each site, sediment will be collected from both the river channel and adjacent mudflats.

Bulk sediment from the river channel will be collected with an Ekman dredge. After the dredge has been retrieved from depth, the top of the dredge will be opened and separate subsamples of sediment will be collected for analysis of fluoride, cadmiun, zinc, selenium, mercury, arsenic, aluminum, iron, and sediment parameters that play a role in trace-metal speciation in sediment (see Table 4-2). Other pertinent details are listed in Table 4-2. If the Ekman dredge cannot penetrate the channel sediments, a heavier Ponar dredge will be used. If a Ponar dredge is used, the collected sediment will be emptied into a plastic bowl or dishpan from which samples will be removed for the various analyses. Bulk sediment from mudflats adjacent to the river channel will be collected from level areas (not the river banks) using a stainless-steel spoon or spade or directly in sample jars by using the jar as a scoop.

If Phase II is triggered, a second round of sediment collections will be obtained from three previously sampled sites in each delta; sediment will be taken from both the river channel and adjacent mudflats for use in toxicity tests with the midge *Chironomus tentans* and the amphipod *Hyullela azteca* (ASTM 1993a). The sites these samples are collected from will be the first, fifth, and tenth site as one proceeds from upstream to downstream in the deltas (see Figures 2-5 and 2-6). Subsamples of sediment for toxicity testing will be handled according to ASTM (1993) specifications and shipped overnight to the contract laboratory conducting the tests. Ammonia will be analyzed during this phase of the investigation.

4.2.2 Benthic Invertebrate Sampling

During Phase I of the Delta Study, midge larvae (the target benthic invertebrate), or amphipods (the alternate invertebrate) will be collected from 10 sites in the Portneuf River delta

(see Figure 2-5) and 10 sites in the Snake River delta (see Figure 2-6). At each site, the invertebrates will be collected from the habitat type (river channel, or adjacent mudflats) where they are observed to be most abundant. The benthic invertebrates will be collected as close as possible to the sites where sediment is collected for chemical analysis and toxicity testing.

Bulk sediment will be collected using one of the methods described in Section 4.2.2.2 and passed through a coarse screen to separate the midge larvae from the sediment. If amphipods are collected instead of midges because they are more abundant, a kick net may also be used during sampling. These sampling methods are described by Merritt and Cummings (1978). The target organisms will be picked from the screen or kick net with forceps and composited in 5-mL acid-cleaned teflon vials.

To accommodate the different analyses being conducted (Cd, Zn, and Se by GFAAS; Hg by CVAFS; F by digestion, distillation, and ion-sensitive electrode), three 5-mL vials will be required per site. The vials need *not* be filled to capacity; composite samples of approximately 2 g fresh weight will be sufficient for the analyses. A 2-g composite sample will occupy a volume of ~2 mL or two-fifths of the vial's capacity. After collection, the vials will be tightly sealed and placed in a cooler with ice for overnight shipment to the laboratory conducting the analyses where it will be stored for Phase II analyses, if necessary. The laboratory conducting the analyses should remove any sediment particles included with the invertebrate samples, and then freeze the samples for later analyses if necessary.

Lastly, voucher specimens will be collected and preserved with alcohol and later identified to the lowest taxonomic level practical.

4.2.3 Fish Sampling

Ten Utah suckers (the target species) or 10 Utah chubs (the alternate species) will be collected from where they are available in the 10-km length of channel in both the Portneuf and Snake River deltas (see Figures 2-5 and 2-6). Prior to collection, all appropriate state and tribal permits will be obtained.

Fish samples will be collected by experienced aquatic biologists using a variety of collection techniques, including electrofishing, gill netting, and seining. The sample areas will be inspected to identify the various types of habitat present and to determine the type of sampling gear most applicable. The following steps will occur at each sampling location:

- The field crew will locate by visual inspection the best site for sampling and the type of gear to be used.

- Before sampling, logbook entries will be made which will include: sampling location; site sketch; area description; field crew members; date; time; weather conditions; and water characteristics. The locations from which fish are collected will be marked with a portable GPS unit, or triangulated with a range finder, and noted in relationship to prominent landmarks.

- The sampling technique used at each location will be determined in the field by the sampling team.

Gill nets made of monofilament line will be 100 feet long, 6 feet high, and of 3, 2, 1, and ½-inch mesh size. The nets will be bottom set, and held vertically in the water by weighted and floating line. The nets will be anchored to the bottom on each end and will be prominently marked on the surface with high visibility buoys. All nets will have identification tags attached to them. Multiple gill nets may be employed at each location. The gill nets may be fished both during the day and night. Fish will be collected from nets in the morning and afternoon.

Electrofishing equipment will include a boat equipped with a portable heavy-duty generator, a control section consisting of a commercially-sold variable voltage pulsator, and two electrodes (anode and cathode). The electrical control section will permit AC output between 50 to 700 volts and DC output between 25 to 350 volts. An individual operating the electroshocker and another individual netting the fish will collect fish, as a third individual operates the boat. The electroshocker set-up may also be operated from shore when fishing in shallow waters, where a boat would prove impractical.

Where practical, a large beach seine will be pulled through shallow areas. The ends of the seine will be pulled up on shore, and captured fish will be confined in the center of the net and collected.

Upon collection of fish, the following steps will occur:

- All nontarget fish species, or target species identified by size as being too small for analysis will be identified by species, counted, and released alive, if possible. Excess target fish species will also be released. Any unwanted dead fish will be disposed.

- Target species selected for analysis will be placed on ice and delivered to shore. Fish of various sizes will be kept, depending on availability a

range of fish sizes will be obtained. Processing will consist of an external examination to note abnormalities such as sores and tumors, weighing to the nearest gram, and measuring of total length to the nearest millimeter.

- In the field, each fish of the target species will have scales removed for age determination. A clean knife will be used to rub off scales in a front to back motion to prevent damage to the fish. Scales will be taken from the left side of the fish, posterior to the dorsal fin and mid-way between the lateral line and the top of the fish. A minimum of 10 scales will be obtained and placed into a scale envelope which will have the sample identification number, species, and date of collection placed on it. After field operations have ended, a determination of fish age will be made using the scales collected in the field.

- Target fish for chemical analysis will be washed in river or reservoir water to remove loosely adherent external contamination. Fish will then be individually wrapped in two layers of aluminum foil and sealed in a plastic bag. A waterproof tag will be placed inside the bag and a sample label placed on the outside. Tags and labels will contain sample number, date, weight and length.

- Once fish are processed, they will be kept on ice until frozen in a secure freezer on site. Fish will be frozen on the day of collection, as soon as possible upon return of the field crew from morning or evening collection periods. A freezer log will be kept and all fish samples will remain frozen until they are shipped to the analytical laboratory.

- Further processing of collected fish (i.e., preparation of whole body samples) will take place at the contract laboratory conducting chemical analysis for the Phase II studies if necessary.

Table 4-1

SEDIMENT COLLECTION AND SAMPLE-HANDLING PROCEDURES

Parameter	Sample Jar Volume	Container Material	Cleaning Procedure	Sample Preservation	Packing and Shipping	Holding Time (Analytical/ Contract)
Acid-volatile sulfide (AVS) and Simultaneously extracted metals (SEM)	250 mL	Glass	Soak 24 hours in 5% HNO3, rinse 5 times with distilled H20	Fill to capacitya. Cool to 4°C.	Low hazard procedures	ASAP
Particle size analysis	250 mL	Glass	Distilled water wash and rinse	Fill to capacity. Cool to 4°C.	Low hazard procedures	28 days/25 days
Total organic carbon (TOC)	250 mL	Glass	Distilled water wash and rinse	Cool to 4°C.	Low hazard procedures	28 days/25 days
Fe, Al, Cd, Zn, F, Hg, Se, As	250 mL	Glass	According to USEPA CLP specifications	Cool to 4°C	Low hazard procedures	TAL: 6 months/35 days Hg: 28 days/26 days
Ammonia (Phase II)	250 mL	Glass		Cool to 4°C.	Low hazard procedures	28 days/25 days

a To prevent loss of sulfide by degassing and oxidation of reduced iron monosulfides, sample jars will be filled to capacity so no head space remains and tightly sealed.

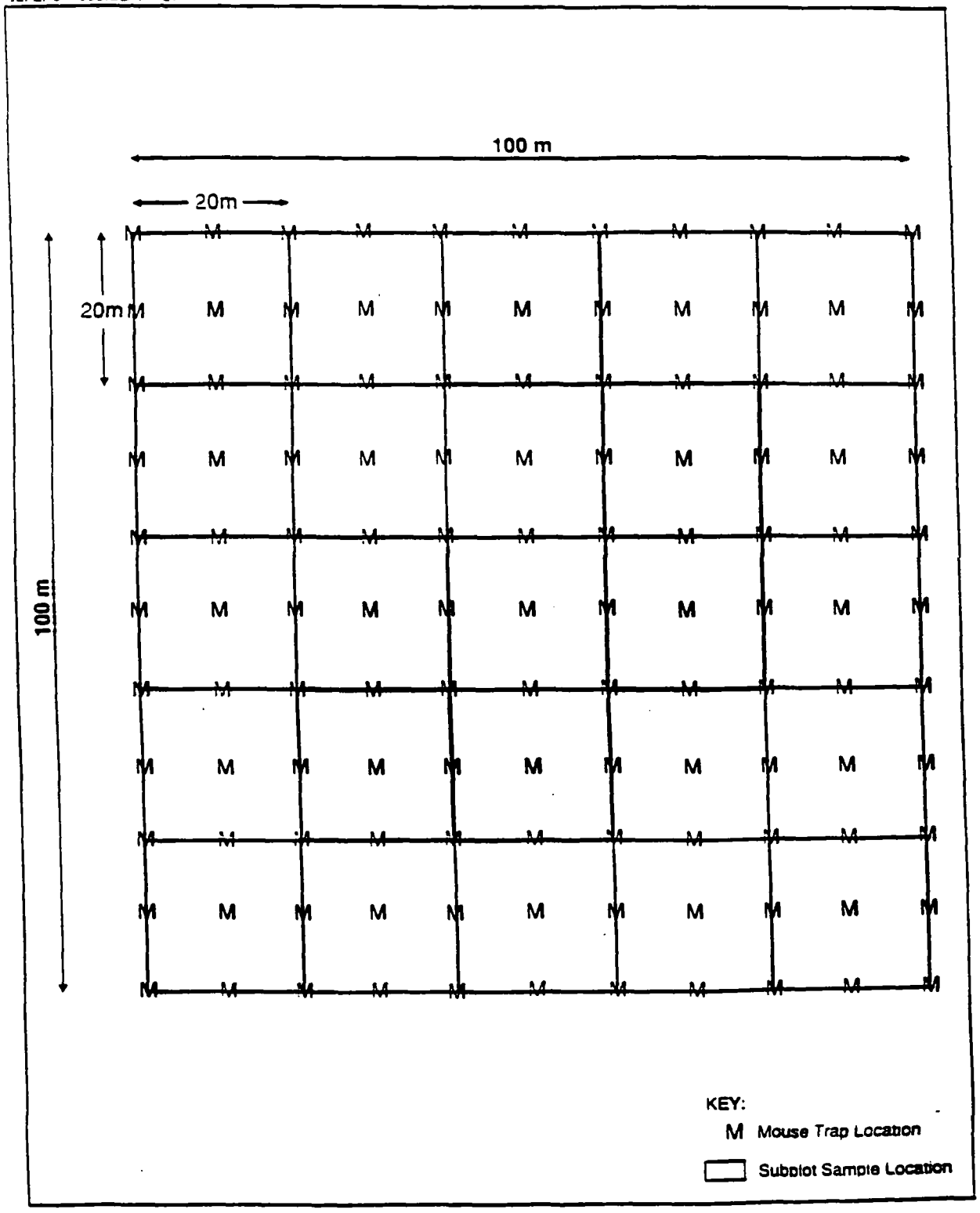


Figure 4-1 IDEALIZED SAGEBRUSH STEPPE SAMPLE PLOT

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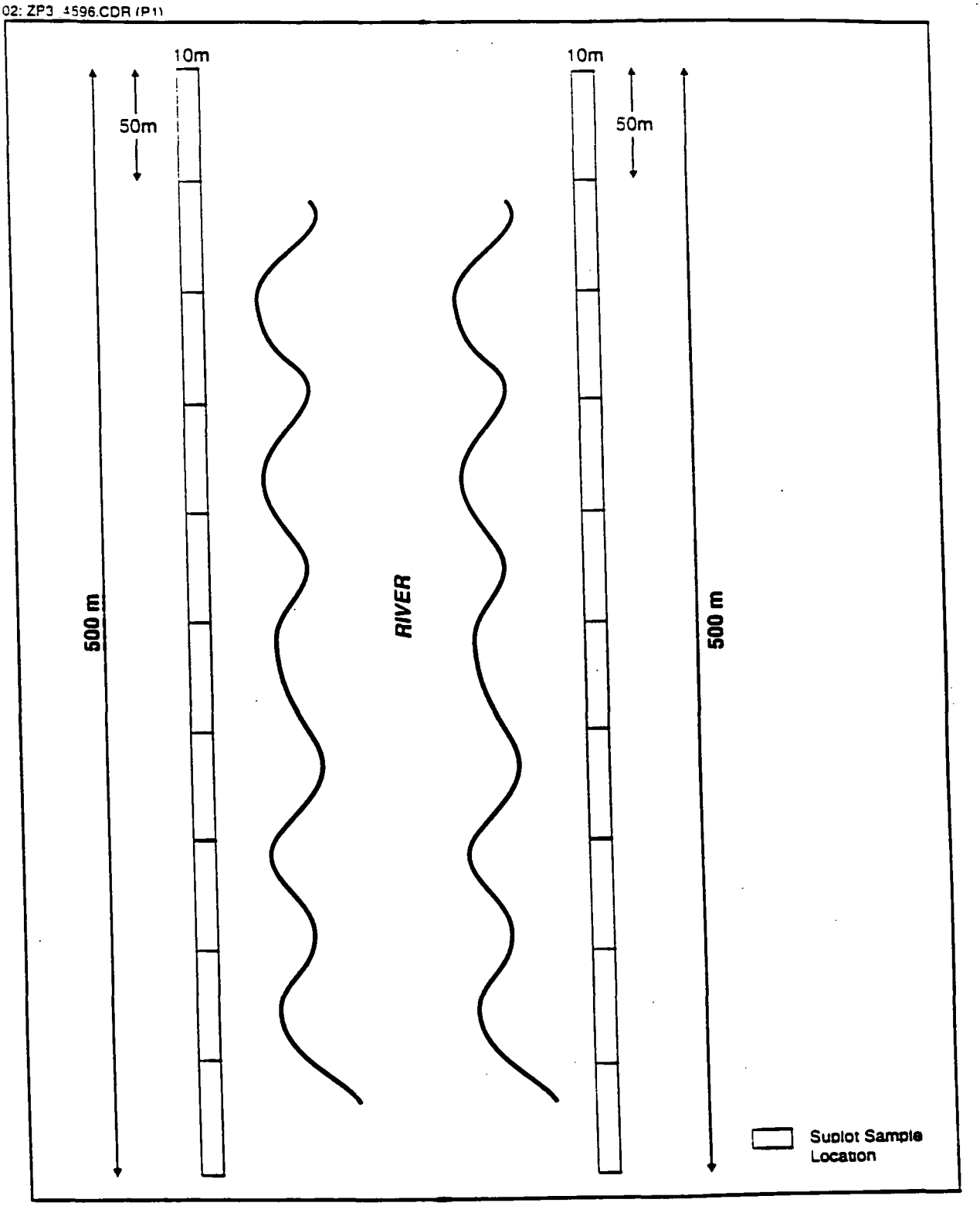

Figure 4-2 IDEALIZED RIPARIAN HABITAT SAMPLE PLOT

5. DISPOSAL OF INVESTIGATION-DERIVED WASTE AND EQUIPMENT DECONTAMINATION

5.1 DISPOSAL OF INVESTIGATION-DERIVED WASTE

Waste soil and sediment will be disposed of in accordance with federal and state regulations as part of the routine waste handling procedures at the site.

5.2 EQUIPMENT DECONTAMINATION

The protocol for decontamination of sampling tools and equipment used during the field activities is described below. The sampling equipment to be cleaned by this procedure are:

- Soil trowel and shovel;
- Knives, shears, or scissors for vegetation sampling;
- Mouse traps;
- Sediment grab sampler (stainless steel spoon, spade, or Ekman dredge); and
- Stainless steel mixing bowl for sediment.

Protocol

Sampling equipment will be cleaned using the following rinse procedures prior to entering the sampling area and before leaving the sampling area. The cleaning procedure is as follows:

- Rinse with tap water,
- Scrub with nonphosphate detergent in tap water,
- Rinse twice with tap water and then deionized water,

- Rinse with fresh, dilute (10%, V:V) nitric acid, and
- Rinse twice with deionized water.

Wash water and rinsate water will be disposed of in accordance with Federal and State regulations as part of the routine waste handling procedures at the site.

6. SAMPLE DOCUMENTATION AND SHIPMENT

This section describes sample handling procedures including sample containers, sample preservation, shipping requirements, and holding times. These procedures are designed to ensure that samples are preserved and transported to the laboratory in a manner that is consistent and maintains sample integrity.

6.1 SAMPLE DOCUMENTATION

After samples have been collected and labeled as defined in the QAPP, they will be transported to the laboratory together with the appropriate chain-of-custody (COC) forms and field data sheets. Upon receipt at the laboratory, the sample custodian will inspect the samples for integrity, check the shipment against the COC form, and sign the COC form. When the shipment and the COC form are in agreement, the sample custodian will enter the samples in the laboratory log and will assign a laboratory identification number to each sample.

6.2 SAMPLE PRESERVATION AND STORAGE

Soil, sediment, mice, and vegetation samples will be preserved immediately following collection by cooling the containerized sample to 4°C using ice.

Upon delivery to the analytical laboratory, all vegetation samples (washed, unwashed) will be dried in an oven at 60°C to a constant weight. The dried tissue will be ground in a Wily mill and may be stored in plastic bags at 4°C.

Mouse, fish, and macroinvertebrate samples may be kept frozen for long-term storage.

6.3 SHIPPING REQUIREMENTS AND HOLDING TIMES

Samples will be packaged for shipment as follows:

- Secure caps or baggies with signed and dated custody seals;
- Attach sample label to each container;
- Wrap glass jars, bottles, and vials in Ziplock bag or place in bubble wrap bag;
- Store on ice in an ice chest immediately after sample collection;
- Include laboratory-prepared trip blanks in each ice chest containing samples for VOC analysis;
- Ship samples to the laboratory on ice in a sealed ice chest containing chain-of-custody documents; chain-of-custody procedures are described in Section 3 of the QAPP;
- Affix signed and dated custody seals to coolers; and
- Ship samples via air courier following all DOT requirements, if any.

Samples will be shipped to an off-site laboratory and will be kept at a temperature of 4°C or lower from the time of collection through the transport of the samples to the laboratory. The laboratory will store the samples as described in Section 6.2 until all analyses have been completed.

7. PERSONNEL AND SCHEDULE

The ecological field team leaders are Dr. Linda Hanna for Sciences International, Inc. (SII) and Dr. Roy Woodward for Bechtel Environmental, Inc. (Bechtel). Sample collection teams will be composed of SII and Bechtel staff and subcontractors who are skilled and knowledgeable in field and laboratory methods. Experts from Idaho State University with knowledge of the Portneuf River and the local ecosystems will be on-site during the field investigation.

Sampling is expected to begin September 19, 1994, and to be completed by October 30, 1994. Any changes in the schedule will be made in consultation with EPA.

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APPENDIX A

DETERMINATION OF SAMPLE SIZE

Numbers of samples to be collected for each media or target species were determined by establishing data quality objectives that permit meaningful statistical comparisons to be made of difference between the site and reference areas. The approach for establishing sample size was in accordance with EPA guidance (EPA 1989, EPA 1992), and was applied to the EMF site using representative data from published literature to estimate the expected degree of variability in study populations.

As noted in EPA 1989, "there is no simple and strictly correct answer" to the question of how many samples to collect. In general. Larger sample sizes provide more precise estimates of sample statistics. such as the average concentration of COPCs in tissues of a given target species. However, considerations of time, money, and availability of the target species can place practical constraints on the numbers of samples collected for site investigations. Therefore. guidelines presented in EPA guidance for the confidence level and power of the statistical tests. and the minimal detectable difference between the site and reference areas. were used to determine sample size.

One of the objectives of the ecological assessment is to collect a sufficient sample size to statistically distinguish potentially impacted areas from reference areas. In statistical terms, the "null hypothesis" states that the mean COPC concentrations in media at the site are the same as the mean COPC concentrations at the reference area. Two types of statistical errors may be made in testing the null hypothesis. Rejecting a null hypothesis when it is true is referred to as a Type I error. That is, a Type I error is committed if samples taken from the EMF site are mistakenly considered to be significantly different from samples taken from a reference area. The probability of avoiding a Type I error is referred to as the "confidence" of the hypothesis test. Conversely,accepting a false null hypothesis is referred to as a Type II error. That is. a Type il error is committed if the site is mistakenly considered to be not significantly different from the reference area. The probability of avoiding a Type II error is referred to as the "power" of the hypothesis test.

In preliminary investigations of hazardous waste sites, the power of the test is considered to be possibly more important than the confidence level. According to EPA (1992), 90% is the minimum power to be used in hypothesis tests for risk assessment purposes. The minimum level of confidence is

considered to be 70%.

Determination of sample size requires specification of the power, confidence, and the magnitude of the difference to be detected (minimal detectable difference = MDD). For sampling of media such as soils, the minimum difference between the mean concentrations of the site and background is considered to be 30% for risk assessment purposes (EPA 1992).

Finally, an estimate of the expected variability or sample populations is needed. For the EMF site, the standard deviation or COPC levels for various sample matrices was obtained from published studies (see Table A-l). These studies were considered to be representative because they examined the same or similar species as the target species for the ecological assessment, and because (with one exception) they were conducted in Idaho or adjacent states.

For the EMF site, the sample size needed to detect a difference of 30% to 50% between the mean COPC concentrations at the site and a reference area. with a power of 90% and a confidence of 80%, was determined. An MDD of 50% was evaluated because of the high variability evident in the biological data presented in Table A-l. In general, an MDD of 50% encompasses 1 standard deviation for most of the data. which is likely to be adequate for risk assessment purposes at the EMF site. A confidence of 80% rather than 70% was evaluated. as 70% was judged to provide too much uncertainty in distinguishing the site from background (that is, the probability of rejecting a true null hypothesis was set at 20% rather than at 30%). The sample size (n) was determined following EPA (1989), and adjusted to provide the required sample size (n') to account for the use of estimated rather than known standard deviations.

Given these data quality objectives, a sample size of 10 appears to be adequate for nearly all target matrices and analytes (Table A-l). A larger sample size was indicated for cadmium in Utah sucker, and for fluoride in sagebrush. A sample size of 30 for Utah sucker is suggested from calculations based on cadmium data for Utah chub taken from Low and Mullins (1990). However, the variability of these data is likely inflated by the fact that measurements were estimated at or below the detection limit. Calculations based on cadmium data for largescale sucker taken from Lowe et al. (1985) support a sample size of less than 10. Therefore, a sample size of 10 was selected for

evaluating cadmium in Utah sucker. For flouride in sagebrush, a sample size of 19 is suggested from calculations based on Arthur and Gates (1988). Therefore as a conservative approach, a sample size of 20 will be targeted for analysis of fluoride in sagebrush foliage at the EMF site.

Portneuf River Delta Investigation – Statistical Analysis*

The results of the Portneuf River delta investigation, conducted in October of 1994, were discussed in section 4.6. This Appendix describes the statistical decision tree analysis used to determine if a Phase II River Delta study should be completed. This analytical approach was presented to EPA Region 10 and is very similar to that used by EPA in the ecological risk assessment. Both approaches used three criteria that would have to be met before Phase II studies would be initiated.

While the first two sets of criteria described below are very similar to those used by EPA, the approaches diverge with respect to the third criterion. EPA relied on the results of sediment toxicity tests to determine that additional Phase II studies were not necessary; the test results demonstrated that the sediments were not toxic.

As described below, Levels of Ecological Concern (i.e., AET sediment values), rather than toxicity test results served as the third criterion. However, although the third criterion differed, both the approach used by EPA and the process described below concluded that Phase II Delta studies were not necessary.

S.1 DECISION TREE FOR DETERMINING THE NEED OF A PHASE II DELTA STUDY

The purpose of the Phase I Delta Study was to determine the concentration and potential ecological significance of EMF-related contaminants of potential concern (COPC) detected in delta sediments. The specific COPCs, defined by EPA, were arsenic, cadmium, fluoride, mercury, selenium, and zinc. Because all of the COPCs exist in the natural environment, constituents such as aluminum and iron, which may coexist with the COPCs in the natural environment, were also analyzed to provide a measure of the natural variation of the COPCs.

The decision tree analysis (Figure S-1) used a combination of statistical and biological decision criteria, to determine if a Phase II assessment should be completed. Briefly, a Phase II assessment would be required if concentrations of COPCs in Portneuf delta sediments collected during Phase I exceeded the following:

- concentrations of COPCs in the Snake River delta sediments,
- concentrations of COPCs in upgradient Portneuf River sediments, and
- a pre-determined Level of Ecological Concern (LEC).

This section provides a detailed description of the statistical analysis used to determine the need for Phase II analyses. Additional details, including the rationale for choosing

specific LECs, are provided in the document "Determination of the need to proceed with Phase II of the EMF river delta study" (SII, 1994).

An analysis of variance (ANOVA) procedure was selected to determine if contaminant concentrations in the Portneuf River differed significantly from concentrations in the Snake River, upgradient sediments, or from LECs. A 2x2x2 factorial ANOVA design was used to make these comparisons. The 2x2x2 design refers to two levels of the following three independent variables:

- river (Portneuf versus Snake),
- depositional features (mudflat versus channel), and
- watermark (above and below the reservoir's high watermark).

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The concentrations of COPCs (As, Cd, F, Hg, Se, and Zn) represented dependent variables in the ANOVA. Concentrations of these sediment COPCs were known to vary in the same manner or direction as the following five sediment constituents; Total Organic Carbon (TOC), the ratio of Acid Volatile Sulfide to Simultaneously Extracted Metals, or AVS/SEM, Al, and Fe. These sediment characteristics were included in the statistical analyses as covariates. The raw data for each sampling site are summarized in Tables 4.6-6 and 4.6-7 for the Portneuf River and Tables 4.6-8 and 4.6-9 for the Snake River.

The main effects were defined as the differences between the two rivers and were referred to as the "river effect", a "deposition feature effect", and a "watermark effect" (i.e., the independent variables). Although three, two-way interactive effects (River*Deposition, River*Watermark, and Deposition*Watermark) and one three-way interaction (River*Deposition*Watermark) could have been analyzed, only the three main effects and those two-way interactions that directly involved a comparison between the two river deltas were actually considered in these analyses. Interactions that did not involve the river deltas were deemed irrelevant and the results of three-way comparisons too difficult to interpret, particularly given the limited number of samples. Thus, the only effects included in the decision process (Figure 1) were the three main effects and the River*Deposition and River*Watermark interactive effects.

Each of the three statistical effects of interest (each of the main effects and the two interactions) was analyzed separately *for each COPC* on the decision tree represented in Figure 1. If *any* of the three effects triggered *all* decision criteria, as defined below, a Phase II assessment for that COPC would be recommended. However, if one or more of the decision criteria were not met, a Phase II assessment would not be initiated.

The first screening level criterion tested was whether COPC concentrations were greater in the Portneuf River delta sediments than in the Snake River delta sediments. A three-way ANOVA of each of the six COPC concentrations was performed to test for interactions among the three independent variables, or main effects (Snake River versus Portneuf River, channel versus mudflat, and above versus below the reservoir high watermark). As with all ANOVAs, the analyses required that the data be normally distributed and that the variances were equal. Homogeneity of variances was tested using the F-statistic, which compared the largest and smallest sample variances (Edwards, 1968). If the F statistic was <0.05, the data were transformed (Edwards, 1968) to achieve equal variances.

S.1.1 Analysis for the River Effect

If the results of the ANOVA indicated that concentrations of COPCs in the two rivers differed significantly ($p \leq 0.2$), a multiple linear regression was conducted to determine if one or more covariates could account for these differences (Figure S-1). A covariate was defined as a variable (TOC, AVS/SEM, Al, or Fe) that could account

[1]Conducted separately for each COPC, for the main effect of River and the interactive effects River* Deposit and River* Watermark

[2]Applies to River effect only

[3]Applies to the interactive effects only

[4]Use only if covariate is aluminum or iron; otherwise, use absolute or transformed concentrations

ANOVA = Analysis of Variance
ANCOVA = Analysis of Covariance
COPC = Contaminant of Potential Concern
LEC = Level of Ecological Concern
MLR = Multiple Linear Regression

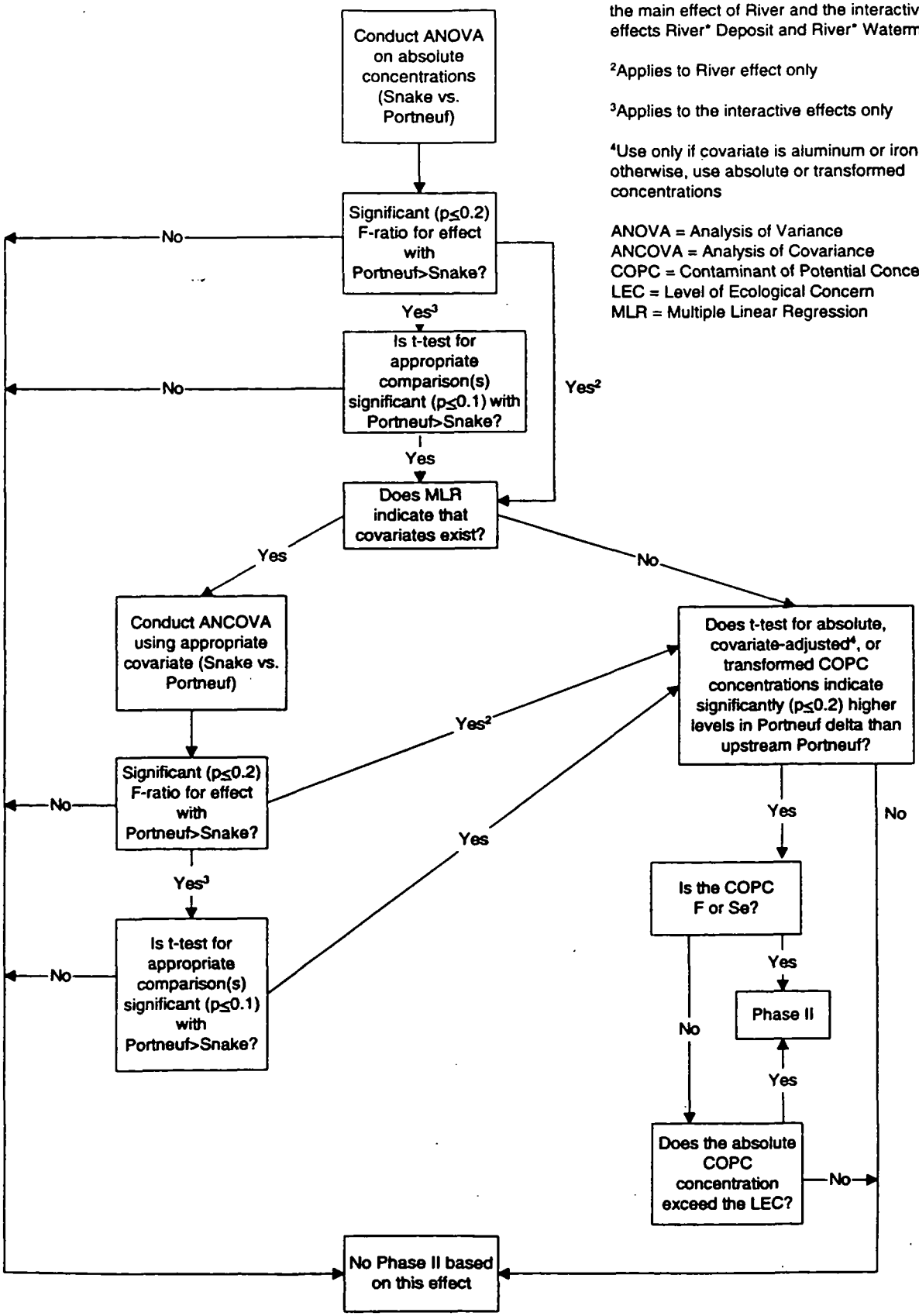

Figure S-1 Flow Diagram of the Statistical Decision Tree[1]

for 65% or more of the variability (that is, R^2=0.65) in COPC concentrations. Data from reference sediments (Snake River samples and Portneuf River samples upstream of the EMF site) were used to identify those covariates that accounted for a significant portion of the variability associated with the COPC concentrations. If none of the covariates accounted for at least 65% of this variability, the data were not "covariate-adjusted". If one or more covariates accounted for $\geq$ 65% of the variability associated with the COPC concentrations, these covariates were used in an analysis of covariance (ANCOVA).

If the ANCOVA results indicated that no significant difference existed between the COPC levels present in the two rivers, Phase II analyses would not be implemented. However, if the COPC concentrations differed significantly, the first decision criterion was met, and an analysis of the second criterion would be initiated. This second criterion involved a t-test that compared the Portneuf delta COPC sediment concentrations with upgradient Portneuf sediment concentrations. Upgradient Portneuf sampling locations were stations 21 through 25 and both A1 and A2 (see figure 2.4-1). If the delta versus upgradient comparison was not statistically significant ($p \leq 0.2$), the Phase II assessment was not recommended. However, if delta concentrations differed significantly from the upstream COPC concentrations, the second decision criterion was met (Figure S-1).

The third screening level criterion compared concentrations of COPCs detected in the Portneuf sediments to levels of ecological concern (LECs) for all contaminants except fluoride and selenium. Data regarding the toxicity of these two contaminants in sediments was too limited to develop LECs. In this instance, Phase II assessment for these two COPCs would be recommended if the first two decision criteria had been met.

S.1.2 Analysis for Two-Way Interactive Effects

If the results of the 2X2X2 factorial design ANOVA indicated that a significant two-way interaction had been identified for either of the two terms, River*Deposit or River*Watermark, then analyses similar to those used to identify a significant river effect would be conducted (Figure S-1). The only exception to this approach was the use of post-ANOVA (and, as appropriate, post-ANCOVA) t-tests. T-tests were conducted to identify the following:

- significant differences between the depositional areas in the two rivers (to address significant River*Deposit interactions),
- significant differences between "above watermark" and "below watermark "sediment concentrations of COPCs in the two rivers (for significant River*Watermark interactions).

Because of these multiple comparisons, the p-level was adjusted to 0.1 by equally partitioning of the overall F-statistic p-level of 0.2. If Portneuf River delta sediment concentrations exceeded Snake River delta sediment concentrations on any of these *post hoc* t-tests, then the next stage of the decision tree process would be initiated.

S.2 RESULTS OF THE DELTA SEDIMENT STUDY

Section 4.6 contains the summary of the statistical analyses for each of the six COPCs present in the delta sediments. As described in section 4.6, none of the sediment COPCs were present at concentrations sufficiently high to warrant a concern for significant ecological impact. A detailed presentation of the decision tree process that was followed to determine the need for a Phase II study is provided below. The mean and standard deviation of COPC concentrations (mg/kg) detected in sediment samples are presented in the following text.

S.2.1 Arsenic

An analysis of means indicated that concentrations of arsenic in Snake River delta sediments (3.1 $\pm$ 2.1mg/kg) were generally greater than concentrations in the Portneuf River delta sediments (2.8 $\pm$ 0.8 mg/kg). These differences were not statistically significant ($p \geq 0.2$). Consequently, arsenic was not considered as a COPC that required further statistical analysis.

S.2.2 Cadmium

These analysis indicated that cadmium concentrations differed significantly between the two rivers ($F=58.44$; $df=1,32$; $p<0.0001$). Cadmium levels in the Portneuf River sediments were 0.93 $\pm$ 0.29 mg/kg and 0.37 $\pm$ 0.21 mg/kg in the Snake River sediments. The lack of significant two-way interactions ($p>0.2$) suggests that excess cadmium accumulation is occurring throughout the Portneuf delta, with no preferential accumulation with respect to deposition area or to water mark.

The regression analysis indicated that the best two-variable model for predicting delta cadmium concentrations included aluminum and iron as covariates. These two covariates accounted for 76.3% (that is, $R^2=0.763$) of the variability in cadmium concentrations. Individually (that is, using the one-variable models), aluminum and iron accounted for 65.9% and 39.6% of the variability, respectively, in cadmium concentrations[1]. Consequently, an ANCOVA was conducted on differences in cadmium concentrations, after adjustment for aluminum. The results of the ANCOVA indicated a significant river effect ($F=35.11$; $df=1,31$; $p \leq 0.0001$) and a significant River*Deposit interaction ($F=5.30$; $df=1,31$; $p=0.0283$). Specifically, the river effect indicates that cadmium concentrations in the Portneuf River delta

[1] The sum of the individual R^2 values for aluminum and iron is greater than the R^2 value when the 2-variable model is used because aluminum and iron are highly correlated ($r=0.93$) with each other; consequently, the use of aluminum or iron separately "overpredicts" the variance in cadmium scores.

sediments remain significantly higher than concentrations of cadmium in the Snake River delta sediments, after adjustment for aluminum. Consequently, Criterion 1 in the decision tree was met. A post-hoc t-test for the River*Deposit interaction was not considered necessary because the river effect was also significant.

Criterion 2 could not be evaluated because six of the seven upgradient sediment samples were non-detects, and could therefore not be used in the analysis (EPA, 1989). Consequently, the decision to proceed with Phase II depended on whether cadmium concentrations exceeded the Level of Ecological Concern (LEC). Both the mean (0.93 mg/kg) and the maximum (1.6 mg/kg) cadmium concentrations in the Portneuf River delta sediments were considerably lower than the LEC of 7 mg/kg. Consequently, based on the decision tree, a Phase II study for cadmium was not recommended.

S.2.3 Fluoride

Fluoride concentrations were significantly ($F=18.80$; $df=1,32$; $p<0.0001$) higher in the Portneuf River delta sediments (345 $\pm$ 65) than in the Snake River delta sediments (247 $\pm$ 75). A significant ($F=3.40$; $df=1,32$; $p=0.743$) River*Deposit interaction was also identified. Subsequent t-test analysis indicated that concentrations of fluoride in the Portneuf channel (357 $\pm$ 55) were statistically equivalent to levels in the Portneuf mudflats (334 $\pm$ 75). Both of these levels were statistically higher ($p<0.1$) than levels in the Snake River mudflats (274 $\pm$ 80), which in turn were higher ($p<0.1$) than levels in the Snake River channel (219 $\pm$ 60). Because no combination of covariates accounted for at least 65% of the variability in fluoride concentrations ($R^2<0.65$), the data could not be further adjusted, and Criterion 1 was met.

The remaining criterion was the comparison of delta fluoride concentrations with upgradient concentrations. One of the upgradient concentrations, 1300 mg/kg at sampling station 23, was considerably higher than the other six concentrations. This value was considered an outlier and was not included in the analysis. The subsequent t-test indicated that Portneuf delta fluoride concentrations were not significantly higher than upgradient concentrations (330 $\pm$ 137; $t=-0.37$, $df=24$, $p=0.71$). Because Criterion 2 was not met, a Phase II study of fluoride levels was not recommended.

S.2.4 Mercury

Mercury was not detected above the instrument detection limit in 95% of the sampling locations in the Portneuf and Snake River deltas. Although Sample Quantitation Limits are available, current guidance (EPA, 1989) indicates that data analysis should not be conducted when the majority of sample concentrations cannot be detected. Consequently, the significance of mercury concentrations in Portneuf delta sediments must be considered a data gap. Nevertheless, the following suggests that any potential EMF site-related mercury releases are biologically insignificant: (1) the two measurable mercury concentrations (0.46,

0.19 mg/kg), located in the Portneuf mudflats, may result from high and variable natural geological variations; and, (2) the higher of these two concentrations was below the LEC of 0.56 mg/kg.

S.2.5 Selenium

An ANOVA performed on selenium sediment concentrations suggested that Portneuf River delta concentrations (0.81 $\pm$ 0.44) were higher than Snake River delta concentrations (0.62 $\pm$ 0.22) (F=3.02; df=1,32; p=0.092). However, the F_{max} test indicated moderate skewness in the selenium sampling distributions. Therefore, to normalize the data, a reciprocal transformation (1/(X+1)) was completed. After data transformation, the results of ANOVAs performed on all effects of interest were not statistically significant (p>0.2). As a result, selenium was not further considered in the Phase II decision process.

S.2.5 Zinc

Zinc levels in Portneuf and Snake River sediments were 42.9 $\pm$ 14.9 and 35.2 $\pm$ 13.3 mg/kg, respectively. Analysis of zinc concentrations present in samples collected above and below the high water mark indicated that the variances were heterogenous. Consequently, a square root transformation, followed by an inverse transformation, was applied to achieve homogeneity. Analysis of the transformed data indicated a statistically significant river effect (F=4.46; df=1,32; p=0.0425), with zinc concentrations in sediments somewhat higher in the Portneuf River than in the Snake River delta.

Multiple regression analysis of the original raw scores revealed that both aluminum and iron concentrations correlated very highly (R^2=0.932 and 0.919, respectively) with zinc concentrations. When zinc was covaried with aluminum, Snake Delta concentrations were actually higher than Portneuf Delta concentrations. Consequently, further analyses using this covariate were not completed. When zinc was covaried with iron, Portneuf Delta concentrations remained slightly higher than Snake Delta concentrations. Analysis of variance of zinc covaried with iron indicated that the river effect remained statistically significant (F=2.20; df=1,31; p=0.15). Similarly, both the River*Watermark (F=5.89; df=1,31; p=0.021) and the River*Deposit (F=2.43, df=1,31; p=0.13) interactions for aluminum-adjusted zinc levels were significant. Therefore, Criterion 1 was met when zinc concentrations were adjusted for iron.

The second criterion compared upgradient zinc concentrations in 7 samples (42 $\pm$ 11) to 20 samples taken from the delta of the Portneuf River (43 $\pm$ 15). The resulting t-test analysis, with equal variances, indicated no significant differences (t=-0.15; df=25; p=0.89) in zinc concentrations between upgradient and delta samples. Consequently, Phase II studies of zinc were not recommended.

Appendix T

Response to EPA PSCS Comments

Responses to EPA Comments on the Preliminary Site Characterization Summary for the EMF Site

GENERAL COMMENTS

1. Numerous conclusions and interpretations are presented throughout this report, and many appear at several locations in the report and are incorporated into summary sections. EPA disagrees with some of these conclusions and interpretations and has provided comments at appropriate points; however, the agency has not attempted to note every occurrence of points with which it disagrees. EPA expects the PRPs to make appropriate revisions to the report in response to the comments provided and to propagate the revisions throughout the report as necessary. This analytical approach was presented to EPA region 10 and is very similar to that used by EPA in the ecological risk assessment. Both approaches used three criteria that would have to be met before Phase II studies would be initiated.

While the first two sets of criteria described below are very similar to those used by EPA, the approaches diverge with respect to the third criterion. EPA relied on the results of sediment toxicity tests to determine that additional Phase II studies were not necessary; the test results demonstrated that the sediments were not toxic.

As described below, Levels of Ecological Concern (i.e., AET sediment values), rather than toxicity test results served as the third criterion. However, although the third criterion differed, both the approach used by EPA and the process described below concluded that Phase II Delta studies were not necessary.

Response: *This comment is addressed through the Remedial Investigation (RI) Report, which provides interpretations and conclusions based on the substantial additional data collectd throughout the RI period. Interpretations and conclusions are presented consistently between detailed sections (RI Report Parts II and III) and the Executive Summary (Part I).*

3. The report states that those waste sources which do not have an associated "sustained head" from site sources should not be considered subject to migration may not be correct. Infiltration and percolation of precipitation may represent a sufficient driving force to move site contaminants to the groundwater in a pulsed fashion.

Response: *The RI Report Part II, Section 4.2.3.2 FMC Facility Soils - Areas without Sustained Hydraulic Head and Section 4.2.2.2 Simplot Facility Soils - Areas without Sustained Hydraulic Head provide a discussion of the sampling and analytical results which support the conclusion that site related constituents have not migrated vertically in areas without sustained hydraulic head. RI Report Part II, Section 3.3.2.4 Recharge Rates and Pumping Rates provides a discussion of the basis for estimated recharge rates for the site in areas not subject to sustained artificial hydraulic head.*

5. EPA has some disagreement with the way site ground water was compared to background ground water in this report (upgradient wells not impacted by the site are referred to as "representative" rather than "background" wells in the PSCR, a convention that will be followed in the remainder of our comments for the sake of consistency.) There are several aspects of this analysis that are questionable as presented in the PSCR. They are: (1) the selection of wells to be included in the pool of "representative" wells, (2) the determination of which representative wells each site well will be compared to, and (3) the statistical analysis used to make the comparisons. These are discussed separately below as well as in specific comments:

(1) Selection of representative wells. The wells selected as "representative" must be free of potential contaminant contributions from the site. The inclusion of Wells 120 and 130 is questionable for the reasons described in the PSCR (primarily the proximity of the wells to potential sources.) The arsenic content of these two wells stands out from the rest of the wells selected as representative. They are also elevated in orthophosphate and total phosphorous (additional site-related constituents) compared to the other wells in the representative group. (Based upon meeting of 5/19/94 wells 120 and 130 will be removed from the monitoring network.)

Furthermore, their elevated chloride content was used to separate them geochemically from the other Bannock Hills wells-- but impacted wells in the former ponds area at FMC are also elevated in chloride. Wells 120 and 130 are the only two wells in the high-chloride subgroup. Because chloride is one of the most mobile constituents in the wastes found in the old pond area, the elevated chloride content in wells 120 and 130, along with other constituents discussed above, may be an indication that they have been impacted by the site rather than that they belong to a separate geochemical regime.

(2) Comparison of representative wells to site wells. Combining the three different geochemical regimes into one group is not justified in the report. Potentially impacted site wells should be compared with the representative wells from the appropriate geochemical regime. In areas where mixing of waters from two regimes occurs, the comparison can be made with both. (See the specific comment below regarding "lumping" of hydrogeochemical regimes.)

(3) Statistical analysis used for comparisons between site wells and representative wells, Page 4.4-6. The mean plus two standard deviations is used to approximate the 95th percentile of the representative samples and is described as being "consistent with EPA Region 10 policy." We do not know of any "Region 10 policy" on this subject. This method is not the appropriate approach at a site such as Eastern Michaud Flats where we have adequate data to compute the 95th percentile directly. Furthermore, the mean plus two standard deviations is only an approximation of the 95th percentile when the population is normally distributed. Environmental concentration data are often lognormally distributed.

We did not see any discussion of distributions in the PSCR and could not tell whether or not this fundamental assumption was even tested.

A more rigorous approach to the use of the 95th percentile as a definition of background ground water concentrations can be found in EPA's Interim Final Guidance *"Statistical Analysis of Ground Water Monitoring Data at RCRA Facilities"* dated February 1989 and the Addendum to the guidance dated July, 1992. (See the section on tolerance intervals.) The guidance also contains specific recommendations for testing the population distribution.

Response: *RI Report Part II, Section 4.4.3 Representative Groundwater Chemistry, provides a detailed discussion of the wells selected as representative for each of the three hydrogeochemical regimes, re-calculated representative levels for each constituent, and a well-by-well comparison to the appropriate hydrogeochemical regime in tabular format. The selection of representative wells and method for calculating representative levels were agreed to by EPA at an EPA/Company meeting on May 19, 1994.*

SPECIFIC COMMENTS

10. Executive Summary

The listing of major chemicals of concern does not include radionuclides. Both results from soil sampling, ground water and air monitoring identify radionuclides at levels which are of concern.

Response: *The RI Report Part I (Executive Summary) does not specifically include a list of chemicals of potential concern. The RI Report Parts II and III provide extensive discussions, tables and figures which include characterization of all chemicals which were investigated, including radionuclides. Please refer to the appropriate section (by media of interest) for detailed presentation of data on radionuclides.*

13. Page ES-4, 1st Bullet

This may be true of the dry gypsum solids on the gypstack, but the gypsum slurry liquid, which is the liquid most likely to be released from the gypstack (page 4.2.2-3, paragraph 4), exceeds the TCLP criteria for cadmium and chromium (Table 4.2.2-1), and its pH is less than 2.0. Therefore, the gypsum slurry liquid exhibits three hazardous waste characteristics (exceeding TCLP criteria for cadmium and chromium, and corrosivity [pH less than 2.0]), and it would be classified as a RCRA hazardous waste if it were subject to RCRA.

Response: *The content of this bullet is not included in the Executive Summary of the RI Report. A detailed descrition of the composition and analysis of gypsum slurry is provided in the RI Report Part II, Section 4.2.2.1 Simplot Potential Sources and Table 4.2.2-1.*

14. Page ES-4, third bullet

. A limited number of constituents in offsite ground water exceed screening levels and MCLs.." The constituents should be listed here.

Response: *The RI Report Part I (Executive Summary) does not include a list of specific constiuents in groundwater either on- or offsite. A detailed discussion of constituent levels in groundwater within different areas of the site is provided in the RI Report Part II, Sections 4.4.4 (at FMC), 4.4.5 (at Simplot), 4.4.6 (Joint Fenceline Area), 4.4.7 (Northern FMC/Simplot Areas), and 4.4.8 (Groundwater North of I-86).*

18. Page ES–6, Summary of Findings

EPA does not agree with the characterization of the nature and extent of contamination in the EMF study area or with the conclusions about the extent of potential exposure of humans and ecological receptors to site-related contaminants. Specific comments are provided at appropriate points in the body of the report.

Response: *This comment is addressed through the RI Report, which provides interpretations and conclusions based on the substantial additional data collected throughout the RI period. Responses to specific comments are provided below, along with reference(s) to the appropriate section of the RI Report where the comment has been addressed, and in the responses to comments on the RI Report.*

26. Page 1.4-1, Paragraph 4

The statement (Sentence 3) that "very little infiltration of naturally occurring water is expected at the facility and virtually none to depth" needs additional support. The rationale presented in the PSCS report appears based on combining the annual precipitation and potential evapotranspiration values. The description of the EMF facilities area climate (Pages 3.5-2 and 3.5-3, Paragraphs 3 and 5) show the precipitation to occur primarily in the winter and spring, while the potential evapotranspiration is approximately ten times larger in summer than in winter. Using annual values to suggest there is very little infiltration of natural water does not seem appropriate, given the climatic patterns. The conclusion (Sentence 4) drawn from using annual data, instead of monthly or seasonal information, needs to be modified. Site waste sources subject to potential subsurface migration should not be restricted only to those sources which are associated with a facility-generated liquid head.

Response: *Support for statements regarding infiltration of precipitation is provided in RI Report Part II, Section 3.3.2.4 Recharge Rates and Pumping Rates and Section 5.3 Factors Affecting Subsurface Constituent Migration. Statements regarding the potential for deep infiltration of precipitation have been revised to better reflect site conditions.*

27. Section 1.4 Site Conceptual Model

The PSCS focuses most of the discussion on current releases or operations, and ignores past practices at the site. For instance, it specifically states that current engineering is such that all runoff is contained, and therefore no transport offsite may occur. This has not always been the case. The PSCS should fully discuss all past practices in characterizing and explaining the extent of contamination.

Response: *Although the facilities' operations and practices have indeed changed and improved over the years of operation, a detailed discussion of the past practices is not possible due to a lack of detailed information (very few employees remain with any specific information regarding plant practices in the 1950s and 1960s) and compiling meaningful, credible information regarding individual incidents would be difficult and would still not create an accurate historical record. Therefore, the potential impacts of any past runoff from the facilities is best assessed via review of the surface soil data (See RI Report Part II, Section 4.3) and surface water and sediment data (See RI Report Part II, Section 4.5).*

29. Page 1.4-3. Section 1.4.3

In the first bullet it is stated that storage piles are unlikely to leach into subsurface soils. Slag pit practices by FMC yield significant quantities of water and a potential for some subsurface contamination.

Response: *The slag pit is not considered a storage pile, nor do current slag pit practices "yield significant quantities of water". Past practices at the FMC slag pit are discussed insofar as the slag pit has been identified as a source of constituents to groundwater underflowing this area, refer to the RI Report Part II, Section 4.4.4 Nature and Extent of EMF-Related Constituents in Groundwater at FMC, and also to the response to RI comment 48.*

33. Page 1.4-4, Fourth Bullet

EPA disagrees with this hypothesis. Observation of the river and the sediment sampling locations selected by the PRPs in point and chute bars during the September 1993 float trip lead the representatives of the oversight agencies to conclude that these locations were not likely to provide an adequate record of site-related contaminants that might have accumulated over the years in fine sediment. Areas of sediment deposition of this type were not observed until the river entered the bottoms shortly before the take-out point.

Response: *Sediment samples were collected in the Fort Hall Bottoms area, and EMF-related impacts were not detected (See RI Report Part II, Section 4.5.2) Additional sediment sampling was performed in the American Falls Reservoir. The results of this investigation, presented in RI Report Part II, Section 4.6, provide additional support for the statement that the Portneuf River has not been adversely affected by past or current EMF facility operations.*

37. Page 2.2-1, Section 2.2, First bullet and elsewhere in PSCS.

It is stated that FMC is operating under a current state permit. FMC has applied for a permit but no action has been taken by the Agency on this application.

Response: *Although the state operating permit expired by its terms in 1985, FMC timely requested renewal of the permit. Under section 16.01.1012,13.f of the state operating permit regulations effective as approved by EPA, the expiration of the permit does not affect the operation of the facility, (i.e., the permit terms remain in effect,) during the permit renewal process.*

40. Table 2.1-2

In the discussion of the radionuclide analyses for the various media, the PRPs state on page 6-9 of the RI workplan (dated 2/28/92): "Samples will be screened for radioactivity by measuring gross alpha and gross beta. Any samples showing radioactivity in excess of upgradient or background levels by a statistically significant margin will be further analyzed to determine specific radionuclides present. ... Surface soil samples will be analyzed for gross alpha and or gross beta and for specific radionuclides by gamma spectroscopy if gross alpha and or gross beta exceed baseline levels." EPA agreed to accept gross alpha and gross beta measurements as a screening tool on the basis of the PRP's agreement to perform the radionuclide specific analyses if the gross alpha and gross beta measurements indicated that elevated radionuclide levels were present.

Gross alpha and gross beta levels appear to be elevated in both soil and groundwater. The PRPs have not provided any information establishing background levels of gross alpha or gross beta nor have they demonstrated that the levels found are not statistically different from background. Therefore, the PRPs should proceed with the radionuclide specific analyses of the samples having elevated gross alpha or gross beta levels. In view of the relatively short half-lives of some of the radionuclides of interest, fresh samples probably will be required.

Response: *Representative levels for gross alpha and gross beta for soils within the facilities are listed on Table 4.2.1-1, Section 4.2 of the RI Report Part II. A comparison of facility source materials and soil sample levels to representative levels is provided in Sections 4.2.2 (Simplot) and 4.2.3 (FMC). Representative levels for gross alpha and gross beta for groundwater within the three hydrogeochemical regimes are listed in the RI Report Part II, Section 4.4.3.6 Radiological Parameters in Representative Groundwater. A comparison of levels measured in groundwater samples to representative levels is provided in Sections 4.4.4 through 4.4.8. Although not all soil samples that were found with gross alpha or gross beta above representative levels were speciated for radioisotopes, specific radioisotope activities in facility soils have been estimated and are presented in Appendix P of the RI Report. In addition, three on-site soil samples at FMC were analyzed using gamma spectroscopy methods. This data is presented on page 4.2-3 of the RI Report. Speciation of selected March 1994 groundwater samples was performed and results are discussed in the RI Report Part II, Section 4.4.9 Radiological Speciation Results. Also refer to the response to RI comment 9.*

64. Section 3.7

This section appears to be adequate, with the exception of the table presented on Page 3.7-2 titled "Overview of Ecological Characterization." Several of the generalizations in this overview table are not supported by the data.

It is incorrect to state that "No important wildlife habitats are present in the EMF study area" (Bullet 2). The important terrestrial and wetland wildlife habitats in the vicinity include sagebrush steppe, grassland, riparian, cliff, and juniper woodland. Some of these habitats are legally protected (e.g., the Michaud Creek and Portneuf River riparian wetlands). Considered as an ecosystem, these habitats support numerous game and nongame species of regulatory concern (e.g., migratory birds).

Bullet 4 identifies the Portneuf River as the only significant aquatic habitat in the study area. The springs associated with the river also are important. In addition, the American Falls Reservoir is an important aquatic habitat downstream from the site. The reduction of water quality from "numerous point and nonpoint sources" presumably includes the influence of the EMF site. Although there are numerous potential sources, only a few have been linked to observable impacts on water quality.

The statement "no endangered or threatened species occur in the portion of the Portneuf River within the study area" is not supported. Bald eagles have been observed in the Portneuf River downstream from the EMF site, as described on Page 3.7-11. Peregrine falcons are occasionally sighted. Sightings of several federal candidate species and state-listed species also have been reported in the Fort Hall Bottoms. These may be outside of the "study area," but it should be noted that the study area is defined arbitrarily, and that the potential ecological risks or releases from the site on ecosystems outside of the 3-mile radius is of concern to the various regulatory agencies and natural resource trustees.

As a general comment, no mention is made in Section 3.7 of stressed vegetation in the Bannock Hills on north-facing slopes adjacent to the site. These were observed by EPA and E & E biologists (Joe Goulet, Pat Cirone, and Steve Peterson) during field reconnaissance after the September 1993 float trip, and could indicate impacts of air emissions from the site.

Response: *The RI Report Part II, Section 3.7, Figure 3.7-1 "Overview of Ecological Characterization" states that there are no critical or special habitats in the study area, which is correct given these defined terms. The figure now states that the most (not only) significant aquatic habitat is the Portneuf River. The figure also states that a number of endangered, threatened or candidate species have been sighted in the Fort Hall Bottoms. Section 3.7 provides supporting information regarding this overview of the ecological characterization of the site.*

65. Page 3.7-9, Section 3.7.1.2, third paragraph under EMF Facilities

It is stated that surface ponds at FMC could potentially attract waterfowl. State personnel have observed American Avocets on Pond 15S. Sonar guns were operating, but were not effective. This section should be revised to reflect the effectiveness of current control measures.

Response: *The RI Report Part II, Section 3.7.1.2, page 3.7-13 notes that the sonar guns and pond crew efforts (shotgun blanks and slingshots) are less effective with American avocets (than with migratory game waterfowl).*

70. Page 4.2-1, 4th Bullet

Explain the basis for the conclusion that at least four characteristic constituents must be present at elevated concentrations for a soil or sediment sample to be regarded as having been impacted by the EMF facilities.

The various constituents of the ore move through the processes used at the EMF facilities in different ways. They appear in various byproducts and waste streams and have been released to the environment in different combinations and proportions. They also migrate differently in the environment. Therefore, there can be no certainty that any four will necessarily be present wherever site-derived contaminants are located.

Response: *The association of four or more of the six characteristic constituents above representative levels with facility impacts was used only within the facilities to screen locations for possible impacts from the various feedstocks, products, byproducts and wastes. This "rule-of-thumb" was not extended to evaluating potential facility impacts at offsite surface sample locations. The four of six constituents were usually among the predominant constituents detected in essentially all of the fill material or EMF-affected soils sampled as part of the potential source and facility soils investigation. For this reason, the presence of four or more of these constituents in excess of representative levels is indicative of EMF facility effects. The PSCS did not state that four of the six constituents "must" be present, but that soils were "unlikely" to have been affected by the EMF facilities unless four of the six constituents were present at "elevated" levels. Nevertheless, the text of the RI Report now states that the presence of four or more of the six constituents above representative levels is indicative of EMF effects, refer to RI Report Part II, Section 4.2.*

71. Section 4.2 and elsewhere throughout the document

A distinction should be made between the facilities' "byproducts" and waste products. Statements such as "widespread use of byproducts for fill and grading has introduced constituents to depths as great as 30 feet" could be made more specific. Is it primarily slag that is being referred to in this way?

Response: *The statement refers to slag, ore and, in some cases, to precipitator dust or gypsum. A categorization of the various materials present at the facilities is provided in the RI Report Part II, Sections 1.1 and 1.2. Also refer to response to RI comment 2.*

72. Page 4.2-2, 1st Bullet, and Section 4.2.1

EPA has previously reviewed the PRPs' approach to defining background or "representative" soil concentrations for the EMF Site and found it unacceptable. Use of concentration values derived by this approach for identifying site-related impacts is also unacceptable. All references to the PRPs' "representative" concentrations should be deleted from the PSCS and should not appear in the RI report.

Response: *A description of the development of soil representative levels is presented in the RI Report Part II, Section 4.2.1 Characterization of Representative Soil Chemistry in the EMF Study Area. As noted in the referenced section, EPA's levels are used in the RI to assess potential EMF effects. In addition to the evaluations presented in Section 4.2, other relevant sections of the report have been revised to reflect the background soil numbers developed by EPA. Also refer to responses to RI comments 34, 35, and 108.*

76. Sections 4.2.2 and 4.2.3

These sections present comprehensive descriptions of potential source areas and on-site soils, but the information is presented in a way that makes it very difficult to get an overall picture of the nature and extent of contamination at the site as a whole or even in the individual Potential Source Areas. The data need to be presented in a way that makes the nature, extent, and patterns of contamination more apparent. Data presentations like those given in Figures 4.2.2-5 through 4.2.2-10 for the gypstacks are helpful. Another approach to consider would be to provide maps showing the spatial distribution of soil contamination. The depth intervals of interest are the surficial material, which is currently available for direct contact; the impacted interval of variable thickness from 0 to 20 or so feet that encompasses most fill areas and incidental surficial contamination, which could be contacted and/or brought to the surface during excavation, construction, or regrading activities; and deeper soils that provide an indication of the areas in which contaminants may be or may have been migrating downward in response to a sustained or intermittent head.

Response: *The RI Report Part II provides all of the pertinent data with respect to potential source areas and facility soils. Process and product, by-product and waste handling descriptions are provided in Sections 1.1 (FMC) and 1.2 (Simplot). A number of data presentation techniques were considered for use in the RI Report. The detailed presentation provided in the RI Report Part II, Section 4.2 (particularly in Figures 4.2.2-4 through 10 (Simplot) and 4.2.3-4 through 9 (FMC)) was selected as the most thorough and informative. Additional data presentations, similar to those provided in PSCS Figures 4.2.2-5 through 4.2.2-10, are provided in the RI Report Part II, Section*

5.3 Factors Affecting Subsurface Migration (Figures 5.3-1a and 5.3-1b) for selected chemicals and selected potential source areas. Interpolation between individual potential source areas, as suggested by the spatial distribution alternative mentioned in the comment, would not provide useful information because of the lack of interrelationship between the potential source areas. Also refer to response to RI comment 106.

80. Page 4.2.2-44, Upper Gypstack Summary

If a substance, like the oxyanions, is not significantly attenuated by soils, a residual contamination front or a vertical gradient would not be expected. Instead, the soils should reflect the concentration of the substance in the soil water or the residual concentration left behind after a sustained head was removed and the soil dried out. The phosphorus and arsenic concentrations in boring S003, which appear to show elevated levels 60 feet into the native soil for P (Figure 4.2.2-7), and 30 feet for As (Figure 4.2.2-6), exhibit such a pattern. This interpretation is also consistent with the presence of elevated levels of phosphorus and arsenic in the groundwater around the gypstacks.

Response: *Clarification of this comment was requested on May 17, 1994. During a conference call on January 11, 1996, the comment was retracted. The substance of this observation is consistent with the RI Report Part II, Sections 4.2.2.3, 4.4.5.4 and 5.3. Also refer to response to RI comment 107.*

81. Page 4.2.3-3, Section 4.2.3.1.

This list of radionuclides associated with slag is not complete.

Response: *The PSCS and RI Report text address all radionuclides for which measurements were made. Analytical results of slag are presented in the RI Report Part II, Scetion 4.2.3.1 FMC Potential Sources and Table 4.2.3-2.*

82. Page 4.2.3-6, Section 4.2.2.1 - IWW Ditch Water and Sediment heading.

The results indicate that, at least occasionally, significant levels of contaminants enter the IWW Ditch and the Portneuf River. This reinforces EPA's position regarding contaminant loading to the Portneuf River. The PSCS must fully address this scenario and estimate its frequency of occurrence during the past.

Response: *Although there have been upset conditions that have introduced wastewater (other than the typical noncontact cooling water) into the IWW system, a reliable estimate of the frequency of upsets in the past is not possible due to the lack of accurate records. Estimates of past occurences would not provide additional benefit to the data in the RI as the "cummulative impact" of such events was investigated directly through the surface water and sediment investigations*

presented in the RI Part II, Section 4.5. Available information on the source and frequency of elevated constituents in the IWW Ditch water is provided in RI Report Part II Section 4.2.3.1 and in Appendix L.

85. Section 4.3.1

EPA disagrees with much of the data interpretation presented in this section concerning the nature and extent of off-site soil contamination. This stems mainly from the use of the PRPs' "representative" concentrations rather than the EPA's background levels as points of comparison for evaluating the data. EPA has previously reviewed and rejected the approach used by the PRPs in deriving their "representative" concentrations. The use of these "representative" concentrations in the PSCS is potentially misleading; therefore, they must be removed.

Response: *A description of the development of soil representative levels is presented in the RI Report Part II, Section 4.2.1 Characterization of Representative Soil Chemistry in the EMF Study Area. As noted in the referenced section, EPA's levels are used in the RI to assess potential EMF effects. In addition to the evaluations presented in Section 4.2, other relevant sections of the report have been revised to reflect the background soil numbers developed by EPA , specifically Section 4.3 Surface Soils also reflects the background levels developed by EPA.*

86. Figure 4.4-1

The color-filled contours in this figure are misleading. The breakpoint between blue and no color appears to have been chosen to give the impression that the arsenic plume does not reach Swanson Road Spring, Batiste Spring, and the Portneuf River, which in fact it does, as shown by the posted concentrations. The arsenic concentration of 0.04 mg/l used as the blue/no color breakpoint has no particular significance. A breakpoint of 0.01 mg/l would be in keeping with the pattern established by the other breakpoint used in the figure; the background concentration in wells around the periphery of the site appears to be about 0.002 to 0.006 mg/l; the MCL is 0.05 mg/l, and the 10^{-4} risk concentration for drinking water is 0.004 mg/l. Revise the figure to avoid the misleading impression.

Response: *The distribution of arsenic in shallow groundwater, shown on Figure 4.4-1 in the PSCS, is now shown in Figure 4.4-14 in the RI Report. The construction of the latter figure addresses the items listed in this comment. The color contouring of the mean arsenic concentrations includes a breakpoint between the blue and no color as the background for the Bannock Range groundwater (labeled - 0.018 mg/L). The labeled purple line represents a concentration of 0.01 mg/L. The labeled breakpoint between the dark and light green colors represents the MCL for arsenic (0.05 mg/L).*

91. Section 4.4.1.1, Selection of Representative Wells

The location of a well with respect to a potential source area in a hydrogeographic regimen, and a well's general chemistry, are important qualifying considerations when selecting wells to represent the general water quality around a hazardous waste site. However, the main reason for defining the representative groundwater chemistry is to have a set of benchmarks to use in determining the nature and extent of contamination at a site. Therefore, an even more important consideration is the level of characteristic site contaminants in a candidate well, particularly when a well is close to, and potentially impacted by, suspected source areas. Several of the 16 wells selected as representative in this section fail the latter test and cannot be considered representative.

As noted in the PSCS, many inorganic chemicals are present at elevated concentrations in various potential source materials and in the soils at the site. Of those, the chemicals that are the most mobile in the subsurface, and therefore most likely to appear in the groundwater, are the alkaline metals and the transition elements that form oxyanions because these chemical species are attenuated little, if at all, by the alkaline soils at the site. Arsenic, boron, and phosphorus are transition elements that form oxyanions, and arsenic and phosphorus also have been identified in the PSCS as indicator chemicals for the site. Wells 120 and 130 have mean concentrations of orthophosphate and total phosphorus 50 and 10 times higher than the other representative wells. Arsenic concentrations in these wells are two to six times higher and boron concentrations are two to four times higher than in the adjacent groundwater regimens (Michaud Flats and Bannock Range). These data indicate that wells 120 and 130 have been influenced by site-related contamination and cannot be used to determine representative groundwater chemistry.

Several other wells, 101, 102, 305, Idaho Power, PEI-1, and PEI-6, also have mean concentrations for one or more chemicals that are substantially higher than the concentrations for the remaining representative wells, which also makes these wells suspect. Some of these values may be artifacts of the way mean concentrations were calculated, and many of the mean concentrations (aluminum, boron, copper, iron, manganese, mercury, thallium, vanadium, and zinc) in Table 4.4-3 for PEI-1 and PEI-6 appear to be inconsistent with the results for individual samples reported in Appendix H. The suspect concentrations for all of these wells must be resolved before these wells can be used to determine representative groundwater chemistry.

The wells included in the representative groundwater database should be reviewed and expanded to include as many wells that are clearly not affected by the site as possible. A number of new wells around the periphery of the site appear to be unaffected by the site and probably could be added to the database. A database that is broadly based spatially as well as temporally will better account for the natural variability in the groundwater chemistry.

Response: *This comment is essentially the same as comment 5. Please refer to response to comment 5 above.*

96. Section 4.4.1.3

Comparisons with representative groundwater chemistry must encompass all of the parameters investigated, not just common ions and metals. In particular, pH, temperature, and radionuclides should not be overlooked. The representative ranges of chemical and radiological constituents in the groundwater must be revised in accordance with previous comments before these ranges can be used to classify wells as impacted or unimpacted. The definition of an unimpacted well must be expanded to include physical and radiological parameters. Provide a way for the reader to review the classification decision made for each well. This should be done in two ways. 1) Provide a table with parameter names and corresponding representative ranges as row headings and the wells as columns. For each well, show the frequency of detection (detects/samples analyzed), the frequency with which each parameter exceeded its representative range, and the maximum value observed. Indicate each well's classification, and highlight any exceedances of the representative ranges. 2) Provide a map showing all of the wells suing different symbols for impacted and unimpacted wells.

Response: *Summary tables have been prepared and are included in the RI Report Part II, Section 4.4. The summary tables provide a comparison of mean concentrations of each parameter in each well with the 95% UCL for representative groundwater, rather than a comparison range.*

Section 4.4.3 of the RI Report contains a detailed description of the representative (background) groundwater chemistry for the 17 wells used to define background. In addition to common ions and metals, subsections address physical parameters (4.4.3.3; pH, specific conductance and temperature), nutrients and fluoride (4.4.3.4), radiological parameters (4.4.3.6) and organic compounds (4.4.3.7) with respect to the definition of representative groundwater chemistry. Mean concentrations fot the 17 wells are listed in Tables 4.4-1, 4.4-2, and 4.4-3.

Figure 4.4-3 shows the locations of the 17 wells utilized to develop background. The locations of these wells and all other wells at or near the facilities, including impacted wells and unimpacted wells that were not part of the representative monitoring well network, are shown on Figure 4.4-2.

97. Sections 4.4.2 through 4.4.4

These sections present large amounts of several types of information (groundwater flow patterns, data on the physical and chemical properties of the groundwater, and the spatial relationships between wells and potential source areas) that must be correlated and integrated in order to understand the groundwater quality and the nature and extent of contamination at the EMF site. These sections also present a number of interpretations and draw a number of conclusions based on the information presented. Unfortunately, the information is not presented in an integrated way that allows the reader to properly evaluate the interpretations and conclusions presented. As a result, it was not feasible to attempt to review all of the detailed interpretations and conclusions presented in these sections. It is also likely that some of these interpretations and conclusions may

change when the representative groundwater concentrations are revised in accordance with previous comments. Therefore, detailed reviews of these sections will not be performed until the representative groundwater levels are revised and the data are presented in a more integrated and comprehensible manner.

What is needed is a series of detailed maps with each individual map showing the site layout, groundwater contours, and the concentrations of a single chemical, or pH, redox, or temperature values. This should be done for all chemicals except those that do not exceed representative levels (as redefined by the earlier comments). Use of black and white line drawings to show the site layout and the groundwater contours (like many of the existing maps) and color-filled contours to show the chemical concentrations should provide an effective presentation. A 10- to 20-step color scale will probably be needed to provide sufficient detail in the concentration patterns. Average concentrations, calculated as recommended in RAGS (Part A) and described above, should provide a representative picture of groundwater quality, at least for the FMC facility. Contaminant levels seem to be more variable at the Simplot facility, perhaps due to changes in the way the gypstacks are used. Maps showing concentration patterns round by round may be needed for some contaminants to understand the nature, extent, and dynamics of groundwater contamination originating from the Simplot facility. Separate maps for the FMC and Simplot facility would be desirable for contaminants, like the primary gypstack contaminants, that have large concentration differences between the two facilities to avoid washing out the concentration patterns at the FMC facility. Posting of well numbers and parameter values would also be helpful. Such a presentation will allow the reader to more easily follow the discussion and evaluate the interpretations presented and the conclusions drawn.

Response: *The discussion, interpretation, tabulation and graphical depiction of groundwater chemistry data presented in Section 4.4 of the RI Report were revised considerably from the PSCS and were intended to address this comment. The RI Report provides all of the pertinent data and information with respect to the nature and extent of site-related constituents in groundwater and the overall presentation represents the approach considered most appropriate, although it is clearly not the only approach for presenting the data.*

RI Report Part II Section 4.4 includes changes to the PSCS in response to this and other related comments, namely the inclusion of color mean isoconcentrations maps for selected chemicals. Mean values used in contouring were calculated according to RAGS (Part A). Most constituents were plotted, however, many metals were unique to the former east overflow pond, and were, therefore, not contoured.

The following specific recommendations were not made for the reasons cited: (1) the round-by-round concentration patterns for Simplot were not mapped because the only significant temporal variation at Simplot was at Well 318, associated with the former east overflow pond; (2) 10 to 20-step color-filled contours are not supported by the dataset, fewer contour intervals were used, but these were selected to maximize the information portrayed in the figures; (3) numbers were not

posted by each well as this would have made the figures illegible. Also refer to response to Comment 86 above.

98. Page 4.4-16

The discussion of the NPL site upstream should include a reference. Both McCarty's/Pacific Hide and Fur and the Union Pacific Railroad Sludge Pit are upstream from the Eastern Michaud Flats site.

Response: *The text in the RI Report on page 4.4-13 identifies the site upstream as the Union Pacific NPL site. The text will be revised to reflect the proper name of this NPL site - Union Pacific Railroad Sludge Pit.*

99. Page 4.4-18, Paragraph 3

The upward vertical gradients have not completely prevented downward migration of site-related contaminants as indicated in this paragraph. Two exceptions noted in the report on Page 4.4-28 are elevated arsenic concentrations found in deeper wells 103 and 117. Revise this paragraph accordingly.

Response: *The text of the RI Report discussing the nature and extent of contamination in groundwater at the FMC facility (pages 4.4-14 to 23) does not contain a statement that upward vertical gradients prevent downward migration of site-related constituents, as was presented on page 4.4-18 of the PSCS. However, on page 4.4-5 of the RI Report, the second sentence of the second full paragraph does make such an assertion. The proposed revision of this sentence reads as follows: "Upward vertical gradients and/or the presence of confining strata appear to have effectively precluded downward vertical migration of dissolved constituents in many areas, and minimized such transport in other areas."*

100. Section 4.4.2.2 and Table 4.4-8

The EMF site is a large heterogeneous site, and most of the chemicals that have been investigated at the site are present at elevated concentrations in one or more of the feedstocks, byproducts, or waste streams managed at the site. Chemicals that are present, even a few times, at concentrations substantially above their representative levels, like barium, mercury and nickel, could reflect actual contamination. The elevated levels of these chemicals should be evaluated in the context in which they occur, not dismissed out of hand.

Response: *None of the elevated levels were dismissed out of hand. Elevated levels were evaluated in the context of the site sources (waste streams, feedstocks, and byproducts), groundwater flow, geology, geochemistry, and other factors. If there are no plausible sources or pathways, past or present, to explain the presence of these constituents, the only alternatives are to*

(1) ascribe every representative level exceedance to the EMF site or (2) accept that the statistics and natural variability adequately account for 95% of the observations and that 5% of the observations will NATURALLY exceed representative levels. (Alternatives 1 and 2 assume absolutely no uncertainty in the data from sampling, lab handling, analysis, or other potential errors, human or otherwise.)

For instance, a number of metals found elevated only in the immediate vicinity of the Simplot former east overflow pond (aluminum, cadmium, chromium, copper, iron, lead, molybdenum, nickel, vanadium and zinc) are discussed in the RI Report (Section 4.4.5.7) with respect to this source. In addition, Tables 4.4-4 through -18 in the RI Report depict concentration data for all parameters for all wells versus the appropriate representative levels.

Due to the fact that EMF is "a large heterogeneous site", natural variability should be expected to be as great as the representative levels are heterogeneous.

105. Page 4.4-36, Paragraph 3 and Tables 4.4-3 and 4.4-14

A number of constituents, including copper, vanadium, and zinc, were erroneously eliminated as site-related groundwater constituents. This appears to have resulted from the use of mean values for wells PEI-1, PEI-6, and 106 (mercury) in Table 4.4-3, and in the derivation of representative concentrations that do not correspond to the data included in Appendix H. Many of the mean concentrations for PEI-6 in Table 4.4-14 are different from those in Table 4.4-3. Perhaps some analytical results were revalidated after Table 4.4-3 was assembled, and the revisions were not incorporated into the table or the representative concentrations. Also, PEI-4 is identified as a representative well in Table 4.4-14 but not in Table 4.4-3.

Response: *As discussed in Section 4.5.7 of the RI Report, copper, vanadium, and zinc were not erroneously eliminated as EMF-related constituents in groundwater. They were ascribed to the former east overflow pond while operational. No other EMF-related sources of these constituents to groundwater have been identified.*

Discrepancies in mean metals concentrations for well PEI-6 have been addressed in the RI Report (see Table 4.4-1). PEI-4 is not identified as a representative well in the RI Report.

117. Page 4.5-4, Paragraph 3

While surface runoff from the site itself may not reach the river, surface runoff from off-site areas subject to aerial deposition of site-related contaminants can occur. Therefore, the aerial deposition/surface runoff pathway cannot be dismissed.

Response: *Surface water runoff from off-site areas subject to aerial deposition of site-related constituents was addressed in Sections 4.5 and 5.1 of the RI Report. This potential pathway is*

addressed on pages 4.5-2, 4.5-26, several places within Section 4.5.2, and page 5.1-2. Based on the analysis of the surface water and sediment data presented in Section 4.5, surface runoff from affected off-site soils was not demonstrated to be a significant migration pathway.

118. Page 4.5-8, Paragraph 5

The stated indication that there is no longer an impact on the Portneuf River from the drainage ditch water appears premature. The Phase I elevated sample was a grab sample, while the Phase II samples were time composites (Page 4.5-7, Paragraph 4). It is not stated whether the EPA sample (Page 4.5-8, Paragraph 3) was a grab or composite sample. Comparing grab with time composite samples may not be applicable if constituent concentrations vary widely over the composite sample time period. In addition, the results of the investigation regarding changes in facility operations should be examined prior to suggesting that the Phase I drainage ditch water sample analytical results no longer represent site operating practices.

Response: *Although there have been upset conditions that have introduced wastewater (other than the typical noncontact cooling water) into the IWW system, under normal operating conditions there is no expectation that extended "peaks" of constituents would be present in the IWW discharge. Therefore, time-composited samples do not subdue "peaks" and are the best representation of average quality of water discharged through the IWW ditch. With respect to the RI, the "cummulative impact" of upset events was investigated directly through the surface water and sediment investigations presented in the RI Part II, Section 4.5. Available information on the source and frequency of elevated constituents in the IWW Ditch water are provided in RI Report Part II Section 4.2.3.1 and in Appendix L.*

119. Section 4.5.1.2 and Table 4.5-1

The text and table will need to be revised after the representative groundwater concentrations are revised in accordance with previous comments.

Response: *As discussed in the responses to PSCS comments 5 and 91, the representative groundwater concentrations presented in the RI Report were recalculated with an updated representative well network and using a methodology acceptable to EPA. The text in Section 4.5.1.2 and the content of Table 4.5-1, as presented in the PSCS, are not included in the RI Report.*

124. Page 4.5-12, Bullet 5 and Page 4.5-31, Paragraph 2

There is no evidence in the site data that the fish farms are contributing phosphate to the river drainage (samples SW05E and F), but the site certainly is (samples SW17, -15 and -14). Revise accordingly.

Response: *The statement is based on a reference (Perry, 1977) found in the RI Report Part II, Appendix A, page A-16 that supports the conclusion that fish farms contribute phosphate to surface water. There is no reason to alter the statements made in the PSCS.*

131. Page 4.5-35, Paragraph 3

Transport of particulate matter from the EMF site to the river via surface runoff or the IWW ditch is only one of several migration pathways by which site-related contaminants could find their way into river sediments. Other migration pathways that must be considered are direct aerial deposition to the river, springs, in the Fort Hall Bottoms, runoff from off-site areas that may have received deposition of airborne contaminants, and migration of contaminants to the river via groundwater. Site-related contaminants, including contaminants other than those listed in paragraph 3, were shown to reach the river via the latter pathway in Sections 4.4 and 4.5 of the PSCS report. Therefore, the presence or absence of just the contaminants listed in paragraph 3 cannot be used as the primary criteria for determining whether sediment contamination is, or could be, site related. Reliance on the absence of this incomplete list of site-related contaminants throughout Section 4.5.3 to conclude that a location does not show site related impacts is misleading and must be revised.

Response: *The "incomplete list" was not relied upon to assess potential site-related constituents at the sediment sample locations. However, this discussion in the PSCS is not included in the corresponding section in the RI Report, refer to the RI Report Part II, Section 4.5.2 Nature and Extent of EMF-Related Constituents in Sediments.*

134. Page 4.5-36, 3rd and 5th Bullets

These conclusions are not supported by the data. Several constituents, including arsenic, barium, beryllium, boron, chromium, copper, iron, nickel, phosphorus, and zinc, appear to be above the average river sediment levels in one or more of the four samples (SDB1 through SDC4) collected from the Fort Hall Bottoms. Many of these constituents are site related, and several were shown in Section 4.4 to be migrating toward the river in groundwater and in Section 4.5.2 to be present at elevated concentrations in surface water samples from Swanson Road and Batiste Springs.

Response: *The statements made in the 3rd and 5th bullets on page 4.5-36 of the PSCS were not carried forward to the RI Report. Also, comparisons of constituent concentrations in sediments to representative levels in soils have been deleted from the Executive Summary of the RI Report (refer to response to RI comment 13).*

137. Page 4.5-40, Last Paragraph

SD19 has higher levels of chromium, phosphorus, selenium, vanadium, and zinc than nearby upstream samples SD20 through SDA2. These chemicals are present at substantial levels in

gypsum slurry and gypsum slurry liquid (Table 4.2.2-1) and are all relatively mobile in the subsurface. Also, Figures 4.4-2 through 4.4-5 indicate that the groundwater plume from the gypstacks comes very close to the river at this point. This pattern suggests the possibility of site-related contamination at this location.

Response: *EMF-related groundwater does not discharge to the river near SD19 because the water levels in the river at this location are higher than groundwater levels in the aquifer. This condition makes it impossible for this groundwater to discharge to the river upstream or at the location near SD19.*

Statistical comparisons of upstream sediment chemistry data to SD-19 sediment results, presented in Section 4.5.2.2 of the RI Report (pages 4.5-32 and 33) show no evidence that the concentrations of the listed constituents at SD-19 are elevated above upstream concentrations. In addition, the concentrations of many constituents are higher at some upstream locations than SD-19 (see Table 4.5-9 in the RI Report). Lastly, the difference in sample characteristics between SD-19 (silty clay) and SD-20 (sand with silt and gravel) suggest that sediment chemistries may also be different.

140. Section 4.5.3.3

Gross alpha and gross beta activities are higher in SD19 than in any of the nearby upstream sediments from SD20 to SDA2. Substantial gross alpha and gross beta activities are present in gypsum slurry and gypsum slurry liquid. This is further evidence of potential site related impacts at this location. See comment on Page 4.5-40, last paragraph, above.

Response: See response to Comment No. 137.

142. Page 4.5-50, Paragraph 1

The fact that similar findings were obtained 12 months apart also could be explained by the fact that the results were obtained during the same part of the annual river cycle. Sediments deposited one year could have been washed downstream by the spring snow melt then replaced by fresh sediment.

Response: *The RI Report does not include a conclusion regarding the relative immobility or mobility of sediments at sample location SD-17 as was presented in the PSCS, refer to the RI Report Part II, Section 4.5.2.3 River Sediments - Detailed Discussion.*