EG&G MOUND-29-04 -03 -06 - -9501090001

Environmental Restoration Program

OPERABLE UNIT 9 HYDROGEOLOGIC INVESTIGATION: BURIED VALLEY AQUIFER REPORT

MOUND PLANT
MIAMISBURG, OHIO

September 1994

Technical Memorandum
(Revision 1)

U. S. Department of Energy
Albuquerque Operations Office

Environmental Restoration Program
EG&G Mound Applied Technologies

F- OU-9
HYDRO

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30 September 1994

EG&G Mound Applied Technologies, Inc.
Attn: Mr. James Rigano
Mail Stop OSE-2
P.O. Box 3000
Miamisburg, Ohio 45343-3000

RE: BOA No. 24251, Task Order No. 16710
Operable Unit 9 Hydrogeologic Investigations
Buried Valley Aquifer Report
Data supplement

RFW WO # 05376-039-001-0500

Dear Mr. Rigano:

Enclosed are complete paper and electronic copies of the data used to compile the Operable Unit 9 Hydrogeologic Investigations: Buried Valley Aquifer Report [Technical Memorandum, Revision 1, September 1994]. Data summaries were provided in that report. These data include groundwater elevation and river stage from continuous monitoring; monthly site-wide measurements; precipitation data obtained from the U.S. geological Survey, Columbus, Ohio; and precipitation data obtained from the Mound Plant. The data files are in either Lotus or ASCII format, as described in the report. Data files are compressed; to decompress them type PKUNZIP.filename.

If you have any questions regarding this matter, please call Bill Criswell at (505) 884-5050 or the Alternate Project Manager, John Price, at (513) 825-3440.

Very truly yours,

ROY F. WESTON, INC.

for William M Little

John W. Thorsen, P.E.
Project Manager

CWC/gy
Attachment

pc w/o: M. Williams
A. Bray

29-04-03-06
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LETTERS\RIG094A.CWC 09/30/94

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F-049
HYDRO

SEP 28 1994

Ms. Diane Spencer
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RECEIVED
OCT 03 1994
Ans'd.....

Mr. Brian Nickel
Ohio EPA
401 E. Fifth Street
Dayton, OH 45402

Dear Ms. Spencer and Mr. Nickel:

As a result of a telephone conversation between Brian Nickel of OEPA and Alec Bay of EG&G regarding the original comment responses, the Buried Valley Report and the associated comment responses have been changed. The enclosed response to comments replaces the earlier response to comments. DOE and EG&G comments are also included for your information. We anticipate the reports will be delivered by the end of September.

If you have any questions, please contact me at (513) 865-3597.

Sincerely,

Arthur W. Kleinrath

Arthur W. Kleinrath
Project Engineer Team Leader

Enclosures

cc w/o enclosures:
Monte A. Williams, EG&G Mound
James J. Zahora, EG&G Mound
William A. Rummel, DOE/Geotech

ENVIRONMENTAL RESTORATION PROGRAM

OPERABLE UNIT 9
HYDROGEOLOGIC INVESTIGATION:
BURIED VALLEY AQUIFER REPORT

MOUND PLANT
MIAMISBURG, OHIO

September 1994

U.S. DEPARTMENT OF ENERGY
ALBUQUERQUE OPERATIONS OFFICE

ENVIRONMENTAL RESTORATION PROGRAM
EG&G MOUND APPLIED TECHNOLOGIES

TECHNICAL MEMORANDUM
(REVISION 1)

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ACRONYMS

BVA	Buried Valley aquifer
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FFA	Federal Facility Agreement
MGD	million gallons per day
MGY	million gallons per year
MSL	mean sea level
NPL	National Priority List (EPA)
OEPA	Ohio Environmental Protection Agency
OU	operable unit
PVC	polyvinyl chloride
QA	quality assurance
RI/FS	remedial investigation/feasibility study
USGS	U.S. Geological Survey

ACKNOWLEDGMENTS

This report was prepared by Roy F. Weston, Inc. Albuquerque, New Mexico, under basic ordering agreement 24251 with EG&G Mound Applied Technologies, Miamisburg, Ohio. Contributing authors include Roberta Bowen, Bill Criswell, Jan Curtis and Paul Darr. Technical support was provided by Mike Byrd and Clark Poore. Terran Corporation provided field and data management support including installation, maintenance and data collection of the river stage gauge and continuous water level monitoring equipment, and compilation of the bedrock topography and unconsolidated isopach maps. Graphics, technical editing and word processing were provided by the Albuquerque office, including technical editor Nancy Blackburn; graphic designers James MacCornack, Mary Reed and Darcel Sandland; word processors Gary Yuhas, Roberta Trujillo, and Linda Keith; and production coordinator Terry Whalen. Technical reviews were provided by William Little and Alec Bray, EG&G Mound Applied Technologies. Revision 1 was revised in response to comments from the U.S. Department of Energy, U.S. Environmental Protection Agency, and Ohio Environmental Protection Agency.

ES.1. EXECUTIVE SUMMARY

Operable Unit (OU) 9 is designated for site-wide studies that provide the framework for the remedial investigation/feasibility study (RI/FS). Investigations that are best conducted for the entire Mound Plant and its regional setting are included in OU 9. The hydrogeologic investigations address the hydrogeologic environment of Mound Plant and the nature and extent of groundwater contamination outside the plant boundaries. The characterization of potential source terms within the plant is generally deferred to other OU investigations. Due to the breath of scope of the OU 9 hydrogeologic investigations, the work required to fulfill the objectives is phased. Technical memoranda that describe methods and results of the OU 9 hydrogeologic investigations are subdivided into the following technical memoranda:

- Bedrock Report,
- Buried Valley Aquifer Report,
- Soil Chemistry Report, and
- Groundwater Sweeps Report.

This report is a technical memorandum of investigative work conducted as part of the OU 9 hydrogeologic investigations in accordance with the OU 9 Site-Wide Work Plan (DOE 1992a). It focuses on the groundwater flow system in the Buried Valley Aquifer on and adjacent to the Mound Plant. This system was described in the OU 9 Site Wide Work Plan to possibly consist of two major aquifer units separated by a glacial till that acted as an aquitard, an assumption not supported in this report. This report provides descriptions of the methodologies and results of work conducted to refine the knowledge of the physical characteristics of the system. The work described in this report includes:

- refinement of the lithologic and stratigraphic database of the Buried Valley Aquifer and tributary valley;
- determination of the nature and extent of the interbedded glacial till deposits within the Buried Valley Aquifer;
- determination of the geotechnical and hydraulic properties of the interbedded glacial till and outwash deposits of the Buried Valley Aquifer;
- definition of the regional water levels in the Buried Valley Aquifer and bedrock systems to calculate temporal variations and interconnections between units;
- determination of the recharge and discharge relationships between the Buried Valley Aquifer and the Great Miami River and the effects of pumping; and

- determination of the interconnection between the Buried Valley Aquifer and the bedrock flow system.

Field studies conducted for this investigation included seismic refraction surveys to define the depth and margins of the Buried Valley Aquifer, installation of monitoring wells and piezometers both on and off Mound Plant property, collection of geotechnical and mineralogical samples to define physical properties of the sediments, installation of a new stage gauge on the Great Miami River slightly downstream from Mound Plant, installation of continuous groundwater level monitoring equipment at 18 select locations, and monthly collection of groundwater elevations across the entire new groundwater monitoring network.

ES.2. LITHOLOGY AND STRATIGRAPHY

The OU 9 drilling program gathered geologic information over a larger area than any previous drilling program. Additionally, on and adjacent to Mound Plant, information on the subsurface materials have been gathered to enhance existing depictions of stratigraphy. All this information is assimilated into the geologic cross sections presented here. These cross sections illustrate the revised conceptual model of the Buried Valley Aquifer, including the following:

- The subsurface expression of the Buried Valley Aquifer is offset from the modern Great Miami River as evidenced by recent exploratory drillings and seismic refraction surveys (Figure ES.1).
- Numerous glacial till lenses present throughout the buried valley do not appear to form continuous aquitards. The till units within the buried valley are thicker and more continuous north of the plant and thinner and discontinuous south of the plant. This appears to affect hydraulic conductivities as they are greater in the southern areas and reduced in the northern areas.
- A precipitously narrow subsurface gorge appears to exist beneath the modern Mound Plant tributary valley, but is not considered to be a groundwater flow path as the gorge is locally known to be filled with dense glacial till and the outwash deposits beneath it are not saturated.

ES.3. HYDROLOGY OF THE BURIED VALLEY AQUIFER

The Buried Valley Aquifer on and adjacent to Mound Plant is conveniently subdivided into 4 blocks to estimate a preliminary water budget (Figure ES.2). The preliminary water budget of the Buried Valley Aquifer on and adjacent to Mound Plant yields the relative magnitude and sources of recharge. Within the vicinity of the Mound Plant production wells in Block 3, infiltration from the Miami-Erie Canal appears to be the greatest single source of recharge. Estimates of infiltration are based on measured stream infiltration, but without regard to evapotranspiration. Considering the currently available data,

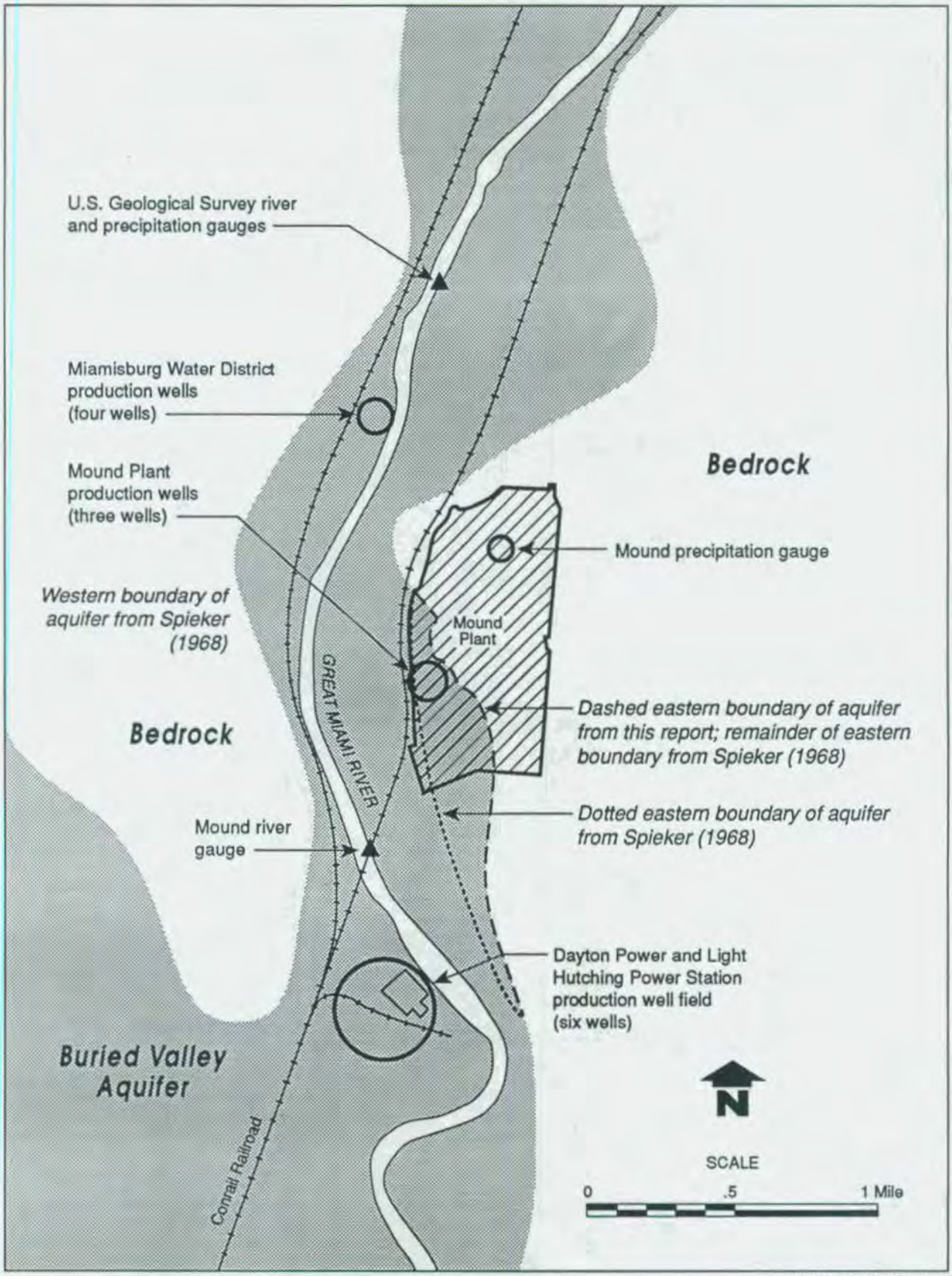

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Figure ES.1. Revised geometry of Buried Valley Aquifer in vicinity of Mound Plant.

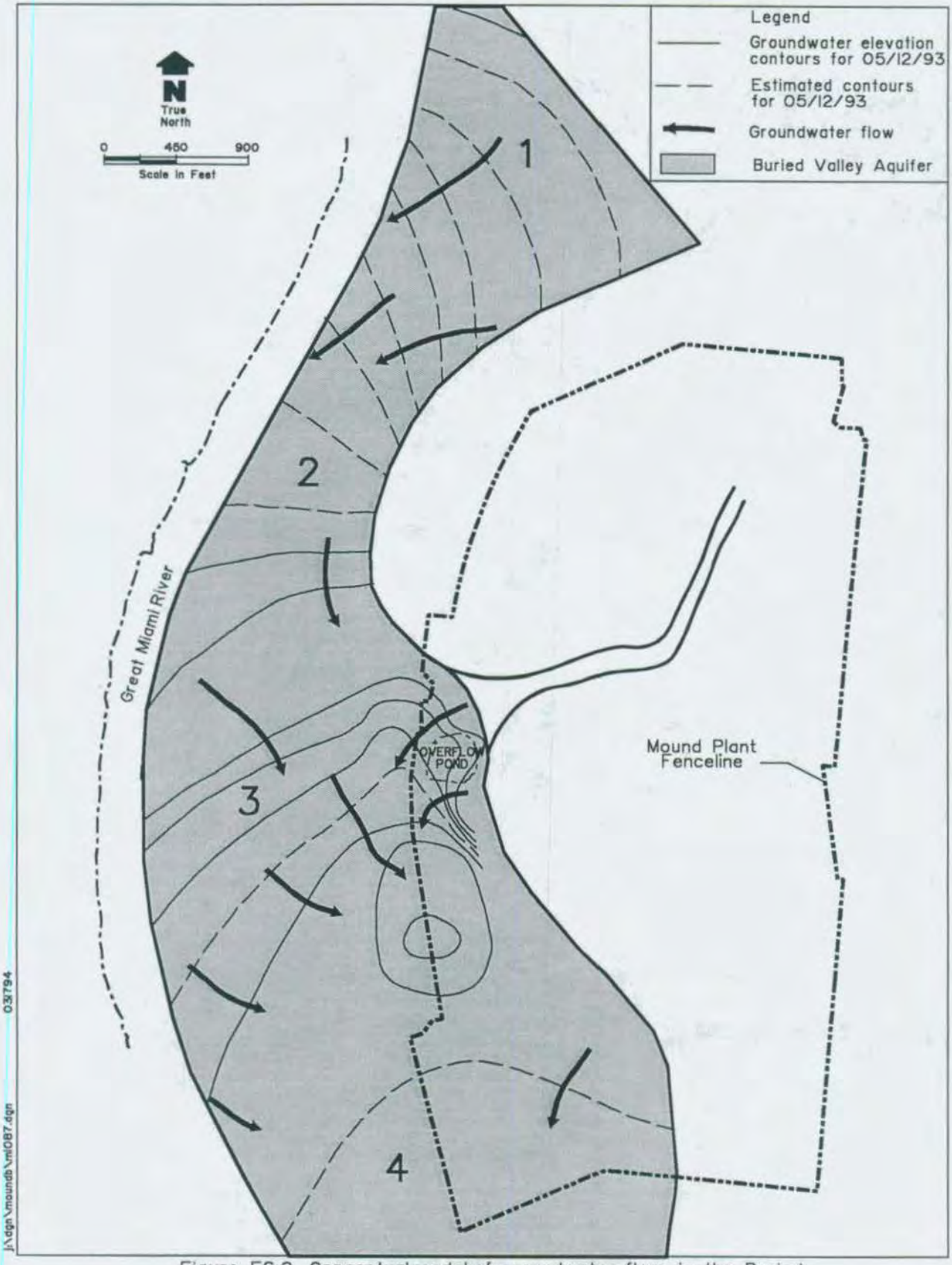

Figure ES.2. Conceptual model of groundwater flow in the Buried Valley Aquifer on and adjacent to Mound Plant.

the relative importance of other sources are ranked accordingly: the southerly gradient of the Buried Valley Aquifer provides the second greatest contribution followed by subflow from the plant tributary valley, leakage from the fractured bedrock, and infiltration of precipitation. Inflow from the Great Miami River appears to provide a relatively minor component to the preliminary budget.

Groundwater levels in well clusters close to the valley margin indicate that groundwater from the bedrock may be also recharging the outwash layers, but groundwater movement in the bedrock has such a smaller volume and moves at a much slower average velocity than it would in outwash because of the significantly lower permeability of the bedrock (DOE 1994b). For well clusters near the middle of the valley, the vertical gradients between the Buried Valley Aquifer and the bedrock is downward into the bedrock. There is no evidence that there is a continuous flow path from the bedrock in the Main or SM/PP Hills to the bedrock in the main valley and from there upward into the Buried Valley Aquifer.

The groundwater flow map indicates that groundwater levels are greatest near the Great Miami River and decrease toward the Mound Plant production wells. This conceptual model suggests that the river, by elevating groundwater levels in its vicinity, is also a barrier to westward groundwater flow from the Plant site. The magnitude of this groundwater mound changes as a function of river stage, and decreases with distance from the river. The fluctuation in river stage directly impacts the groundwater levels in monitoring wells throughout the Buried Valley Aquifer by changing the elevation of the groundwater discharge point at the river.

ES.4. REVISED CONCEPTUAL MODEL OF THE BURIED VALLEY AQUIFER

This report presents a large body of evidence that serves to refine the conceptual model of the Buried Valley Aquifer. The revision significantly changes the conceptual model to one in which the Buried Valley Aquifer is viewed as a single unit. Glacial tills are present throughout the buried valley, but they do not serve as aquitards to groundwater flow. There appear to be three geographic settings which affect groundwater in the Buried Valley Aquifer adjacent to Mound Plant. North of Mound Plant in the City of Miamisburg (Block 1), the valley is relatively wide, with hydraulic gradients indicating flow is southward. The flow in this area is probably controlled by the river stage and the pumping of the municipal production wells. In Blocks 1 and 2, groundwater flow in the Buried Valley Aquifer appears to be controlled by the narrowing of the river valley and the shallower depth to bedrock. The smaller cross sectional area results in a steepening of the hydraulic gradients in this area. In Block 3 west of Mound Plant (Figure ES.2), pumping for the Mound Plant water supply has disrupted the southwest flow direction observed in adjacent areas. The man-made influences that have impacted groundwater flow in the vicinity of Mound Plant include 1) pumping activity at Mound Plant production wells, which creates

a potentiometric low along the western edge of Mound Plant and induces groundwater flow toward that low; and 2) sporadic pumping at Miamisburg Municipal Well No. 2 (0912), which may create a local potentiometric low and locally induce groundwater flow to the northwest. In the far southern part of the Buried Valley Aquifer (Block 4), flow is from the Great Miami River and bedrock toward the south.

ES.5. SUMMARY OF RECOMMENDATIONS

As a result of data analysis for this report it is apparent that the conceptual model of groundwater flow within the Buried Valley Aquifer is quite different than the one proposed in the OU 9 Workplan (DOE 1992a). The consequences of this revised conceptual model is that data gaps and additional data needs are identified. The following data gaps are identified:

- Infiltration rates from the Miami-Erie Canal;
- Water levels and gradients west of the Main Hill and southwest of the SM/PP Hill;
- Discharge rates and resulting water levels in the Miamisburg and Dayton Power and Light well fields; and
- Discharge for the Great Miami River at the Mound Plant gauge.

Additional work is recommended to fill these data gaps:

- Install weirs at either end of the Miami-Erie Canal and monitor the changes in flow with time in the canal.
- Install shallow piezometers west of the Main Hill and southwest of the SM/PP Hill in the Buried Valley Aquifer. Monitor water levels with time and response to river stage rises.
- Obtain discharge records and water level data for production wells in Miamisburg and at the Hutching Power Station. If necessary, install piezometers to evaluate the extent of the drawdown cone from both well fields.
- Develop a rating curve and cross section for the Mound Plant gauge at the Miami River. Determine if losses in flow between the USGS gauge and the Mound Plant gauge can be determined with any confidence.

SECTION 1

1. INTRODUCTION

The Mound Plant in Miamisburg, Ohio (Figure 1.1) is operated for the U.S. Department of Energy (DOE) by EG&G Mound Applied Technologies. The plant started operation in 1949 and is an integrated research, development, and production facility that operates in support of the DOE weapons and energy programs (DOE 1993a).

The Mound Plant was placed on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, also known as Superfund) National Priorities List (NPL) on November 21, 1989, (54 Federal Register 48184). The facility was added to the NPL as a consequence of historic disposal practices and releases of contaminants to the environment. Pursuant to its NPL status, the DOE signed a CERCLA Section 120 Federal Facility Agreement (FFA) with the U.S. Environmental Protection Agency (EPA) that became effective October 11, 1990 (Administrative Docket #VW-'90-C-075). The Ohio EPA (OEPA) became a signatory to the agreement in July 1993. The terms of the FFA require that the DOE develop and implement remedial investigations and feasibility studies and conduct interim remedial actions to ensure that environmental impacts associated with past and present activities at the site are thoroughly investigated and appropriate action is taken to protect the public health, welfare, and the environment.

Due to the number of potential release sites (more than 300) and the overall complexity of the remedial investigation/feasibility study (RI/FS), the site is divided into nine operable units (OUs) to facilitate program management (DOE 1992a). Currently, six OUs remain; the others have been closed and the sites reassigned. Operable Unit 9 is designated for site-wide studies that provide the framework for the RI/FS. Investigations that are best conducted for the entire Mound Plant and its regional setting are included in OU 9. As described in the OU 9 Site-Wide Work Plan (DOE 1992a), the hydrogeologic investigations address the hydrogeologic environment of Mound Plant and the nature and extent of groundwater contamination outside the plant boundaries. The characterization of potential source terms within the plant is generally deferred to other OU investigations. Because of the scope of the OU 9 hydrogeologic investigations, the work required to fulfill the objectives is phased. Reports that describe methods and results of the OU 9 hydrogeologic investigations are subdivided into the following technical memoranda:

- Well Information Report,
- Bedrock Report,
- Buried Valley Aquifer Report,

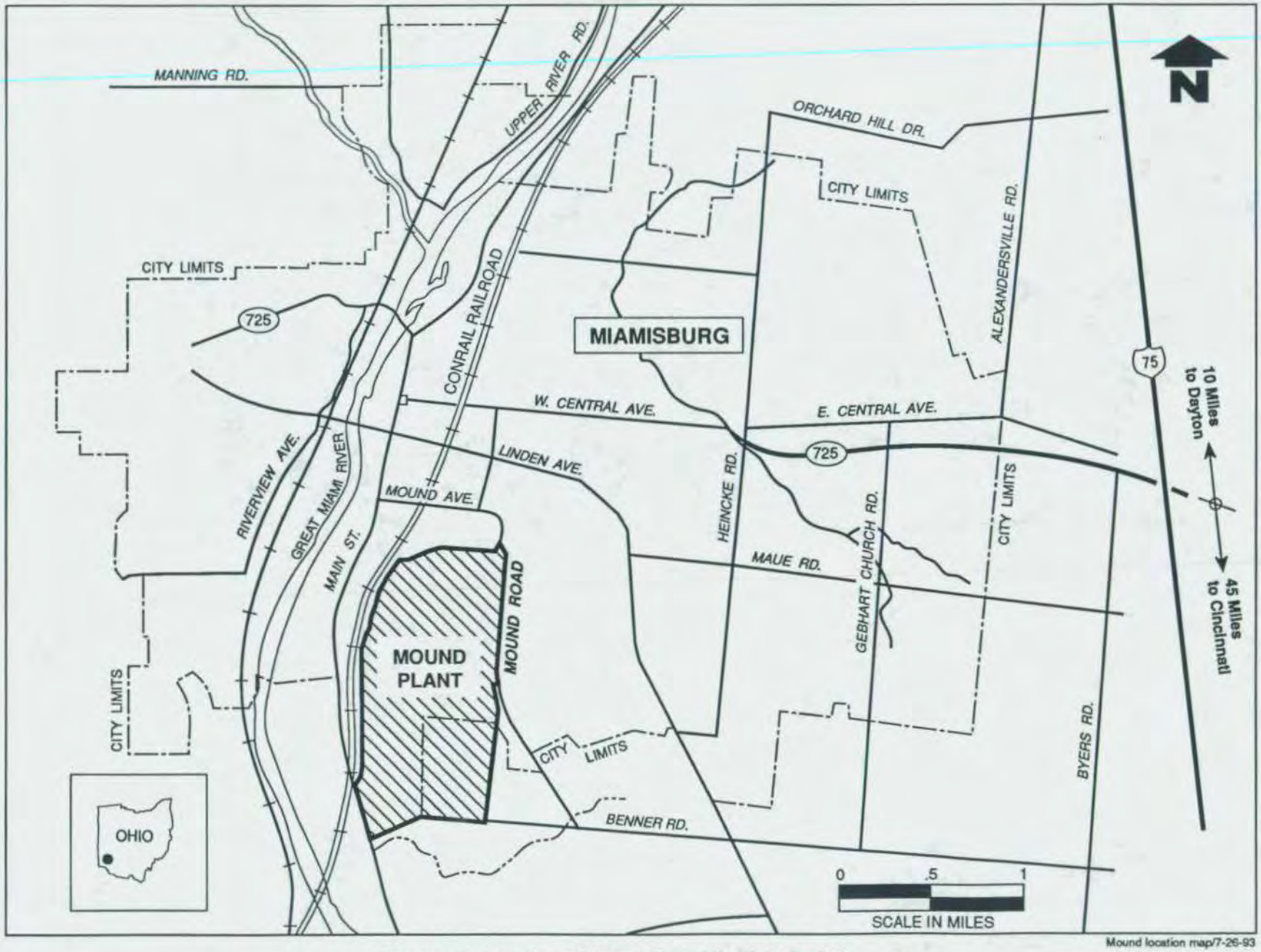

Figure 1.1. Location of Mound Plant, Miamisburg, Ohio.

- Soil Chemistry Report, and
- Groundwater Sweeps Report.

1.1. SCOPE OF REPORT

This technical memorandum of investigative work was developed as part of the OU 9 hydrogeologic investigations in accordance with the OU 9 Site-Wide Work Plan (DOE 1992a). It focuses on the groundwater flow system in the Buried Valley Aquifer and contiguous deposits on and adjacent to the Mound Plant. This system was described in the OU 9 Site Wide Work Plan to possibly consist of two major aquifer units separated by a glacial till that acted as an aquitard, an assumption not supported in this report. This report provides descriptions of the methodologies and results of work conducted to refine the knowledge of the physical characteristics of the system. The work described in this report includes:

- refinement of the lithologic and stratigraphic database of the Buried Valley Aquifer and tributary valley;
- determination of the nature and extent of the interbedded glacial till deposits within the Buried Valley Aquifer;
- determination of the geotechnical and hydraulic properties of the interbedded glacial till and outwash deposits of the Buried Valley Aquifer;
- definition of the regional water levels in the Buried Valley Aquifer and bedrock systems to calculate temporal variations;
- determination of the recharge and discharge relationships between the Buried Valley Aquifer and the Great Miami River and the effects of pumping; and
- determination of the interconnection between the Buried Valley Aquifer and the bedrock flow system.

Section 2 summarizes the field methods of the investigations, and provides summaries of the new monitoring wells and piezometers installed, methods of water level measurements, installation of new river stage gauge and other continuous monitoring equipment, and other investigations relevant to the results presented in this report. Specifications of new OU 9 monitoring wells and piezometers are included in Appendix A.

Section 3 describes the methods and results of the seismic refraction surveys performed. Detailed cross sections along each transect are included in Appendix B.

Section 4 describes the methods and results of the geotechnical and clay mineralogy analyses performed. Laboratory reports are reproduced in Appendix C.

Section 5 presents new geologic cross sections, a revised bedrock topography map, and a revised isopach map of unconsolidated deposits.

Section 6 described results of water level analysis, and evaluates interaction between units of the Buried Valley Aquifer, the Great Miami River and the bedrock flow system. A preliminary water budget for the Buried Valley Aquifer on and adjacent to Mound Plant is presented.

Section 7 presents the revised conceptual model of the Buried Valley Aquifer and contiguous deposits.

Summaries of the recommendations for additional work are given in Section 8. These recommendations are discussed in the preceding sections as appropriate and are summarized in Section 8 for ease of reference.

Companion reports provide additional data and information relevant to this investigation. The OU 9 Hydrogeologic Investigation: Well Information Report (DOE 1994a) provides lithologic and completion logs for all new monitoring wells and piezometers referenced in this report, as well as data for the new survey conducted. Older well logs are included in the Site Scoping Report: Volume 2 - Geologic Log and Well Information Report (DOE 1992c). The OU 9 Hydrogeologic Investigation: Bedrock Report (DOE 1994b) provides lithologic and stratigraphic data on the bedrock, as well as results and interpretations of the fracture studies and borehole geophysics conducted. The OU 9 Hydrogeologic Investigation: Soil Chemistry Report (DOE 1994c) provides analytical data on samples collected as part of the monitoring well and piezometer installations.

1.2. OVERVIEW OF PLANT SETTING AND PHYSICAL CHARACTERISTICS

The plant boundaries include the developed areas containing the Main Hill and SM/PP Hill on the north or old property and the undeveloped area on the south or new property. The plant comprises 306 acres with approximately 182 acres on the north property and 124 acres on the south property. The U.S. Geological Survey (USGS) 7.5-minute quadrangle map for Miamisburg, Ohio, shows this area at 80° 17′ 20" north latitude and 39° 37′ 30" west longitude and is included in the Site Scoping Report: Volume 5, Topographic Map Series (DOE 1992b).

The dominant physical features of the Mound Plant are the two adjoining hills (Main and SM/PP) that are underlain by Ordovician Age bedrock and a thin veneer of glacial till. A plant drainage ditch flows

through the center of the plant site, dividing the Main Hill and the SM/PP Hill (Figure 1.2). The crests of these hills average 880 ft above mean sea level (MSL); the plant drainage ditch begins at an elevation of 770 ft MSL and discharges into the retention basins at 706 ft MSL. Most of the north property drains into the plant drainage ditch, which discharges into the southern portion of the Miami-Erie Canal.

The topography of the south property is gradually sloping from a high point of 890 ft MSL in the northeastern corner to a low point of 700 ft MSL at and along the western boundary. The general surface water flow on the south property is from east to west toward the Miami-Erie Canal.

Adjacent to and onlapping to the west side of the plant is a glacially carved, relatively broad valley partially filled with unconsolidated glacial sediments and alluvium from the modern Great Miami River. The floodplain of Great Miami River historically spread across much of the surface of the buried valley, but has been contained in this century by engineered levees and control structures built and maintained by the Miami Conservancy District. The unconsolidated deposits are all considered Quaternary Age and are the major source of groundwater in the vicinity of the Mound Plant and throughout the Miami Valley. The Buried Valley Aquifer is considered a sole source aquifer (53 Federal Register 25670).

Figure 1.2. General topography of Mound Plant.

SECTION 2

2. SUMMARIES OF FIELD INVESTIGATIONS

The investigation of hydrogeology and groundwater contamination at Mound Plant has two main objectives: to revise the conceptual model of the hydrogeologic environment at Mound Plant and to define the nature and extent of groundwater contamination outside the plant boundaries. Section 2 of this report presents a summary of the field work that was performed as part of the Operable Unit 9 hydrogeologic investigations in accordance with the OU 9 Site-Wide Work Plan (DOE 1992a). The major elements of the field program are summarized in Table II.1. Field tasks for borehole geophysics, railroad cut mapping and rock core analysis are not included in this report, but can be found in the Operable Unit 9 Hydrogeologic Investigation: Bedrock Report (DOE 1994b). The analytical results from subsurface soil samples collected during the drilling task are also not included in this report, but can be found in the Operable Unit 9 Hydrogeologic Investigation: Soil Chemistry Report (DOE 1994c). All field activities were performed in accordance with the OU 9 Site-Wide Work Plan (DOE 1992a).

2.1. MONITORING WELL AND PIEZOMETER INSTALLATION

The OU 9 Site-Wide Work Plan (DOE 1992a) proposed the installation of 43 monitoring wells and 27 piezometers located on and off the Mound Plant Site. The majority of the proposed monitoring wells and all piezometers have been completed with only a few variations from the OU 9 work plan as shown on Table A.1, Appendix A. Overall, 36 wells, 27 piezometers, and 3 borings were completed. Well and piezometer installation is summarized below.

From January to May 1993, 36 monitoring wells were installed on and off the Mound Plant site as shown on Figure 2.1. Proposed well 0331 is postponed for further evaluation, and a borehole was drilled for well number 0391, but was abandoned because no water producing zone was found. An additional borehole, 0396, was drilled near the Great Miami River for supplemental geologic information, then was abandoned. A third borehole, 0384, was abandoned after elevated readings on the organic vapor analyses indicated organic vapors as high as 200 parts per million (ppm) that are now interpreted to be methane, but were unknown at the time. Table A.1 presents a well completion summary for all proposed OU 9 monitoring wells.

From January to May 1993, 27 piezometers were installed to better define the groundwater flow systems west of the Mound Plant, in the tributary valley, and in the vicinity of the Mound Plant production wells as shown on Figure 2.2. Most piezometers were screened at the water table; some are clustered to provide data on vertical conditions. The proposed location for piezometer P026 was moved, but other variations from the OU 9 work plan are slight. Table A.1 presents a piezometer completion summary for all proposed OU 9 piezometers.

Table II.1. Summary of OU 9 Field Program

Date	Activity	Objective
July-September 1992 February-March 1993	Seismic refraction	- To locate bedrock lows and channels that may provide preferential pathways for groundwater contaminant migration and to locate the eastern edge of the Buried Valley Aquifer
January-May 1993	Well and piezometer installation	- To refine the interpretation of the thickness and extent of lithologic and hydrostratigraphic units
April 1993	Soil boring 0396	- To provide supplemental geologic information west of the Mound Plant near the Great Miami River
February-April 1993	Geotechnical samples	- To determine hydraulic properties and chemical attenuation characteristics of the Buried Valley deposits
March-April 1993	Clay mineralogy samples	- To characterize the clay mineralogy by X-ray diffraction of the Buried Valley deposits
March-June 1993	Well development	- To remove the fines from the well in order to assess groundwater quality
April-May 1993	Well abandonment	- To abandon wells that could provide a potential conduit for groundwater migration between the shallow and deeper parts of the Buried Valley Aquifer
July 1993	Natural gamma logging	- To refine the interpretation of the thickness and areal extent of the aquifers and aquitards that form the Buried Valley Aquifer
July-December 1993	Long-term water level monitoring	- To determine hydraulic relationships between hydrostratigraphic units - Determine groundwater flow patterns and seasonal variation - Determine hydraulic relationship of hydrostratigraphic units

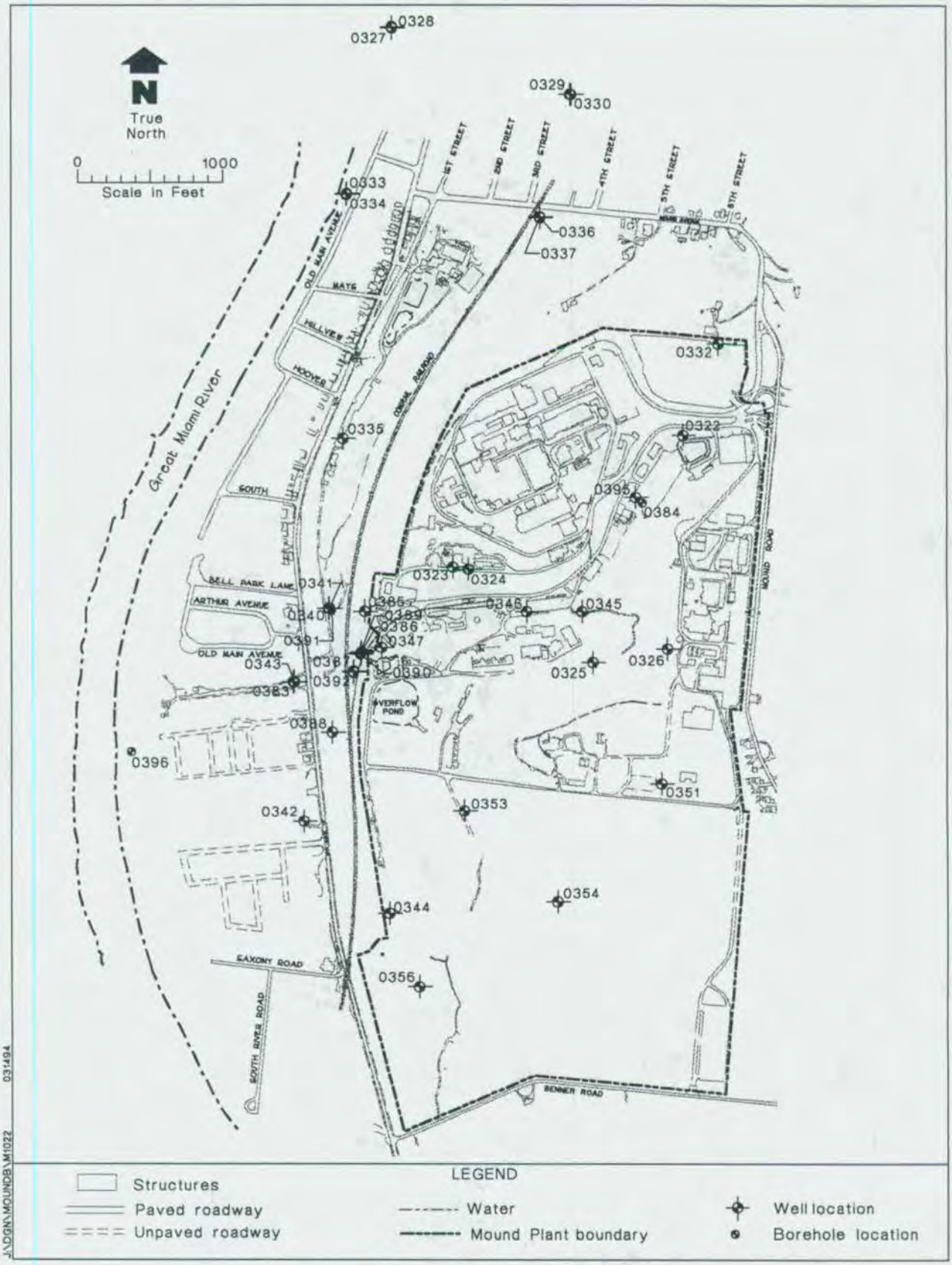

Figure 2.1. Locations of new OU9 monitoring wells.

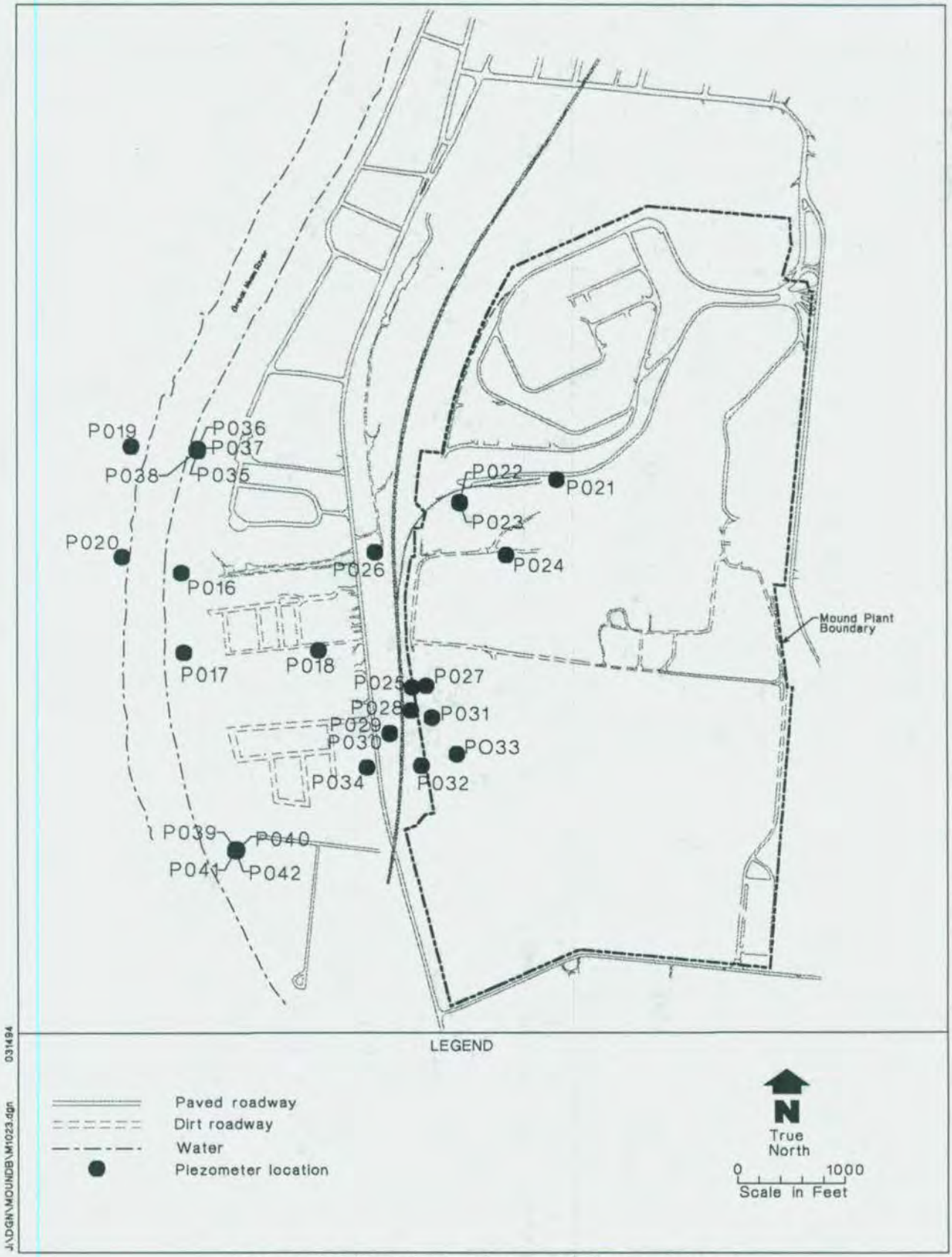

Figure 2.2. Locations of new OU9 piezometers.

The installation of monitoring wells and piezometers involved two different types of drill rigs: a sonic rig and a conventional cable tool rig. The rotosonic method uses a sonic drill head that imparts a series of high frequency, sinusoidal wave vibrations into a steel drill pipe that creates a cutting action at the bit face. The first (inner) pipe, either 6- or 8-inch diameter corebarrel (depending on whether a 2- or 4-inch casing completion is planned), was vibrated and advanced at 5- to 20-ft intervals into the formation collecting an undisturbed sample. The second (outer) pipe was then advanced while water was pumped between the pipes to prevent particles from jamming the pipes together. The outer casing held the hole open and prevented collapse while the core barrel was brought up. The formation material was then extracted by vibrating the core barrel, which allowed relatively undisturbed material to slide into long plastic sample bags. The core was then screened for organic vapors, logged, and sampled. Core material was then placed in drums for proper disposal. This method was efficient and quality core was available for all well logging and sampling; core barrels were easily and effectively decontaminated for continuous sampling purposes. The cable tool is an old technology, using a driven casing that is simply pounded into place. A drive shoe at the base of the casing breaks the formation apart while water is poured into the hole to maintain a slurry and allow the cuttings to be removed intermittently by a bailer.

Monitoring wells were constructed of 4-inch stainless steel for screen and riser material. Piezometers were constructed of 2-inch polyvinyl chloride (PVC) casing for screen and riser material. Filter pack material consisted of medium-size (10/20) silica sand and seal material of quarter-inch bentonite pellets. The annulus of wells and piezometers were then grouted to surface with a mixture of portland cement and 5 percent bentonite. All wells and piezometers have locking well caps or locking case caps and were finished as flush mounts or as stick-ups with steel protective casings. The Hydrogeological Investigations: Well Information Report (DOE 1994a) provides construction specifications for all monitoring wells and piezometers. Standard operating procedures were used in all drilling, sampling, and installation of monitoring wells and piezometers as outlined in the OU 9 Site-Wide Work Plan (DOE 1992a).

2.2. WELL DEVELOPMENT

Each monitoring well and piezometer was developed a minimum of forty-eight hours after grouting was complete. Well development is important in that it removes the fines from the well or aquifer formation near the screen. Overpumping, i.e., pumping at a high rate, was the primary method that was used for development. A bailer was also used on those low-volume wells where a pump could not be fully utilized. Most of the wells produced up to 5 gallons per minute (gpm) and required a 2-inch Grundfos® submersible pump to adequately develop the well. Only a few wells produced greater than 5 gpm and

required a 4-inch Franklin® submersible pump. Equipment decontamination was performed on the pumps/bailers according to SOP 1.6, General Equipment Decontamination (DOE 1993c). All water produced by development and decontamination was containerized. The field parameters measured during well development are pH, Ec, water temperature, and turbidity. The field measurements recorded during development are summarized in Appendix A.

During the development of monitoring wells and piezometers, several were found to produce water at a very low rate (0322, 0323, 0324, 0325, 0335), and four monitoring wells were dry (0340, 0385, 0390, 0395). For those wells that did not produce sufficient water and had extremely low recharge rates (less than 0.06 gpm), each well was pumped dry three times, except at 0323 and 0325. Monitoring well 0325 was revisited a second time, but could not be developed because its paired well 0355 contained a pressure transducer for recording continuous water levels. Pumping 0325 could have disturbed the water level monitoring at 0355 at the time. Monitoring well 0325 still needs further development. Monitoring well 0323 was only pumped once (4 gallons). The second visit to 0323 showed the well to be essentially dry. For those wells that are completely dry, nothing can be done to develop them.

2.3. WELL ABANDONMENT

The abandonment of monitoring wells 0001, 0002, 0003, 0004, 0006, and 0008 was performed in May 1993 under compliance with the Mound Abandonment Program Plan. The well locations are shown on Figure 2.3.

The wells were originally installed in the mid-1970's as part of the Buried Valley Aquifer Evaluation Project to characterize tritium contamination off-plant in the Buried Valley Aquifer (Dames and Moore 1976). The construction details shows a gravel pack that extends virtually the entire length of the casing. The absence of an intermediate bentonite seal could have provided a potential conduit for groundwater migration between the upper and lower parts of the Buried Valley Aquifer. In accordance with good groundwater protection management practices, these wells no longer served any useful purpose for the site-wide groundwater monitoring program. To this end, these wells have been properly abandoned in compliance with the OU 9 Site-Wide Well Decommissioning and Abandonment Program Plan (DOE 1992f). The following paragraphs provide a narrative of conditions encountered at each well. A summary of well abandonment is provided in Table II.2. Since the geology of the wells to be abandoned was known only from older drill reports, each well was logged with a portable natural-gamma sonde. These logs are included in Appendix A.3 with other natural gamma logs.

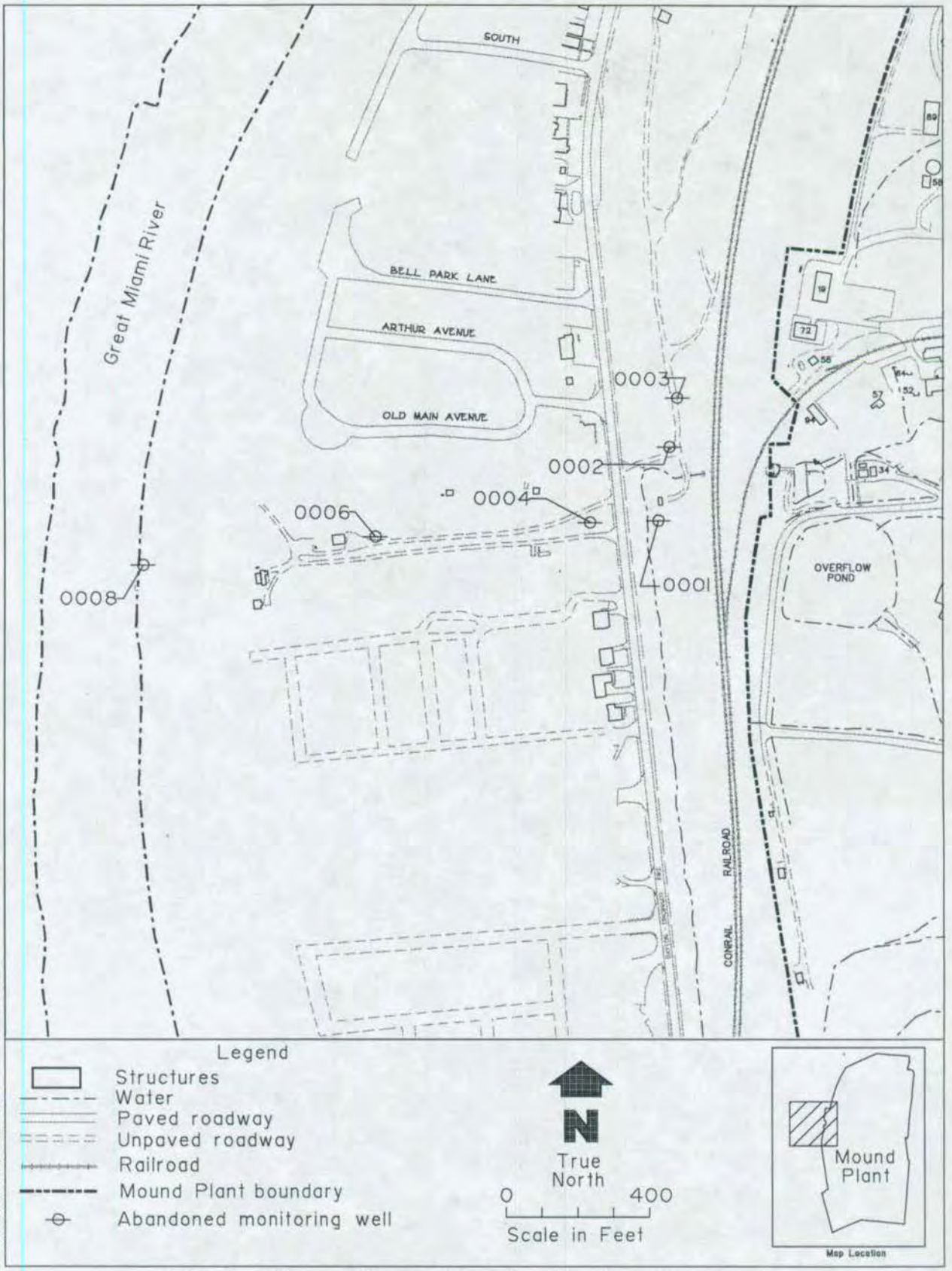

Figure 2.3. Location of older, abandoned monitoring wells.

Table II.2. Summary of Well Abandonment, Mound Plant, Miamisburg, Ohio

Well ID	Well Total Depth (ft)	PVC Casing Removed (ft)	Screen Removed (ft)	PVC Casing Destroyed in Hole (ft)	Screen Left in Hole (ft)
0001	67	51	–	14	2
0002	67	47	12	3	5
0003	32	30	2	–	–
0004	59	30	2	27	–
0006	120	118	2	–	–
0008	142.5	34	–	106.5	2

Two types of drilling techniques were utilized during the abandonment of these wells. For wells 0008 and 0001, a sonic drill rig was used and was found to be poorly effective. For the remaining well abandonments (0002, 0003, 0004, 0006) a hollow-stem auger drill rig was mobilized to the site and was utilized to abandon each well.

Well 0008 was the first well to be abandoned using the sonic rig technique. The construction log indicated that the depth of the well was 143 ft, but only 129 ft were accessible during the natural gamma survey obtained as part of the abandonment procedure. During overdrilling, it was very apparent that the existing borehole was not straight and was significantly out of plumb. Since the sonic rig drills a plumb borehole, it could not exactly follow the borehole. Pieces of the old PVC casing recovered during overdrilling indicated that the drill casing was only partially in contact with the old well casing. The upper 34 ft of old casing were recovered nearly intact, but only 1 ft of PVC casing materials was recovered below that depth. A total of 145 ft was drilled and, as the drill casing was withdrawn, the borehole was grouted to within 2 ft of the surface. The surface was then backfilled with soil and was reseeded.

Well 0001 was the last well to be abandoned with the sonic rig. The existing log indicates that the well was cased to 67 ft, but was originally drilled to 153 ft and backfilled. Only 18 ft were accessible during the natural gamma survey, indicating that the casing was probably broken at a pipe joint. During overdrilling, it was also apparent that the existing borehole was not straight and was out of plumb, but not to the degree of well 0008. Pieces of the old PVC casings recovered during overdrilling indicated that the drill casing was mostly in contact with the old well casing. Much of the old PVC casing was shattered or ground to pieces during overdrilling and settled to the bottom of the borehole as it was recovered. A total of about 51 ft of PVC casing is estimated to have been recovered. The old well screen was not recovered. At the 68 ft depth, however, it was apparent that the sonic drill technique could not follow the backfilled portion of the older borehole, so the drill casing was withdrawn and the borehole grouted to within 2 ft of the surface.

In both instances, it is apparent that the sonic drill technique could not effectively follow the twisted nature of the older boreholes. Within the context of the environment of the Buried Valley Aquifer, the abandoned wells 0001 and 0008 do not pose any residual problems. Sufficient well construction materials were removed to indicate that much of the older boreholes were grouted closed. The exact relationship of the grouted borehole to the older well bore cannot, however, be firmly established. With this reservation, WESTON requested that a hollow-stem auger drill rig be used for the remaining well abandonment.

A hollow-stem auger drill rig was utilized for the remaining wells. This rig, equipped with 4 1/4-inch inner diameter hollow stem augers, was utilized to overdrill and remove the 3-inch diameter PVC casing and annular material. A 1 5/8 -inch steel center rod was inserted inside the PVC well casing to guide and keep the hollow-stem augers centered on the monitoring well during over-drilling. The gravel filter pack materials were washed out. Once the annular space was removed, the 3-inch monitoring well casing and screen were removed. Once brought to the surface, the casing and screen materials were cut up, steamed cleaned, and then placed in a Mound Plant solid waste dumpster. During the abandonment of wells 0001, 0002 and 0003 Mound Plant provided health physics support to do "wipe" analyses of the PVC casing and screen material. Immediately following over-drilling and removal of the well casing, a cement/bentonite slurry was prepared and pumped under positive pressure through a tremie pipe into the borehole while simultaneously removing the augers. The grout was terminated approximately 2 ft below ground surface; the remaining 2 ft was backfilled with soil and was seeded.

Well 0004 was the first well to be abandoned under the hollow-stem auger drill rig program. The borehole log indicated that the well was cased to 59 ft, but was originally drilled to 60 ft and backfilled 1 ft. A total of 54 ft was accessible during the natural gamma survey. After the 1 5/8 -inch rod was emplaced and the augers were at a depth of 59.5 ft, the initial pulling of the rods began. Approximately 20 ft of PVC casing was recovered. When the final rods were removed from the borehole it was noticed that the last 5-ft section of rod was broken off and remained in the bottom of the borehole, most likely at the 55- to 59.5-ft depth. It was apparent that the 5-foot section of steel rod could not be recovered and was therefore grouted in. When the last 10 ft of augers were pulled, another 10 ft of PVC casing and 2 ft of screen was recovered. A total of 30 ft of PVC casing and 2 ft of the old well screen was successfully removed from well 0004. The remainder 27 ft of PVC well casing was shredded during the over-drilling process.

Well 0002 was the second well to be abandoned with the auger drill rig. The borehole log indicated that the well was cased to 67 ft but was originally drilled to 70 ft and backfilled 3 ft. A total of 61 ft was accessible during the natural gamma survey. Approximately 47 ft of PVC casing and 12 ft of screen were recovered. Three ft of PVC casing and 5 ft of screen were shredded and remains in the bottom of the borehole. The borehole was grouted to within 2 ft of the surface.

Well 0003 was the third well to be abandoned with the auger drill rig. The borehole log for well 0003 indicated that it was cased to 32 ft, but was originally drilled to 55 ft and backfilled. The natural gamma survey logged a total depth of 28 ft. All PVC casing and screen materials were recovered from well 0003 for a total of 30 ft of PVC and 2 ft of screen. The borehole was grouted to within 2 ft of the surface.

Well 0006 was the last well to be abandoned. The borehole log for well 0006 indicated that it was cased to 120 ft, but was originally drilled to 133.8 ft and backfilled. Upon opening the well cap, it was discovered that 0006 was a 4-inch well, not a 3-inch well as shown on the borehole log construction diagram. To accommodate the 4-inch diameter well, it was necessary to use 6 1/4-inch (instead of 4 1/4-inch) inner-diameter augers. The driller was not able to drill with 6 1/4-inch augers beyond approximately 70 ft without the addition of a drilling fluid (i.e.,bentonite slurry) to lubricate the augers. It was agreed by EG&G, EPA, and OEPA that well 0006 was to be drilled out to a depth below the till unit that was approximately 95 to 100 ft. Any casing left in the hole from 100 to 120 ft would be filled with grout. Additionally, the driller would be able to use a bentonite slurry with increasing depth. Well 0006 was overdrilled to 95 ft. It was discovered after the initial pull of the PVC casing that only the first 5 ft of the casing was 4 inches in diameter. A copper/steel pitless adaptor was found at approximately 10 ft. Apparently, the 4-inch section of PVC casing was an addition to the well when the pitless adaptor was secured during pump installation. It was difficult to estimate the footage of the PVC casing because so much was ground up by the augers. However, since the 2-ft screen was recovered it is assumed that all 118 ft of the PVC casing was removed.

2.4. NATURAL GAMMA LOGGING

Natural gamma radiation logs were collected at 19 existing wells and nine new wells, in accordance with the Site-Wide Work Plan (DOE 1992a). Locations of wells where the logging was performed are shown on Figure 2.4; Table II.3 lists the wells and the depths of the logs. Natural gamma logs could not be performed on three of the proposed wells (0116, 0302, and 0343) due to continuous water level monitoring at these locations. Both WESTON and Terran Corporation performed natural gamma logging with Terran logging wells 0001, 0002, 0006 and 0008 with an analog instrument. WESTON logged the remainder of the wells with a digital instrument. The objective of the natural gamma logging was to refine the interpretation of the thickness and areal extent of the aquifers and aquitards that form the Buried Valley Aquifer. All natural gamma logs are included in Appendix A.3. Further discussion on the natural gamma methods and results can be found in subsection 5.2.

2.5. SEISMIC REFRACTION SURVEY

The seismic refraction survey was one of the first OU 9 field activities to be performed. Field work for the OU 9 seismic investigation was conducted in three phases beginning in July 1992. All field work was completed on 1 March 1993. Data was collected from both onsite and offsite transects (Plate 1). The objective of the seismic refraction survey was to locate bedrock lows and channels that may provide preferential pathways for groundwater contaminant migration, and to locate the eastern edge of the Buried Valley Aquifer. Three lines planned to the west of Main Street were deleted from

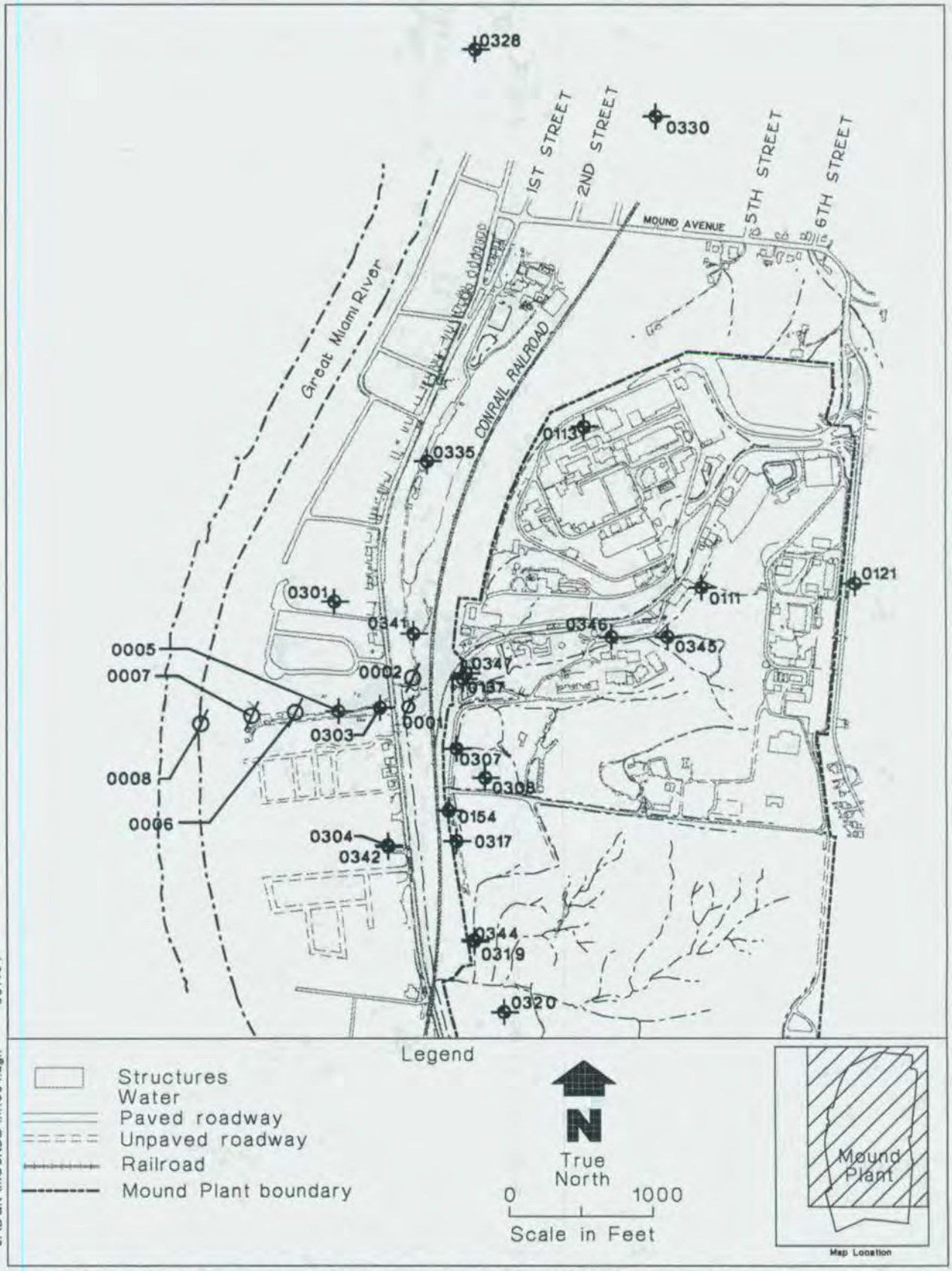

Figure 2.4. Locations of wells where natural gamma measurements were performed.

Table II.3. Summary of Borehole Natural Gamma Investigation

Well ID	Depth (ft)	Contractor	Comments
0001 (Existing)	67	Terran	
0002 (Existing)	67	Terran	
0005 (Existing)	56	WESTON	
0006 (Existing)	120	Terran	
0007 (Existing)	80	WESTON	
0008 (Existing)	143	Terran	
0111 (Existing)	67	WESTON	
0113 (Existing)	56	WESTON	
0116 (Existing)	81	NA	No log performed; water level recording device in well
0121 (Existing)	109	WESTON	
0137 (Existing)	75	WESTON	
0154 (Existing)	47	WESTON	
0301 (Existing)	88	WESTON	
0302 (Existing)	120	NA	No log performed; water level recording device in well
0303 (Existing)	94	WESTON	
0304 (Existing)	104	WESTON	
0307 (Existing)	50	WESTON	
0308 (Existing)	70	WESTON	
0317 (Existing)	60	WESTON	
0319 (Existing)	55	WESTON	
0320 (Existing)	40	WESTON	
0328 (New)	111	WESTON	
0330 (New)	166	WESTON	
0335 (New)	55	WESTON	
0341 (New)	55	WESTON	
0342 (New)	160	WESTON	
0343 (New)	90	NA	No log performed; water level recording device in well
0344 (New)	175.5	WESTON	
0345 (New)	42	WESTON	
0346 (New)	46	WESTON	
0347 (New)	69	WESTON	

NA - not available

the field program because of the anticipated large size of the explosive charges that would have been required and the proximity of the lines to residential areas. The sizes of the charges required did not become evident until the first phase of field work was complete.

2.6. LAND SURVEY

As a result of the discrepancies noted in the OU 9 Site-Wide Work Plan (DOE 1992a), all existing monitoring wells, as well as all new monitoring wells, piezometers and soil borings, were surveyed for horizontal and vertical location. Horizontal control was held to ±0.5 ft; vertical control was held to ±0.1 ft. As result of the survey, it was noted that the Mound Plant monuments are poorly located in respect to the national datums available, both horizontal and vertical. Details of the survey are discussed in the Hydrogeological Investigations: Well Information Report (DOE 1994a).

Horizontal coordinates were recorded in the North American Datum of 1983 (NAD83) and recalculated to the North American Datum of 1927 (NAD27). Errors in the horizontal distances ranged over 400 ft east and north. To maintain internal program consistency, all horizontal coordinates were recalculated to the Mound Plant control network. This is referred to as the plant datum in this and accompanying OU 9 reports. Tables of monitoring wells and piezometer coordinates in all datums are presented in the Hydrogeological Investigations: Well Information Report (DOE 1994a).

Vertical coordinates were recorded in the North American Vertical Datum of 1988 (NAVD88) and the National Geodetic Vertical Datum of 1929 (NGVD29). Errors in the vertical elevations are systematic. To maintain internal program consistency, all vertical elevations are recalculated to the Mound Plant control network. This is referred to as the plant datum in this and accompanying OU 9 reports. To reconcile vertical elevations and to adjust elevations to plant datum, 1.77 ft must be added to elevations reported in the NAVD88 datum, and 1.15 ft must be added to elevations reported in NGVD29 datum. Tables of monitoring wells and piezometer elevations in all datums are presented in the Hydrogeological Investigations: Well Information Report (DOE 1994a).

2.7. LONG-TERM WATER LEVEL MONITORING

Water level measurements performed as part of the hydrogeological investigations included monthly measurements at all monitoring wells and piezometers and continuous measurements at selected wells and piezometers for six months in order to better understand hydraulic relationships among hydrostratigraphic units.

Water levels were measured manually at all new and existing wells at least once a month from April through December 1993, with the exception of July and August. Water levels were measured manually according to Mound Plant ER Program SOP 3.1, Water Level Measurement (revision 1).

Continuous water level measurements were taken at selected wells and piezometers on an hourly basis (Figure 2.5). Measurements were actually recorded every minute and averaged for the hour. *In-situ*® pressure transducers were instrumented in each well/piezometer to measure water level changes. Continuous measurements were made at 18 wells or piezometers including P001, P008, P014, P017, P020 and P021, P035 through P042, 0116, 0302, 0343, and 0387.

Barometric pressure was recorded during the long-term water level monitoring to supplement the data.

2.8. RIVER STAGE AND PRECIPITATION MEASUREMENTS

Daily precipitation and river stage data were collected to provide data on the possible driving forces for the observed hydraulic heads. The precipitation data were recorded at gauges at the Mound Plant and at the USGS monitoring station on the Great Miami River, located approximately 1 1/2 miles northwest of Mound Plant near the corner of North Miami Avenue and Ferry Street in Miamisburg (Figure 2.6). The river stage data for the Great Miami River were recorded at upstream and downstream locations relative to the Mound Plant. The upstream gauge is the existing USGS gauge at the location previously described and the down stream gauge was newly installed for this investigation. The USGS gauge elevation is 678.60 ft MSL (NGVD29) or 679.75 ft MSL (plant datum). The USGS gauge elevation was recalculated to plant datum to maintain a consistent elevation datum for all data.

A new river stage recording station originally was to be constructed on the Great Miami River due west of the Mound Plant near piezometer P016 to provide data related to changes in river stage that could be compared to changes in groundwater levels. The Miami Conservancy District did not approve the construction of the river stage recording station at that location. Instead, a river stage monitoring station was located south of the Mound Plant at the Conrail trestle at the Great Miami River (Figure 2.5).

The new river stage gauge replaced an older existing one and consists of a manual staff gauge and a new calibrated pressure transducer and data logging equipment. The new pressure transducer is located in a 1-inch diameter galvanized steel pipe drive point approximately 25 ft long with a 2-ft screen at the base. The pipe was bolted to the cement footing of the trestle; the screen was positioned just below the water, with care being taken not to submerge the screen into the substrate.

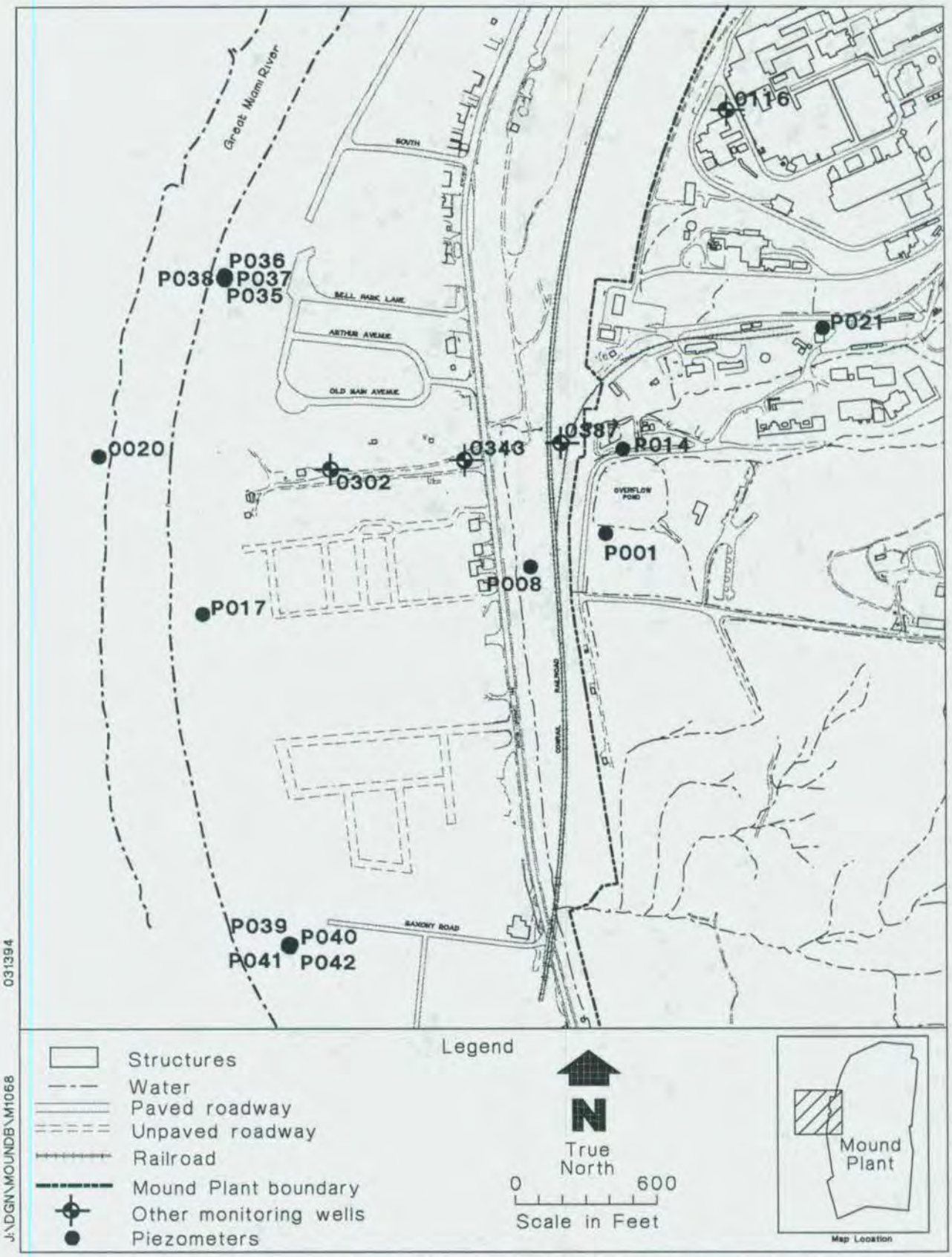

Figure 2.5. Locations where continuous water level measurements were performed.

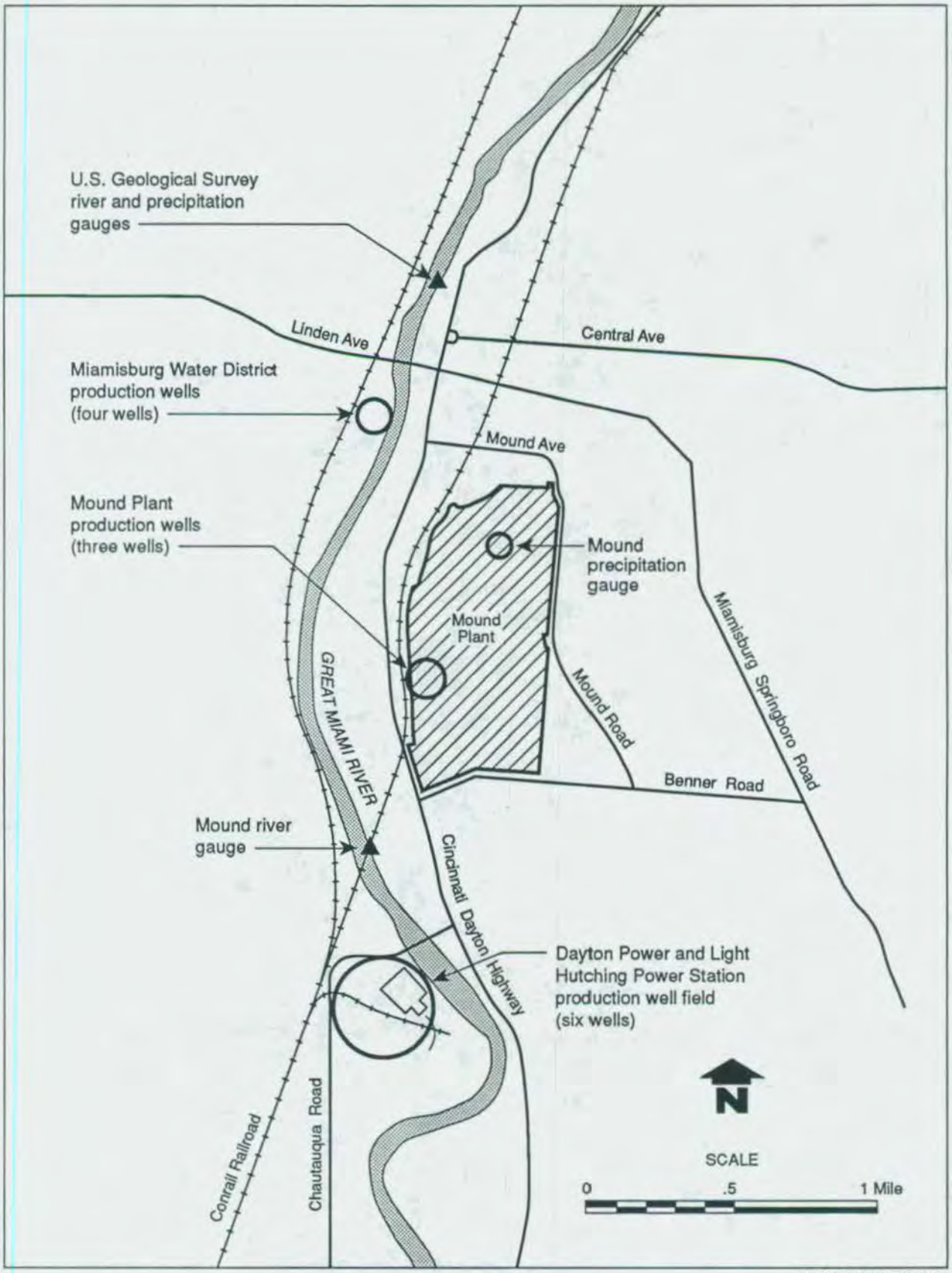

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Figure 2.6. Locations of river stage and precipitation measuring stations in the vicinity of Mound Plant.

A NEMA-1 utility box for the data logging equipment was installed at the top of the galvanized pipe. The elevation of the transducer was surveyed to obtain absolute river stage elevations. Water level measurements were taken every 15 minutes beginning in April 1993.

The new gauge was monitored from 1 July 1993 through 31 December 1993 as part of the OU 9 field investigation. The elevation of the transducer used to measure stage at the Mound Plant gauge is 682.47 ft MSL (plant datum). All elevations of water levels and well construction information in this report are provided in plant datum.

2.9. SUBSURFACE SOIL SAMPLING

2.9.1. Geotechnical

Geotechnical samples were collected from six borehole locations as shown on Table II.4 and were submitted to Bowser-Morner Inc. for geotechnical analysis. All of the proposed locations were sampled in addition to one piezometer location: P026 (Figure 2.7). Geotechnical samples were collected to determine hydraulic properties and chemical attenuation characteristics of the Buried Valley deposits. Soil pH analysis was performed on each sample in the field. In general, geotechnical samples were not collected in areas suspected to be contaminated. Two geotechnical samples were collected from each stratigraphic unit encountered. Further discussion of the geotechnical results and discussion is in Section 4.

2.9.2. Clay Mineralogy

In addition to geotechnical analysis, samples were collected at clay-rich horizons in each stratigraphic unit encountered at locations 0342 and 0343 to characterize clay mineralogy by X-ray diffraction. Three clay-rich samples were collected at borehole 0342 at depths of 10, 75, and 95 ft. Two samples were collected at 0343 at depths of 37 and 57 ft. X-ray diffraction analysis was performed by Lamda Laboratories. The clay mineralogy results and further discussion are in Section 4.

Table II.4. Summary of Geotechnical Soil Samples

Location I.D.	Depth Interval (ft bgs)
0341	17-18
0342	7-10
0342	73-75
0342	90-95
0343	20-28
0343	30-37
0343	56-58
0343	66-67
0343	75-80
0344	15-18
0344	19-25
0344	25-30
0344	30-35
0344	35-40
0344	55-60
0344	60-65
0344	105-115
0346	24-25
0346	34-35
0386	27-33
0386	34-35
0386	48-55
0386	80
P026	48
P026	83

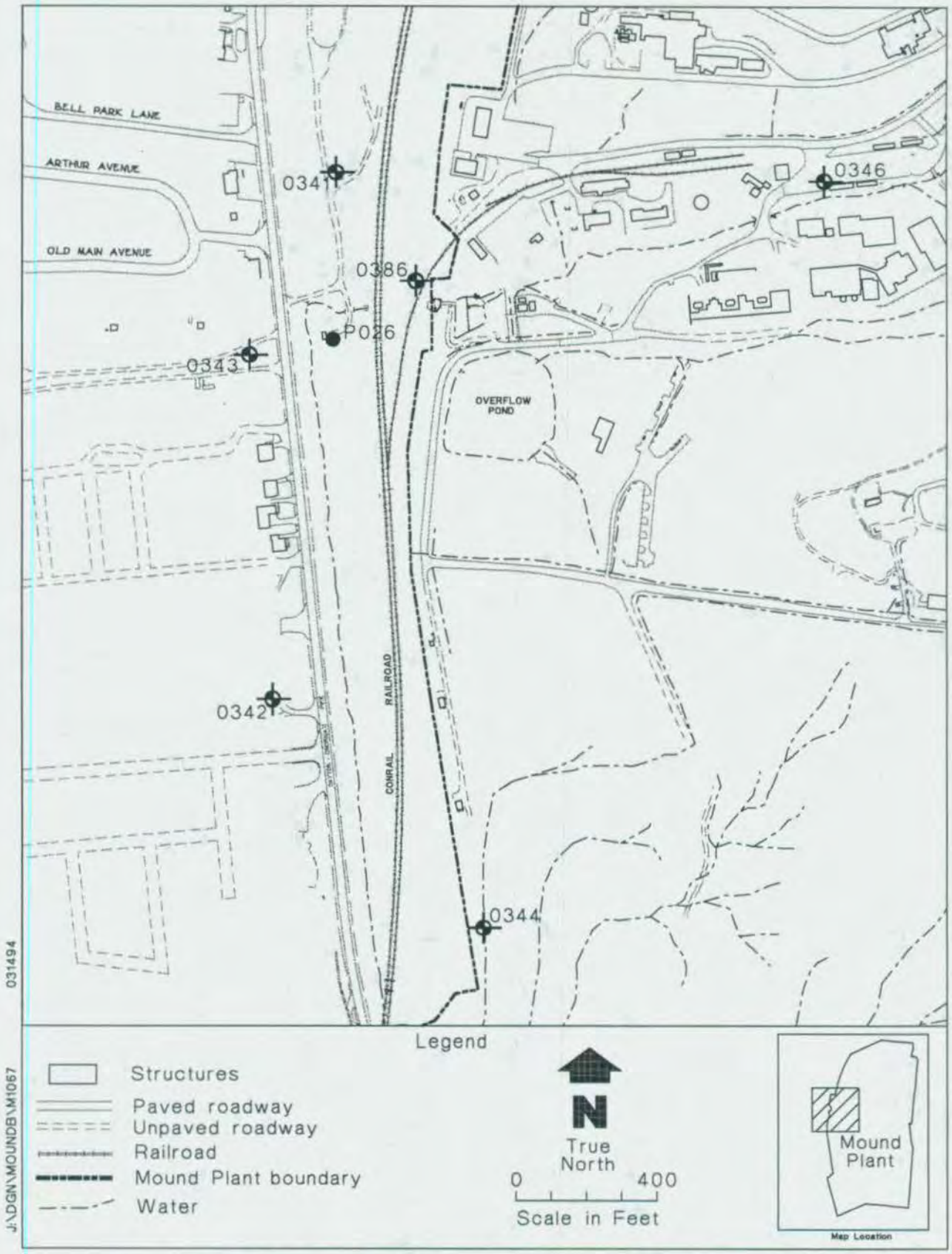


Figure 2.7. Locations where geotechnical samples were collected.

SECTION 3

3. SEISMIC REFRACTION SURVEY

In support of the hydrogeologic characterization of the Site, a seismic refraction survey was performed at the Mound Plant to 1) define bedrock topography and identify bedrock lows and channels that could provide a preferential pathway for contaminant migration from the Site; and 2) define the eastern margin of the Buried Valley Aquifer on the southern part of the plant, known as the New Property. This work was performed in accordance with the scope described in the Operable Unit 9 Site-Wide Work Plan [Final] (DOE 1992a).

A preliminary seismic refraction survey was performed in June 1989 for reconnaissance purposes (DOE 1990). The results of the preliminary survey indicated that the seismic refraction method is effective in defining depths to bedrock and the bedrock surface, but geophone spacing and shot energies were not sufficient to image the deeper parts of the Buried Valley Aquifer in the southern part of the plant. The reconnaissance also indicated significant cultural interferences in the plant valley including high levels of background noise from motors and generators.

Field work for the Operable Unit 9 seismic refraction investigation, implemented using a phased approach due to contractual obligations, was completed on March 1, 1993. Phase I was performed from July 14 to 24, 1992 with approximately 11,500 linear feet of data collected. Field work for Phase II was performed from September 9 to 17, 1992, with all of the proposed on-site transects completed. Approximately 9,900 linear feet of data were collected during the Phase II effort. Phase III was performed from February 23 to March 1, 1993, and included all of the proposed off-site transects to the east of Main Street (the Dayton-Cincinnati Highway). A total of approximately 2,070 linear feet of data were collected during the Phase III field effort. Three lines planned to the west of Main Street were deleted from the program because of the anticipated large size of explosive charges that would have been required and the proximity of the seismic lines to residential areas (Plate 1). The sizes of the charges required did not become apparent until the first phase was completed.

3.1. SCOPE OF SEISMIC REFRACTION SURVEY

The refraction method was used to delineate the bedrock surface from the overlying unconsolidated materials. The refraction method involves the use of seismic waves with trajectories along tops of layers that have appreciably greater velocities than those of any overlying formations. The data generated by a single refraction survey line are best represented by a plot of the first-arrival times of the head wave, a critically refracted seismic wave, versus the detector's distance, nicknamed the time-distance plot. These plots are contained in Appendix B.1. Plate 1 shows the location of the seismic refraction transects collected during the study, and also shows control points and exploratory borings

and wells used as check points to calibrate accuracy of the seismic refraction method in determining depth to bedrock.

All seismic refraction data were interpreted with the SIPT1 seismic interpretation program, a delay time and ray-tracing program developed by the United States Geological Survey in conjunction with the United States Bureau of Mines. This program interactively incorporates a minimum of four shot-points for each 12-geophone spread. The SIPT1 outputs provide the depth of refracting layers beneath each geophone and shot point. Under ideal conditions, depths calculated using the SIPT1 program should be within ±10% of the true depth of the interface, as determined from borehole logs. The ±10% accuracy is sufficient for the intended uses of the data. The theoretical foundations and limitations of the seismic refraction method, and use of the SIPT1 seismic interpretation program, are presented in Appendix B.2. Calculated bedrock depths were compared at seismic line intersection points with measured depths from adjacent exploratory borings and wells. This comparison shows a high degree of correlation between measured and calculated bedrock depths, as well as between intersecting seismic lines that were independently interpreted.

3.2. FIELD METHODS

The methods discussed here are consistent with Mound Plant Standard Technical Procedures 1.2.2 "Seismic Refraction", and 1.2.3 "Use of Electronically Detonated Black Powder Shells (Betsy Seismic Shells) as a Seismic Source". Data were collected with an EG&G Geometrics Model 2401 signal enhancing seismograph with 14 Hz geophones and cables with 50-ft take-outs. This instrument has an instantaneous floating point gain that automatically adjusts gains to the incoming seismic signal on each channel. Field data were digitally recorded for computer processing and selection of first arrivals. Hard copies of numeric values and seismic traces were reviewed in the field to ensure sufficient data were collected along each transect.

Overall, data quality was excellent in most areas, providing a high degree of confidence in the interpretation of the geophysical data. Energy was provided at shot points with either a 20-lb sledge hammer striking a metal plate placed on the ground, or by buried black powder charges. Many of the seismic lines were acquired through pavement with a sledge hammer sound source and a modified placement of the geophones. For the modified geophone setup, the geophone was placed upright in wooden blocks through which holes had been drilled. This allowed the geophone arrangement to remain upright and in contact with the pavement. Early arrivals of low-amplitude pavement waves were detected in the near geophones (velocity inversion), causing additional interpretation of data from refraction work performed on pavement. Data acquisition through pavement was successful, as pavement arrivals can generally be differentiated from later arrivals by a comparison of wave

amplitudes and relative arrival times. Where adjacent noise sources or electrical interference was present (see subsection 3.3.2), filters were used to decrease noise and increase data quality.

Data were acquired along seismic lines 1, 2 (spreads 1 and 2), and 10 during the Phase I field effort, but the data were difficult to interpret because of signal attenuation and deep bedrock in the area. For this reason, these lines were repeated during the Phase II field effort, with larger explosive charges buried at depths of greater than 6 ft. A power auger was used to drill the deep shot holes. Explosive charges, employing up to 7,000 grains of black powder, were wired together in parallel to provide the energy required to characterize the deep bedrock underlying these transects. The increase in explosive charge size and depth of burial provided greater signal penetration and improved data quality along these lines.

During the Phase III field effort, conducted in the winter, a frozen surface layer was encountered that caused a velocity inversion. This velocity inversion complicated data collection with a sledge hammer sound source (e.g., seismic line 27), but did not adversely affect data quality where explosive charges buried at a minimum depth of 6 ft were used as a sound source. Due to property ownership issues, buried explosive charges could not be used on line 27. This line was the only case where the frozen layer adversely affected the data. Even though the frozen layer and pavement cases are similar, the pavement case did not preclude collecting usable data. Compared to the interference produced in the frozen layer case, the interfering waves generated in the pavement case attenuated quickly and did not travel further than the first few geophones. The difference in the attenuation of waves in the pavement case versus the frozen layer case is due to: 1) the pavement waves were high frequency waves, 2) the pavement had more discontinuities, and 3) the pavement was a thinner layer than the frozen ground.

Geophone and shot-point elevations were surveyed with an engineering level and tripod during the field investigations to the nearest 0.1 ft. Transect end-points were marked in the field with wooden stakes, located with respect to existing structures or benchmarks with a tape measure, and plotted on a map. Several seismic line end-points were later surveyed by a registered land surveyor for accurate placement on the site map. State plane coordinates for the surveyed seismic refraction transect end-points are presented in Appendix B.3.

3.2.1. Spread Configurations

Figure 3.1 shows the typical seismic line spread configuration used in the survey. A combination of 5-ft and 20-ft geophone spacings and shot-point offsets are shown in this example. The closely spaced geophones at each end and in the middle of the array provide information about shallow

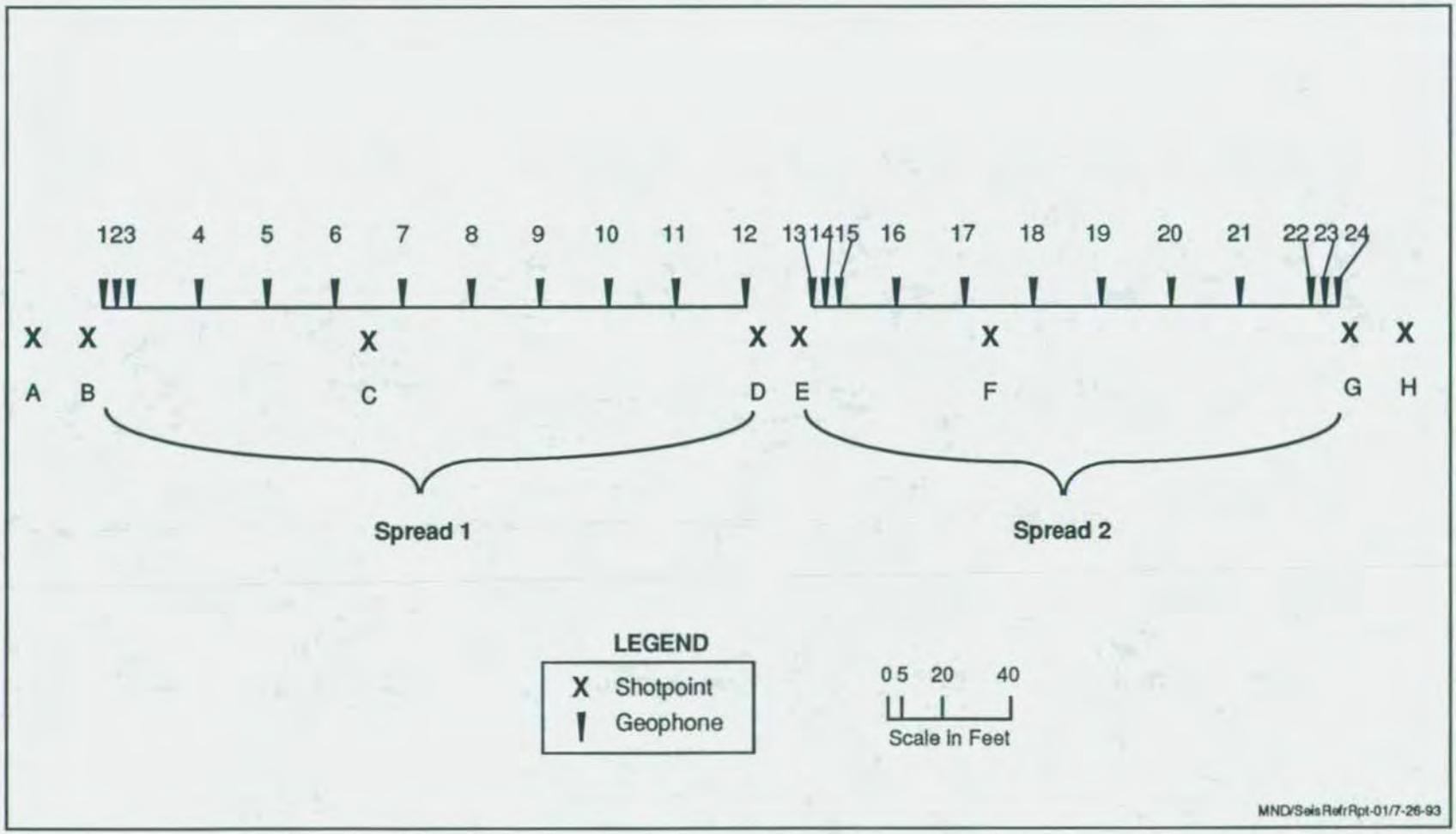


Figure 3.1. Typical layout for a seismic refraction survey in a shallow environment.

refractors when combined with the near offset shots. The wider spaced geophones in this configuration provide a 24-geophone seismic line length that is suited for characterizing refractors as deep as approximately 100 ft. Geophone spacings of greater than 20 ft were used in combination with more closely spaced geophones in areas where bedrock depths exceeded 100 ft.

The configuration shown in Figure 3.1 is for a line consisting of 24 geophones. For lines consisting of 12 geophones, closely spaced geophones were placed at the beginning and end of the line. For more than 24 geophones, closely spaced phones were placed at the beginning of each 12-geophone spread, and at the beginning and end of the last 12-geophone spread in the line. In this way, accurate information about shallow refractors was collected periodically along the entire length of each line.

The SIPT1 program will interactively incorporate as many as seven shot points for each spread. The configuration shown in Figure 3.1 may be either interpreted as a single 24-geophone spread or as two 12-geophone spreads, depending on the quality of data and the depth of the targeted refractor. If the data are interpreted as two 12-geophone spreads, all of the shot points may be used, with the center shots (shots D and E) used for both spreads. If the data are interpreted as one 24-geophone spread, only seven of the eight shot points may be used in the interpretation.

Most of the seismic lines in the study were longer than a single 24 geophone line and tranversed relatively thin soils mantling bedrock. These lines were interpreted as two 12-geophone spreads. Spread 1 was often moved after acquisition of data from shot E (Figure 3.1). Spread 1 was then deployed beyond spread 2 to form a new spread (spread 3), and data acquisition continued. This "leap-frogging" of 12-geophone spreads provided an efficient means of acquiring data without having to repeat shot points.

3.2.2. Ambient Noise

Because some of the seismic lines were located in residential areas, near active roadways, or near operating plant equipment, ambient, or background, noise was often a problem. Sources of noise included automobile traffic, overhead aircraft, passing trains, and Mound Plant equipment.

High-pass filters were used in some areas to minimize the effect of adjacent noise sources, and shots were fired during relatively quiet periods. Low-pass filtering was not used because of the greater propagation of low frequency signals and the low center frequency of the geophones (14 Hz). The notch filter was set at 60 Hz throughout the study to minimize the effect of electrical interference from power lines. When using the sledge hammer for a sound source, a number of stacked (repeated) shots were recorded to decrease the amplitude of random noise and increase the signal. Despite high noise

levels in some areas, high quality data were collected throughout the survey with stacking, filtering, and shooting during quiet periods.

3.3. DATA REDUCTION AND PROCESSING

Appendix B.4 contains a data reduction and processing flow diagram and examples of data outputs from all the steps in the process. Digital data collected along each transect were processed and interpreted using the SIPT1 program to provide the depth to refracting horizons beneath each geophone and shot point. Digitally recorded field records were imported into the SIPIK first arrival pick program by Rimrock Geophysics, Inc., to identify the first arrival of energy at the geophones (first breaks). The program has digital filtering capabilities and individual trace size adjustments for each channel to optimize records. After records were optimized and first arrival picks were made, the records were printed on a laser printer or a 24-pin dot matrix printer. Raw field records collected during the survey are not presented in this report but have been retained in permanent project files.

After selection of first arrivals, data were formatted for the SIPT1 program using the SIPIN program by Rimrock Geophysics, Inc. Input files include spread geometry, first arrival times, elevation of shot points and geophones, depth of burial of shots, and Y-offsets where necessary. The Y-offset is the distance, in feet, from the shot point to the refraction line, measured perpendicular to the line. The Y-offsets are documented in the field notebooks and the SIPT outputs. A Y-offset was required in instances where the shot point could not be placed directly on-line with the geophones and other shot points, usually due to cultural interferences. In addition, time-distance plots were generated with effects of elevation removed for lines with high topographic relief. These plots were then used to determine layer assignments, which are manually determined input parameters for SIPT1 interpretations. In order to calculate the velocity of layers it was necessary to combine several field spreads. In some instances (such as lines where individual layers had variable velocities along their length), a velocity was determined from only one spread. For instances such as lines with deep refractors and simple 2-layer cases, multiple spreads were combined and the velocities calculated.

Data were optimized after several interactive runs through the SIPT1 program. After seismic refraction line profiles were created for each seismic line, they were compared to data from boreholes and at points of intersection to provide correlation and increase confidence in the results. Where discrepancies existed, profiles were revised with additional runs through the SIPT1 program. The boreholes provide points of calibration for one location along the line. This point is observed until the desired results are obtained, and the rest of the line is interpreted to be as true to that calibration as possible. When all of the correlations were complete, final profiles were created using the Grapher package by Golden Software, Inc.

3.4. RESULTS

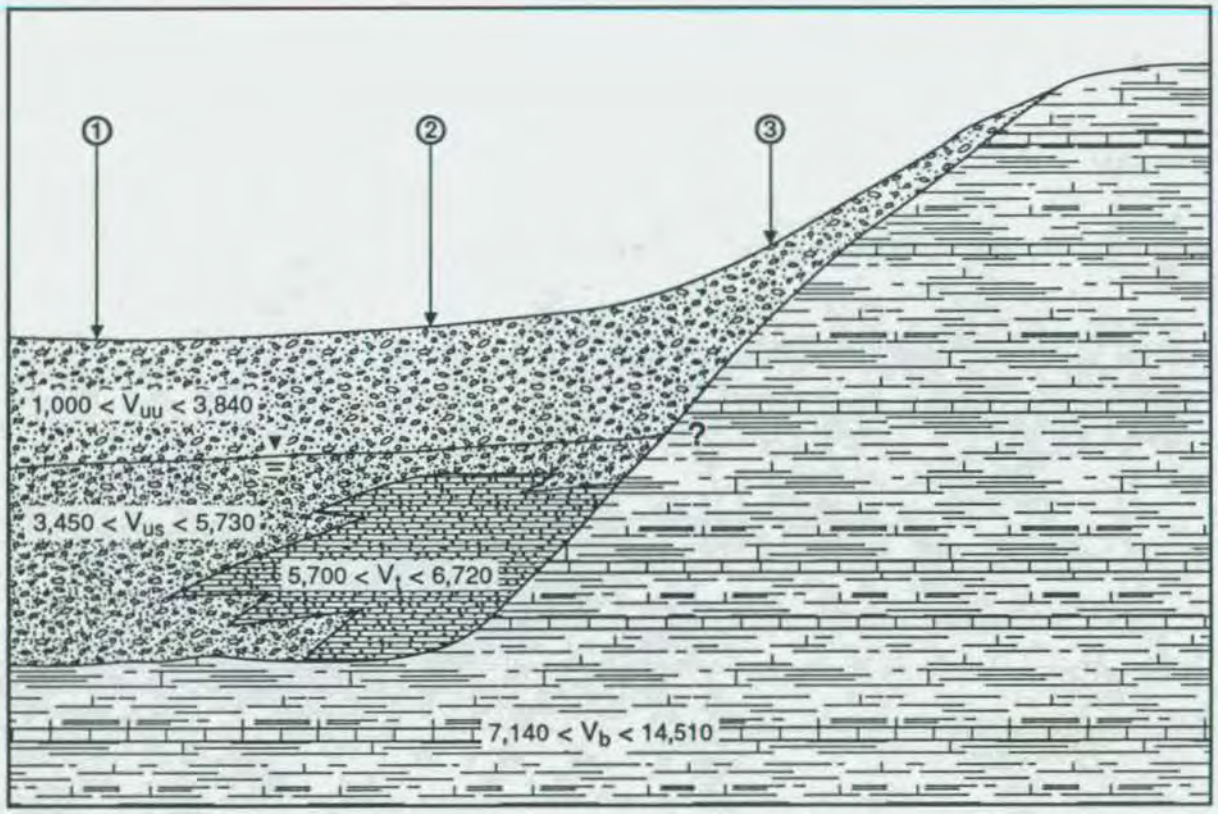
Appendix B.1 contains all of the seismic refraction line profiles derived from the data collected during this study. Line numbers correspond to the numbers on the seismic line location map (Plate 1), while spread numbers refer to each sequential group of 12 geophones. Horizontal distances on the profile correspond to horizontal distances on the seismic line location map. However, individual spreads are not identified along a single line due to the scale of the map.

In most cases three layers were identified in the subsurface, and are interpreted to represent 1) unsaturated, unconsolidated materials, 2) saturated, unconsolidated materials, and 3) bedrock. In some cases four refractors were present. The fourth refractor, an intermediate velocity layer, has been interpreted to be glacial till. In some areas, where bedrock is shallow, only two refracting layers were present: unsaturated, unconsolidated materials, and bedrock. Figure 3.2 is a schematic cross section that shows the different velocity layers in these relationships.

General trends in bedrock topography were identified during the study. The shallowest bedrock occurs beneath the Main Hill, the SM/PP Hill, and along the road to Post 2 (contractor's gate). In general, topographic highs are associated with shallow unconsolidated materials mantling bedrock throughout the study area. Calculated depths to bedrock range from approximately 250 ft in the southwest corner of the New Property (seismic lines 1 and 2), to 10 ft adjacent to the contractor's parking lot and along the access road to Post 2 (seismic lines 5 and 23).

The tributary valley between the Main Hill and the SM/PP hill (also known as the Mound Plant drainage ditch) was difficult to image because of buried pipelines and culverts and cultural noise (high volume water pumps and the wastewater treatment plant). These buried items, along with the background noise, limited data acquisition across the stream channel. Data quality was also poor along seismic line 18, located along the flank in the middle reach of the valley, due once again to nearby low frequency noise and underground utilities. Data along this line were not interpreted because of low quality.

Seismic line 13 west of Mound Plant runs normal to the trend of the Buried Valley Aquifer in the middle reach, and indicates that bedrock depth increases to the west. The bedrock depth beneath spreads 2 and 3 of seismic line 13 approaches the limit for signal penetration with a sledge hammer sound source. The southern end of seismic line 26, located west of the Conrail tracks, shows increasing bedrock depth along the northern flank of the tributary channel. Acquisition of additional data in the northern portion of the tributary channel would be useful, but would probably require explosive charges to provide sufficient signal.



V_b = Velocity (ft/sec) in bedrock.
V_t = Velocity (ft/sec) in glacial till.
V_{us} = Velocity (ft/sec) in unconsolidated, saturated materials.
V_{uu} = Velocity (ft/sec) in unconsolidated, unsaturated materials.
Velocity values are derived from Table V.3.

▼ Denotes water table

NO SCALE

Three common situations along seismic refraction profiles at Mound Plant:

1. Three-layer case: $(V_1 = V_{uu}) < (V_2 = V_{us}) < (V_3 = V_b)$.
2. Four-layer case: $(V_1 = V_{uu}) < (V_2 = V_{us}) < (V_3 = V_t) < (V_4 = V_b)$.
3. Two-layer case: $(V_1 = V_{uu}) < (V_2 = V_b)$.

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Figure 3.2. Schematic cross section showing the layer velocity relationships at Mound Plant.

Seismic lines 14, 15, 16, and 17 were collected through pavement in the North Parking Lot. The slope of the bedrock in this area may be along the flank of the northern end of the tributary channel. Based on current data, it is not clear whether the north end of the tributary channel is truncated by a bedrock high (groundwater divide) to the east of the Main Hill. Other data, collected after the completion of the on-site seismic refraction transects, indicate bedrock to be at a depth of 13 ft at monitor well location 0332, located at the northern edge of the North Parking Lot. At monitor well location 0322, located just north of the asphalt lined pond west of Building 61, bedrock is at a depth of 42.5 ft below ground surface. Data along these transects indicate a gradual slope of the bedrock surface toward the northeast.

Data collected in the New Property indicate that bedrock becomes deeper to the south and west. The deepest bedrock in the study area lies beneath the southwest corner of the New Property. Calculated bedrock depths exceed 225 ft at the west ends of seismic lines 2 and 10 (Plate 1). Borehole 0356, drilled approximately 300 ft north of the western end point of seismic line 10, encountered bedrock at a depth of 181 ft. Seismic line 1 was not interpreted because of an apparent velocity inversion that masked arrivals from the bedrock surface. Seismic line 10 was rerun because of the initial poor data recovery due to the great depth to bedrock in that area. Likewise, spreads 1 and 2 of seismic line 7 were not interpreted due to the great depth of bedrock and the apparent velocity inversion. The deep bedrock in the southwest corner of the New Property may be related to the buried valley formed by the ancestral Great Miami River. The refraction data and the drilling data indicate that the axis of the buried valley may lie along the eastern portion of the present Great Miami River floodplain. If this is so, it means the southwest corner of the New Property overlies a portion of the buried valley.

East of the Great Miami River floodplain, still within the New Property, data indicate the overlying unconsolidated materials to be thin. Depth to bedrock is shallow at the northern end of seismic line 7, and at the eastern ends of seismic lines 2, 8, 9, and 10. Calculated bedrock depths were less than 15 ft along seismic lines 3, 22, and 23.

One objective of the seismic refraction survey was to define the eastern boundary of the Buried Valley Aquifer beneath the New Property. Figure 3.3 shows the approximate eastern Buried Valley Aquifer boundary as defined by the seismic refraction data. The data show the Buried Valley Aquifer is present below a large portion of the New Property. The seismic refraction line profiles were used to approximate the eastern boundary of the Buried Valley Aquifer, as shown in Figure 3.3. The 680 ft elevation of the bedrock surface was used to determine this boundary. This elevation was used because the Great Miami River, as well as the general groundwater surface in the Buried Valley Aquifer, has an elevation of approximately 680 ft. Groundwater elevations discussed in subsection

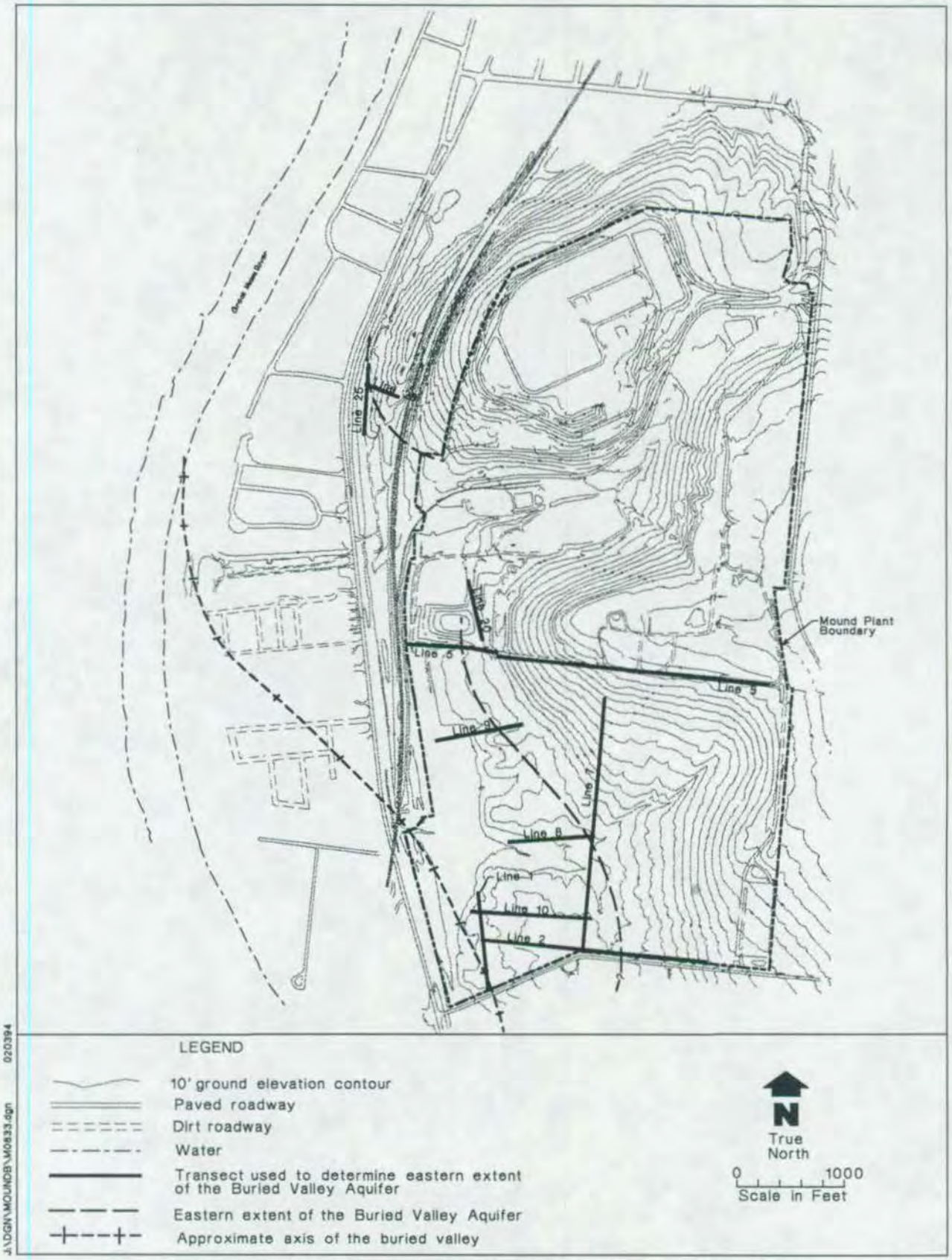


Figure 3.3. Approximate eastern extent of the Buried Valley Aquifer as determined from seismic refraction profiles.

6.3.3 indicate elevations of 681 to 683 ft; these small differences are considered relatively unimportant.

Transects in the Miamisburg City Park and along the West Boundary Road were collected in the winter when there was a frozen surface layer that caused a velocity inversion. This velocity inversion complicated the interpretation of data collected with a sledge hammer sound source, but did not adversely affect data quality when explosive charges, buried at a minimum depth of 6 ft, were used as a sound source. Seismic line 27 was collected using a sledge hammer source and was not interpreted because of the velocity inversion caused by the frozen surface layer. Transects collected in the Miamisburg City Park and along the West Boundary Road indicate that the bedrock surface slopes to the west, toward the Great Miami River. In addition, the bedrock surface slopes to the south at the south end of seismic line 26. This is probably related to the intersection of the tributary channel with the buried valley.

3.4.1. Correlation of Bedrock Elevations

In general, the correlations between measured and calculated bedrock elevations are very good. Most of the seismic transects are located near wells or exploratory borings, and several transects intersect one another. Comparison of calculated bedrock depths to depths measured in boreholes, and comparison of calculated depths at intersection points, are effective methods for determining the accuracy of the interpretations. Furthermore, these comparisons aid in identifying problems such as hidden layers and velocity inversions.

Table III.1 compares bedrock elevations calculated along seismic transects with elevations measured in adjacent boreholes. Column 1 is the seismic line location identification. Column 2 is the calculated bedrock depth as determined from the seismic refraction data. Columns 3 and 4 are the measured depth to bedrock and the referenced borehole location identification. Column 5 shows the distance along the seismic refraction line (provided as horizontal distance along the bottom of the seismic refraction line profiles in Appendix B.1). Column 6 shows the direction and distance from the seismic refraction line to the adjacent borehole. Column 7 is the difference, in feet, between the calculated and measured depth to bedrock.

Table III.2 compares calculated bedrock elevations at seismic line intersection points. This correlation of bedrock depths for intersecting, or nearly intersecting, seismic refraction lines is a check on the depth at one given point as determined from two separate seismic lines. Of the 20 intersecting points listed in Table III.2, five had insufficient quality data at the intersection points to generate a profile. Of the remaining 15 intersecting points, the majority had elevation differences of 0 to 5 ft. Two

Table III.1. Mound Plant Seismic Refraction Data

Seismic Line #	Calculated[a] Bedrock Elev. (ft)	Measured[b] Bedrock Elev. (ft)	Adjacent Borehole #	Dist. Along (3) Refraction Line (ft)	Dist. from Refraction Line (ft)	Depth to Bedrock Difference (ft)
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	-	-	-	-	-	-
3	799	808	BH 697	135	105 E	9
4	664	662	0306	165	0	2
4	664	655	0310	170	0	9
4	664	662	0153	185	0	2
4	664	666	0063	65	100 E	2
4	664	671	0374	55	170 E	7
4	664	670	P 006	60	165 E	6
4	669	666	0393	190	70 E	3
4	<674	<668	0307	345	70 E	-
4	667	665	P 002	320	140 E	2
4	<673	<663	0152	470	15 W	-
4	670	665	P 007	570	0	5
5	658	666	0063	110	35 N	8
5	659	670	P 006	170	25 N	11
5	662	666	0393	70	155 N	4
5	677	678	P 015	340	175 S	1
5	716	716	0382	480	90 N	0

Table III.1. (Page 2 of 4)

Seismic Line #	Calculated[a] Bedrock Elev. (ft)	Measured[b] Bedrock Elev. (ft)	Adjacent Borehole #	Dist. Along (3) Refraction Line (ft)	Dist. from Refraction Line (ft)	Depth to Bedrock Difference (ft)
5	726	727	0353	574 (4)	200 S	1
5	880	880	0350	2470 (4)	120 N	0
5	651	<668	0305	135	40 S	-
5	658	667	0309	150	30 S	9
5	653	<679	BH 701	255	140 S	-
5	795	798	BH 696	910	10 S	3
5	848	860	BH 450	1385	15 N	12
5	855	857	BH 673	1470	25 S	2
5	856	868	BH 451	1530	10 N	12
5	859	861	BH 441	1660	5 S	3
5	861	869	BH 669	1850	15 S	8
6	-	-	-	-	-	-
7	742	754	0354	1200	30 E	11
8	-	-	-	-	-	-
9	600	593	P 033	135	150 S	7
9	600	<639	0076	-65	10 S	-
10	-	-	-	-	-	-
11	883	889	BH 402	35	80 E	6
11	846	871	BH 118	410	5 E	25
11	868	876	BH 465	330	15 E	8
11	881	891	BH 470	75	45 W	10

Table III.1. (Page 3 of 4)

Seismic Line #	Calculated[a] Bedrock Elev. (ft)	Measured[b] Bedrock Elev. (ft)	Adjacent Borehole #	Dist. Along (3) Refraction Line (ft)	Dist. from Refraction Line (ft)	Depth to Bedrock Difference (ft)
11	866	877	BH 461	335 (4)	120 E	11
11A	-	-	-	-	-	-
12	879	880	0350	115	10 E	1
12	874	880	BH 478	60	25 W	6
12	885	884	BH 600	515	50 E	1
12A	862	875	BH 117	70	150 W	13
12A	850	865	BH 259	370	30 E	15
12A	848	855	BH 260	385	50 E	7
12A	856	855	0326	235	0	1
13	718	709	0345	260	10 S	9
13	734	708	BH 276	210 (4)	35 S	26
14	773	777	0332	610	30 S	4
15	-	-	-	-	-	-
16	-	-	-	-	-	-
17	783	777	0332	25	10 E	6
18	-	704	0314	-35	0	-
19	-	-	-	-	-	-
20	725	715	0352	25	30 W	10
21	801	796	0318	25 (4)	450 N	5
21	788	777	BH 263	-70	30 N	11
21	826	817	BH 419	510	35 N	9

Table III.1. (Page 4 of 4)

Seismic Line #	Calculated[a] Bedrock Elev. (ft)	Measured[b] Bedrock Elev. (ft)	Adjacent Borehole #	Dist. Along (3) Refraction Line (ft)	Dist. from Refraction Line (ft)	Depth to Bedrock Difference (ft)
21	828	830	BH 574	700	80 N	2
22	-	-	-	-	-	-
23	-	-	-	-	-	-
24	699	681	0335	260	30 W	18
25	-	-	-	-	-	-
26	667	663	0340	430	20 E	4
27	-	-	-	-	-	-
28	-	-	-	-	-	-

NOTE: Correlation of bedrock elevations calculated from seismic refraction data with bedrock elevations measured in boreholes.

[a]Determined from seismic refraction time - distance calculations.
[b]Determined from borehole drilling.

Table III.2. Correlation of Seismic Refraction Intersection Points, Mound Plant

Seismic Line Number	Interpreted Bedrock Elevation (ft)	Intersecting Line Number	Interpreted Bedrock Elevation (ft)	Elevation Difference (ft)
1[a]	-	2	-	
1[a]	-	10	-	
2[b]	787	3[b]	793	-6
2	-	7[a]	-	0
3	827	22	825	2
4[b]	663	5[b]	662	1
5[b]	865	12[b]	868	-3
5[b]	725	20[b]	726	-1
7[b]	708	8[b]	706	2
7[a]	-	10	-	
11A[b]	776	13	775	1
14[b]	779	16[b]	784	-5
14[b]	768	17[b]	772	-4
15	790	16	786	4
15	781	17	779	2
19[b]	799	21[b]	799	0
24	-	27[a]	-	
25	683	26	675	8
25	680	28	688	-8

[a] These lines have insufficient data (no interpretive profile) at the point of intersection.
[b] Elevations for lines that nearly intersect are from projections based on trends.

notable exceptions include the intersecting points on seismic lines 25/26 and seismic lines 25/28. For unknown reasons, these lines had discrepancies of 8 ft in bedrock elevation. This discrepancy should have been minimized by using a velocity override value for the "V_2" layer as was done for the seismic line 25 profile.

3.4.2. Seismic Wave Propagation Velocities

Table III.3 summarizes the seismic wave propagation velocities measured in this study. The refracting horizons identified are interpreted to include unsaturated and unconsolidated materials, saturated and unconsolidated materials, glacial till, and bedrock. These interpretations are based on the geologic setting of the refraction transects, seismic wave propagation velocities, and lithologic data from adjacent boreholes. The velocity of seismic wave propagation ranges from 1,000 to 4,230 ft/s through unsaturated and unconsolidated materials; 4,090 to 5,730 ft/s through saturated and unconsolidated materials; 5,800 to 6,720 ft/s through glacial till; and 7,140 to 14,510 through bedrock. There is some overlap between the velocity range for saturated and unsaturated unconsolidated materials, and the interpretation was based on the geologic setting of the transect and information from adjacent seismic lines and boreholes.

3.5. DISCUSSION

Overall, the seismic refraction survey proved effective for mapping bedrock topography beneath the Mound Plant. The comparison of calculated depths with boreholes and at intersection points indicate that the survey results were accurate. The seismic refraction data, along with others, e.g., borehole lithologic logs, are used in the creation of the bedrock topography map and the lithologic cross sections presented in sections of this report.

The specific objectives of the seismic refraction survey were to 1) define bedrock topography and identify bedrock lows and channels that could provide a preferential pathway for contaminant migration from the Mound Plant; and 2) define the eastern margin of the Buried Valley Aquifer along the southern part of the plant, known as the new property or the south property. These objectives were met with qualifications. The preliminary survey (DOE 1990) indicated the seismic refraction method was effective in locating depths to bedrock and identification of the bedrock surface. This conclusion is supported in the present study. The locations and spread configurations of the survey lines in the current study were determined from evaluation of plant maps, aerial photographs and an understanding of the geologic environment to be characterized. These were predicated on the scale of apparent deep portion of the Buried Valley Aquifer depicted in the preliminary bedrock topography map presented in the OU 9 Site-Wide Work Plan. One interpretation of the deep zone was that it may have represented

Table III.3. Summary of Seismic Velocities, Mound Plant

Seismic Line Number	Velocity (ft/sec) in Unconsolidated Unsaturated	Velocity (ft/sec) in Unconsolidated Saturated	Velocity (ft/sec) in Till	Velocity (ft/sec) in Bedrock
2	1670	4200	6430	10590
3	1360-1430	-	-	9690-9910
4	1280-1340	4550-4900	-	9670-12070
5	1220-2220	4090-4900	-	7770-12000
6	1255-1450	3450-4820	-	7140-8720
7	1160-3840	-	-	8480-10200
8	1470	4370	-	12080
9	1590	5730	-	14200
10	1860	4340	6450	14510
11	1440-3530	-	-	9460-11410
11A	1520	-	-	9520
12	1660-2090	-	-	13510-11630
12A	2050	-	-	12390
13	1330-2130	4720-5500	-	8000-10350
14	1350	5470	-	9800
15	1850	5350	-	10290
16	2030	5500	-	10540
17	2160-2630	4300-5700	-	9940-10670
19	1700	-	-	8870
20	1320	4940	-	10190
21	1700	-	-	9300
22	1800-1880	-	-	8750-8800
23	1920-2290	-	-	9670-12210
24	1000-1070	-	5800-6510	9840-9090
25	1190	-	5700	11150
26	1260	-	6720	12030
28	1330	5660	-	9480

the confluence of a buried tributary with the ancestral river. This is judged not to be the case in this report (see subsection 5.9).

Although general trends of bedrock topography are determined by the seismic refraction survey, the definition of high-relief bedrock topography and identification of steep-sided bedrock lows and channels is problematic. The general trends of buried bedrock topography determined by the seismic refraction survey is complemented by data from the recent drilling program. Although undetected by the seismic refraction survey, detailed logs from the subsequent drilling program reveal an apparently narrow, deep gorge buried beneath the sediments in the Mound Plant valley. This buried gorge appears to be approximately 30- to 50-ft wide and varies from 110-ft deep in the upper reaches of the plant drainage ditch and 140-ft deep in the lower reaches. The trend of the gorge appears to parallel the plant drainage, but where it has been identified, it does not lie directly under the active surface stream. Although it is recognized that the plant valley and drainage ditch generally parallel the buried gorge, it is not apparent from present topography what the exact trend of the gorge may be, either north of or west of the current valley expressions.

None of the seismic lines in either the present or the preliminary surveys (DOE 1990) directly crossed the suspected trend of the gorge. In the lower plant valley, the northern end of seismic line 4 stops short of extending across the suspected gorge. The operation of high volume water pumps, and the wastewater treatment plant in the lower valley, caused high levels of ambient noise which precluded the northward continuation of seismic line 4. Seismic line 18 crossed a portion of the plant valley with the appropriate geometry, but the data was inherently noisy and impossible to interpret and therefore an extension of the line northward was not attempted. In the upper valley, seismic line 19 stopped short of crossing the suspected gorge and seismic line 21 runs parallel to the suspected trend of the gorge. Lines 19 and 21 were designed to look for buried tributaries to the plant drainage ditch.

Not knowing the geometry of the gorge, this refraction program was not designed to image a channel this steep and narrow and buried so deeply beneath the tills and sediments on the plant tributary valley. The spread configurations of the seismic lines were determined from the scale of both the exposed terrain and the deep portion of the Buried Valley Aquifer in the southwestern part of the plant The spread configurations of the seismic lines may not have provided sufficient resolution to identify the buried gorge had the lines extended across its trend. Imaging a gorge that is deeper than it is wide requires a phased survey in which geophone spacing, line length and shot points are moved incrementally. The image resolution is dependent on geophone spacing, but depth of penetration is dependent on line length. Narrower geophone spacings will provide higher resolution of the bedrock surface, but wider geophone spacings are required to provide deeper penetration. The maximum length of the line is determined from a fixed number of 24 geophones currently available at the site. An array

that may be used to detect a feature such as the gorge would require a very tight geophone spacing (5- and 10-foot), multiple shots along the line, extremely long offset shots (100- to 200-foot), and the use of large explosive charges. Larger seismic refraction studies using oil field exploratory methods are possible, but require major changes in field methods, equipment, and computer software.

The objective to define the eastern margin of the Buried Valley Aquifer was accomplished. The seismic refraction data again compliment the data from the drilling program. In the southern part of the new property, the base of the Buried Valley Aquifer is observed in monitoring well 0356 to be 181-ft deep. This is supported by the results from Line 2 that indicate the base of the Buried Valley Aquifer may be as deep as 225 ft. This is interpreted to indicate that the present river course generally follows the ancient valley, but since the time of the deep incision, the river has established a floodplain wider than the deep portions of the buried valley. The modern river is channeled along a course that crosses the buried channel meanders. The actual axis of the deep portions of the buried valley appears to occupy a meander that trends southeasterly beneath the southern portion of Mound Plant. The trend of the eastern margin of the Buried valley aquifer is interpreted from this study to mimic the axial geometry of the buried channel. The surface topography in the southern part of the plant indicates that the eastern margin of the Buried Valley Aquifer approximately follows the 730-ft surface contour (Figure 3.2).

SECTION 4

4. GEOTECHNICAL INVESTIGATIONS

As part of the OU 9 hydrogeological investigation, geotechnical analyses were performed to determine physical characteristics of the matrix of geologic materials in the Buried Valley Aquifer. The objective of the study was to provide specific data on the hydraulic properties and chemical attenuation characteristics of the glacial till deposits interbedded with the highly permeable glacial outwash deposits that comprise the Buried Valley Aquifer. The preliminary conceptual model of the aquifer outlined in the OU 9 Site-Wide Work Plan (DOE 1992a) was one where upper and lower outwash units were separated by a relatively thick till unit that formed a central aquitard. Results discussed throughout this report indicate that the tills are typically thin and discontinuous in places. These results suggest that the hydraulic interconnection between upper and lower outwash deposits are unlikely to be dependent on the characteristics of the intervening till units.

Descriptions and discussions of site-specific geotechnical investigations in a small area of the Buried Valley Aquifer are given in the Operable Unit 1 Remedial Investigation Report (DOE 1994d). The subsections that follow provide descriptions and results of the geotechnical and x-ray diffraction analyses. The complete geotechnical testing results are presented in Appendix C, Geotechnical and X-Ray Diffraction Test Results.

4.1. GEOTECHNICAL ANALYSES

4.1.1. Methods

Geotechnical samples were collected from selected stratigraphic units to characterize the physical conditions of the unconsolidated sediments. Samples were collected from various monitoring well boreholes and submitted to Bowser and Morner Laboratories for geotechnical analysis. Twenty-two geotechnical samples were collected from boreholes 0341, 0342, 0343, 0344, 0346, and 0386. The well boring locations are shown in Figure 2.7. The depths and corresponding geological units from which the samples were collected, as well as relevant geotechnical data, are summarized in Table IV.1.

The following parameters were measured by the specified procedure:

- Particle-Size Analysis of Soils - ASTM D422
- Specific Gravity of Soils - ASTM D854
- Laboratory Compaction Characteristics of Soil Using Modified Effort (12,400 ft.-lbf/ft^3 (600kN-m/m^3)) - ASTM D1557

Table IV.1. Geotechnical Test Results for OU 9 Well Borings

Monitoring Well/ Piezometer ID	Sample ID	Depth (ft)	Visual Lithology	Moisture Content (%)	Cation Exchange Capacity meq/100 gms	Specific Gravity	Particle Sizes (%)					USCS Classi-fication	Lost on Ignition (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Hydraulic Conductivity	
							Cobble	Gravel	Sand	Silt	Clay					(cm/sec)	(ft/day)
0341	0020	17.0-18.0	Glacial Till	9.4	4.9	2.73	0	9	30	31	30	ML-SM	1.5	144.8	132.3	4.0×10^{-9} 7.0×10^{-9}(a)	1.1×10^{-5} 2.0×10^{-5}
0342	0010	7.0-10.0	Glacio-fluvial Outwash	8.5	4.1	2.75	0	56	35	5	4	GW-GM	0.8	134.7	130.7	4.4×10^{-5}	0.1
0342	0075	73.0-75.0	Glacial Till	11.7	4.5	2.73	0	16	40	25	19	SM	1.4	142.0	127.0	2.3×10^{-8}	1.0×10^{-4}
0342	0095	90.0-95.0	Glacio-fluvial Outwash	22.8	3.1	2.71	0	3	84	7	6	SP	1.2	124.8	111.5	3.5×10^{-5}	9.9×10^{-2}
0343	0028	20.0-28.0	Glacio-fluvial Outwash	Saturated	8.4	---	0	42	38	11	9	GM	1.3	120.5	119.6	1.9×10^{-5}	5.3×10^{-2}
0343	0037	30.0-37.0	Glacio-fluvial Outwash	Saturated	3.0	---	0	38	49	7	6	SM	1.1	133.0	132.4	3.3×10^{-4}	0.9
0343	0057	56.0-58.0	Glacio-fluvial Outwash	7.3	4.4	2.74	0	32	42	16	10	SM	0.7	141.7	132.1	1.5×10^{-5}	4.2×10^{-2}
0343	0067-0080	66.0-80.0	Glacial Till	11.4	10.0	2.73	0	10	31	27	32	CL	2.1	133.7	120.1	2.9×10^{-9} 2.5×10^{-9} (a)	8.2×10^{-6} 7.1×10^{-6}
0344	0018	15.0-18.0	Glacio-fluvial Outwash	9.9	3.48	2.74	0	48	42	10	---	GW-GM	0.8	147.6	133.7	5.0×10^{-6}	1.4×10^{-2}
0344	0025	19.0-25.0	Glacio-fluvial Outwash	6.6	4.13	2.74	0	63	29	8	---	GP-GM	0.9	145.6	137.1	3.0×10^{-4}	0.8
0344	0030	25.0-30.0	Glacial Till	5.8	1.20	2.72	0	28	47	15	10	SM	0.7	140.0	133.2	1.1×10^{-6}	3.1×10^{-3}
0344	0035	30.0-35.0	Glacial Till	7.0	4.24	2.74	0	21	54	15	10	SM	1.0	140.8	134.6	5.4×10^{-7}	1.5×10^{-3}
0344	0040	35.0-40.0	Glacial Till	8.6	9.24	2.71	0	23	43	19	15	SM	1.2	136.2	127.6	4.2×10^{-5}	0.1
0344	0060	55.0-60.0	Glacio-fluvial Outwash	21.2	1.85	2.71	0	2	91	7	---	SP	0.5	111.0	106.9	5.5×10^{-4}	1.5
0344	0065	60.0-65.0	Glacio-fluvial Outwash	22.5	1.85	2.69	0	0	85	15	---	SM	0.8	105.2	103.2	3.3×10^{-4}	0.9
0344	0115	105.0-115.0	Glacio-fluvial Outwash	8.6	1.41	2.71	0	33	65	2	---	SP	1.1	125.6	121.1	4.9×10^{-4} 3.5×10^{-4} (a,b)	1.4 1.0
0346	0025	24.0-25.0	Glacial Till	9.7	4.4	2.73	0	13	31	29	27	CL	1.3	139.3	127.0	2.5×10^{-9}	7.1×10^{-6}
0346	0035	34.0-35.0	Glacio-fluvial Outwash	8.9	4.3	2.65	0	48	32	8	12	GM	1.6	138.3	134.8	3.5×10^{-7}	1.0×10^{-3}

Table IV.1. (page 2 of 2)

Monitoring Well/ Piezometer ID	Sample ID	Depth (ft)	Visual Lithology	Moisture Content (%)	Cation Exchange Capacity meq/100 gms	Specific Gravity	Particle Sizes (%)					USCS Classi-fication	Lost on Ignition (%)	Wet Unit Weight (pcf)	Dry Unit Weight (pcf)	Hydraulic Conductivity	
							Cobble	Gravel	Sand	Silt	Clay					(cm/sec)	(ft/day)
0386	0033	27.0-33.0	Glacio-fluvial Outwash	6.6	2.6	2.76	0	47	32	11	10	GM	1.9	148.2	139.3	7.3×10^{8} 1.9×10^{8} (a,c)	2×10^{4} 1×10^{4}
0386	0035	34.0-35.0	Glacial Till	10.5	2.5	2.73	0	12	36	31	21	ML	2.2	155.2	140.4 131.9 (a)	9.8×10^{9} 9.2×10^{9} (a)	2.8×10^{5} 2.6×10^{5}
0386	0055	48.0-55.0	Glacio-fluvial Outwash	10	4.0	2.80	23	43	21	9	4	GM	0.8	136.4	133.8	4.7×10^{7}	1.3×10^{3}
0386	0080	80.0	Glacio-fluvial Outwash	11.5	1.5	2.77	0	54	38	4	3	GP-GM	1.4	126.9	125.4	9.1×10^{5}	0.2

(a) Retested value.
(b) Remolded specimen.
(c) Remolded specimen from oven dry material.

- Laboratory Determination of Water (Moisture) Content of Soil and Rock - ASTM D2216 Classification of Soils for Engineering Purposes - ASTM D2487
- Moisture, Ash, Organic Matter of Peat and Other Organic Soils - ASTM D2974
- Maximum Index Density and Unit Weight of Soils and Calculation of Relative Density - ASTM D4254
- Measurement of Hydraulic Conductivity of Saturated Porous Materials using a Flexible Wall Permeameter - ASTM D5084
- Cation-Exchange Capacity of Soils (Sodium Acetate) - EPA Method 9081 A

Thin-walled Shelby tubes were chosen as the means to collect an undisturbed sample of the fine-grained unconsolidated subsurface sediments. In collecting Shelby tube samples from the glacial till and the glacio-fluvial outwash materials, the thin-walled steel tubes collapsed prior to obtaining sufficient sample volume.

As a secondary choice for sample collection, soil samples were obtained during normal drilling operations. The well borings were advanced by the sonic drilling technique and samples for geotechnical and mineralogical analysis were collected directly from the soil recovered during normal drilling operations. The sonic drilling technique employs a tube approximately 7 inches in diameter and of various lengths, that is vibrated into the subsurface soils. These core tubes were 5-, 10-, or 20-ft in length and soil recovery was nearly 100 percent, providing enough bulk sample for the required geotechnical and mineralogical testing.

Cohesionless sandy samples, predominately glacio-fluvial outwash materials, obtained through this means are considered disturbed samples. During geotechnical testing, these samples have to be remolded in testing cylinders in preparation for geotechnical testing. Additionally, many samples of the glacial till material were recovered in solid core-like samples and were trimmed down to fit into the testing cylinder for hydraulic conductivity testing. These sample preparations impact the hydraulic conductivity testing and remolded specimens can have a much different particle structure than the original *in-situ* state and may affect the hydraulic conductivity result. However, testing results between undisturbed and remolded samples showed little or no difference in hydraulic conductivity.

Eight samples of the glacial till and 14 samples of the glacio-fluvial outwash materials were collected. The glacial till materials were collected at depths ranging from 17.0 to 18.0 ft to 73.0 to 75.0 ft and glacio-fluvial outwash materials were collected at depths ranging from 7.0 to 10.0 ft to 105.0 to 110.0 ft.

4.1.2. Results

The results of the geotechnical analyses are shown in Table IV.1. The complete laboratory report is included in Appendix C.1. The mean hydraulic conductivity value for the glacio-fluvial outwash materials is 1.8×10^{-5} cm/sec and ranges from 5.0×10^{-4} to 1.9×10^{-8} cm/sec. The geometric mean hydraulic conductivity value for the glacial till is 2.0×10^{-8} cm/sec and ranges from 4.2×10^{-5} to 1.5×10^{-9} cm/sec. The clay contents for the glacial tills ranges from 10 to 30 percent, overlapping with values for glacio-fluvial outwash deposits that range from 4 to 15 percent.

4.1.3. Discussion

The mean values for the hydraulic conductivity of glacial outwash and till are within the range of values assigned to similar geologic materials, silty sand and glacial till (Freeze and Cherry 1979). Values for the hydraulic conductivity are consistent with the particle-size distribution reported (Table IV.1). Samples with very low hydraulic conductivity also possess relatively high clay contents, consistent with the interpretation that very fine-grained particles, such as clays, tend to reduce pore space and reduce conductivity. Some of the tills, however, reportedly possess relatively low clay mineral contents, down to 10 percent, and hence are not as clay-rich as they may appear in the field. The balance of the fines probably consists of "rock flour," essentially very finely comminuted rocks.

Locally, the low hydraulic conductivity of the till may provide for confining conditions to be present. Leakage would be slow through those units with lower hydraulic conductivity. Some of the tills units appear to possess hydraulic conductivities as high as the outwash deposits. Although the tills may provide locally confined conditions, the discontinuous nature of the tills and the range of physical properties certainly indicate that the tills do not prevent recharge to lower sands and gravels of the Buried Valley Aquifer.

The samples of the outwash deposits themselves probably do not represent the full range of deposits comprising the Buried Valley Aquifer. Although some samples possess up to 63 percent gravel, none of the samples indicate cobble-sized materials. The latter are likely to possess the greatest hydraulic conductivities in the Buried Valley Aquifer. Sampling simply did not include the coarsest deposits in the cores recovered.

The permeabilities of the samples tested are not necessarily representative of the entire aquifer owing to stratification and the presence of less and more permeable horizons. Laboratory derived values are typically less than those measured in the natural environment. Measurements of hydraulic conductivity from aquifer tests in the Buried Valley Aquifer are presented in Section 5 that follows.

4.2. X-RAY DIFFRACTION

4.2.1. Methods

Geotechnical samples were collected from selected stratigraphic units to characterize the physical conditions of the unconsolidated sediments. Samples were collected from various monitoring well boreholes and submitted to Lambda Research, Inc., for clay mineralogy. The well boring locations are shown in Figure 2.7. The technique by which each sample was prepared, how the diffraction pattern was obtained and various phases were analyzed are presented in Appendix C.2.

4.2.2. Results

Table IV.2 summarizes the results of the semi-quantitative phase analysis and the x-ray fluorescence analysis of the clay samples. The complete laboratory report is included in Appendix C.2. The diffraction patterns of the clay samples, absolute intensity, relative intensity, angle, d-spacing and half width for peaks in the diffraction patterns are provided in Appendix C.2. Additionally, diffraction pattern and peak information for the calibration and the output from the quantitative analysis program are also included in this appendix.

The portion of the samples passing the 200 mesh fraction seem to contain more minerals than actual clay. The minerals identified are quartz, calcite, dolomite, stilbite, anorthite, and hydrosodalite. The clays are identified as montmorillonite, illite, and kaolinite. The major constituents in most samples are quartz, calcite, and dolomite. Anorthite, montmorillonite, and illite could be considered as secondary phases while kaolinite, stilbite, and hydrosodalite form the minor phases. Montmorillonite and illite are the major clay phases present with kaolinite a secondary clay phase.

4.2.3. Discussion

The x-ray diffraction results indicate the presence of clays including montmorillonite, illite, and kaolinite. Clay minerals are important in contaminant attenuation in that they possess unbalanced, negative electrical surface charges. The larger the surface areas, the greater the reactive nature of the clay species. Clay minerals owe their properties to definite crystal structures composed primarily of aluminum, silica, and oxygen. Kaolinite (formula $Al_4Si_4O_{10}(OH)_8$) is a clay mineral with relatively low specific surface area, i.e., surface per unit mass, that ranges from 5 to 20 m^2/g, indicating that kaolinite is poorly reactive. Illite (formula $KAl_4Si_7AlO_{20}(OH)_4$) has a higher specific surface area that ranges from 80 to 120 m^2/g. Montmorillonite (typical formula $AlMgSi_8O_{20}(OH)_4$) is the most reactive of the group with specific surface areas that range from 700 to 800 m^2/g. Montmorillonite is part of

Table IV.2. Clay Mineralogy Test Results for OU 9 Well Borings

			X-Ray Diffraction - Quantitative Phase Analysis										X-Ray Diffraction Fluorescence Analysis
			WEIGHT PERCENT										
Sample ID	Depth (ft)	Visual Lithology	Montmorillonite	Illite	Stilbite	Kaolinite	Hydrosodalite	Quartz	Anorthite	Calcite	Dolomite	Percent Crystallinity	Elements
MND20-0342-0010	7.0-10.0	Glacio-fluvial Outwash	12	13	2	3	0	16	4	7	48	96	Fe, Ca, Si, K, Ti, Al
MND20-0342-0075	73.0-75.0	Glacial Till	6	8	2	6	0	15	8	27	26	98	Ca, Fe, Cl, Si, P, Al
MND25-0342-0075[a]	73.0-75.0	Glacial Till	6	7	0	6	0	17	6	30	34	107	
MND20-0342-0095	90.0-95.0	Glacio-fluvial Outwash	7	5	3	4	0	24	10	5	38	96	Fe, Ca, Si, Ti
MND20-0343-0057	56.0-58.0	Glacial Till	4	6	0	5	1	18	4	15	40	94	K, Cr, Ca, Al, Si
MND20-0343-0037	30.0-37.0	Glacio-fluvial Outwash	20	13	0	5	0	16	6	22	21	103	Fe, Ca, Si, Cl, Al

[a]Repeat measurement
Al - Aluminum
Ca - Calcium
Fe - Iron
K - Potassium
Si - Silicon
Ti - Titanium
Cr - Chromium

a group of clay mineral called smectities that are termed expandable clays, because they may absorb large amounts of water, organic compounds and ions between their sheetlike mineral grains. This property gives soils the ability to shrink and swell, and gives the glacial till deposits the ability to absorb chemical compounds, metals and other possible contaminants.

Clay minerals in soils and fine-grained sediments are part of a group of materials with electrostatic surface charges called colloids. Colloids also include sesquioxides, which are hydrated iron and aluminum minerals and humus or decomposed organic materials. The unbalanced negative surface charges of colloids are typically balanced by positively charged cations that are attracted to the surface. The ability of interlayer cations to replace the cations in nearby solutions is called cation exchange. The total number of positive charges that can be exchanged in a soil matrix is independent of the cation species and is expressed as the cation exchange capacity.

In addition to the net negative surface charge of clays, the edges often carry a net positive charge, which provides exchange sites for the anions. Since the surface area far exceeds the edge area, the cation exchange capacity typically exceeds the anion exchange capacity. Kaolinite has the greatest anion exchange capacity of the clay minerals.

The relatively higher proportions of montmorillonite clay in the outwash deposits in comparison with the till deposits, the high variation in the cation exchange capacity, and the greater thicknesses of the outwash deposits suggests that the outwash deposits may actually possess greater affinities to retard contaminant migration than the tills present. Locally, some of the till units have much greater cation exchange capacity than the outwash deposits. Actual attenuation will depend on species, i.e., oxidation state of metals and absorption and partition characteristics of specific chemical compounds. Detailed discussions are beyond the scope of this investigation.

4.3. SOIL PH

4.3.1. Methods

Soil pH measurements were performed according to the electrometric procedure SW-9045 on all soil samples that were collected for geotechnical measurements. To perform these measurements, equal weights of the soil sample and deionized water were added to a polyethylene bottle. The bottle was shaken until the soil was suspended. The soil was allowed to settle for one hour prior to measurement. The pH measurement was taken in the suspended water with an Analytical Measurements Model 107 pH meter. Care was taken not to place the probe into the soil that had settled at the bottom of the polyethylene bottle.

4.3.2. Results

The results of the soil pH measurements are shown in Table IV.3. In all, 23 soil pH measurements were taken with pH values ranging from 6.2 to 7.8. The arithmetic mean soil pH value is 7.1

4.3.3. Discussion

The measurement of pH provides values of concentrations of H^+ and OH^- in solution. These species contribute to acidity and alkalinity, but within the pH range commonly seen in natural water they are minor constituents. The principal solutes that constitute acidity or alkalinity are imparted to natural water during its passage in liquid from through the hydrologic cycle (USGS, 1986).

Most natural waters contain substantial amounts of carbon dioxide species. The regional geology of southwestern Ohio has a predominance of limestone, calcium carbonate, rock that is exposed at the surface. Weathering of the limestone produces, under various conditions, numerous chemical reactions. The chemical reaction between slightly acidic rain water and the limestone rock produces a bicarbonate (HCO_3^-). The bicarbonate ion provides for strong buffering capabilities (Lerman 1979). The soil pH values measured on and adjacent to Mound Plant are representative of the values expected in a such a geologic setting, i.e., values centered around neutral (pH 7).

Table IV.3. Soil pH Data

Sample Location	Sample Depth (ft)	pH
0341	20	7.1
0342	10	6.8
0342	75	7.0
0342	95	7.1
0343	28	6.9
0343	57	7.0
0343	57	7.0
0343	80	7.1
0344	18	7.3
0344	25	7.4
0344	30	6.9
0344	35	6.2
0344	40	7.8
0344	60	7.7
0344	65	7.3
0346	25	7.0
0346	35	7.0
0386	33	7.0
0386	35	7.8
0386	55	7.7
0386	80	7.8
P026	48	7.2
P026	83	7.2

SECTION 5

5. LITHOLOGY AND STRATIGRAPHY

A detailed investigation of the unconsolidated deposits that underlies the Mound Plant has been conducted as part of the Operable Unit 9 hydrogeologic investigations. These lithologic studies refine the lithologic database to assist in establishing the hydrogeology of the unconsolidated deposits. Initial descriptions of the unconsolidated deposits were provided in the OU 9 Site-Wide Work Plan (DOE 1992a) and Evaluation of the Buried valley Aquifer Adjacent to Mound Laboratory (Dames and Moore 1976). The unconsolidated deposits are all considered Quaternary age and are the major source of groundwater in the vicinity of the Mound Plant and throughout the Miami Valley. The Buried Valley Aquifer consists of saturated glacial deposits in the Great Miami River valley. The Buried Valley Aquifer occupies a deep channel that roughly follows the course of the Great Miami River. The previous studies did not provide sufficient detail to resolve specific questions concerning the extent, geometry and stratigraphy of the unconsolidated deposits north and south of the Mound Plant and in the Mound Plant tributary valley.

The subsections that follow provide descriptions of the lithology of the unconsolidated deposits under and adjacent to the Mound Plant and places it within regional context. Geologic cross sections are presented that incorporate and interpret new subsurface data. These cross sections provide characterizations of the areal extent and thickness of the Buried Valley Aquifer and interlayered deposits.

5.1. METHODS

As part of the OU 9 hydrogeologic investigations, continuous cores were collected from all monitoring well and piezometer borings and selected monitoring wells were logged with a natural gamma probe. The Natural gamma provides additional information and an independent measure of the thickness and areal extent of the aquifer and aquitards in the deposits that form the Buried Valley Aquifer. Additional new installations were performed as part of the OU 1 Remedial Investigation: Proposal for Additional Work (DOE 1992e). Although many borings were installed only to the water table, many borings were completed to bedrock. Monitoring well and piezometer completion data and lithologies for the new OU 1 and OU 9 installations are presented in the OU 9 Hydrogeologic Investigations: Well Information Report (DOE 1994a). Additional data for municipal, production and monitoring wells existing prior to the recent OU 1 and OU 9 installations are provided in the Site Scoping Report: Volume 2 - Geologic Log and Well Information Report (DOE 1992c).

5.2. NATURAL GAMMA LOGGING

The OU 9 Site-Wide Work Plan (DOE 1992a) proposed natural gamma logs be performed on 21 existing wells and 15 new wells. Five of the 15 new wells included the deep bedrock coreholes (0348, 0349, 0350, 0352, 0355). The natural gamma logs and results for the bedrock coreholes are not included in this discussion but can be found in the OU 9 Hydrogeologic Investigation: Bedrock Report (DOE 1994b). Natural Gamma logs were performed at those wells shown in Figure 2.4. The objective of the natural gamma logging is to refine the interpretation of the thickness and areal extent of the aquifers and aquitards that form the Buried Valley Aquifer. The investigations on existing monitoring wells was predicated on the basis that the drilling techniques used on previous boreholes may not have been able to allow thin till layers to be identified. Natural gamma logs on the selected new monitoring wells would provide a calibrated reference in which to compare the logs compiled on the older, existing wells. The sonic drilling method, provided stratigraphic details not available from other drilling methods previously employed. Accurate stratigraphy was obtained with almost 100 percent recovery of unconsolidated materials to all depths drilled. Lenses of glacial till and outwash as thin as 0.25-ft are described. No previous field investigation has provided this level of detail. As such, the natural gamma logs provide a tool for evaluating the lithology in older boreholes.

5.2.1. Methods of Natural Gamma Logging

The gamma log provides a record of the total gamma radiation detected in a borehole that is within a selected energy range. Under most conditions, 90 percent of the gamma radiation detected probably originates from material within 6 to 12 inches of the borehole wall. The most significant naturally occurring, gamma-emitting radioisotopes are potassium-40 and daughter products of the uranium- and thorium-decay series-hence the name natural gamma log. Gamma logs are the most widely used nuclear logs for identification of lithology and for stratigraphic correlation.

Natural gamma equipment used for logging included a MGX digital logger and a combination stratigraphic Gamma/Electric probe. A portable computer and printer was also used in the field. Terran Corporation acquired natural gamma logs with a Neltronic Instrument Corporation Model KD Logger equipped with a Model GM sonde. Before a well was logged, the cable, head pulley, and the electric probe were decontaminated according to SOP 1.6, General Equipment Decontamination. Two equipment rinsate samples were taken as a field quality control parameter in order to assure proper decontamination methods. Analytical results are available in Appendix A.4. One trip blank sample accompanied the samples to the lab. Prior to sample shipment, a portion of each rinsate water sample was given to the Mound Plant Soil Screening Facility for tritium and gross alpha screening purposes. Water rinsate screening results determined shipping classification and accompanied the samples to the analytical laboratory. Laboratory analysis was performed by IT Corporation.

Most geophysical logging can be performed with the probe moving up or down the monitor well. Each well was logged at an approximate speed of 10-15 ft/min. The bottom 50-ft section of each monitor well was logged first by placing the probe at the bottom and moving the probe up the monitor well. This served as a quality assurance (QA) check of the validity of the monitor well logged. After the quality assurance gamma log was run, the probe was positioned at the top of the monitor well. The entire gamma log was run from top to bottom. Both the QA log and the entire log are provided in Appendix A.3. Terran collected natural gamma logs from bottom to top. Terran conducted two runs with two ranges: 2.5 millivolts (mv)/5 count per second (cps) and 5mv/10cps at each well (0001, 0002, 0006 and 0008) with a different scale.

5.2.2. Results - New Wells

Natural gamma logging was performed on several new wells. The new wells were drilled by rotosonic methods which produced a 5-inch core and was nearly 100 percent recovered. The natural gamma logs together with the drilling log would provide the most complete and accurate stratigraphic correlation of the Buried Valley deposits to date. Each gamma log was compared to the drilling log to locate lithologic discrepancies, if any. For all of the new borings surveyed, including 0328, 0330, 0335, 0341, 0342, 0344, 0345, 0346 and 0347 the correlations between natural gamma and the borings logs indicated good correlations. Well 0343 did not have the natural gamma logging performed due to a water level recording device in well.

5.2.3. Results - Existing Well Network

Several of the existing wells at the Mound Plant were installed in 1976 and 1989 by drilling methods (air rotary and cable tool) where core recovery was poor. Two correlations were performed on each natural gamma log. First, the gamma log was compared to the drilling log to determine any lithologic discrepancies. Second, most of the existing wells are now paired with a newly installed well that was drilled by rotosonic methods which allowed a 5-inch core to be retrieved at a recovery rate of nearly 100 percent. The size of the core and the high recovery rate provided a thorough geologic log of the Buried Valley deposits. The gamma log of the existing well was then compared to the geologic drilling log of its paired new well. The following is a summary of the existing monitoring wells and their associated natural gamma log results. A similar summary will follow on the new wells.

- 0001 - Natural gamma logging was performed by Terran Corporation. The well was only able to be logged to 18 ft. bgs because the casing was broken off and out of plumb. The log does indicate good correlation.

- 0002 - Natural gamma logging was performed by Terran Corporation. Good correlation.

- 0003 - This well was not originally proposed for natural gamma logging. A natural gamma log was however conducted at 0003 as part of the well abandonment program and procedures. Terran corporation performed the natural gamma logging. Results indicate good correlation

- 0005 - good correlation

- 0006 - Natural gamma logging was performed by Terran corporation. Results indicate good correlation.

- 0007 - Good correlation overall except at 28-32 ft below ground surface (bgs). The natural gamma log shows this interval as a potential till interval which is absent on the drilling log for several wells in the immediate vicinity: 0007, 0302, 0128, and 0396.

- 0008 - Natural gamma logging was performed by Terran Corporation. Only a 129 ft was accessible during the natural gamma logging (total depth of well is 143 ft) because the well is out of plumb. This was determined during drilling at the time the well was abandoned. Natural gamma results indicate good correlation.

- 0111 - Good correlation. Seal is nicely defined in the natural gamma log at 51.5-54 ft bgs.

- 0113 - Good correlation...nicely shows interbeds of limestones and shales with slightly stronger peaks where the seal is present at 32-37 ft bgs. and at 42-45.5 ft bgs.

- 0116 - Did not perform natural gamma logging at 0116 due to water level recording device in well.

- 0121 - Good correlation.

- 0137 - Good correlation with drilling log for 0137 and its paired well 0347 especially with the till interval from 20-34.5 ft bgs.

- 0154 - Fairly good correlation with drilling log for 0154 and 0394 which is located approximately 90 feet north of 0154. The natural gamma log shows the seal from 31-34 ft. bgs.

- 0301 - The natural gamma log correlates poorly with the last 25 ft of the drilling log from well 0301. The drilling log shows clay is present from 55-85 ft bgs. and the seal is set from 54.5-69.5 ft bgs. The natural gamma log shows a peak at the start of the seal (54.5 ft) but decreases at 60 ft. The till is not evident in the natural gamma log. Evidently, the clay content is not as high as the driller's log indicated.

- 0302 - Did not perform natural gamma logging at 0302 due to continuous water level recording equipment in well.

- 0303 - Good correlation with drilling log except at 55-65 ft bgs. The drilling log for 0303 shows this interval to be clay-rich but the natural gamma log does not strongly support this. However, the drilling log for new monitor well 0343 which is paired with monitor well 0303 supports the clay-rich areas.

- 0304 - Good correlation with drilling log except at the interval from 22-32 ft bgs. The drilling log for 0304 shows a silty dense clay interval but the gamma response is not very strong here. Additionally, paired well 0342 which is a new well shows an absence of this clay layer at 22-32 ft bgs. However, there is a good gamma response for a small till unit at 87-92 ft bgs. that correlates nicely to the drilling log for both 0304 and 0342.

- 0307 - Good correlation.
- 0308 - Good correlation.
- 0317 - Good correlation.
- 0319 - Good correlation. A till unit is present at 31-40 ft bgs. in both drilling logs for 0319 and its paired well 0344, but the gamma response is not very strong until the last few feet.
- 0320 - Good correlation.

5.3. DESCRIPTION OF LITHOLOGY

The unconsolidated deposits in the area of Mound Plant consist of glacial deposits of Quaternary Age and recent alluvium associated with the Great Miami River and its tributaries. The glacial deposits in the area of Mound Plant consist of ground moraines tills and water-laid drift deposits transported downstream of the glacier. General and specific descriptions of these deposits are provided below.

5.3.1. Till Deposits

Till deposits consist of poorly sorted rocks that result from ground moraine. A ground moraine is the material deposited from a glacier on the ground surface over which the glacier has moved. As the glacier became thinner and lighter it is unable to carry along beneath it all the sediment it has lodged under it. This sediment load begins to lodge and form a sheet beneath the glacier. This sheet of sediment is called a ground moraine. The ground moraine is made up only in part by sediment carried beneath the ice. The other component of the ground moraine is the materials bound-up within the glacier and released as the glacial ice melts. As the glacier melts the material is set free of part of the load carried in the ice.

Ground moraines range in thickness from 2 feet to 100 feet, and average about 30 feet, but can locally be absent where bedrock highs project through the till sheet (Spieker 1961). The composition of the till is comprised primarily of silt- and clay-sized material with subordinate amounts of sand and gravel to boulder sized material. The sand, gravel and larger sized material all lack sorting.

Tills encountered in the cores obtained from boreholes during this investigation range from less than 1 to 47 feet thick. They are typically tones of gray, moderately cohesive, dry to moist, poorly sorted silty to sandy clays with some angular to subrounded gravel to boulder size materials. Locally, till deposits are very stiff, and highly plastic indicative of high clay contents. Yellowish brown colors are observed at the tops of some units indicating the presence of oxidized iron minerals and soil

development (paleosols). Detailed descriptions are provided in the Hydrogeologic Investigations: Well Information Report (DOE 1994a).

5.3.2. Outwash Deposits

Water-laid drift deposits are comprised of any rock material, such as boulders, till, gravel, sand, or clay, transported by a glacier and deposited by or from the ice or by or in water derived from the melting of the ice. These deposits are referred to as outwash deposits and take several different forms such as valley-train deposits, kames, outwash-plains deposits, and sediments having been deposited in glacial lakes. In the Miamisburg area, by far the most important outwash deposits are the valley-train deposits. They form when glaciers terminate on a surface having sloping valleys where sediment is carried down valley by streams. Such glacial streams are overloaded with sediment so that numerous bars, shoals, and natural levees form, thus filling valleys with alluvium (Fenneman 1916). Alluvial deposits associated with the modern Great Miami River are grouped with the glacial outwash and are not differentiated in this report.

Outwash deposits encountered in the cores obtained from boreholes during this investigation range from less than 1 to 27 feet thick. They are typically tones of yellow-browns in shallow zones to grays in deeper zones, loose to crumbly, locally dry, but typically moist to saturated, moderately to well sorted sands and gravels. Lenses of well sorted coarse gravel are commonly intercalated with thicker deposits (10 to 15 feet) of well sorted medium- to coarse-grained sand. Detailed descriptions are provided in the Hydrogeologic Investigations: Well Information Report (DOE 1994a).

5.4. COMPILATION OF GEOLOGIC CROSS SECTIONS

Stratigraphy determined from soil cores recovered during the most recent drilling program, utilizing the sonic drilling method, provided stratigraphic details not available from other drilling methods previously employed. Accurate stratigraphy was obtained with almost 100 per cent recovery of unconsolidated materials to all depths drilled. Lenses of glacial till and outwash as thin as 0.25-ft are described. No previous field investigation has provided this level of detail. Utilizing new geologic information and incorporating geologic information obtained from previous drilling programs, 8 new cross sections have been developed. Figure 5.1 depicts the traces of the cross sections described below.

In uniting previous and present geologic logs into cross sections, problems arise with respect to correlating geologic units of similar lithologic character from borehole to borehole. Not only are glacial deposits regarded as one of the most variable and complex of all geologic materials, but previous investigators did not have the luxury of continuous 4- and 6-inch cores from which to describe

subsurface materials encountered while drilling and sampling. Therefore, the cross sections presented here are interpretations of geologic continuity based upon selected former drilling logs and new lithologic descriptions from geologic cores obtained with the sonic drilling method. Cross section interpretations were checked against borehole logs, results of the seismic refraction surveys, isopach map of unconsolidated deposits and bedrock topography for consistency.

As with all cross sections in this report, the limestone and shale bedrock is depicted according to the stratigraphic formations identified in the Hydrogeologic Investigations: Bedrock Report (DOE 1994b). The perched water table within the fracture carapace is also depicted from the same report. Groundwater in the bedrock is generally confined to a fracture flow system and the rocks are typically dry unless intercepted by a fracture. Groundwater seeps on the northern face of the bedrock are shown generically. Colluvial hillslope deposits are omitted for clarity.

5.4.1. Cross section A-A'

Cross section A-A' (Plate 2) generally trends north to south adjacent to the western plant boundary and the western part of Area B. A preliminary version of this section was included in the OU 9 Site-Wide Work Plan (DOE 1992a). A revised cross section was included in the OU 1 Remedial Investigation Report (Plate 1, DOE 1994d). Cross section A-A' follows exactly the trend of the OU 1 section northward through Area B, but diverges north of Area B toward the northwest. The OU 1 section depicts subsurface conditions immediately north of Area B, whereas section A-A' depicts the entire section across the tributary valley onto the bedrock to the north. Three important changes have been made to the interpretation of subsurface geology since the preliminary sections were published.

First, a deep narrow gorge is depicted to be buried beneath the tributary valley. The exact location and geometry of the buried gorge within the trace of cross section A-A' is unknown. There are no indications of the gorge at locations 0387 or 0389 (Figure 5.1). West of cross section A-A', at P026 (cross section CC') the gorge extends to an elevation of 580 ft MSL. This gorge is interpreted to trace eastward from P026 along an unknown, but probably circuitous course and most probably passes through cross section A-A' although there is not direct evidence. The gorge appears to be filled with a dense, firm till deposits at P026 and is so shown in cross section A-A'.

Second, an irregular till deposit is depicted at 690 to 670 ft elevation MSL across the middle and southern portions of cross section A-A'. This till was shown in the preliminary sections (DOE 1992a) to be continuous from its shallow expression at 0152 southward to 0076. The actual presence of the till at locations 0071 and 0271 is speculative because of the quality of those well logs (DOE 1992c). The absence of the till at location P031, however indicates that the till is not present and is interpreted

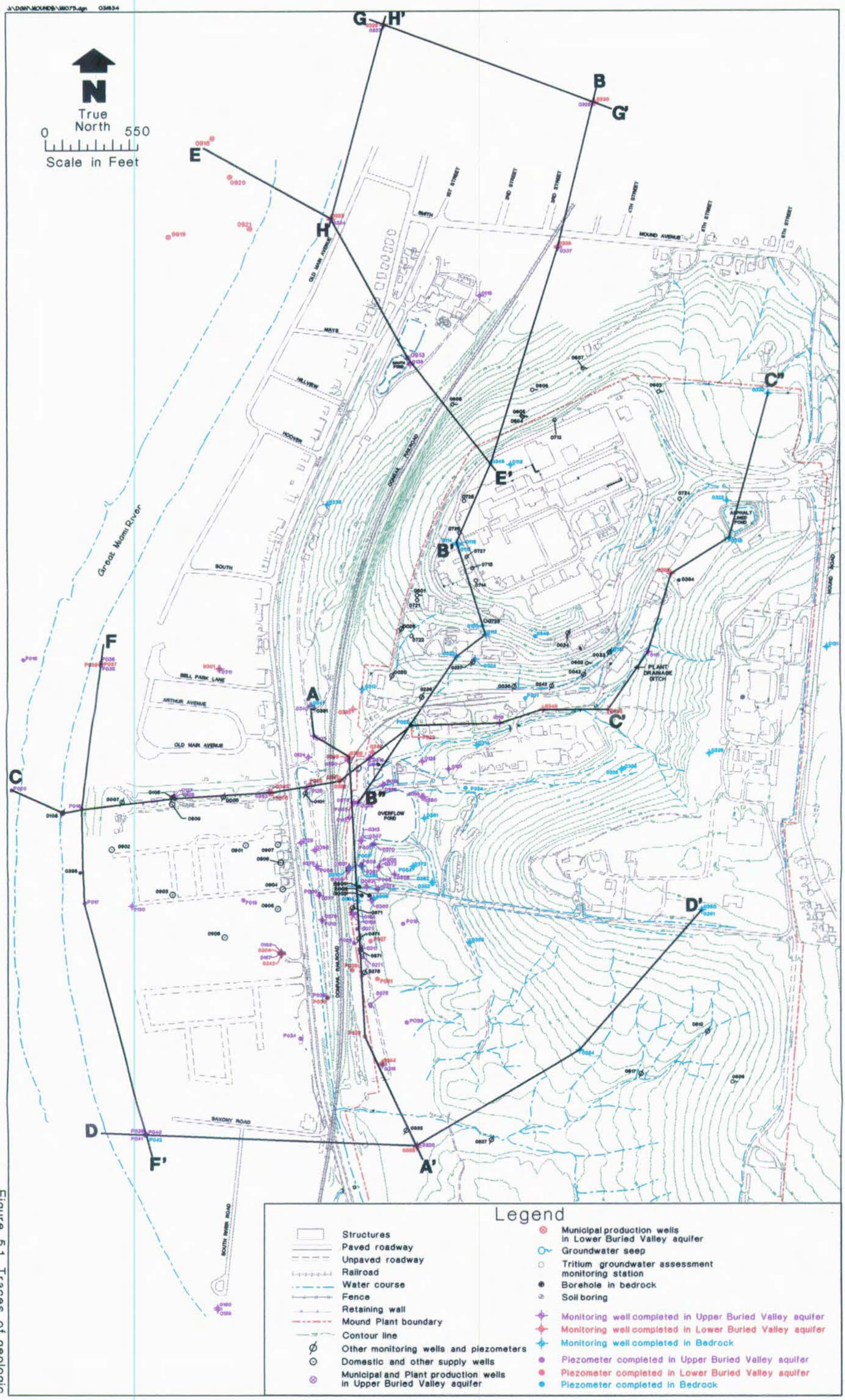


Figure 5.1 Traces of geologic cross sections.

to have been eroded away. The depiction in cross section A-A' of the distribution of till deposits indicates that although they are locally laterally continuous, they are missing in many areas and do not provide extensive aquitards to groundwater flow.

Third, the geometry of the deep part of the buried valley near locations 0344/0319 and 0320/0356 is revised. In the preliminary cross section A_2-A_3 (DOE 1992a) a much narrower buried valley was depicted. Based on the preliminary bedrock topography and limited subsurface data, it was postulated in the OU 9 Site-Wide Work Plan that a possible tributary valley lay buried in this vicinity. Based on these data, the seismic survey was designed to delineate the subsurface conditions in this area. The revised interpretation presented in this report is that this deep portion of the buried valley simply represents a broad meander. The axis of the buried valley lies further to the east of the modern Great Miami River than previously thought. This broad meander also expresses itself north of the plant in cross sections F-F' and G-G', described below.

5.4.2. Cross section B-B'

Cross section B-B' (Plate 3) generally trends north to south from the city of Miamisburg, through the Main Hill and the lower reach of the plant drainage ditch to the northern edge of Area B. A preliminary version of the southern portion of this cross section was presented as cross section C_1-C_8 in the OU 9 Site-Wide Work Plan (DOE 1992a). The northern portion is entirely new, as not enough data existed to create this section prior to this investigation.

The southern portion of cross section B-B' depicts important revisions. First, the inferred buried gorge is interpreted to be present beneath the plant drainage ditch (actually shown as the retention basins). As discussed in references to cross section A-A' above and C-C' below, the specific geometry of the buried gorge is unknown. The actual location of the buried gorge along cross section B-B' is also unknown.

The northern portion of cross section B-B' depicts the interpretation of the Buried Valley Aquifer north of Mound Plant in the city of Miamisburg. A thick till sequence is shown that thins toward the Main Hill. The actual continuity of the thinner tills beneath locations 0118 and 0138 is unknown as these two boreholes are shallow (DOE 1992a).

5.4.3. Cross section C-C'

Cross section C-C' (Plate 2) generally trends west to east to northeast. A preliminary version of this section was included in the OU 9 Site-Wide Work Plan (DOE 1992a). A revised cross section was

included in the OU 1 Remedial Investigation Report (Plate 1, DOE 1994d). Cross section A-A' follows exactly the trend of the OU 1 section eastward up the plant drainage ditch to monitoring well 0345, but then continues northward toward the northeast corner of the plant and monitoring well 0332. Beyond the fact that new data allows an extension of the section, two important revisions have been made.

First, in the westernmost portion of cross section C-C', several discontinuous till units are now distinguished within the outwash deposits of the Buried Valley Aquifer. Where a single irregular till unit was shown in the preliminary section, at least 4 units are now known at location 0303/0343. Exactly how or if these are continuous with a single thin till unit at location 0006/0302 is unknown. The revised conceptual model does not consider that the till forms an aquitard between the upper and lower parts of the Buried Valley Aquifer.

Second, also in the westernmost portion of cross section C-C', a buried gorge is depicted to be filled with a dense glacial till deposit. The preliminary section depicted this till near the base of a steeply dipping bedrock surface, termed the transition zone. The transition zone was considered to be a narrow zone, generally oriented north to south in which the buried bedrock surface dropped steeply into the main buried valley. The bottom of the main buried valley was thought to extend westward from the transition zone (see subsection 5.8.2 below). The revised cross section C-C' now shows that the bottom of the main buried valley shallows eastward from 0006/0302 to 0303/0343. In fact, monitoring well 0343 was originally scheduled to be completed another 50 ft deeper than it actually was in order to monitor what was thought to be one of the deepest parts of the Buried Valley Aquifer. When drilled, bedrock was surprisingly shallow and the screen was set in outwash near well 0303. As discussed throughout this report, the true geometry of the buried gorge is unknown, but the depth at location P026 (cross section C-C') is one of the known data points.

5.4.4. Cross section D-D'

Cross section D-D' (Plate 4) generally trends southwest from the SM/PP Hill to the Great Miami River. This is a new cross section, as not enough data existed to create this section prior to this investigation. Cross section D-D' depicts an interpretation normal to the axis of the buried in the southern part of the Mound Plant. The exact geometry of the buried valley is unknown for certain; it may occur as depicted in cross section F-F'; i.e., gently sloping toward the valley axis, or it may occur as a more entrenched valley with narrower, steeper walls bounded by flatter terraces. Tills are generally absent in this reach of the valley. The continuity of the single till deposit at near 670 ft elevation MSL at location 0356 is unknown, but most likely forms little of an aquitard in the area.

5.4.5. Cross section E-E'

Cross section E-E' (Plate 4) generally trends northwest from the Main Hill to the Miamisburg municipal well field. This is a new cross section, as not enough data existed to create this section prior to this investigation. Still, the subsurface data is limited and obtained from a pair of boreholes and extrapolated to wells within the Miamisburg municipal well field (CH2M Hill 1991). Cross section E-E' indicates that a till unit at an elevation of approximately 600 ft MSL extends across the buried valley, but is possibly interrupted at location 0333. Whether this till unit is as continuous as shown is unknown. The section also depicts a dashed line along the bedrock surface east of location 0333. The actual geometry of this contact is unknown. Location 0333 is interpreted to record the deepest segment of this part of the buried valley.

5.4.6. Cross section F-F'

Cross section F-F' (Plate 5) generally trends north to south along the eastern margin of the Great Miami River. This is a new cross section, as not enough data existed to create this section prior to this investigation. Still, the subsurface data is limited and obtained from two clusters of boreholes at either end of the section and a single exploratory boring (0396). Cross section F-F' indicates that the approximate axis of the buried valley occurs near boring 0396. The true geometry of the bedrock contact is not well known; it may occur as depicted in cross section F-F'; i.e., gently sloping toward the valley axis, or it may occur as a more entrenched valley with narrower, steeper walls bounded by flatter terraces. Tills are generally absent in this reach of the valley. The continuity of the single till deposit at near 610 ft elevation MSL at location 0396 is unknown.

5.4.7. Cross section G-G'

Cross section G-G' (Plate 5) generally trends west to east within the city of Miamisburg, north of Mound Plant. This is a new cross section, as not enough data existed to create this section prior to this investigation. Still, the subsurface data is limited and obtained from two clusters of boreholes at either end of the section. Cross section G-G' indicates that thick till deposits are present at location 0330. As depicted these tills are correlated with a thinner sequence at location 0328. Thinner tills are present below the thick till sequence at 0330; whether the thin till sequence in 0328 is correlative with the thick unit at 0330 is speculative. An alternate interpretation is that the thinner sequences near elevation 640 ft MSL may be continuous and the thicker sequence may be entirely eroded away. Cross section G-G' also indicates that the approximate axis of the buried valley occurs near monitoring well 0330. Whether the valley continues to be this deep east of 0330 is unknown.

5.4.8. Cross Section H-H'

Cross section H-H' (Plate 5) generally trends north to south within the city of Miamisburg and along the eastern margin of the Great Miami River. It may be considered an extension of cross section F-F', but not enough information exists to connect the two. This is a new cross section, as not enough data existed to create this section prior to this investigation. Still, the subsurface data is limited and obtained from two clusters of boreholes at either end of the section. Cross section H-H' indicates that two relatively thin till deposits are present across the area. Cross section H-H' also indicates that the approximate axis of the buried valley occurs south of monitoring well 0333. As stated above, the exact geometry of the buried valley is not well known.

5.5. DISCUSSION OF CROSS SECTIONS

The OU 9 drilling program gathered geologic information over a larger area than any previous drilling program. Additionally, on and adjacent to Mound Plant, information on the subsurface materials have been gathered to enhance existing depictions of stratigraphy. All this information is assimilated into the geologic cross sections presented here. These cross sections show the preliminary conceptual model of the Buried Valley Aquifer requires revisions. These revisions are:

- The subsurface expression of the Buried Valley Aquifer is offset from the modern Great Miami River;
- Numerous till lenses present throughout the buried valley do not appear to form continuous aquitards;
- Till units within the buried valley are thicker and more continuous north of the plant and thinner and discontinuous south of the plant;
- The transition zone, a narrow, steeply dipping bedrock contact along the eastern margin of the buried valley margin, does not exist as previous envisioned; and
- A precipitously narrow subsurface gorge appears to exist beneath the modern tributary valley.

5.6. GEOMETRY OF THE BURIED VALLEY AQUIFER

One goal of the current drilling program was to drill and sample to bedrock at several locations within the floodplain of the Great Miami River. Information obtained from this drilling has provided a much different picture of the position of the buried valley with respect to the present topography of the Great Miami River Valley. The Buried Valley Aquifer occupies a trough that has been cut down into bedrock to an elevation of at least 522 ft. At 0344 and 0356, unconsolidated materials are 175.5 and 181.5 ft

thick, respectively. The elevations atop bedrock at these two locations are 525.9 and 522.6 ft, respectively. Conversely, where it might be expected the Buried Valley Aquifer is at its thickest, near the modern Great Miami River, bedrock is relatively shallow, encountered at a depth of 52 ft at P042 and an elevation of 637.2 ft. This places the main axis of the buried valley underlying the southwestern portion of the south Mound Plant property, more than 1,500 ft east of the modern river (Figure 5.2).

West of Mound Plant, just south of the Mound Plant outfall into the Great Miami River, bedrock is encountered in 0396 at a depth of 162 ft, at an elevation of 529.6 ft. At this location, the axis of the Buried Valley Aquifer appears to lie almost directly below the current position of the Great Miami River.

North of the Mound Plant, bedrock is encountered in 0330 and 0333 at depths of 172 and 166 ft, respectively, at elevations of 536.0 and 540.3 ft, respectively. Again, this places the main axis of the Buried Valley Aquifer in a position east of the present Great Miami River. Cross section G-G' from location 0327/0328 extending east to 0329/0330 shows the bedrock surface dipping towards the east (Plate 5). This indicates the axis of the Buried Valley Aquifer is at or just east of location 0327/0328.

5.7. EXTENT OF BURIED TILLS

At locations where the buried valley is thick and bedrock is deep, as well as within shallower portions of the Buried Valley Aquifer, glacial tills are present at various depths. An exception is at piezometer locations P039-P042, west of Saxony Road. At this location, P042 encountered bedrock at a relatively shallow depth of 52 ft and no till unit was encountered.

Buried tills are present in the tributary valley that separates the Main Hill from the SM/PP Hill. As shown in cross section B-B', the buried till within the tributary valley correlates well from location to location. This buried till can be traced from 0322, near the main entrance gate, down the tributary valley to its terminus at 0387/0392, just west of Mound Plant security fence along the railroad spur onto Mound Plant. At this location, the till was either never deposited or has been eroded. Therefore, the western extent of this buried till probably extends no further than the present day Conrail railroad tracks west of Mound Plant.

South of the tributary valley, the probable remnants of this same buried till can be traced out into the eastern portion of the buried valley, extending southward at least as far as location 0356. Locally, this buried till is not present. For example, at locations 0071 and 0271 no till unit is reported. These are two of Mound Plant's production wells, drilled in 1961 and 1948, respectively. The lithologic description of subsurface materials of these two wells show sand and gravel with clay. There is no inference to this material being a buried glacial till. The drilling method for these two wells is not

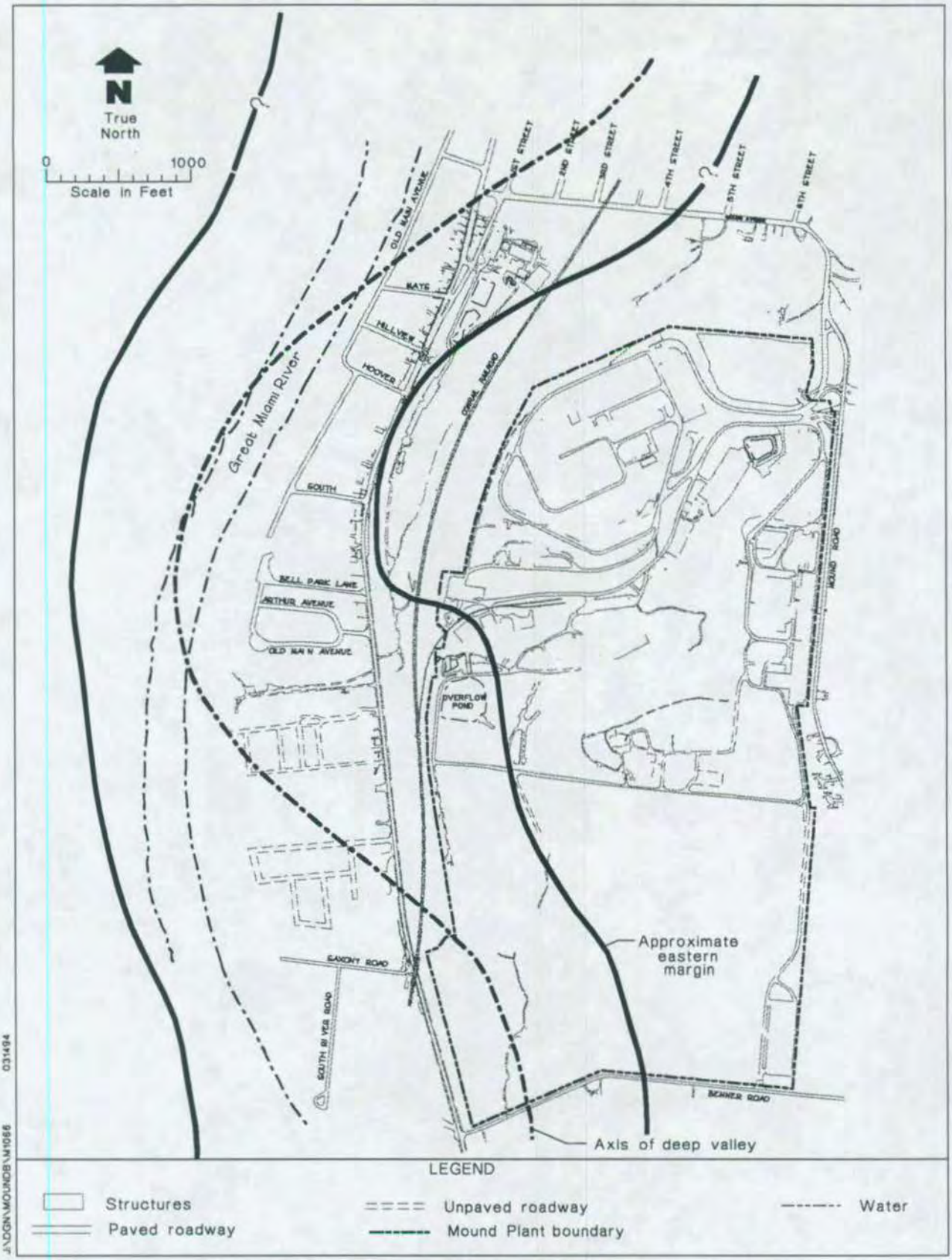


Figure 5.2. Revised geometry of Buried Valley Aquifer.

stated, but 26-inch casing was set so the drilling method was probably cable tool, a method in which identification of thin beds is difficult to impossible.

The same buried till is also absent from P007 and 0375, probably removed by erosion from the stream that occupies the present day tributary valley. Just north of the tributary valley, the buried till outcrops along the southwestern flank of Mound Plant's Main Hill and is exposed along the southern portion of the engineered cut for the Conrail railroad tracks.

Cross sections G-G' and H-H'(Plate 5), located north of Mound Plant in the city of Miamisburg, depict the presence of two buried tills. The upper buried till is present in the buried valley at approximately the same elevation as the buried till previously discussed. The surface of the buried till varies in elevation indicating the till was exposed to erosion prior to being buried. The bottom elevation of this till, approximately 640 feet, is similar in elevation to buried tills found at four locations drilled in the city of Miamisburg; 0327/0328, 0329/0330, 0333/0334, and 0336/0337. The similar elevation is representative of a depositional feature of the buried till. This buried till is less than seven feet thick at location 0336/0337, at the intersection of Mound Avenue and the Conrail railroad tracks, to over 34 feet thick at 0329/0330 located north along 3rd Street.

5.8. PALEO TOPOGRAPHY

Two major revisions to the conceptual model of the Buried Valley Aquifer are affected by revisions of bedrock topography presented in this report. First, a buried gorge is interpreted to be present beneath the plant drainage ditch. Second, the western foot of the SM/PP Hill is buried beneath glacial deposits along the western plant boundary.

5.8.1. Buried Gorge

Unique subterranean features are present at two locations in the bedrock surface at and adjacent to Mound Plant. These features are both thought to be associated with the tributary valley that forms the plant drainage ditch. One feature is located beneath the parking lot adjacent to Mound Plant's fire station, Building 98, and the other is adjacent to well 0912 (formerly Miamisburg #2, see DOE 1993b). At both locations, boreholes drilled through the unconsolidated sediments have encountered bedrock at depths that are unusually deep considering depth to bedrock encountered at nearby locations.

Borehole logs from previous Mound Plant investigations (DOE 1993b), along with one borehole from this investigation, provide a picture of the varied bedrock relief in the upper reaches of the tributary valley. The depth to bedrock varies greatly over short distances; at location 0395, bedrock is deeper

then the 93 feet drilled; only 50 feet east, boring 0386 indicated a depth to bedrock of 16-feet. Inspection of the Mound Plant boring logs published in the Site-Scoping report: Volume 2 Addendum - Stratigraphic and Lithologic Logs (DOE 1993b) indicates similar relationships. Two borings (361 and 363) recorded depths to bedrock of over 100-feet; a few feet away, many other borings indicated depths to bedrock that ranged down to 25-feet (Figure 5.3). The deepest borings appeared so anomalous that they were discounted in the preliminary version of the bedrock topography map, described below. These data suggest that a deep narrow paleo valley in the bedrock at the head of the present tributary valley. It is apparent that the bedrock surface exhibits considerable relief over a very short distance. Considerable fill has been placed in this portion of the tributary valley. The parking lot caps a historic debris disposal area, referred to as Area 7 (DOE 1993a).

The other location where boreholes have been drilled that indicate a large amount of bedrock relief over a very short distance is in the area of P026 (Figure 5.4). Cross section C-C' shows an area around P026 and locates several wells important to this discussion. Older monitoring well 0001, now abandoned, was drilled in 1976 to a depth of 153.5 ft and bedrock was encountered at 151 ft (Dames and Moore 1976). Upon inspection of the drillings logs for new monitoring wells 0343, 0387 and 0386 (depths to bedrock of 95, 82 and 87 feet, respectively) it was thought that the deep borehole at 0001 must have been erroneous. Piezometer P026 was consequentially drilled a few feet away from 0001 as an exploratory boring. It encountered bedrock at 141 ft below ground surface and was subsequently completed as a piezometer.

These two locations, over 2,400 ft apart, exhibit a similar feature in the bedrock surface, a deep, relatively narrow, canyon cut into bedrock. It is speculation that this buried gorge enters the Mound Plant northward of 0395, meanders through the plant beneath the plant drainage ditch, and exits the plant beyond P026. The relative position beneath the tributary valley between 0395 and P026 is unknown, but is likely circuitous. At P026, the direction this bedrock feature takes beneath the Buried Valley Aquifer is also unknown. At P026, the canyon is filled with 49 ft of till overlying 7 ft of outwash material filling the very bottom of the canyon. The lowest bedrock elevation of the gorge feature is 565 ft at P026. This is 42 ft higher than the lowest elevation of bedrock encountered anywhere in the subsurface, 522.6 ft at 0356. This suggests that the buried gorge was fully developed prior to the full down-cutting associated with the deep-stage glacial, discussed below. That is to say that the buried gorge may not grade to the lowest base level in the main buried valley; the buried gorge may represent a buried hanging valley downstream of P026.

An analogously narrow and precipitous gorge is known to be exposed in the region. An entrenched canyon on the Little Miami River at Yellow Springs, Ohio, exhibits similar morphology. However, it is not known whether the two features are related in time or origin.

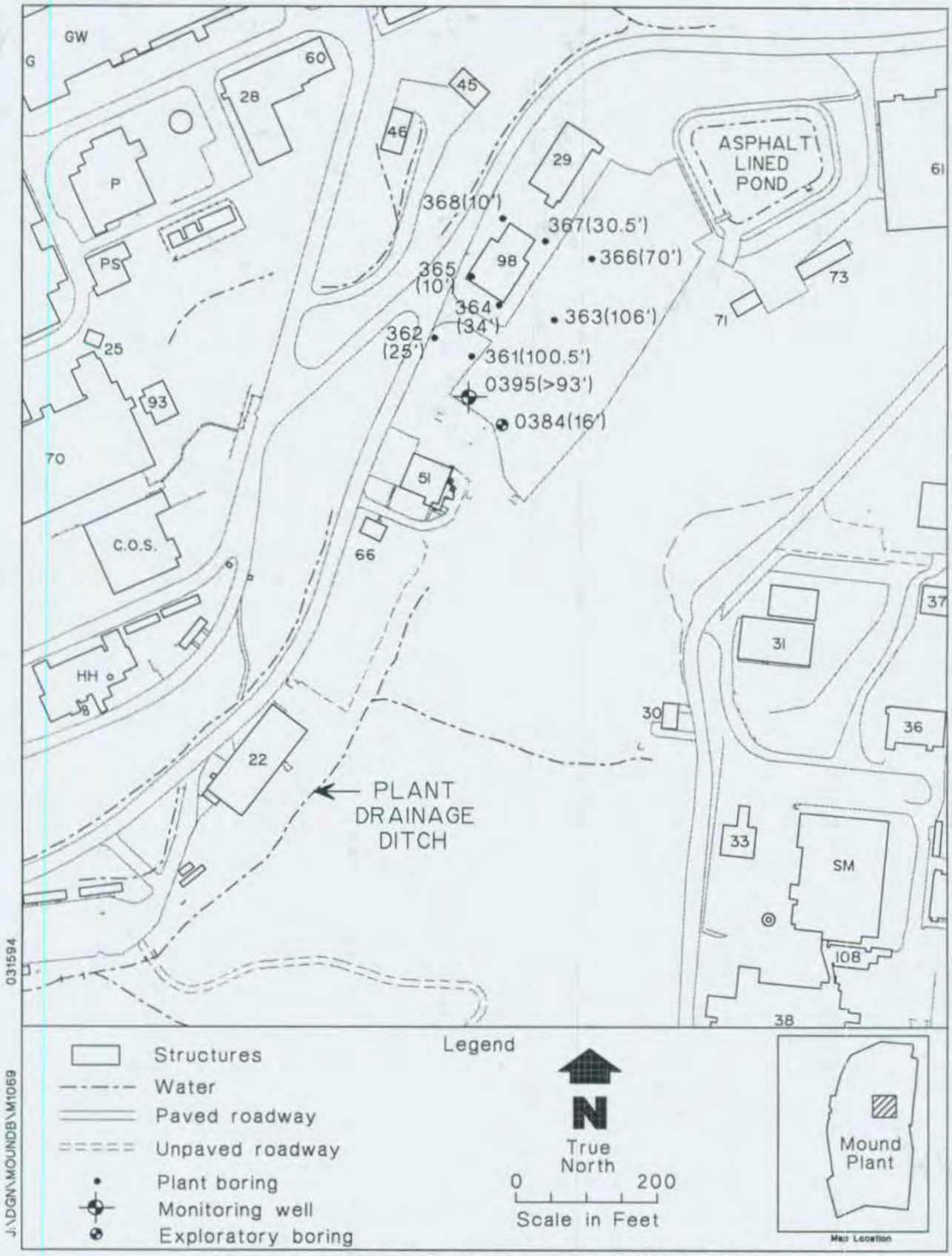


Figure 5.3. Locations of borings in upper part of Mound Plant that define the buried gorge.

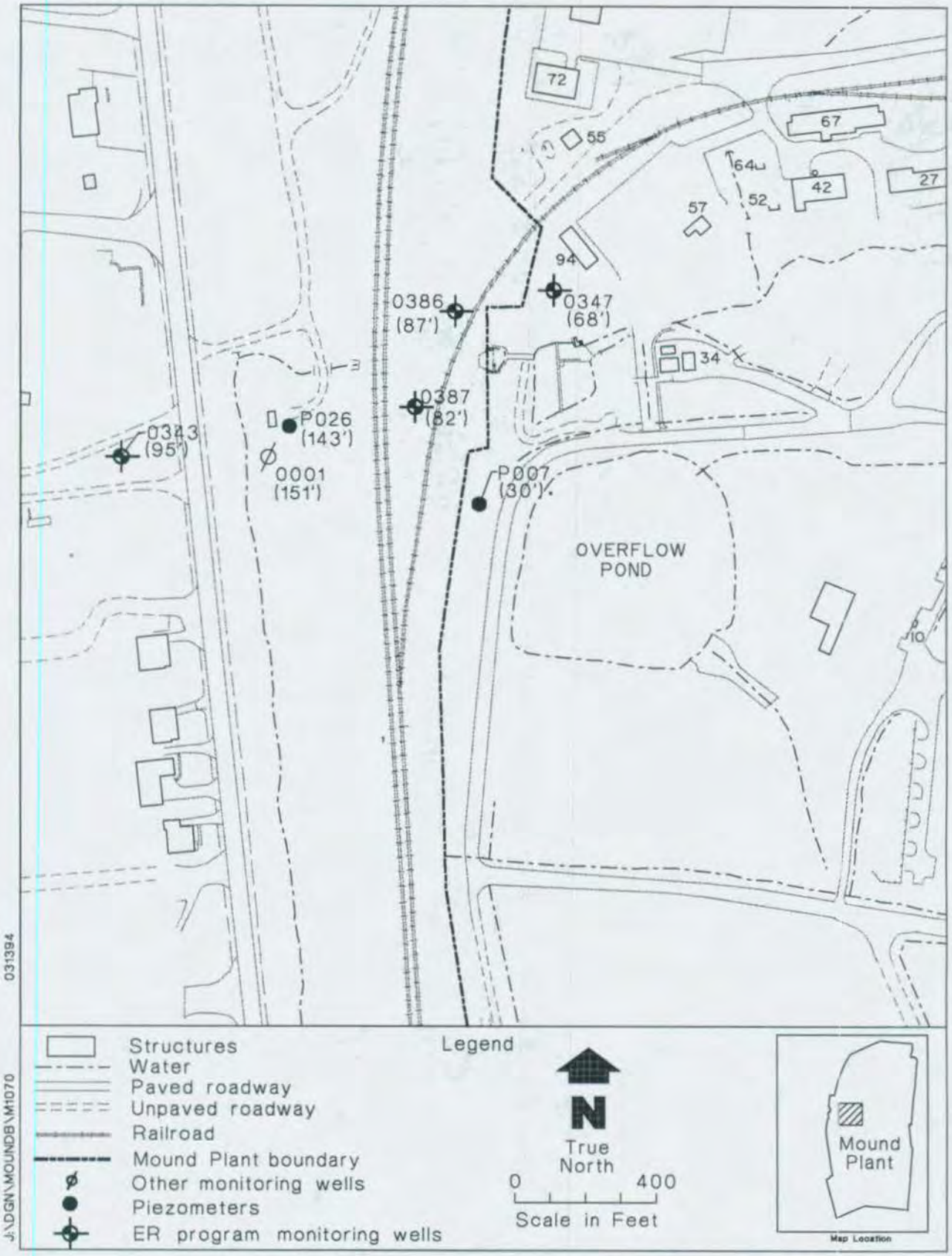


Figure 5.4. Locations of borings in lower plant valley where buried gorge is defined.

5.8.2. Revision of the Transition Zone

The OU 9 Site-Wide Work Plan described the transition zone as a narrow zone, oriented north to south in which the buried bedrock surface dropped steeply into the main buried valley. It was considered to be the glacially scoured eastern margin of the Buried Valley Aquifer. This transition, as conceptualized, does not exist. Before the recent hydrogeological field investigations, contingency plans for drilling into the transition zone were made because it was not known exactly how deep or how many monitoring wells may have been needed to properly monitor the aquifer over its vertical extent. Due to the inferred steep bedrock slope, movement of the location of a monitoring well or piezometer a few feet east or west may have resulted in significant changes in the vertical depth to bedrock.

The recent field investigations of both OU 1 (DOE 1994d) and OU 9 indicate that the eastern margin of the Buried Valley Aquifer is relatively shallow with a much gentler bedrock slope than previously envisioned. The bedrock high that forms the SM/PP Hill slopes westward across the central part of Mound Plant, across Area B. The western footslope of the SM/PP Hill is then buried beneath glacial outwash and till deposits near the western boundary of the plant. The northern margin of the SM/PP Hill appears to be bounded by a buried precipitous gorge, described above. The southern boundary apparently slopes relatively gently into the main Buried Valley Aquifer.

A second interpretation of the transition zone affects groundwater gradients. The transition zone is recognized as the area in which groundwater gradients pass from the relatively steep gradients offered by the bedrock topography along the western boundary of Mound Plant to the very low shallow gradients associated with the main Buried Valley Aquifer. The north to south trend of the transition zone in OU 9 Site Wide Work Plan must be revised to one oriented more northwest to southeast, i.e, it must reflect the geometry of the buried valley, as groundwater gradients still must pass through a transition into the main part of the Buried Valley Aquifer. The actual hydrology of the zone is complicated by the pumping of the Mound Plant production wells, discussed in Section 6 of this report.

5.9. BEDROCK TOPOGRAPHY MAP

A revised map of bedrock topography is presented in Plate 6. This map was compiled from an extensive set of soil borings conducted by Mound Plant for engineering and foundation studies, seismic refraction studies, as well as borings for monitoring wells and piezometers installed as part of the remedial investigations. Elevations of bedrock topography were compiled by subtracting the depth of bedrock from the surface elevation. A preliminary bedrock topography map was published in the Site

Scoping Report: Volume 2 Addendum - Stratigraphic and Lithologic Logs (DOE 1993b) and the OU 9 Site-Wide Work Plan (DOE 1992a). Figure 5.5 presents a revised interpretation based on the borings recently installed as part of this and the OU 1 field investigations (DOE 1994d). A large-scale map with data points is provided as Plate 6. Two important revisions have been made to the map.

First, the contours along the plant drainage ditch reflect the presence of the buried gorge described above. This buried gorge is interpreted to be very narrow, and its exact trace through the tributary valley is unknown. The trace of the gorge and the contour shapes are considered to be greatly simplified in Figure 5.5. The apparent closed contour in the lower reach of the plant drainage ditch is probably an artifact of the contour routine. The trend of the gorge in the northeastern part of the Mound Plant is also unknown, but it probably traces through the apparent 780 ft elevation saddle (Plate 6).

Second, the elevation contours in the southern part of the map area now reflect the presence of the axis of the buried valley. The geometry of the main buried valley is interpreted to form a broad meander that is not expressed in the modern Great Miami River. The deep axis of the buried valley curves eastward onto the south part of Mound Plant. The contours in the south central part of the map are probably more linear than depicted. The remaining closed contour is probably also an artifact of the contouring routine. Data points near the Great Miami River now allow the inclusion of contours on the west side of the buried valley. The preliminary data indicated a deep segment in this region, but insufficient data were available to interpret it properly. Part of the seismic refraction study, described in Section 3 of this report, was designed to identify the possible presence of a buried tributary valley in this area. The geometry and spacing of the seismic refraction survey was predicated on the preliminary bedrock topographic map. The results of the seismic refraction survey do not indicate a buried tributary in the southern part of Mound Plant.

5.10. ISOPACH MAP OF UNCONSOLIDATED DEPOSITS

A map of unconsolidated deposits is presented in Figure 5.6. Plate 7 provides a large-scale map with data points. This map was also compiled from an extensive set of soil borings conducted by Mound Plant for engineering and foundation studies, seismic refraction studies, as well as borings for monitoring wells and piezometers installed as part of the remedial investigations. The map was compiled by simply contouring depths to bedrock from the data set. The unconsolidated deposits include all glacial till and outwash that mantle the bedrock topography and act as valley fill materials. Artificial fill on the Main Hill is also included. A preliminary isopach map of unconsolidated deposits was published in the Site Scoping Report: Volume 2 Addendum - Stratigraphic and Lithologic Logs (DOE 1993b) and the OU 9 Site Wide Work Plan (DOE 1992a). Plate 7 presents a revised

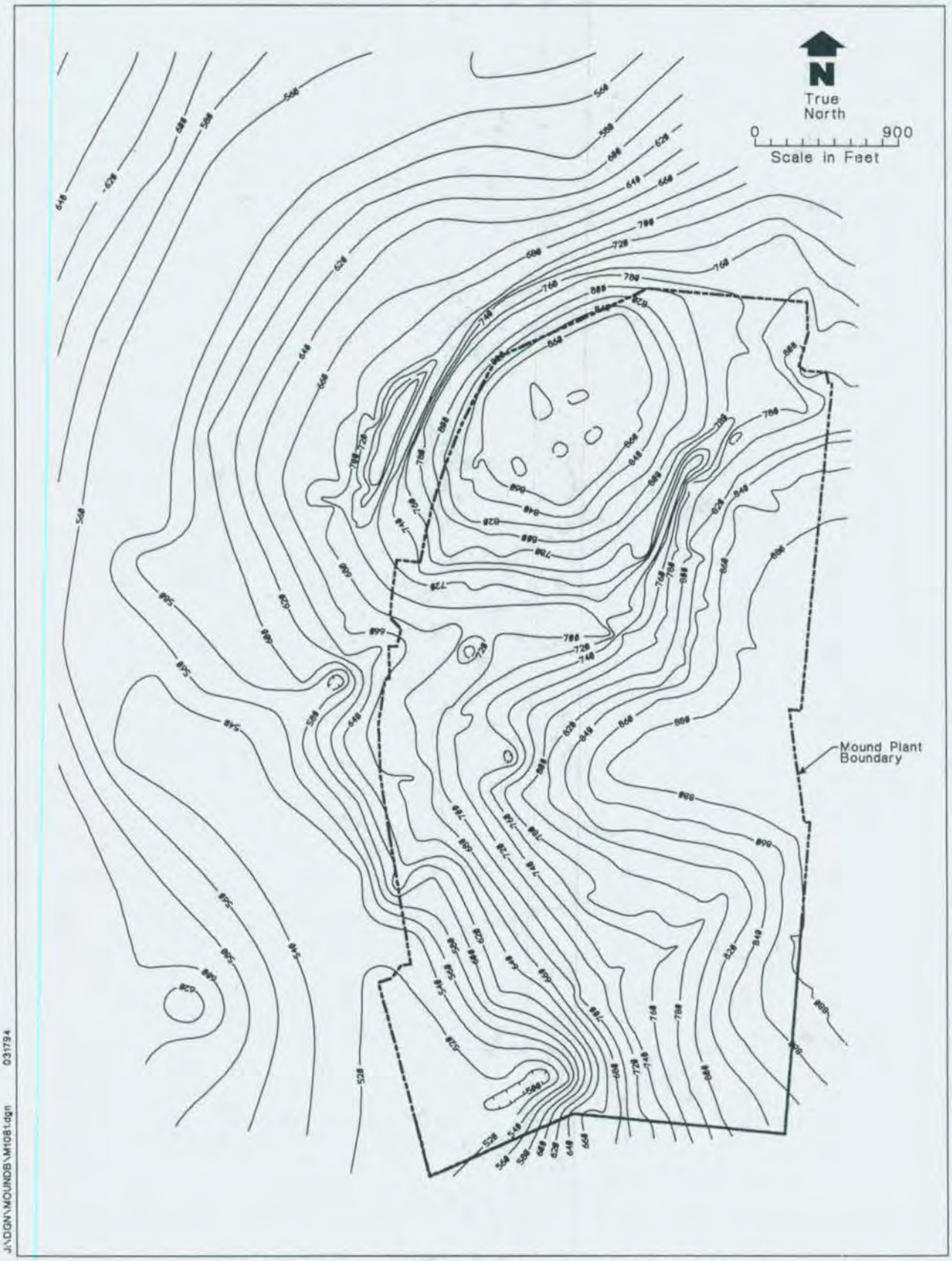


Figure 5.5. Revised bedrock topography map.

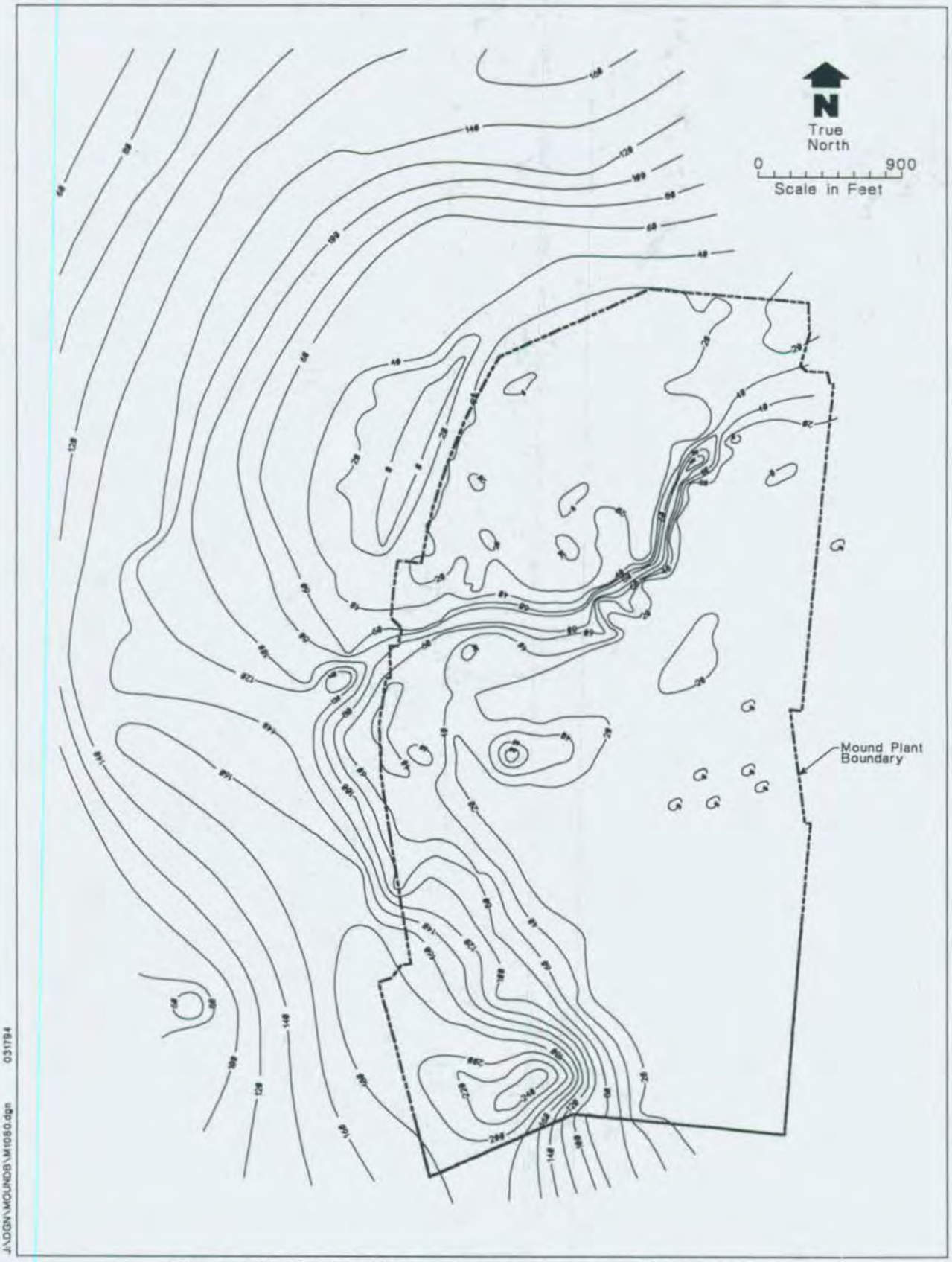


Figure 5.6. Revised isopach map of unconsolidated deposits.

interpretation based on the borings recently installed as part of this and the OU 1 field investigations (DOE 1994d). Two important revisions have been made to the map.

First, the contours along the plant drainage ditch and the southern part of Mound Plant now reflect the same changes made to the bedrock topographic map, described above. Second, isopach contours are compiled for the area immediately west of the northern part of Mound Plant. These are calculated from the seismic data used in the bedrock map, as well as new borings logs (DOE 1994a). The seismic data was not included in the preliminary map because it was felt that it did not offer the tolerance needed to contour the unconsolidated deposits. With the calibration now offered by the new borings, this data is included and the map depicted the geometry of the valley fill sediments.

5.11. DISCUSSION OF REGIONAL GLACIAL GEOLOGY

The Miamisburg area lies within the Till Plains section of the Central Lowland physiographic province. The uplains area are the remnants of a peneplain, a land surface worn down by erosion to a nearly flat or broadly undulating plain. This ancient upland surface, which truncates the broad Cincinnati arc, developed in late Tertiary time (Fenneman 1916) and has been extensively dissected. Also in late Tertiary time, the Northern Hemisphere began to experience continental glaciation where ice sheets extended nearly 2,700 miles across the northern conterminous United States (Richmond and Fullerton 1986).

Pleistocene glaciation in North America is divided into four stages. From oldest to youngest these stages are Nebraskan, Kansan, Illinoian, and Wisconsin (Figure 5.7). Recent literature suggests the abandonment of these terms (Richmond and Fullerton 1986); however, they are retained for usage herein to add continuity in referring to the existing literature on the subject of glaciation in southwestern Ohio. In the area of Miamisburg, this dissected surface is buried by Illinoian and Wisconsin age glacial deposits. Table V.1 depicts the subdivisions of the Wisconsonian and Illinoian glacial stages in southwestern Ohio. The last continental glacier in southwestern Ohio was 18,000 to 20,000 years ago (Forsyth 1961, Lowell et al. 1990).

As continental glaciers advanced and retreated across southwestern Ohio, preglacial valleys were filled in and watershed drainages changed. This process and resultant imprint on surface topography happened a number of times and is well documented (Fenneman 1916; Spieker 1961; Durrel 1961; and Teller and Goldthwait 1991). Each advancing and retreating ice sheet left an imprint on the pre-existing topography.

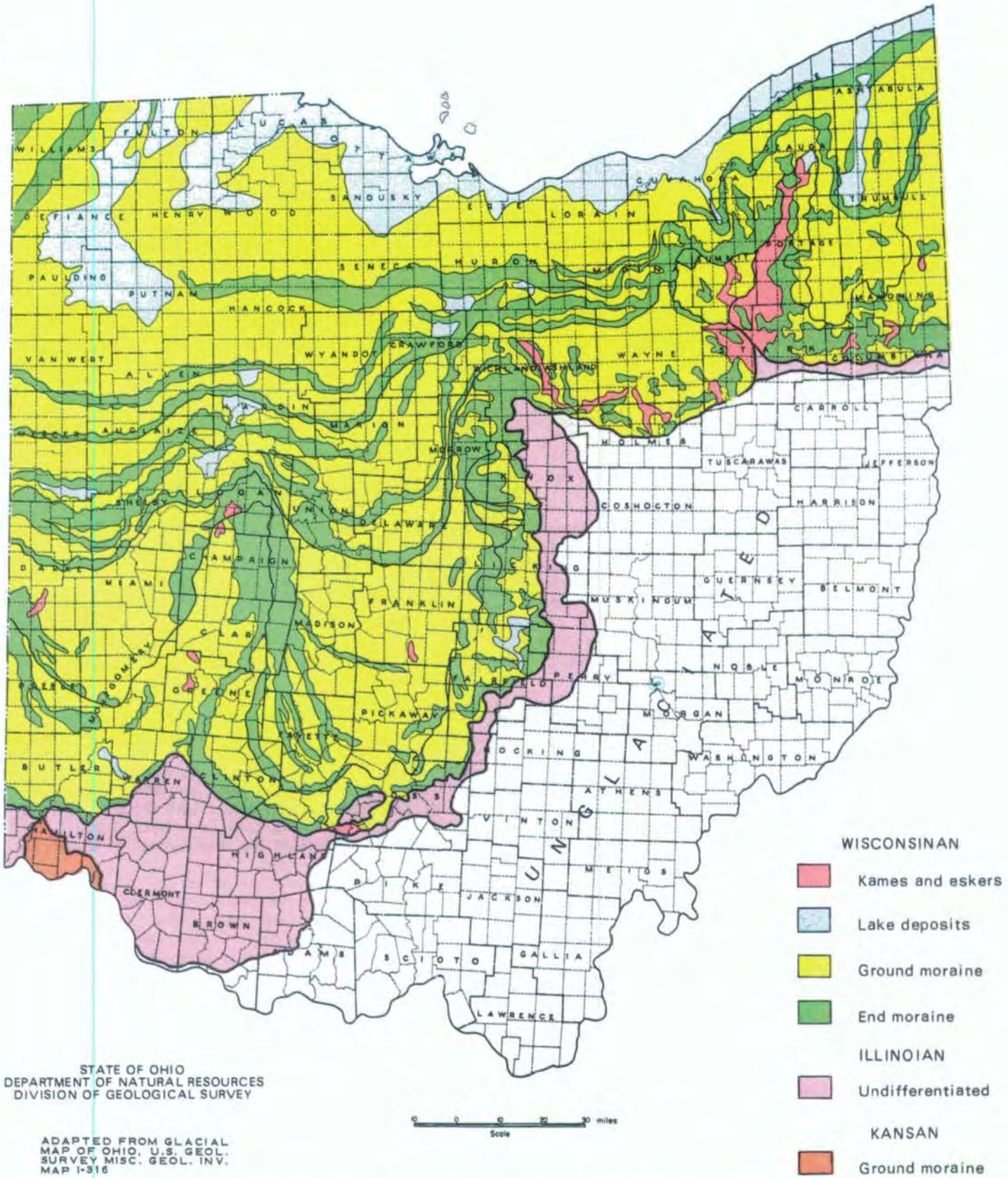


Figure 5.7. Geologic map of glacial deposits of Ohio (adapted from State of Ohio, Department of Natural Resources, map I-316).

Table V.1. Subdivisions of the Wisconsonian and Illinoian Stages in Southwestern Ohio

Wisconsonian Glacial Stage	Knightstown Phase Crawfordsville Interphase Crawfordsville Phase Shelbyville Interphase Shelbybille Phase	**Camden Stade**
	Connersville Interstade Fayette Stade Sidney Interstade Fairhaven Stade New Paris Interstade Whitewater Stade	
Sangamon Interglacial Stage	Weathering	
Illinoian Glacial Stage	Richmond Stade Abington Interstade Centerville Stade	

The late Tertiary early Pleistocene preglacial drainage consisted of an unnamed north-flowing system. Upon the advance and retreat of Nebraskan ice (oldest of four glacial stages of the Pleistocene), a subsequent arcuate system of drainage formed called the Teays Cycle drainage (Durrell 1961). The disruption of the vast northward-flowing Teays Cycle drainage system and other contemporaneous rivers to the east caused drainage water to find new outlets around the Kansan ice sheet (second oldest glacial stage) to the west. Many divides were breached in the evolution of a new drainage system, named the Deep Stage drainage, which bears only slight resemblance to the older Teays system (Durrell 1961).

In the area of southwestern Ohio, the Deep Stage drainage system became established along pre-existing drainage but often in the reverse direction. The Deep Stage drainage system was, in turn, modified by the Illinoian and Wisconsin glacial stages. The deposits of the last two glacial stages filled in Deep Stage valleys. When the ice of the Wisconsin stage melted, the resulting topography was not very different from that of the present.

The course of the present day Great Miami River approximately follows a paleo valley that can be traced back to the ancestral Old Kentucky River of Teays-age existence (Teller and Goldthwait 1991). Through the numerous glacial advances and retreats, this valley has been maintained and received considerable fluvial sediment. The depositional history and age of these sediments are not well understood (Durrell 1961).

These discussions highlight the probability that the state of Ohio is criss-crossed with numerous buried valleys of varying ages and flow directions. The apparent buried gorge beneath the plant tributary valley is undoubtedly a remnant of an older, yet abandoned drainage system. From the available information, the buried gorge drained toward the south, but whether it pre-dates or post-dates the full development of the deep-stage incision of the buried valley is unknown. The fact that the gorge appears to be infilled with relatively dense, impermeable glacial till indicates that it is not part of the subsurface drainage within the plant tributary valley. The correlation of the dense till within the gorge with other deposits encountered during the recent investigations cannot be made with the existing data.

SECTION 6

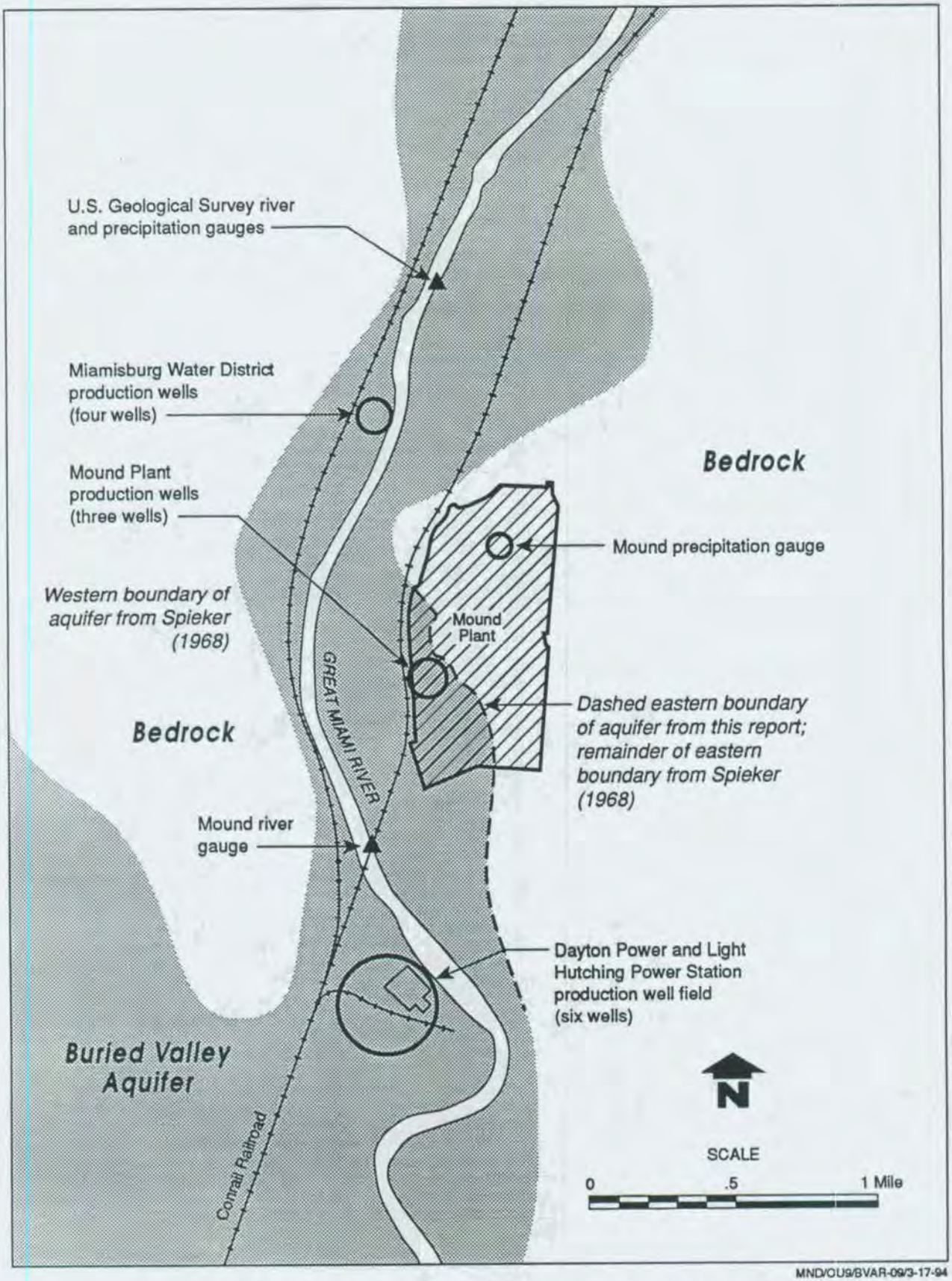
6. HYDROGEOLOGY

The hydrologic properties of the Buried Valley Aquifer and contiguous deposits on and adjacent to Mound Plant have been analyzed as part of the OU 9 hydrogeological investigations. The objectives of these studies are to 1) determine the hydraulic properties of the Buried Valley Aquifer; 2) define the regional water levels in the Buried Valley Aquifer and bedrock systems in order to calculate hydraulic gradients; 3) determine the recharge and discharge relationships between the Great Miami River and the Buried Valley Aquifer; 4) determine the effects of pumping on these systems; and 5) determine the degree of interconnection between the upper and lower units of the Buried Valley Aquifer and between the Buried Valley Aquifer and the bedrock. This section integrates the results of the previous data collection activities undertaken for the remedial investigation in Area B (DOE 1994d) with the hydrogeologic field investigations conducted under the auspices of OU 9. The results from these investigations are used to develop a conceptual model for groundwater movement within the glacio-fluvial sediments of the Buried Valley Aquifer.

The subsections that follow describe the methods and results of efforts to characterize the Buried Valley Aquifer and contiguous deposits. Subsection 6.1 provides a brief summary of hydrogeologic conditions at the Mound Plant as they apply to groundwater flow within the Buried Valley Aquifer. Subsection 6.2. presents the physical description of the aquifer including summaries from the 1993 and 1990 aquifer tests (DOE 1994d). Subsection 6.3. is a description of the groundwater flow system including monthly groundwater levels, seasonal variations, and horizontal gradients. Subsection 6.4. provides a preliminary water budget of the Buried Valley Aquifer with focus on the area impacted by Mound Plant pumping. Included in this budget are the recharge and discharge mechanisms that currently define groundwater flow within the Buried Valley Aquifer as interpreted from field data (including groundwater levels, precipitation, river stage and pumping). Subsection 6.5. provides a summary of the important results of these evaluations. Subsection 6.6. provides recommendations for additional work.

6.1. SITE HYDROGEOLOGY

The aquifer system at the Mound Plant consists of two different hydrogeologic environments: groundwater flow through the bedrock beneath the hills and groundwater flow within the unconsolidated glacial deposits and alluvium associated with the Buried Valley Aquifer in the Great Miami River valley (Figure 6.1). The bedrock flow system is dominated by fracture flow; the Buried Valley Aquifer is dominated by porous flow with interbedded gravel deposits providing the major pathway for water movement.



MND/OU9/BVAR-09/3-17-94

Figure 6.1. Location map of Buried Valley Aquifer in vicinity of Mound Plant.

The bedrock flow system consists of a thick sequence of interbedded shale and limestone that are flat-lying. The lithology possesses little primary permeability, but has enhanced permeability due to bedding-plane fractures and through-penetrating vertical fractures that decrease in frequency and interconnection with depth from the surface. This fracture network is termed the fracture carapace. Details of the fracture carapace and revisions of the conceptual model for the bedrock were presented in the Hydrogeological Investigations: Bedrock Report (DOE 1994b).

The Great Miami River flows within a broad, sediment-filled valley. The valley axis was carved into bedrock by interglacial streams and filled with sediment from receding Pleistocene glaciers. As with most of the groundwater resources in southwestern Ohio, the productive water-bearing deposits consist of glacial outwash (see section 5.3). Along the Great Miami River, the aquifer is termed the Buried Valley Aquifer, and has been deemed a sole source (53 FR 25670). Regionally, the course of the modern Great Miami River follows the trend of the Buried Valley Aquifer, but within the Mound Plant area the Buried Valley Aquifer is divided into two sections separated locally by bedrock highs, as described by Watkins and Spieker (1971). In the Miamisburg region, the Buried Valley Aquifer narrows from the north, passing through one of its narrowest reaches immediately west of the Mound Plant (Figure 6.1). The buried valley makes a broad easterly meander through the south part of Mound Plant as it widens southward. The two sections of the Buried Valley Aquifer rejoin south of the Dayton Power and Light Hutchings Power Station.

The direction of flow of groundwater is generally southward, following the southward course of the Great Miami River. In evaluating the groundwater resources of the region, Spieker (1968) identified the extensive development of the Miamisburg area and the potential for reversed gradients due to the heavy municipal and industrial pumpage. Significant reduction in the regional gradient in 1964 from 5 foot per mile (ft/mi) to about 1 ft/mi were noted. Reversals in direction of flow were also noted around the Miamisburg and Dayton Power and Light well fields (Figure 6.1). The Mound Plant well field was not included in the study (Spieker 1968).

The preliminary conceptual model of the Buried Valley Aquifer (DOE 1992a) held that it consisted of two layers of relatively thick outwash deposits separated by a glacial till to form upper and lower aquifers. This paper presents a large body of evidence that serves to refine the conceptual model of the Buried Valley Aquifer. The revision significantly changes the conceptual model to one in which the Buried Valley Aquifer is viewed as a single unit. Glacial tills are present throughout the buried valley, but they do not serve as continuous aquitards to groundwater flow in the immediate vicinity of Mound Plant. For ease of discussion, the descriptors upper and lower Buried Valley Aquifer are retained to describe the relative completion depth of wells in the Buried Valley Aquifer. These descriptors do not refer to two units that are hydrologically separate as used originally. Descriptions and discussions of the lithology and stratigraphy are presented in section 5 of this report.

A complete description of flow within the Buried Valley Aquifer requires an understanding of the interaction of the Buried Valley Aquifer with the Great Miami River and other surface water features, with the bedrock flow system, and with pumping at the Mound Plant. The locations of the monitoring wells and piezometers completed in the Buried Valley Aquifer and in the bedrock in and adjacent to the Mound Plant are shown in Plate 8. These wells and piezometers provide the basic geologic and hydrologic information necessary for the aquifer characterization and the spatial distribution of hydraulic head in the aquifer with time.

6.2. AQUIFER PROPERTIES

The aquifer properties of interest are transmissivity and hydraulic conductivity, measures of the ability of the aquifer to convey water, and the storativity, a measure of the ability of the aquifer to contain or store water. Three aquifer tests, together with slug tests and laboratory permeability tests, have been performed to define these properties. The most recent aquifer test was conducted in 1993. The results of that test are summarized below and discussed in detail in the OU 1 Remedial Investigation Report (DOE 1994d). Results of the 1990 test are compared with the results from the 1993 test. Results from earlier, non-ER Program aquifer tests are summarized in Appendix D.1. Results from the slug tests and laboratory permeability tests are discussed in the OU 1 Remedial Investigation Report (DOE 1994d) and the OU 9 Site-Wide Work Plan (DOE 1992a).

6.2.1. 1993 Aquifer Test

An aquifer test was conducted at Mound Plant production well #1 (0071) from 14 May through 28 June 1993 to determine aquifer characteristics in and around Area B. Sixty-two wells and piezometers in the vicinity of Area B, both on and off the Mound Plant, were monitored for drawdown during the aquifer test. Precipitation, barometric pressure, water levels within the overflow pond and river stage data were collected for the analysis of pumping test results. Flow from wells 0071 (used during the aquifer test) and 0076 (Mound Plant supply well) was metered, although the meter at 0076 malfunctioned during the last half of the aquifer test. Pressure transducers and water level sounders were used to measure drawdown data. The pumping rate in 0071 averaged 669 gpm over the duration of the pumping phase of the test. Variations in the pumping rate in 0071 were less than 2 percent.

6.2.1.1. Results of 1993 Aquifer Test Analysis

Although 62 wells were monitored during the test, only the data from 13 wells were selected for analysis on the basis of distance from the pumped well, screened interval and formation of completion, and the data quality (primarily the amount of noise in the record). The wells selected provided good

areal coverage in the Mound Plant area and were completed in both the upper and lower Buried Valley Aquifer and in the bedrock. Of the 62 wells monitored during the aquifer test, nine wells showed little or no effect from pumping at well 0071 after correction for the regional decline in water levels (0302, 0017, P035-P038, 0159, 0333 and 0334).

Transmissivity values were calculated from individual well responses for the entire period of pumping for the aquifer test and for the period before 20,000 minutes. The 20,000 minute increment was chosen because changes in river stage after that introduced several perturbations into the system. The two analyses were run to determine if the river stage rise after 20,000 minutes had an effect on the calculated transmissivity and storativity values. For the analysis of data collected before 20,000 minutes, the transmissivity ranged from 27,500 ft^2/day to 55,200 ft^2/day. For the entire aquifer test, the transmissivities ranged from 33,900 ft^2/day to 57,800 ft^2/day. Transmissivities changed less than 10 percent between the two analyses. Storativities for the entire test and the early time ranged from 0.04 (well 0394 completed in bedrock) to 0.23 (well 0912, completed in the Buried Valley Aquifer) and 0.04 (well 0394) to 0.34 (well 0309, completed in bedrock), respectively. In general, the data from the earlier part of the test yielded lower storativities. The transmissivity and storativity values calculated from the 1993 aquifer test demonstrate that aquifer characteristics varied by screened lithology and location of the monitoring wells (Figure 6.2).

Three distance-drawdown analyses were run using the drawdown measured at 17,280 minutes to determine whether transmissivity varied with direction from the pumped well. The wells used in the distance-drawdown analyses were selected based on the distance from the pumped well, the saturated thickness of the aquifer, and the depth of well completion. Every attempt was made to use wells that were located in a specific direction and completed in similar material. The first analysis, on a line running north from the pumped well in the Buried Valley Aquifer (wells P013, P009, P008, 0129, and 0912), had a transmissivity of 45,000 ft^2/day and a storativity of 0.12 (DOE 1994d). The second analysis, on a line to the northeast from the pumped well (wells 0394, 0393, P003, 0313, P001, and P014) had a transmissivity of 39,600 ft^2/day and a storativity of 0.09 (DOE 1994d). The third analysis was on a line south from the pumped well (wells P029, P030, P032, P013, and 0157). The transmissivity and storativity were 47,500 ft^2/day and 0.11, respectively (DOE 1994d). As with the aquifer test analysis, the distance-drawdown analyses showed a decrease in transmissivity to the north and east of the pumped well where saturated thicknesses are less (Figure 6.2). The storativities calculated in the distance-drawdown analyses are equal to the median storativity calculated in the aquifer test.

Although it would be expected that the transmissivities calculated for wells completed in the bedrock and the Buried Valley Aquifer would be greatly different, this was not true for the Mound Plant aquifer test. The interconnection between the bedrock and the Buried Valley Aquifer allows pressure changes

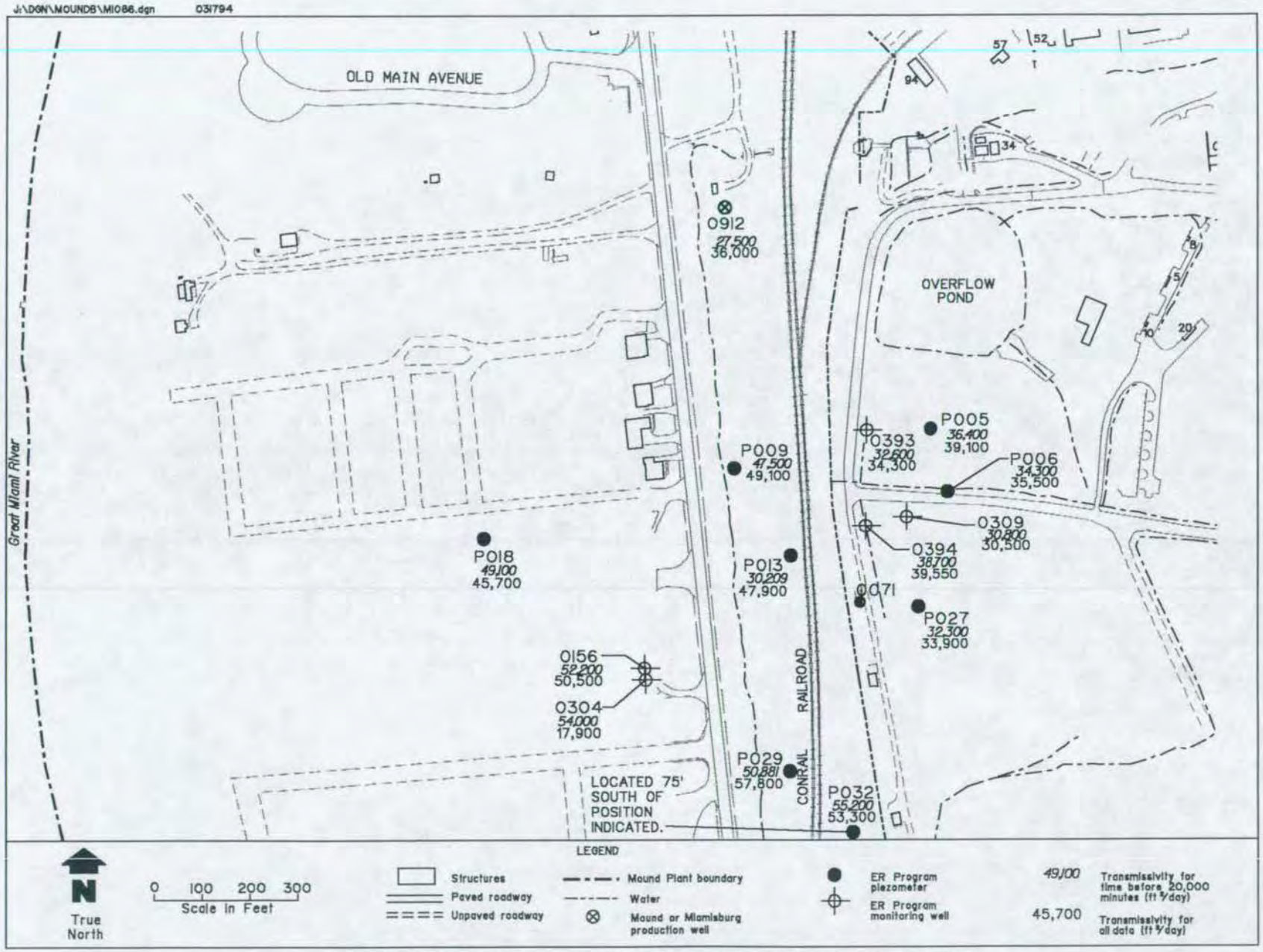


Figure 6.2. Geographic distribution of transmissivity calculated for Buried Valley Aquifer from 1993 aquifer test.

to be readily transmitted to the bedrock wells. This is shown by the small vertical gradients at well clusters (subsection 6.3.8.1). The bedrock wells within the zone of influence responded in a fashion similar to the wells completed in the Buried Valley Aquifer. These data indicate that within the zone of influence identified by the aquifer test, water levels in bedrock are controlled by pressure in the overlying Buried Valley Aquifer.

6.2.1.2. Conclusions Regarding Groundwater flow

The drawdown data from each well were compared to the barometric pressure, river stage, precipitation, and 0076 pumping plots to identify the effect of each variable on each well. The following conditions were observed in the monitoring wells during the test:

- Precipitation had no direct effect on water levels during the duration of the aquifer test.
- Diurnal fluctuations similar to the diurnal change in barometric pressure was observed in those wells completed in or beneath fine-grained material such as till or wells completed in the bedrock.
- Pre-test monitoring showed there was a regional decline in water levels that appeared to be directly affected by the river stage. Wells closest to the Great Miami River responded to a rise in river stage within 24 hours. This response is seen in piezometer cluster P035-P042, as well as indicated wells listed in Appendix D.1. Well 0159, located approximately 2500 ft south of pumped Well 0071, showed that the regional water level decline was also affected by the river stage. A well-defined decline rate, 0.08 ft/day, was calculated for the period from 2 May 1993 through 31 May 1993.
- The river stage increased from 0.5 to 1.5 ft over the last 14 days of the aquifer test. This rise in the river stage resulted in a decrease in the regional decline rate from 0.08 ft/day to 0.022 ft/day. In addition, several wells, including wells P006, 0309, and P032, showed water level recoveries of less than 0.1 ft during the same time period.
- The regional decline rate in the Buried Valley Aquifer is caused by a net deficit in the water budget in this area. Inflows to the area include recharge from the Great Miami River and the bedrock and from inflow of water from upgradient areas. Outflow occurs from pumping, evapotranspiration, and flow to downgradient areas. Outflow greater than inflow during a given time period results in a decline in water levels.

6.2.2. Previous Aquifer Tests

In addition to the extensive test conducted in 1993, aquifer tests were conducted on wells completed in the Buried Valley Aquifer on or adjacent to Mound Plant in 1961, 1976, 1986, 1987 and 1990. These tests were described in the OU 9 Site-Wide Work Plan (DOE 1992a). The 1961 test was performed on the Mound Plant production wells; the 1976 and 1987 tests were performed on well 0912, a renovated Miamisburg production well that has been used for remedial pumping of the Buried

Valley Aquifer (DOE 1992a). The results from these tests are summarized in Table IV.1; additional data is summarized in Appendix D.1.

The 1990 aquifer test at Mound Plant Production well #1 (well 0071) was conducted under the ER Program to determine aquifer characteristics in and around Area B, a known historic landfill area. Fifteen wells in Area B were monitored for drawdown. The pumping rate averaged 546 gpm over the duration of the pumping phase of the test, but variations in the pumping rate of plus or minus 150 gpm occurred at approximate 360,000-gallon intervals, due to filter backwash and recharge at the water conditioning plant.

6.2.3. Transmissivity

Transmissivity is a measure of the ability of the aquifer to convey water. It is the product of the hydraulic conductivity and the saturated aquifer thickness. It can be expressed as flow rate in gallons per day through the saturated thickness of the aquifer per unit width of the aquifer (gal/day/ft or ft^3/day/ft). Transmissivity can be determined directly from the aquifer test analysis.

Transmissivity values calculated from individual well responses in the 1990 test ranged from 37,000 ft^2/day to 83,000 ft/day (Table VI.1). The transmissivity values calculated from the 1993 test for the time before 20,000 minutes ranged from 27,500 ft^2/day to 55,200 ft^2/day. The highest values from both tests were in the southern wells, where the aquifer-saturated thickness is greatest and where the aquifer material is largely glacial outwash (Appendix D.1). Transmissivity values were lower to the north and east because of the smaller saturated thickness and the greater percentage of low permeability till. The average value of the 1993 test (40,842 ft^2/day) compares well with the average of previous tests. It is believed that the results from the 1993 test are the most reliable because there was better control of factors affecting the drawdown at the monitoring wells and the response of the aquifer to the Great Miami River could be evaluated.

6.2.4. Hydraulic Conductivity

Hydraulic conductivity is also a measure of the ability of the aquifer to carry water. It is expressed as flow of water through a unit area of the aquifer under a unit hydraulic gradient (a factor of proportionality gal/day/ft^2 or ft/day). It is calculated from the transmissivity by dividing by saturated thickness. For the 1993 aquifer test, hydraulic conductivity was calculated by dividing the transmissivities by the saturated thickness of the aquifer at the pumping well.

Table VI.1. Summary of Aquifer Parameters

Test Date	Transmissivity (ft^2/day)	Storativity	Hydraulic conductivity (ft/day)
1993	30,000 - 55,000	.01 - 0.28	460 - 900
1990	37,000 - 83,000	.04 - .20	NC
1987	13,000 - 57,000	0.9 - 0.5	155 - 1,200
1986	5,300 - 31,000	0.03 - .05	NC
1976	13,000 - 24,000	0.02 - 0.9	104 - 1,300
1961	27,000 - 96,000	.0006 - .04	NC

Results of the aquifer tests performed on the Buried Valley Aquifer on and adjacent to the Mound Plant indicate that hydraulic conductivity ranges from approximately 500 to 900 ft/day with an average of 680 ft/day (Table VI.1). Results of older tests indicate a wide range from 100 to 1,300 ft/day.

6.2.5. Storativity

Storativity is a measure of the ability of the aquifer to contain or store water and is expressed as a dimensionless number. In confined aquifers, it is defined as the amount of water released through a vertical column and is due to the compressibility and elasticity of the aquifer and the water. In an unconfined system such as the Buried Valley Aquifer, the volume of water taken into or released from storage is due to dewatering or refilling of the connected pore space. For practical purposes the storativity equals the effective porosity (specific yield) and represents the drainable pore volume of the aquifer.

The storativity values for the Buried Valley Aquifer ranged from 0.04 to 0.24 for the 1990 test and from 0.01 to 0.34 for the 1993 test. The values varied based upon location. Results from the older tests showed a wide range from 0.0006 to 0.20 (Table VI.1).

6.3. GROUNDWATER FLOW IN THE BURIED VALLEY AQUIFER

This subsection provides a summary of groundwater movement within the Buried Valley Aquifer with time. Included are discussions of the effects of the Great Miami River and topography on groundwater flow and the interaction between the Buried Valley Aquifer and the bedrock. As part of these analyses, monthly water level contour maps were generated, hydrographs for selected wells were plotted and the horizontal and vertical gradients were calculated for different locations in and adjacent to the Mound Plant. All of these tools were used to evaluate the spatial and temporal changes in flow in the Buried Valley Aquifer.

6.3.1. Compilation of Groundwater Elevations

Monthly and continuous groundwater levels were collected at selected locations in the groundwater monitoring network at Mound Plant (Plate 8). Monthly water level measurements were collected in approximately 145 wells and piezometers at the Mound Plant from April through December 1993. The wells and piezometers measured were completed in the bedrock and in the Buried Valley Aquifer. In addition, water levels were measured by hand weekly during the May 1993 aquifer test in Area B (DOE 1994d) to provide a quality control check on data collected by transducers. As part of OU 9 field activities, continuous water levels were measured in 18 monitoring wells and piezometers from 1 July

to 31 December 1993, Figure 2.5. The water level data collected from the three activities were used to generate hydrographs (subsection 6.3.2.), transects showing the changes in water levels with time in wells located along a line (subsection 6.3.3.) and water elevation maps (subsection 6.3.4.).

The groundwater levels measured in each of the 18 wells monitored continuously from 1 July 1993 through 31 December 1993 were recorded as a height above a transducer. These water levels had to be converted to absolute elevations so that comparisons could be made between wells and the Great Miami River. The determination of the elevation of a water level at a specific height above a transducer is made from the depth to water below the top of casing usually at the time of installation. Comparisons of the monthly water levels with the corresponding transducer data indicates that the initial transducer elevations in some cases were in error. To develop a base elevation between the hand measurements and the transducer measurements, a linear regression was run for the monthly water levels and transducer measurements. The best-fit line was then used to calibrate the transducer measurements to absolute elevations. In several wells, the data fell on two nearly parallel lines. This was a result of the removal of the transducer for groundwater sampling and the re-installation of the transducer at a different depth after sampling. In these situations, two different best-fit lines were generated and the elevations were calculated for before and after the transducer was removed. The regression data are included in Appendix D.2.2. and are summarized in Table VI.2.

6.3.2. Hydrographs

Hydrographs for each monitoring well and piezometer are included in Appendix D.2. These hydrographs show the change in water elevation with time in the 145 wells and piezometers that were monitored monthly (Appendix D.2.2). The hydrographs were used as a means to evaluate the accuracy of the hand measured water levels and to select the data that would be used to generate the water level contour maps.

In addition to the monthly water level hydrographs, hydrographs were plotted for the 18 wells that were monitored continuously from 1 July 1993 through 31 December 1993 (Appendix D.2.3). These hydrographs were plotted with the Great Miami River stage elevation for the Mound river gauge to compare the changes in groundwater elevation with the changes in river stage with time.

6.3.3. Transects

Transects were constructed that show the change in river stage in the Great Miami River and in groundwater levels with time in wells located along a line perpendicular or parallel to the Great Miami River, Appendix D.2.4. Transects were created for the upper Buried Valley Aquifer, lower Buried

Table VI.2. Base Water Level Elevation for Conversion of Telog Measurements

Well	Date	TOC Elevation (ft msl)	Hand Measurement Depth Below TOC (ft)	Telog Measurement Height Above Transducer (ft)	Water Level Elevation (ft msl)	Comments
P001	11/1/93	719.48	39.12	8.617	680.36	
P008	7/15/93	702.29	17.39	8.2427	684.9	
P014	8/2/93	719.1	36.49	5.3871	682.61	
P017	8/2/93	690.48	9.68	6.265105	680.8	
P020	12/14/93	690.86	6.25	5.525812	684.61	
P021	12/15/93	747.51	21.93	6.222188	725.58	
P035	9/2/93	688.05	6.8	14.478	681.25	Transducer moved 10/19
	12/14/93	688.05	3.43	21.234	684.62	Transducer moved 10/19
P036	9/2/93	688.35	7.11	19.91402	681.24	
P037	9/2/93	688.28	7.3019	14.915	680.9781	Transducer moved 10/19; Hand meas. depth calc. using best fit line
	11/11/93	688.28	7.29	15.24	680.99	Transducer moved 10/19
P038	7/15/93	687.87	2.76	24.024	685.11	
P039	9/2/93	689.22	8.75	8.2463	680.47	
P040	11/2/93	689.01	8.83	17.11502	680.18	
P041	9/2/93	689.08	8.61	17.99267	680.47	Hand meas. depth calc. using best fit line
P042	11/2/93	689.13	16.56	20.03164	672.57	
0116	12/14/93	873.43	59.5	10.799881	813.93	Hand meas. depth calc. using best fit line
0302	7/1/93	692.73	10.21	8.4681	682.52	
0343	9/2/93	696.57	15.95	9.8148	680.62	Transducer moved 9/16
	11/2/93	696.57	16.09	10.153	680.48	Transducer moved 9/16
0387	8/2/93	722.7	40.03	9.9179	682.67	

TOC - Top of casing

Valley Aquifer, and bedrock to evaluate whether there is a difference in response based upon completion depth. These transects also were used to evaluate the seasonal changes in flow between the river and adjacent wells and the change in groundwater response with distance from the Great Miami River.

6.3.4. Comparison of Groundwater Elevation Maps

Groundwater elevation maps for the Buried Valley Aquifer were contoured for May (wet season) and September (dry season), Figures 6.3 and 6.4, respectively. Precipitation is higher in May and lower in September. The wet and dry season months were determined from the average precipitation for each month and from the hydrographs. Because the shallow groundwater gradients in the alluvial fill merge rapidly with the steep gradients in the adjacent hills, the contour interval on the water level maps changes. The wells included in the data base were selected on the basis of formation of completion. Water elevations in bedrock wells were not included in the map. The resulting contour maps are believed to be a reasonable representation of typical groundwater conditions during the spring and fall of 1993. Groundwater elevation contour maps for additional months are included in Appendix D.2.1.

Groundwater in the Buried Valley Aquifer flows in a direction at right angles (perpendicular) to the contour lines. Relatively sparse groundwater level data have been collected in the northern and southern part of the Mound Plant (Blocks 1, 2 and 4, Figure 6.3). Consequently, groundwater flow in this area is inferred from surface topography, the bedrock structural contour map and the extrapolation of measured data to be in a southwesterly direction. In general, groundwater flow in Block 1, which is beneath the floodplain of the Great Miami River west of the Mound Plant, is to the southwest. The contours show inflow from the bedrock to the Buried Valley Aquifer.

Groundwater flow within Block 2 is toward the south with minor inflow from the adjacent bedrock. Flow within Block 3, the area surrounding the Mound Production wells, is toward the pumping wells. Flow within Block 4, the area west of the SM/PP Hill, is toward the south with inflow from both the bedrock and the Great Miami River.

The water level map for September shows water levels that are lower than water levels in the May 1993 map, ranging from less than 1.5 ft in Block 1 in the northern part of the map to more than 3.0 ft in Block 4, in the southern portion of the map. The water elevation in Mound Production well 0076 remains the same for both maps. However, the drawdown cones developed by pumping in the Mound Production wells is steeper and larger in the September map and smaller in areal extent in the May map. Both maps show the cone as an ellipse with the long axis parallel to the bedrock/Buried Valley Aquifer boundary to the east and the Miami-Erie Canal on the west. Both maps also show the effect

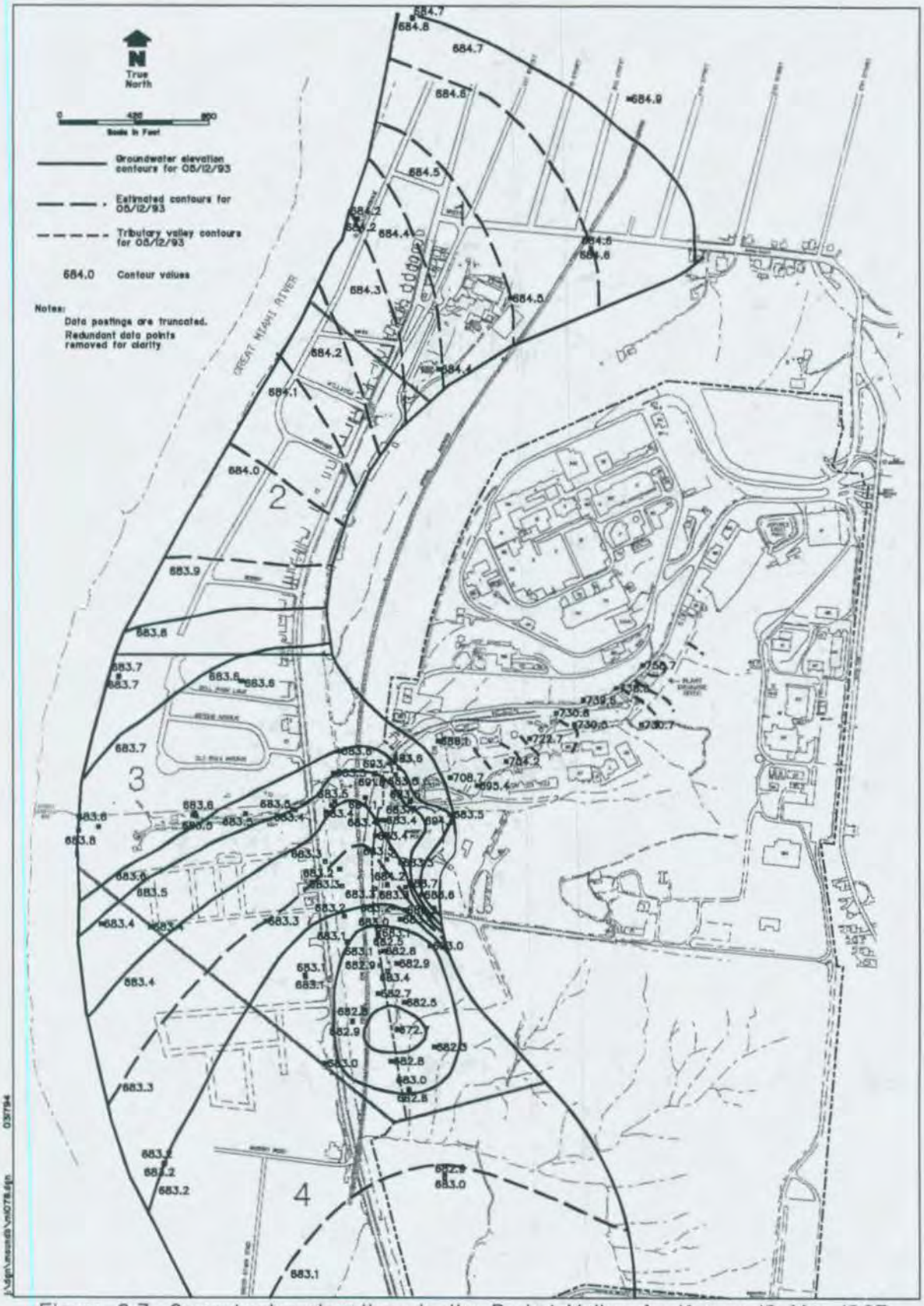


Figure 6.3. Groundwater elevations in the Buried Valley Aquifer on 12 May 1993.

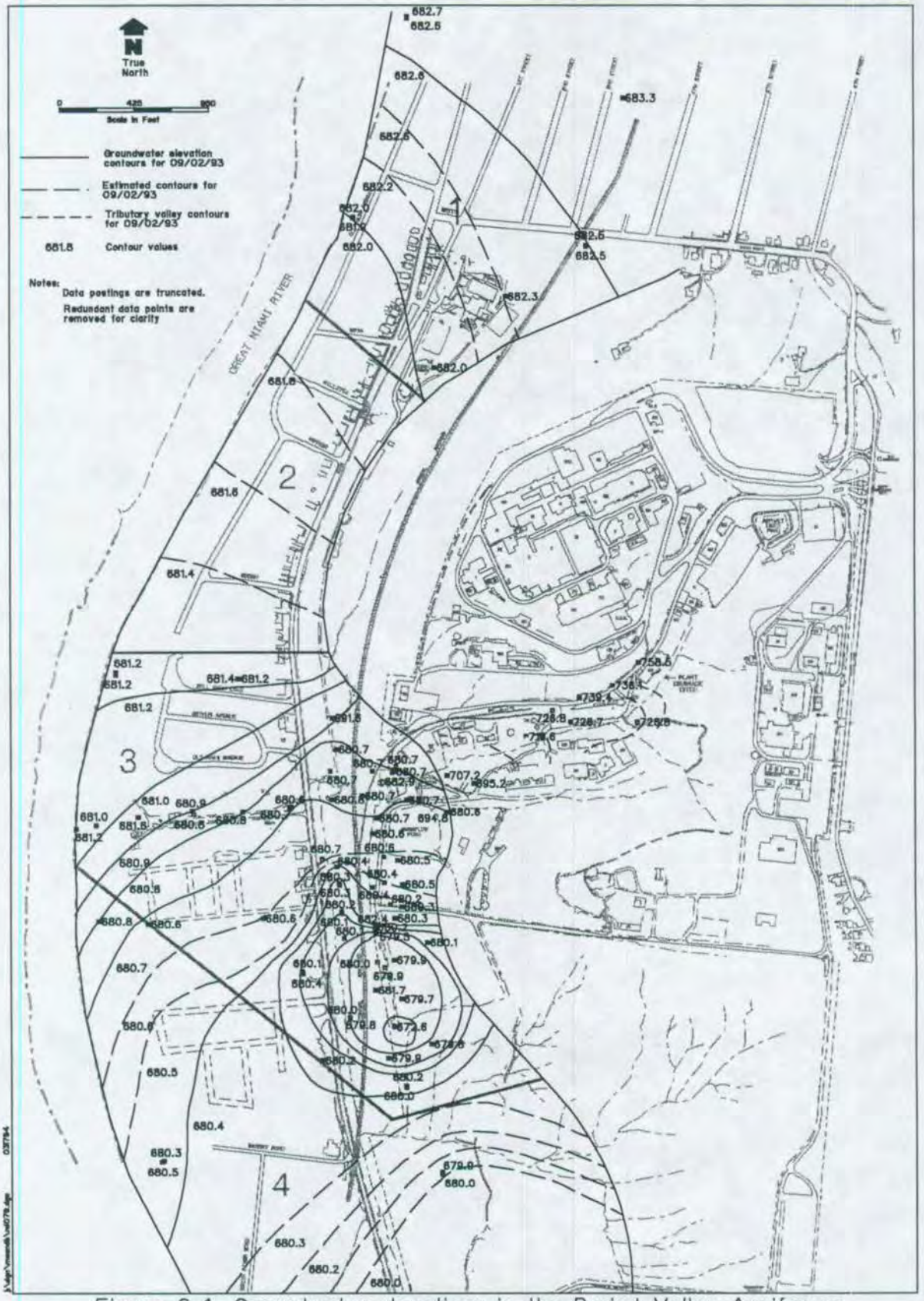


Figure 6.4. Groundwater elevations in the Buried Valley Aquifer on 2 September 1993.

of infiltration from the Miami-Erie Canal as reflected in higher water levels in wells near the canal. From the shape of the drawdown cone, it appears that both production wells, 0271 and 0076 had pumped during the period immediately preceding the water level measurements used in both maps. A second cone does not show around 0271 on the water level map because water levels are not available for that well.

6.3.5. Horizontal Gradients

Groundwater flow within the Buried Valley Aquifer in Block 1 is toward the southwest as shown in Figures 6.2 and 6.3. Horizontal gradients in this area are less than 0.0002 ft/ft. They vary with stage in the Great Miami River. Horizontal gradients in Block 2 are generally less than 0.0048 ft/ft. The horizontal gradient in Block 4 is estimated to be 0.0002 ft/ft. This gradient does not appear to change seasonally.

Block 3, the south-central area of the Buried Valley Aquifer to the west of Mound Plant, is the major area of interest because pumping for the Mound Plant water supply has disrupted the southwest flow direction observed in adjacent areas. The man-made influences that have impacted groundwater flow in the vicinity of Mound Plant include 1) pumping activity at Mound Plant production wells 0071, 0076 and 0271, which creates a potentiometric low along the western edge of Area B and induces groundwater flow toward that low; and 2) sporadic pumping at Miamisburg Municipal Well No. 2 (0912), which creates a local potentiometric low and locally induces groundwater flow to the northwest.

As part of the 1993 aquifer test analysis, a capture zone map was generated to determine the areal extent of the drawdown cone created by the pumping for the test and the Mound Plant water supply. The capture zones for both 0071 (the pumped well) and 0076 (a nearby Mound Plant production well) are delineated by the 1.0 ft drawdown contour on Figure 6.5. This provides a conservative estimate of the area in which water movement is toward the two pumping wells.

In addition to the localized effect from the Mound Production wells, a regional influence on water levels has been created by the pumping for Miamisburg and Dayton Power and Light. The pumping at these two locations has lowered water levels in the Mound Plant area by reducing river stage. The lower river stage has resulted in lower groundwater levels in the aquifer.

In addition to the groundwater flow in the main portion of the Buried Valley Aquifer, there is flow within the glacio-fluvial sediments of the Plant tributary valley. Groundwater flow within the sediments

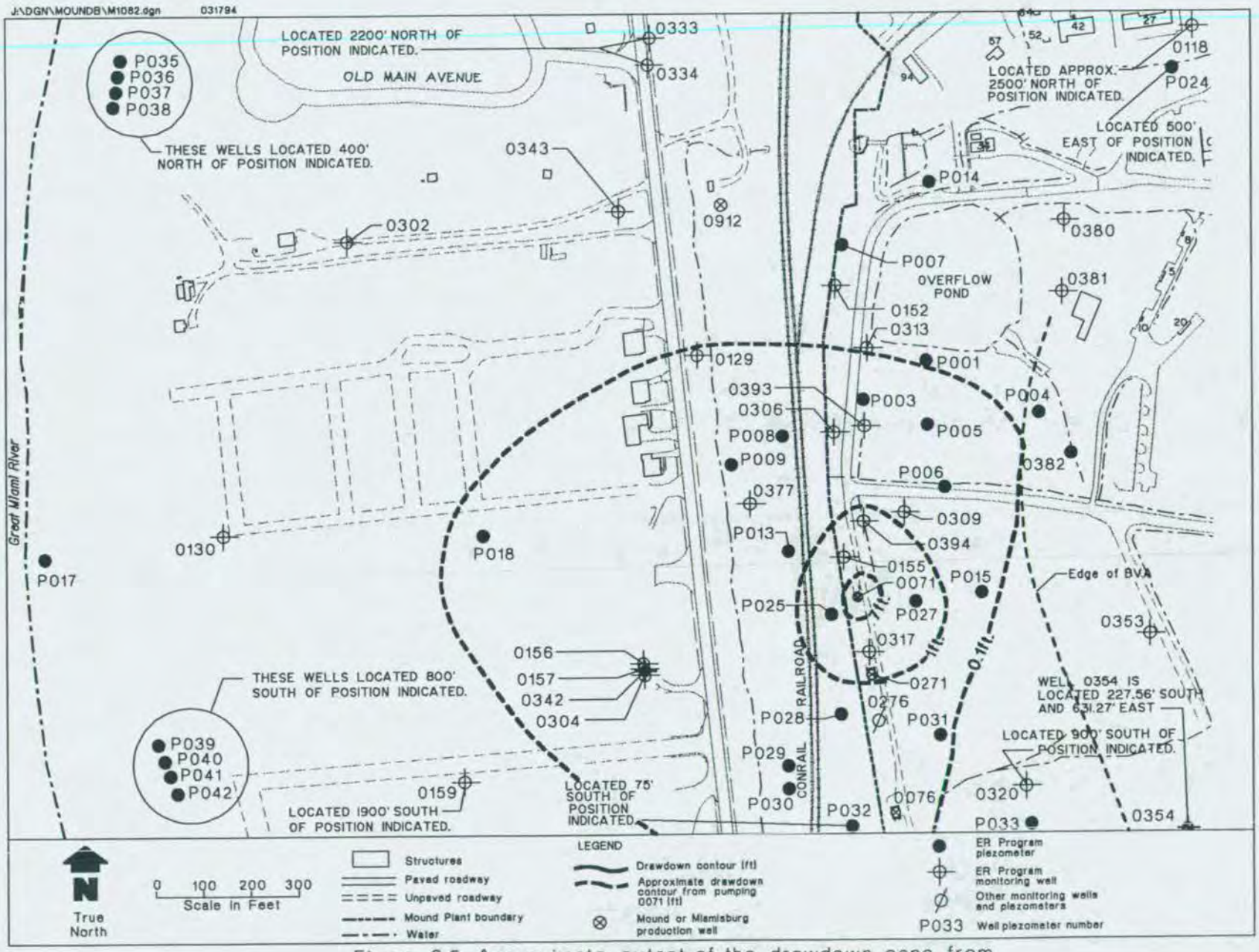


Figure 6.5. Approximate extent of the drawdown cone from the pumping of well 0071 during the OU1 aquifer test in 1993.

of the tributary valley is to the west and southwest, also aligned with the tributary valley topography. Horizontal gradients of up to 0.05 ft/ft exist in the tributary valley and decrease to 0.01 ft/ft as the valley enters the main river valley. These gradients, as well as the lack of response to seasonal groundwater level changes in the Buried Valley Aquifer indicate that the tributary valley is not part of the main aquifer system but that it does contribute flow to the Buried Valley Aquifer. Water levels in the tributary valley are interpreted to be controlled by precipitation and by the slope of the underlying bedrock. Variability in hydraulic gradients is a result of changes in the slope of the underlying bedrock surface.

6.3.6. Groundwater Response to Great Miami River

As part of the OU 9 hydrogeological investigations, a new river stage gauge was installed adjacent to Mound Plant in the Great Miami River and monitored beginning 1 July 1993 (Figure 6.1). For comparison, data from the existing USGS Miamisburg gauge were obtained from the USGS, Columbus, Ohio (see subsection 2.8). The stage in the Great Miami River was recorded as an average every 15 minutes at the new Mound gauge and every hour at the USGS gauge. For ease of analysis, the data at the Mound gauge was averaged over a one-hour interval. Figure 6.6 is a summary plot of the river elevation at both gauges. Both show peak river stage elevations after precipitation events with lowest flow occurring from 27 July through 11 November 1993. Comparison of the river stage elevations with groundwater elevations in the hydrographs from the 18 wells monitored continuously shows that the fluctuations in river stage elevation are mimicked by the hydraulic heads in the Buried Valley Aquifer. A lag time of 24 to 36 hours is observed between river stage rise and groundwater level rise. All of the wells within the Buried Valley Aquifer, regardless of completion depth, show a similar response. Interpretation of borehole logs indicates that a continuous unconsolidated aquifer extends from the Great Miami River to the western edge of the Mound Plant (see cross section CC', Plate 2) and that wells completed in the Buried Valley Aquifer are hydraulically connected to the Great Miami River.

6.3.6.1. Variation With Time Across the Aquifer

Five transects were plotted to show the changes in water levels with time and distance away from the Great Miami River. The locations of these transects are shown in Figure 6.7. The first and second transects were plotted for the wells completed in the shallower portions of the Buried Valley Aquifer (Figure 6.8) and the deeper portions of the Buried Valley Aquifer (Figure 6.9). These two transects are approximately perpendicular to the river. The third transect is parallel to the river, from the northern river piezometer cluster to the southern river piezometer cluster (Figure 6.10). The fourth transect is for the three bedrock wells (Figure 6.11). The last transect is for the four monitoring well

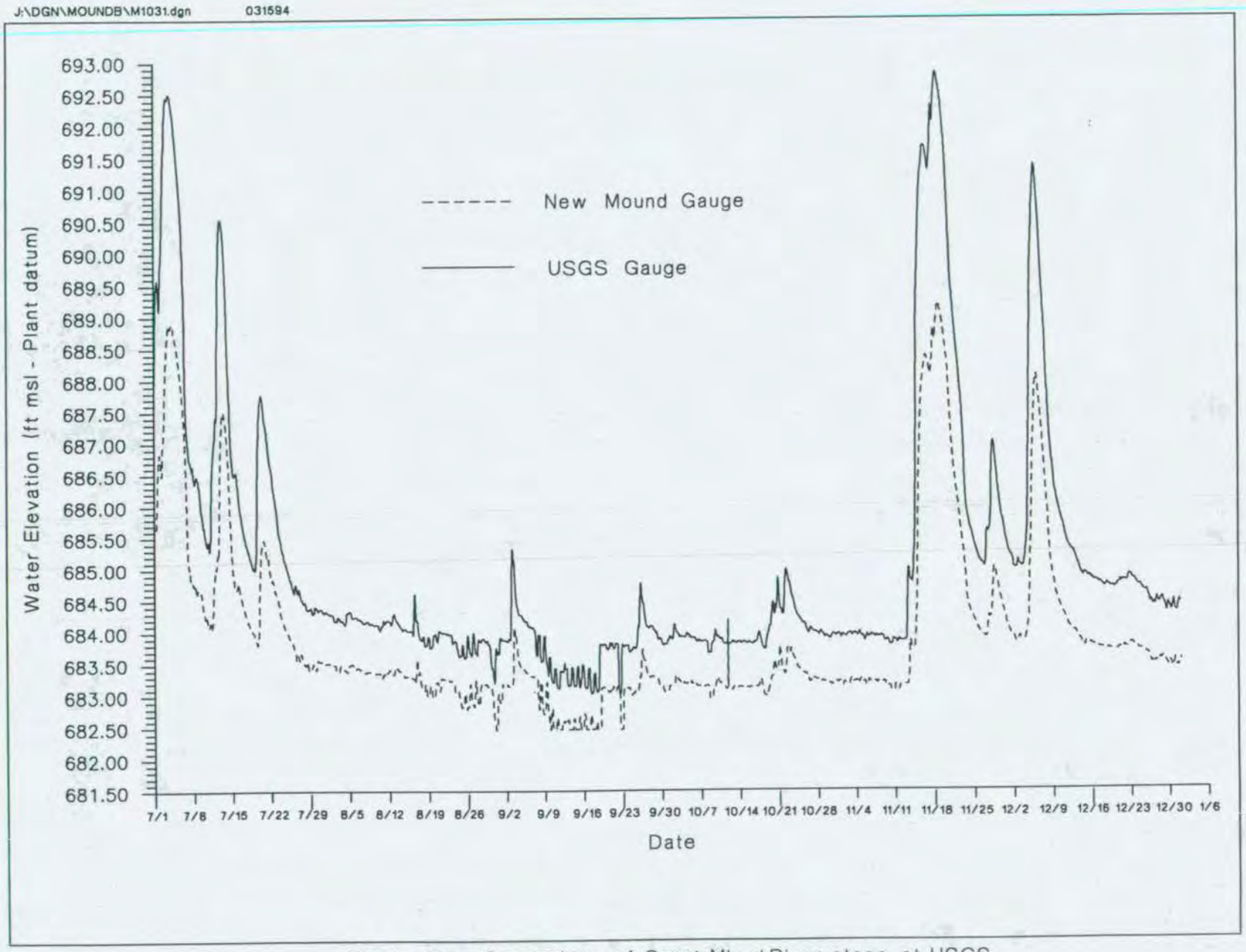


Figure 6.6 Comparison of Great Miami River stage at USGS and Mound gauges, from 1 July 1993 to 31 December 1993.

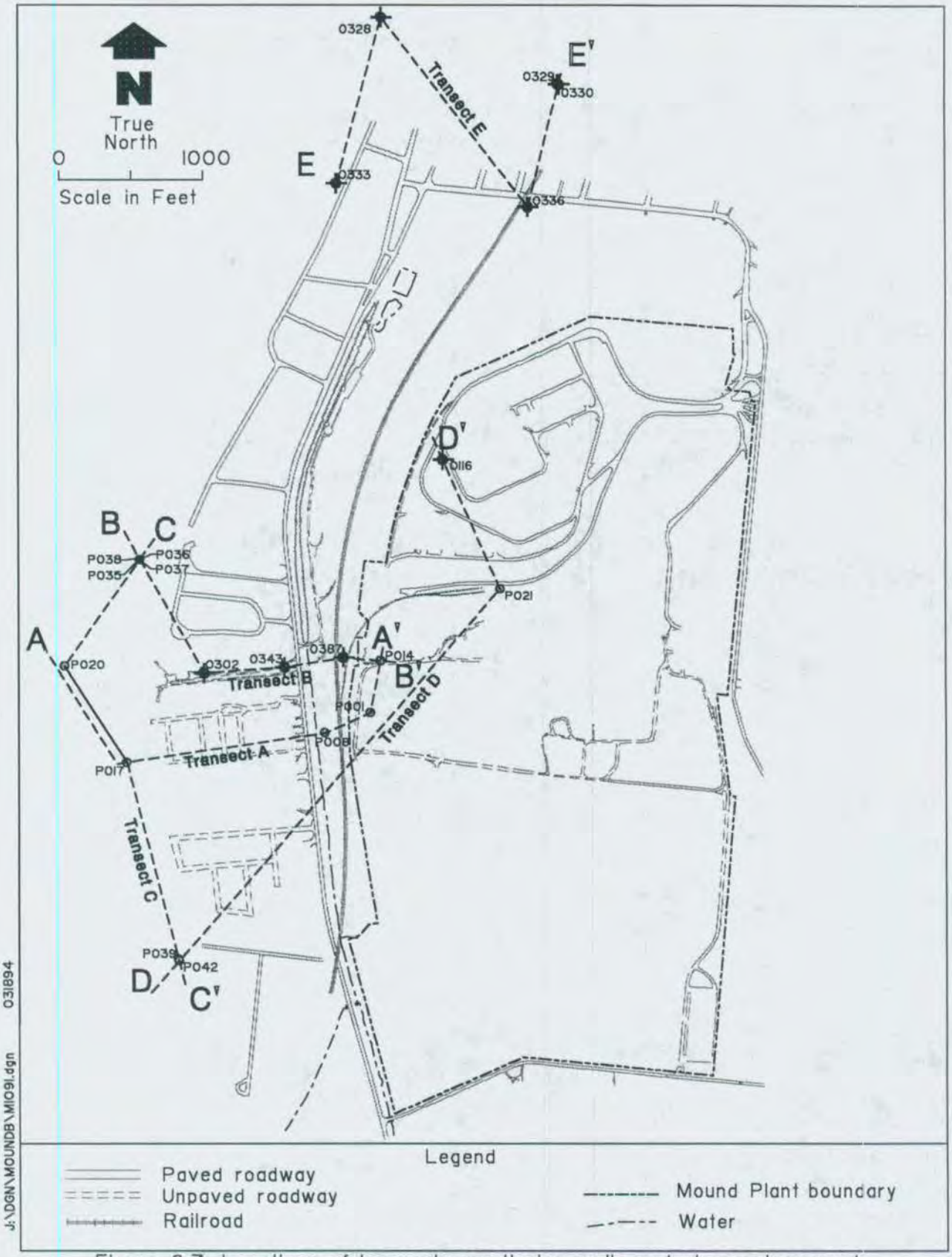


Figure 6.7. Locations of transects, monitoring wells, and piezometers used for evaluation of Buried Valley Aquifer response to the Great Miami River.

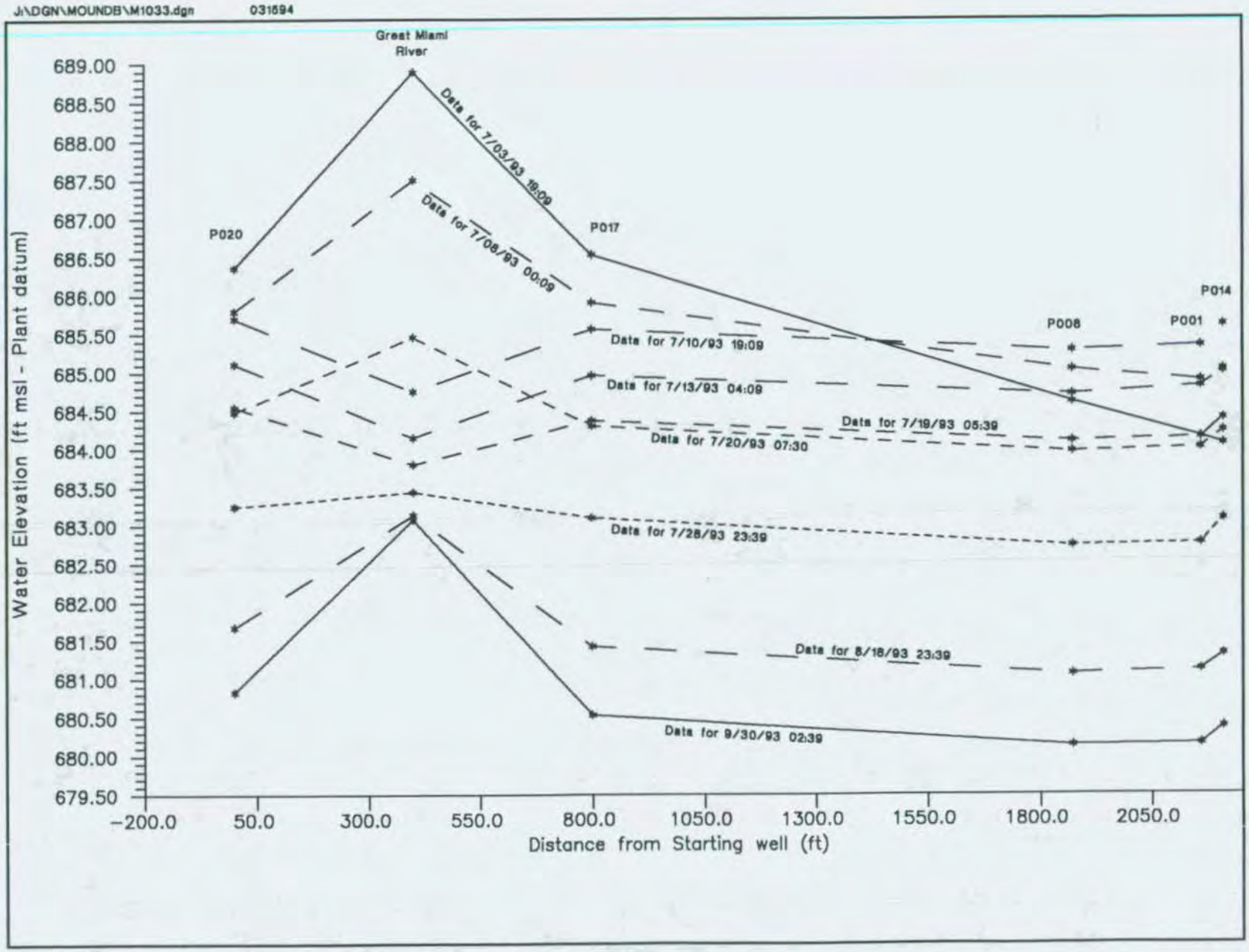


Figure 6.8 Comparison of groundwater elevations with time for wells completed in the Upper Buried Valley Aquifer along transect A

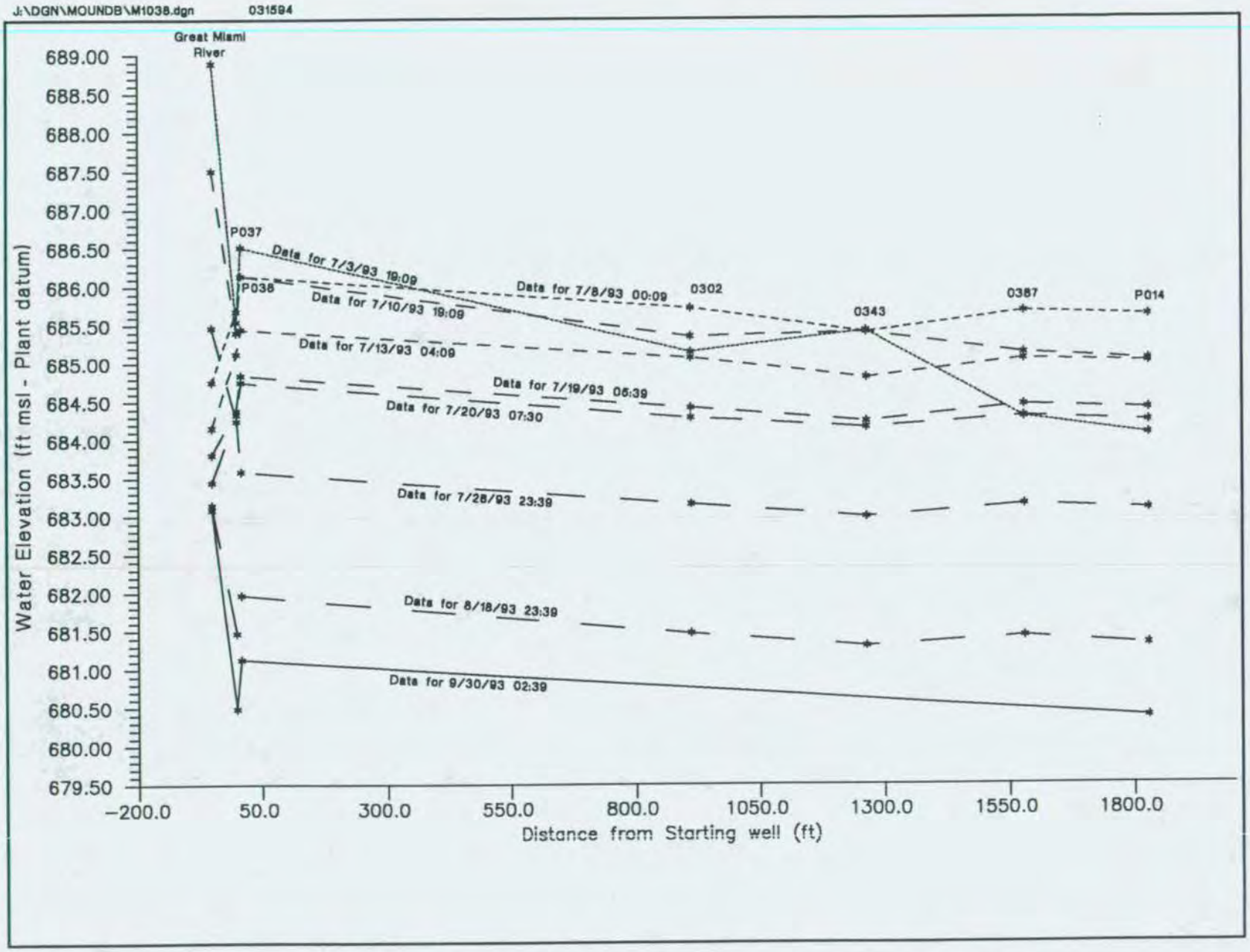


Figure 6.9 Comparison of groundwater elevations with time for wells completed in the Lower Buried Valley Aquifer along transect B.

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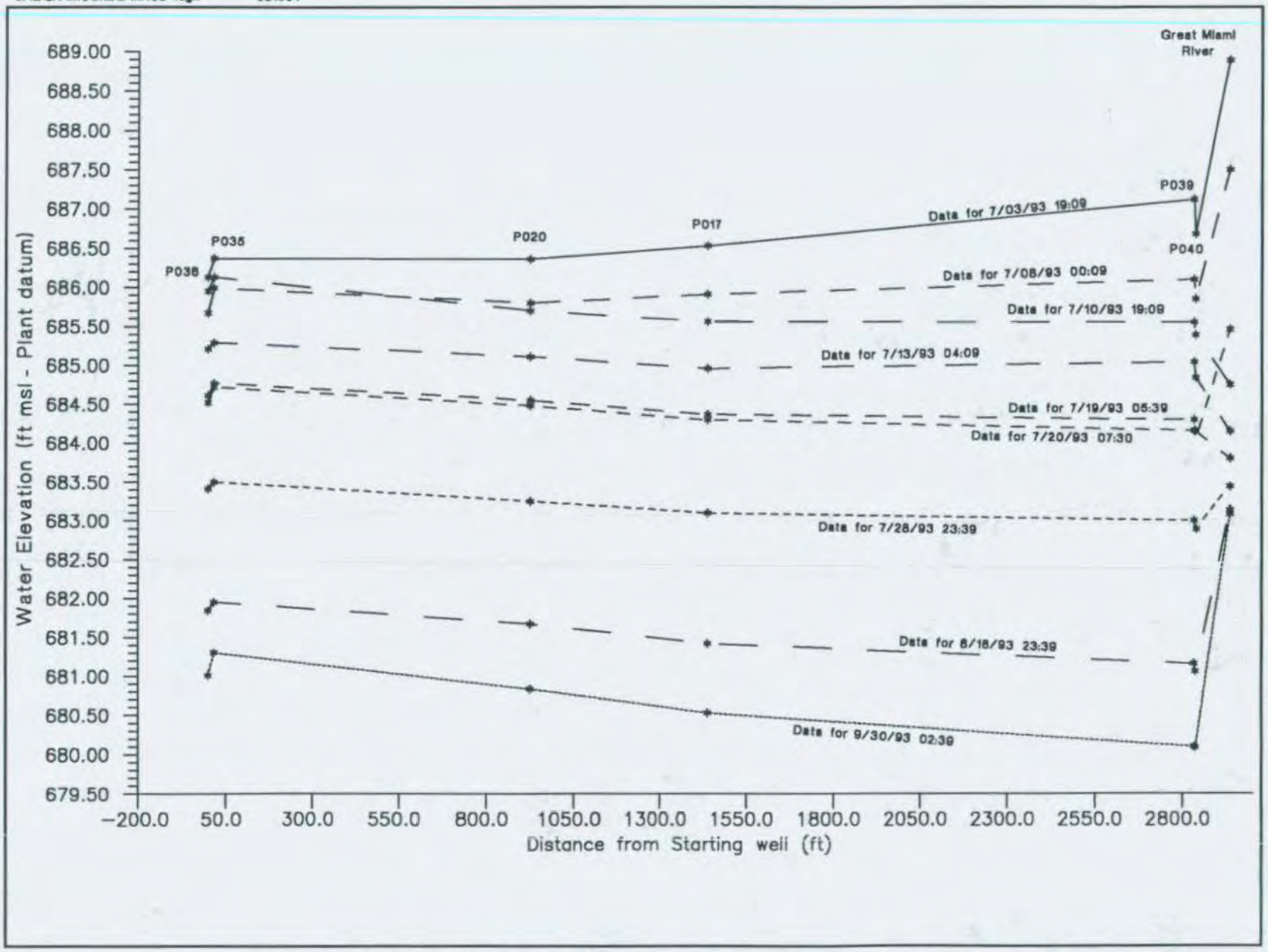

Figrue 6.10 Comparison of groundwater elevations with time for wells completed in the Upper Buried Valley Aquifer along transect C.

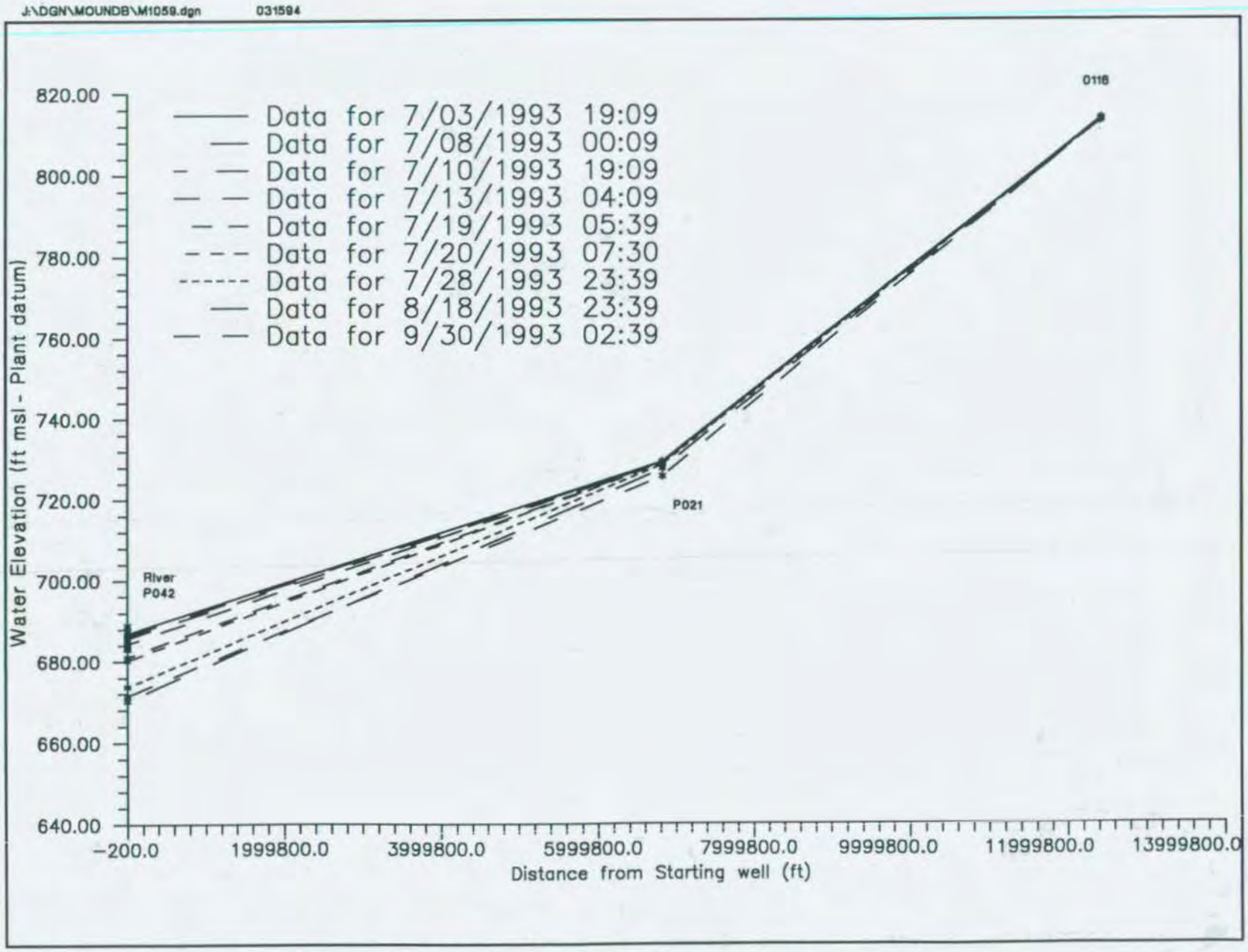

Figure 6.11 Comparison of groundwater elevations with time for wells completed in the bedrock along transect D.

clusters in the north part of the map area (Figure 6.12). The data used in the transects was selected to best illustrate the relationship between the stage in the Great Miami River and the groundwater elevations in the wells with time. The data times for each of the transects is the same although the interval between the data plotted on each transect is irregular.

All of the transects show that water levels in the Buried Valley Aquifer wells and piezometers change with time and river stage. Groundwater levels are highest immediately following high river stage and dissipate slowly with time. Groundwater elevations measured from July through December 1993 are highest in July and December and lowest for the intervening months. The direction of flow, whether from the river to the groundwater or from the groundwater to the river, reverses for short periods of time but is generally from the river to the groundwater. Gradients away from the river, particularly during the summer and fall months, are very small. The relationship between the groundwater elevations in P020, the Great Miami River stage and the groundwater elevations in piezometers P035-P039 indicates that the Great Miami River acts as both a recharge and discharge line depending upon the season for both the east and west sides of the Great Miami River (Figure 6.8). Groundwater elevations at P020, on the west side of the river, and at P035, on the east side of the river are nearly the same. The water levels in P035 are generally less than 0.30 ft lower than water levels in P020. The difference in water levels between P020 on the west side of the river and P035 on the east side of the river indicates that if a gradient exists, it is from the west toward the Mound Plant and not from the Mound Plant beneath the river toward the west.

For the 18 wells monitored, the peak in the groundwater head is delayed 24 to 36 hours, depending upon distance from the river and the magnitude of the difference in water elevations between the river and the groundwater. For example, on 3 July 1993, the peak groundwater level in P035 (adjacent to the river) occurs 22 hours after the peak stage in the river (Appendix D.2.2). For that same event, the groundwater level in P014 (adjacent to the Overflow Pond) doesn't peak until 72 hours later than the river (Figure 6.13). However, by 3 September 1993, the response in the groundwater to the change in the river stage is much quicker. The groundwater levels in P035 and P014 peak less than 4 hours and 36 hours, respectively, after the peak river stage. During the time when the river stage elevations are greater than the groundwater elevations, flow is into the Buried Valley Aquifer. From August through November 1993 the difference in river stage elevation and groundwater elevation at P035 ranges from 0.30 ft to 2 ft. The largest difference occurs in the first two weeks of November. The difference in river stage elevation and groundwater elevation at P014 for the same time period ranges from 0.4 ft to 2.6 ft.

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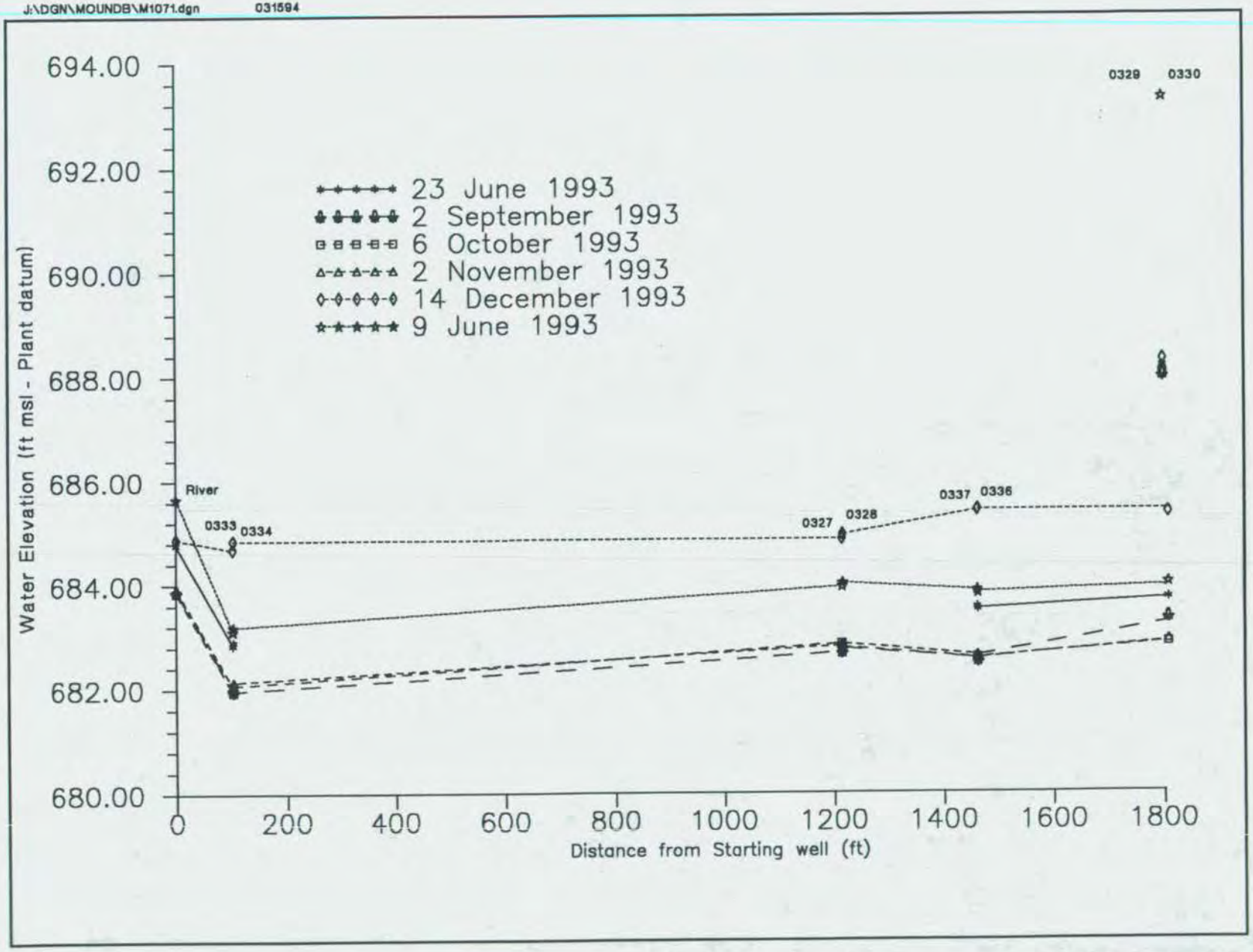

Figure 6.12 Comparison of groundwater elevations with time for wells along transect E.

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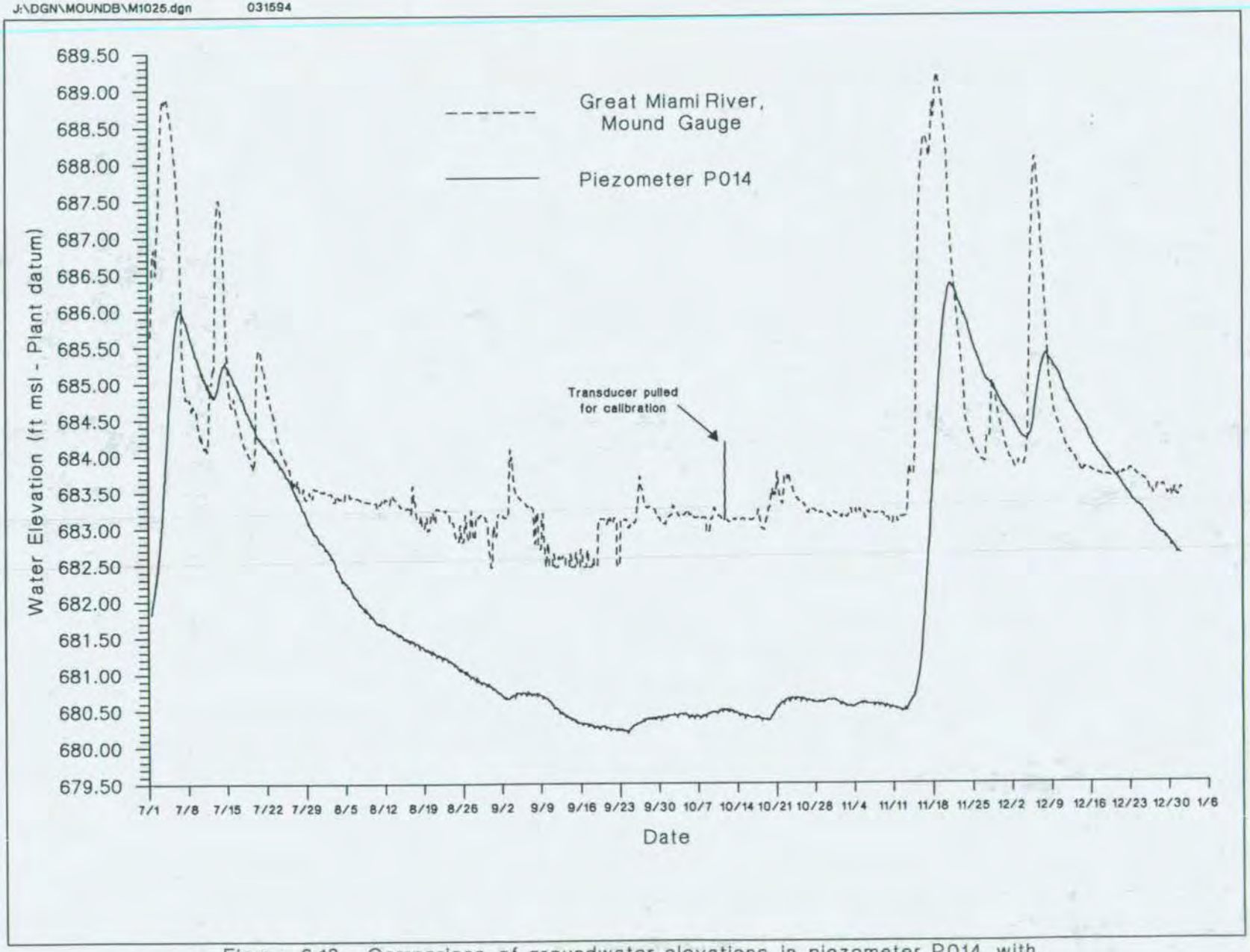

Figure 6.13 Comparison of groundwater elevations in piezometer P014 with stage in the Great Miami River from 1 July 1993 to 31 December 1993.

6.3.6.2. Variation with Depth Within the Aquifer

Comparison of the continuously measured groundwater elevations and river stage data confirms that the water elevation in the river exceeds the mean groundwater elevation in the wells and piezometers in the central Mound Plant area except for short periods immediately following regional precipitation events. Figures 6.13 and 6.14 show the Great Miami River stage elevation at the Mound gauge and the hydrographs for P014, completed in the deeper part of the Buried Valley Aquifer, and 0387, completed in the shallower part of the Buried Valley Aquifer for the period from 1 July through 31 December 1993. Both wells are located in the eastern margin of the Buried Valley Aquifer within Mound Plant (Plate 8). The change in groundwater head copies the change in river stage with time, although the peak groundwater level is delayed and reduced in magnitude from the peak river stage. There is little difference in the groundwater response to river stage rise in either well. The hydrographs for other well clusters completed in different depths of the Buried Valley Aquifer, P035-P038 and P039-P041, show little difference in response to river stage rise based upon depth of completion (Appendix D.2.2). However, the groundwater level response is modified by the presence of till units above the well screens.

6.3.7. Topographic and Bedrock Influences

Bedrock topography has a strong influence on surface topography which, in turn, has a strong effect on the water table elevations. The two principal bedrock and topographic highs, the Main Hill and the SM/PP Hill, are separated by a well-developed tributary valley. The tributary valley dips steeply to the west/southwest at both the ground and bedrock surfaces. Westward toward the Great Miami River floodplain both the land surface and bedrock surface flatten out. Water levels and the margins of the Buried Valley Aquifer strongly mimic the land surface and bedrock topography.

North of Mound Plant in Miamisburg, the valley is relatively wide, with hydraulic gradients indicating flow is southward. The flow in this area is probably controlled by the river stage and the pumping of the municipal production wells (Figure 6.3). In Blocks 1 and 2, groundwater flow in the Buried Valley Aquifer appears to be controlled by the narrowing of the river valley and the shallower depth to bedrock. The smaller cross sectional area results in a steepening of the hydraulic gradients in this area.

Groundwater flow in Block 3 is influenced primarily by the SM/PP Hill and the very broad river valley (Figure 6.3). The groundwater contour map suggests that groundwater flows west from this topographic and bedrock high. At the base of the SM/PP Hill, where the thickness of the unconsolidated sediments increases significantly, the hydraulic gradients decrease significantly. From the geologic and geophysical data, the main axis of the buried valley appears to curve south eastward

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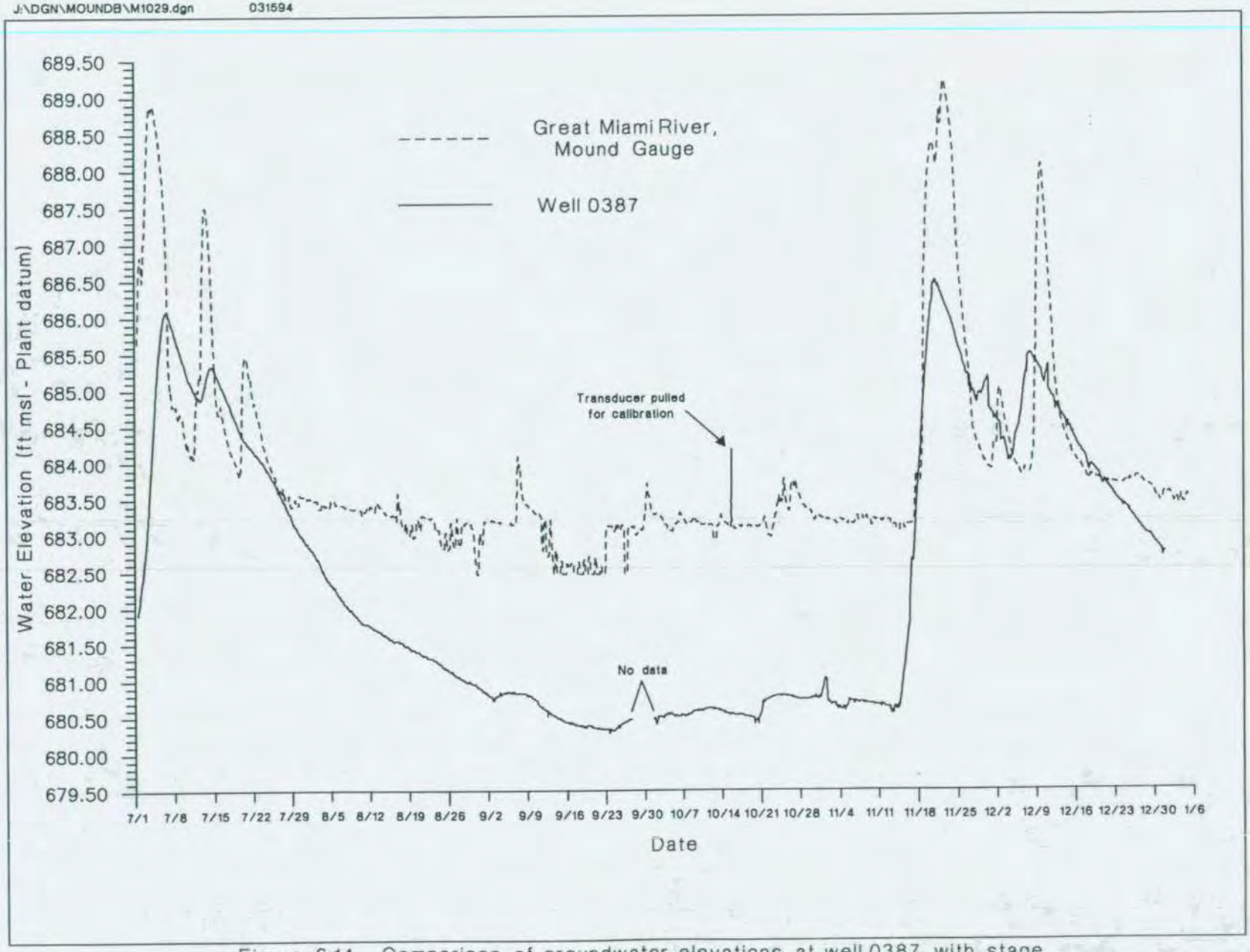

Figure 6.14 Comparison of groundwater elevations at well 0387 with stage in the Great Miami River from 1 July 1993 to 31 December 1993.

beneath Mound Plant. The river does not overlay the deepest part of the buried valley but continues southward over the shallower part of the Buried Valley Aquifer. It is believed that the western bank of the river abuts bedrock. The eastern margin of the aquifer is interpreted from the seismic refraction data to parallel the 730-ft topographic contour (see section 3).

At the Mound Plant tributary valley, the eastern margin of the Buried Valley Aquifer is defined by the response of water levels in monitoring wells to regional water level changes. In particular, water levels in monitoring well cluster 0137/0347 and 0380 respond to changes in the stage of the Great Miami River. Upgradient, monitoring wells 0125 and 0119 do not respond to river stage but rather appear to respond to precipitation. Based on these data, the eastern margin of the Buried Valley Aquifer does not extend up the tributary valley. As described in subsection 6.3.4. groundwater flow in the tributary valley is along the buried bedrock slope. The groundwater in the tributary valley is not considered part of the Buried Valley Aquifer in this report.

6.3.8. Aquifer Interactions

Analyses of the well cluster hydrographs, engineering properties, and aquifer test data indicate that stratigraphy has a strong influence on groundwater flow patterns at Mound Plant. Groundwater flow beneath the water table occurs within glacial outwash, glacial till, and bedrock. Of these lithologies, outwash and bedrock are the largest in volumetric extent, while till is present in lesser amounts. Because hydraulic conductivities in the outwash are several orders of magnitude larger than conductivities in the till and are larger than the average hydraulic conductivities in the bedrock, it appears that the largest volume of groundwater flow away from Mound occurs primarily through the outwash (DOE 1994d)(see Appendix D.1). It is recognized that individual fractures within the bedrock may provide more rapid conduits for flow than the alluvium, however, both the volume of water stored in the bedrock and the water available to maintain that storage are small.

6.3.8.1. Vertical Gradients

Vertical gradients are used to show direction of flow between wells installed in the shallow Buried Valley Aquifer and in the deeper Buried Valley Aquifer and the bedrock. Groundwater elevations in nested wells are compared with the screen depths to determine in which direction groundwater flow is occurring. Vertical gradients were calculated for two hydraulic conditions, under equilibrium conditions from monthly water level measurements and under the stressed conditions developed during the aquifer test (Appendix D.2.3). The groundwater system under non-stressed conditions appears to be in equilibrium with vertical gradients ranging from 0.004 ft/ft to 0.011 ft/ft. The data available from the monthly measurements and the continuously monitored wells indicate that gradients are

upward in the area adjacent to the bedrock along the Mound Plant west boundary and are downward in wells adjacent to the Great Miami River (Figure 6.15). The gradients in wells adjacent to the river increase or decrease seasonally depending upon river stage.

Two of the well clusters, 0128-0302 and 0343-0383, do not fit the general pattern. These two clusters are located along the pipe that transmits water from the Mound Plant to the National Pollution Discharge Elimination System outfall. The vertical gradients in these two wells are downward. Other clusters located along the margin of the Buried Valley Aquifer have vertical gradients that are upward. Clusters along the river have gradients that are downward. Well cluster 0128-0302 is the only cluster in the main Buried Valley Aquifer, so it is difficult to determine whether a downward gradient exists in the main portion of the Buried Valley Aquifer, as indicated by wells 0128-0302, or whether this cluster is an anomaly. The downward gradient could apply to the main portion of the aquifer as a whole or the gradient could be localized in the area of the NPDES outfall as a result of leakage from the outfall pipe or other municipal water transmission pipes in the area. The gradient could also be caused by an error in data measurements, but because there are no other well clusters completed in the main portion of the Buried Valley Aquifer, no conclusions can be drawn for direction of flow in the main Buried Valley Aquifer.

The vertical gradients calculated for the well clusters that were monitored continuously or for the wells that were measured monthly were consistent during the summer months. This would indicate that the gradients in all of the clusters do exist and are not simply a result of measurement errors.

Groundwater level data for stressed conditions were available for two well clusters, the river piezometers P039-P042 and 0393/P003 south of the Overflow Pond. The groundwater levels in P042 (completed in bedrock) were compared with levels in P041 (completed in the lower Buried Valley Aquifer). Groundwater in P042 responds to river stage rises but the hydrograph does not resemble the hydrograph drawn for P041 (Appendix D.2.2). For example, as regional water levels decline in P041, the water levels in P042 are rising. One hypothesis is that the interconnection between the Buried Valley Aquifer and the bedrock in this area is less than in areas closer to Mound Plant and that little water is being transmitted through the bedrock fractures. The continued recovery of water levels in P042 could be a result of the lowering of water levels during well development and the slow refilling of the wellbore with time. It is also possible that P042 is partially confined and is responding to pressure changes in the Buried Valley Aquifer and not the immediate transmittal of water.

To test the theory that P042 is partially confined, the well was bailed in November 1993. In the beginning of November, the hydrograph for P042 shows a water level rise that is in direct response to a rise in river stage. During the time the river stage was rising, P042 was bailed and the water level recovery measured. After three weeks, the water level in P042 had still not recovered to the pre-bailed levels (see hydrograph Appendix D.2.2). The downward vertical gradient between P041 and P042, before P042 was bailed, stabilized at approximately 0.65 ft/ft during August. By October, gradients were around 0.50 ft/ft. After the well was bailed, the gradients increased to 1.6 ft/ft. It appears that P042 may be partially confined.

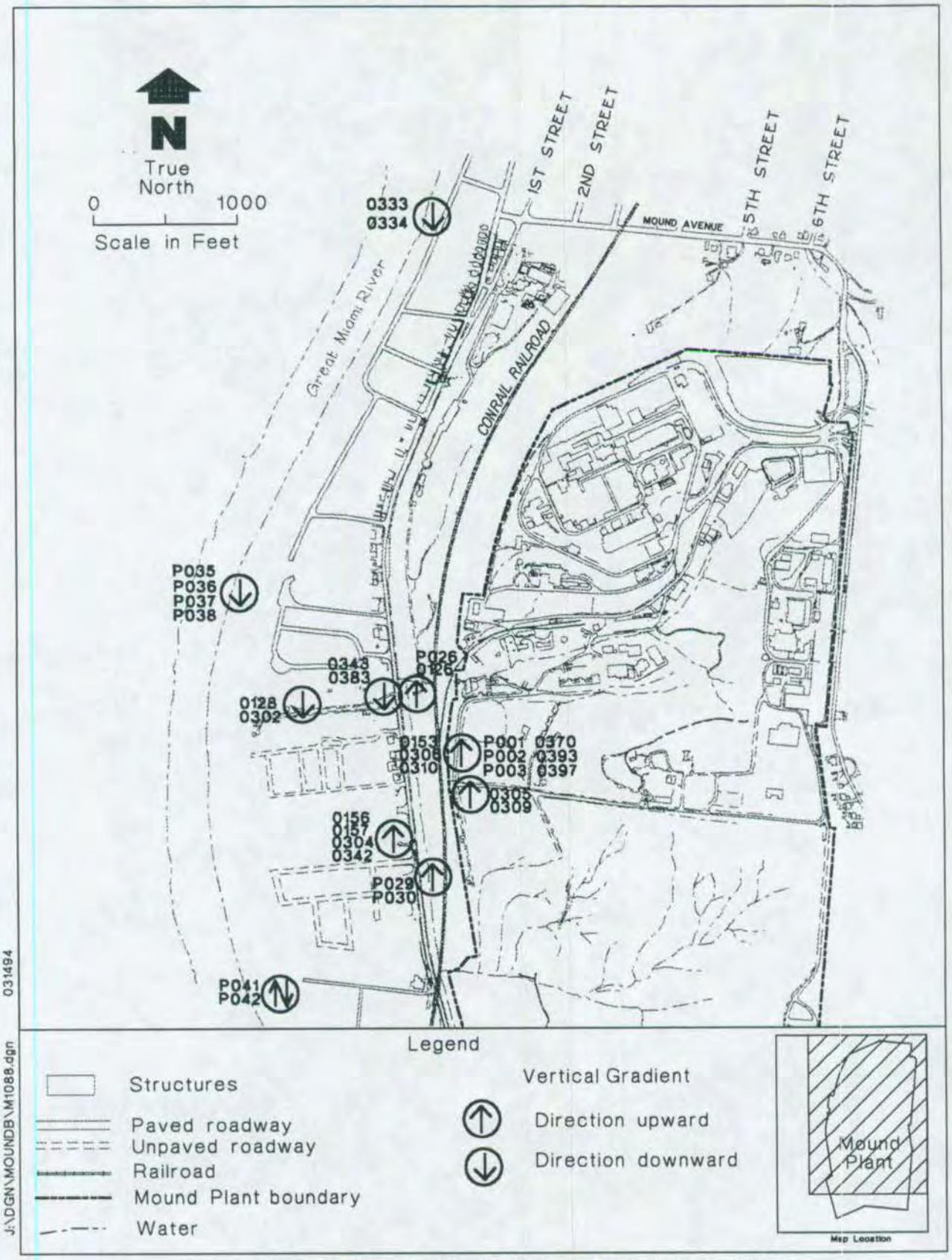

Figure 6.15. Locations and directions of vertical gradients.

P003 and 0393, completed in the Buried Valley Aquifer and the bedrock, respectively, were monitored during the 1993 aquifer test, Figure 6.15. Conversion of the drawdown data to groundwater elevations showed that a 0.2 ft difference existed in drawdowns measured in the two wells during the aquifer test. P003 had greater drawdown but recovered more quickly. Well 0393 had less drawdown but recovered more slowly. Before the aquifer test, water levels in both wells were the same. After the aquifer test began, the differences in response to the aquifer test are reflected in the difference in the drawdown. The vertical gradient, under equilibrium conditions is negligible, under the aquifer test, the gradient upward, from the bedrock, varied between 0.09 and 0.12 ft/ft. This indicates that the bedrock and Buried Valley Aquifer are interconnected, both wells responded to the aquifer test, but that recharge is coming from the bedrock in this area.

6.3.8.2. Hydraulic Connection Between Upper and Lower Units of the Buried Valley Aquifer

Vertical hydraulic gradients were calculated at the North and South River piezometer clusters at the Mound Plant and in wells monitored during the Area B aquifer test (DOE 1994d). The gradients in the wells near the river fluctuate with the river stage. Deeper wells in general showed less response than shallow wells, as in the North River Piezometer cluster (P035, P036, P037, and P038) (Appendix D.2.2). The presence of a till layer above the screened interval, however, may increase the magnitude of the water level response in the well or piezometer. This is seen in P037. It can also have the opposite effect, a decrease in water level response, as seen in P038. Positive gradients indicate downward flow; negative gradients indicate upward flow. Small vertical hydraulic gradients indicate a high degree of interconnection within the saturated, unconsolidated materials. Except in the northernmost part of the map area (Figure 6.1) there is no hydrogeologic evidence for a continuous till layer separating the upper portion of the Buried Valley Aquifer from the deeper portion of the aquifer in the Mound Plant area. The glacial tills are more continuous in the area north of Mound Plant as shown by the differences in water levels in wells 0329 and 0330. Water levels in 0329 are generally 4 ft higher than water levels in 0330. Well 0329 is screened above a thick till unit. Well 0330 is screened below the till. It appears that water levels in 0329 are perched on the till unit and are not part of the regional groundwater system.

As discussed in section 5, the distribution of the interbedded till units is consistent with the geometry of the buried valley. In the northern area, where the valley is very wide, the ancient river had room to meander and did not erode till deposits on the valley edge. The topographic narrowing of the valley west of the Mound Plant Main Hill, provided little room for the river to migrate laterally. In this reach, the tills were probably eroded.

6.3.8.3. Hydraulic Connection Between the Buried Valley Aquifer and Bedrock

The degree of interconnection between the Buried Valley Aquifer and the bedrock depends upon location at Mound Plant. The bedrock wells at higher elevations on the Mound Plant, on the Main Hill and the SM/PP Hill, show no response to changes in groundwater elevation in the Buried Valley Aquifer. Water levels in the bedrock wells and piezometers located along the flanks of the Buried Valley Aquifer and in the floodplain of the Great Miami River respond to changes in river stage in a manner similar to changes in water levels in wells completed in the Buried Valley Aquifer.

The continuous monitoring of the 18 wells and piezometers in the Mound Plant area helps establish the relationship between the bedrock flow system and the Buried Valley Aquifer. A water level transect was constructed for the three wells completed in the bedrock that were continuously monitored, P042, P021 and 0116 (Figure 6.7). These data indicate that the head in P042 responds to changes in river stage and recharge with time (Figure 6.11). Whether P042 responds to the regional decline cannot be determined because the water level does not appear to be in equilibrium (as discussed in subsection 6.3.8.1). P021, on the south side of the tributary valley, responds to the regional water level decline but shows no response to river stage rises. Well 0116, on the Main Hill, shows the regional water level decline but at a much reduced rate from that seen in either P042 or P021. Well 0116 also shows a response to precipitation events greater than 0.30 inch but no response to river stage rises. The water level rise caused by the precipitation is short lived, less than 36 hours. The range in long-term water levels in 0116 is less than 0.7 ft while the short-term rise after the precipitation is as much as 9.5 ft. The water level response in well 0116 may be caused by leakage around the well casing or by rapid flow through the fracture system.

The relative impermeability of the bedrock is illustrated by comparing water levels in piezometer P042 and well 0352, both completed in bedrock. P042 was bailed on 23 November 1993 during a period of increasing river stage (Figure 6.16). Despite the increased stage, the water level in P042 had not recovered to pre-bailed levels three weeks after the bailing. This indicates that the inflow to P042 is less than 0.01 gpm. This calculation was based upon the water level recovery and the volume of water needed to re-fill the wellbore. It was assumed that bailing caused negligible drawdown away from the borehole. For the bedrock piezometer P042, the gradient between the Buried Valley Aquifer and the bedrock is downward, from the Buried Valley Aquifer into the bedrock. There is no evidence that there is a continuous flow path from the bedrock in the SM/PP Hill to the bedrock in the main valley and from there upward into the Buried Valley Aquifer.

On 4 February 1993, a mini-aquifer test was run in well 0352 which is drilled in bedrock on the SM/PP Hill. The well was pumped for 2 hours and 19 minutes at an approximate rate of 2.3 gpm. This rate

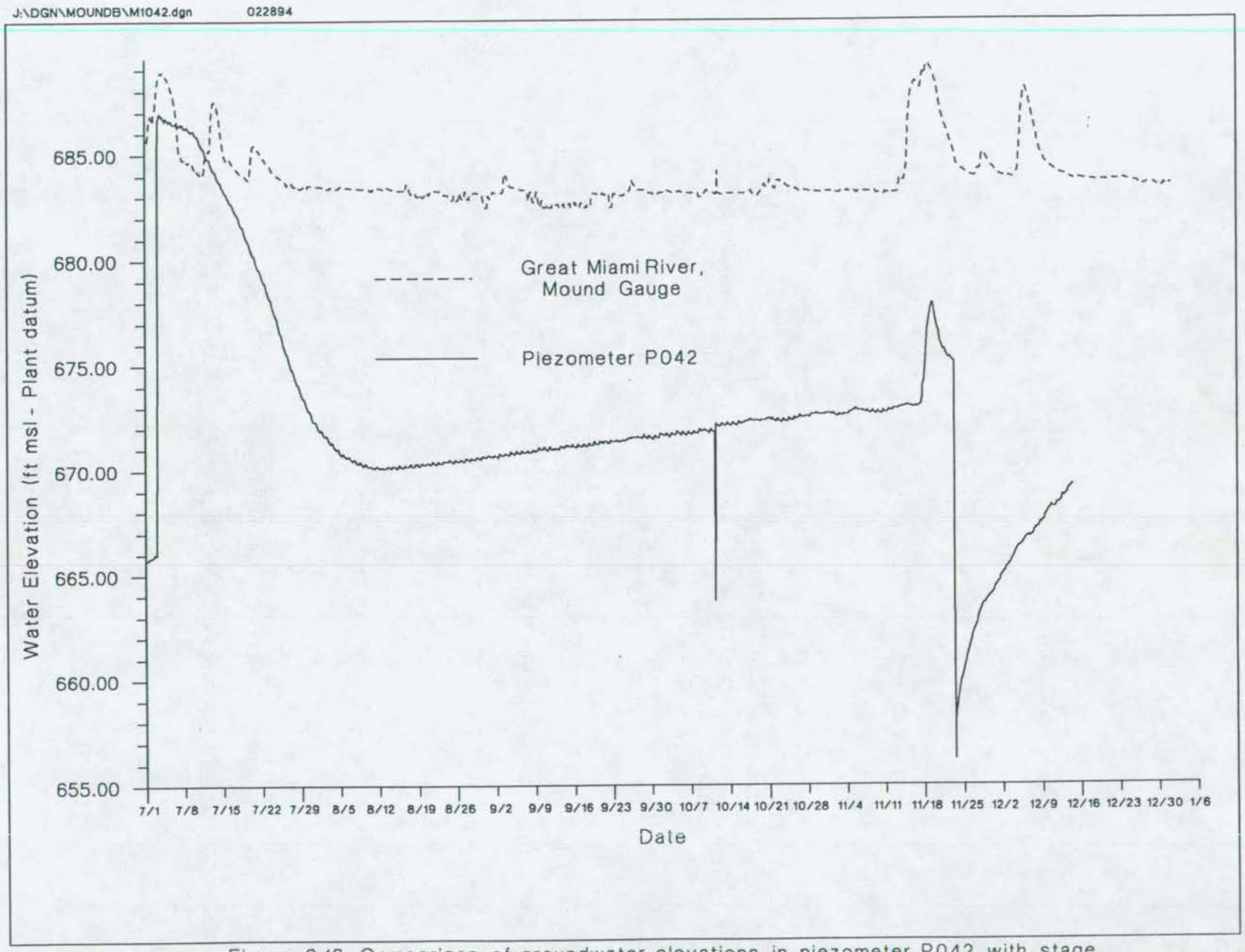

Figure 6.16. Comparison of groundwater elevations in piezometer P042 with stage in the Great Miami River (Mound gauge) from 1 July 1993 to 31 December 1993.

resulted in 13.47 ft of drawdown and a residual drawdown of 2.15 ft seven days later (Appendix D1). The slow recovery of this well indicates that the hydraulic conductivity of the bedrock is relatively low compared to the Buried Valley Aquifer (1 ft/day compared to 700 ft/day) and that there is insufficient flow to replace the water removed from the wellbore in a timely fashion.

The response of the bedrock wells completed in the main part of the Buried Valley Aquifer to the aquifer test indicates that pressure changes are readily transmitted from the Buried Valley Aquifer to the bedrock.

Because highly permeable deposits of outwash sand and gravel overlying bedrock are present in and around Mound Plant (Plates 2 and 3), the outwash is capable of transporting significant volumes of groundwater. Groundwater levels in some of the well clusters (e.g., wells 0305 and 0309, and wells 0156, 0157, and 0304) indicate that groundwater from the bedrock may be also recharging the outwash layers, but groundwater movement in the bedrock has a much smaller volume and moves at a much slower average velocity than it would in outwash because of the significantly lower permeability of the bedrock (DOE 1994b).

6.4. WATER BUDGET

The water budget for the Buried Valley Aquifer consists of inflow and outflow. Inflows include infiltration of precipitation, recharge from the river when the river stage is at a higher elevation than the groundwater elevation, leakage from man-made surface drainage features and water transmission lines, and flow from upgradient areas. Outflows include pumping, evapotranspiration, and flow out of the area. Under steady state conditions, with no change in inflow and outflow, there is no change in average water levels within an area with time. This report presents a preliminary water budget for the Buried Valley Aquifer in the immediate vicinity of Mound Plant. For the purposes of this preliminary budget, the groundwater system on and adjacent to Mound Plant is assumed to be in a steady-state condition. Pumping for the Miamisburg, Dayton Power and Light Company and Mound Plant water supply has impacted the groundwater flow system, both recharge and discharge, and the water levels measured in wells in the area. The current steady-state condition has been achieved since inflow and outflow, including pumping, have stabilized at lower groundwater elevations than those that existed before pumping began. The current conditions represent equilibrium between water stored in the aquifer and groundwater that flows into and out of the Buried Valley Aquifer in this area. Figure 6.17 depicts the areas and lengths of boundaries used for estimation of inflows and outflows in the preliminary water budget. It is emphasized that the estimation errors are large and that the preliminary water budget is a first attempt to estimate these parameters for the Mound Plant Site.

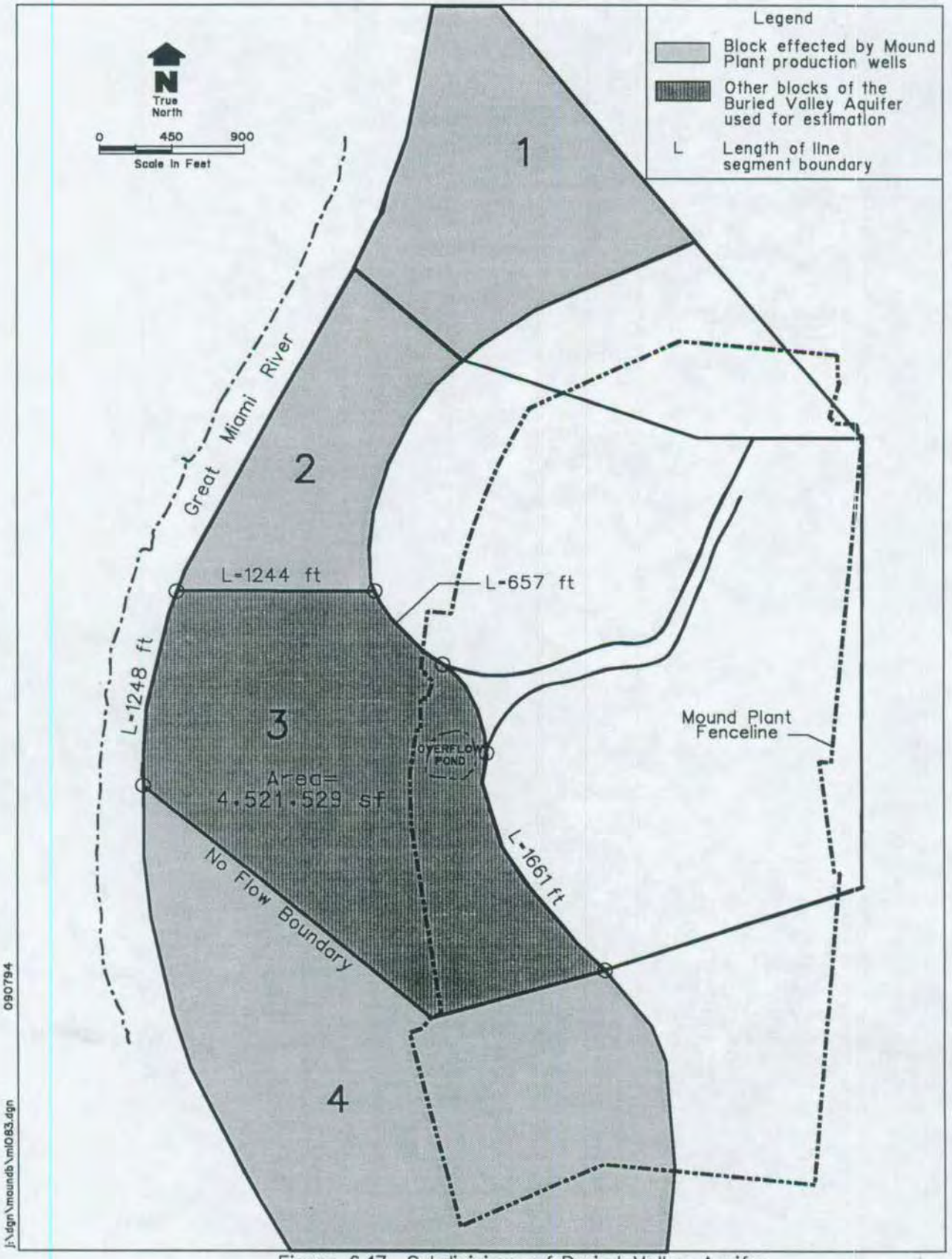

Figure 6.17. Subdivisions of Buried Valley Aquifer used for water budget estimates

The immediate area of concern is the area to the west of Mound Plant that is impacted by pumping and water discharge from the Mound Plant, shown as Area 3. The areas shown on Figure 6.17 were developed using the groundwater contour maps to delineate distinct regions in which flow is relatively uniform. For example, in Block 1 flow is from the Mound Plant and areas northward toward the southwest. In Block 2, flow is toward the south and southeast but at a steeper gradient than in Block 1 because of the smaller cross-sectional area of saturated sediments. The hydraulic gradients at the boundary between Blocks 2 and 3 may decrease because of leakage from water distribution and storm sewer lines at the head of Block 3. Block 3 is the major area of interest at Mound Plant because it is the region that is most directly impacted by Mound Plant pumping and discharge. The majority of flow is toward the Mound production wells. In Block 4, the volume of the Buried Valley Aquifer begins to increase and the groundwater movement is toward the south and southwest. The water budget for Block 3 is discussed in the following subsections and summarized in Table VI.3. The entire water budget and methods of calculation are discussed in Appendix D.3.1.

6.4.1. Inflow

Interpretation of the groundwater data for the Mound Plant and of references on regional hydrogeology indicate that there are five sources of inflow to the Buried Valley Aquifer:

- direct infiltration of precipitation, and percolation of runoff;
- infiltration from the Great Miami River during periods when river stage is higher than groundwater elevations within the Buried Valley Aquifer;
- groundwater inflow across the eastern and northeastern boundaries of the Buried Valley Aquifer;
- inflow to the Buried Valley Aquifer from the Mound Plant tributary valley; and
- percolation from surface water bodies on and adjacent to Mound Plant including the Miami-Erie Canal from water transmission lines.

6.4.1.1. Precipitation

Precipitation and the subsequent infiltration of that water to the groundwater system is a minor source of groundwater recharge to the Mound Plant area. Average rainfall in Montgomery County is approximately 37.5 inches per year, of which 6 inches a year or less contribute to groundwater recharge on a regional basis (Schairbaum and Frost 1988). Average monthly precipitation totals from the USGS range from 2.5 to 4.75 inches, with May and June having the highest average monthly precipitation of 4 to 4.75 inches, and October and December having the lowest totals, ranging from

Table VI.3. Water Budget for the Area Impacted by Mound Plant Pumping

Component	Length (ft)	Saturated Thickness (ft)	Hydraulic Gradient (ft/ft)	Hydraulic Conductivity (ft^2 /day)	Flow			Comment
					ft^3/day	gpd	MGY	
Inflow								
Precipitation in the Buried Valley alluvium							16.8	(4.8E ft^2) (0.5 ft/yr)[a] = 2.25E6 ft/yr
Miami-Erie Canal						275,000	100	from infiltration study[b]
Great Miami River	1,248	150	0.0003	70	3,900	29,400	10.7	Gradients from 5/12/93 water level map
Buried Valley Aquifer	1244	75	0.00038	400	14,000	105,000	38.4	
Bedrock	2,318	40	0.09	1	8,300	62,400	22.8	
Tributary Valley	135	30	0.05	55	11,100	83,300	30.4	
Subtotal							219.1	
Outflow								
Pumpage							196	Appendix D.5.1

[a]Schairbaum and Frost 1988
[b]Styron and Meyer 1981
gpd - gallons per day
MGY - million gallons per year

approximately 2.5 to 2.75 inches. Appendix D.4 includes data from both Mound Plant and USGS rain gauges (Figure 6.1; see description section 2.8).

Within the Mound Plant area, the fraction of precipitation contributing to the groundwater may be less than the regional value because of man-made surface features, including paved roads and drainage structures, which enhance surface runoff. Precipitation that infiltrates to the flow system on the Main and SM/PP Hills is integrated into the outflow rate from the bedrock for the Mound Plant area. Therefore, the contribution from precipitation to the bedrock flow does not need to be calculated. Infiltration of precipitation in the area underlain by the Buried Valley Aquifer does need to be calculated. If it is assumed that 6 inches of rainfall reaches the groundwater system as recharge in Block 3 as recharge, the total volume of recharge from precipitation is 2,250,000 ft^3 (16,800,000 gallons). This is enough water to supply the plant for approximately 34 days (<10 percent of the plant supply).

Figure 6.18 shows the recorded precipitation at both gauges for the period from 1 July through 31 December 1993. A comparison of the precipitation measured at the Mound gauge with the precipitation recorded at the USGS gauge indicates that there is a difference in the amount of precipitation measured at both gauges (Appendix D.4). For example, on 20 October 1993, 0.8 inch was measured at the USGS gauge while 1.12 inches were recorded at the Mound gauge. The next day, 21 October 1993, there was no precipitation recorded at the USGS gauge, but the Mound gauge recorded 0.08 inches of precipitation. For the six month period from July 1993 through December 1993, the total precipitation at the Mound gauge was 15.59 inches and at the USGS gauge it was 12.86 in. The difference between the two gauges was 2.73 inches for the six month period.

6.4.1.2. Estimation of Inflow from the Great Miami River

The Great Miami River is generally considered to be the greatest single influence on groundwater in the Buried Valley Aquifer. The change in groundwater head observed in monitoring wells mirrors the change in river stage with time, although the peak groundwater level is delayed with time and reduced in magnitude from the peak river stage. For the 18 wells monitored continuously, the peak in the groundwater head is delayed 24 to 36 hours, depending upon distance from the river and the magnitude of the difference in water elevations between the river and the groundwater. During the time when the river stage elevations are greater than the groundwater elevations, flow is into the Buried Valley Aquifer.

The supposition that the river acts as a source of recharge to the Buried Valley Aquifer is confirmed by a second set of data collected during the 1993 aquifer test (DOE 1994d), the decrease in the regional decline rate during the aquifer test. During the aquifer test, river stage fluctuated as much

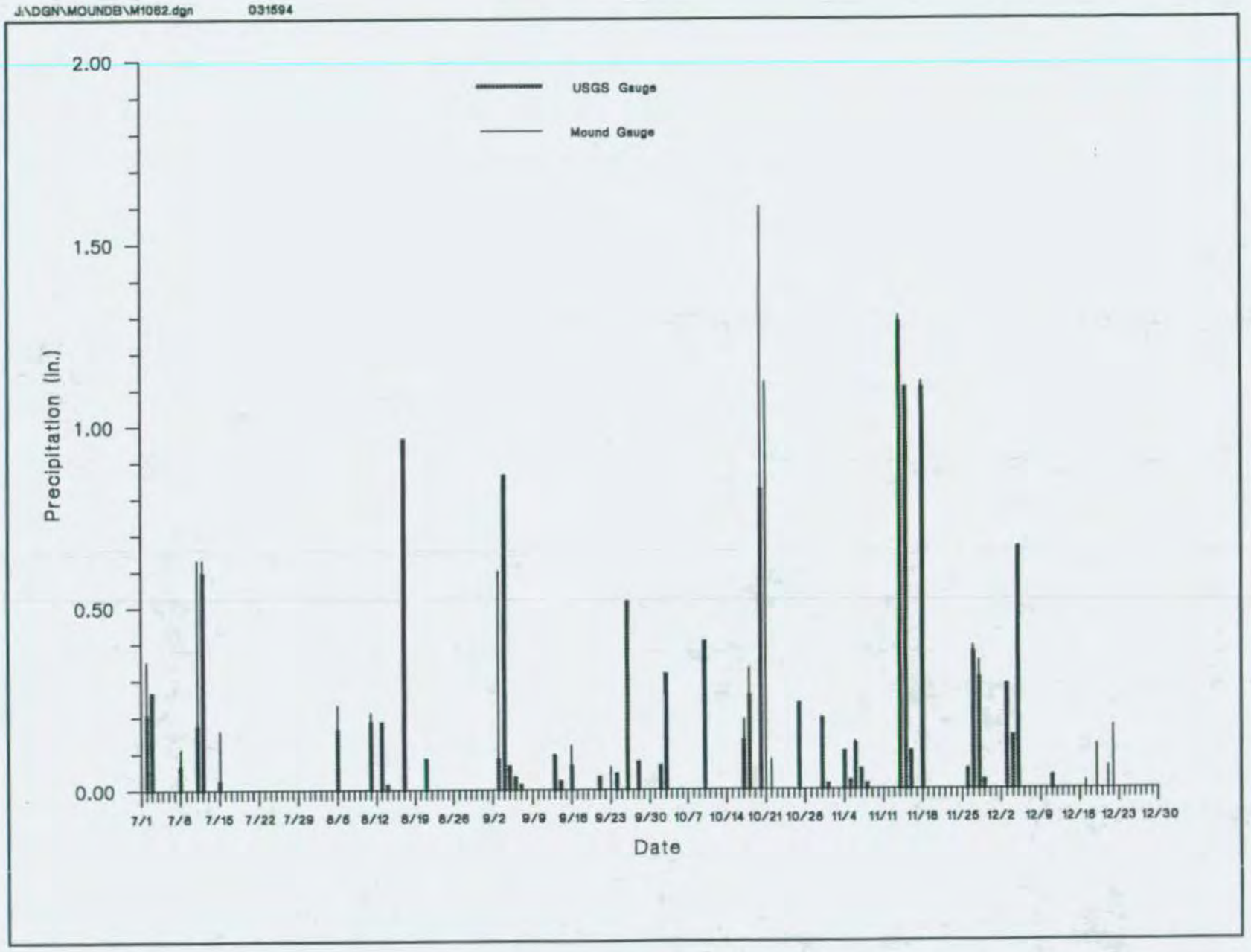

Figure 6.18. Precipitation measured at USGS and Mound gauges from 1 July 1993 to 31 December 1993.

as 1.5 ft. The maximum rise in river stage of 1.5 ft occurred at the beginning of the aquifer test. Between day 15 and the end of the test, the river stage fluctuated from 0.5 to 1.2 ft higher than the baseline stage measured at the beginning of the test. These rises in river stage resulted in a decrease in the average rate of groundwater level decline from 0.08 ft/day to 0.02 ft/day. The decrease was measured in wells not affected by the aquifer test: P035-P039, 0333, 0334, and 0159. A similar change was seen in all of the wells in the Buried Valley Aquifer, regardless of completion depth.

If the assumption is made that Darcy's law is valid, the flow across the width of the Buried Valley Aquifer from the Great Miami River to the Mound Plant in Block 3 (Figure 6.17) can be calculated. The volume of flow entering the southern area of the Buried Valley Aquifer on and adjacent to the Mound Plant (Block 3) is 3,900 ft^3/day (29,400 gpd) (Table VI.3).

6.4.1.3. Groundwater Flow Across the Northern Buried Valley Aquifer Boundary

Groundwater flow across the northern boundary of Block 1 (Figure 6.3) is interpreted to represent inflow into the area of the Buried Valley Aquifer investigated in this report. Flow into Block 1 is estimated from the length of the line segment, average hydraulic gradient and conductivity. Results and discussion are presented in Appendix D.3.

6.4.1.4. Groundwater Flow Across the Bedrock/Buried Valley Aquifer Contact

The water level data indicate that the aquifer is being recharged by groundwater flow from the east through bedrock. The bedrock is dominated by a fracture flow system (details are provided in the Hydrogeologic Investigations: Bedrock Report (DOE 1994b)). Two different methods are used to estimate the amount of inflow from the bedrock (Appendix D.3), both based on data reported in the Bedrock Report (DOE 1994b). These two methods calculate the flow rate per unit length of contact between bedrock and the Buried Valley Aquifer (Figure 6.3). Descriptions of the fracture flow system indicate that the fractured carapace is approximately 100 ft thick and that numerous seeps and springs outcrop along exposed bedrock faces on the Main and SM/PP Hills.

The results of these estimates indicate that flow from the bedrock may supply recharge to the southern part of the Buried Valley Aquifer of up to 62,400 gallons per day in Block 3. On the Main Hill, recharge rates to northern areas may be as high as 68,000 gallons per day. This assumes that all water flowing through the fracture carapace is discharged into the Buried Valley Aquifer and none is lost to surface flow; not a practical assumption, but reasonable considering the large magnitude of possible error. The flow rates calculated per unit length range from 0.012 to 0.03 gallons per minute (gpm). This is relatively consistent with values observed in surface seeps. For instance, a 0.02 gpm

estimate means that 2 gpm flow is possible every 100 feet of segment length. The flow rates described in Appendix D.3 are interpreted to represent all flow to the Buried Valley Aquifer from the bedrock fracture system; most of the bedrock flow on hillslopes may occur within the unconsolidated slope materials, some may express itself as a groundwater seeps or springs. Groundwater seeps are known to range from less than 1 to 5 gpm on the Main Hill. Very weak seeps can be found on the exposed bedrock surface at the railroad cut (DOE 1992a, 1994b), as well as many areas around the hills.

6.4.1.5. Percolation from Surface Water Features

There are three types of surface water features located on Mound Plant that could be recharge sources, drainage ditches, french drains, and the ponds used for runoff control such as the retention basins and the overflow pond (Figure 6.19). Each is discussed below.

Surface drainage on the Mound site is collected by the plant drainage ditch, an interconnecting series of retention basins, and the overflow pond in Area B. Runoff from the Main Hill is transported down the plant drainage ditch into the retention basins and/or the overflow pond. Runoff from the northeastern portion of the SM/PP Hill is first collected in an asphalt-lined pond and is then transported in the plant drainage ditch to the retention basins. Runoff from the western portion of the SM/PP Hill is either delivered to the overflow pond in Area B or flows along the ditch on the south side of the site sanitary landfill, where it is diverted to a south-trending ditch located on the western margin of the spoils area.

Water is ponded in the retention basins to allow suspended sediments to settle and to be removed before discharge. The basins receive rainfall runoff in addition to approximately 410,000 gallons per day of single pass cooling water, cooling tower blowdown and water softener backwash via the plant drainage ditch (DOE 1992a). During periods of high flow when the retention basins are filled to capacity, excess water flows into the overflow pond in Area B via the spillway at the northeast corner of the overflow pond. Water that is released from a standpipe in the northwest corner of the overflow pond, and from the retention basins, passes through a National Pollution Discharge Elimination System outfall and is released to an abandoned section of the Miami Erie Canal. Water then flows from the canal in an open ditch to the Great Miami River. The overflow pond and retention basins are lined to prevent percolation into the groundwater system; the plant drainage ditch and the Miami-Erie Canal are not lined (see subsection 6.4.1.7 below).

A special case is the overflow pond located in Area B. It has had a historical impact on the groundwater system that appears to have been corrected. The groundwater level map for June 1992

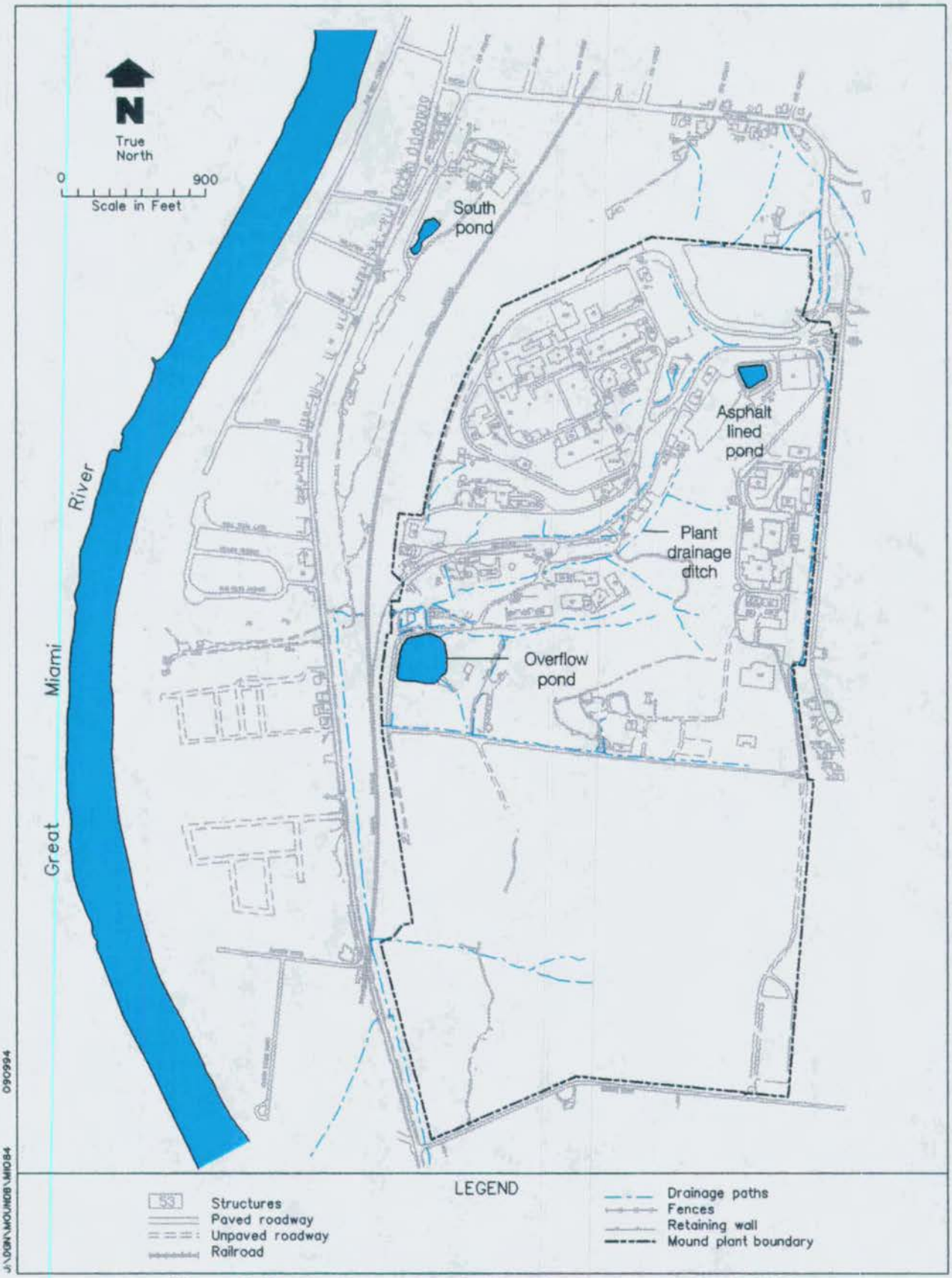

Figure 6.19 Surface water features in the Mound Plant vicinity.

suggests that the Area B overflow pond may have been leaking and providing recharge to the groundwater system (DOE 1994d). Leakage could have occurred in three ways:

- between the casing and the wellbore of monitoring well 0055 (formerly located in the overflow pond), due to a poor bentonite seal within the annulus of the well bore;
- through improperly abandoned test holes drilled into the bottom of the pond when it was initially constructed; and
- through the bottom of the pond.

Comparison of water level measurements in 1988 for well 0055 versus groundwater levels in adjacent wells indicate that the annulus around well 0055 leaked when the water level in the pond exceeded the ground surface elevation of well 0055 (DOE 1994d). Since the proper abandonment of well 0055 on 21 September 1992, water level maps have not shown the groundwater mounding in the vicinity of the overflow pond. The overflow pond is lined, therefore leakage through the undisturbed liner of the overflow pond is thought to be minimal.

The site sanitary landfill, located to the south of the overflow pond, has two sets of subsurface drains that may, at times, transport water. Perforated plastic drains at the base of the encapsulated trash within the landfill are designed to drain leachate into the overflow pond. Except for approximately 6 months after the installation of the landfill, these drains have reportedly been dry. A series of five parallel, east-to-west-trending french drains installed beneath the landfill is designed to transport infiltrating moisture away from the landfill. The drains were recently found to be dry (DOE 1994d).

6.4.1.6. Inflow from the Mound Plant Tributary Valley

The tributary valley acts as a collection area for infiltration of runoff and discharge from the bedrock. Hydraulic gradients in the valley are controlled by the slope of the bedrock surface beneath the alluvial fill. The inflow from the tributary valley is estimated using Darcy's Law by multiplying the saturated cross sectional area by the hydraulic gradients and hydraulic conductivity within the valley. An area upgradient of the Buried Valley Aquifer margin is used. The area of flow is estimated to be rather narrow, as expressed by surface topography and cross section AA' (Plate 2). An average width of 140 ft and average saturated thickness of 30 ft results in a cross sectional area of 4200 ft^2. Hydraulic gradients through this reach are relatively steep (0.05 ft/ft). Hydraulic conductivities are unknown, but are assumed to vary from 10 to 100 ft/day due to the high proportion of tills relative to more conductive sand and gravel deposits. Geologic logs indicate that the valley does not contain the large gravel deposits typically found out in the main buried valley. Based on these data, estimated flow rates

may range from 2,100 to 21,000 ft^3/day. Converting these estimates yields an order of magnitude of 15,700 to 157,000 gpd (5.7 to 57 MGY). Considering the large sources of error, an estimate of 72,000 gpd (26 MGY) is considered reasonable.

6.4.1.7. Infiltration from the Miami-Erie Canal

A remnant of the Miami-Erie Canal is located immediately west of the Mound Plant (Figure 6.20). The canal is divided into northern and southern segments as a result of the installation of a one-way valve in the mid-1970s (DOE 1992a). The northern segment is relatively dry and does not carry water except during heavy rainfall. The southern segment is an active waterway that receives water from the Mound Plant drainage ditch through a discharge point regulated by a permit under the National Pollution Discharge Elimination System (DOE 1992d). In a report compiled by Styron and Meyer (1981), an evaluation of the rates of infiltration along the southern part of the canal was conducted after installation of monitoring equipment (Dames and Moore 1977). Styron and Meyer (1981) reported that:

> "On the average, and excluding rainy days, the flow into the canal is 42 L/s (671 gallons per minute (gpm)) and the flow out is 30 L/s (480 gpm). The loss of 12 L/s (191 gpm) accounts for 28.5 percent of the total flow. Since the travel time is fairly short (100 minutes) to travel the 762 m (2,500 ft), very little of this loss can be attributed to evapotranspiration. There was no significant difference in the rate of water loss between clear, windy days and overcast days, further supporting this point. The conclusion is that about 1.04×10^6 L (275,000 gallons) of water is lost each day from the ditch to the aquifer. During periods of rainfall when the ground becomes saturated, losses in the canal drop to about 20 percent of the total flow; some of this may be attributed to infiltration enroute. During periods of high flow in the canal not related to rainfall, losses increase to almost 35 percent of the total flow, probably in direct proportion to the applied head. ... The distribution of this loss cannot be determined from the available data."

These data indicate that infiltration from the Miami-Erie Canal may supply up to 275,000 gpd to the Buried Valley Aquifer. In relation to the other sources of recharge, this is certainly one of, if not the single largest source of recharge in the immediate area of Mound Plant. Insufficient data exists, however, to effectively evaluate the results. None of the actual data from the stream measurements were included in the report nor were any of the constraints and assumptions used to estimate the recharge rate. Reports of flow through the National Pollution Discharge Elimination System discharge point for 1977 when the original analysis was performed indicate a range from 0.18 to 0.90 million gallons per day (MGD) with an average of 0.38 MGD (Farmer and Carfagno 1978). An annual average discharge rate of 0.50 MGD was measured in 1991 with a range in discharge from 0.0 to 2.38 MGD (EG&G 1992). It appears that actual discharge may have increased since 1977. However, physical conditions within the active reach of the Miami-Erie Canal may have changed since 1977 when the

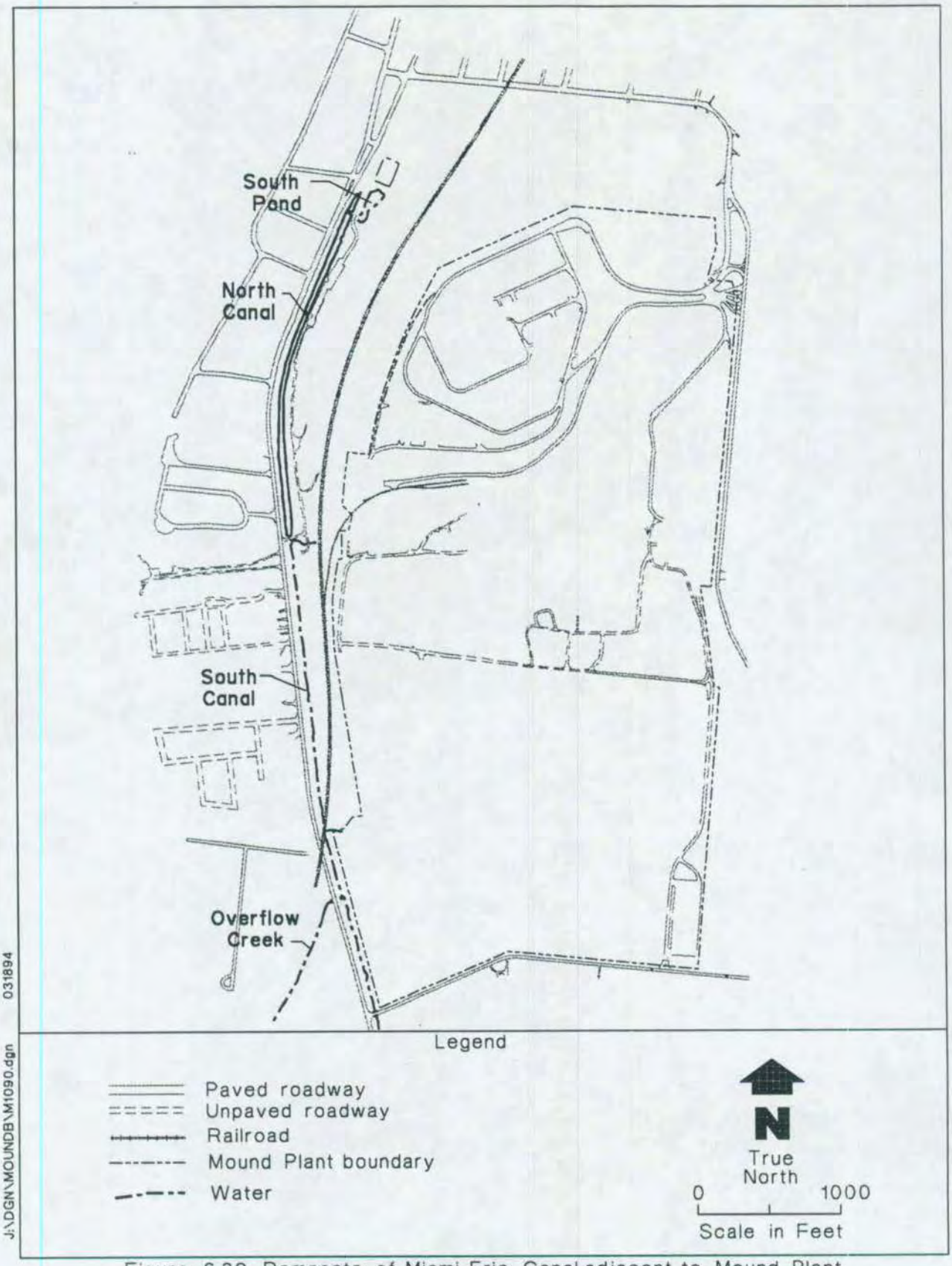

Figure 6.20. Remnants of Miami-Erie Canal adjacent to Mound Plant.

measurements were obtained so the applicability of the 1977 infiltration rates to 1994 is not known. Additional work to evaluate the infiltration from the Miami-Erie Canal to the Buried Valley Aquifer is recommended (see subsection 6.6 below).

6.4.2. Discharge

Discharge from the Buried Valley Aquifer occurs by four mechanisms, pumping, discharge to the river, flow across the southern edge of the Buried Valley Aquifer adjacent to the Mound Plant, and by evapotranspiration.

6.4.2.1. Active Pumping Locations

Daily 1992 pumping rates for the Mound Plant are presented in Appendix D.5.1. The volumes of water shown in Table D.5.1 are not measured at the Mound Plant production wells (the production wells are not metered) but are volumes of water softened for the plant. These data indicate that the average annual usage is approximately 195 million gallons. The Mound Plant production wells are assumed to be the largest single discharge of groundwater within the southern part of the Buried Valley Aquifer.

Well 0912 (Miamisburg Production Well #2) is pumped as needed to control tritium levels in the Buried Valley Aquifer. Over the last 5 years, well 0912 has been pumped a total of 18 days. No pumping occurred in 1992 and 1993. No long-term pumping effects have been observed.

6.4.2.1.1. Municipal and Industrial Production.

Water wells at the Miamisburg municipal well field, which are completed in the Buried Valley Aquifer, pumped 691.57 million gallons in 1992 (Appendix D.5.2). Wells at the Dayton Power and Light Hutching Power Station pumped 208 million gallons in 1992 (Figure 6.1). The Miamisburg municipal wells are located approximately 0.5 miles upstream of Mound Plant on the opposite side of the Great Miami River, while the wells at the Hutching Power Station are 1.5 miles downstream of Mound Plant, also on the west side of the Great Miami River. Spieker (1968) noted that a decline in regional groundwater gradients was evident in the Miamisburg area. The very low groundwater gradient in the Buried Valley Aquifer adjacent to Mound Plant (approximately 1 ft/mile) is evidence that the regional gradient (approximately 5 ft/mile) may be a result of the extensive development of the area (Spieker 1968). Whether pumping for the Dayton Power and Light Company power station and the Miamisburg municipal supply have affected water levels in the Mound Plant area are not known. From river stage elevations and adjacent groundwater levels (wells 0328, 0329, 0330, 0333, 0334, 0336 and 0337) it appears that the Great Miami River and the Buried valley aquifer are still hydraulically

connected. The pumping in the two well fields may have lowered the Great Miami River stage and in that may have lowered the inflow in the Buried Valley Aquifer adjacent to Mound Plant. Verbal communications with personnel from the Miami Conservancy District indicate that regional water levels in the Buried valley Aquifer were in a decline through the 1970s and 1980s. Measurements since 1988 indicate regional water level rebounds. Additional data collection is recommended to quantify these effects (see subsection 6.6).

The municipal and industrial production wells are not considered in the preliminary water budget compiled for the southern part of the Buried Valley Aquifer. Evidence that the Great Miami River provides a hydraulic barrier to westerly flow indicates that the Dayton Power and Light Company production wells are hydraulically isolated from the area of interest. In the northern part of the Buried Valley Aquifer, the narrow valley and horizontal gradients toward the south indicate that the Miamisburg wells do not impact the area in Block 3, except through the effects on the river.

6.4.2.2. Discharge to the Great Miami River

Flow does occur from the aquifer to the river immediately after the decline in peak river stage (Figures 6.13 and 6.14). This is interpreted to be a release of water from bank storage, the temporary storage of infiltrated river water in the sediments along the river bank that is returned to the river when river stage is less than groundwater elevations. Based upon the average length of time that river stage was lower than groundwater levels during the six months of continuous monitoring, less than four weeks, it is expected to be a minor component of aquifer discharge. There are insufficient data to quantify the discharge to the Great Miami River.

6.4.2.3. Flow Across the Southern Boundary

Groundwater is lost from the Mound Plant area as sub-flow to the south in the main aquifer valley. The southern boundary of Block 3 is interpreted to be a no-flow boundary because all flow within Block 3 appears to be captured by the plant production wells. Groundwater does move off the Mound Plant in Block 4. A simple Darcy's Law calculation is used to estimate flow leaving the area in and adjacent to Mound Plant for Block 4 (Figure 6.17). If one assumes an average saturated thickness and width for the Buried Valley Aquifer of 100 ft and 1,642 ft, respectively; an average hydraulic conductivity of 700 ft/day (see subsection 6.3, Aquifer Properties), and an average hydraulic gradient of 0.00018 ft/ft (see subsection 6.3); the flow across this boundary is 20,700 ft^3/day. This converts to 154,800 gallons per day (gpd) and 56 million gallons per year (MGY). The water level maps for the spring and fall indicate that groundwater flow across the southern boundary probably varies with time. Gradients are very low and perhaps change northward during some measuring periods. The large cross section width indicates that flow is not insignificant in either direction.

6.4.2.4. Evapotranspiration

Water is lost from the groundwater system as evaporation when the water table is within a few feet of the land surface or when plants are present whose rooting depths are sufficient to reach the water table. It is expected that both direct evaporation and evapotranspiration are minor components of the water budget. Neither have been quantified for the Mound Plant area. Except for the corridor of riparian vegetation along the Miami-Erie Canal, most of the vegetation directly over the Buried Valley Aquifer consists of grasses. Wooded stretches are present on the hillslopes, which may reduce the amount of bedrock water that reaches the aquifer from the SM/PP Hill.

6.4.2.5. Summary of Water Budget

Preliminary estimates of inflows and outflows to the Buried Valley Aquifer provide an order of magnitude water budget for the areas on and adjacent to Mound Plant. Within Block 3, the southern part of the Buried Valley Aquifer affected by the plant production wells, the water budget is constructed such that:

$$Qout = Qin$$
$$Qout = Qp$$
$$Qin = Qpr + Qb + Qr + Qt + Qm + Qn$$

where:
- Qp = pumping at production wells;
- Qpr = infiltration from precipitation in the Buried Valley Aquifer;
- Qb = inflow from bedrock;
- Qr = inflow from the Great Miami river;
- Qt = inflow from the Mound Plant tributary valley;
- Qm = inflow from the Miami-Erie Canal; and
- Qn = inflow across the northern boundary.

Preliminary estimates of these parameters indicate that:

- outflow from pumping discharges 196 MGY;
- outflow across the southern boundary is nil;
- inflow from precipitation is 16.8 MGY;
- inflow from the Great Miami River is 10.7 MGY;

- inflow from bedrock is 22.8 MGY;
- subflow from the Buried Valley Aquifer is 38.4 MGY;
- subflow from the tributary valley 30.4 MGY; and
- inflow from the Miami-Erie Canal is 100 MGY.

These estimates indicate that the water balance in the southern part of the Buried Valley Aquifer on and adjacent to Mound Plant may be expressed as:

Qout = 196 MGY; and Qin = 219.1 MGY.

This suggests that the preliminary water budget possesses an inherent error of at least 12 percent. This error may be considered to be spread across all parameters and may affect individual parameters more greatly than others. The inflow from the Miami-Erie Canal and the Buried Valley Aquifer appear to be the greatest inputs. Inflow from the Great Miami River appears to be a relatively minor component of the preliminary budget, even less than leakage from bedrock. This preliminary water budget is meant to show the relative magnitudes of inflow and outflow and should not be construed as either complete or accurate.

6.5. CONCLUSIONS

The Buried Valley Aquifer on and adjacent to Mound Plant is conveniently subdivided into 4 blocks for evaluation purposes (Figure 6.21). Groundwater movement within the Buried Valley Aquifer in Block 1 northwest of Mound Plant is primarily to the southwest. In areas where sparse water level data are available, as in Block 2 directly west of the Main Hill, it is assumed that water levels are controlled by the configuration of the Buried Valley Aquifer and bedrock topography. Groundwater flow in Blocks 1 and 2 generally parallels the Great Miami River, with flow into the river.

Groundwater movement within the Buried Valley Aquifer in Block 3 west of Mound Plant is generally from upgradient areas to the plant production wells. The southern boundary of Block 3 is interpreted to be a no-flow zone as all groundwater within Block 3 appears to be captured by the plant production wells. Recharge to the Block 3 groundwater system (Figure 6.21) occurs primarily in four ways (in order of decreasing magnitude): infiltration from the Miami-Erie Canal; the southerly gradient of the Buried Valley Aquifer; subflow from the plant tributary valley; leakage from the fractured bedrock; infiltration of precipitation; and inflow from the Great Miami River.

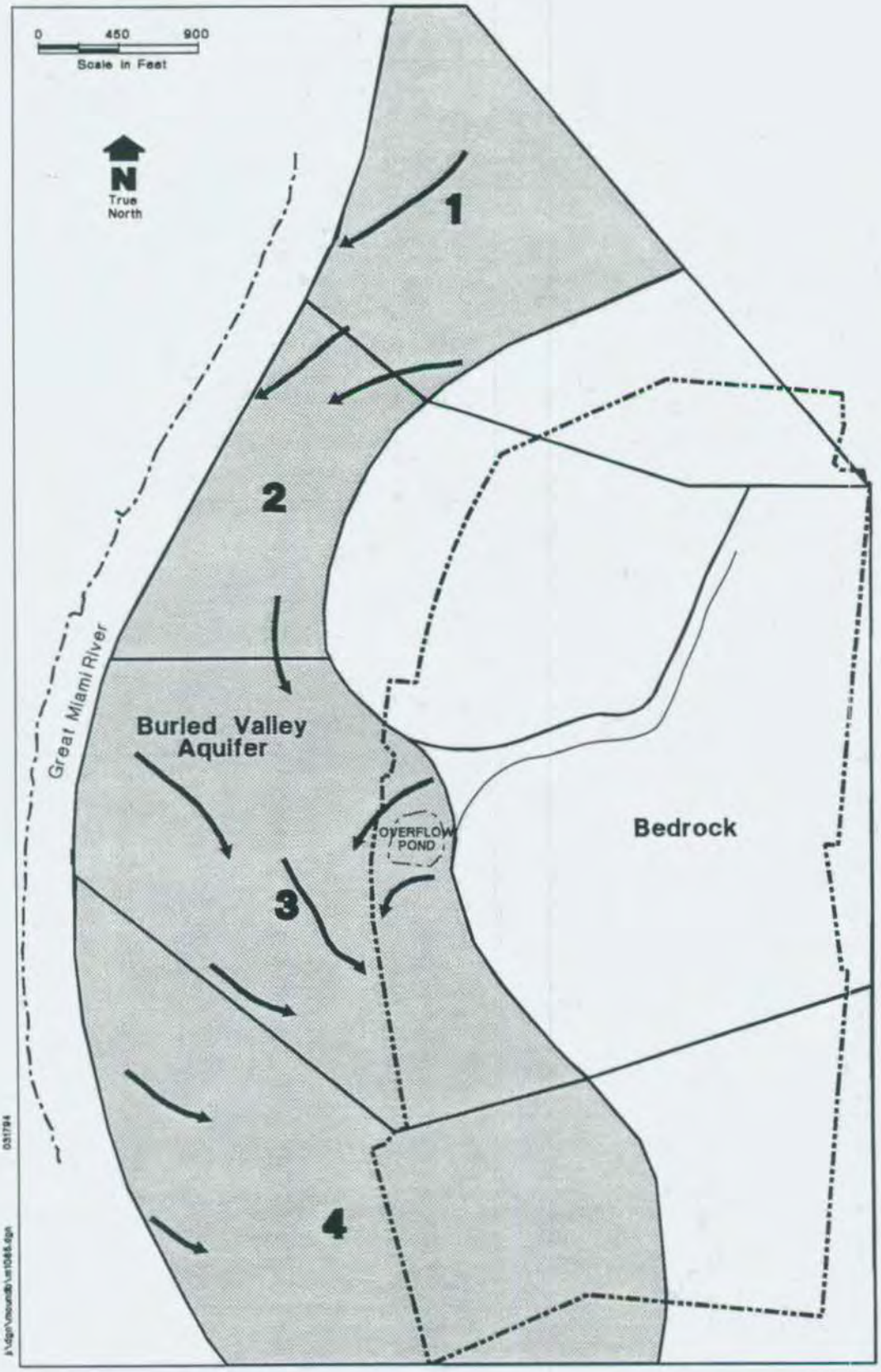

Figure 6.21. Preliminary flow directions of the Buried Valley Aquifer on and adjacent to Mound Plant.

Based upon the continuous monitoring of 18 wells and piezometers during the latter part of 1993, the average seasonal variation in water levels is about 3 ft, with lower water levels from August through November, and higher water levels following higher stages in the Great Miami River. Maximum water levels vary up to 8 ft with changes in river stage. Hydraulic gradients do not change appreciably by season. Gradients throughout the Buried Valley Aquifer on and adjacent to Mound Plant are relatively low ranging from <2 to 5×10^{-4} ft/ft.

The available data indicates that the Great Miami River, by elevating groundwater levels in its vicinity, is also a barrier to westward groundwater flow from the plant site. The magnitude of this groundwater mound changes as a function of river stage, and decreases with distance from the river. The fluctuation in river stage directly impacts the groundwater levels in monitoring wells throughout the Mound Plant by changing the elevation of the groundwater discharge point at the river.

Water level data indicate that groundwater flow in the tributary valley is to the west with extremely high gradients (0.05 ft/ft due west) because of the steep slope of the bedrock surface which controls the elevation of the saturated alluvium in the tributary valley. Water flowing south from the Main Hill and water flowing north/northwest from the SM/PP Hill are incorporated into the westerly flow direction and transported through the tributary valley to the Buried Valley Aquifer. The tributary valley is not considered part of the Buried Valley Aquifer as water levels in the tributary valley are interpreted to be controlled by precipitation and by the slope of the underlying bedrock. Variability in hydraulic gradients is a result of changes in the slope of the underlying bedrock surface.

The extent to which the Buried Valley Aquifer and the bedrock are interconnected depends upon location within the area. Groundwater in shallow bedrock wells that are located in the Great Miami River floodplain is interconnected with groundwater in the Buried Valley Aquifer, as demonstrated by the water level response in bedrock wells and piezometers to river stage rises. Groundwater in wells completed in bedrock at higher elevations on the Main Hill and SM/PP Hill does not appear to be interconnected with the Buried Valley Aquifer water. This is shown by the lack of response in these wells to the changes in river stage and to the pressure changes transmitted by the Buried Valley Aquifer away from the river.

The transmissivity calculated for the Buried Valley Aquifer from the 1993 aquifer test (DOE 1994d) indicate that values ranged from 27,500 ft^2/day to 55,200 ft^2/day. Storativities ranged from 0.04 to 0.34, respectively. Hydraulic conductivities range from 400 to 900 ft/day. The higher values were calculated for the region of Block 3 where the interbedded glacial tills are relatively thin and discontinuous. The hydraulic conductivities appear to decrease northward as the thicknesses and continuity of the interbedded glacial tills increases.

Although it would be expected that the transmissivities calculated for wells completed in the bedrock and the Buried Valley Aquifer would be greatly different, this is not true for the region along the valley margin. The interconnection between the bedrock and the Buried Valley Aquifer allows pressure changes to be readily transmitted to the bedrock wells. This is shown by the upward vertical gradients at well clusters near the eastern valley margin. The bedrock wells respond in a fashion similar to the Buried Valley Aquifer wells, because their water levels are controlled by pressure in the overlying Buried Valley Aquifer. For well clusters near the middle of the valley, the vertical gradients between the Buried Valley Aquifer and the bedrock is downward into the bedrock. There is no evidence that there is a continuous flow path from the bedrock hills to the bedrock in the main valley and from there upward into the Buried Valley Aquifer.

Regionally, groundwater pumping at the Dayton Power and Light Hutching Power Station and the Miamisburg municipal well field have little or no effect on the groundwater flow patterns at Mound Plant because of the high transmissivity and specific yield values of the Buried Valley Aquifer. The effect of pumping at these two locations is also expected to be small because they are across the Great Miami River from Mound. The Great Miami River is in dynamic equilibrium with the Buried Valley Aquifer and acts as a discharge boundary in the north and as a recharge boundary in the south (Figure 6.21).

6.6. RECOMMENDATIONS

As data analysis progressed for this report it became apparent that the conceptual model for groundwater flow within the Buried Valley Aquifer was quite different than the one proposed in the OU 9 Work Plan (DOE 1992a). Evaluation of the current data and the level of quality and coverage indicates some areas may require additional information. These areas include the following data groups:

1) Infiltration rates from the Miami-Erie Canal;

2) Discharge rates and resulting water levels in the Miamisburg and Dayton Power and Light well fields; and

3) Discharge for the Great Miami River at the Mound Plant gauge;

Additional work is recommended as noted below:

1) Install weirs at either end of the Miami-Erie Canal and monitor the changes in flow with time in the canal.

2) Obtain discharge records and water level data for production wells in Miamisburg and at the Hutching Power Station. If necessary, install piezometers to evaluate the extent of the drawdown cone from both well fields. These data are not critical unless groundwater modeling indicates particular sensitivity to goundwater withdrawal on the west side of the Great Miami River.

3) Develop a rating curve and cross section for the Mound Plant gauge at the Miami River. Determine if losses in flow between the USGS gauge and the Mound gauge can be determined with any confidence. These data are likely to be unobtainable, as the slight differences in river stage along the reach adjacent to Mound Plant are likely to be less than the measurement errors.

SECTION 7

7. REVISION OF CONCEPTUAL MODEL OF THE BURIED VALLEY AQUIFER

The unconsolidated Quaternary age deposits are the major source of groundwater resources in the vicinity of Mound Plant and the Miami Valley. In 1988, the Buried Valley Aquifer was designated as a sole source aquifer in recognition of its importance as a resource and its susceptibility to contamination. The Buried Valley Aquifer consists of the saturated glacial outwash deposits in the Great Miami River valley. The Buried Valley Aquifer occupies a deep bedrock channel that roughly follows the course of the modern Great Miami River. The buried valley is filled with unconsolidated glacial deposits of two types: ice-laid, nonstratified drift, known as tills; and water-laid, stratified drift, known as outwash. In historic use, the term "buried valley aquifer" is usually reserved for the outwash in the modern topographic valley. Published maps of the extent of the Buried Valley Aquifer do not include the groundwater within the tributary valley along the Mound Plant drainage ditch (Spieker 1968). The OU 9 Site-Wide Work Plan (DOE 1992a) recognized that the water-bearing unconsolidated deposits within this tributary are contiguous with similar deposits within the main valley and considered the tributary as part of the Buried Valley Aquifer. The tributary valley is not considered a part of the Buried Valley Aquifer in this report.

A conceptual model of the Buried Valley Aquifer, based on a series of monitoring wells installed mainly in the west-central part of the Mound Plant and along a line extending to the Great Miami River, was presented by Dames and Moore (1976) and repeated in the OU 9 Site-Wide Work Plan (DOE 1992a). This model was one in which the Buried Valley Aquifer consisted of two layers of relatively thick outwash deposits separated by a glacial till to form upper and lower aquifers. The upper unit reportedly had a maximum thickness of 95 feet and was composed of poorly sorted coarse sand and gravel, under water table conditions. The lower unit reportedly had a maximum thickness of 44 feet, with similar composition, but under semiconfined conditions (DOE 1992a). The upper outwash unit extended onto the Mound Plant along the tributary valley; the lower unit was only known to occur in the far southwestern corner of the plant property. This paper presents a large body of evidence that serves to refine the conceptual model of the Buried Valley Aquifer. The revision significantly changes the conceptual model to one in which the Buried Valley Aquifer is viewed as a single unit. Glacial tills are present throughout the buried valley, but they do not serve as aquitards to groundwater flow.

Regionally, the modern Great Miami River follows the Buried Valley Aquifer, but is locally separated by bedrock highs, as described by Watkins and Spieker (1971). In the Miamisburg region, the Buried Valley Aquifer narrows from the north, passing through one of its narrowest reaches immediately west of the Mound Plant (Figure 7.1). Whereas the Great Miami River is nearly banked against the bedrock on its western side, the buried valley makes a broad easterly meander through the south part of Mound

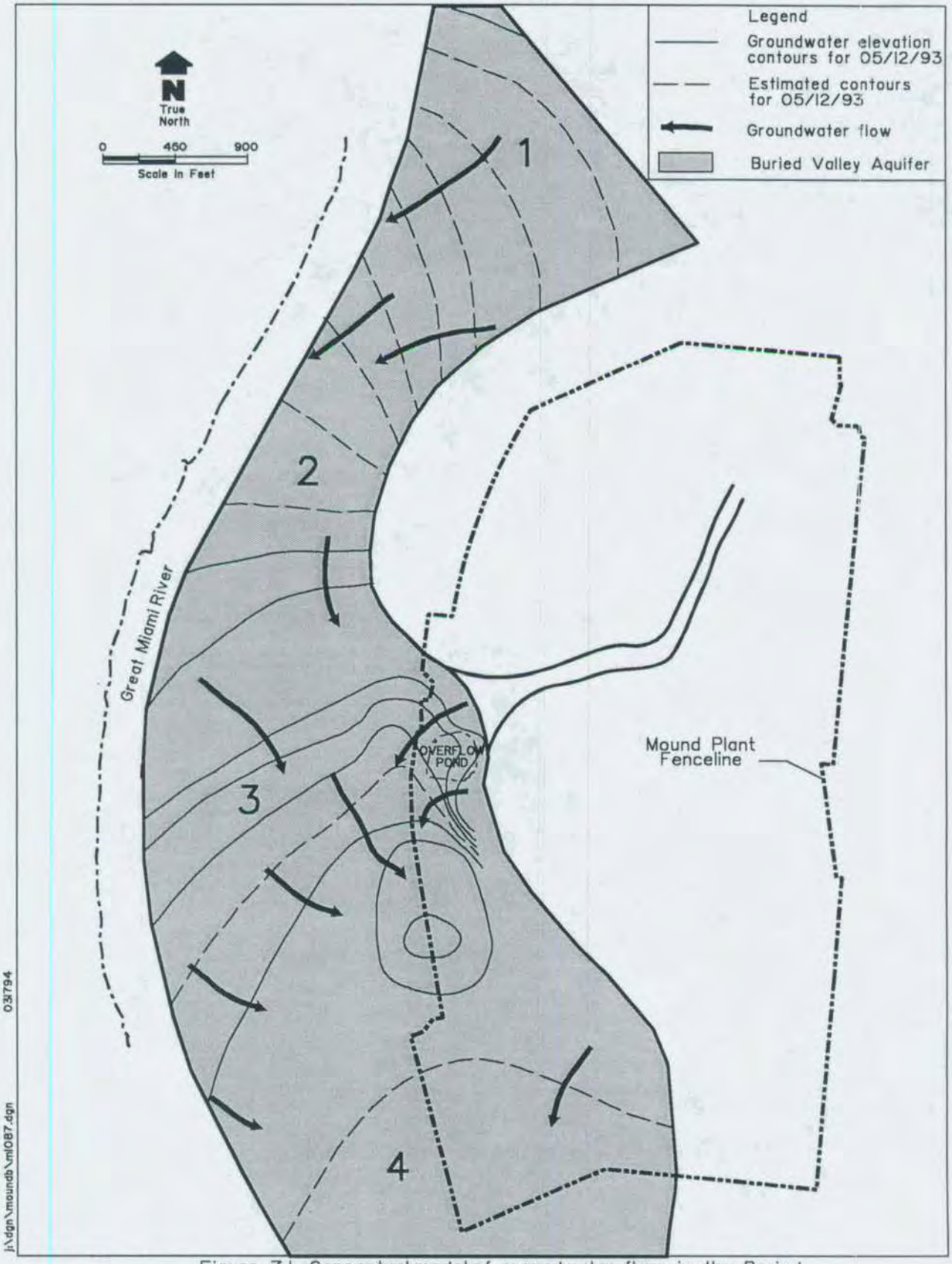

Figure 7.1. Conceptual model of groundwater flow in the Buried Valley Aquifer on and adjacent to Mound Plant.

Plant as it widens southward. This broad meander onto the south part of Mound Plant is much more extensive than previously envisioned. The map of Spieker (1968) depicts the Buried Valley Aquifer immediately beneath the Great Miami River throughout the reach adjacent to Mound Plant. In the revised conceptual model, the deep axis of the Buried Valley Aquifer meanders eastward of the Great Miami River both north and south of Mound Plant (Figure 7.2). The geometry of the Buried Valley Aquifer is revised to indicate that it maintains its width through the reach adjacent to Mound rather than narrowing as much as shown by Spieker (1968).

The OU 9 Site-Wide Work Plan described a narrow zone, oriented north to south along the western boundary of the Mound Plant in which the buried bedrock surface dropped steeply into the main buried valley. This transition zone was considered to be the glacially scoured eastern margin of the Buried Valley Aquifer. This transition, as conceptualized, does not exist. The recent field investigations of both OU 1 (DOE 1994d) and OU 9 (this report) indicate that the eastern margin of the Buried Valley Aquifer is relatively shallow with a much gentler bedrock slope than previously envisioned. The bedrock high that forms the SM/PP Hill slopes westward across the central part of Mound Plant, across Area B. The western footslope of the SM/PP Hill is then buried beneath glacial outwash and till deposits near the western boundary of the plant. The northern margin of the SM/PP Hill appears to be bounded by the plant tributary valley. The southern boundary apparently slopes relatively gently into the main Buried Valley Aquifer.

There appear to be three distinct areas of groundwater in the Buried Valley Aquifer adjacent to Mound Plant. North of Mound Plant in Miamisburg, the valley is relatively wide, with hydraulic gradients indicating flow is southward (Figure 7.1). The flow in this area is probably controlled by the river stage and the pumping of the municipal production wells. In Blocks 1 and 2, groundwater flow in the Buried Valley Aquifer appears to be controlled by the narrowing of the river valley and the shallower depth to bedrock. The smaller cross sectional area results in a steepening of the hydraulic gradients in this area. In the south-central area of the Buried Valley Aquifer to the west of Mound Plant, pumping for the Mound Plant water supply has disrupted the southwest flow direction observed in adjacent areas. The man-made influences that have impacted groundwater flow in the vicinity of Mound Plant include the pumping activity at Mound Plant production wells, which creates a potentiometric low along the eastern edge of the Buried Valley Aquifer. In the far southern part of the Buried Valley Aquifer, flow is from the Great Miami River and bedrock toward the south.

In addition to the groundwater flow in the main portion of the Buried Valley Aquifer, there is flow within the glacio-fluvial sediments of the Mound Plant tributary valley. Groundwater flow within the sediments of the tributary valley is to the west and southwest, also aligned with the tributary valley topography. The lack of response in the tributary valley to seasonal groundwater level changes in the

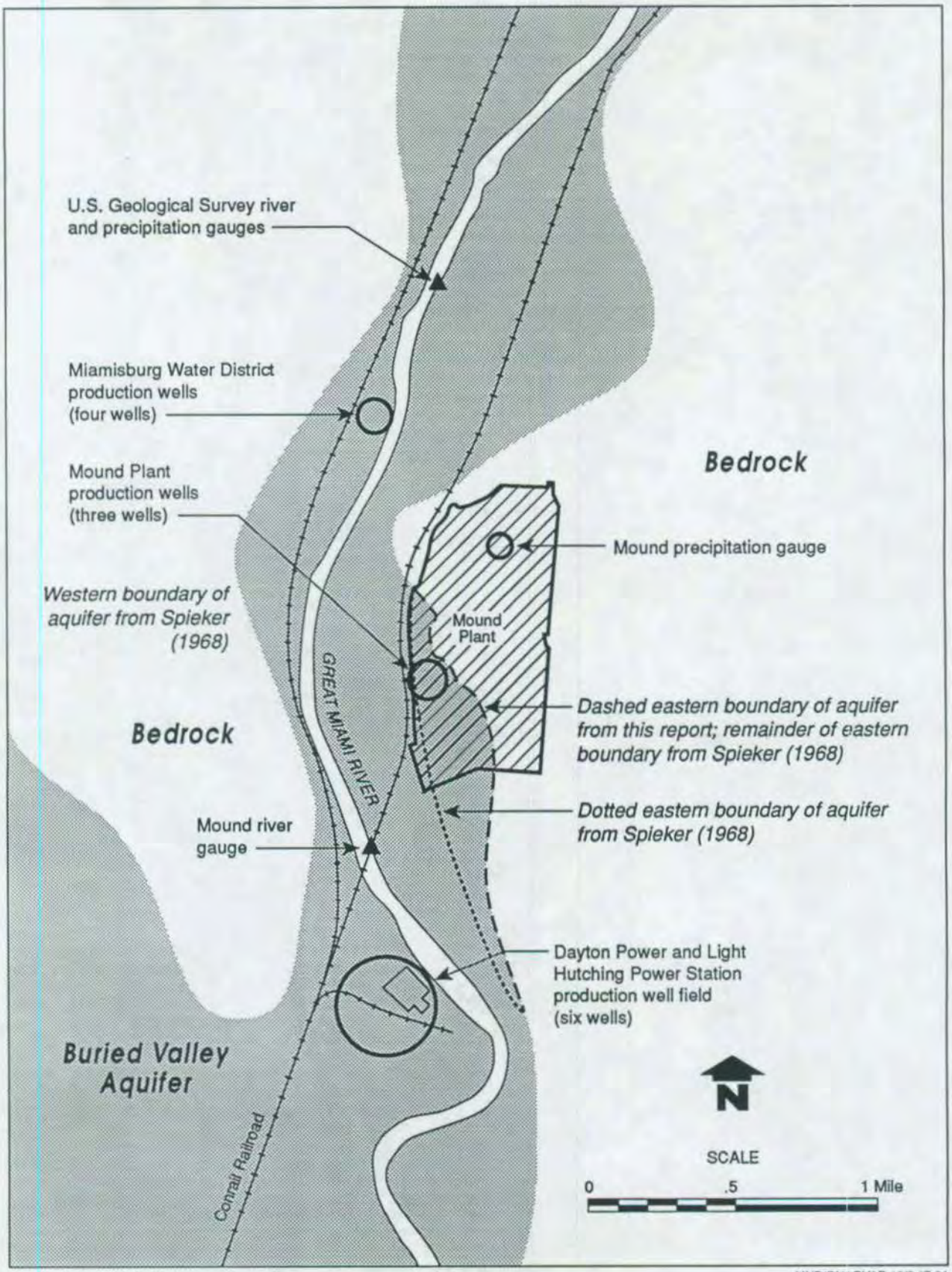

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Figure 7.2. Revised geometry of Buried Valley Aquifer in vicinity of Mound Plant.

Buried Valley Aquifer indicates that the tributary valley is not part of the main aquifer system but that it does contribute flow to the Buried Valley Aquifer. Water levels in the tributary valley are interpreted to be controlled by precipitation and by the slope of the underlying bedrock. Variability in hydraulic gradients is a result of changes in the slope of the underlying bedrock surface. A precipitously narrow subsurface gorge appears to exist beneath the modern Mound Plant tributary valley, but is not considered to be a groundwater pathway as the gorge is locally known to be filled with dense glacial till and the outwash deposits beneath it are not saturated.

Measurements of very small vertical hydraulic gradients indicate a high degree of interconnection within the saturated, unconsolidated materials. Except in the northernmost part of the map area (Figure 6.1) there is no hydrogeologic evidence for a continuous till layer separating the upper portion of the Buried Valley Aquifer from the deeper portion of the aquifer in the Mound Plant area. The glacial tills are more continuous in the area north of Mound Plant as shown by differences in water levels. It appears that water levels in shallow wells are locally perched on the till unit north of Mound Plant and are not part of the regional groundwater system. Groundwater levels in well clusters close to the valley margin indicate that groundwater from the bedrock may be also recharging the outwash layers, but groundwater movement in the bedrock has such a smaller volume and moves at a much slower average velocity than it would in outwash because of the significantly lower permeability of the bedrock (DOE 1994b). For well clusters near the middle of the valley, the vertical gradients between the Buried Valley Aquifer and the bedrock is downward into the bedrock. There is no evidence that there is a continuous flow path from the bedrock in the SM/PP Hill to the bedrock in the main valley and from there upward into the Buried Valley Aquifer.

The groundwater flow map indicates that groundwater levels are greatest near the Great Miami River and decrease toward the Mound Plant production wells. This conceptual model suggests that the river, by elevating groundwater levels in its vicinity, is also a barrier to westward groundwater flow from the Plant site. The magnitude of this groundwater mound changes as a function of river stage, and decreases with distance from the river. The fluctuation in river stage directly impacts the groundwater levels in monitoring wells throughout the Mound Plant by changing the elevation of the groundwater discharge point at the river.

The preliminary water budget compiled in this report for the Buried Valley Aquifer yields the relative magnitude of outflows and sources of recharge. Within the vicinity of the Mound Plant production wells, infiltration from the Miami-Erie Canal appears to be the greatest single source of recharge. Estimates of infiltration are based on measured canal infiltration, but without regard for evapotranspiration. Considering the currently available data, relative importance of other sources are ranked accordingly: southerly gradient of the Buried Valley Aquifer provides the second greatest

contribution followed by subflow from the plant tributary valley, leakage from the fractured bedrock, and infiltration of precipitation. Inflow from the Great Miami River appears to provide a relatively minor component of the preliminary budget.

SECTION 8

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ER PROGRAM

MOUND PLANT

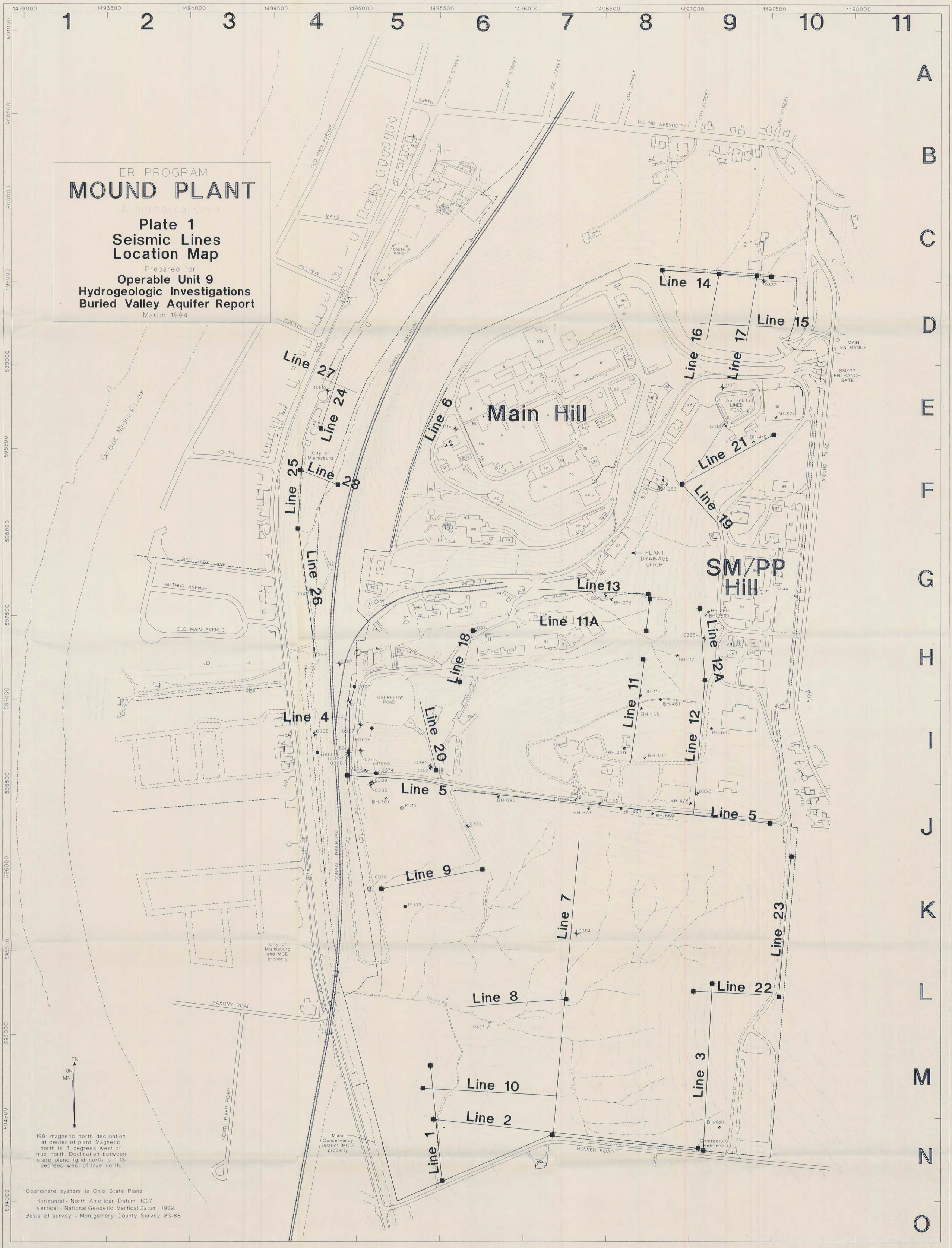
Miamisburg, Ohio

Plate 1
Seismic Lines Location Map

Prepared for

Operable Unit 9
Hydrogeologic Investigations
Buried Valley Aquifer Report

March 1994



53 Structures
Paved roadway
Unpaved roadway
Railroad
Water course
Fence
Retaining wall
Mound Plant boundary
Property boundary
Contour line
Seismic line completed
Seismic line not interpreted
Seismic line deleted

ER Program monitoring wells
Other monitoring wells and piezometers
Plant production wells
Piezometers
Borehole
Seismic line end point surveyed May 1993

NOTES:

1. The electronic base map data file was obtained by WESTON from Woolpert Consultants, Inc., Dayton, Ohio. The data were photogrammetrically compiled from aerial photography dated 12/08/85.

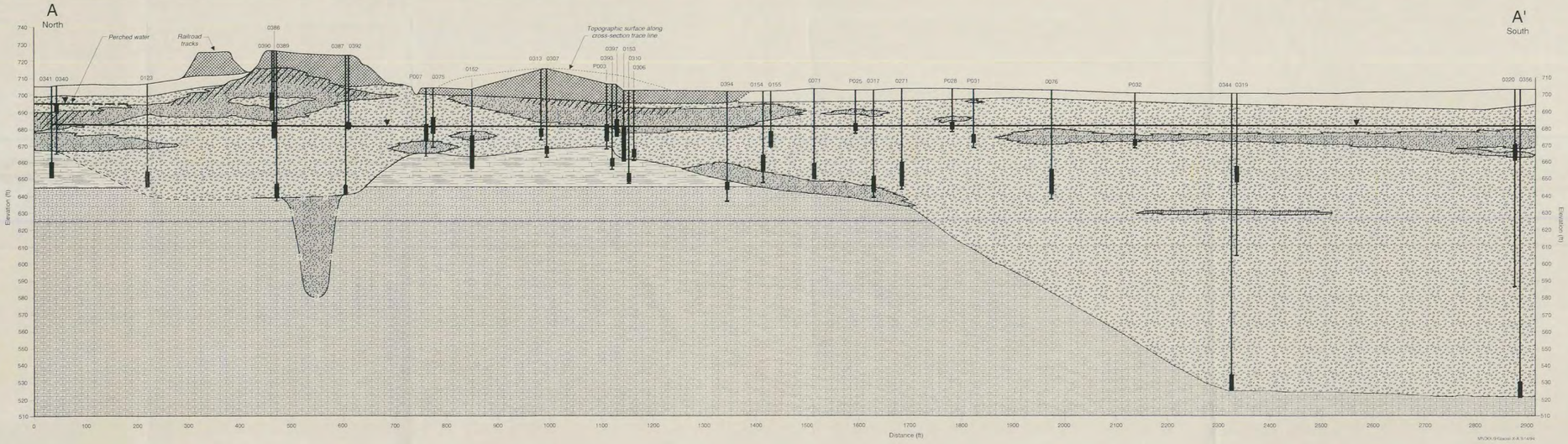
2. WESTON converted MOUND plant coordinates to Ohio State Plane Coordinates using an algorithm provided by Oak Ridge National Laboratory, Grand Junction Project Office.

3. Area west of Dayton-Cincinnati Pike was digitized from a hand drafted map, dated 3/12/86 from Monsanto Research Corp.

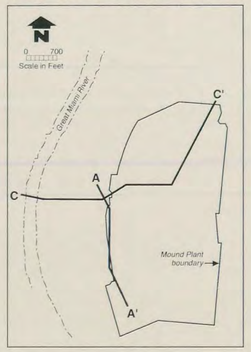
4. Only boreholes and monitoring wells that were used for control of line end points are shown. Only the repeated line 10 is shown for clarity. End point markers are shown were surveyed; some marking stakes were destroyed before they could be surveyed. In the latter case, the end points were recovered from detailed field mapping conducted at the time of the refraction surveys.

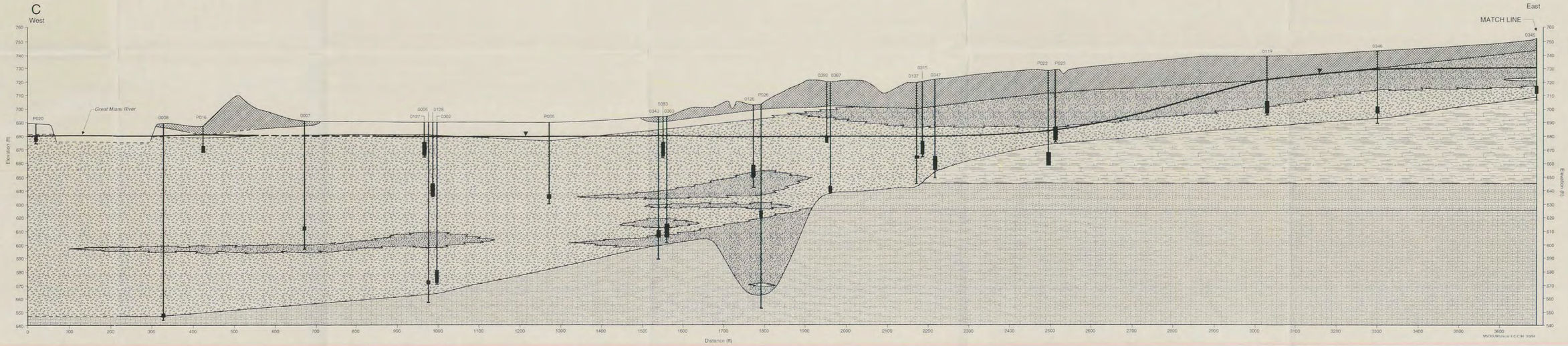
Contour interval 10 ft.

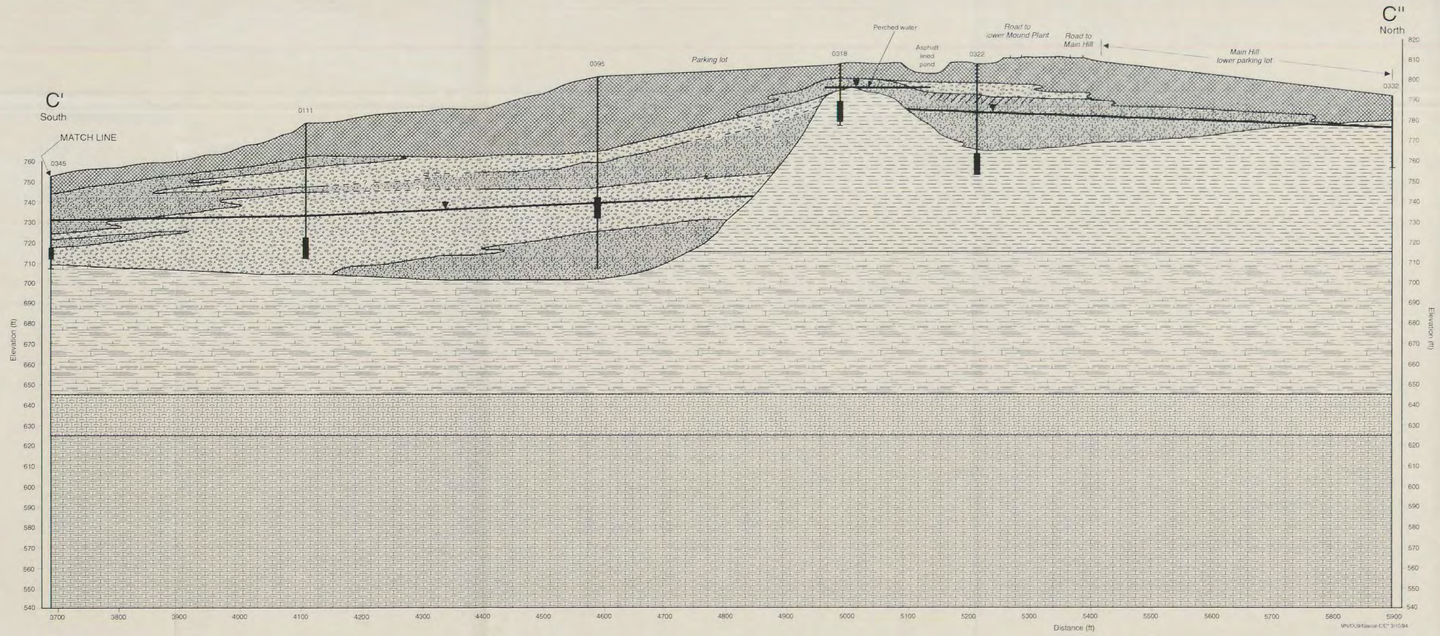
0 100 200 400 600 800 1000
Scale in Feet



Location of cross sections







LEGEND

Unconsolidated Deposits

Recent

- Artificial fill: consists of variable proportions of gravel, sand and clay
- Alluvium
- Regolith: undifferentiated surface deposits of weathered bedrock, and colluvial and alluvial materials
- Lake deposit: silt- and clay-sized particles

Quaternary

- Glacial till, yellow brown: oxidized zone, perhaps buried soil
- Glacial till: clay containing variable proportionsof gravel, sand and silt
- Glacial outwash: sand and gravel containing some silt and trace amounts of clay

Bedrock Stratigraphy

System	Series	Group	Formation
UPPER ORDOVICIAN	Cincinnatian	Richmondian	Whitewater Formation
			Liberty Formation
			Waynesville Formation
		Maysvillian	Oregonia Formation
			Mount Auburn Formation
			Corryville Formation

0153 Well borehole number

P004 Piezometer borehole number

Inferred contact

Well borehole showing screened interval

Exploratory borehole

Static water

Inferred water level

Vertical Scale in Feet: 0 – 30

Horizontal Scale in Feet: 0 – 100

ER PROGRAM

MOUND PLANT

Miamisburg, Ohio

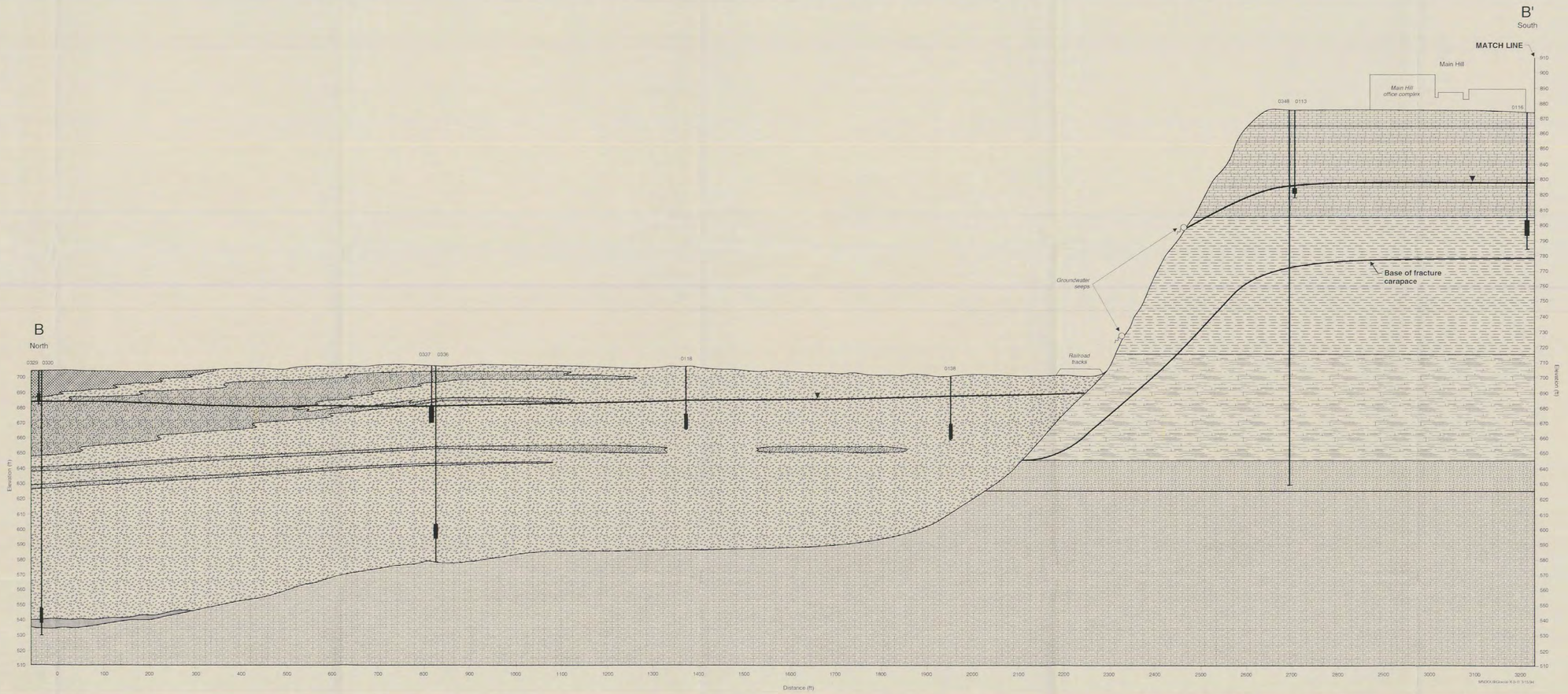
Plate 2

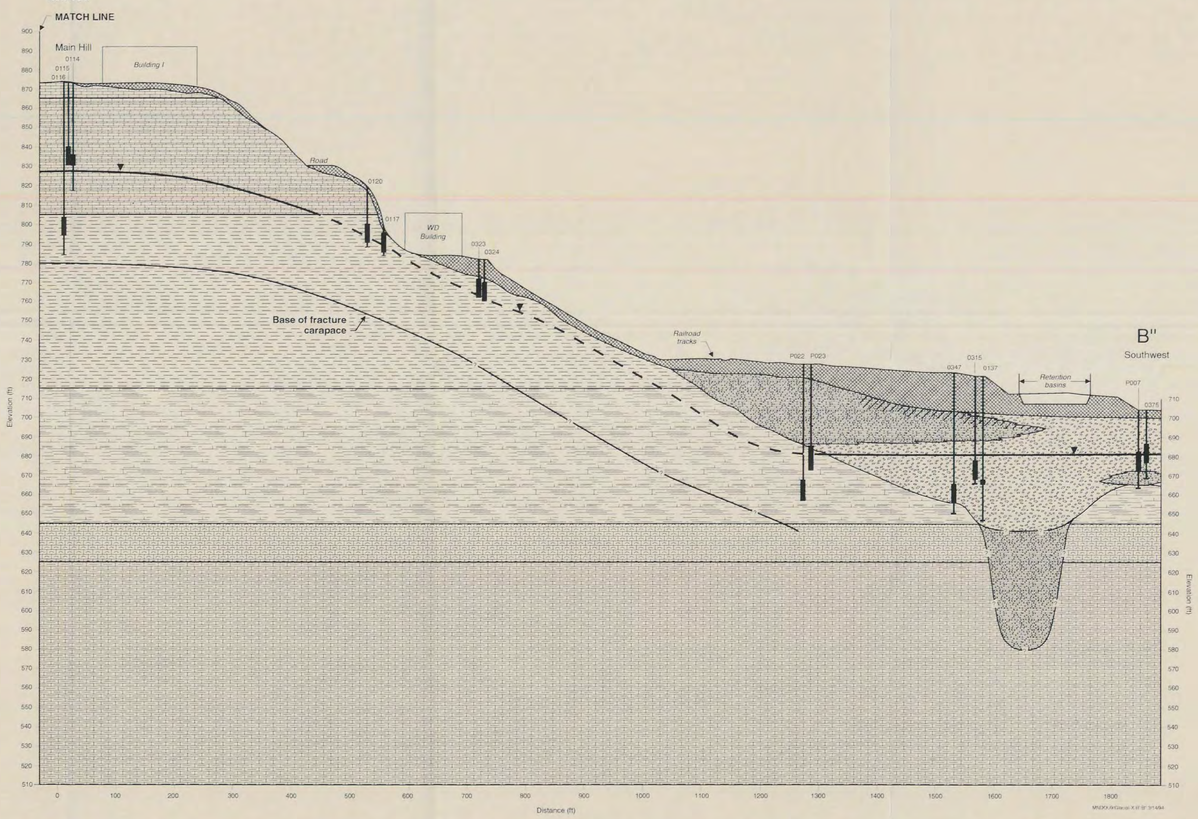
Geologic Cross Sections A-A', C-C', C'-C''

Prepared for

Operable Unit 9
Hydrogeologic Investigations
Buried Valley Aquifer Report

March 1994





LEGEND

Unconsolidated Deposits

Recent

- Artificial fill: consists of variable proportions of gravel, sand and clay
- Alluvium
- Regolith: undifferentiated surface deposits of weathered bedrock, and colluvial and alluvial materials
- Lake deposit: silt- and clay-sized particles

Quaternary

- Glacial till: yellow brown; oxidized zone, perhaps buried soil
- Glacial till: clay containing variable proportions of gravel, sand and silt
- Glacial outwash: sand and gravel containing some silt and trace amounts of clay

Bedrock Stratigraphy

System	Series	Stage		
UPPER ORDOVICIAN	Cincinnatian	Richmondian	Whitewater Formation	
			Liberty Formation	
			Waynesville Formation	
		Maysvillian	Oregonia Formation	
			Mount Auburn Formation	
			Corryville Formation	

0153 Well borehole number

P004 Piezometer borehole number

Inferred contact

Well borehole showing screened interval

Exploratory borehole

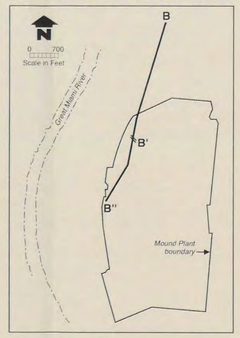
Static water

Inferred water level

Vertical Scale in Feet: 0 – 30

Horizontal Scale in Feet: 0 – 100

Location of cross section



ER PROGRAM

MOUND PLANT

Miamisburg, Ohio

Plate 3

Geologic Cross Sections B-B', B'-B''

Prepared for

Operable Unit 9
Hydrogeologic Investigations
Buried Valley Aquifer Report

March 1994

LEGEND

Unconsolidated Deposits

- Recent
  - Artificial fill: consists of variable proportions of gravel, sand and clay
  - Alluvium
  - Regolith: undifferentiated surface deposits of weathered bedrock, and colluvial and alluvial materials
  - Lake deposit: silt- and clay-sized particles
- Quaternary
  - Glacial till, yellow brown: oxidized zone; perhaps buried soil
  - Glacial till: clay containing variable proportionsof gravel, sand and silt
  - Glacial outwash: sand and gravel containing some silt and trace amounts of clay

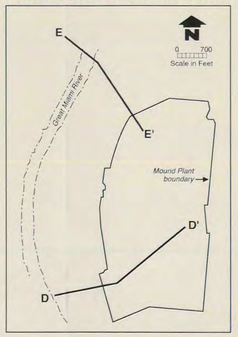
Bedrock Stratigraphy

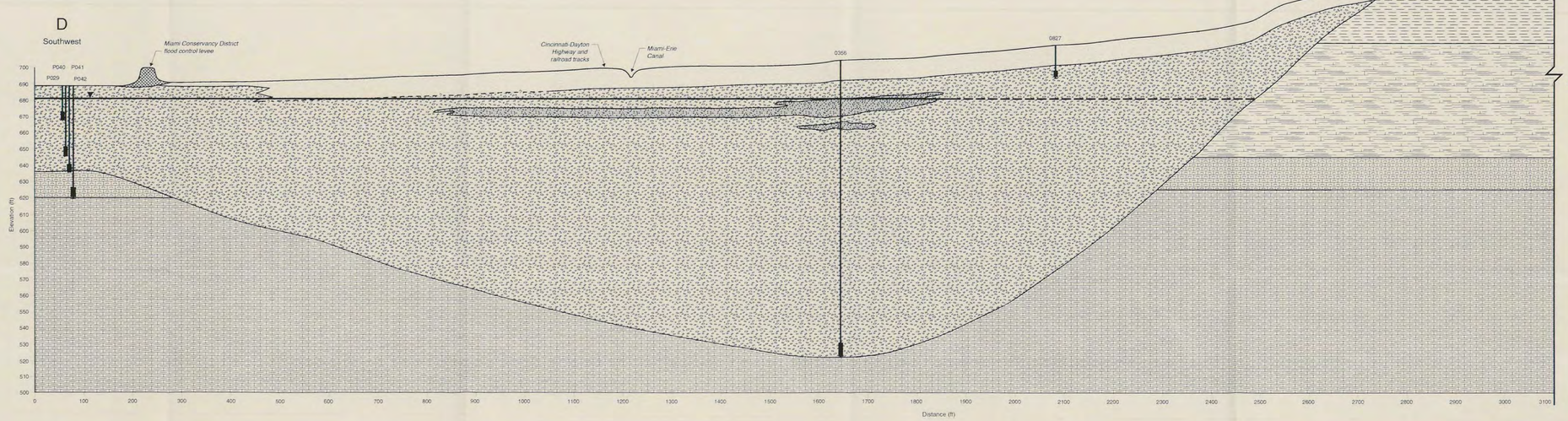
System	Series	Stage	Formation
UPPER ORDOVICIAN	Cincinnatian	Richmondian	Whitewater Formation
			Liberty Formation
			Waynesville Formation
		Maysvillian	Oregonia Formation
			Mount Auburn Formation
			Corryville Formation

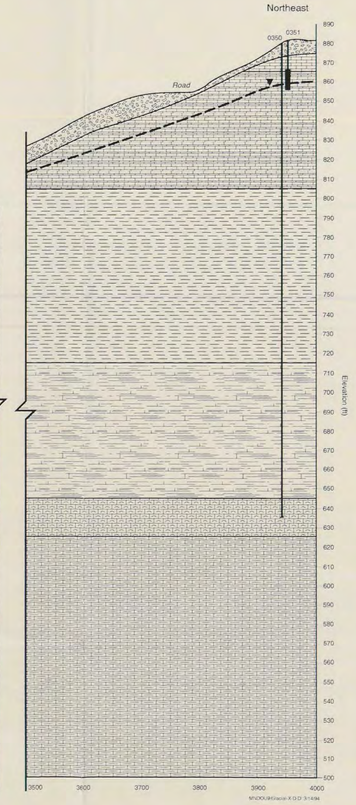
- 0153 Well borehole number
- P004 Piezometer borehole number
- Inferred contact
- Well borehole showing screened interval
- Exploratory borehole
- Static water
- Inferred water level

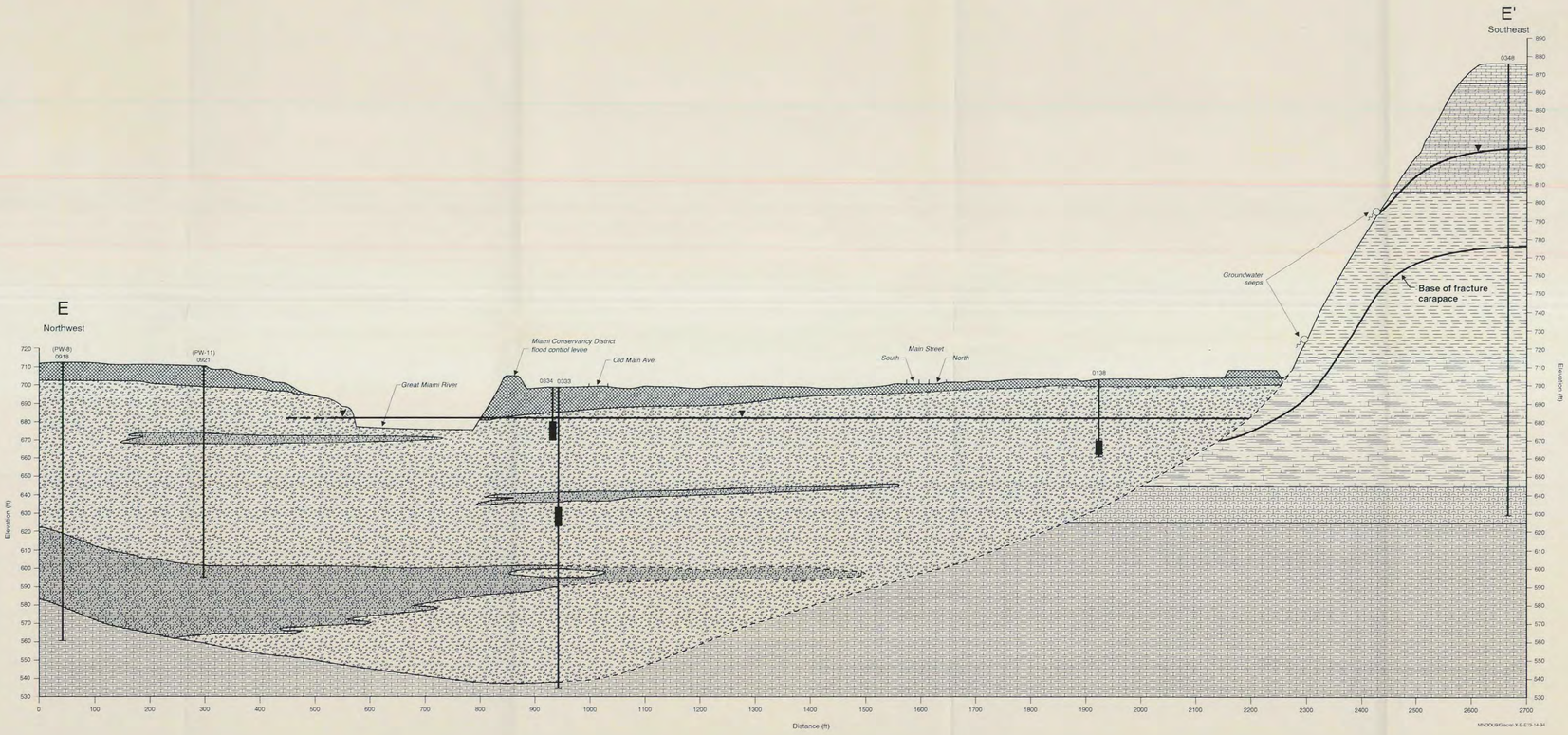
Vertical Scale in Feet: 30 – 0
Horizontal Scale in Feet: 0 – 100

Location of cross sections









ER PROGRAM

MOUND PLANT

Miamisburg, Ohio

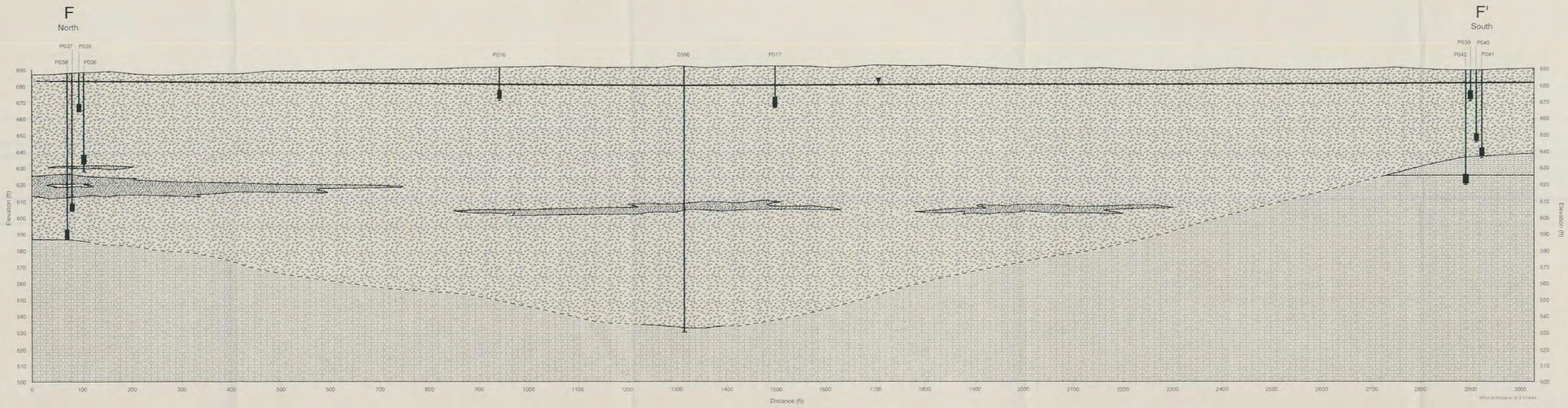
Plate 4

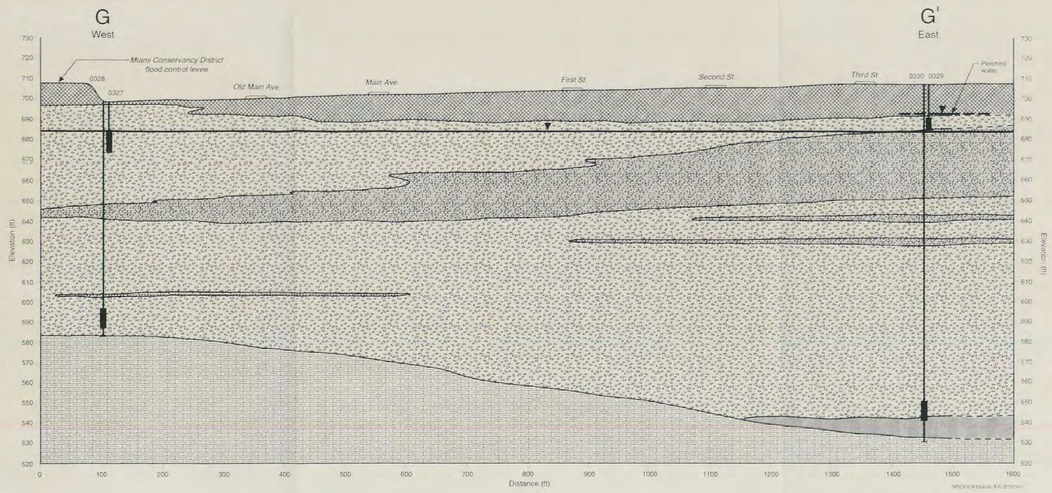
Geologic Cross Sections D-D', E-E'

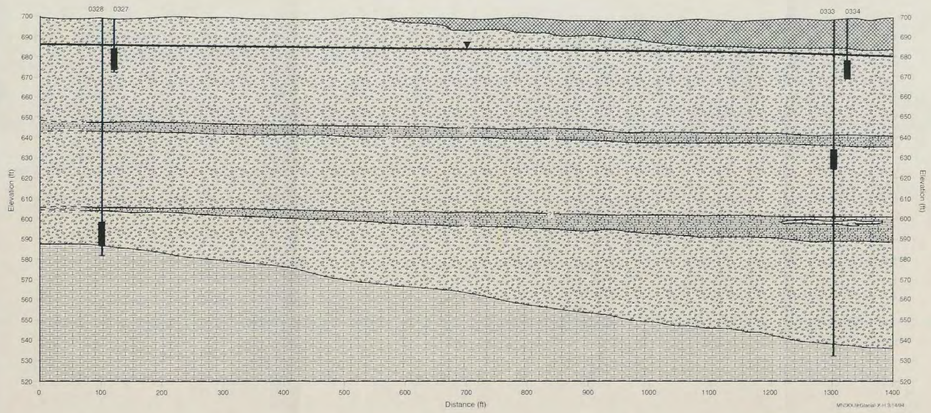
Prepared for

Operable Unit 9
Hydrogeologic Investigations
Buried Valley Aquifer Report

March 1994







LEGEND

Unconsolidated Deposits

Recent

- Artificial fill: consists of variable proportions of gravel, sand and clay
- Alluvium
- Regolith: undifferentiated surface deposits of weathered bedrock, and colluvial and alluvial materials

Quaternary

- Lake deposit: silt- and clay-sized particles
- Glacial till, yellow brown: oxidized zone, perhaps buried soil
- Glacial till: clay containing variable proportions of gravel, sand and silt
- Glacial outwash: sand and gravel containing some silt and trace amounts of clay

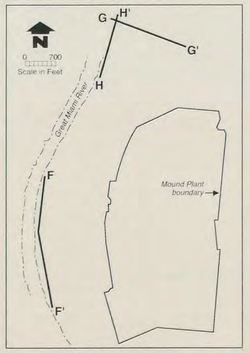
Bedrock Stratigraphy

System	Series	Stage	Formation
UPPER ORDOVICIAN	Cincinnatian	Richmondian	Whitewater Formation
			Liberty Formation
			Waynesville Formation
		Maysvillian	Oregonia Formation
			Mount Auburn Formation
			Corryville Formation

0153 Well borehole number
P004 Piezometer borehole number
Inferred contact
Well borehole showing screened interval
Exploratory borehole
Static water
Inferred water level

Vertical Scale in Feet: 0, 30
Horizontal Scale in Feet: 0, 100

Location of cross sections



ER PROGRAM

MOUND PLANT

Miamisburg, Ohio

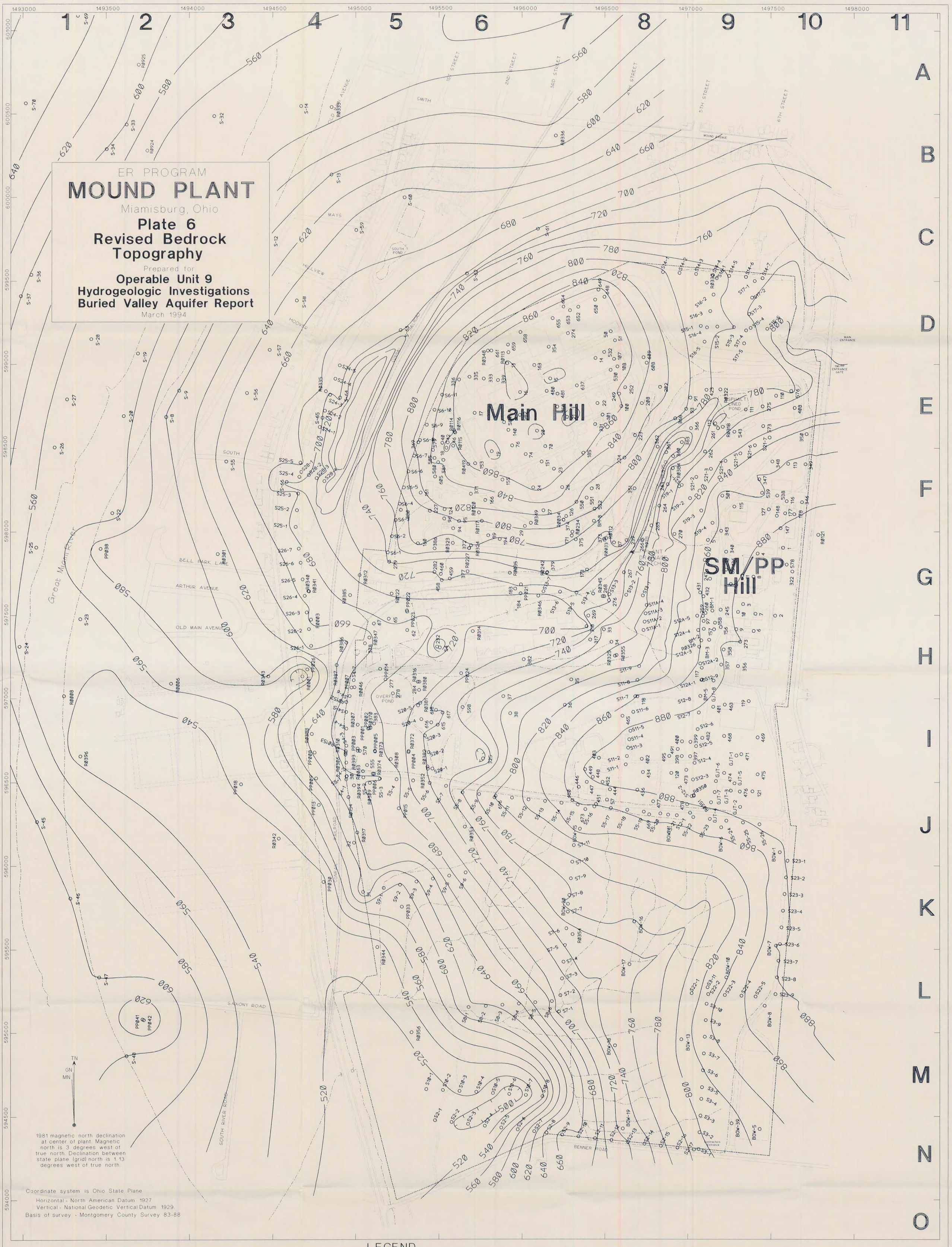
Plate 5

Geologic Cross Sections F-F', G-G', H-H'

Prepared for

Operable Unit 9
Hydrogeologic Investigations
Buried Valley Aquifer Report

March 1994



LEGEND

- Structures
- Paved roadway
- Unpaved roadway
- Railroad
- Water course
- Fence
- Retaining wall
- Mound Plant boundary
- 660 — Bedrock elevation contour (feet above MSL)

- Well, Boring, or seismic point
- S-10 — Seismic data provided by USGS survey of the Lower Great Miami River Valley, 1971. MSL calculated using USGS quadrangles: Miamisburg, 1987 and Franklin, 1981.
- R0111 — Well depth does not reach bedrock used for verification only

Contour interval = 20 feet

1. The electronic base map data file was obtained by WESTON from Woolpert Consultants, Inc., Dayton, Ohio. The data were photogrammetrically compiled from aerial photography dated 12/08/85.

2. WESTON converted MOUND plant coordinates to Ohio State Plane Coordinates using an algorithm provided by Oak Ridge National Laboratory, Grand Junction Project Office.

3. Area west of Dayton-Cincinnati Pike was digitized from a hand drafted map, dated 3/12/86 from Monsanto Research Corp.

4. Contours for bedrock topography were compiled by Terran Corporation, Fairborn, Ohio by subtracting depth to bedrock from surface contour elevations. Depth to bedrock determined from Mound Plant soil borings, seismic refraction studies and borings for ER Program monitoring wells and piezometers. (Revised 2/9/94)

0 100 200 400 600 800 1000
Scale in Feet

WESTON
MANAGERS DESIGNERS/CONSULTANTS

J:\DGN\MOUNDB\MIO76.dgn 031594

ER PROGRAM

MOUND PLANT

Miamisburg, Ohio

Plate 7
Revised Isopach map of unconsolidated deposits

Prepared for

Operable Unit 9
Hydrogeologic Investigations
Buried Valley Aquifer Report

March 1994

Main Hill

SM/PP Hill

Great Miami River

1981 magnetic north declination at center of plant. Magnetic north is 3 degrees west of true north. Declination between state plane (grid) north is 1.13 degrees west of true north.

Coordinate system is Ohio State Plane
Horizontal - North American Datum 1927
Vertical - National Geodetic Vertical Datum 1929.
Basis of survey - Montgomery County Survey 83-88

LEGEND

- Structures
- Paved roadway
- Unpaved roadway
- Railroad
- Water course
- Fence
- Retaining wall
- Mound Plant boundary
- Isopach contour (feet)

- Well, Boring, or seismic point
- Seismic data provided by USGS survey of the Lower Great Miami River Valley, 1971. MSL calculated using USGS quadrangles: Miamisburg, 1987 and Franklin, 1981.
- Well depth does not reach bedrock used for verification only

Contour interval = 20 feet

1. The electronic base map data file was obtained by WESTON from Woolpert Consultants, Inc., Dayton, Ohio. The data were photogrammetrically compiled from aerial photography dated 12/08/85.

2. WESTON converted MOUND plant coordinates to Ohio State Plane Coordinates using an algorithm provided by Oak Ridge National Laboratory, Grand Junction Project Office.

3. Area west of Dayton-Cincinnati Pike was digitized from a hand drafted map, dated 3/12/86 from Monsanto Research Corp.

4. Contours for thickness of unconsolidated deposits were compiled by Terran Corporation, Fairborn, Ohio from depth to bedrock, as determined from Mound Plant soil borings, seismic refraction studies and borings for ER Program monitoring wells and piezometers. (revised 2/9/94)

0 100 200 400 600 800 1000
Scale in Feet

WESTON
MANAGERS DESIGNERS/CONSULTANTS

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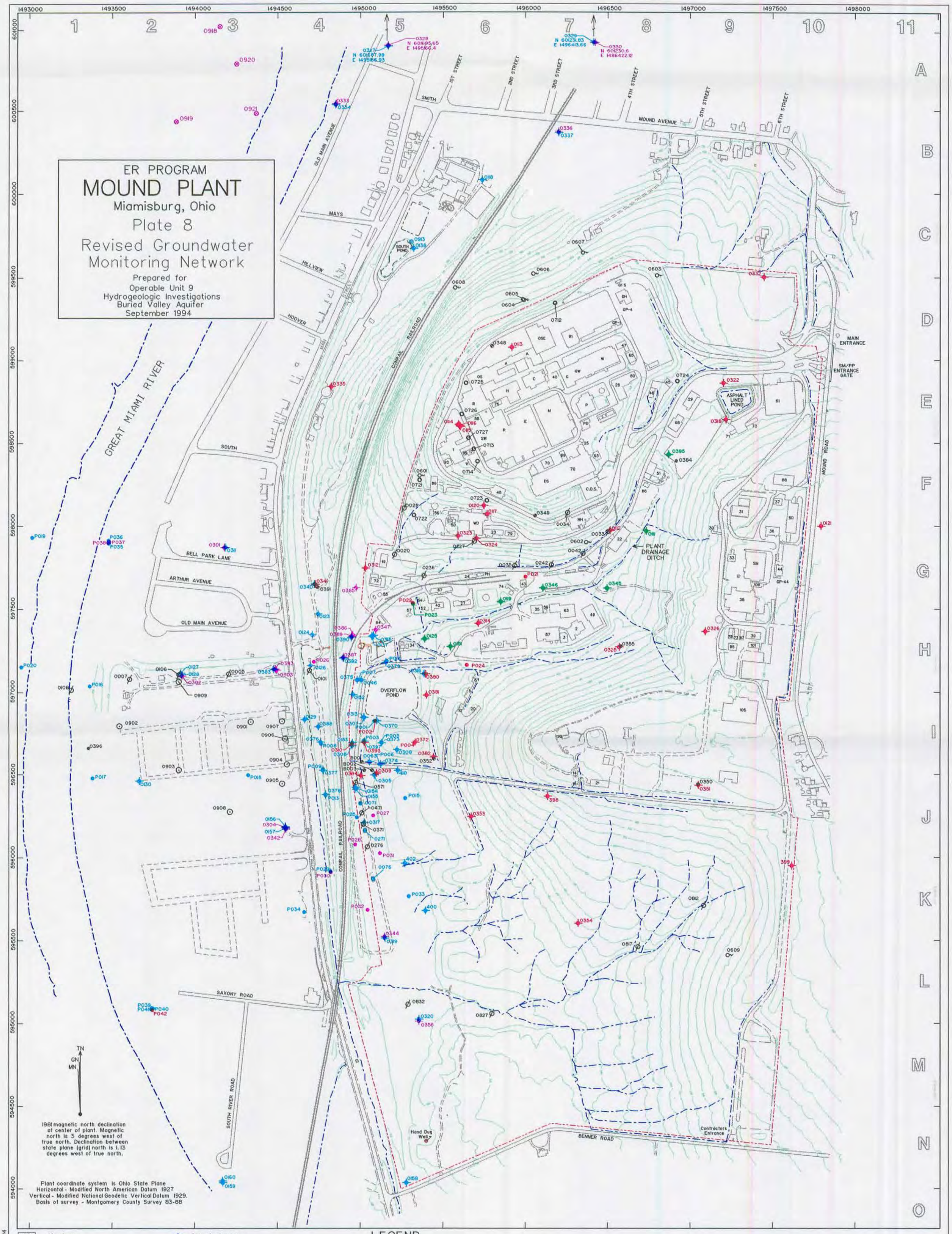


LEGEND

- Structures
- Paved roadway
- Unpaved roadway
- Railroad
- Water course
- Fence
- Retaining wall
- Mound Plant boundary
- Contour line
- Other monitoring wells and piezometers
- Domestic and other supply wells
- Municipal and Plant production wells in Upper Buried Valley aquifer
- Municipal production wells in Lower Buried Valley aquifer
- Groundwater seep
- Tritium groundwater assessment monitoring station
- Borehole in bedrock
- Soil boring
- Piezometer completed in unconsolidated sediments
- Monitoring well completed in unconsolidated sediments
- Monitoring well completed in Upper Buried Valley aquifer
- Monitoring well completed in Lower Buried Valley aquifer
- Monitoring well completed in Bedrock
- Piezometer completed in Upper Buried Valley aquifer
- Piezometer completed in Lower Buried Valley aquifer
- Piezometer completed in Bedrock

1. The electronic base map data file was obtained by WESTON from Woolpert Consultants, Inc., Dayton, Ohio. The data were photogrammetrically compiled from aerial photography dated 12/08/85.

2. WESTON converted MOUND plant coordinates to Ohio State Plane Coordinates using an algorithm provided by Oak Ridge National Laboratory, Grand Junction Project Office.

3. Area west of Dayton-Cincinnati Pike was digitized from a hand drafted map, dated 3/12/86 from Monsanto Research Corp.

4. New monitoring wells and piezometers and the older existing ER Program monitoring wells were resurveyed in reference to control monuments established by the National Geodetic Survey. Horizontal coordinates were established in the North American Datum of 1983 (NAD 83) and transformed into NAD 27 using a program called NADCON. Because discrepancies were noted between the reported and measured Mound Plant monuments, a second transformation of the data to conform to the plant coordinates was necessary. The transformed plant coordinates are referred to as Modified NAD27 and Modified NGVD29. Modified horizontal coordinates are approximately 400 feet south and west of NAD27. Modified vertical coordinates are 1.15 feet higher than NGVD29.

5. Older unused monitoring wells and piezometers, domestic wells, municipal and plant production wells were not resurveyed. The location coordinates of these wells and piezometers remain unchanged from previously published ER Program maps.

Contour interval 10 ft.

0 100 200 400 600 800 1000
Scale in Feet

WESTON
MANAGERS DESIGNERS/CONSULTANTS

J:\DGN\MOUNDB\M1123.DGN 092794

9501090001

APPENDIX A

MONITORING WELL AND PIEZOMETER INFORMATION

APPENDIX A

APPENDIX A

MONITORING WELL AND PIEZOMETER INFORMATION

A.1. MONITORING WELL AND PIEZOMETER SPECIFICATIONS

A.2. MONITORING WELL AND PIEZOMETER DEVELOPMENT

A.3. NATURAL GAMMA LOGS

A.3.1. REGULAR PLOTS

A.3.2. QUALITY ASSURANCE PLOTS

A.3.3. NATURAL GAMMA FROM ABANDONED WELLS

A.4. ANALYTICAL RESULTS OF RINSATE SAMPLES FROM NATURAL GAMMA EQUIPMENT

A.1. MONITORING WELL AND PIEZOMETER SPECIFICATIONS

Table A.1. Monitoring Well, Piezometer, and Exploratory Boring Specifications

Location	Formation of Completion	Well Diameter (inch)	Ground Elevation (MSL)	Borehole Total Depth (ft bgs)	Well Total Depth (ft bgs)	Competent Bedrock		Screened Interval (ft bgs)	Bentonite Cement Grout (ft bgs)	Bentonite Seal (ft bgs)	Filter Pack Interval (ft bgs)	First Water (ft bgs)	Comments
P016	Upper BVA	2	689.09	20.00	20.00	>	20.0	14.5-19.5	0-10	10-12	12-20	10.0	completed as proposed
P017	Upper BVA	2	690.49	25.00	25.00	>	25.0	20-25	0-15	15-17	17-25	24.5	completed as proposed
P018	Upper BVA	2	692.58	160.00	24.00		155.0	14-19	0-9.5	9.5-11.5	11.5-24	13.0	completed as proposed
P019	Upper BVA	2	699.58	11.00	11.00	>	11.0	6-11	0-2	2-4.5	4.5-11	6.5	completed as proposed
P020	Upper BVA	2	691.26	15.00	13.00	>	15.0	10-15	0-4	4-6	6-13	10.0	completed as proposed
P021	Bedrock	2	745.43	33.00	31.00		23.0	26-31	0-22	22-24	24-31	-	completed as proposed
P022	Bedrock	2	730.66	70.00	70.00		43.6	60-70	0-53.5	53.5-57.5	57.5-70	-	completed in bedrock; not at water table as proposed
P023	US	2	730.39	47.00	47.00	see	P022	42-47	0-38	38-40	40-47	-	completed in outwash between upper till unit and bedrock
P024	Bedrock	2	741.60	43.00	40.00		42.0	35-40	0-31	31-33	33-40	35.0	no BVA; only till over bedrock; completed in bedrock
P025	Upper BVA	2	703.77	25.00	24.50	>	25.0	19-24	0-15	15-17	17-24.5	20.0	completed as proposed
P026	Lower BVA	2	705.87	150.00	85.00		140.9	78-83	0-72	72-75	75-85	23.0	location changed to near well 0126; completed in BVA
P027	Lower BVA	2	703.39	40.00	35.00	>	40.0	30-35	0-25	25-27	27-35	25.0	completed as proposed
P028	Lower BVA	2	709.72	30.00	28.00	>	30.0	23-28	0-19	19-21	21-28	25.0	completed as proposed
P029	Upper BVA	2	702.21	28.00	28.00	>	28.0	23-28	0-18	18-20	20-28	23.0	completed as proposed
P030	Lower BVA	2	701.65	176.00	89.00	>	176.0	82-87	0-78	78-80	80-89	45.0	completed as proposed
P031	Lower BVA	2	700.97	35.00	30.00	>	35.0	25-30	0-19.5	19.5-22	22-30	19.0	completed as proposed
P032	Lower BVA	2	707.60	35.00	34.00	>	35.0	29-34	0-25	25-27	27-34	15.0	completed as proposed
P033	Upper BVA	2	701.73	115.00	25.00		107.0	20-25	0-14	14-17	17-25	15.0	completed as proposed
P034	Upper BVA	2	691.22	20.00	18.00	>	20.0	12.7-17.7	0-9	9-11	11-18	12.0	completed as proposed

Table A.1. (page 2 of 4)

Location	Formation of Completion	Well Diameter (inch)	Ground Elevation (MSL)	Borehole Total Depth (ft bgs)	Well Total Depth (ft bgs)	Competent Bedrock		Screened Interval (ft bgs)	Bentonite Cement Grout (ft bgs)	Bentonite Seal (ft bgs)	Filter Pack Interval (ft bgs)	First Water (ft bgs)	Comments
P035	Upper BVA	2	688.16	25.00	25.00	see	P038	20-25	0-15	15-18	18-25	11.0	completed as proposed
P036	Upper BVA	2	688.14	60.00	55.00	see	P038	50-55	0-42	42-46	46-55	11.0	completed as proposed
P037	Lower BVA	2	688.43	85.00	85.00	see	P038	80-85	0-65	65-78	78-85	11.0	completed as proposed
P038	Lower BVA	2	687.88	103.00	98.00		101.0	93-98	0-86	86-90	90-98	12.5	completed as proposed
P039	Upper BVA	2	689.35	20.00	20.00	see	P042	15-20	0-11	11-13	13-20	12.0	completed as proposed
P040	Upper BVA	2	689.41	42.00	42.00	see	P042	37-42	0-33	33-35	35-42	12.0	completed as proposed
P041	Upper BVA	2	689.30	52.00	52.00	see	P042	47-52	0-42	42-45	45-52	12.0	completed just above bedrock; no till unit
P042	Bedrock	2	689.15	68.50	68.50		52.0	63.5-68.5	0-56	56-59	59-68.5	12.0	completed in bedrock; no till unit
0322	Bedrock	4	809.84	55.00	55.00		42.5	45-55	0-39	39-43	43-55	-	completed as proposed
0323	W.bedrock	4	786.12	20.00	18.00		18.0	13-18	0-9	9-11	11-18	-	completed as proposed
0324	W.bedrock	4	784.87	25.00	20.00		20.5	15-20	0-10	10-13	13-20	-	completed as proposed
0325	Bedrock	4	796.96	30.00	30.00		16.0	20-30	0-14	14-18	18-30	-	completed as proposed
0326	Bedrock	4	875.52	33.00	33.00		19.0	23-33	0-18	18-21	21-33	-	completed as proposed
0327	Upper BVA	4	698.69	25.00	25.00	see	0328	15-25	0-9	9-12	12-25	13.5	completed as proposed
0328	Lower BVA	4	698.65	116.00	111.00		114.0	101-111	0-93	93-97	97-111	13.5	completed as proposed
0329	Upper BVA	4	707.95	23.00	22.00	see	0330	17-22	0-12	12-15	15-22	79.0	completed as proposed
0330	Lower BVA	4	707.97	175.00	166.00	>	175.0	156-166	0-148	148-152	152-166	79.0	completed as proposed
0332	Bedrock	4	794.32	35.00	35.00		16.0	22-32	0-17	17-20	20-35	-	completed as proposed
0333	Lower BVA	4	700.34	165.00	75.00		163.0	65-75	0-55	55-63	63-75	15.0	completed as proposed
0334	Upper BVA	4	700.50	29.00	29.00	see	0333	19-29	0-13	13-16	16-29	15.0	completed as proposed
0335	Bedrock	4	705.92	81.00	55.00		23.0	49.5-53.5	0-44	44-47.5	47.5-55	-	completed as proposed
0336	Lower BVA	4	710.23	130.00	117.00		125.0	104-114	0-98	98-102	102-117	87.0	completed as proposed

Table A.1. (page 3 of 4)

Location	Formation of Completion	Well Diameter (inch)	Ground Elevation (MSL)	Borehole Total Depth (ft bgs)	Well Total Depth (ft bgs)	Competent Bedrock		Screened Interval (ft bgs)	Bentonite Cement Grout (ft bgs)	Bentonite Seal (ft bgs)	Filter Pack Interval (ft bgs)	First Water (ft bgs)	Comments
0337	Upper BVA	4	710.10	37.00	37.00	see	0336	27-37	0-19	19-23	23-37	87.0	completed as proposed
0340	Upper BVA	4	706.27	40.00	17.00		41.0	9-14	0-4.5	4.5-7	7-17	-	no lower BVA; completed above till unit
0341	Bedrock	4	706.40	55.00	55.00		41.0	45-55	0-40	40-43	43-55	-	completed as proposed
0342	Lower BVA	4	692.49	163.00	160.00		162.0	150-160	0-140	140-145	145-160	10.0	completed as proposed
0343	Lower BVA	4	696.70	105.00	90.00		95.0	84-89	0-76	76-80	80-90	35.0	completed as proposed
0344	Lower BVA	4	701.38	175.50	175.50	>	175.5	165.5-17 5.5	0-155	155-162	162-175. 5	64.5	completed as proposed
0345	US	4	753.80	45.00	40.00		43.0	35-40	0-30	30-32	32-40	35.0	completed as proposed
0346	US	4	745.31	53.00	48.00		50.0	41-46	0-35	35-38	38-48	28.0	completed in LBVA; not bedrock as proposed
0347	US	4	724.89	73.00	67.00	>	73.0	57-67	0-49	49-55	55-67	41.0	completed as proposed
0348	-	NA	876.39	248.68	NA		3.0	NA	NA	NA	NA	25.0	well not installed pending further evaluation
0349	-	NA	825.03	201.25	NA		23.5	NA	NA	NA	NA	38.0	well not installed pending further evaluation
0350	-	NA	887.40	248.00	NA		6.0	NA	NA	NA	NA	23.0	well not installed pending further evaluation
0351	Bedrock	4	886.89	20.00	20.00		6.0	10-20	0-6	6-9	9-20	-	completed as proposed
0352	-	NA	738.16	102.20	NA		21.5	NA	NA	NA	NA	-	well not installed pending further evaluation
0353	Bedrock	4	744.95	18.00	18.00		16.0	13-18	0-7	7-10	10-18	13.0	well not installed; exclusively bedrock as proposed
0354	Bedrock	4	767.95	23.00	23.00		12.5	13-23	0-8	8-11	11-23	16.0	completed as proposed

Table A.1. (page 4 of 4)

Location	Formation of Completion	Well Diameter (inch)	Ground Elevation (MSL)	Borehole Total Depth (ft bgs)	Well Total Depth (ft bgs)	Competent Bedrock		Screened Interval (ft bgs)	Bentonite Cement Grout (ft bgs)	Bentonite Seal (ft bgs)	Filter Pack Interval (ft bgs)	First Water (ft bgs)	Comments
0355	-	NA	796.99	201.70	NA		15.0	NA	NA	NA	NA	-	well not installed pending further evaluation
0356	Bedrock	4	704.07	182.00	182.00		181.5	172-182	0-162	162-168	168-182	45.0	completed as proposed
0383	Upper BVA	4	696.39	30.00	29.00	>	30.0	19-29	0-10	10-14	14-29	-	completed as proposed
0384	BORING	NA	803.02	32.00	NA		31.0	NA	NA	NA	NA	-	borehole abandoned; redrill as 0395
0385	Lower BVA	4	725.61	40.00	29.00		38.0	21-26	0-16	16-19	19-29	25.0	completed in outwash between two till layers; borehole was dry
0386	Lower BVA	4	726.82	88.00	87.00		87.0	77-87	0-70	70-74	74-87	39.0	completed as proposed
0387	Lower BVA	4	722.82	82.00	82.00		82.0	77-82	0-69	69-72	72-82	-	completed as proposed
0388	Upper BVA	4	700.35	60.00	30.00		56.0	19.6-29.6	0-15	15-18	18-30	16.0	completed as proposed
0389	Lower BVA	4	726.66	52.00	52.00	see	0386	42-52	0-37	37-40	40-52	39.0	completed below till unit
0390	Upper BVA	4	726.54	35.00	35.00	see	0386	25-35	0-20	20-23	23-35	39.0	completed above till unit
0391	BORING	NA	706.32	35.00	NA	see	0341	NA	NA	NA	NA	-	location changed to near 0340/0341 borehole was abandoned; dry
0392	Upper BVA	4	722.79	45.00	45.00	see	0387	40-45	0-34	34-37	37-45	-	completed below till unit
0395	US	4	803.25	95.00	75.00	>	95.0	60-70	0-50	50-56	56-75		completed as proposed; replaced well 0384 which was abandoned
0396	BORING	NA	689.57	162.00	NA	>	162.0	NA	NA	NA	NA		located by Great Miami River; drilled to bedrock then abandoned

NA - Not applicable
ft bgs - feet below ground surface
BVA - Buried Valley Aquifer
MSL - mean sea level
US - unconsolidated sediments

A.2. MONITORING WELL AND PIEZOMETER DEVELOPMENT

FINAL WELL DEVELOPMENT FIELD PARAMETERS
MOUND PLANT
MIAMISBURG, OHIO

Welldev2.wk3

Well Numbe	Initial Water Level (TOC)	Yield during development (GPM)	Initial PID (units)	Measurements @ completion of Development				
				pH	Ec (umhos/cm)	Temp. (degree C)	Turbidity (NTU)	Color
0322	25.20	–	0	*7.88	*1188	*12.6	*>200	–
0323	16.20	–	0	Not enough water to sustain pumping				–
0324	12.91	0.063	0	**7.09	**262	**20.0	**173	–
0325	18.91	–	0	Well is pumped dry immediately				–
0326	14.60	2	0	8.30	–	–	–	–
0327	11.40	2.8	0	8.00	1404	12.4	4.6	Clear
0328	11.60	7.5	0.6	7.72	430	14.1	9.0	Clear
0329	19.22	<1	0	7.42	863	12.0	8.7	Clear
0330	22.11	5	0	7.49	867	9.7	2.1	Clear
0332	15.32	0.333	0	5.83	1355	13.2	15.6	Clear
0333	14.18	5	0	7.17	818	15.4	–	Clear
0334	14.82	5	0	7.33	1052	13.1	2.0	Clear
0335	7.75	–	0	8.51	1209	13.4	31.0	–
0336	25.00	6	0	7.64	1088	11.1	1.3	Clear
0337	25.00	5	0	7.24	1045	10.9	5.4	Clear
0340	DRY	–	–	–	–	–	–	–
0341	22.52	2	0	7.92	851	12.5	9.0	Clear
0342	10.15	3	0.8	7.20	724	15.4	5.8	Clear
0343	12.15	1–3	0	8.68	966	8.3	36	Yellow–grey
0344	19.10	10	0.8	7.80	987	14.5	2.8	Clear
0345	27.45	4	0.5	7.86	1485	14.0	18.0	Clear
0346	14.50	5	0	7.09	213	15.5	1.0	Clear
0347	42.40	2	0.6	6.20	1925	14.5	2.5	Clear
0351	13.97	0.625	0	7.41	1430	11.9	97.0	Clear
0353	0.00 artesian	0.5	–	7.00	1291	15.5	13.0	Clear

FINAL WELL DEVELOPMENT FIELD PARAMETERS
MOUND PLANT
MIAMISBURG, OHIO

Welldev2.wk3

Well Numbe	Initial Water Level (TOC)	Yield during development (GPM)	Initial PID (units)	Measurements @ completion of Development				
				pH	Ec (umhos/cm)	Temp. (degree C)	Turbidity (NTU)	Color
0354	12.81	<1	0	7.14	825	15.6	>100	Grey
0356	21.50	10	0	8.09	976	14.2	2.3	Clear
0383	12.15	5	0	7.20	1072	14.8	7.0	Clear
0386	42.10	5	0.8	6.54	1414	13.5	3.1	Clear
0387	38.40	3.3	–	7.10	1467	13.0	4.1	Clear
0388	18.5	3.5	0.4	7.17	1680	13.2	11	Clear
0389	41.70	2.5	0.2	7.00	1405	13.6	19	Clear
0392	38.20	2.5	0.4	7.23	1498	13.0	5.0	Clear
0395	DRY	–	–	–	–	–	–	–

* – well pumped dry after approximately 2 gallons removed.
** – Well pumped dry after approximately 15 gallons removed.

FINAL PIEZOMETER DEVELOPMENT FIELD PARAMETERS
MOUND PLANT
MIAMISBURG, OHIO

Welldev.wk3

Well Numbe	Initial Water Level (TOC)	Yield during development (GPM)	Initial PID (units)	Measurements @ completion of Development				
				pH	Ec (umhos/cm)	Temp. (degree C)	Turbidity (NTU)	Color
PO16	5.92	5	0	7.90	923	12.1	9	Clear
PO17	6.32	5	0	7.99	759	10.3	15	Clear
PO18	8.39	0.5	0	8.23	879	11.0	58	Clear
PO19	5.95	4	0	7.70	765	7.8	8.8	Clear
PO20	6.52	5	0	7.67	1156	6.5	12	Clear
PO21	19.77	<1	0	7.21	224	16.1	1.0	Clear
PO22	46.22	0.162	0	7.77	678	15.6	>200	–
PO23	44.14	not enough water to sustain pumping to take measurments						–
PO24	11.98	.25	0.8	7.10	2890	13	70	Clear
PO25	20.96	5	1.0	6.91	15760	13.5	12.5	Clear
PO26	20.80	5	0	7.51	764	15.1	8.0	Clear
PO27	21.15	5	–	6.56	meter down	14	17	Clear
PO28	29.18	.25	1.2	6.78	1264	9.7	98	Clear
PO29	19.73	4	0.8	7.46	973	14.5	7.1	Clear
PO30	19.42	4	0.8	7.75	870	15	15	Clear
PO31	19.30	4.2	0.8	5.99	1649	14	20	Clear
PO32	24.64	5	1.0	7.72	1024	12.0	32	Clear
PO33	19.42	1.5	0.8	6.31	694	9.1	20	Clear
PO34	7.20	4	0	7.50	657	8.0	23	Clear
PO35	3.70	5	0	7.61	703	18.2	10	Clear
PO36	3.86	5	0	7.58	973	17.2	8.5	Clear
PO37	4.08	5	0	7.73	993	19.7	8	Clear
PO38	3.50	5	0	7.62	857	17.7	4.3	Clear
PO39	5.37	5	6	7.97	633	9.0	5.3	Clear
PO40	5.22	4	5	7.76	770	21.5	3.0	Clear

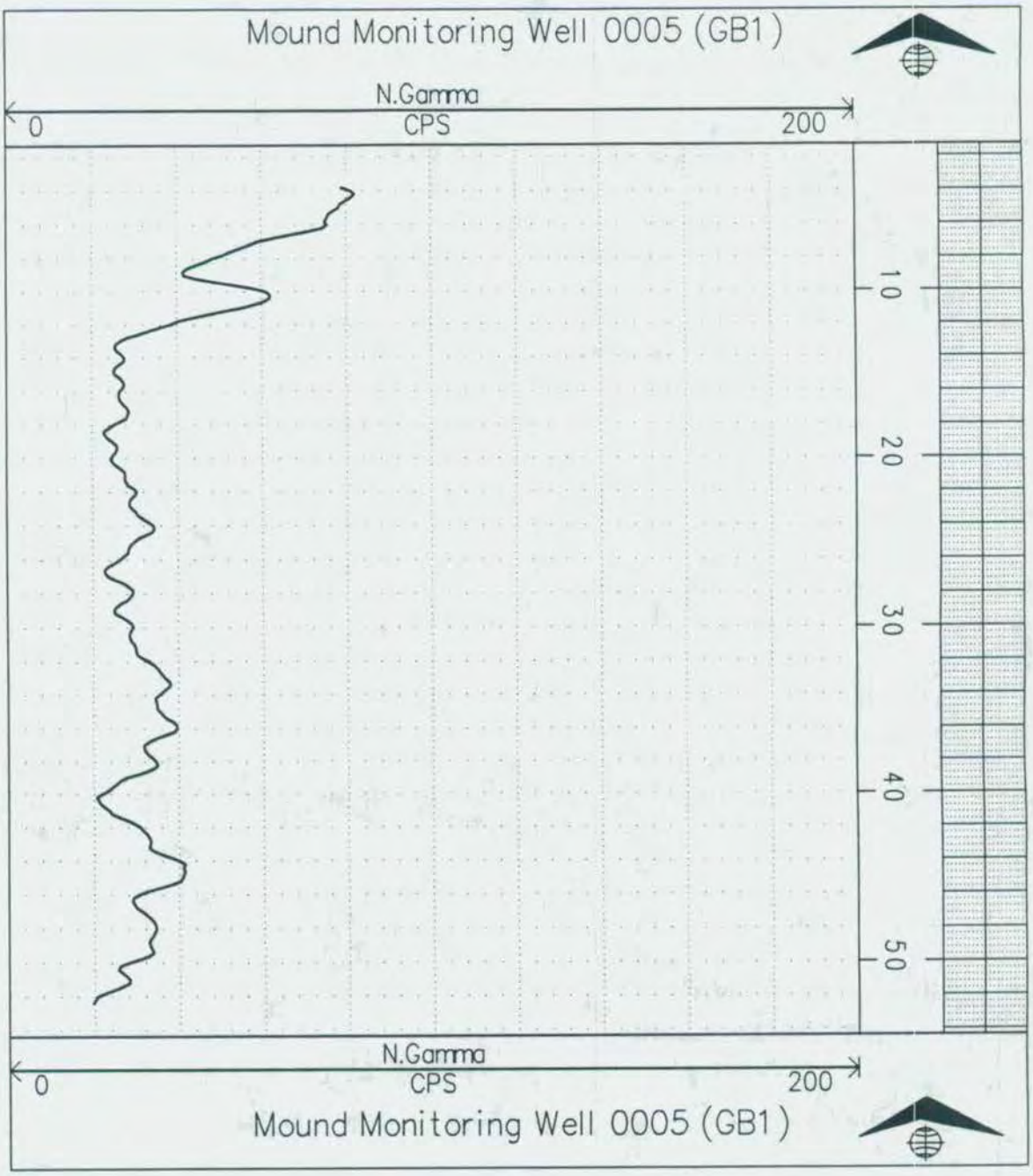
FINAL PIEZOMETER DEVELOPMENT FIELD PARAMETERS
MOUND PLANT
MIAMISBURG, OHIO

Welldev.wk3

Well Numbe	Initial Water Level (TOC)	Yield during development (GPM)	Initial PID (units)	Measurements @ completion of Development				
				pH	Ec (umhos/cm)	Temp. (degree C)	Turbidity (NTU)	Color
PO41	5.15	5	5	7.43	936	13.8	5.0	Clear
PO42	2.0	–	0	7.50	319	18.7	>100	–

A.3. NATURAL GAMMA LOGS

A.3.1. REGULAR PLOTS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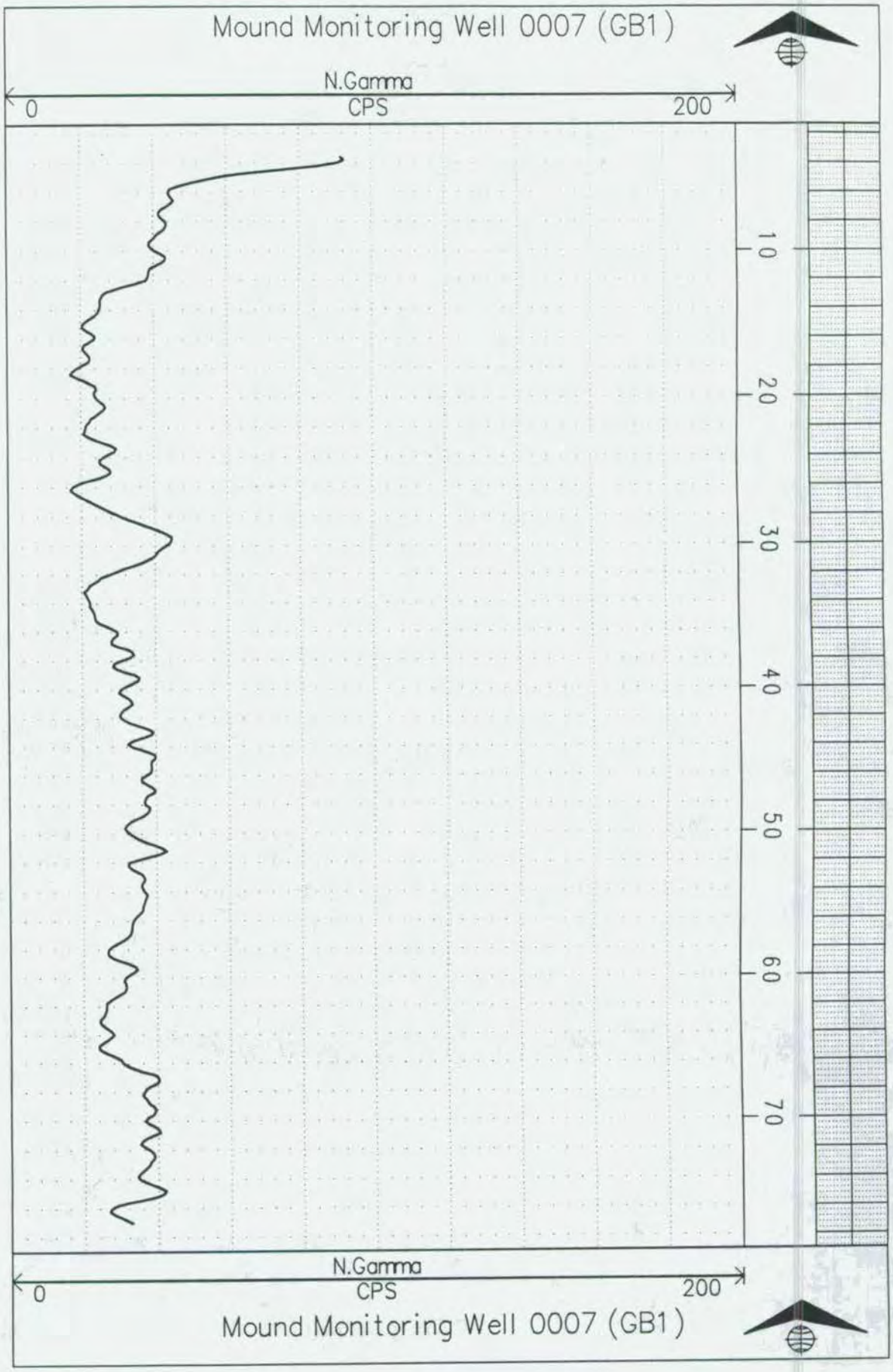
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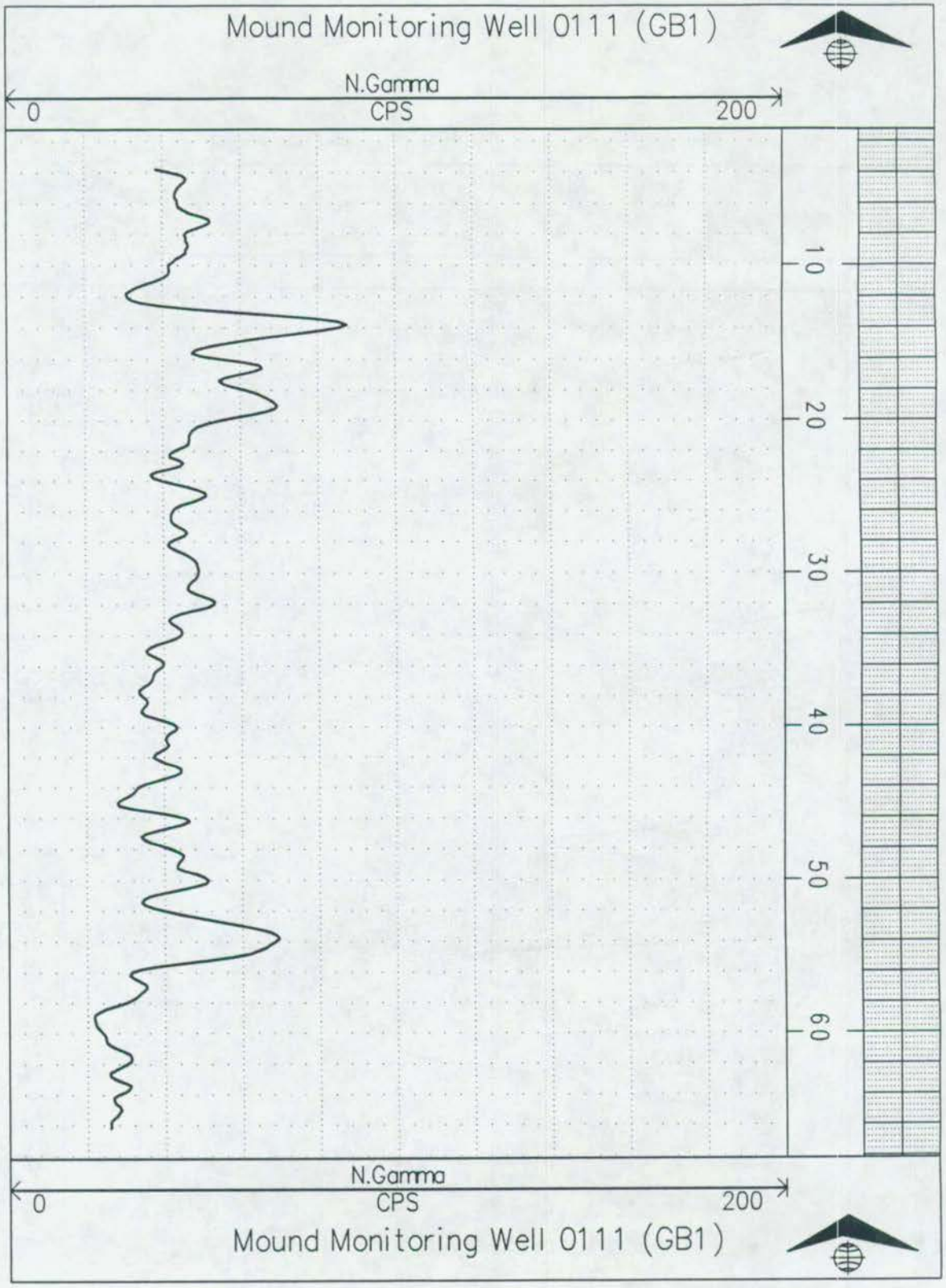
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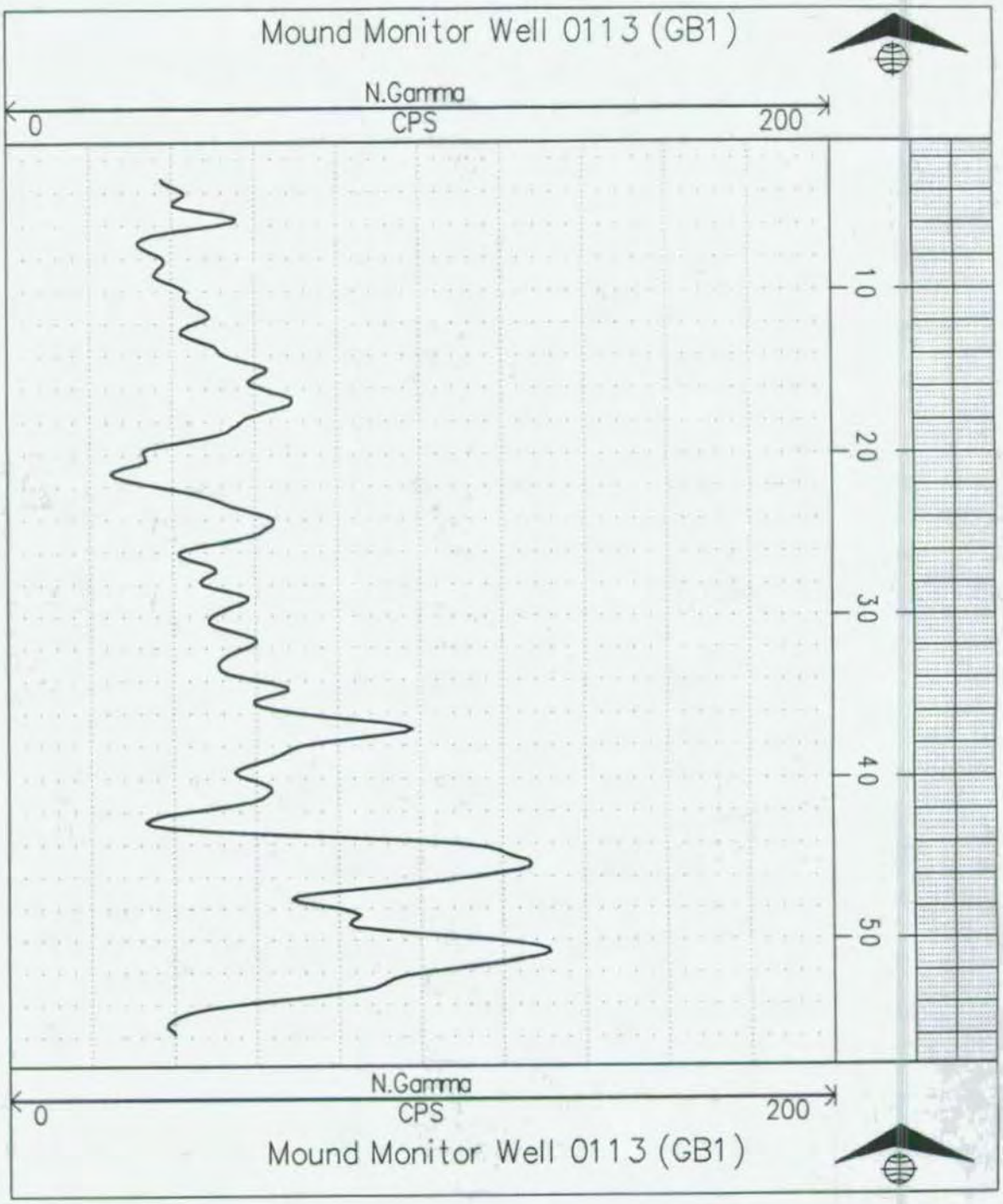
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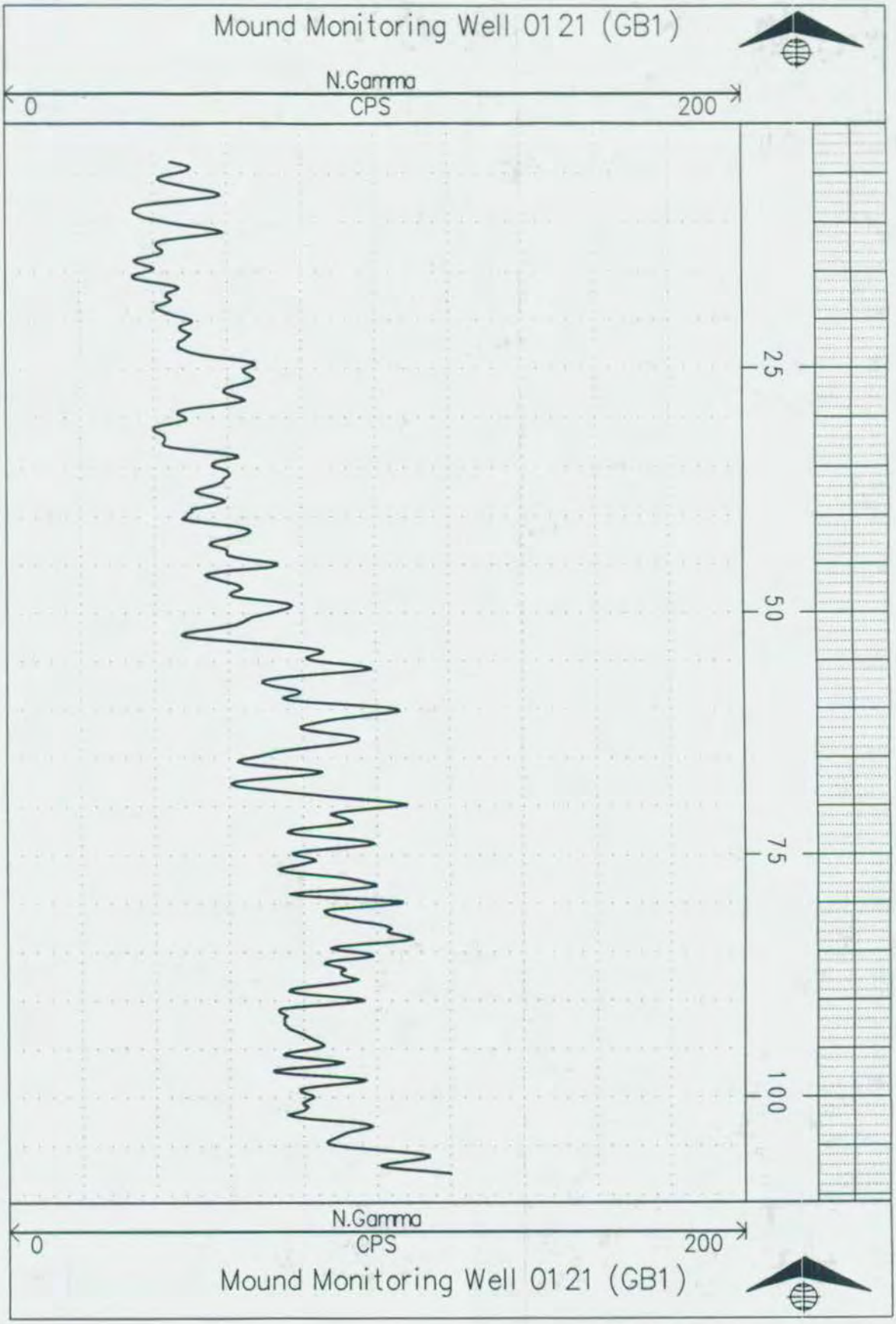
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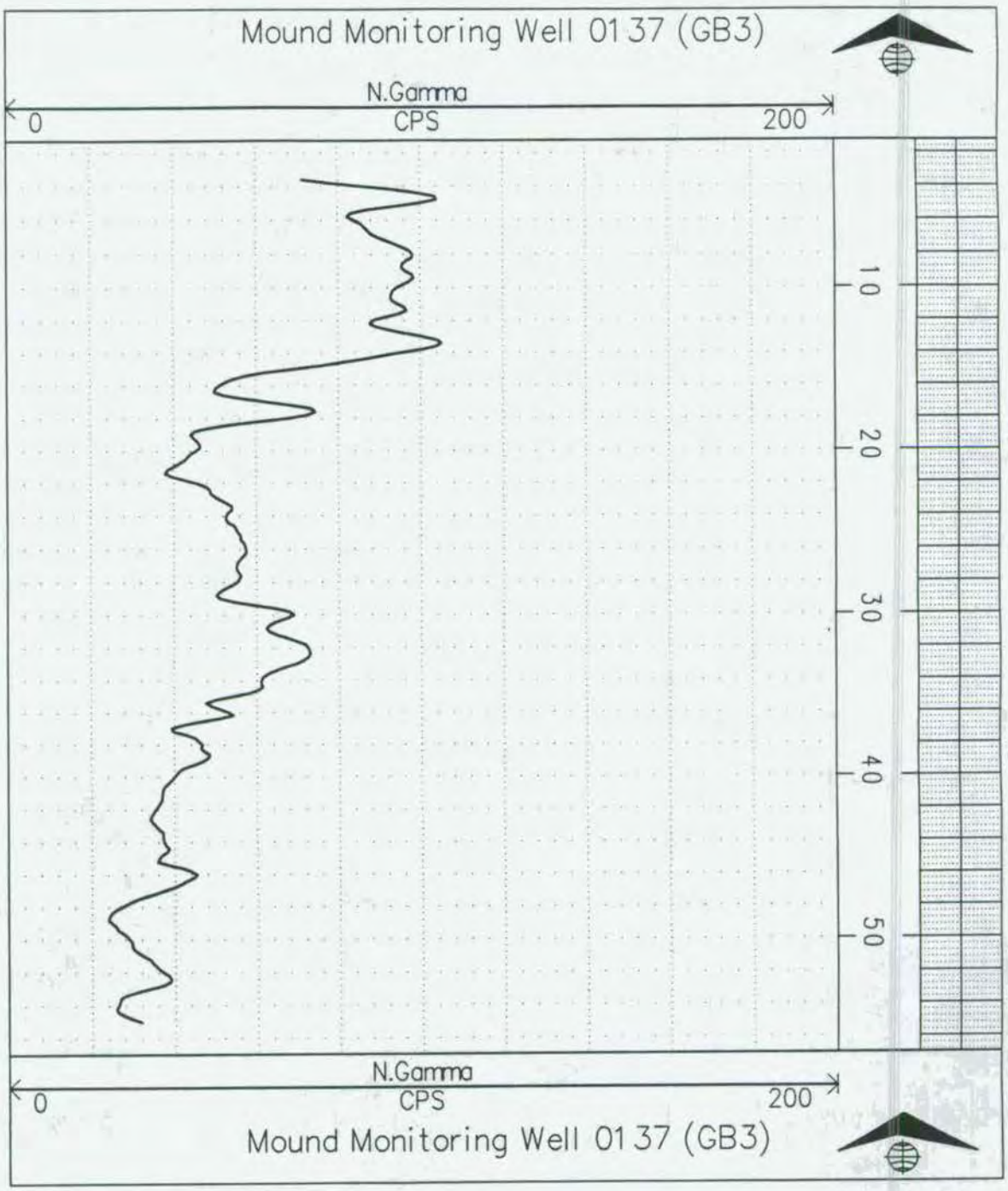
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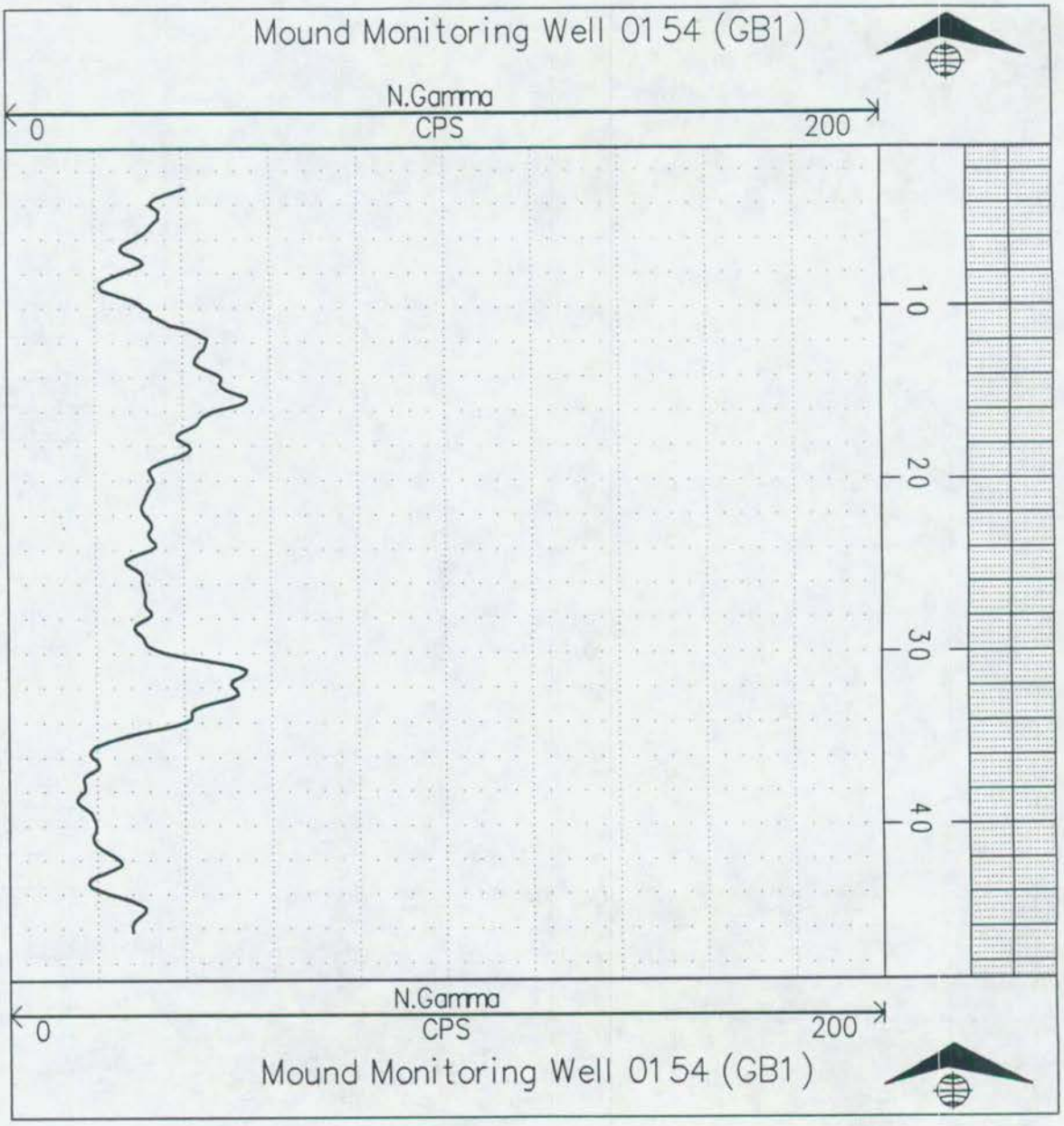
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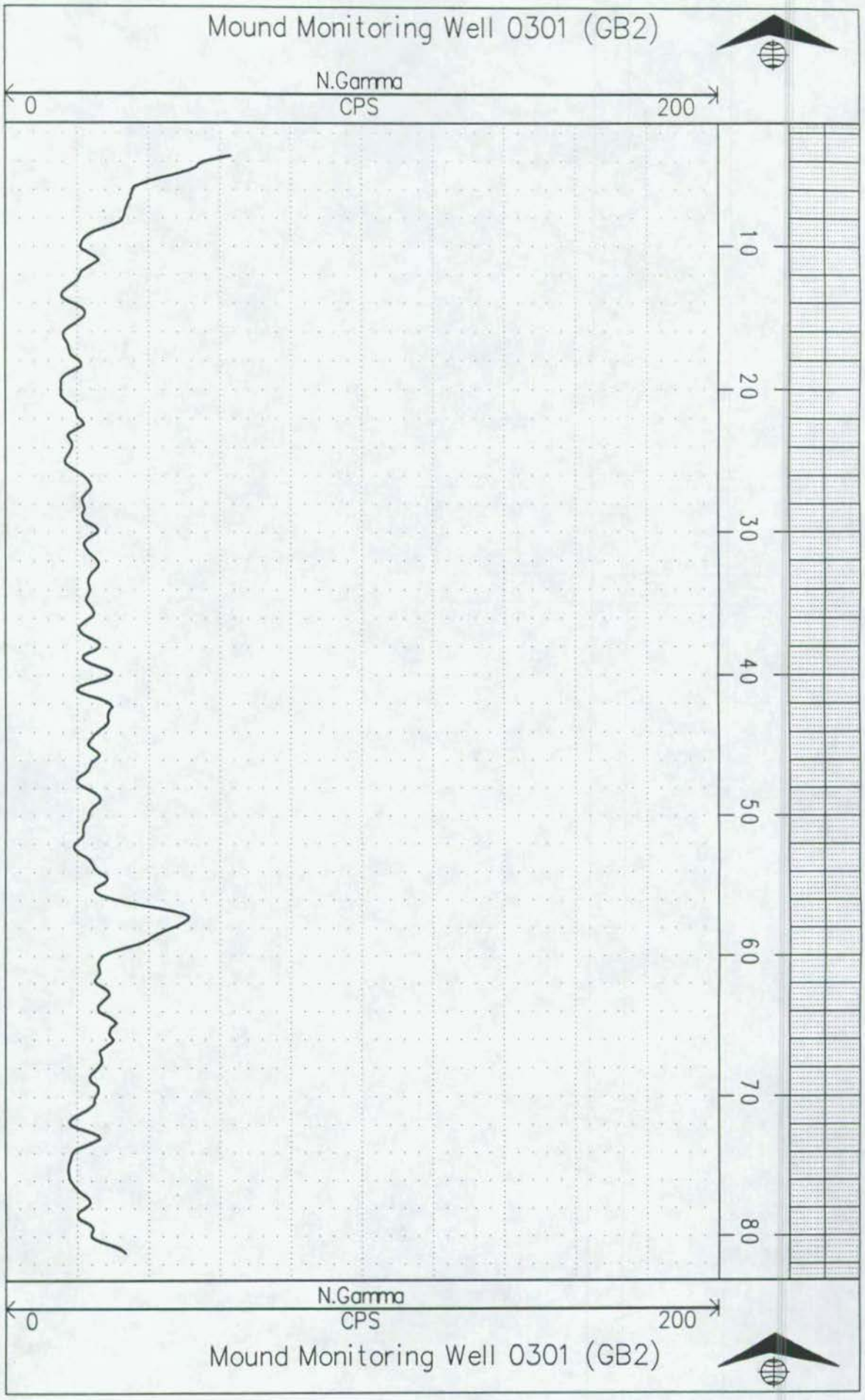
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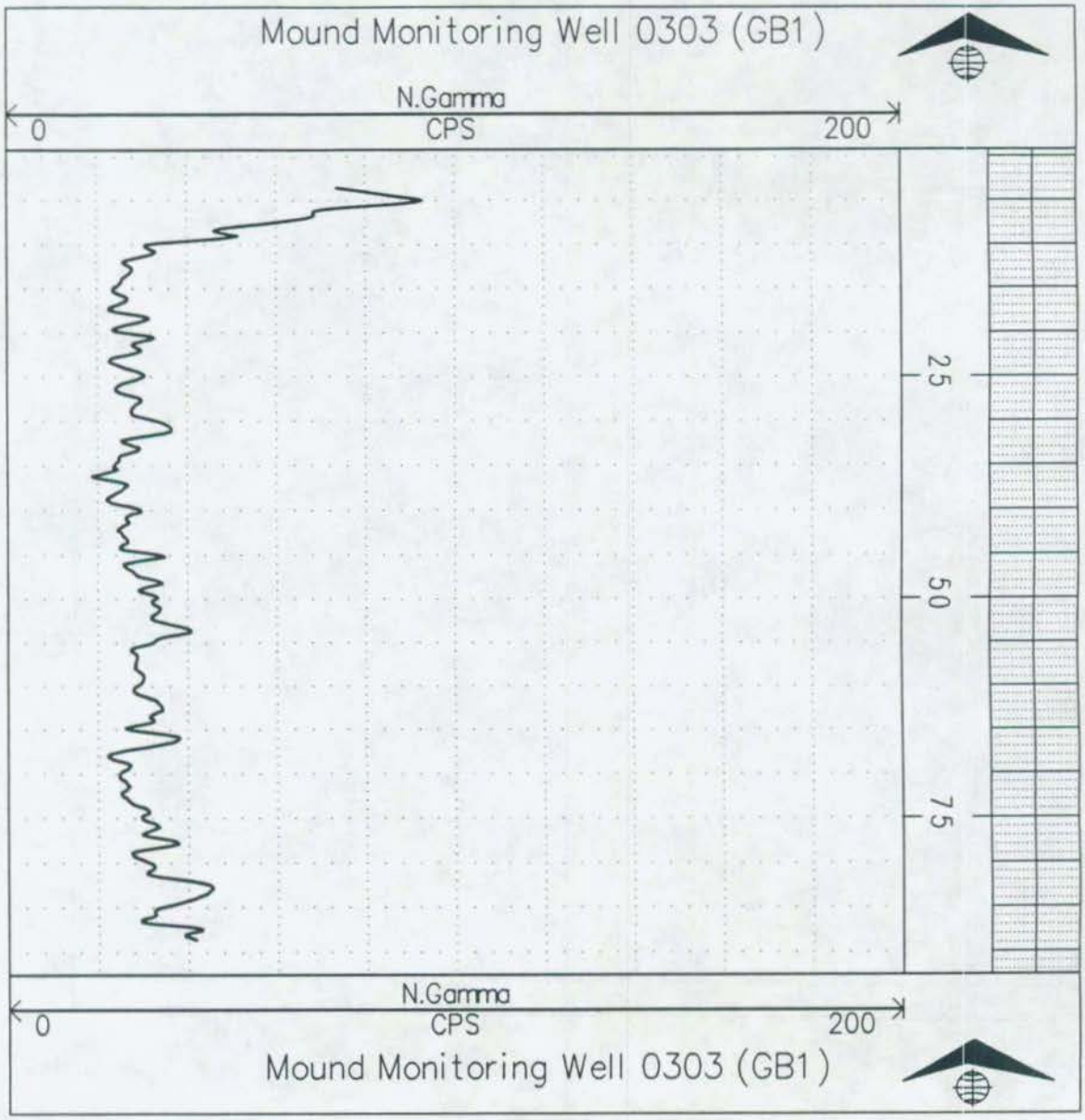
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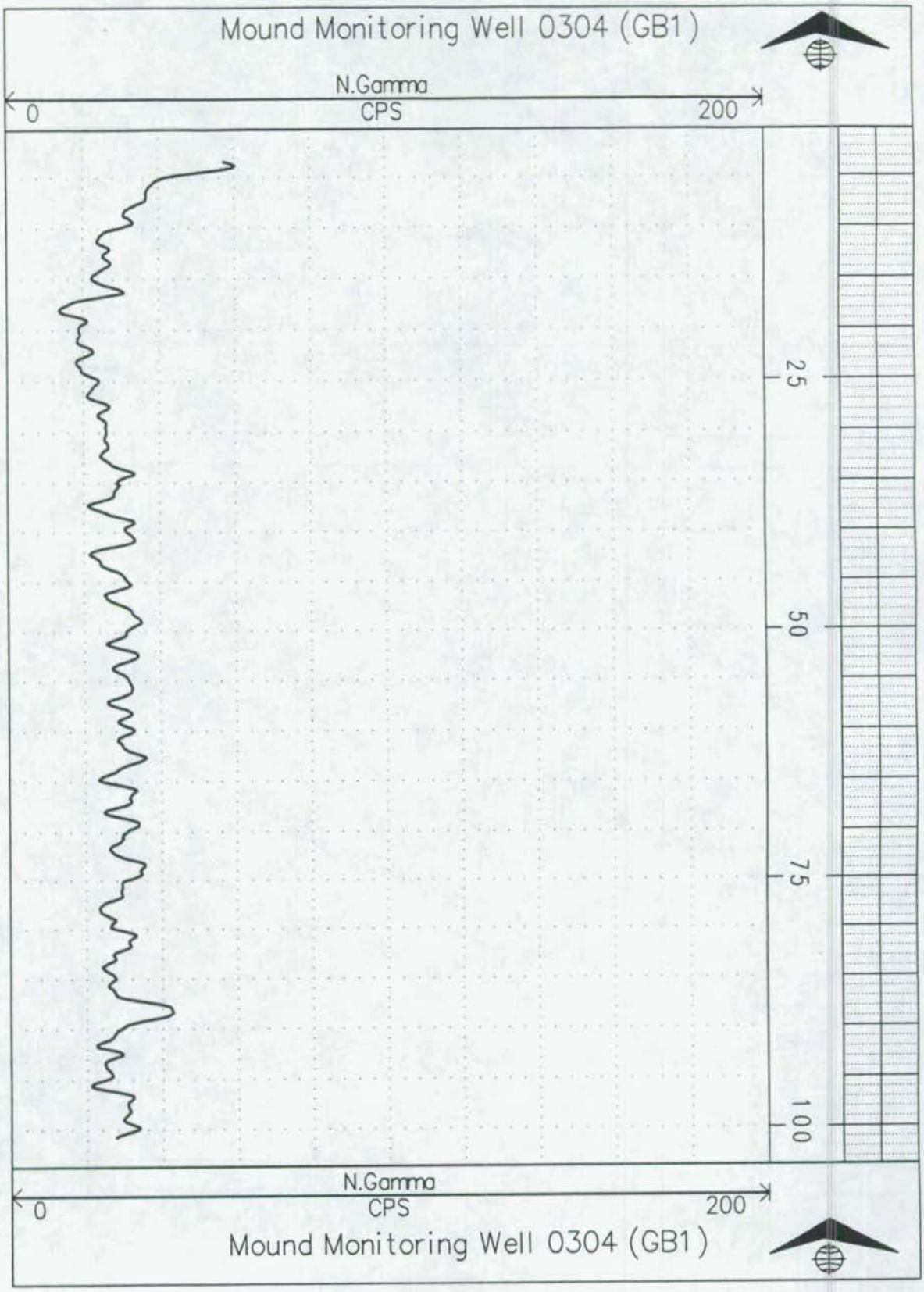
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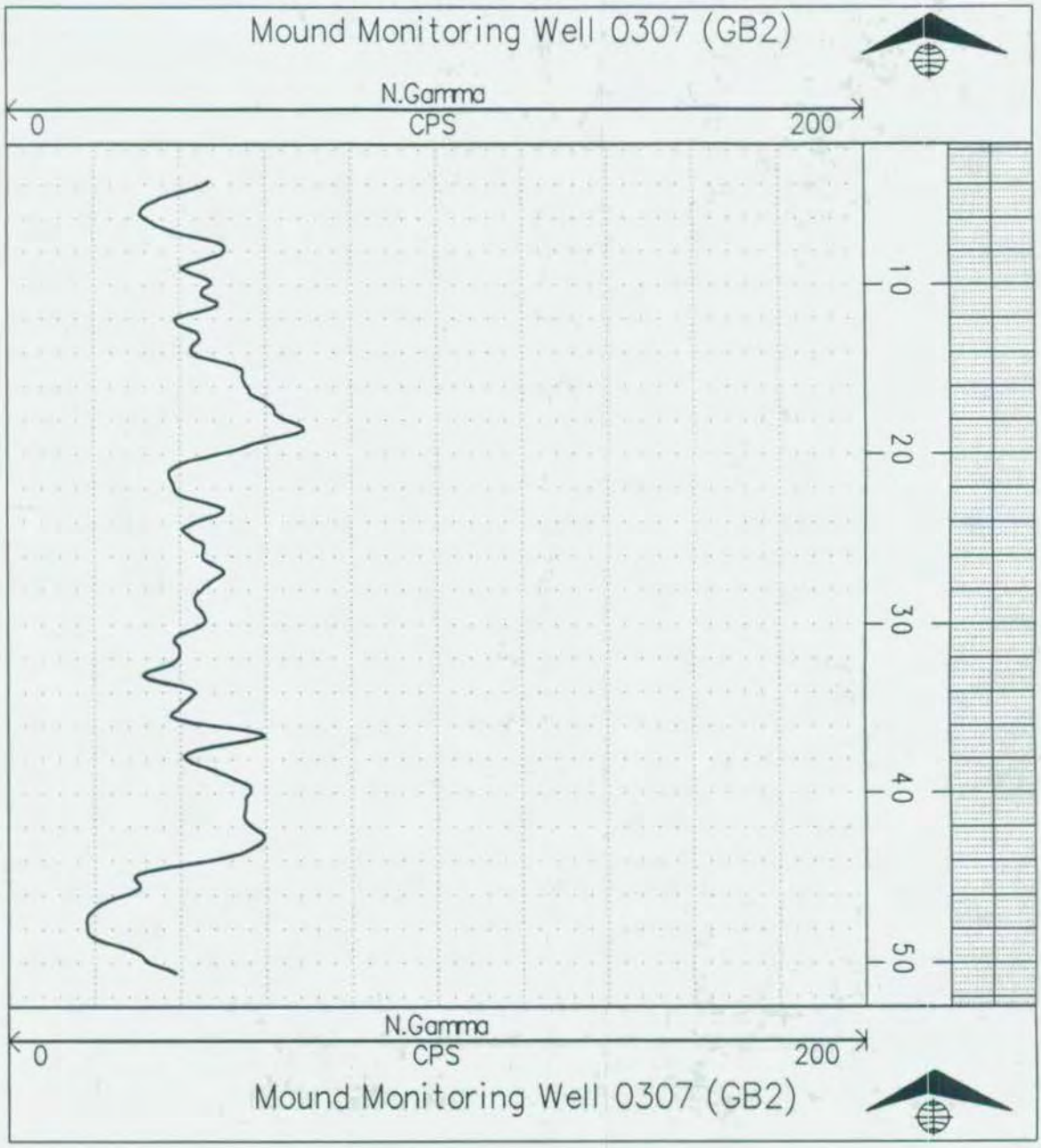
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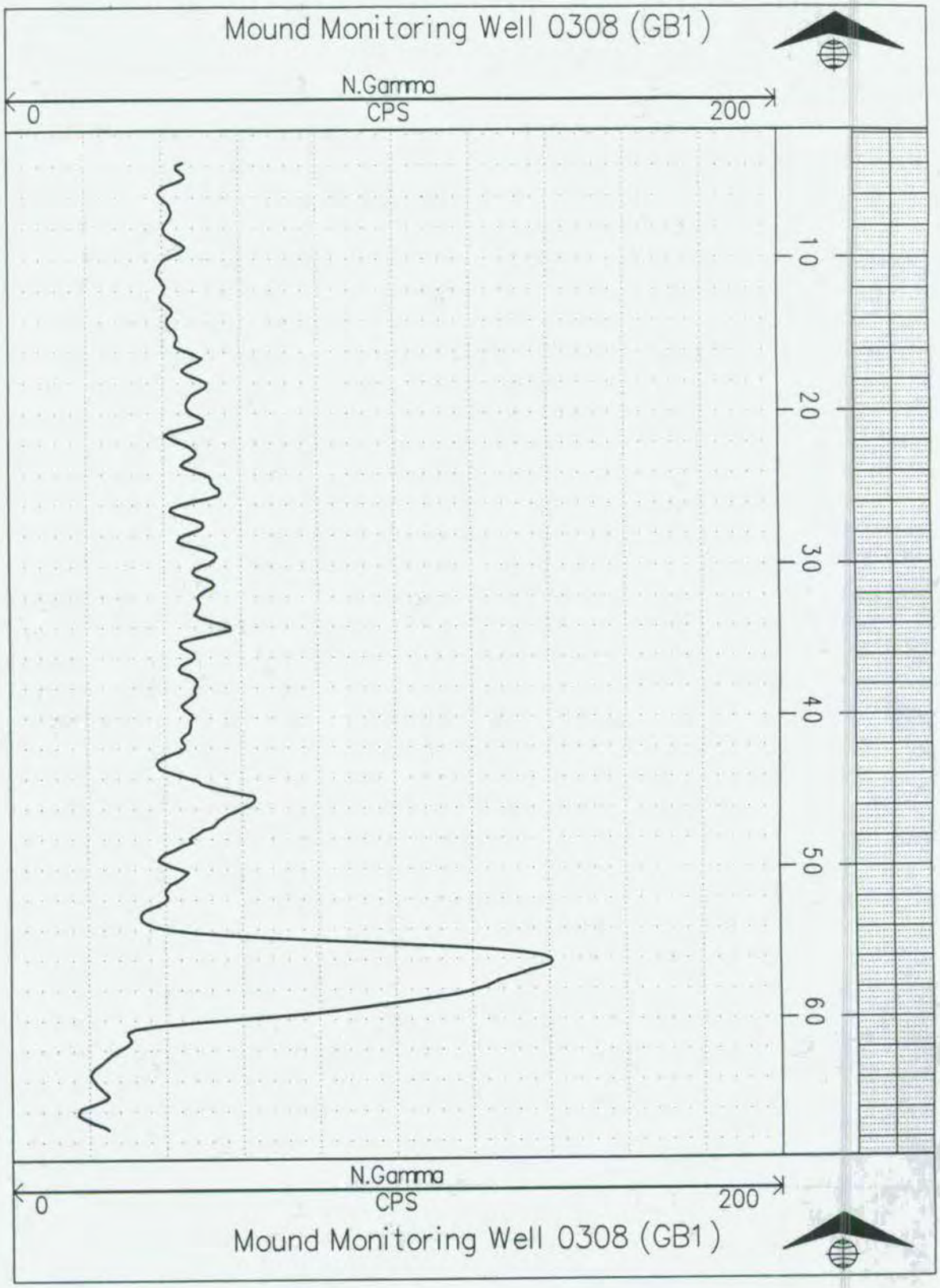
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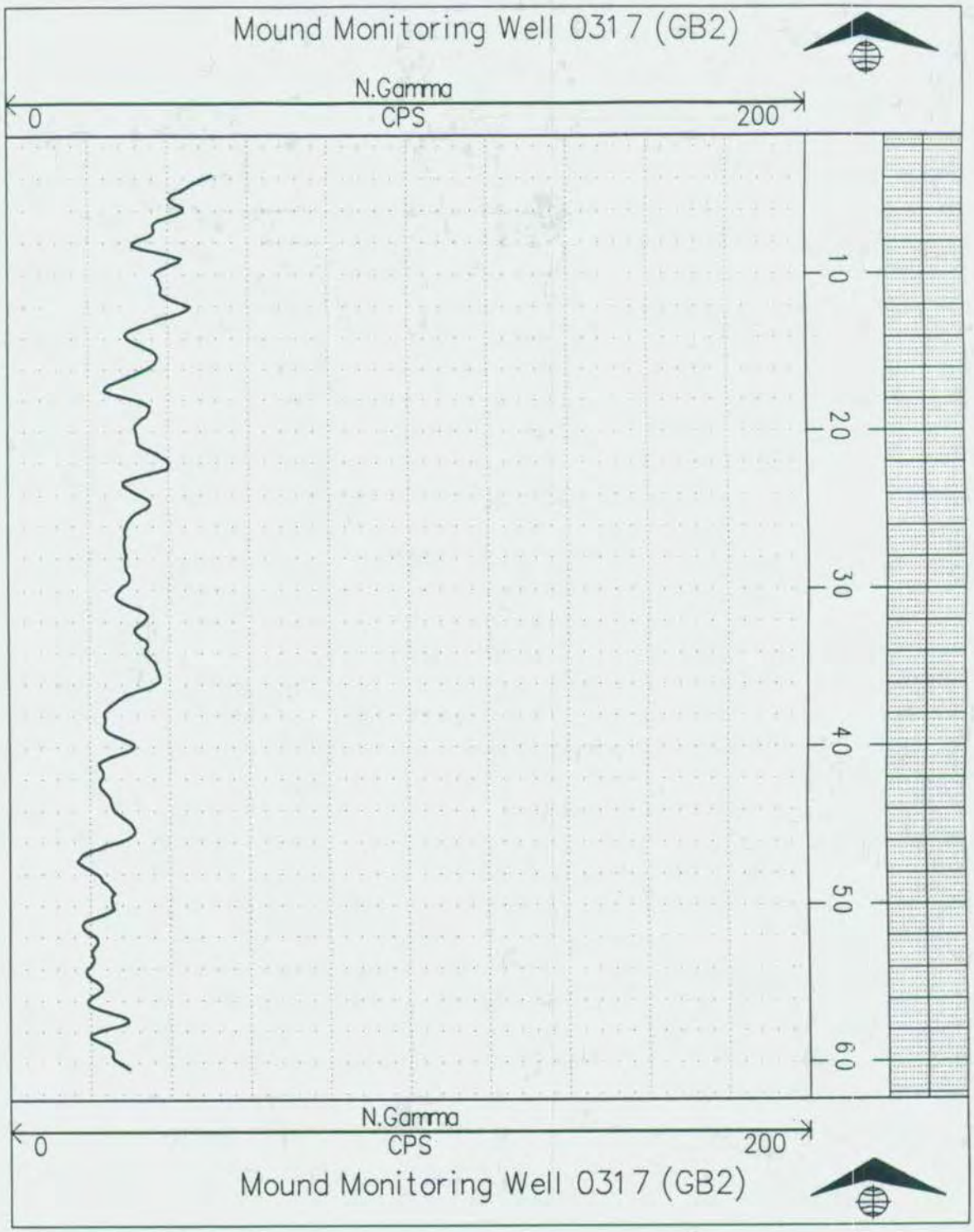
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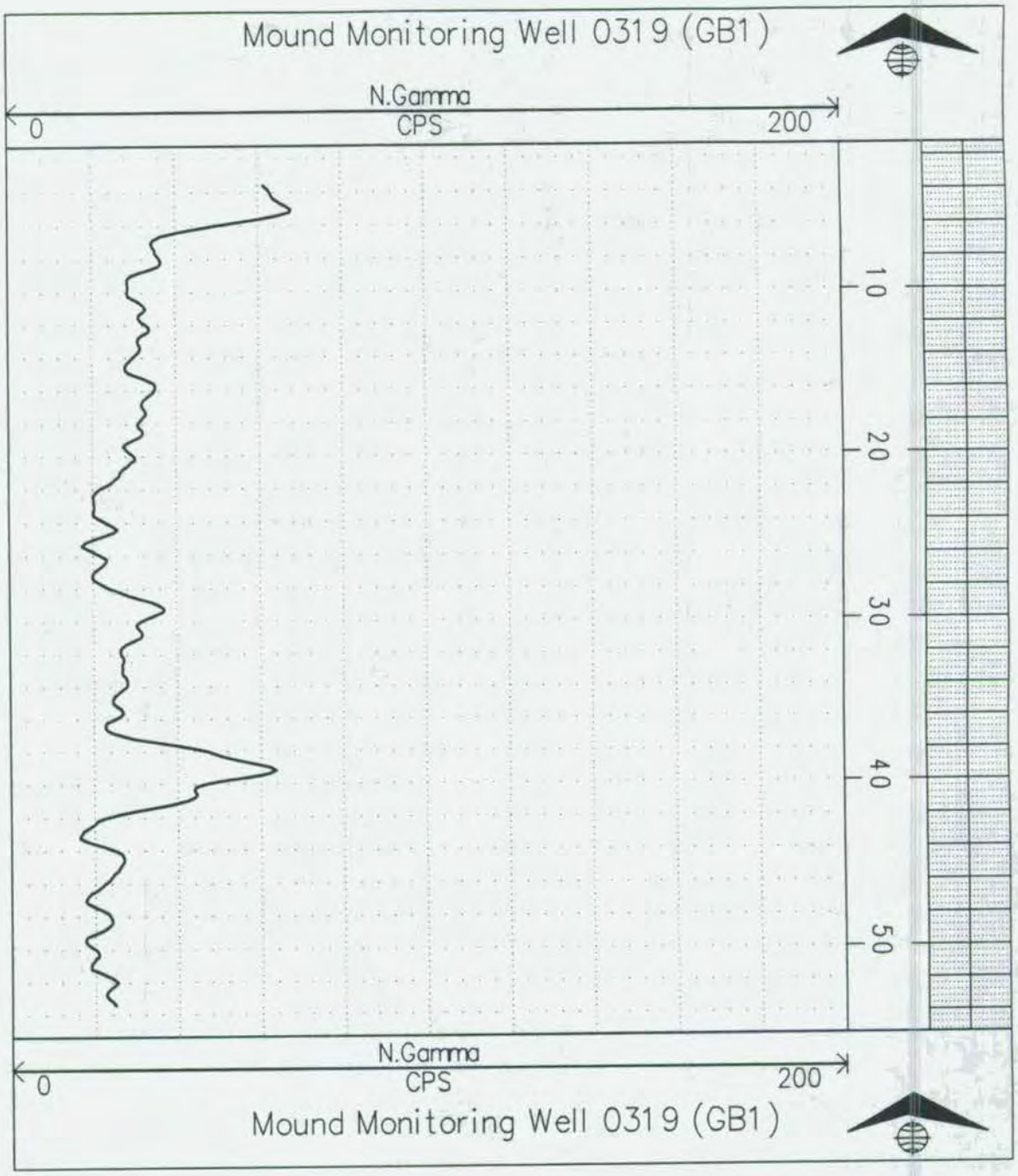
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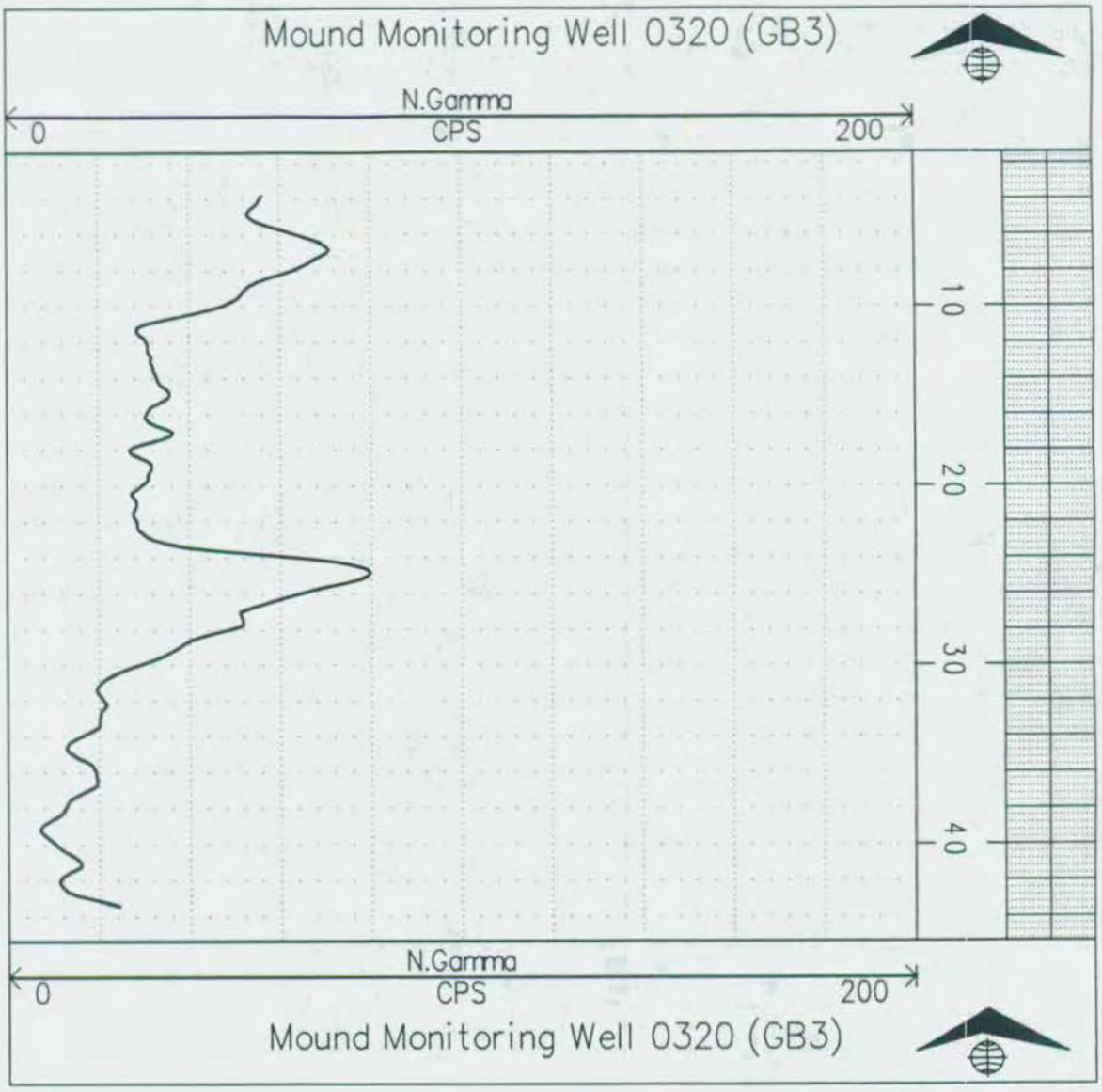
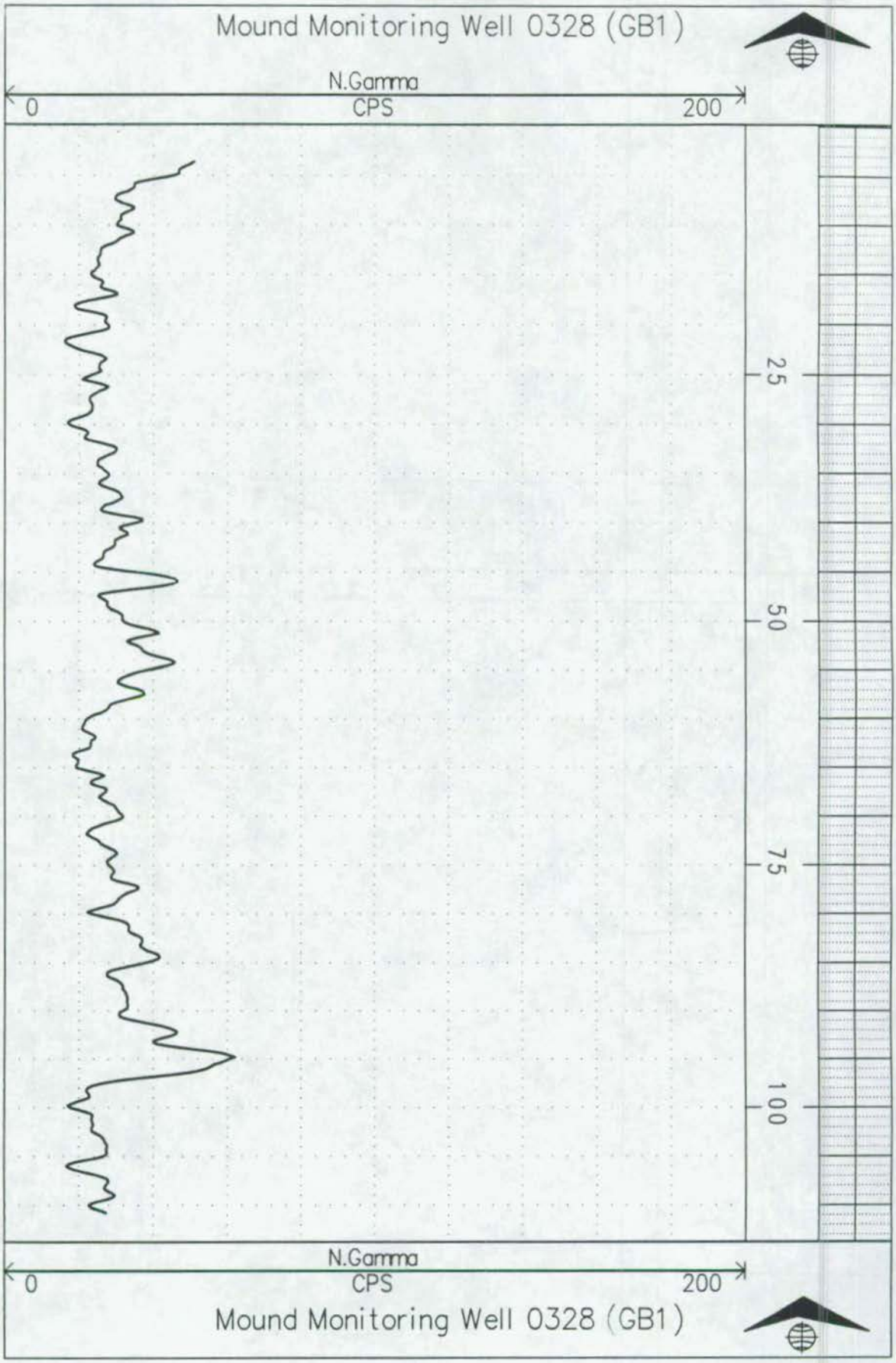
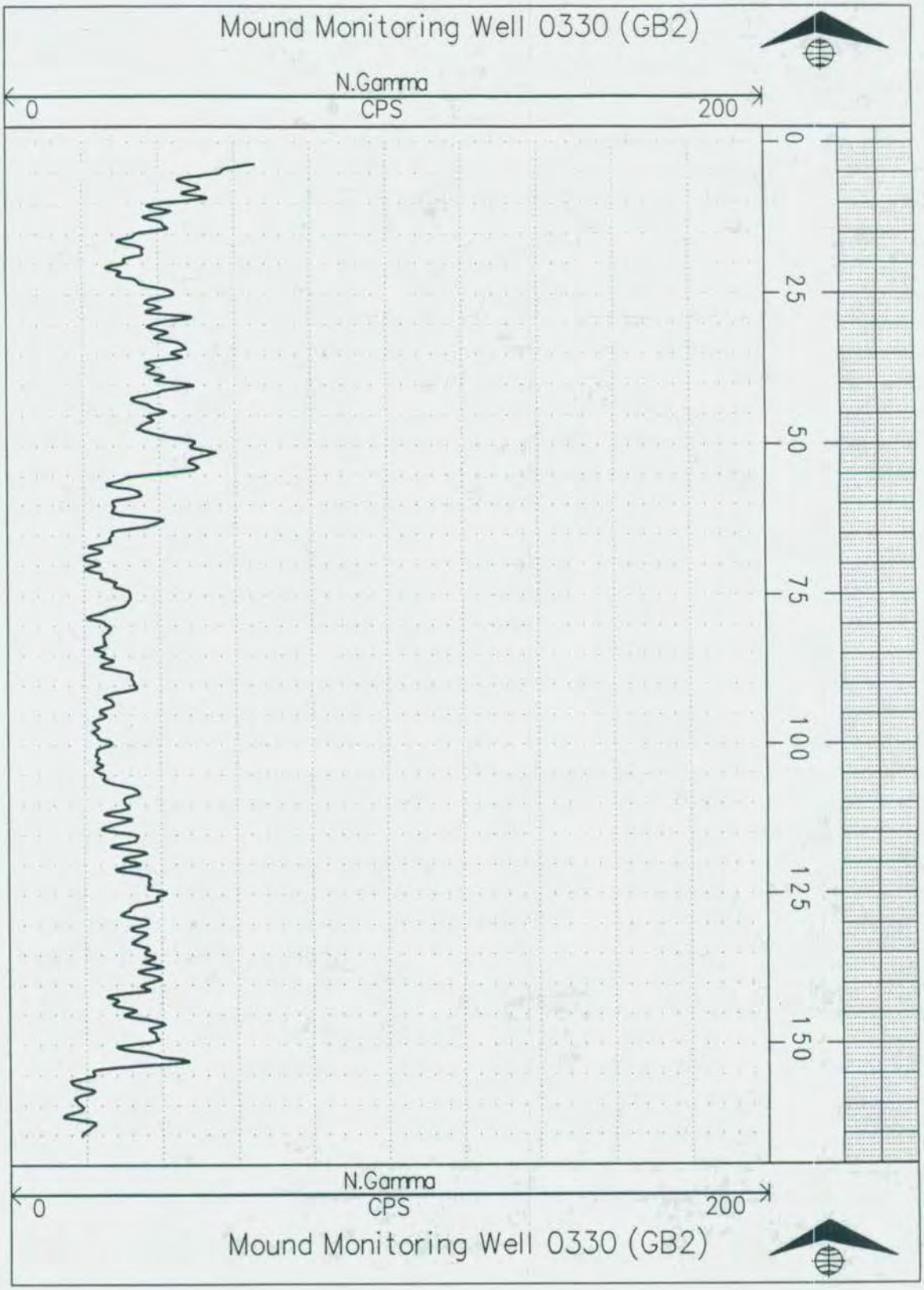
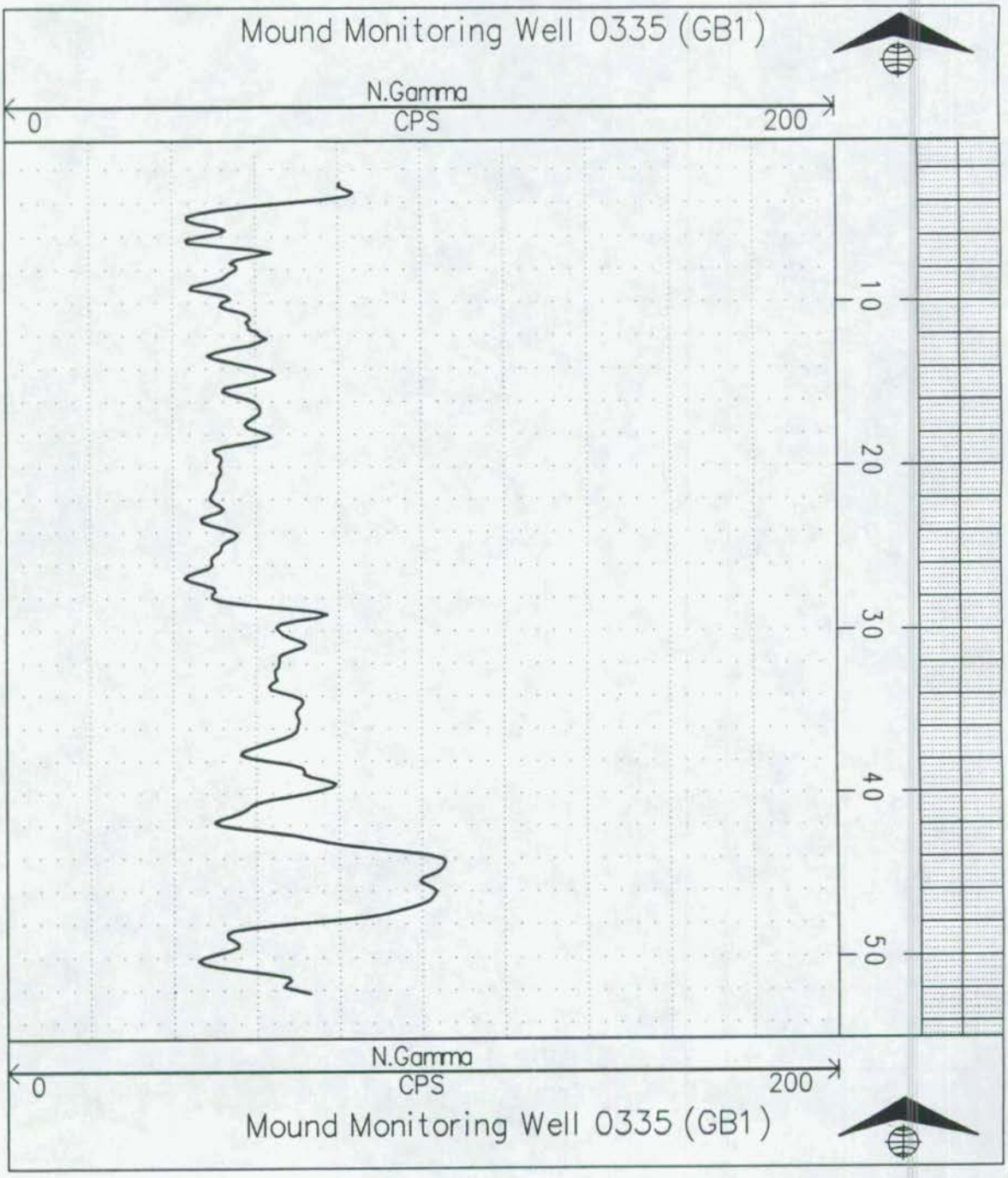
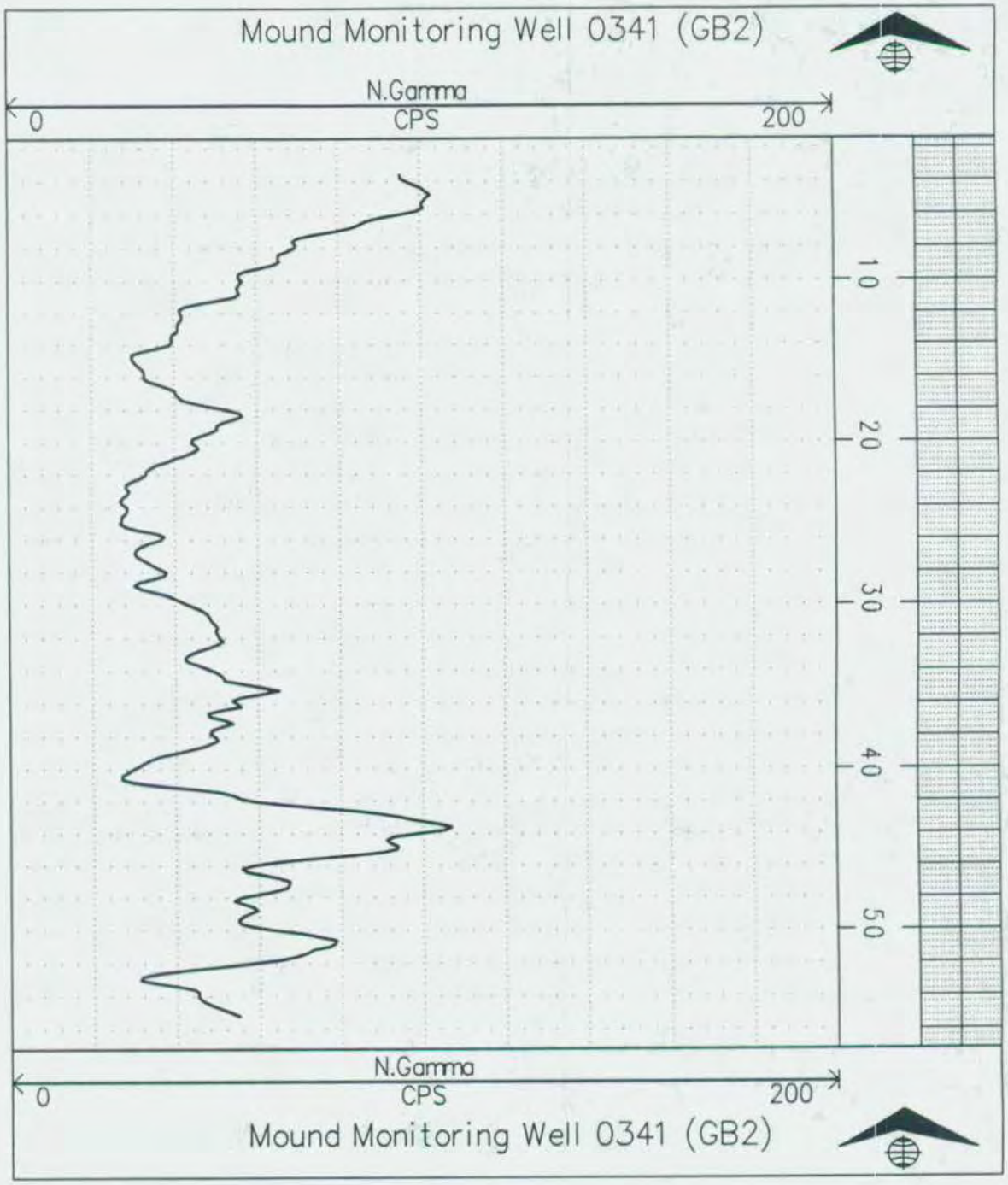
200
Mound Monitoring Well 0319 (GB1)

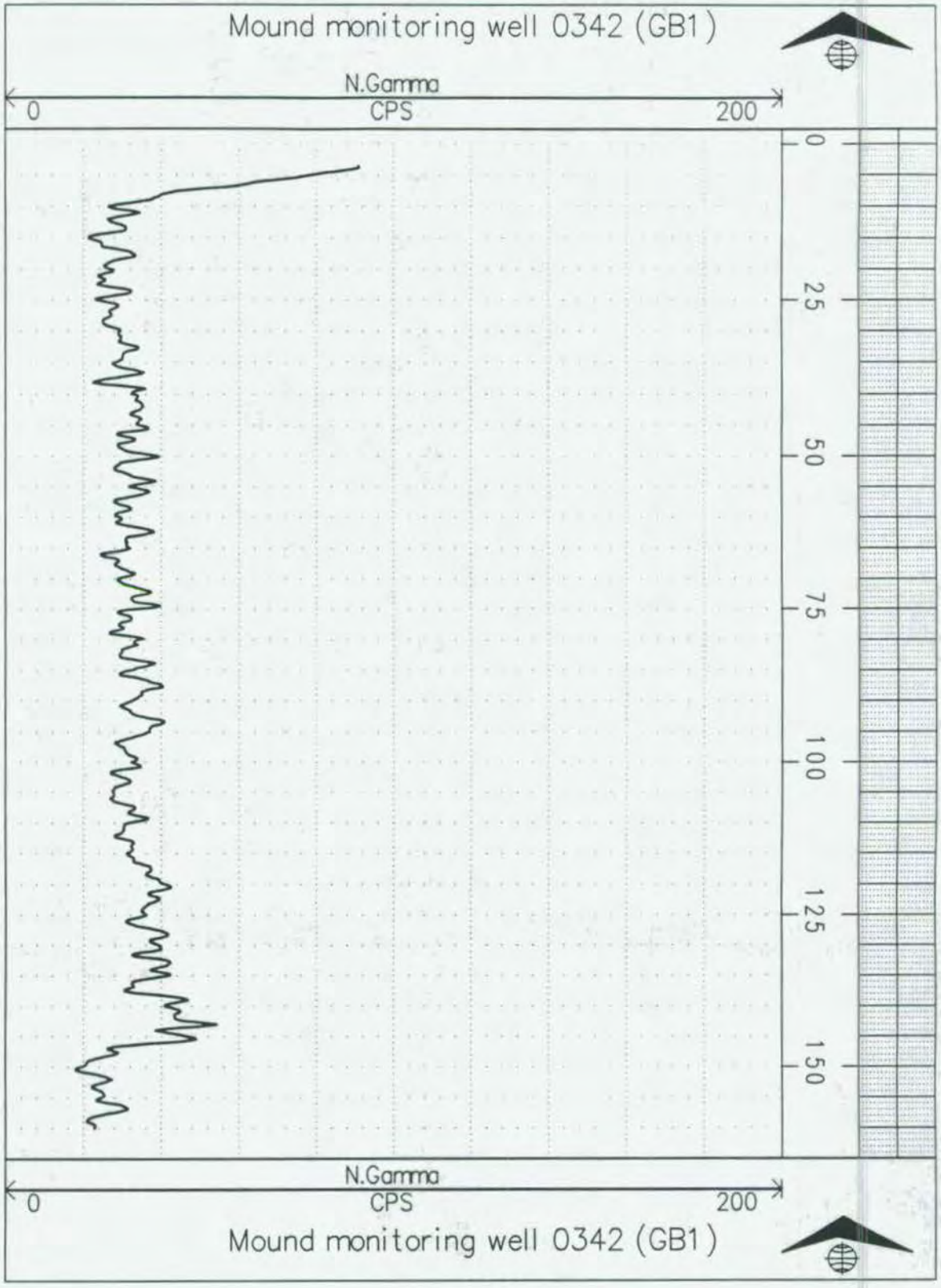

Mound Monitoring Well 0320 (GB3)
N.Gamma
CPS
0
200
10
20
30
40
N.Gamma
CPS
0
200
Mound Monitoring Well 0320 (GB3)

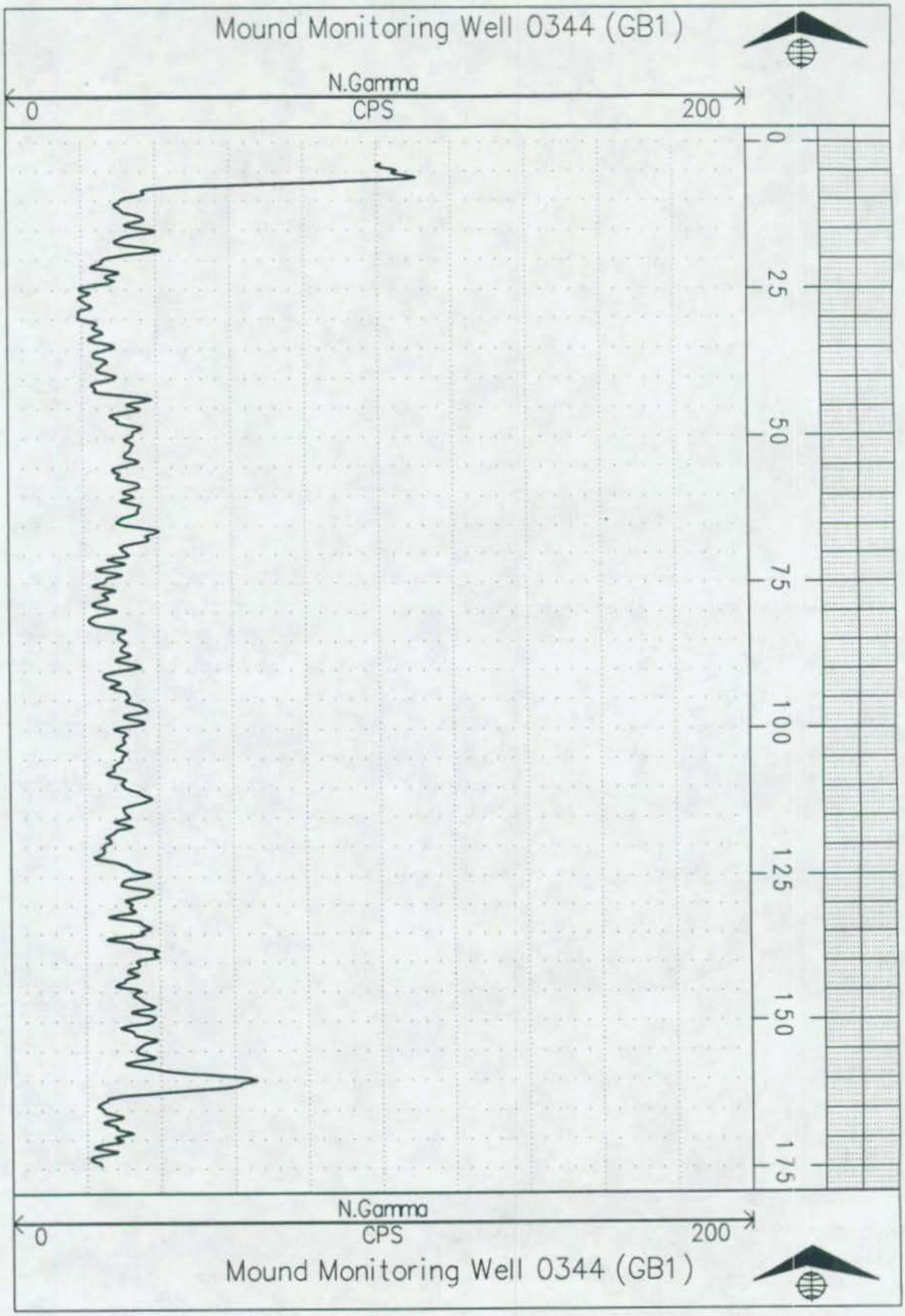

Mound Monitoring Well 0328 (GB1)
N.Gamma
CPS
0
200
25
50
75
100
N.Gamma
CPS
0
200
Mound Monitoring Well 0328 (GB1)

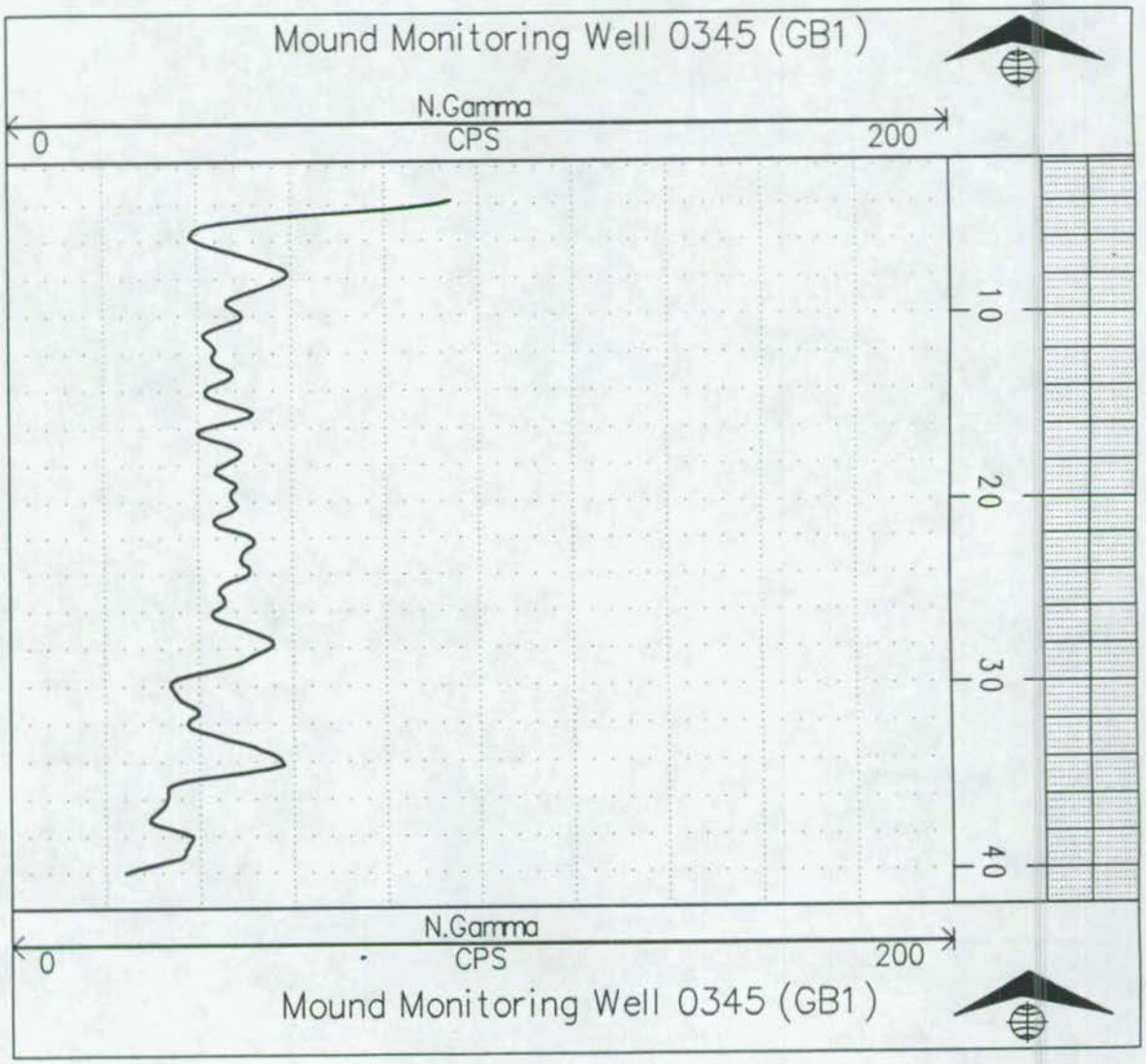

Mound Monitoring Well 0330 (GB2)
N.Gamma
CPS
0
200
0
25
50
75
100
125
150
N.Gamma
CPS
0
200
Mound Monitoring Well 0330 (GB2)

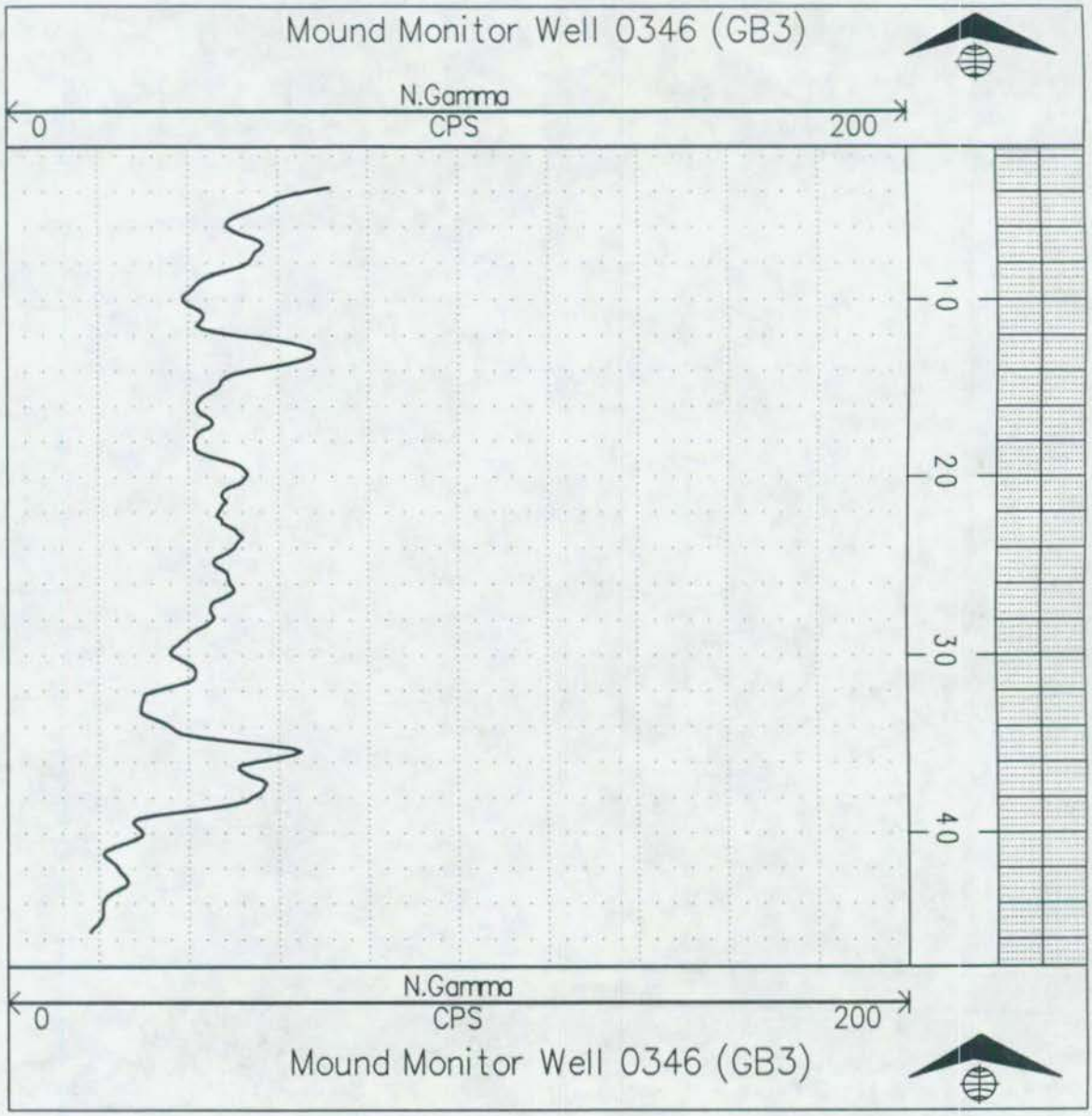

Mound Monitoring Well 0335 (GB1)
N.Gamma
CPS
0
200
10
20
30
40
50
N.Gamma
CPS
0
200
Mound Monitoring Well 0335 (GB1)

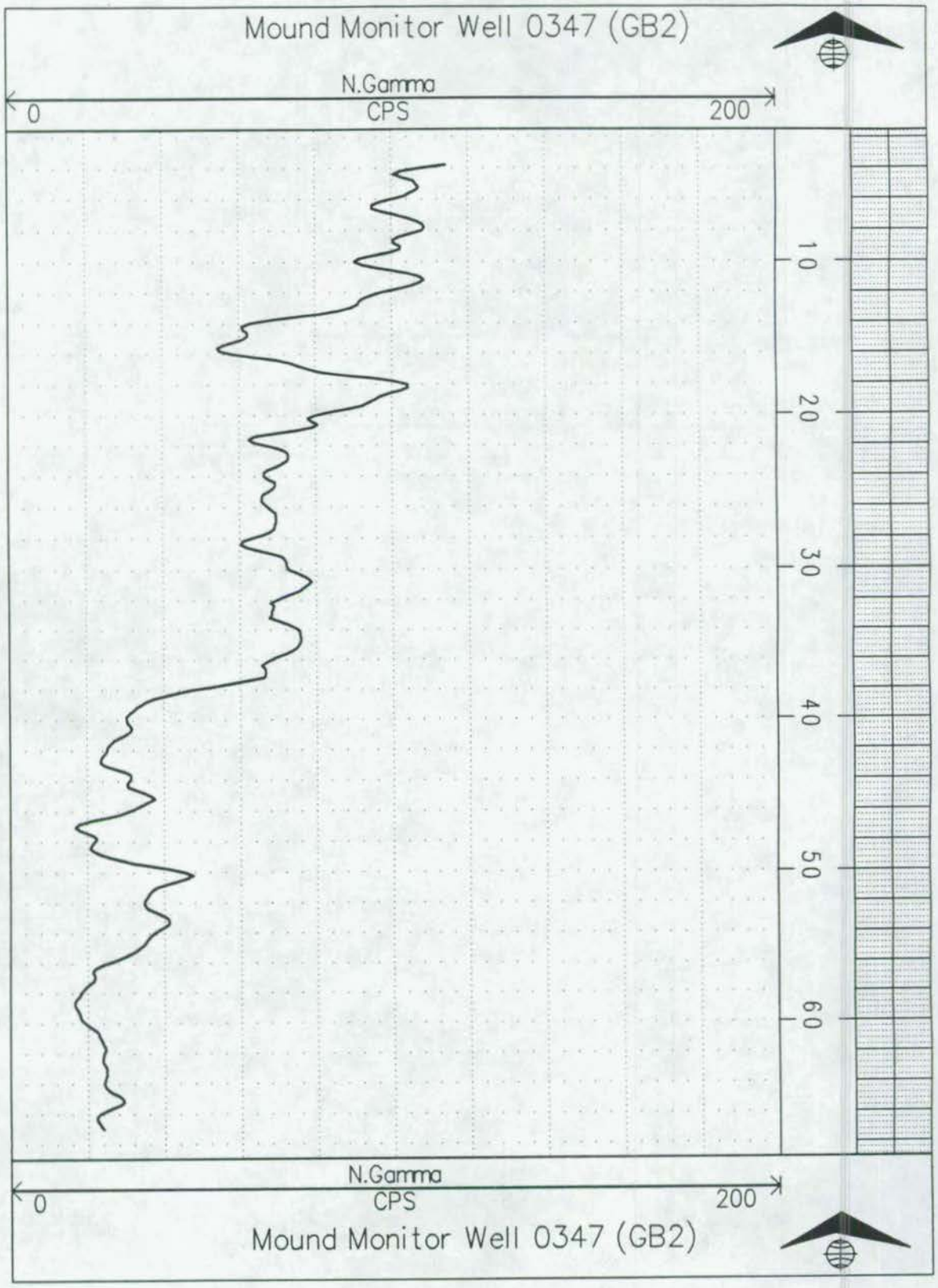

Mound Monitoring Well 0341 (GB2)
N.Gamma
CPS
0
200
10
20
30
40
50
N.Gamma
CPS
0
200
Mound Monitoring Well 0341 (GB2)


Mound monitoring well 0342 (GB1)
N.Gamma
0
CPS
200
0
25
50
75
100
125
150
N.Gamma
0
CPS
200
Mound monitoring well 0342 (GB1)

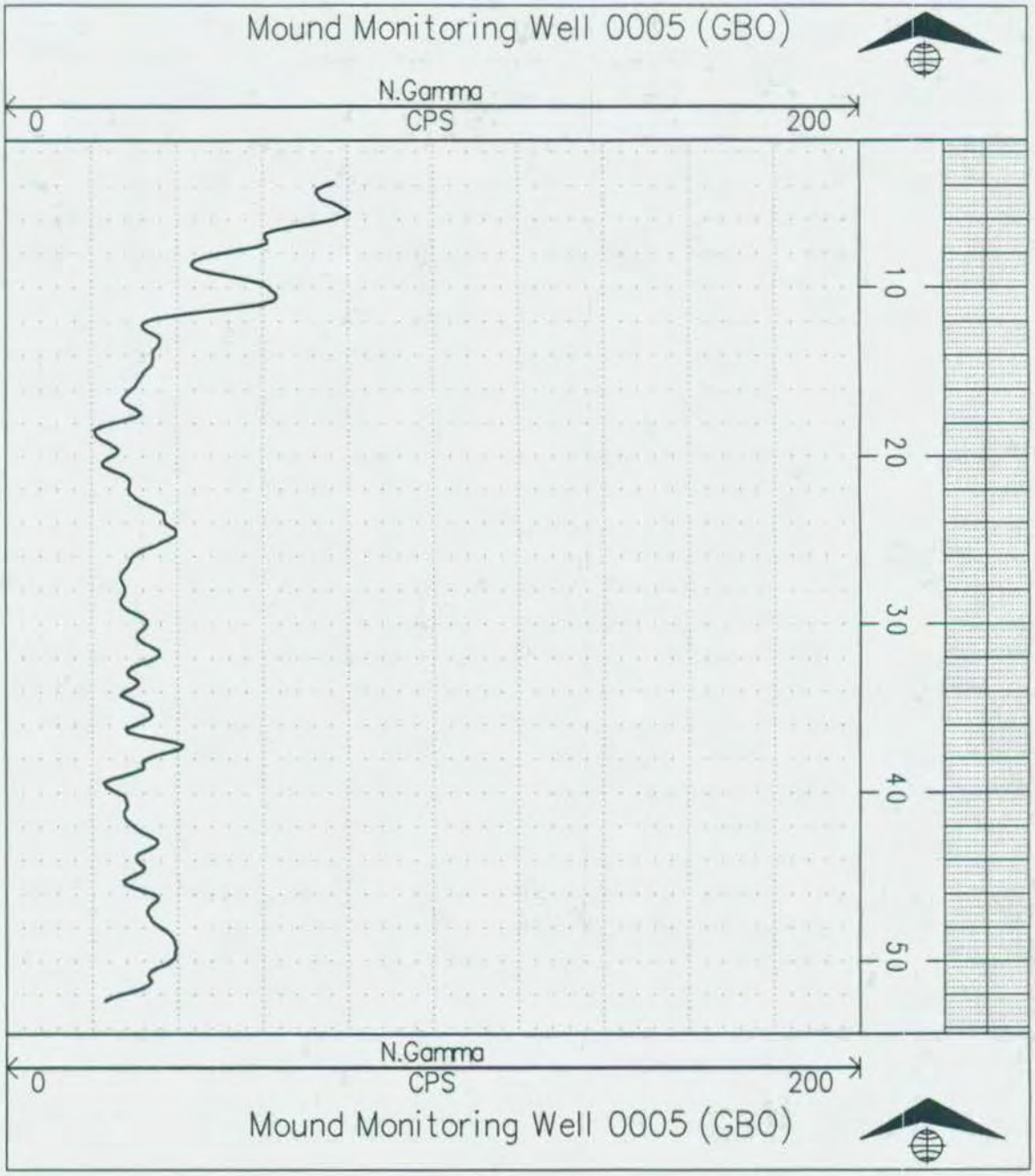

Mound Monitoring Well 0344 (GB1)
N.Gamma
CPS
0
200
0
25
50
75
100
125
150
175
N.Gamma
CPS
0
200
Mound Monitoring Well 0344 (GB1)

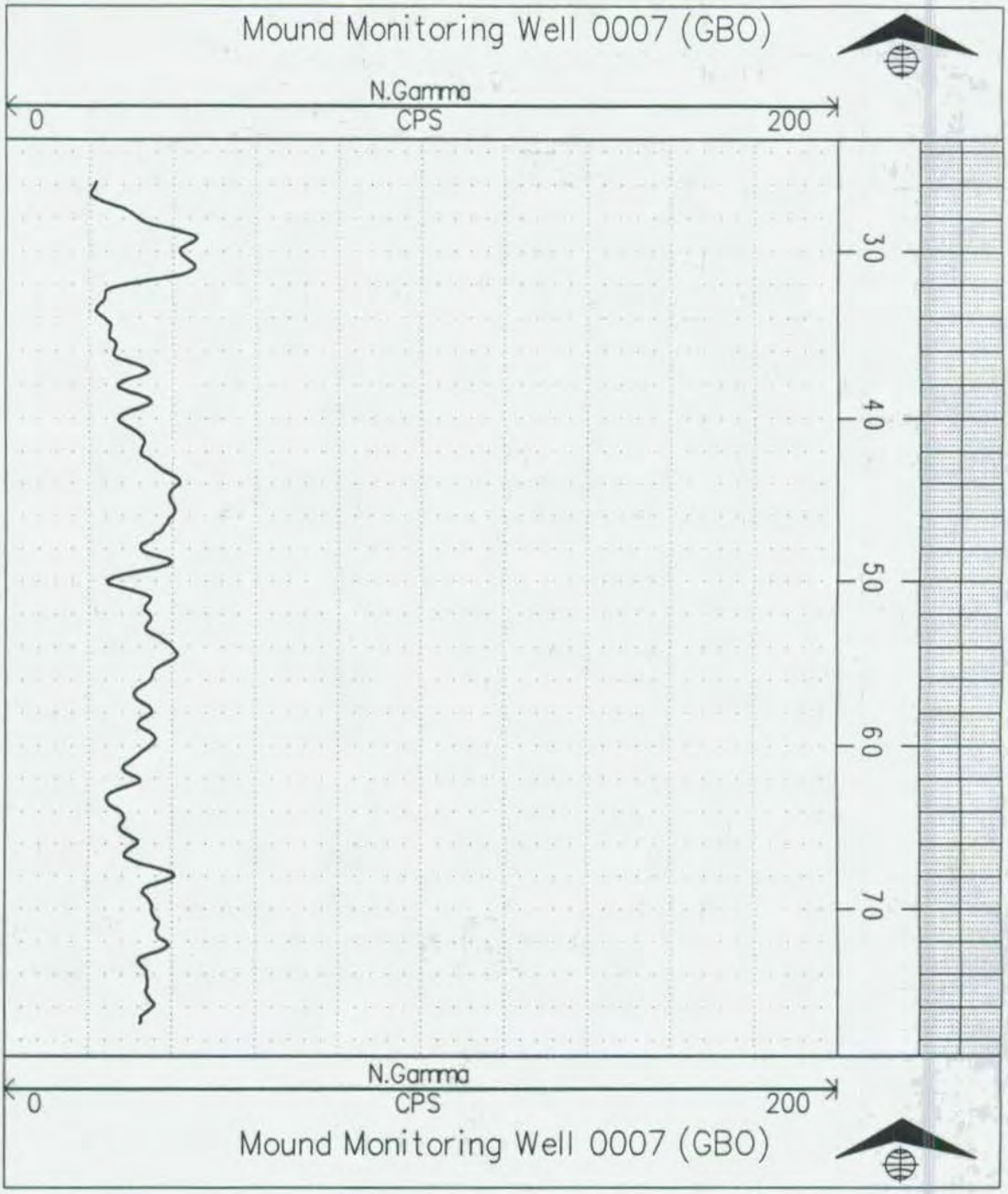

Mound Monitoring Well 0345 (GB1)
N.Gamma
CPS
0
200
10
20
30
40
N.Gamma
CPS
0
200
Mound Monitoring Well 0345 (GB1)

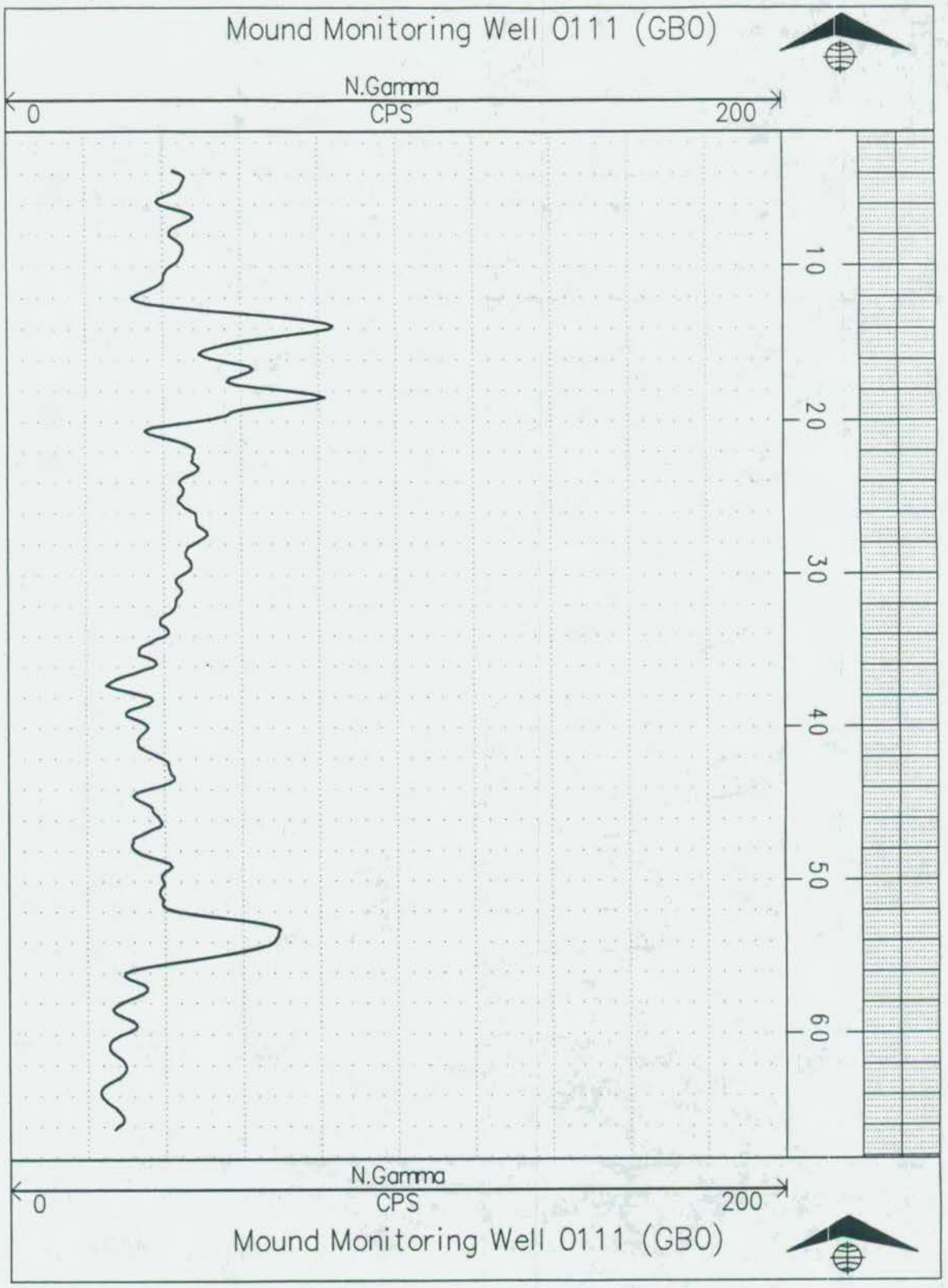

Mound Monitor Well 0346 (GB3)
N.Gamma
0
CPS
200
10
20
30
40
N.Gamma
0
CPS
200
Mound Monitor Well 0346 (GB3)

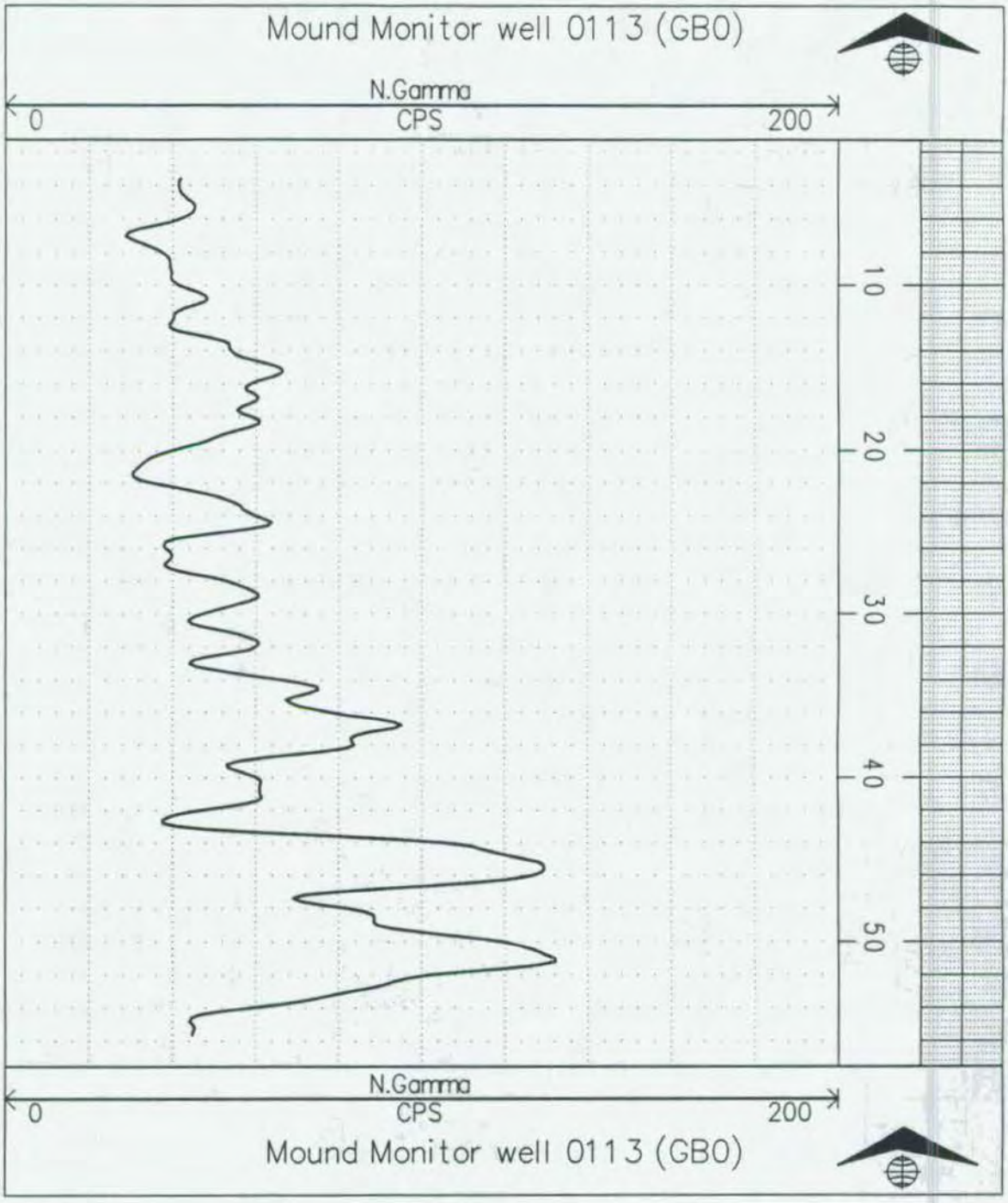

Mound Monitor Well 0347 (GB2)
N.Gamma
CPS
0
200
10
20
30
40
50
60
N.Gamma
CPS
0
200
Mound Monitor Well 0347 (GB2)

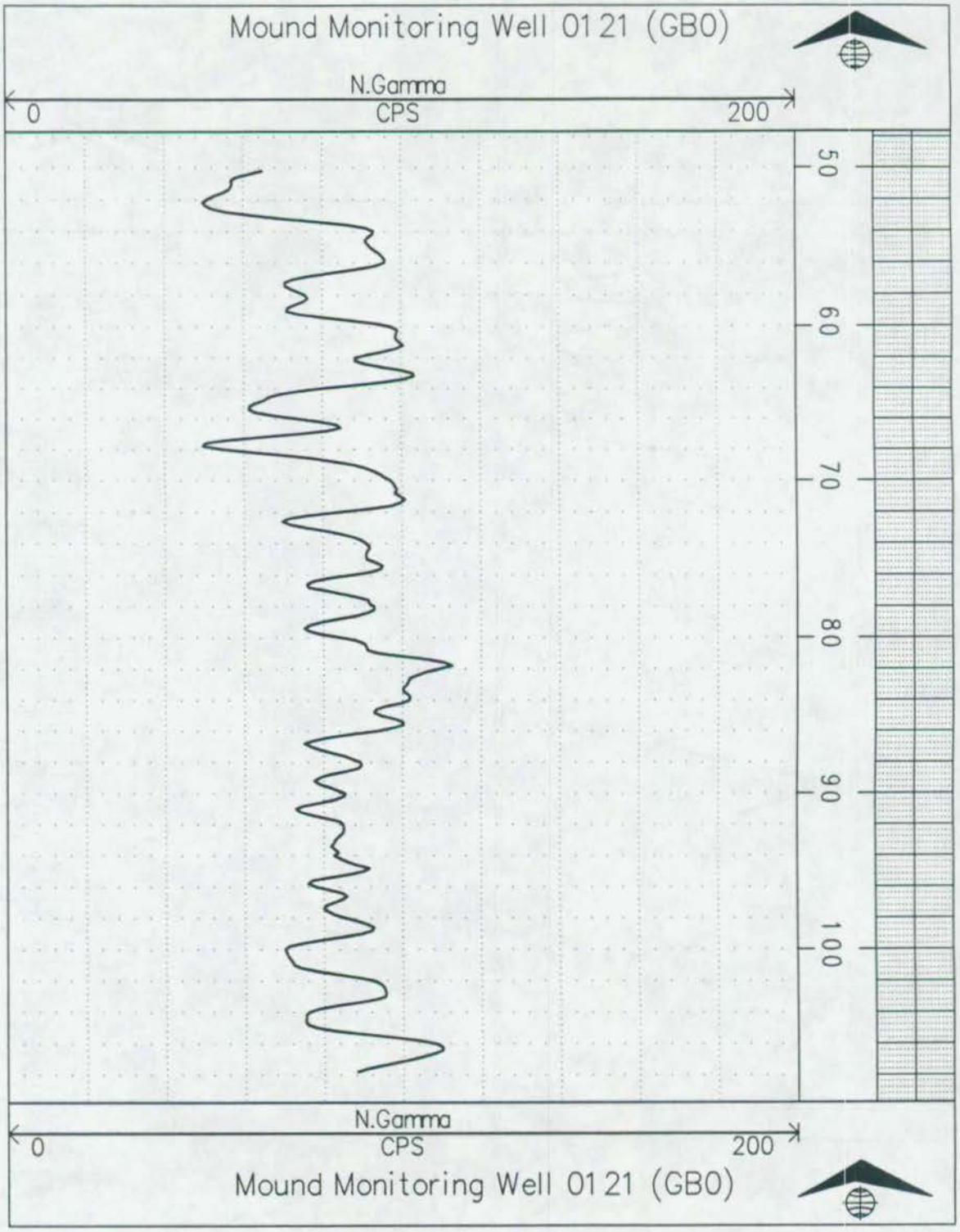
A.3.2. QUALITY ASSURANCE PLOTS

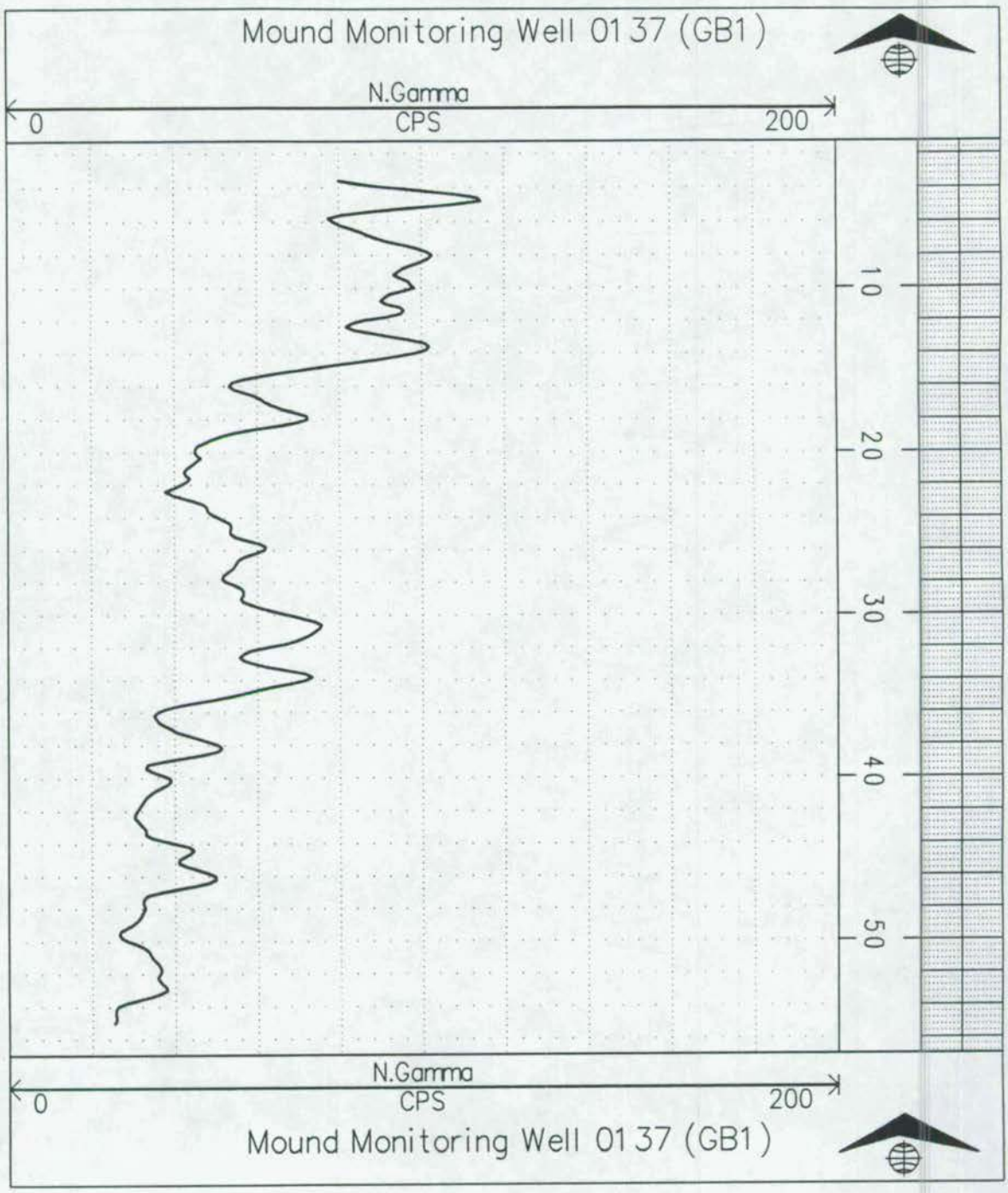

Mound Monitoring Well 0005 (GBO)
N.Gamma
CPS
0
200
10
20
30
40
50
N.Gamma
CPS
0
200
Mound Monitoring Well 0005 (GBO)

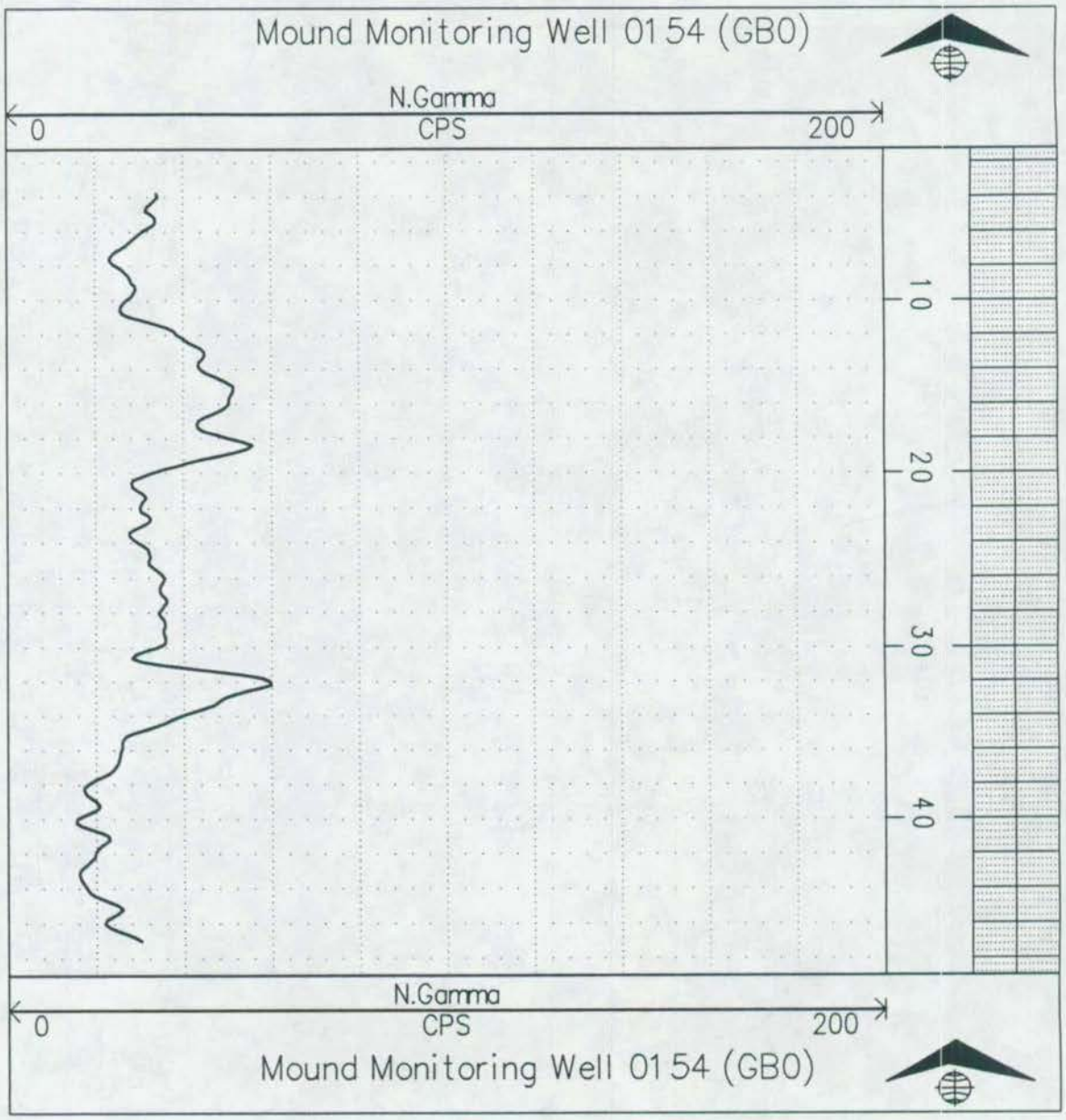

Mound Monitoring Well 0007 (GBO)
N.Gamma
CPS
0
200
30
40
50
60
70
N.Gamma
CPS
0
200
Mound Monitoring Well 0007 (GBO)

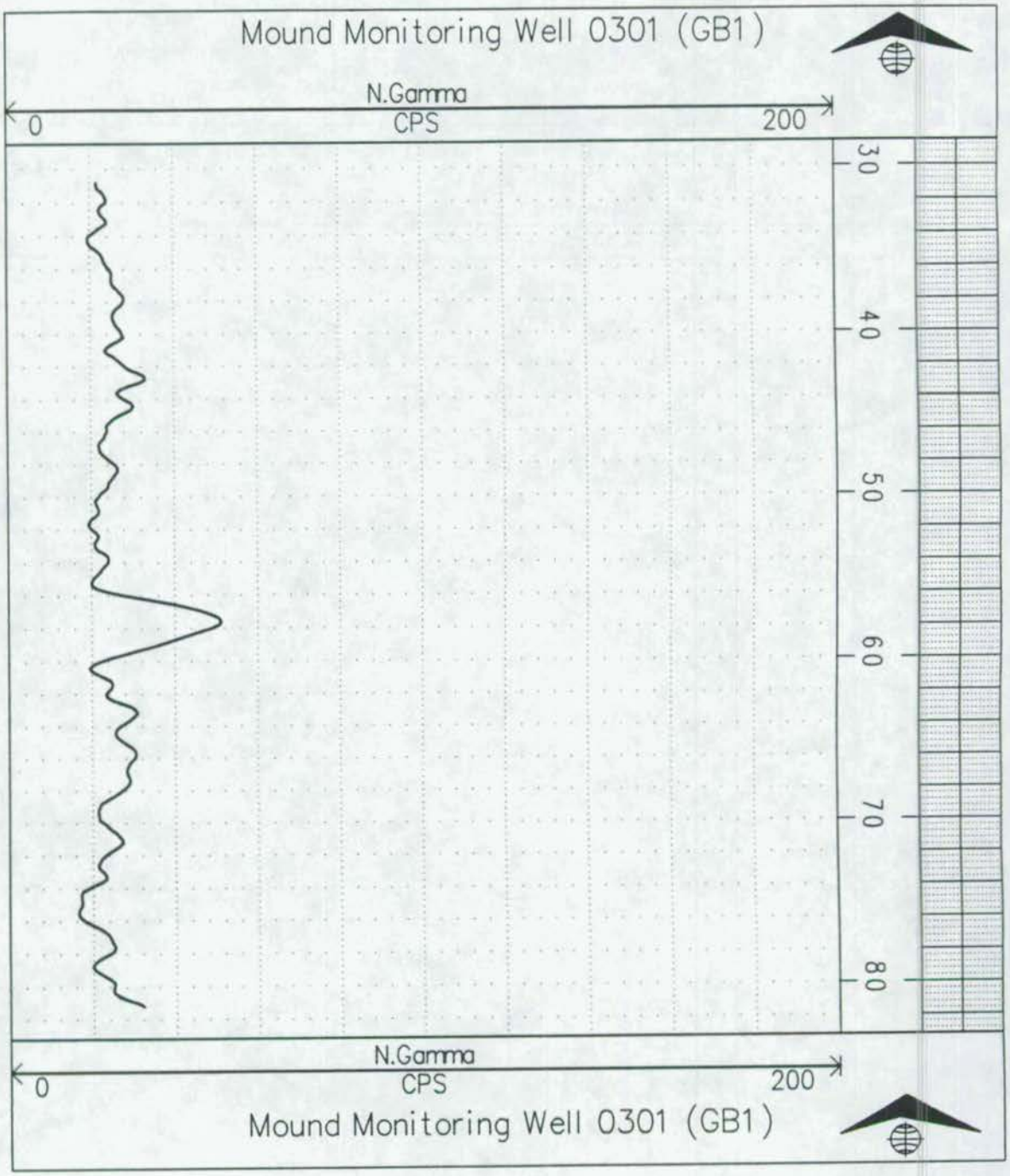

Mound Monitoring Well 0111 (GBO)
N.Gamma
0
CPS
200
10
20
30
40
50
60
N.Gamma
0
CPS
200
Mound Monitoring Well 0111 (GBO)

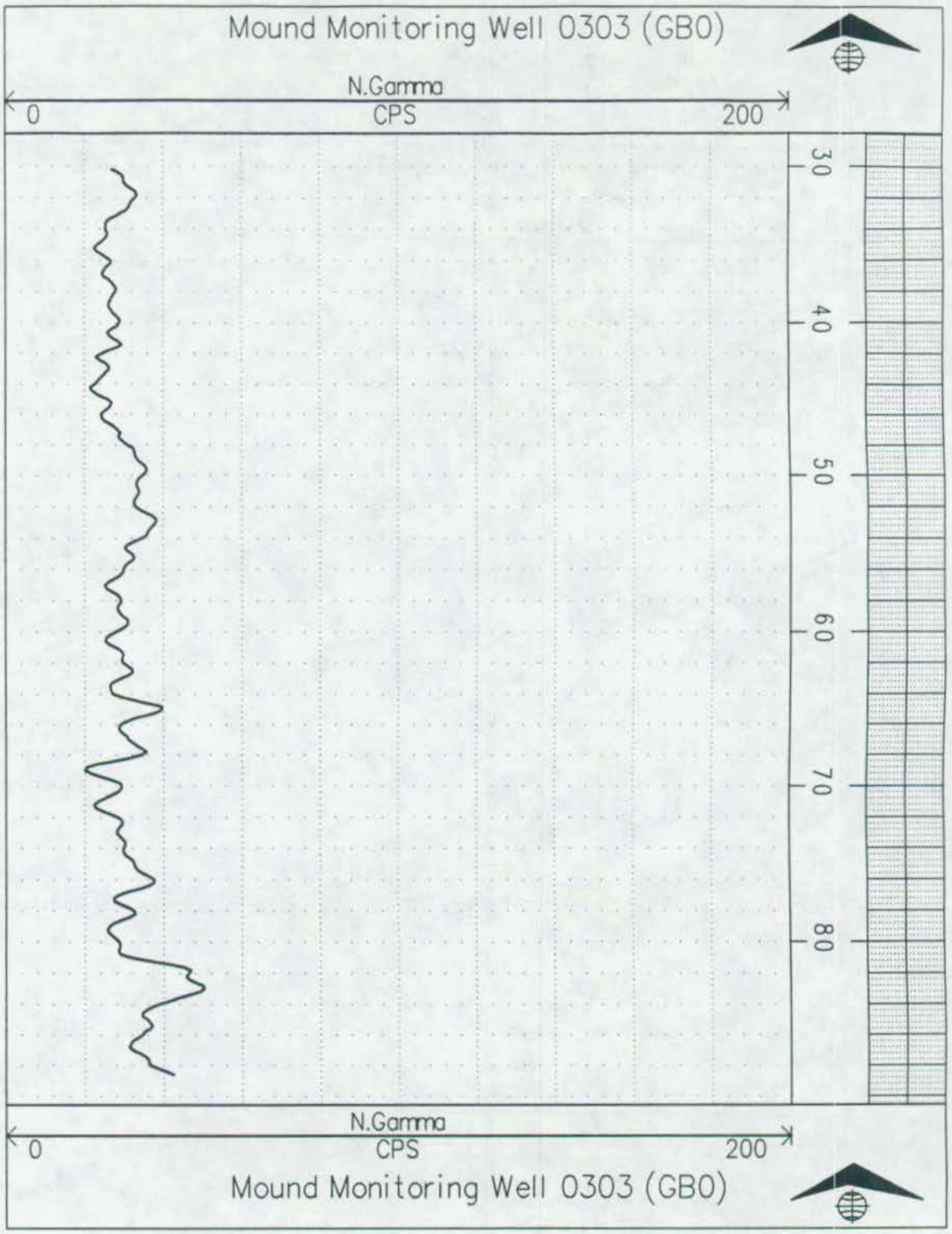

Mound Monitor well 0113 (GBO)
N.Gamma
CPS
0
200
10
20
30
40
50
N.Gamma
CPS
0
200
Mound Monitor well 0113 (GBO)

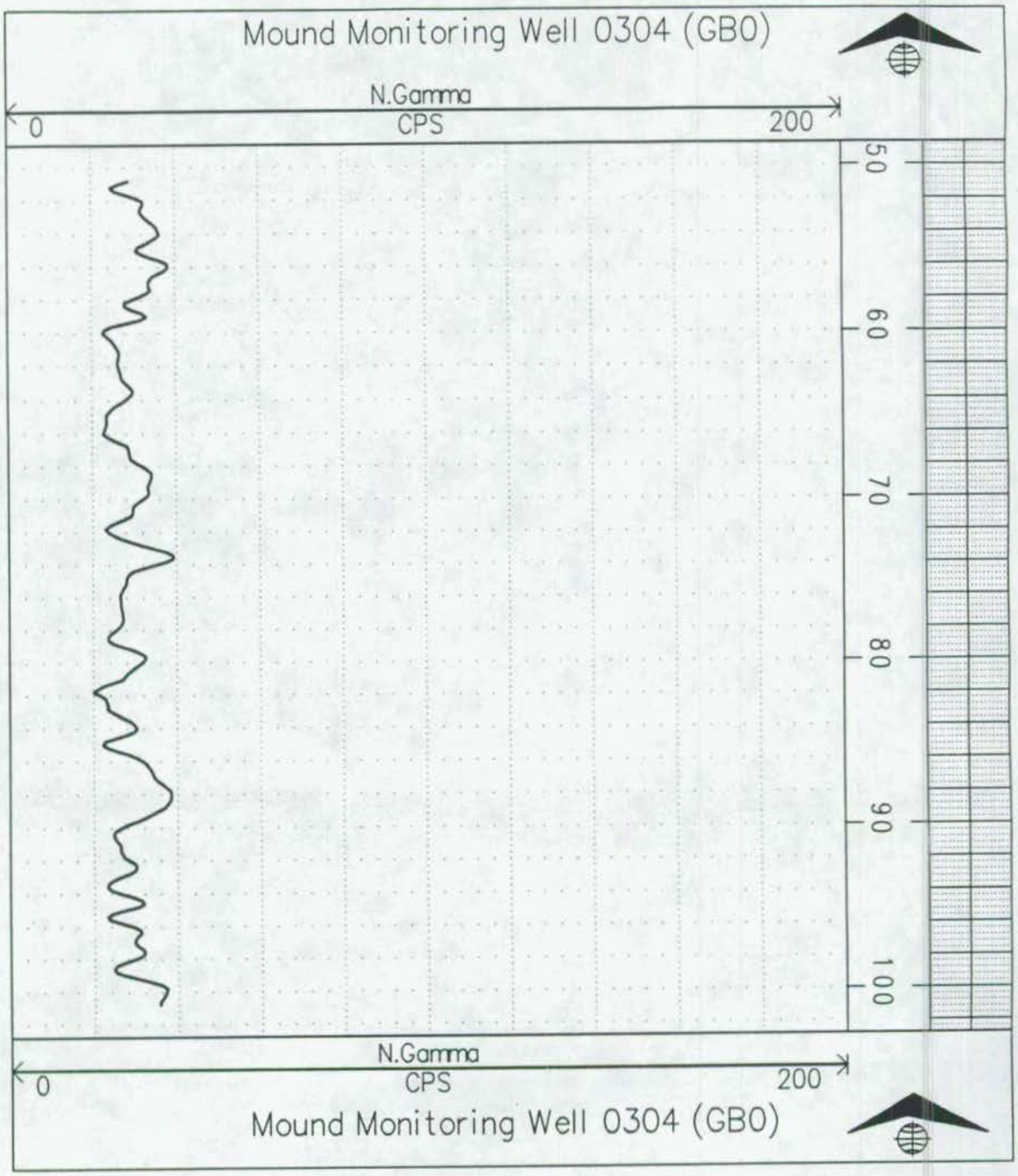

Mound Monitoring Well 0121 (GBO)
N.Gamma
0
CPS
200
50
60
70
80
90
100
N.Gamma
0
CPS
200
Mound Monitoring Well 0121 (GBO)

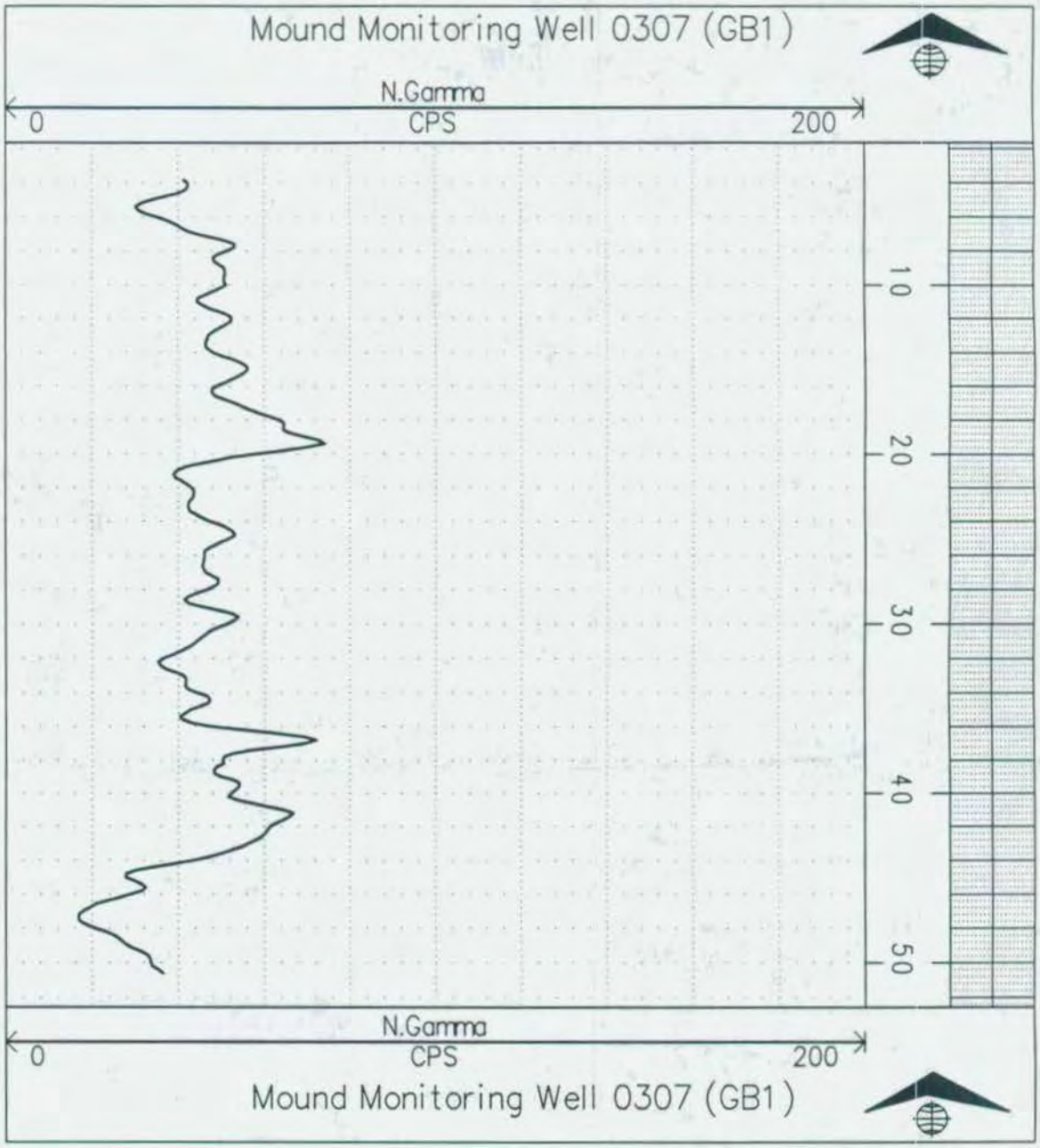

Mound Monitoring Well 0137 (GB1)
N.Gamma
CPS
0
200
10
20
30
40
50
N.Gamma
CPS
0
200
Mound Monitoring Well 0137 (GB1)

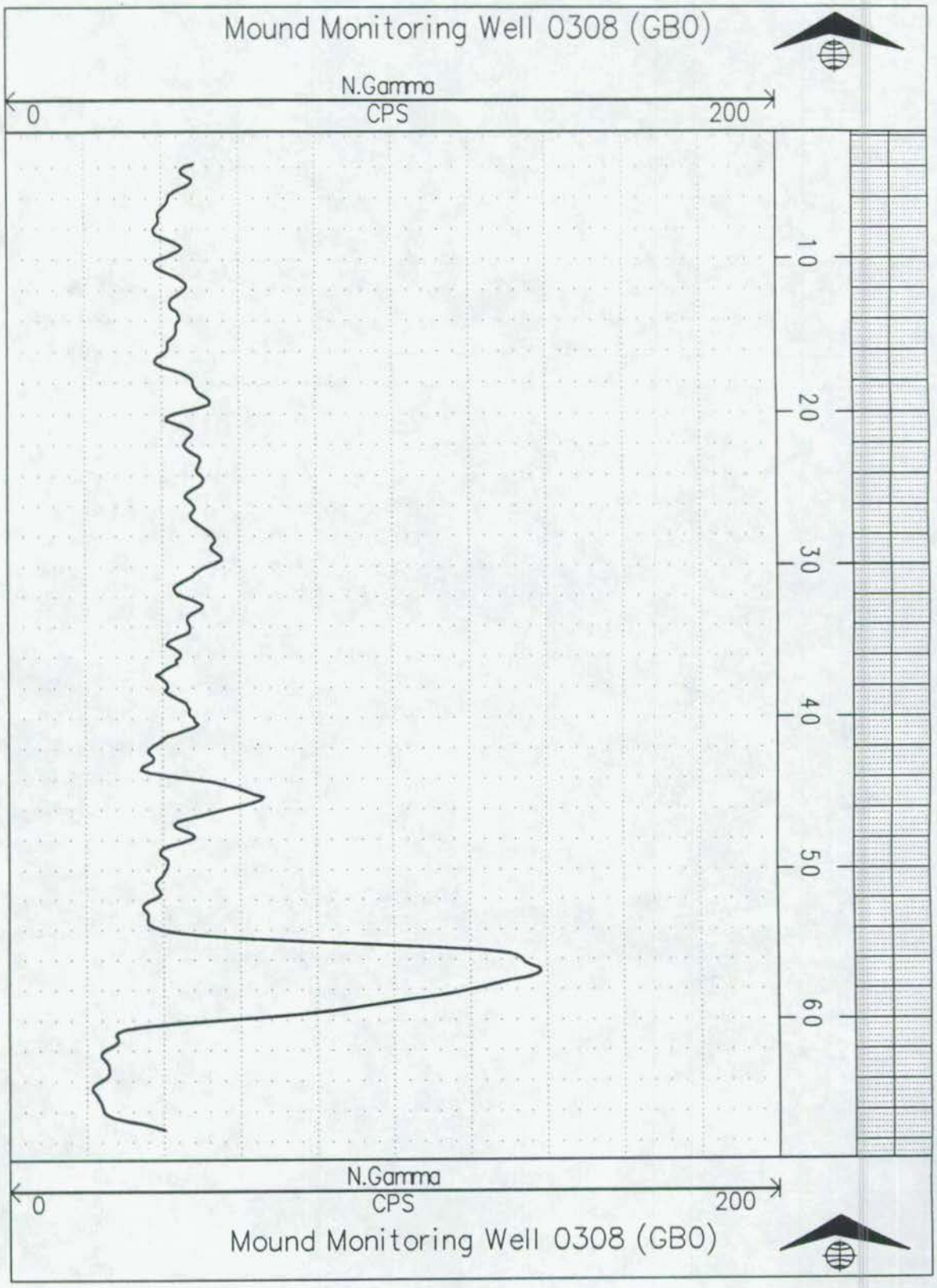

Mound Monitoring Well 0154 (GBO)
N.Gamma
0
CPS
200
10
20
30
40
N.Gamma
0
CPS
200
Mound Monitoring Well 0154 (GBO)

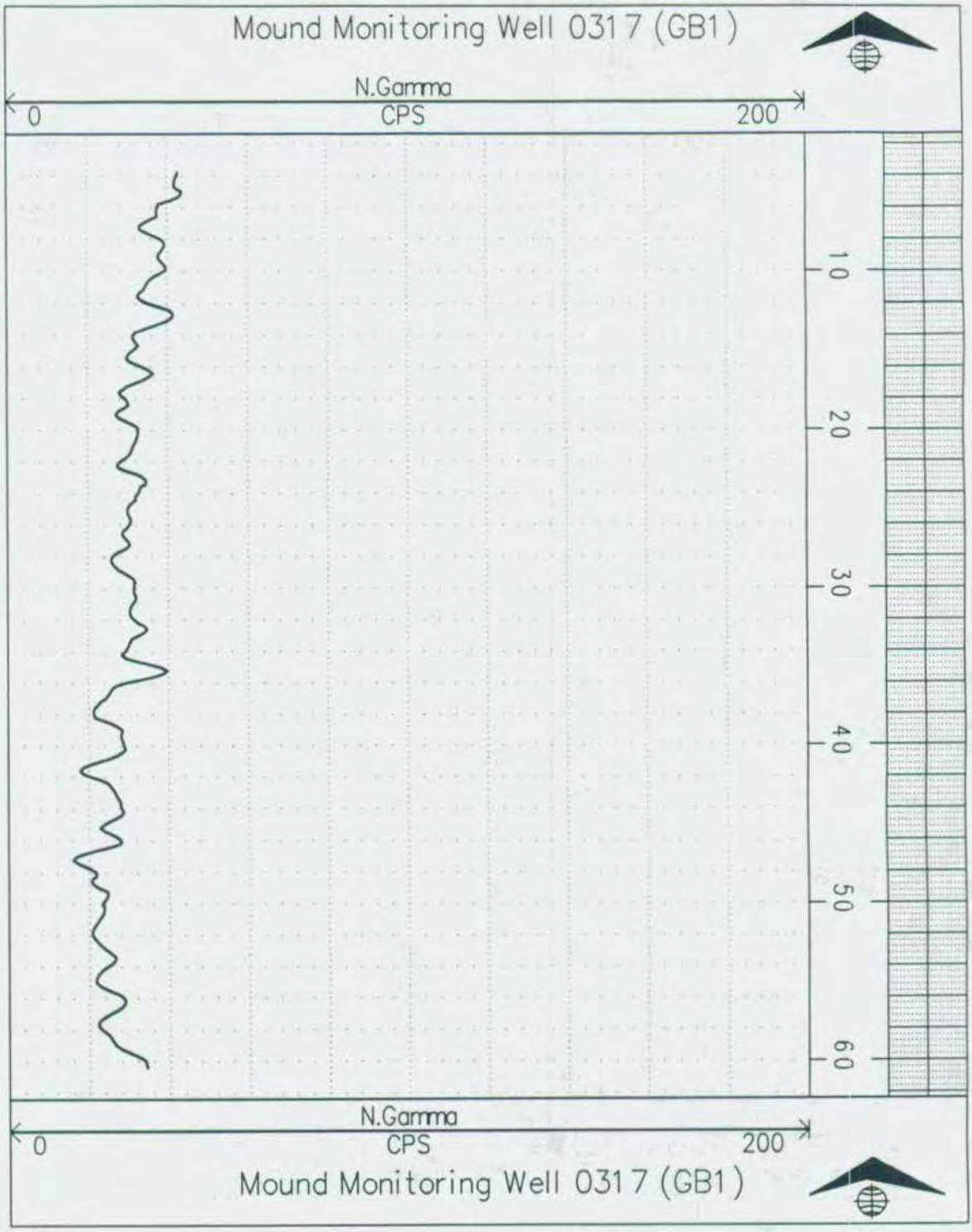

Mound Monitoring Well 0301 (GB1)
N.Gamma
CPS
0
200
30
40
50
60
70
80
N.Gamma
CPS
0
200
Mound Monitoring Well 0301 (GB1)

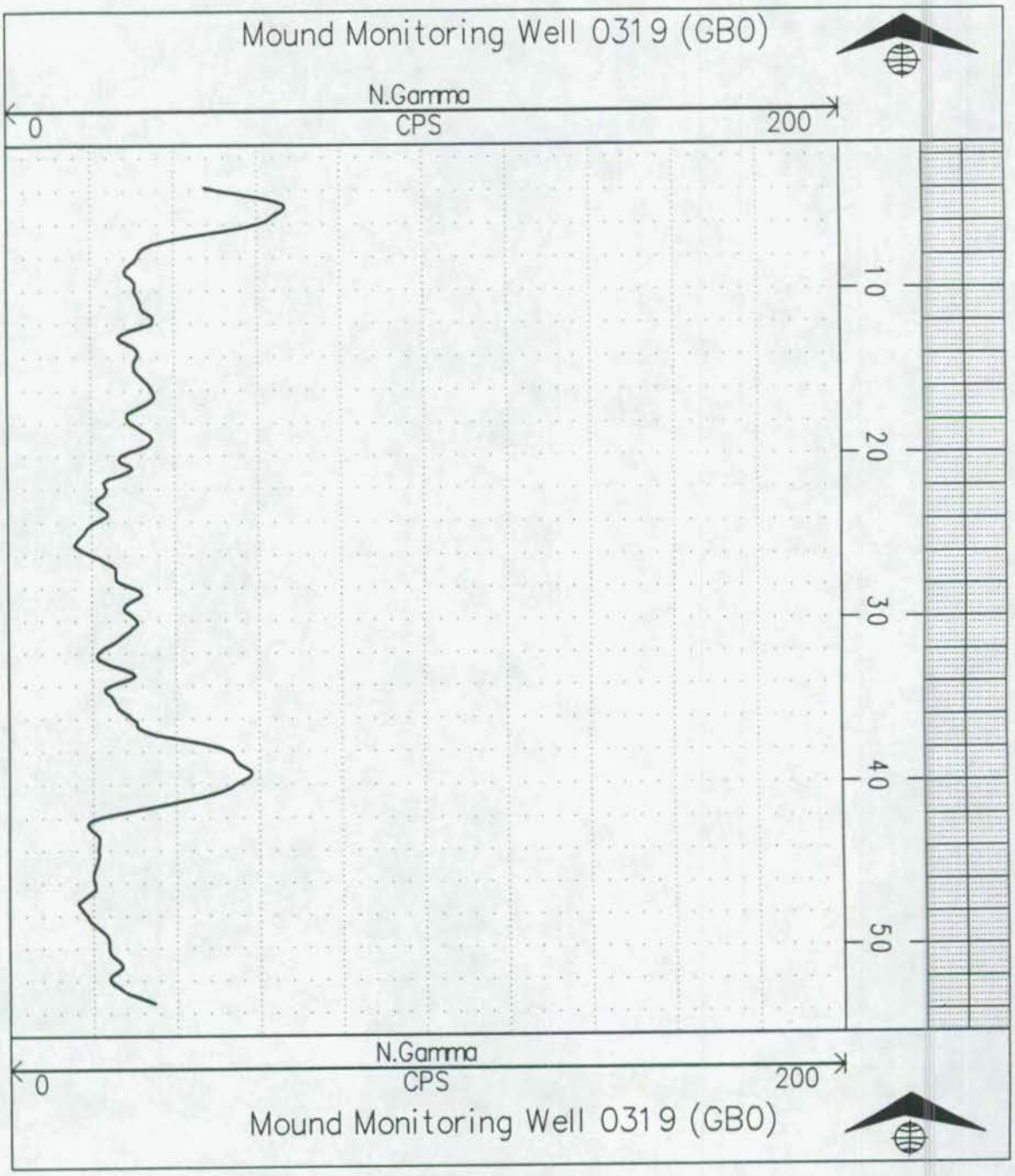

Mound Monitoring Well 0303 (GBO)
N.Gamma
CPS
0
200
30
40
50
60
70
80
N.Gamma
CPS
0
200
Mound Monitoring Well 0303 (GBO)

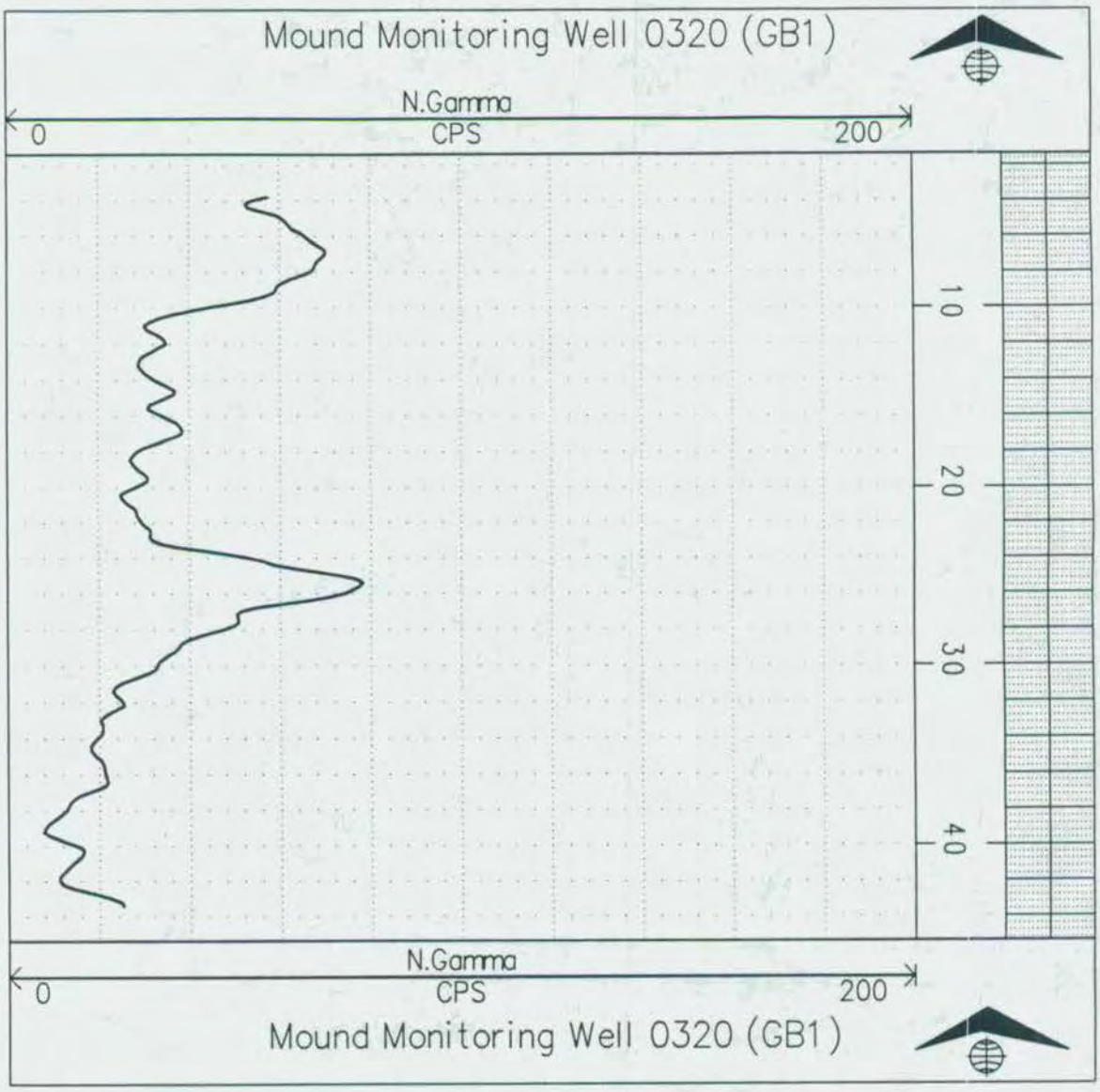

Mound Monitoring Well 0304 (GBO)
N.Gamma
CPS
0
200
50
60
70
80
90
100
N.Gamma
CPS
0
200
Mound Monitoring Well 0304 (GBO)

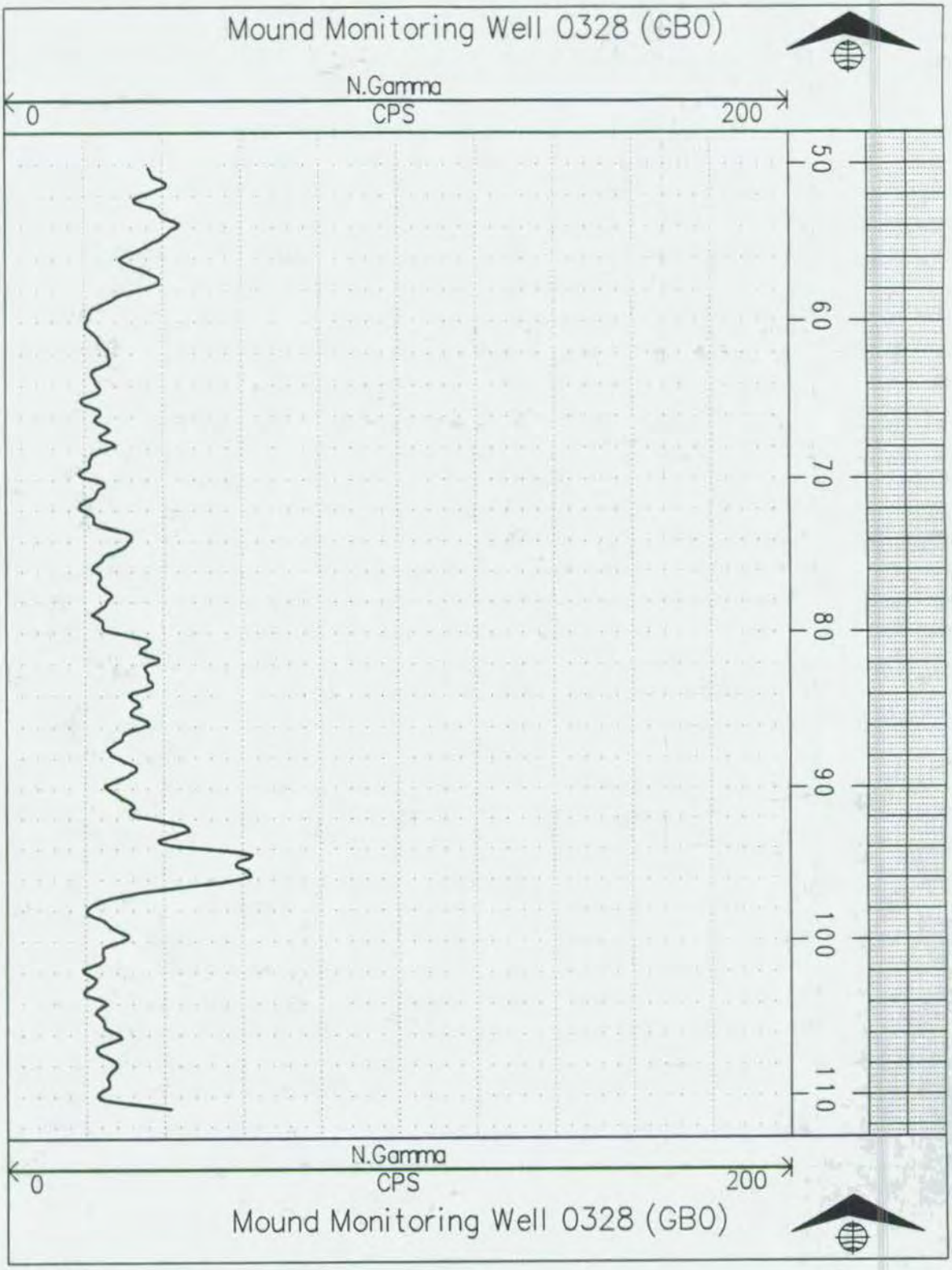

Mound Monitoring Well 0307 (GB1)
N.Gamma
CPS
0
200
10
20
30
40
50
N.Gamma
CPS
0
200
Mound Monitoring Well 0307 (GB1)

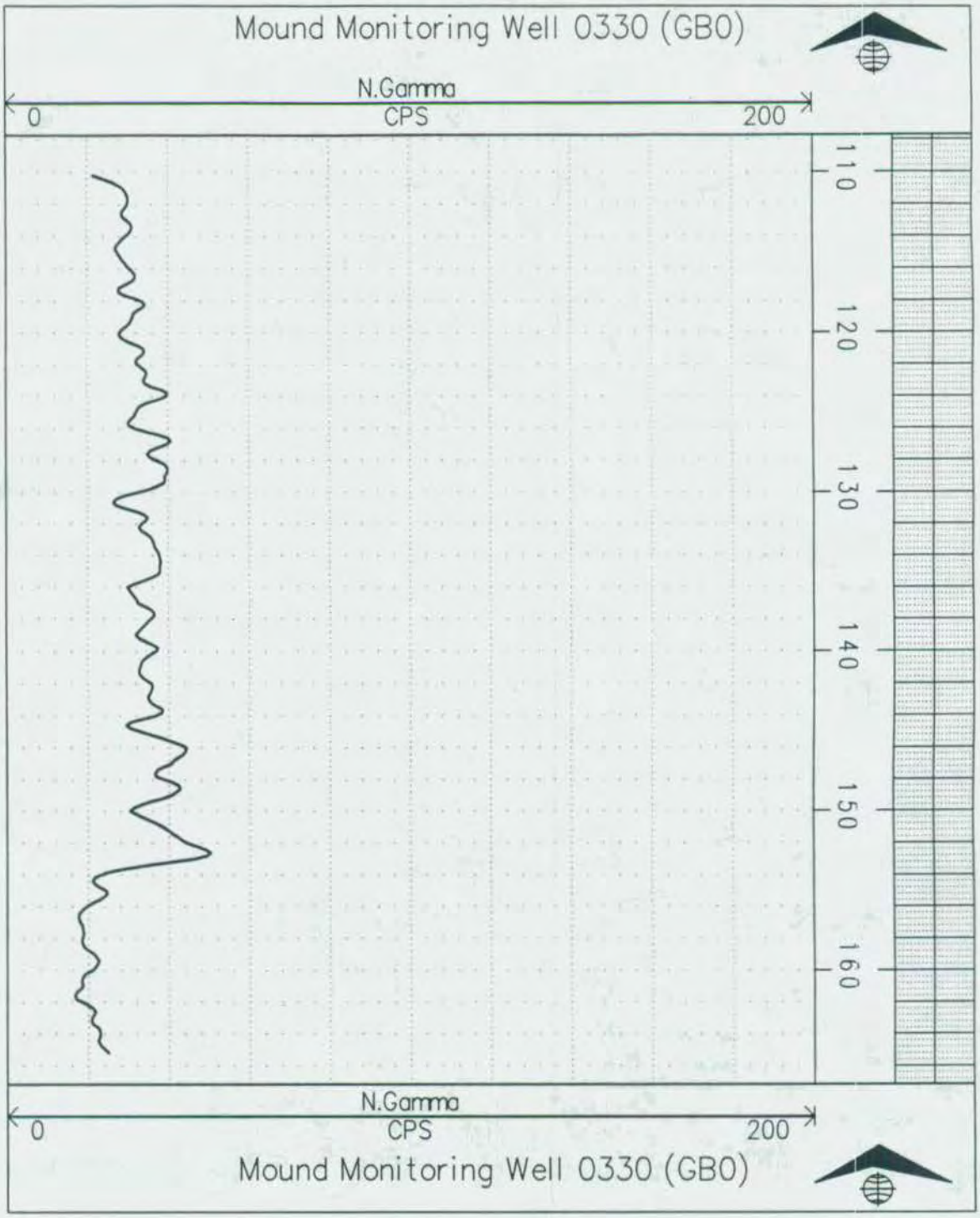

Mound Monitoring Well 0308 (GBO)
N.Gamma
CPS
0
200
10
20
30
40
50
60
N.Gamma
CPS
0
200
Mound Monitoring Well 0308 (GBO)

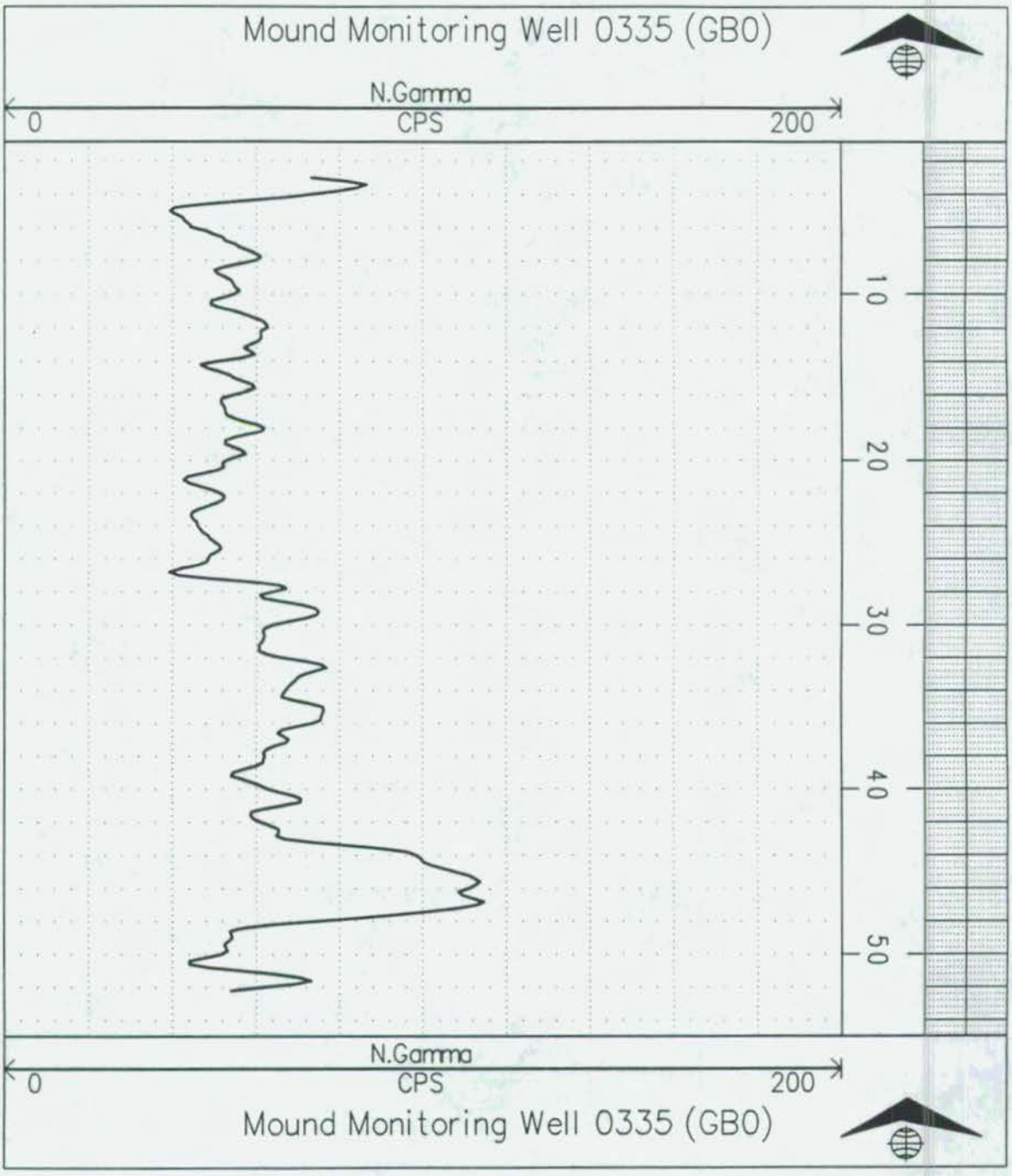

Mound Monitoring Well 0317 (GB1)
N.Gamma
0
CPS
200
10
20
30
40
50
60
N.Gamma
0
CPS
200
Mound Monitoring Well 0317 (GB1)

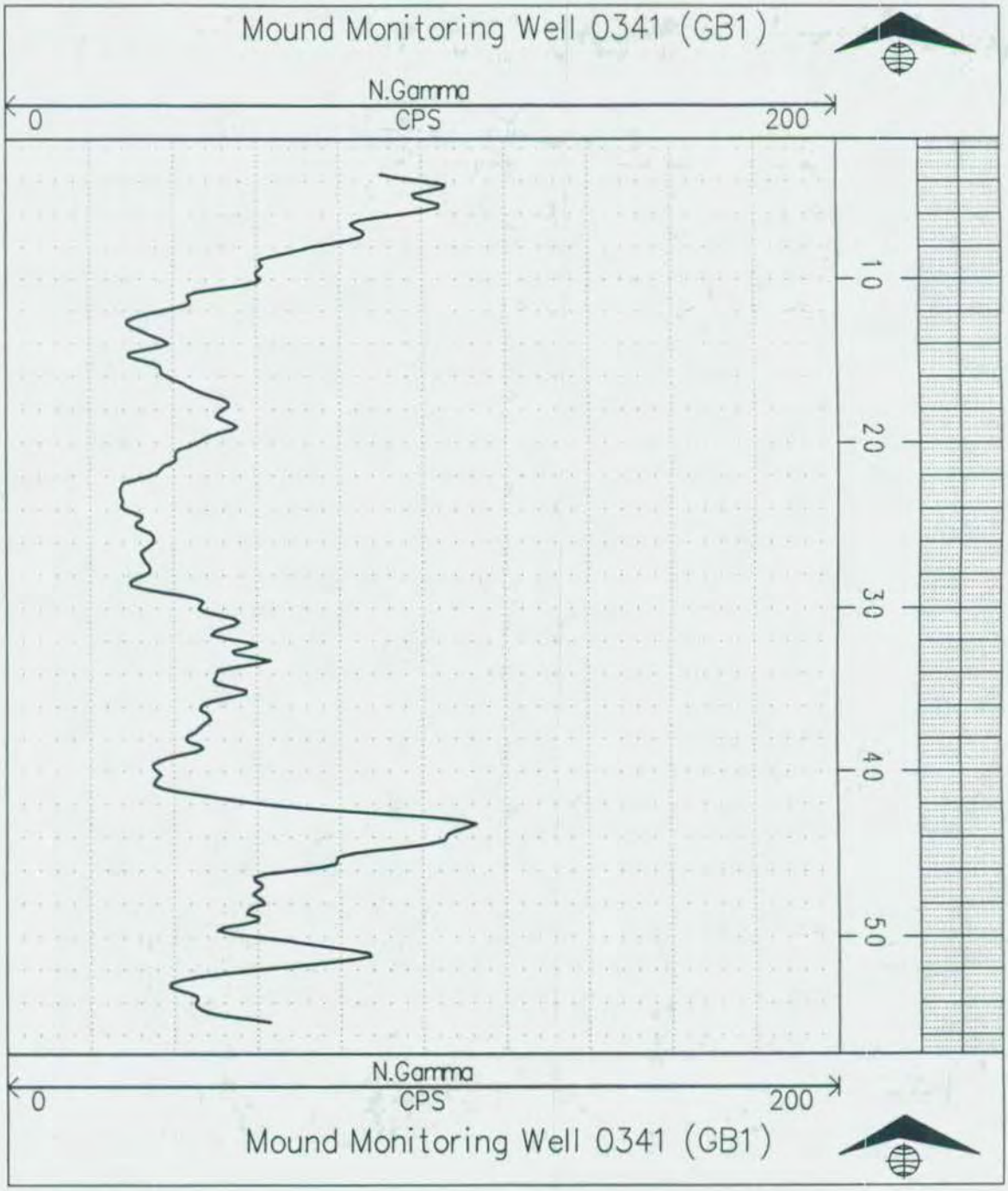

Mound Monitoring Well 0319 (GBO)
N.Gamma
CPS
0
200
10
20
30
40
50
N.Gamma
CPS
0
200
Mound Monitoring Well 0319 (GBO)

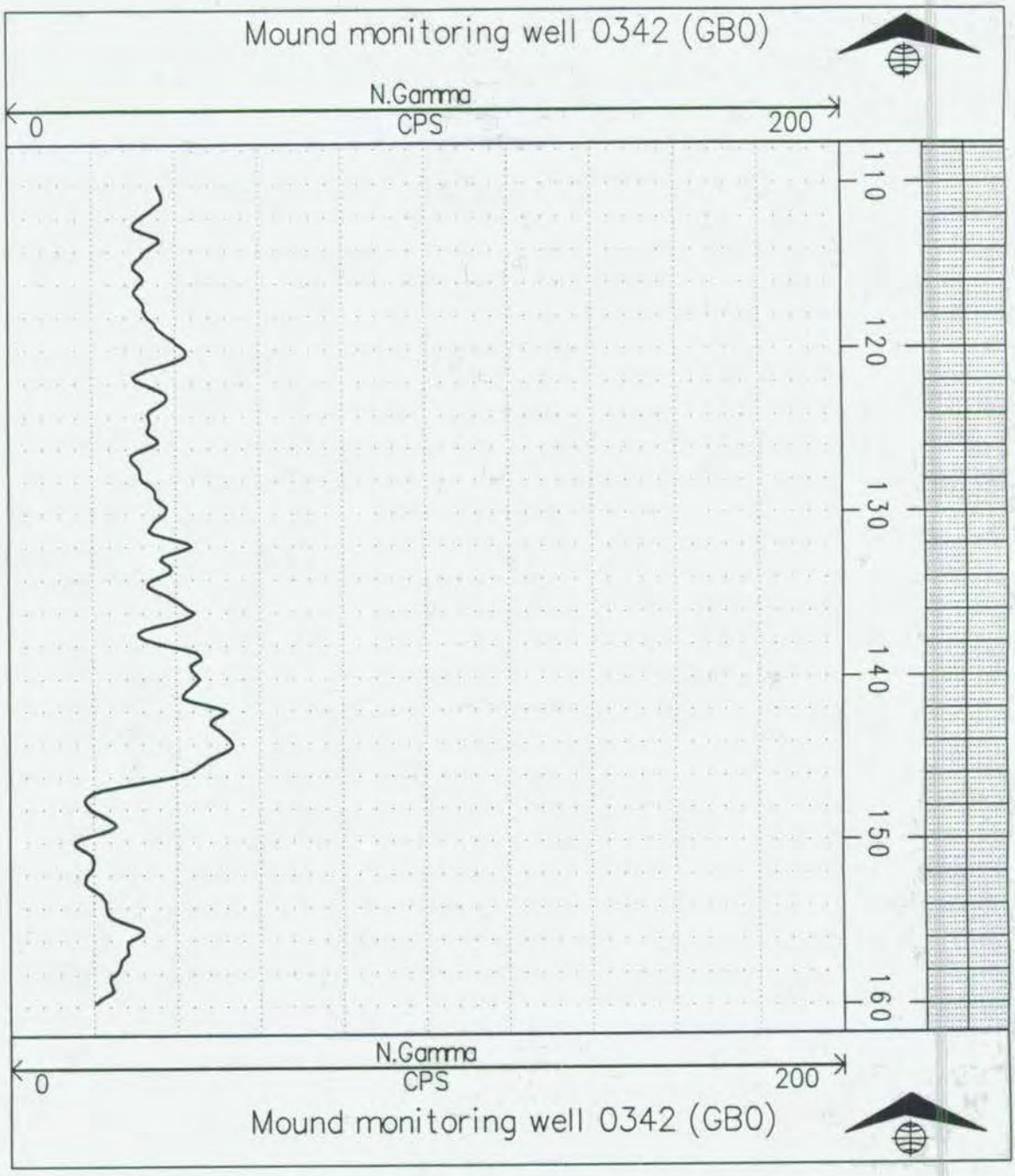

Mound Monitoring Well 0320 (GB1)
N.Gamma
0
CPS
200
10
20
30
40
N.Gamma
0
CPS
200
Mound Monitoring Well 0320 (GB1)

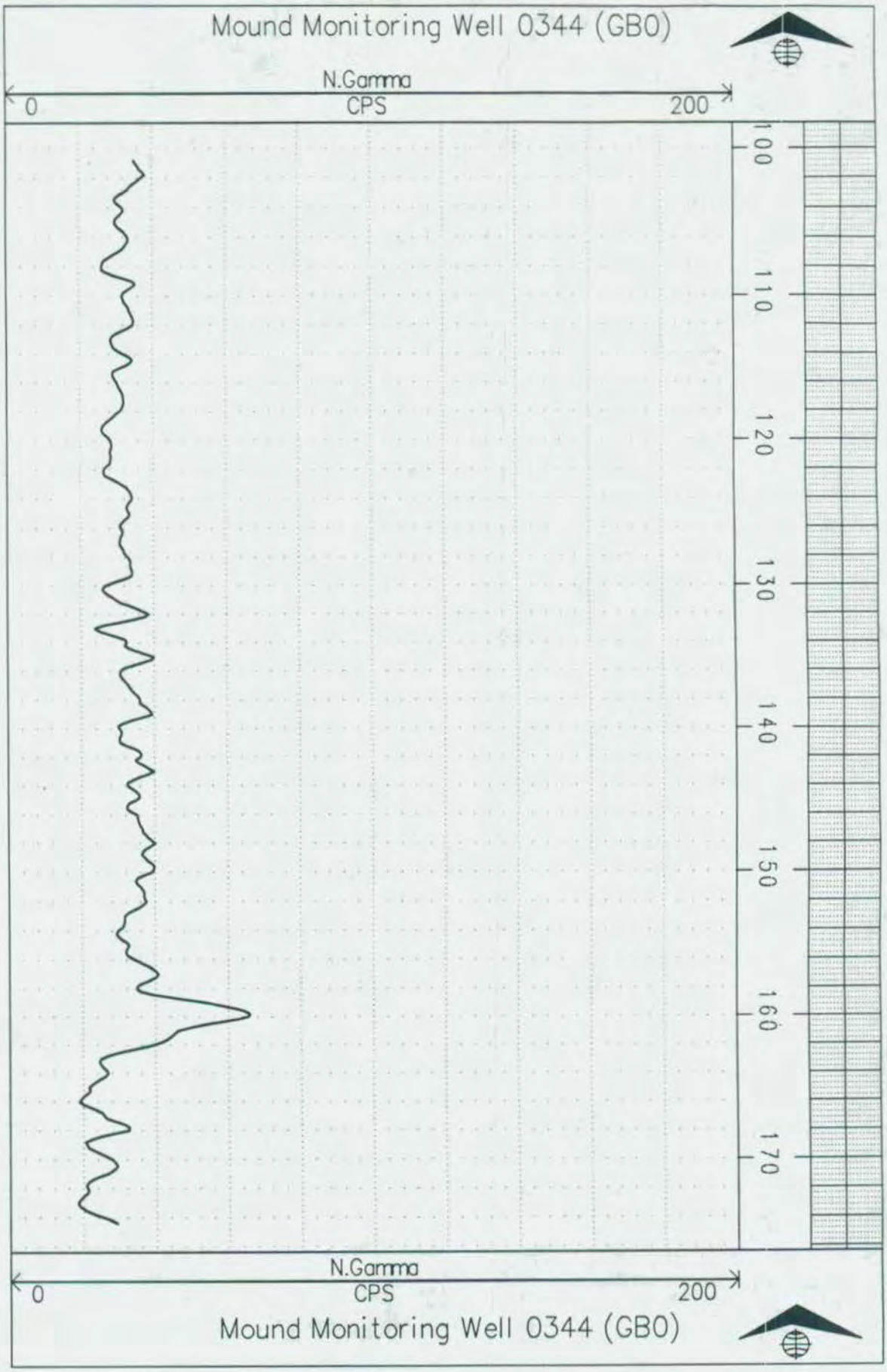

Mound Monitoring Well 0328 (GBO)
N.Gamma
CPS
0
200
50
60
70
80
90
100
110
N.Gamma
CPS
0
200
Mound Monitoring Well 0328 (GBO)

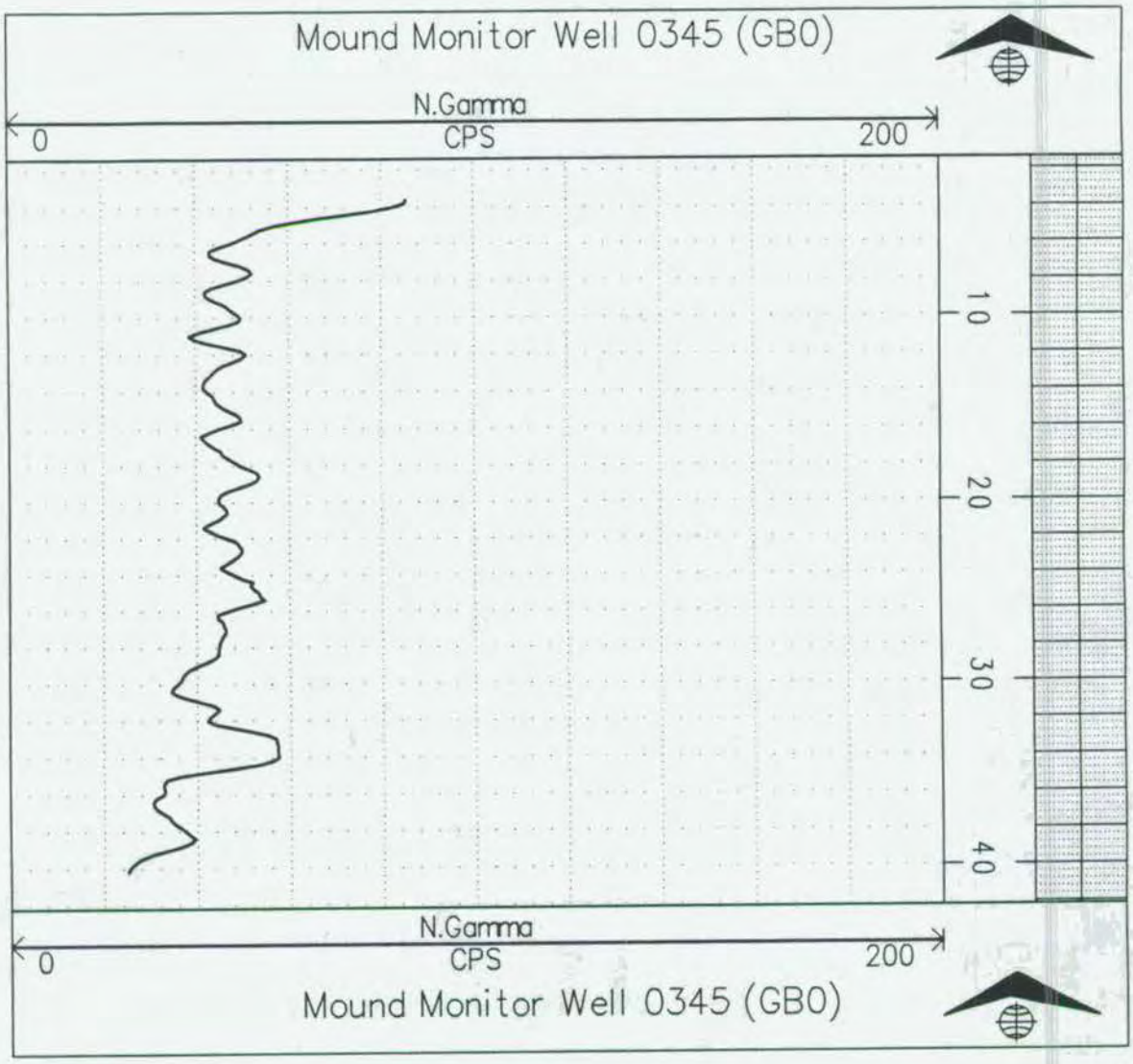

Mound Monitoring Well 0330 (GBO)
N.Gamma
0
CPS
200
110
120
130
140
150
160
N.Gamma
0
CPS
200
Mound Monitoring Well 0330 (GBO)

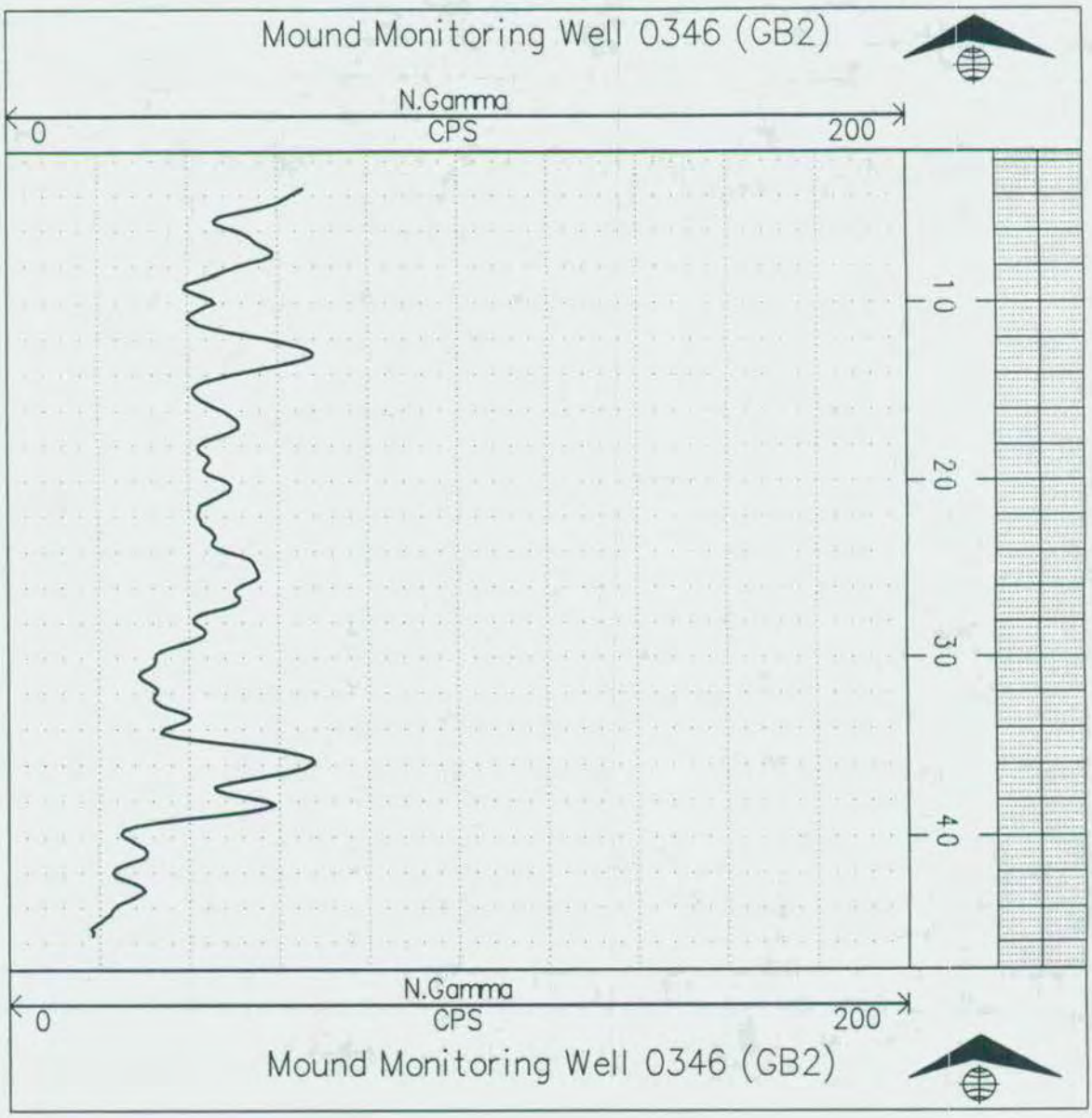

Mound Monitoring Well 0335 (GBO)
N.Gamma
CPS
0
200
10
20
30
40
50
N.Gamma
CPS
0
200
Mound Monitoring Well 0335 (GBO)

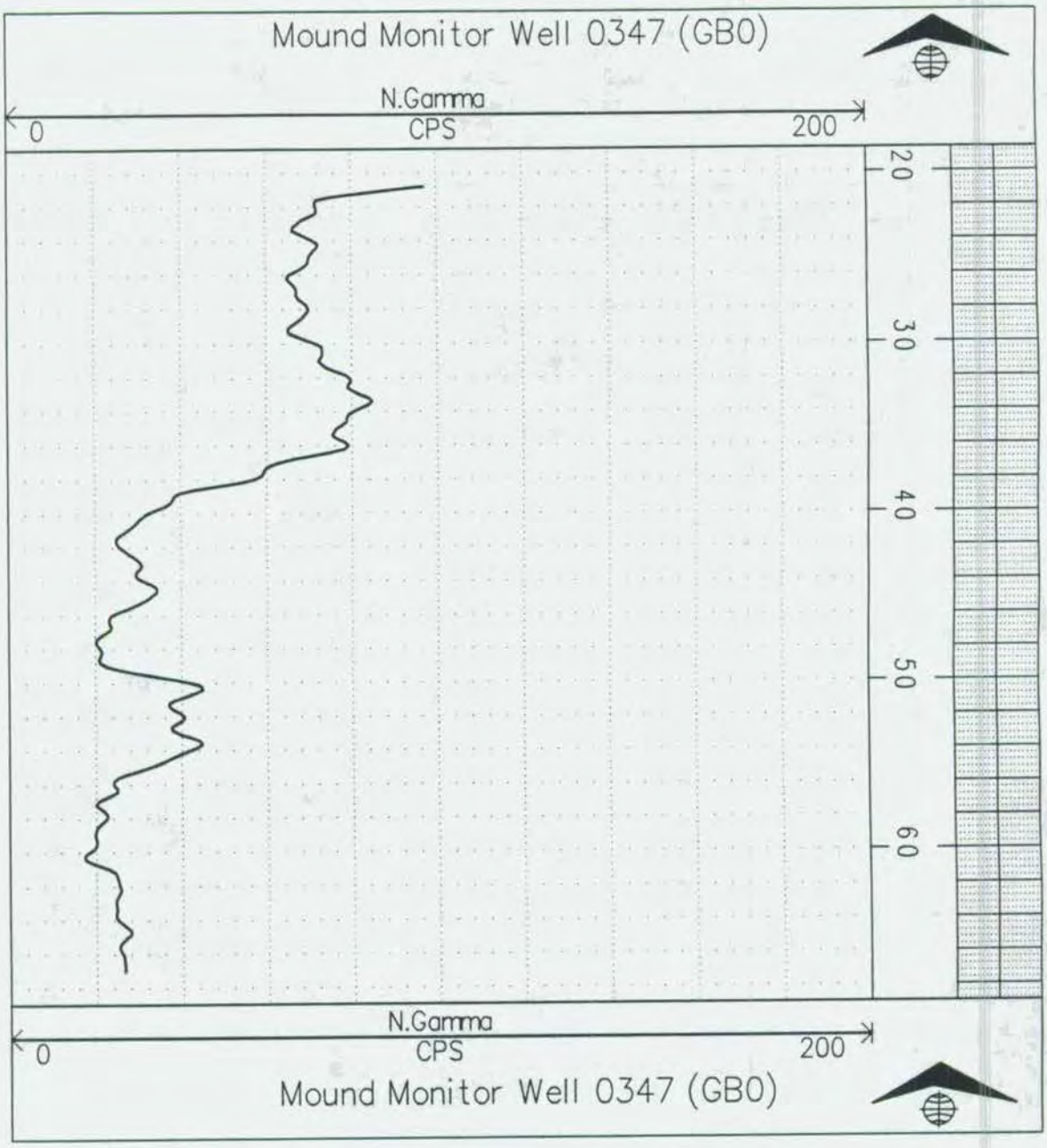

Mound Monitoring Well 0341 (GB1)
N.Gamma
0
CPS
200
10
20
30
40
50
N.Gamma
0
CPS
200
Mound Monitoring Well 0341 (GB1)


Mound monitoring well 0342 (GBO)
N.Gamma
CPS
0
200
110
120
130
140
150
160
N.Gamma
CPS
0
200
Mound monitoring well 0342 (GBO)


Mound Monitoring Well 0344 (GBO)
N.Gamma
CPS
0
200
100
110
120
130
140
150
160
170
N.Gamma
CPS
0
200
Mound Monitoring Well 0344 (GBO)


Mound Monitor Well 0345 (GBO)
N.Gamma
0
CPS
200
10
20
30
40
N.Gamma
0
CPS
200
Mound Monitor Well 0345 (GBO)

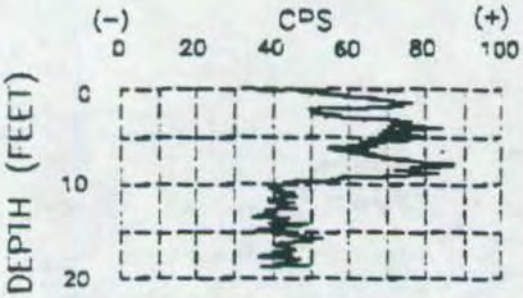

Mound Monitoring Well 0346 (GB2)
N.Gamma
0
CPS
200
10
20
30
40
N.Gamma
0
CPS
200
Mound Monitoring Well 0346 (GB2)


Mound Monitor Well 0347 (GBO)
N.Gamma
CPS
0
200
20
30
40
50
60
N.Gamma
CPS
0
200
Mound Monitor Well 0347 (GBO)

A.3.3. NATURAL GAMMA FROM ABANDONED WELLS

OW-1

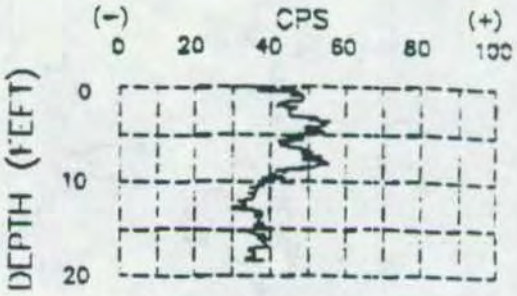
NATURAL GAMMA LOG



Logged: 4/26/93 @ 1026
Depth: 18'
Scale: 2.5/5-5

OW-1

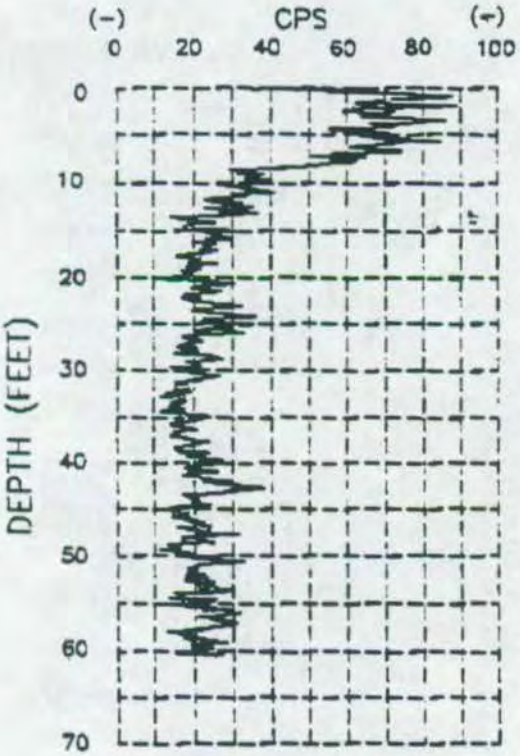
NATURAL GAMMA LOG



Logged: 4/26/93 @ 1033
Depth: 18'
Scale: 5/10-10

OW-2

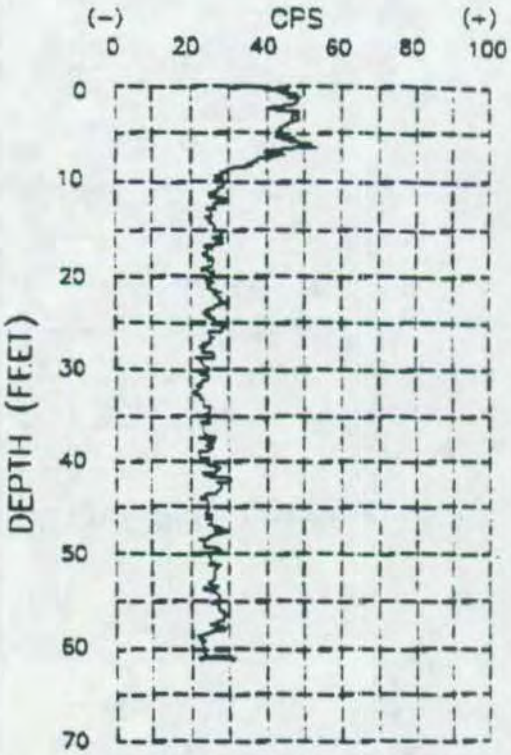
NATURAL GAMMA LOG



Logged: 4/26/93 @ 0940
Depth: 61'
Scale: 2.5/5-5

OW-2

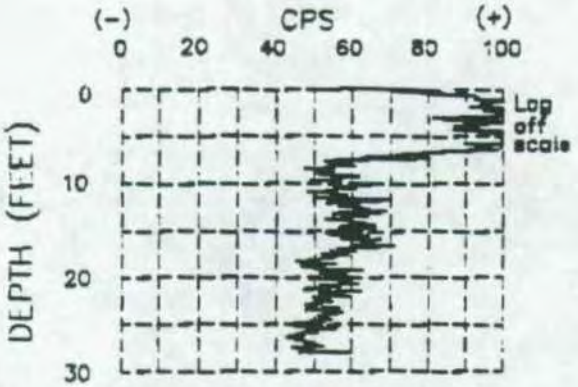
NATURAL GAMMA LOG



Logged: 4/26/93 @ 0955
Depth: 61'
Scale: 5/10-10

OW-3

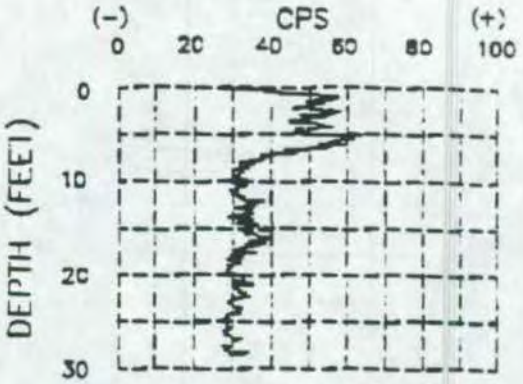
NATURAL GAMMA LOG



Logged: 4/28/93 @ 0815
Depth: 28'
Scale: 2.5/5-5

OW-3

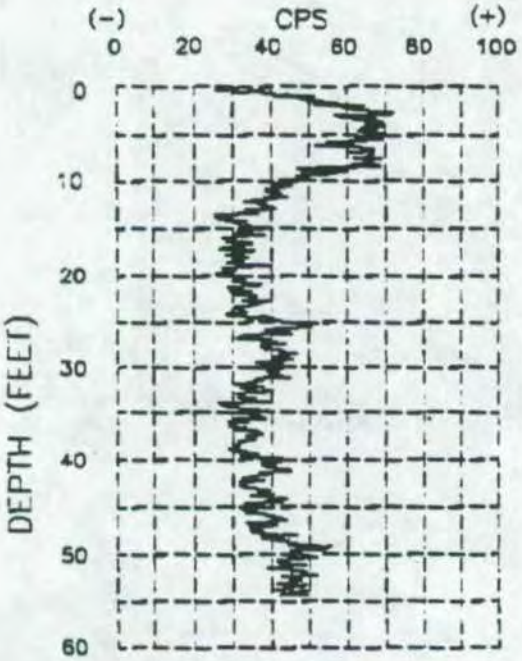
NATURAL GAMMA LOG



Logged: 4/28/93 @ 0830
Depth: 28'
Scale: 5/10-10

OW-4

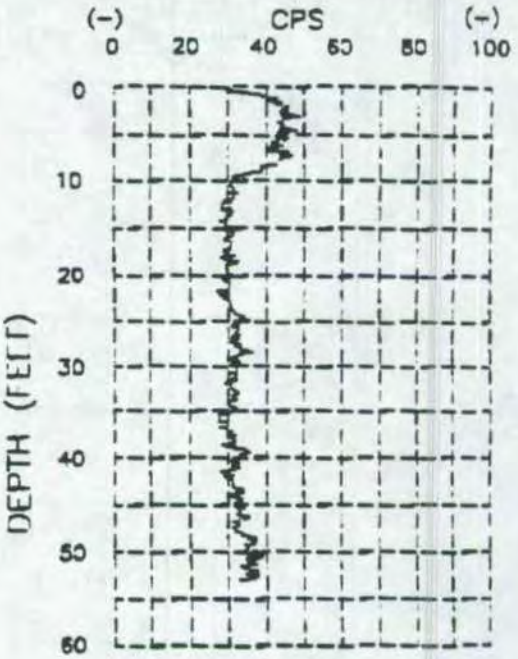
NATURAL GAMMA LOG



Logged: 4/26/93 @ 1103
Depth: 54'
Scale: 2.5/5-5

OW-4

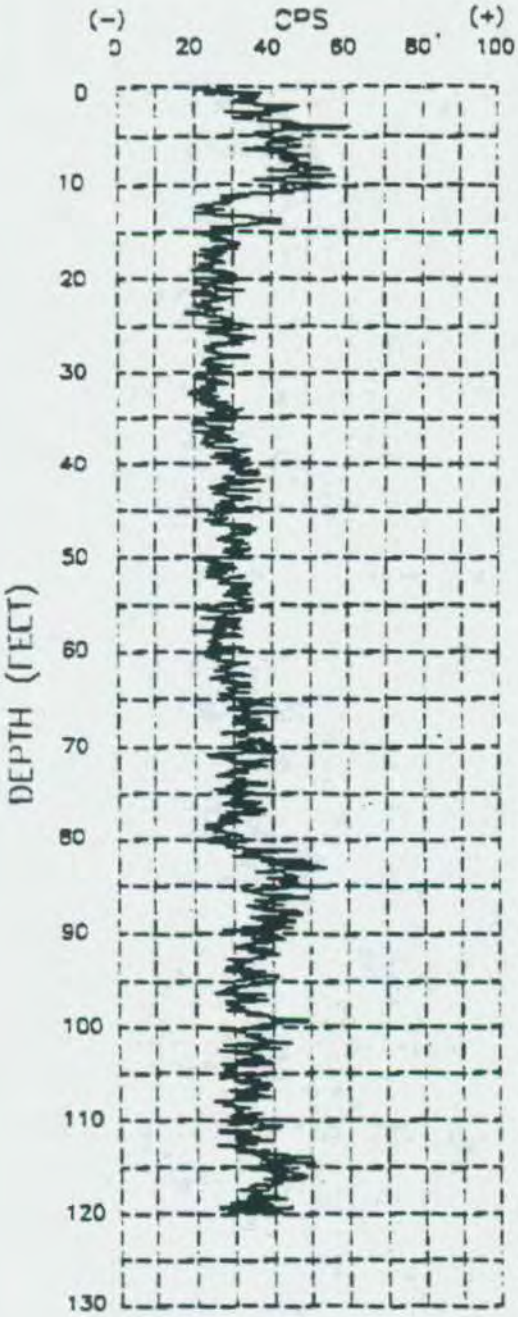
NATURAL GAMMA LOG



Logged: 4/26/93 @ 1111
Depth: 54'
Scale: 5/10-10

OW-6

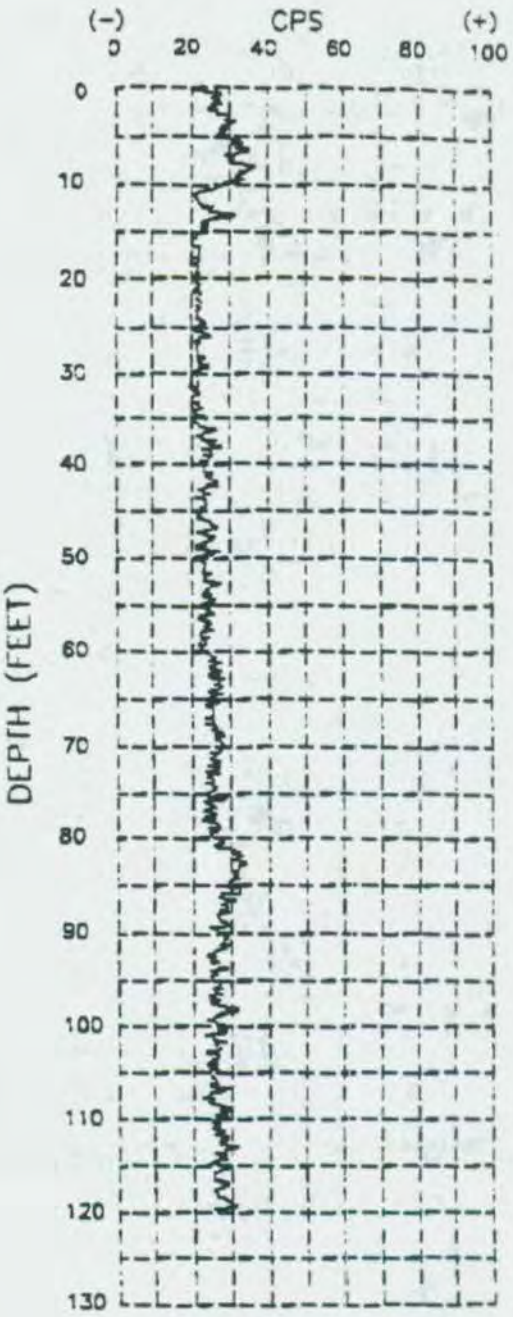
NATURAL GAMMA LOG



Logged: 4/28/93 @ 0900
Depth: 121'
Scale: 2.5/5-5

OW-6

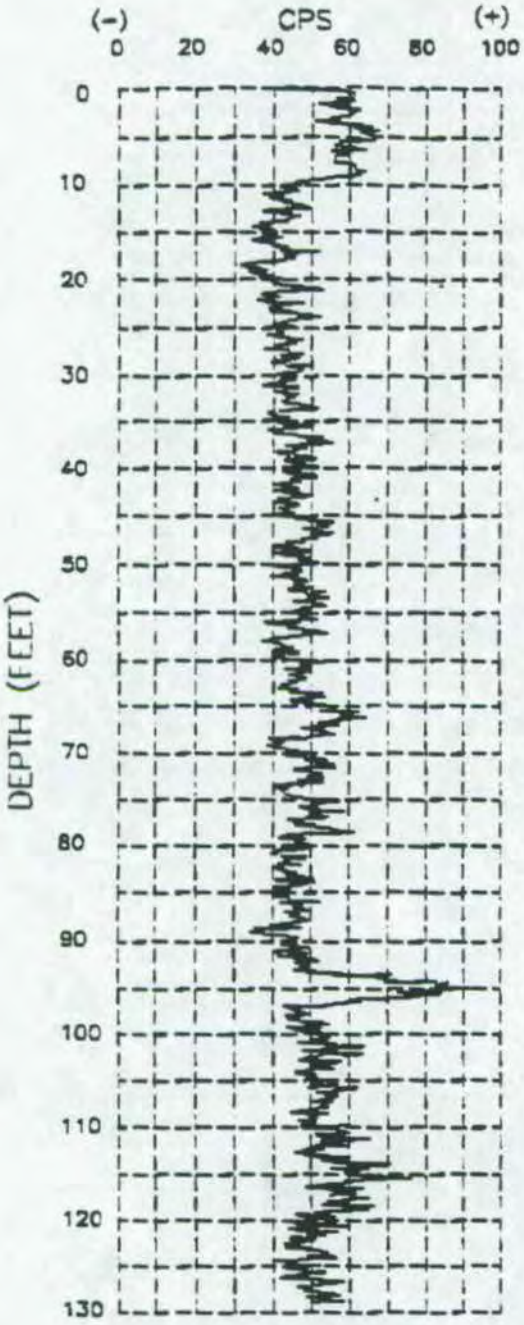
NATURAL GAMMA LOG



Logged: 4/28/93 @ 0932
Depth: 121'
Scale: 5/10-10

OW-8

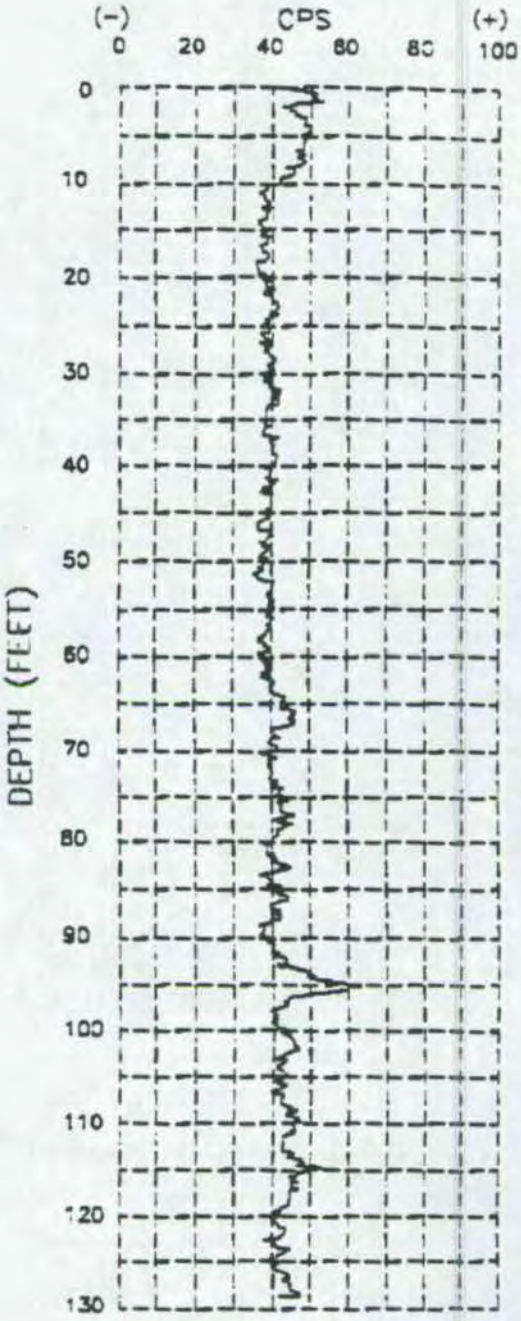
NATURAL GAMMA LOG



Logged: 4/27/93 @ 1545
Depth: 129'
Scale: 2.5/5-5

OW-8

NATURAL GAMMA LOG



Logged: 4/27/93 @ 1600
Depth: 129'
Scale: 5/10-10

A.4. ANALYTICAL RESULTS OF RINSATE SAMPLES FROM NATURAL GAMMA EQUIPMENT

SURFACE WATER QUALITY DATA BY LOCATION
SITE: MND20 MOUND OPERABLE UNIT 9
LOCATION: 0005
NORTH COORDINATE: 597110.75 FT
EAST COORDINATE: 1494205.19 FT
07/13/93 TO 07/13/93
REPORT DATE: 02/14/94

PARAMETER NAME	LOG DATE	SAMPLE ID	UNITS OF MEASURE	PVI	PARAMETER VALUE	DETECTION LIMIT	LAB CODE	DILUTION FACTOR
1,1,1-TRICHLOROETHANE	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	5.	ITA	1.00
1,1,2,2-TETRACHLOROETHANE	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	5.	ITA	1.00
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHA	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	5.	ITA	1.00
1,1,2-TRICHLOROETHANE	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	5.	ITA	1.00
1,1-DICHLOROETHANE	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	5.	ITA	1.00
1,1-DICHLOROETHENE	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	5.	ITA	1.00
1,2-DICHLOROETHANE	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	5.	ITA	1.00
1,2-DICHLOROETHENE	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	5.	ITA	1.00
1,2-DICHLOROPROPANE	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	5.	ITA	1.00
1,2-DIETHYLBENZENE	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	5.	ITA	1.00
1,3-CIS-DICHLOROPROPENE	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	5.	ITA	1.00
1,3-TRANS-DICHLOROPROPENE	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	5.	ITA	1.00
2-BUTANONE	07/13/93	2001	UG/L	ND	-	10.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	10.	ITA	1.00
2-HEXANONE	07/13/93	2001	UG/L	ND	-	10.	ITA	1.00

PARAMETER VALUE INDICATOR (PVI): ND- NOT DETECTED

SURFACE WATER QUALITY DATA BY LOCATION
SITE: MND20 MOUND OPERABLE UNIT 9
LOCATION: 0005
NORTH COORDINATE: 597110.75 FT
EAST COORDINATE: 1494205.19 FT
07/13/93 TO 07/13/93
REPORT DATE: 02/14/94

PARAMETER NAME	LOG DATE	SAMPLE ID	UNITS OF MEASURE	PVI	PARAMETER VALUE	DETECTION LIMIT	LAB CODE	DILUTION FACTOR
2-HEXANONE	07/13/93	4001	UG/L	ND	-	10.	ITA	1.00
4-METHYL-2-PENTANONE	07/13/93	2001	UG/L	ND	-	10.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	10.	ITA	1.00
ACETONE	07/13/93	2001	UG/L	ND	-	10.	ITA	1.00
	07/13/93	4001	UG/L	J	3.	10.	ITA	1.00
ACETONITRILE	07/13/93	2001	UG/L	ND	-	100.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	100.	ITA	1.00
ACRYLONITRILE	07/13/93	2001	UG/L	ND	-	100.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	100.	ITA	1.00
BENZENE	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	5.	ITA	1.00
BISMUTH-207	07/13/93	4001	PCI/L	ND	-	12.	ITA	1.00
BISMUTH-210	07/13/93	4001	PCI/L	ND	-	14.	ITA	1.00
BROMODICHLOROMETHANE	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	5.	ITA	1.00
BROMOFORM	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	5.	ITA	1.00
BROMOMETHANE	07/13/93	2001	UG/L	ND	-	10.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	10.	ITA	1.00
CARBON DISULFIDE	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00
	07/13/93	4001	UG/L		5.	5.	ITA	1.00
CESIUM-137	07/13/93	4001	PCI/L	ND	-	13.	ITA	1.00
CHLOROBENZENE	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	5.	ITA	1.00
CHLOROETHANE	07/13/93	2001	UG/L	ND	-	10.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	10.	ITA	1.00

PARAMETER VALUE INDICATOR (PVI): ND- NOT DETECTED

SURFACE WATER QUALITY DATA BY LOCATION
SITE: MND20 MOUND OPERABLE UNIT 9
LOCATION: 0005
NORTH COORDINATE: 597110.75 FT
EAST COORDINATE: 1494205.19 FT
07/13/93 TO 07/13/93
REPORT DATE: 02/14/94

PARAMETER NAME	LOG DATE	SAMPLE ID	UNITS OF MEASURE	PVI	PARAMETER VALUE	DETECTION LIMIT	LAB CODE	DILUTION FACTOR
CHLOROETHENE (VINYL CHLORIDE)	07/13/93	2001	UG/L	ND	-	10.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	10.	ITA	1.00
CHLOROMETHANE	07/13/93	2001	UG/L	ND	-	10.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	10.	ITA	1.00
COBALT-60	07/13/93	4001	PCI/L	ND	-	15.	ITA	1.00
DIBROMOCHLOROMETHANE	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	5.	ITA	1.00
DICHLOROMETHANE-METHYLENE CHLORIDE	07/13/93	2001	UG/L	B	15.	5.	ITA	1.00
	07/13/93	4001	UG/L	JB	2.	5.	ITA	1.00
ETHYLBENZENE	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	5.	ITA	1.00
HEXANE	07/13/93	2001	UG/L	ND	-	10.	ITA	1.00
	07/13/93	4001	UG/L		130.	10.	ITA	1.00
IODOMETHANE	07/13/93	2001	UG/L	ND	-	10.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	10.	ITA	1.00
POTASSIUM-40	07/13/93	4001	PCI/L	ND	-	220.	ITA	1.00
STYRENE	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	5.	ITA	1.00
TETRACHLOROETHENE	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	5.	ITA	1.00
TETRACHLOROMETHANE (CCL4)	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	5.	ITA	1.00
TOLUENE	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00
	07/13/93	4001	UG/L	J	3.	5.	ITA	1.00
TOTAL XYLENES	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00
	07/13/93	4001	UG/L	J	1.	5.	ITA	1.00
TRICHLOROETHENE	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00

PARAMETER VALUE INDICATOR (PVI): ND- NOT DETECTED

SURFACE WATER QUALITY DATA BY LOCATION
SITE: MND20 MOUND OPERABLE UNIT 9
LOCATION: 0005
NORTH COORDINATE: 597110.75 FT
EAST COORDINATE: 1494205.19 FT
07/13/93 TO 07/13/93
REPORT DATE: 02/14/94

PARAMETER NAME	LOG DATE	SAMPLE ID	UNITS OF MEASURE	PVI	PARAMETER VALUE	DETECTION LIMIT	LAB CODE	DILUTION FACTOR
TRICHLOROETHENE	07/13/93	4001	UG/L	ND	-	5.	ITA	1.00
TRICHLOROMETHANE (CHLOROFORM)	07/13/93	2001	UG/L	ND	-	5.	ITA	1.00
	07/13/93	4001	UG/L	J	2.	5.	ITA	1.00
TRITIUM	07/13/93	4001	PCI/L	ND	-	210.	ITA	1.00
VINYL ACETATE	07/13/93	2001	UG/L	ND	-	10.	ITA	1.00
	07/13/93	4001	UG/L	ND	-	10.	ITA	1.00

PARAMETER VALUE INDICATOR (PVI): ND- NOT DETECTED

DATA FILE NAME: K:\DART\MND\MND20\SWQ10001.DAT

SURFACE WATER QUALITY DATA BY LOCATION
SITE: MND20 MOUND OPERABLE UNIT 9
LOCATION: 0303
NORTH COORDINATE: 597134.54 FT
EAST COORDINATE: 1494493.75 FT
07/12/93 TO 07/12/93
REPORT DATE: 02/14/94

PARAMETER NAME	LOG DATE	SAMPLE ID	UNITS OF MEASURE	PVI	PARAMETER VALUE	DETECTION LIMIT	LAB CODE	DILUTION FACTOR
1,1,1-TRICHLOROETHANE	07/12/93	4001	UG/L	ND	-	5.	ITA	1.00
1,1,2,2-TETRACHLOROETHANE	07/12/93	4001	UG/L	ND	-	5.	ITA	1.00
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHA	07/12/93	4001	UG/L	ND	-	5.	ITA	1.00
1,1,2-TRICHLOROETHANE	07/12/93	4001	UG/L	ND	-	5.	ITA	1.00
1,1-DICHLOROETHANE	07/12/93	4001	UG/L	ND	-	5.	ITA	1.00
1,1-DICHLOROETHENE	07/12/93	4001	UG/L	ND	-	5.	ITA	1.00
1,2-DICHLOROETHANE	07/12/93	4001	UG/L	ND	-	5.	ITA	1.00
1,2-DICHLOROETHENE	07/12/93	4001	UG/L	ND	-	5.	ITA	1.00
1,2-DICHLOROPROPANE	07/12/93	4001	UG/L	ND	-	5.	ITA	1.00
1,2-DIETHYLBENZENE	07/12/93	4001	UG/L	ND	-	5.	ITA	1.00
1,3-CIS-DICHLOROPROPENE	07/12/93	4001	UG/L	ND	-	5.	ITA	1.00
1,3-TRANS-DICHLOROPROPENE	07/12/93	4001	UG/L	ND	-	5.	ITA	1.00
2-BUTANONE	07/12/93	4001	UG/L	ND	-	10.	ITA	1.00
2-HEXANONE	07/12/93	4001	UG/L	ND	-	10.	ITA	1.00
4-METHYL-2-PENTANONE	07/12/93	4001	UG/L	ND	-	10.	ITA	1.00
ACETONE	07/12/93	4001	UG/L	J	2.	10.	ITA	1.00
ACETONITRILE	07/12/93	4001	UG/L	ND	-	100.	ITA	1.00
ACRYLONITRILE	07/12/93	4001	UG/L	ND	-	100.	ITA	1.00
BENZENE	07/12/93	4001	UG/L	ND	-	5.	ITA	1.00
BISMUTH-207	07/12/93	4001	PCI/L	ND	-	11.	ITA	1.00
BISMUTH-210	07/12/93	4001	PCI/L	ND	-	15.	ITA	1.00

PARAMETER VALUE INDICATOR (PVI): ND- NOT DETECTED

SURFACE WATER QUALITY DATA BY LOCATION
SITE: MND20 MOUND OPERABLE UNIT 9
LOCATION: 0303
NORTH COORDINATE: 597134.54 FT
EAST COORDINATE: 1494493.75 FT
07/12/93 TO 07/12/93
REPORT DATE: 02/14/94

PARAMETER NAME	LOG DATE	SAMPLE ID	UNITS OF MEASURE	PVI	PARAMETER VALUE	DETECTION LIMIT	LAB CODE	DILUTION FACTOR
BROMODICHLOROMETHANE	07/12/93	4001	UG/L	ND	-	5.	ITA	1.00
BROMOFORM	07/12/93	4001	UG/L	ND	-	5.	ITA	1.00
BROMOMETHANE	07/12/93	4001	UG/L	ND	-	10.	ITA	1.00
CARBON DISULFIDE	07/12/93	4001	UG/L		39.	5.	ITA	1.00
CESIUM-137	07/12/93	4001	PCI/L	ND	-	17.	ITA	1.00
CHLOROBENZENE	07/12/93	4001	UG/L	ND	-	5.	ITA	1.00
CHLOROETHANE	07/12/93	4001	UG/L	ND	-	10.	ITA	1.00
CHLOROETHENE (VINYL CHLORIDE)	07/12/93	4001	UG/L	ND	-	10.	ITA	1.00
CHLOROMETHANE	07/12/93	4001	UG/L	ND	-	10.	ITA	1.00
COBALT-60	07/12/93	4001	PCI/L	ND	-	14.	ITA	1.00
DIBROMOCHLOROMETHANE	07/12/93	4001	UG/L	ND	-	5.	ITA	1.00
DICHLOROMETHANE-METHYLENE CHLORIDE	07/12/93	4001	UG/L	JB	3.	5.	ITA	1.00
ETHYLBENZENE	07/12/93	4001	UG/L	ND	-	5.	ITA	1.00
HEXANE	07/12/93	4001	UG/L		180.	10.	ITA	1.00
IODOMETHANE	07/12/93	4001	UG/L	ND	-	10.	ITA	1.00
POTASSIUM-40	07/12/93	4001	PCI/L	ND	-	140.	ITA	1.00
STYRENE	07/12/93	4001	UG/L	ND	-	5.	ITA	1.00
TETRACHLOROETHENE	07/12/93	4001	UG/L	ND	-	5.	ITA	1.00
TETRACHLOROMETHANE (CCL4)	07/12/93	4001	UG/L	ND	-	5.	ITA	1.00
TOLUENE	07/12/93	4001	UG/L	J	3.	5.	ITA	1.00
TOTAL XYLENES	07/12/93	4001	UG/L	J	1.	5.	ITA	1.00

PARAMETER VALUE INDICATOR (PVI): ND- NOT DETECTED

SURFACE WATER QUALITY DATA BY LOCATION
SITE: MND20 MOUND OPERABLE UNIT 9
LOCATION: 0303
NORTH COORDINATE: 597134.54 FT
EAST COORDINATE: 1494493.75 FT
07/12/93 TO 07/12/93
REPORT DATE: 02/14/94

PARAMETER NAME	LOG DATE	SAMPLE ID	UNITS OF MEASURE	PVI	PARAMETER VALUE	DETECTION LIMIT	LAB CODE	DILUTION FACTOR
TRICHLOROETHENE	07/12/93	4001	UG/L	ND	-	5.	ITA	1.00
TRICHLOROMETHANE (CHLOROFORM)	07/12/93	4001	UG/L	J	2.	5.	ITA	1.00
TRITIUM	07/12/93	4001	PCI/L	ND	-	210.	ITA	1.00
VINYL ACETATE	07/12/93	4001	UG/L	ND	-	10.	ITA	1.00

PARAMETER VALUE INDICATOR (PVI): ND- NOT DETECTED

DATA FILE NAME: K:\DART\MND\MND20\SWQ10002.DAT

WESTON Analytics Use Only
REA38148

Custody Transfer Record/Lab Work Request

WESTON

Page 1 of 1

Client: EG&G
Est. Final Proj. Sampling Date:
Work Order #: 05376-039-001-0100
Project Contact/Phone #: 513-825-3440
AD Project Manager: GORDON HORN
QC: Del: TAT:
Date Rec'd: Date Due:
Account #:

Refrigerator #																		
#/Type Container	Liquid	2										1	2					
	Solid																	
Volume	Liquid	40ml										250 ml	1 GAL					
	Solid																	
Preservatives		HCl																
ANALYSES REQUESTED →		ORGANIC: VOA	BNA	Pest/PCB	Herb				INORG: Metal	CN		TRITIUM	GAMMA					

MATRIX CODES:	Lab ID	Client ID/Description (Jc) 0303	Matrix QC Chosen (✓) MS	MSD	Matrix	Date Collected	Time Collected	VOA	BNA	Pest/PCB	Herb				Metal	CN	TRITIUM	GAMMA				
								WESTON Analytics Use Only														
S - Soil		MND20-0343-4001			W	7/12/93	1330	X									X	X				
SE - Sediment		MND20-0005-4001			W	7/13/93	0900	X									X	X				
SO - Solid		MND20-0005-2001			W	7/13/93	0900	X														
SL - Sludge																						
W - Water																						
O - Oil																						
A - Air																						
DS - Drum Solids																						
DL - Drum Liquids																						
L - EP/TCLP Leachate																						
WI - Wipe																						
X - Other																						
F - Fish																						

FIELD PERSONNEL: COMPLETE ONLY SHADED AREAS

Special Instructions:

DATE/REVISIONS:
1.
2.
3.
4.
5.
6.

WESTON Analytics Use Only

Samples were:
1) Shipped ___ or Hand Delivered ___
Airbill # _____
2) Ambient or Chilled
3) Received in Good Condition Y or N
4) Labels Indicate Properly Preserved Y or N
5) Received Within Holding Times Y or N

COC Tape was:
1) Present on Outer Package Y or N
2) Unbroken on Outer Package Y or N
3) Present on Sample Y or N
4) Unbroken on Sample Y or N

COC Record Present Upon Sample Rec't Y or N

Discrepancies Between Samples Labels and COC Record? Y or N
NOTES:

Relinquished by	Received by	Date	Time	Relinquished by	Received by	Date	Time
[signature]	T. Hardbert	7/13/93	0955				
[signature]		7/14/93	1130				

RFW 21-21-001/A-7/91 ____ L372 ____ L373 ____ L375 ____ L377 ____ L378 Ref# _____ Cooler# _____ 381 596a

APPENDIX B

SEISMIC REFRACTION DATA

APPENDIX B

SEISMIC REFRACTION DATA

B.1. REFRACTION LINE PROFILES

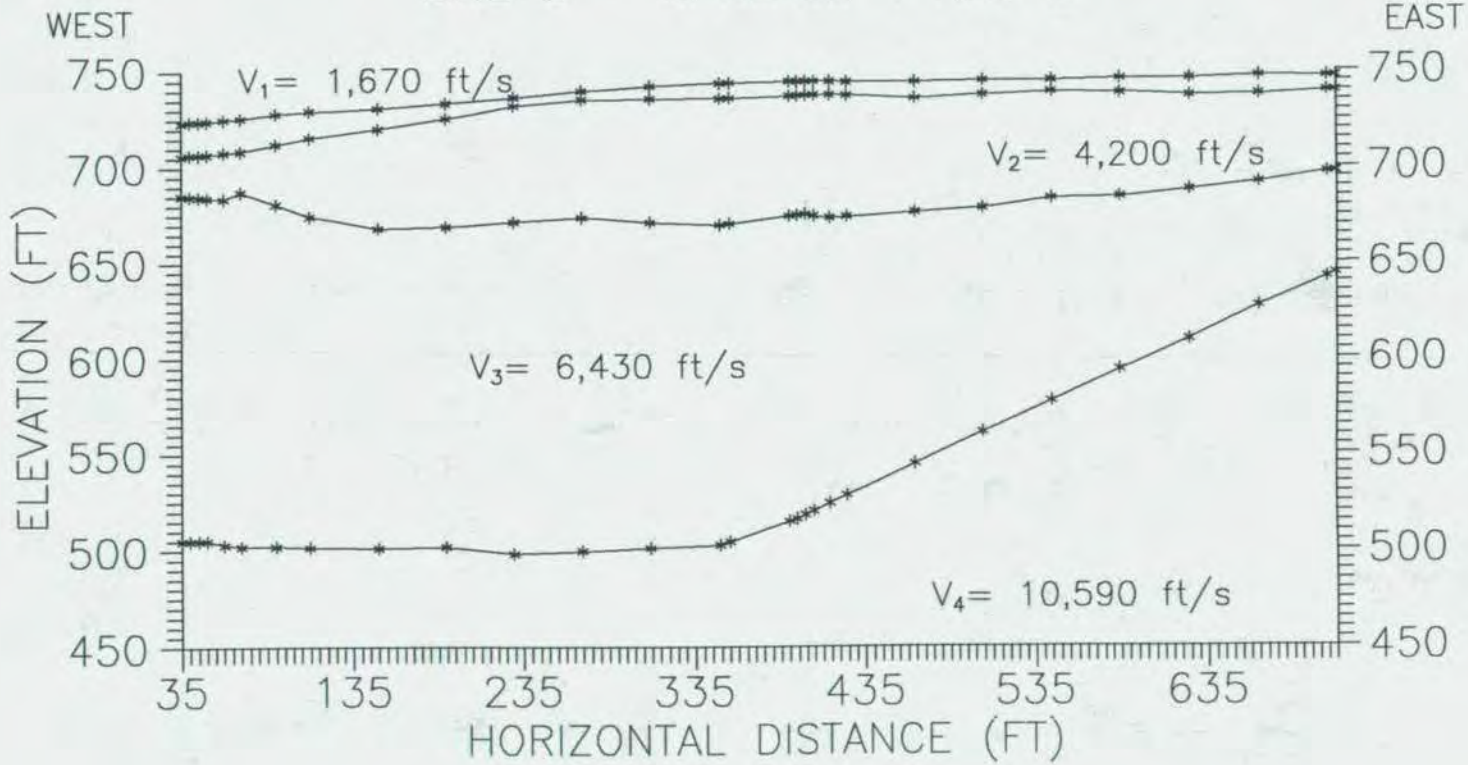
B.2. SEISMIC REFRACTION TECHNIQUE

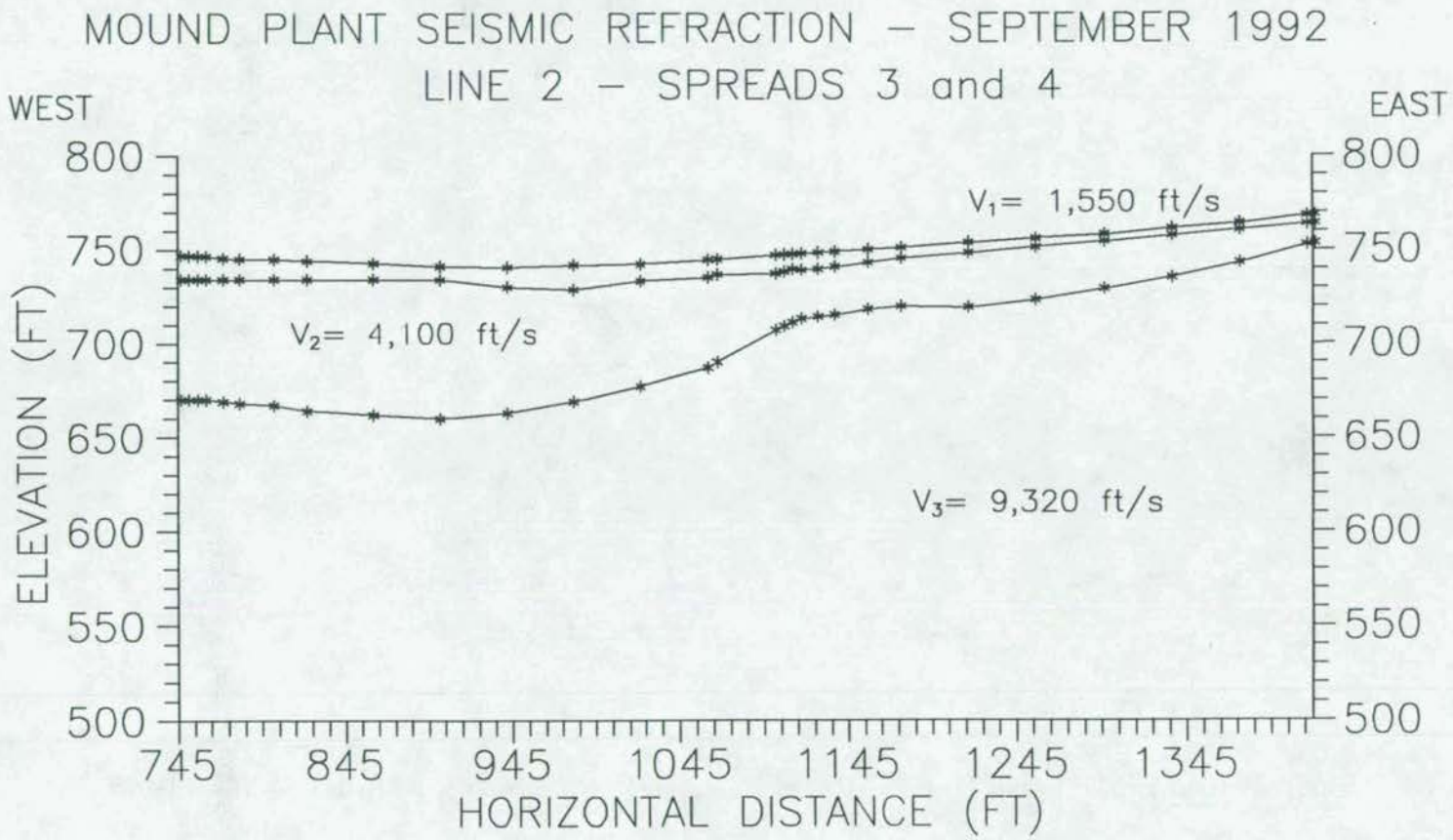
B.3. STATE PLANE COORDINATES OF LINE END POINTS

B.4. DATA REDUCTION AND PROCESSING FLOW DIAGRAM AND EXAMPLES

APPENDIX B.1. REFRACTION LINE PROFILES

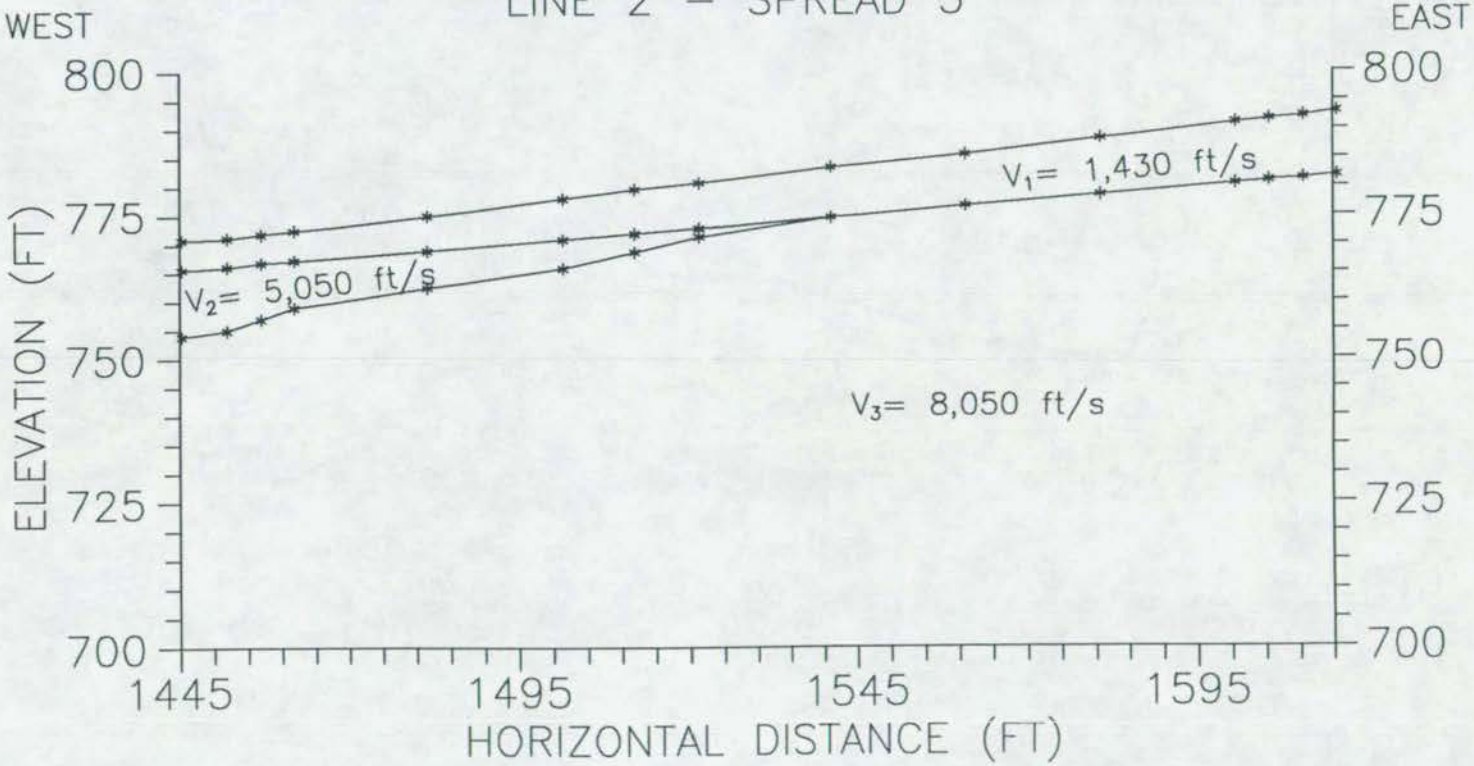
MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1993
LINE 2 – SPREADS 1 AND 2

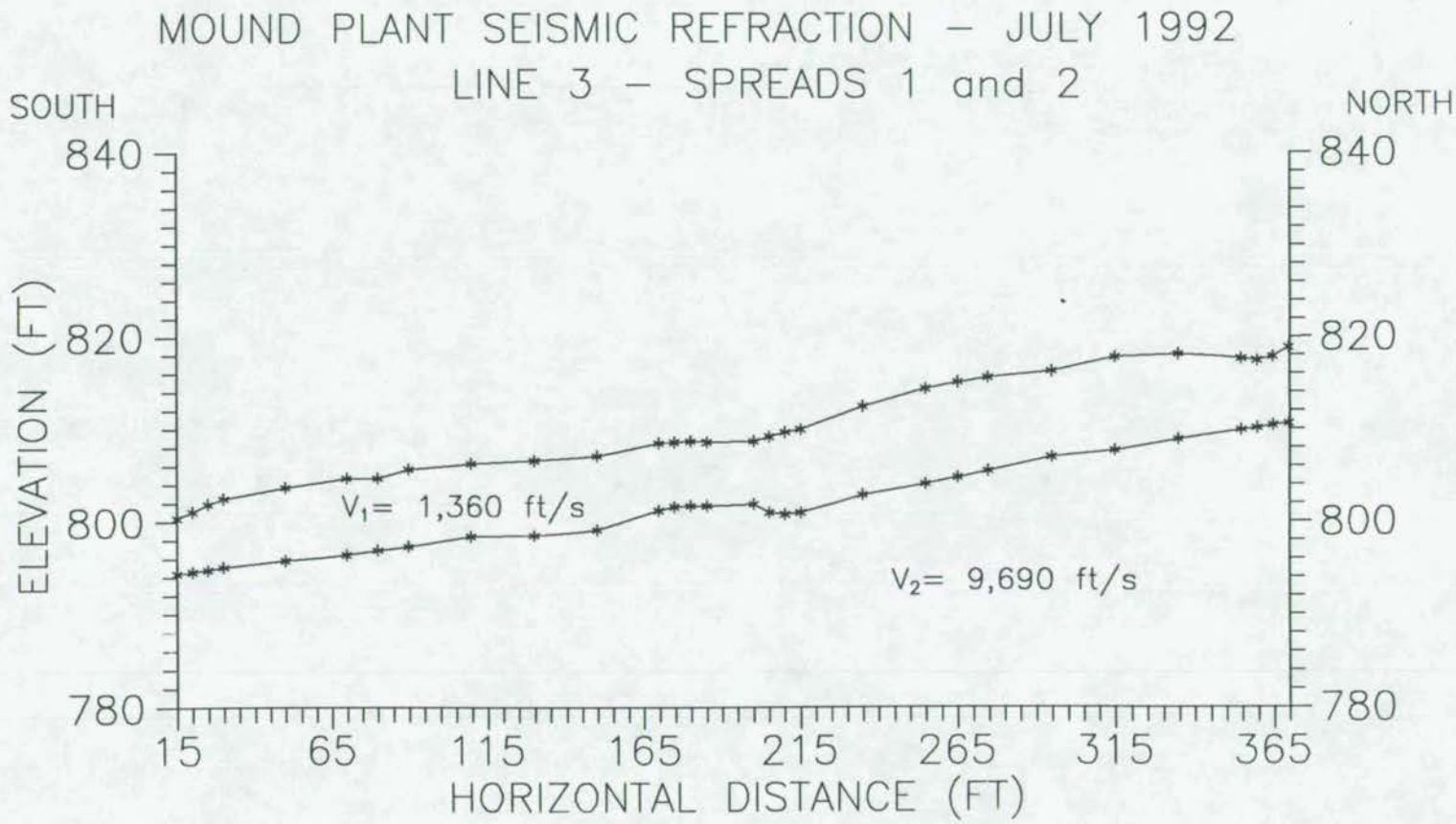


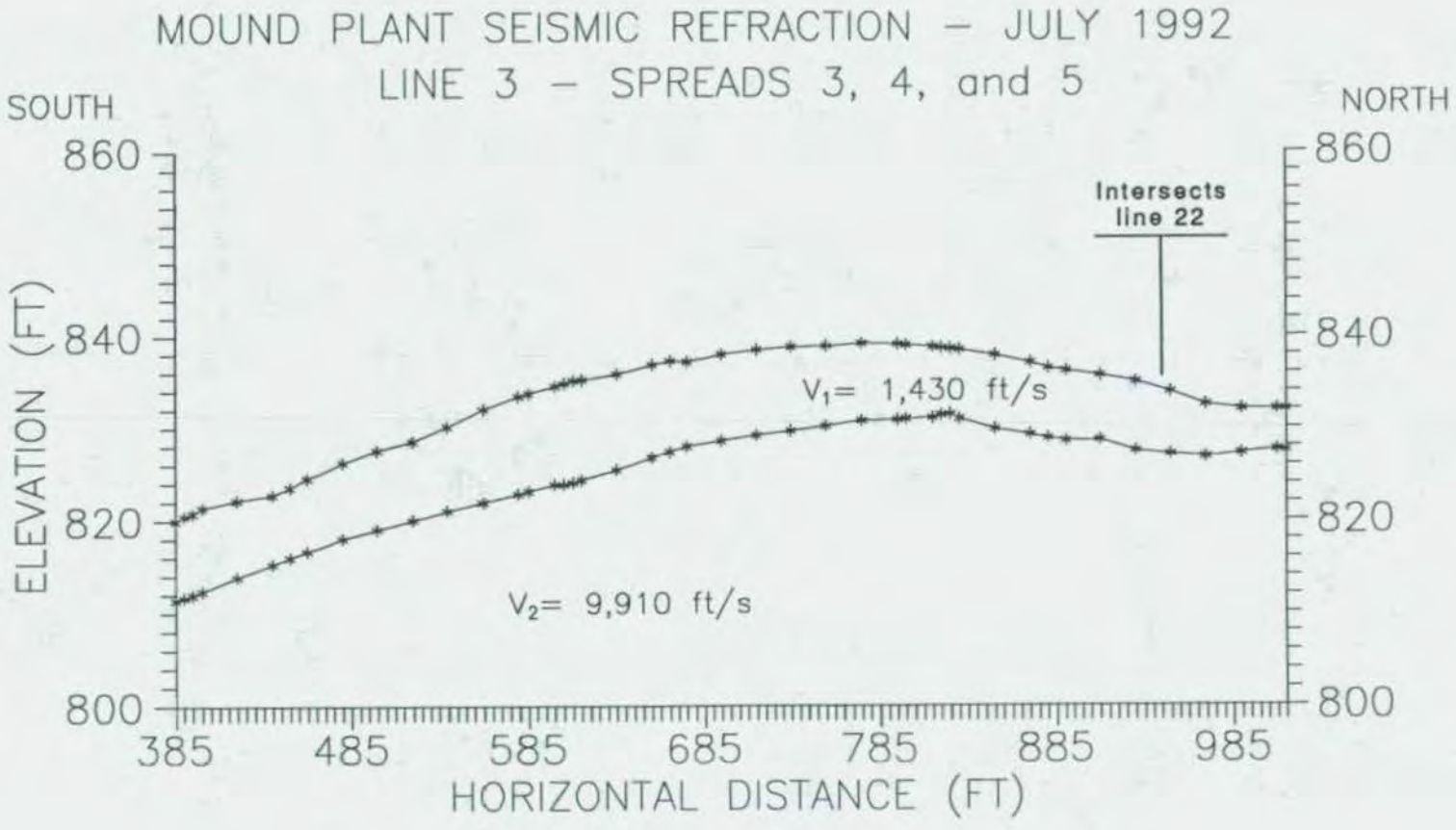

MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992
LINE 2 – SPREADS 3 and 4
WEST
EAST
ELEVATION (FT)
800
750
700
650
600
550
500
V1= 1,550 ft/s
V2= 4,100 ft/s
V3= 9,320 ft/s
745
845
945
1045
1145
1245
1345
HORIZONTAL DISTANCE (FT)

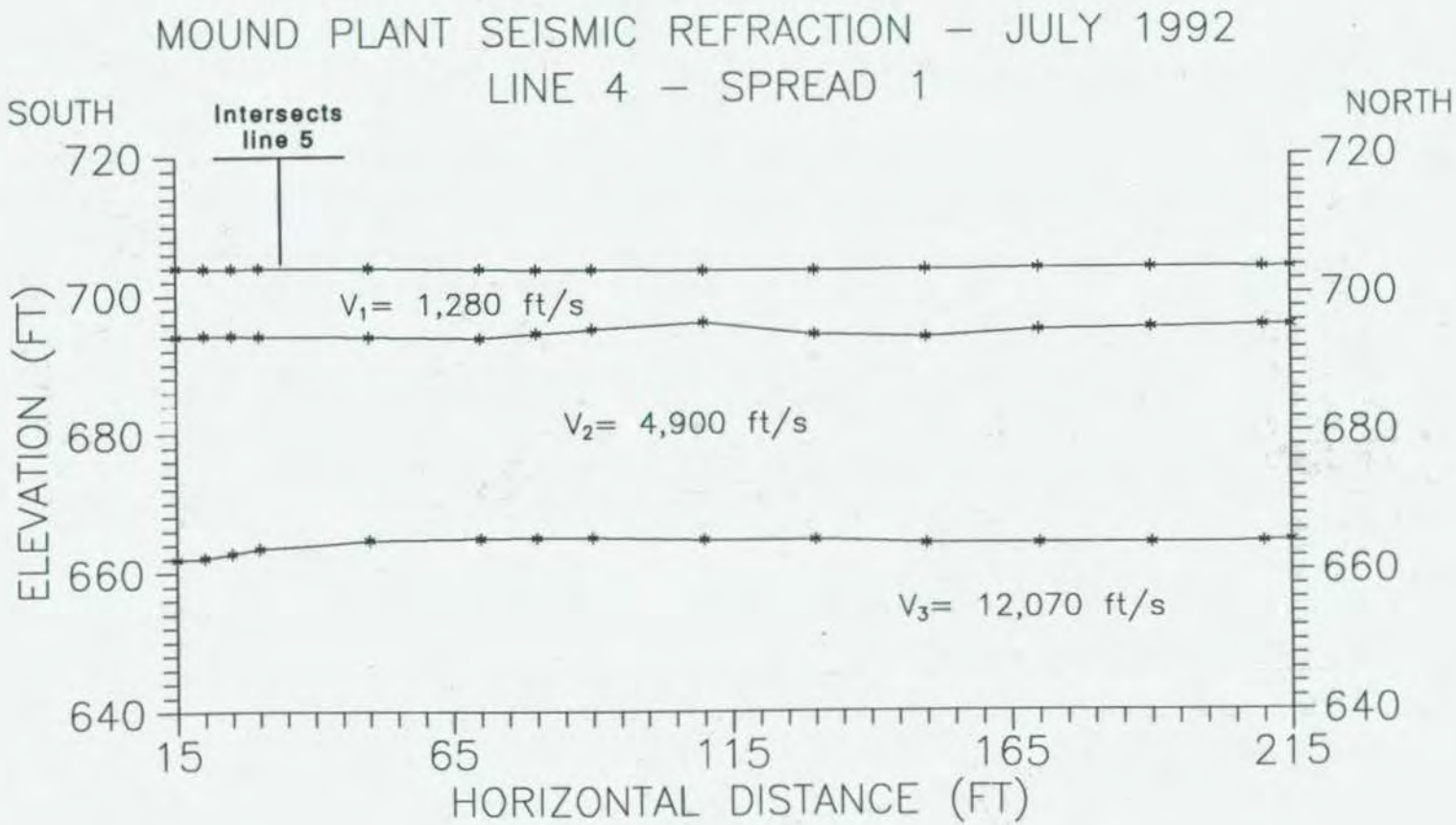
MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992

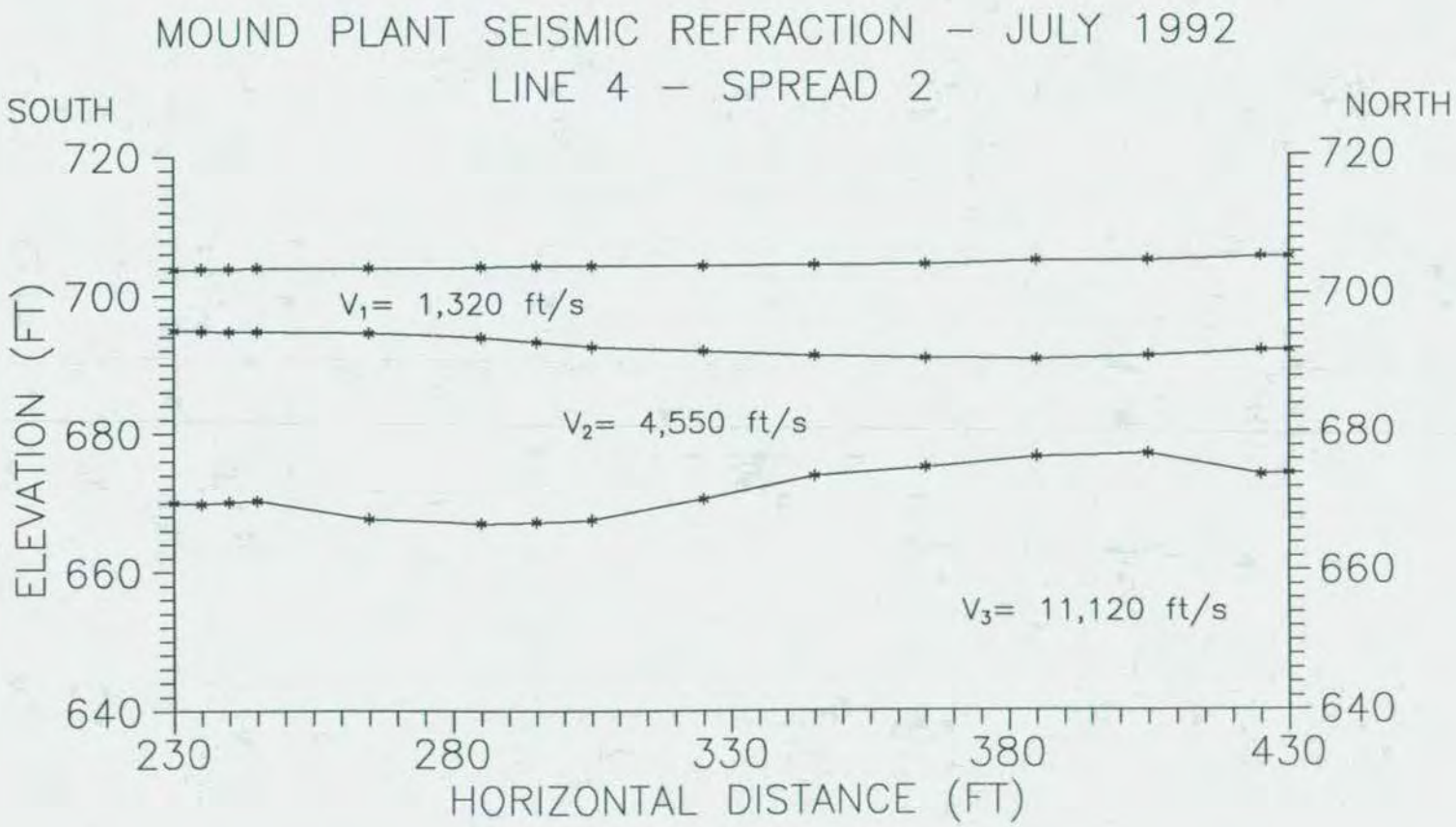
LINE 2 – SPREAD 5

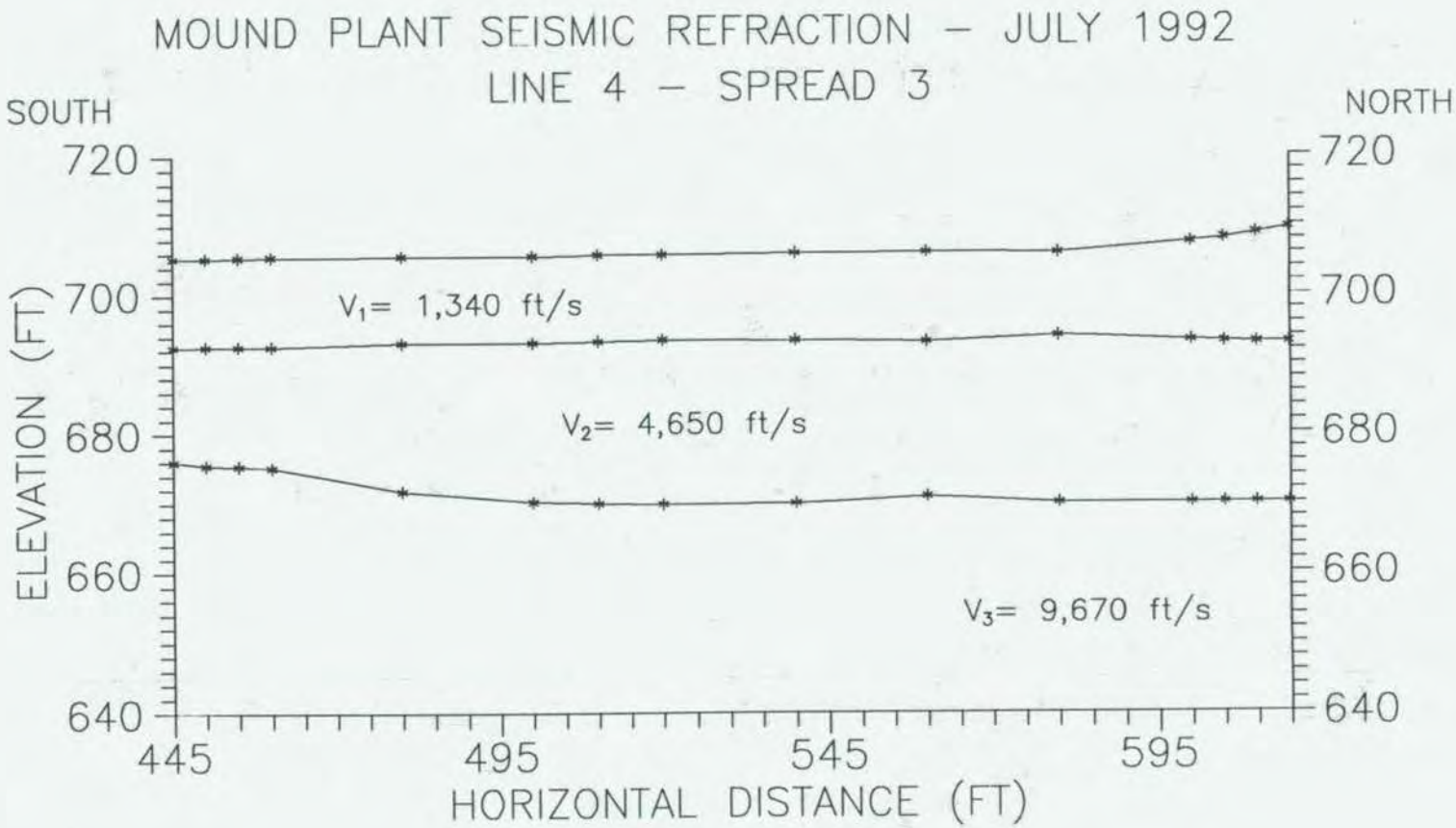


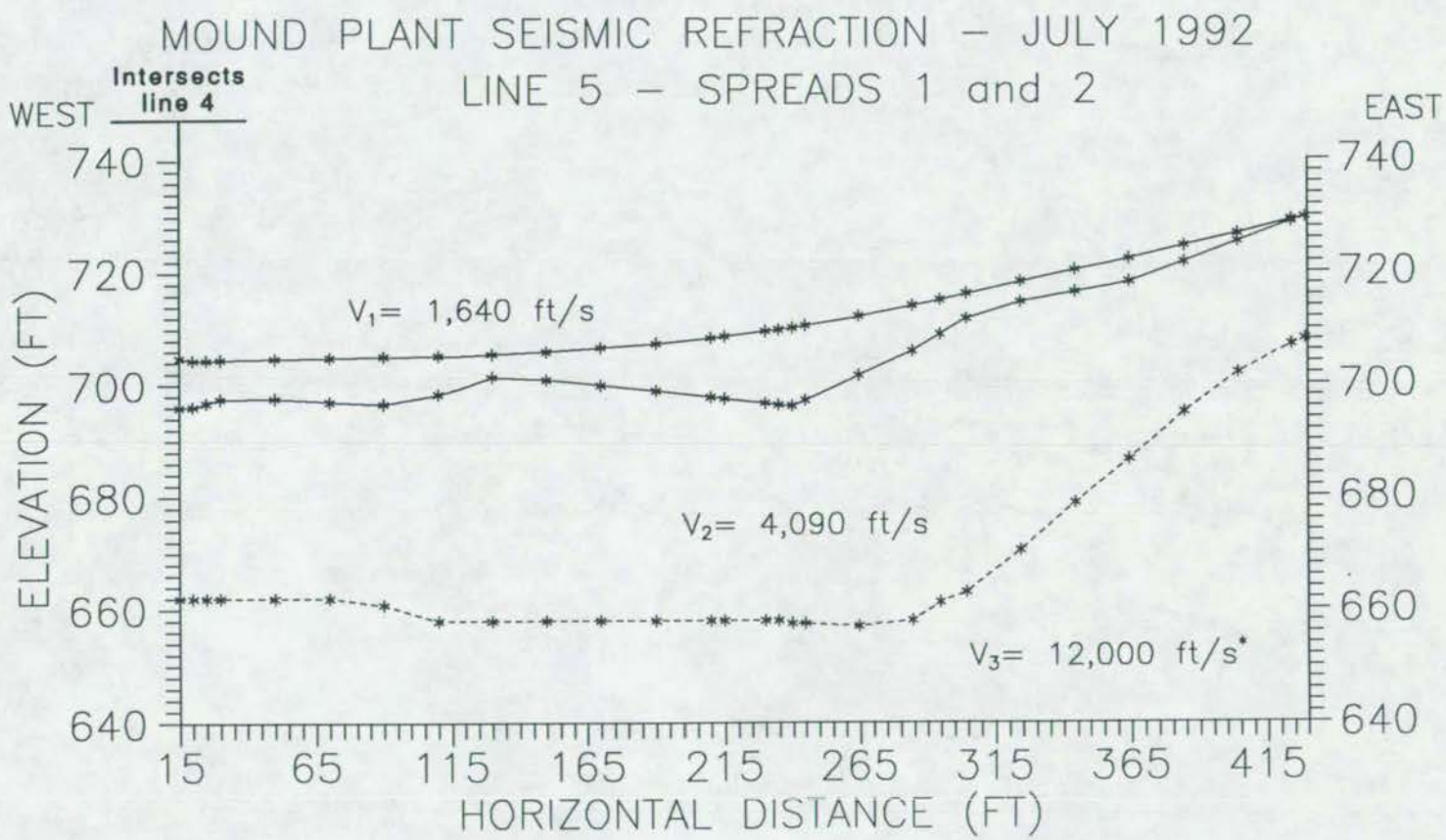

MOUND PLANT SEISMIC REFRACTION – JULY 1992
LINE 3 – SPREADS 1 and 2
SOUTH
NORTH
840
820
800
780
ELEVATION (FT)
V1= 1,360 ft/s
V2= 9,690 ft/s
15
65
115
165
215
265
315
365
HORIZONTAL DISTANCE (FT)


MOUND PLANT SEISMIC REFRACTION – JULY 1992
LINE 3 – SPREADS 3, 4, and 5
SOUTH
NORTH
860
840
820
800
ELEVATION (FT)
Intersects line 22
V_1= 1,430 ft/s
V_2= 9,910 ft/s
385
485
585
685
785
885
985
HORIZONTAL DISTANCE (FT)

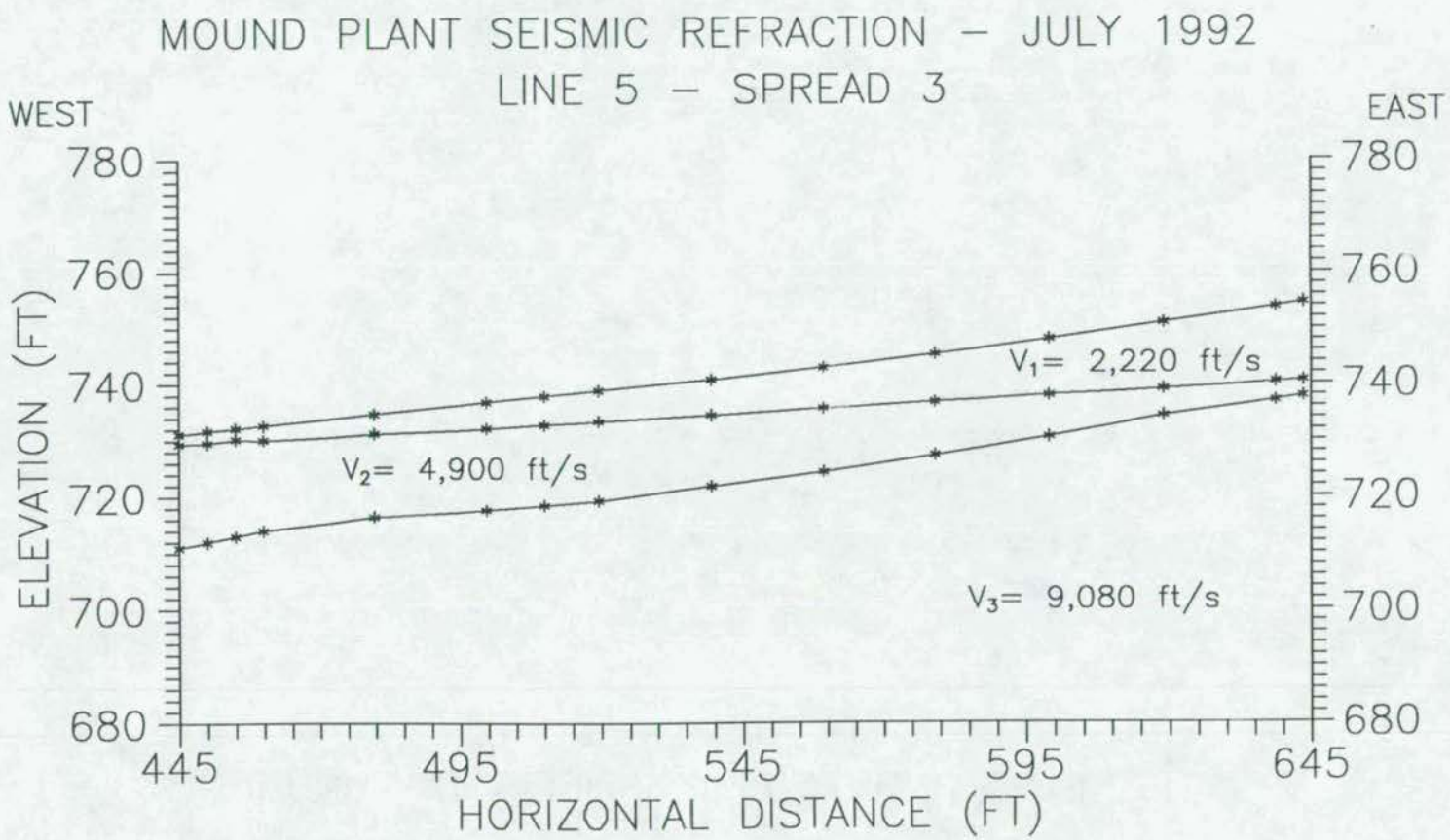

MOUND PLANT SEISMIC REFRACTION – JULY 1992
LINE 4 – SPREAD 1
SOUTH
NORTH
Intersects line 5
720
700
680
660
640
ELEVATION (FT)
V1= 1,280 ft/s
V2= 4,900 ft/s
V3= 12,070 ft/s
15
65
115
165
215
HORIZONTAL DISTANCE (FT)

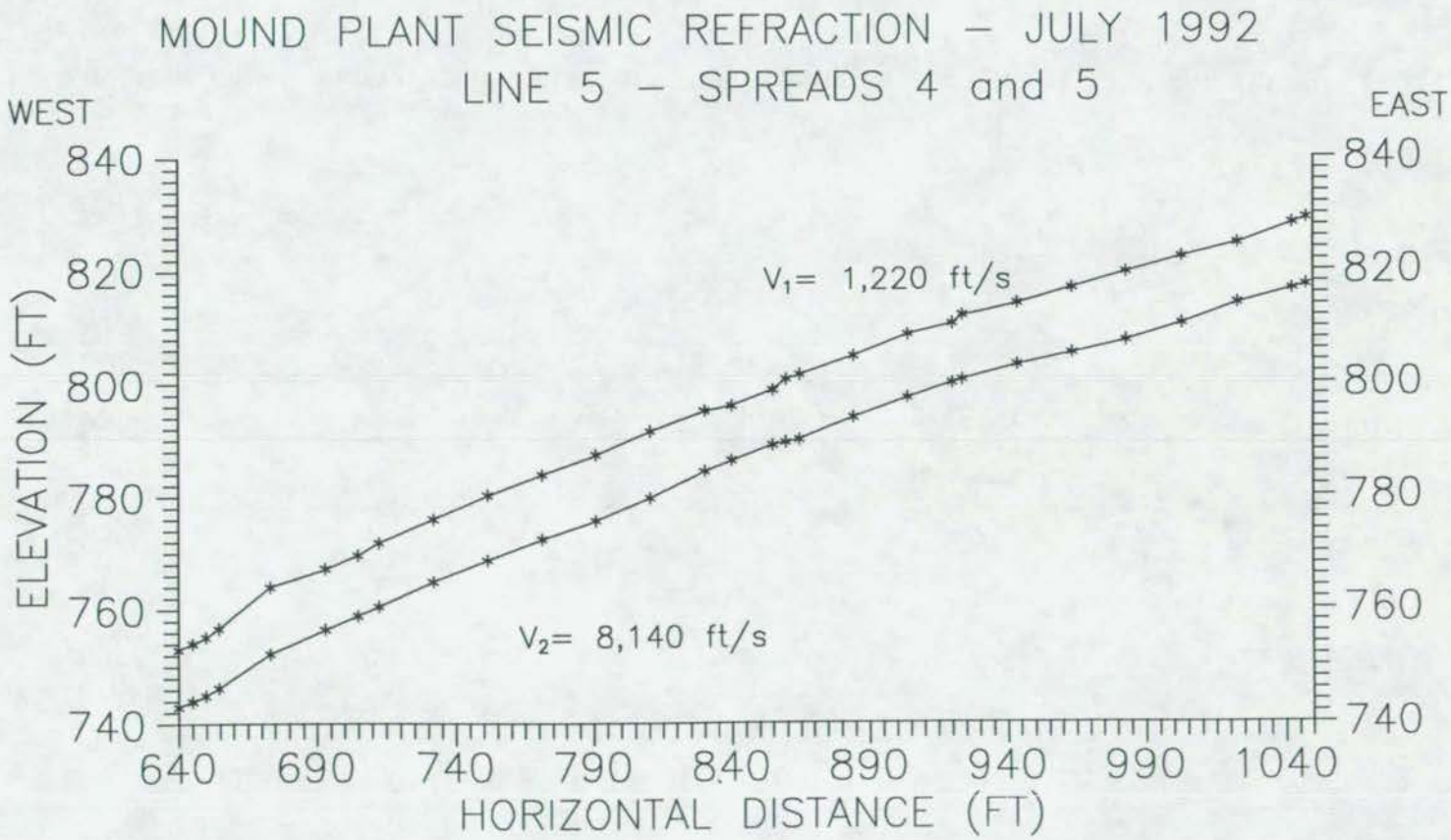

MOUND PLANT SEISMIC REFRACTION – JULY 1992
LINE 4 – SPREAD 2
SOUTH
NORTH
720
700
680
660
640
ELEVATION (FT)
V1= 1,320 ft/s
V2= 4,550 ft/s
V3= 11,120 ft/s
230
280
330
380
430
HORIZONTAL DISTANCE (FT)

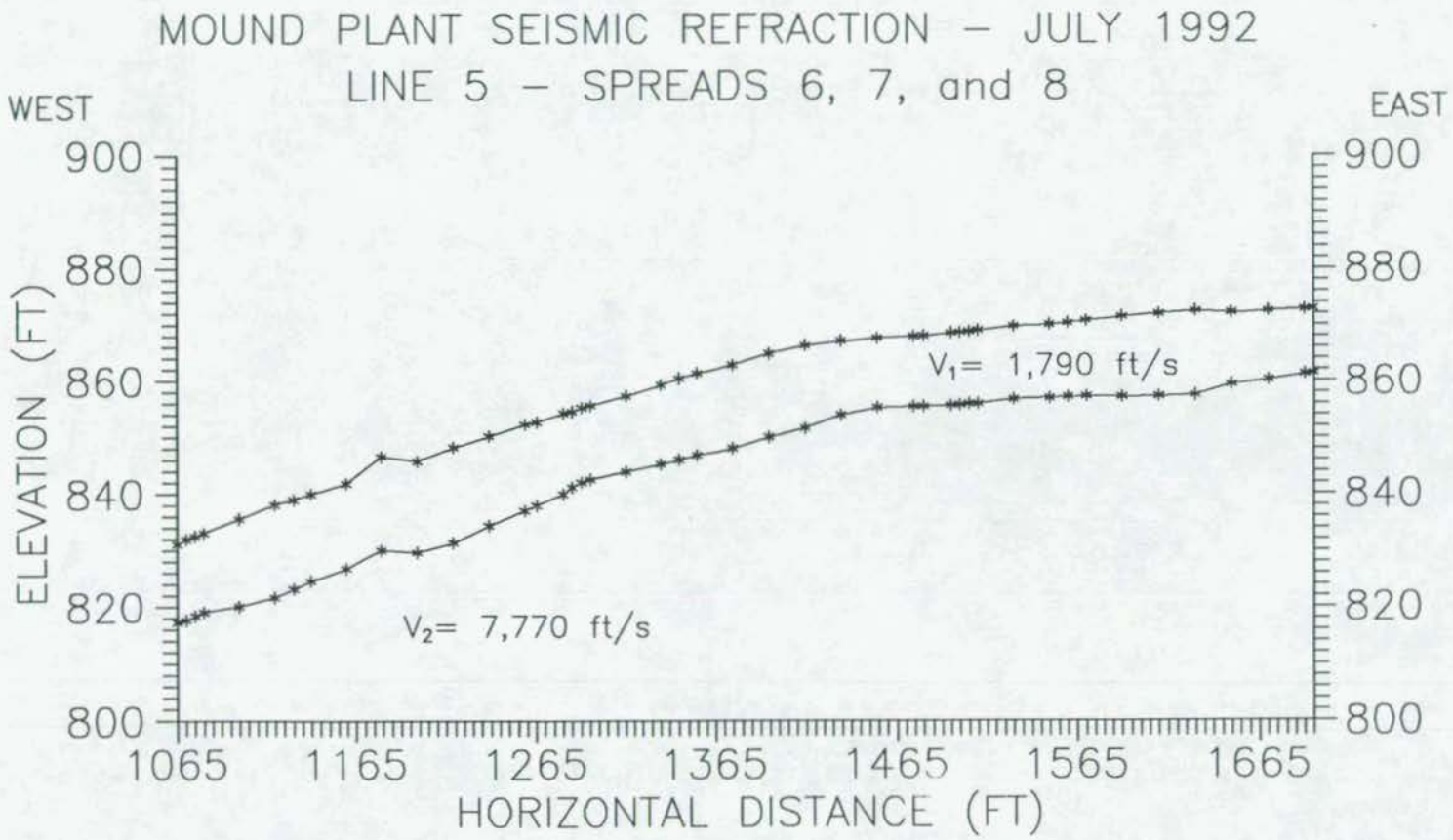

MOUND PLANT SEISMIC REFRACTION – JULY 1992
LINE 4 – SPREAD 3
SOUTH
NORTH
720
700
680
660
640
ELEVATION (FT)
V1= 1,340 ft/s
V2= 4,650 ft/s
V3= 9,670 ft/s
445
495
545
595
HORIZONTAL DISTANCE (FT)

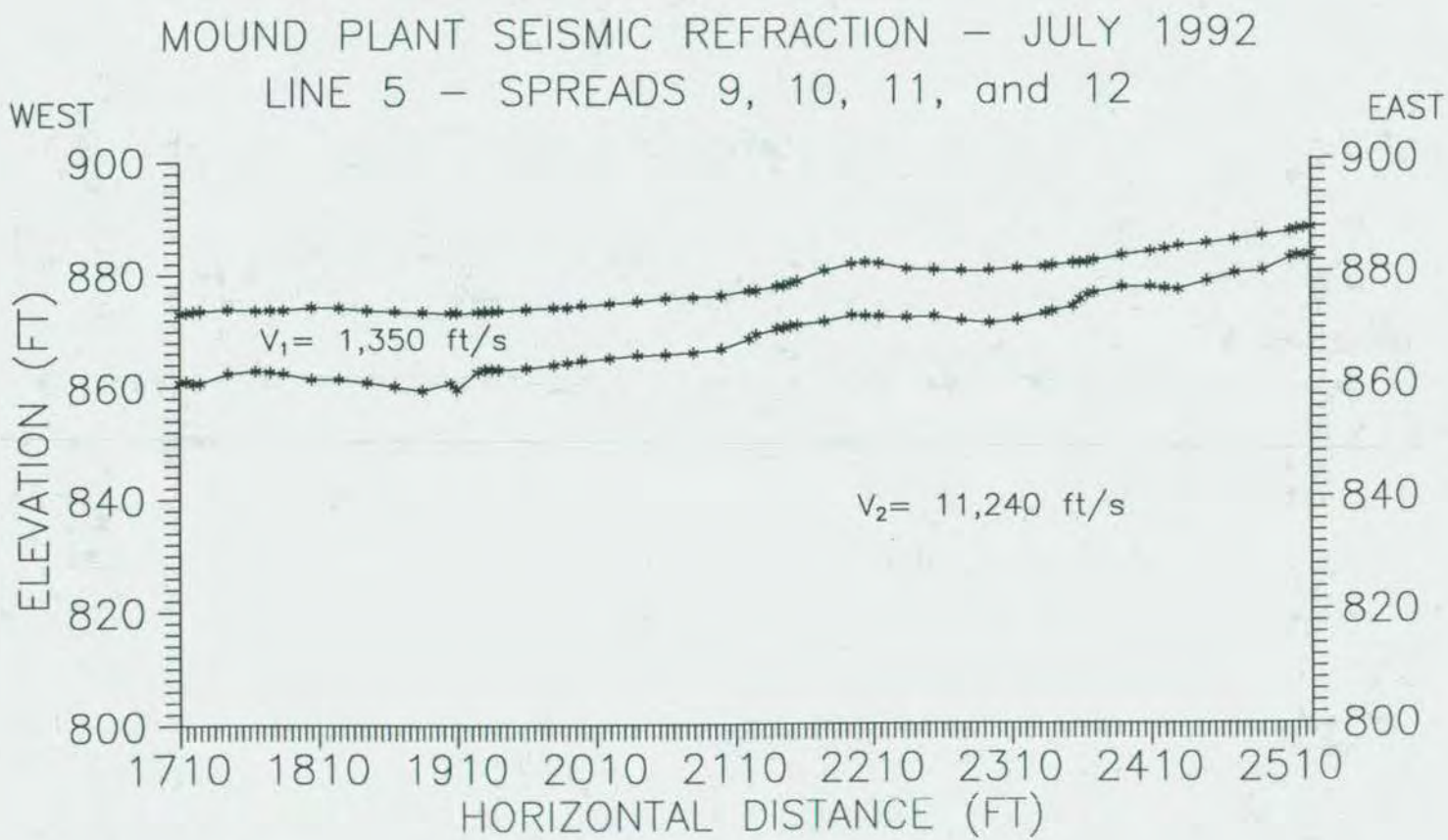


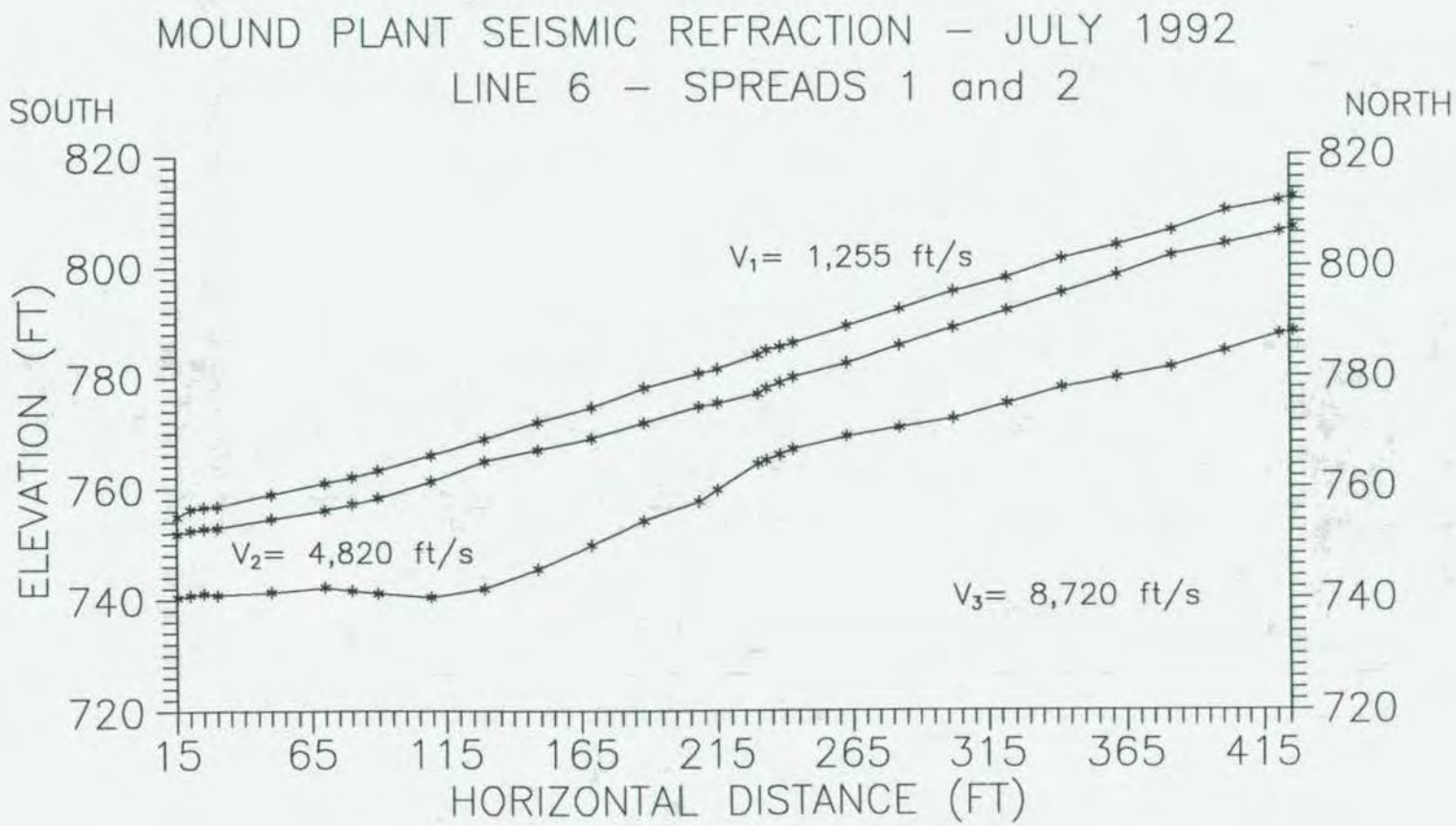
* = Velocity override value.

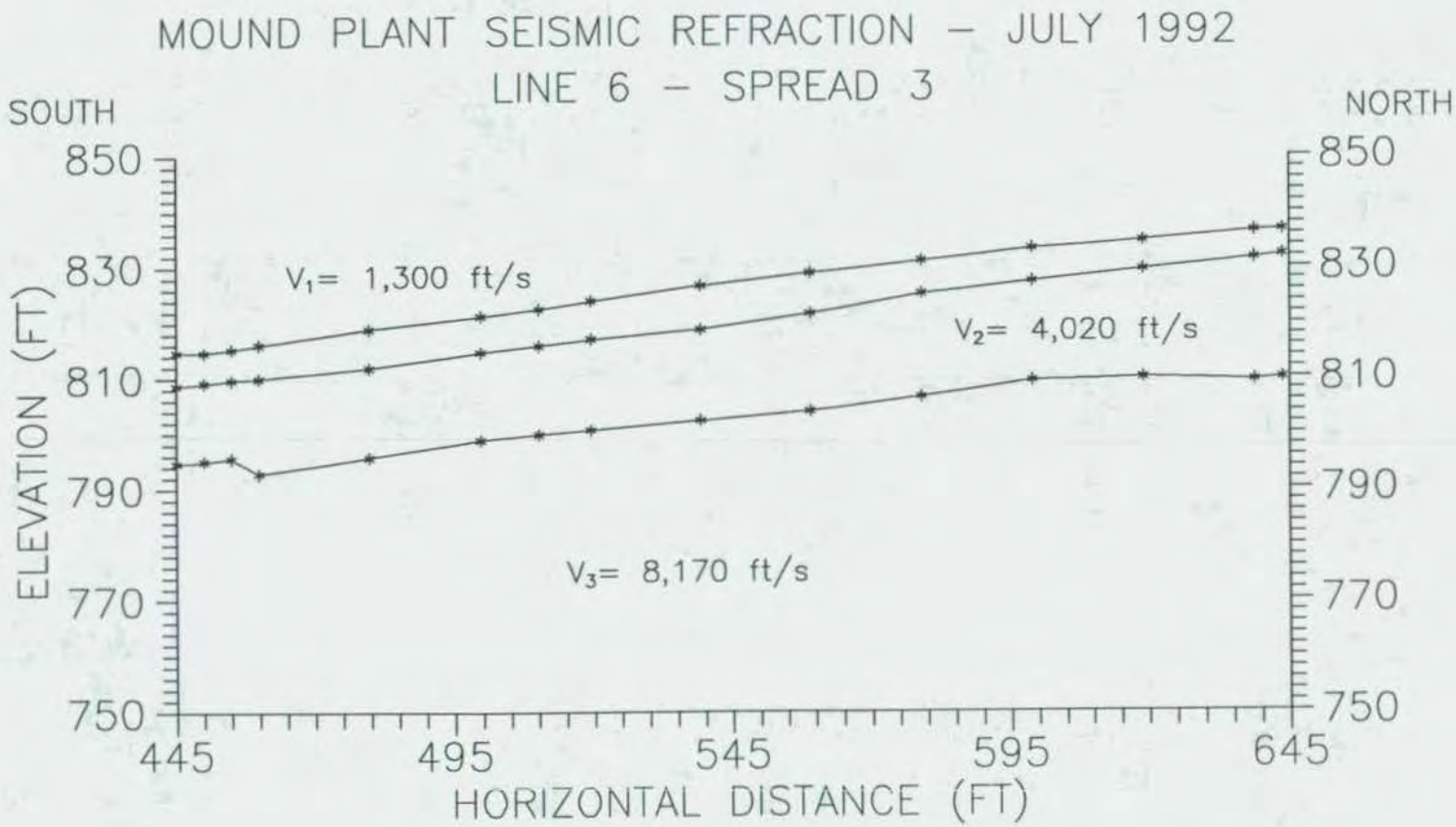

MOUND PLANT SEISMIC REFRACTION – JULY 1992
LINE 5 – SPREAD 3
WEST
EAST
780
760
740
720
700
680
ELEVATION (FT)
V_1= 2,220 ft/s
V_2= 4,900 ft/s
V_3= 9,080 ft/s
445
495
545
595
645
HORIZONTAL DISTANCE (FT)

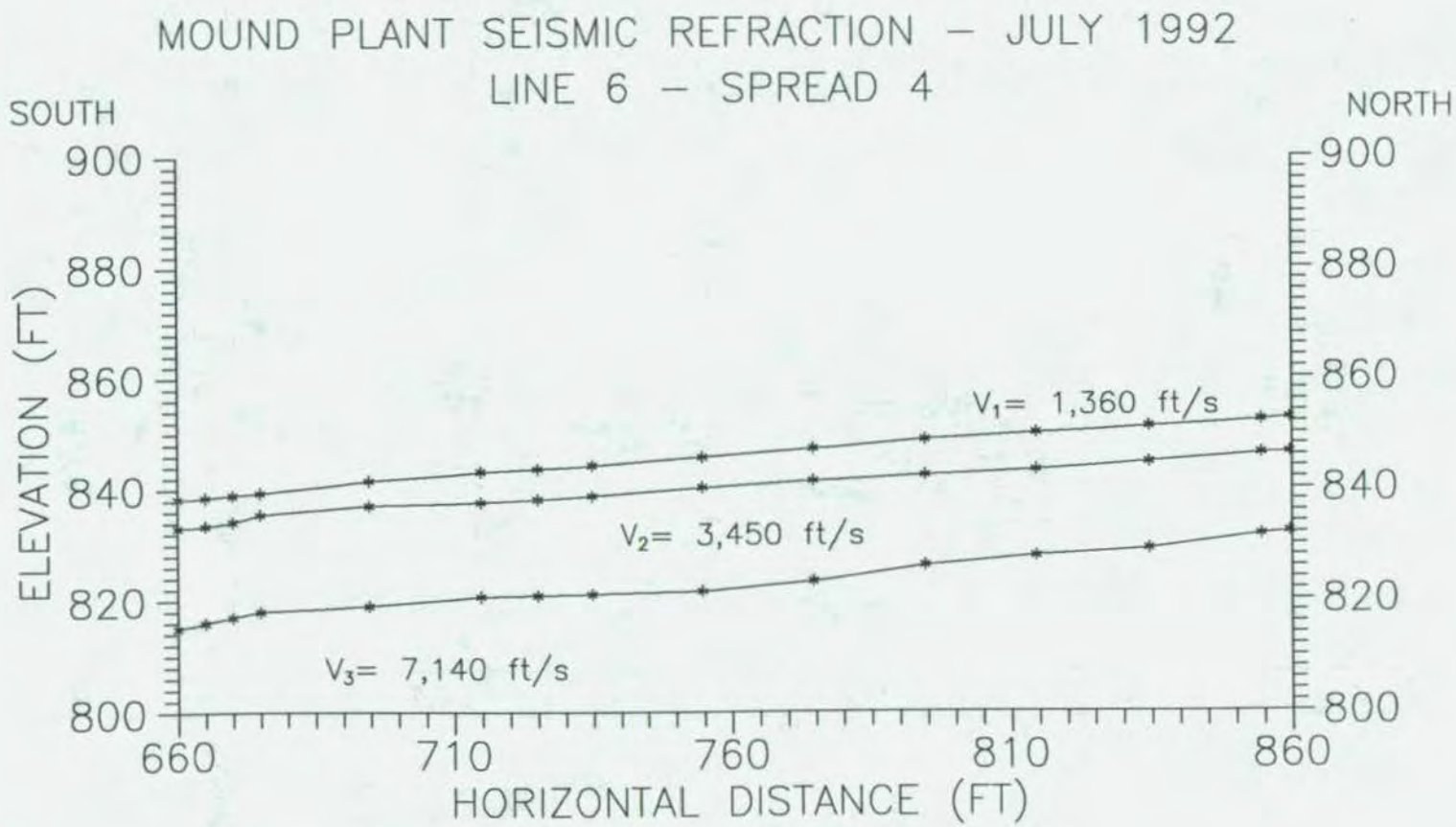

MOUND PLANT SEISMIC REFRACTION – JULY 1992
LINE 5 – SPREADS 4 and 5
WEST
EAST
ELEVATION (FT)
840
820
800
780
760
740
640
690
740
790
840
890
940
990
1040
HORIZONTAL DISTANCE (FT)
V1= 1,220 ft/s
V2= 8,140 ft/s

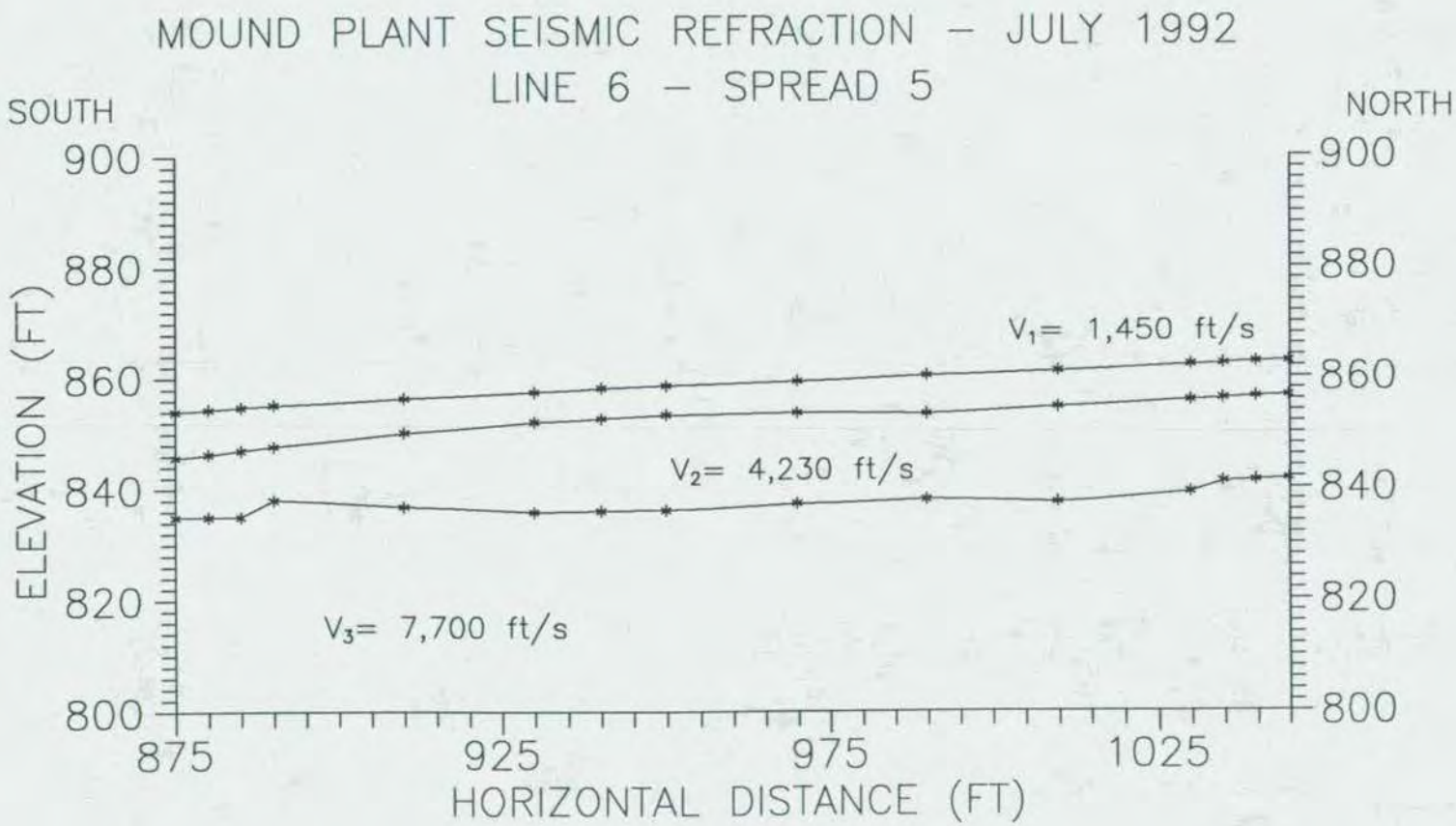

MOUND PLANT SEISMIC REFRACTION – JULY 1992
LINE 5 – SPREADS 6, 7, and 8
WEST
EAST
900
880
860
840
820
800
ELEVATION (FT)
V_1= 1,790 ft/s
V_2= 7,770 ft/s
1065
1165
1265
1365
1465
1565
1665
HORIZONTAL DISTANCE (FT)

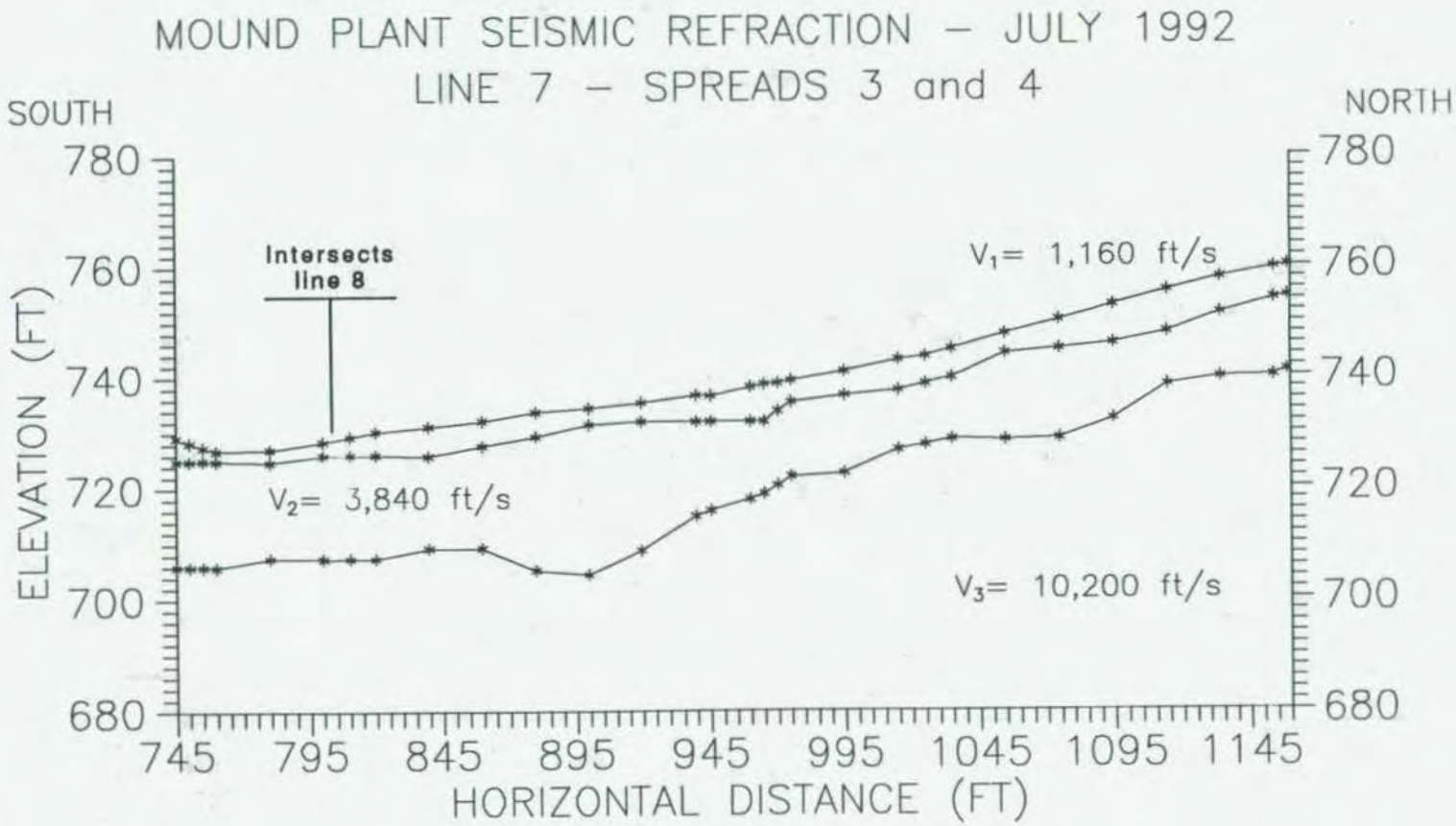

MOUND PLANT SEISMIC REFRACTION – JULY 1992
LINE 5 – SPREADS 9, 10, 11, and 12
WEST
EAST
900
880
860
840
820
800
ELEVATION (FT)
V1= 1,350 ft/s
V2= 11,240 ft/s
1710 1810 1910 2010 2110 2210 2310 2410 2510
HORIZONTAL DISTANCE (FT)

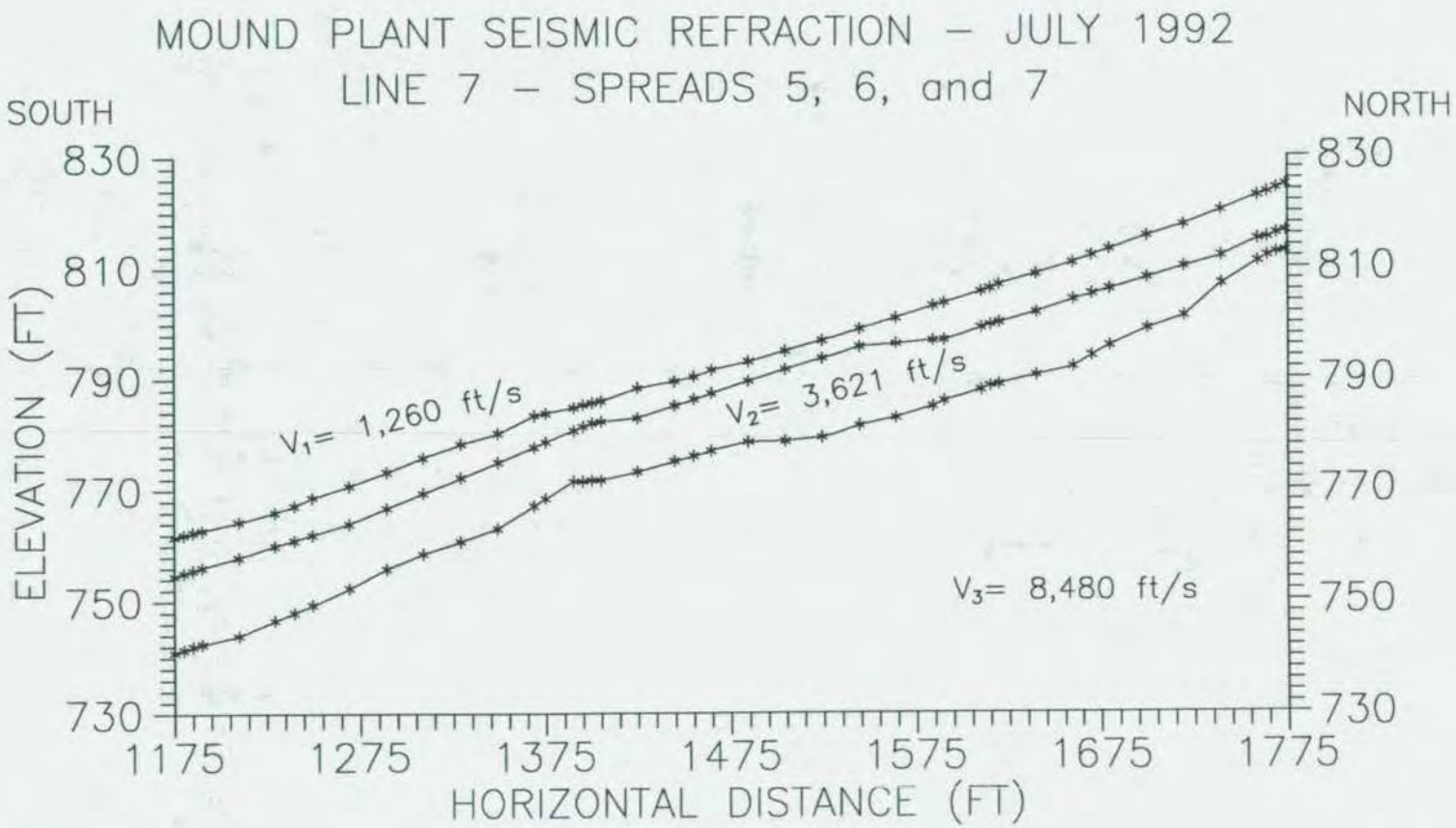

MOUND PLANT SEISMIC REFRACTION – JULY 1992
LINE 6 – SPREADS 1 and 2
SOUTH
NORTH
ELEVATION (FT)
820
800
780
760
740
720
V1= 1,255 ft/s
V2= 4,820 ft/s
V3= 8,720 ft/s
15
65
115
165
215
265
315
365
415
HORIZONTAL DISTANCE (FT)

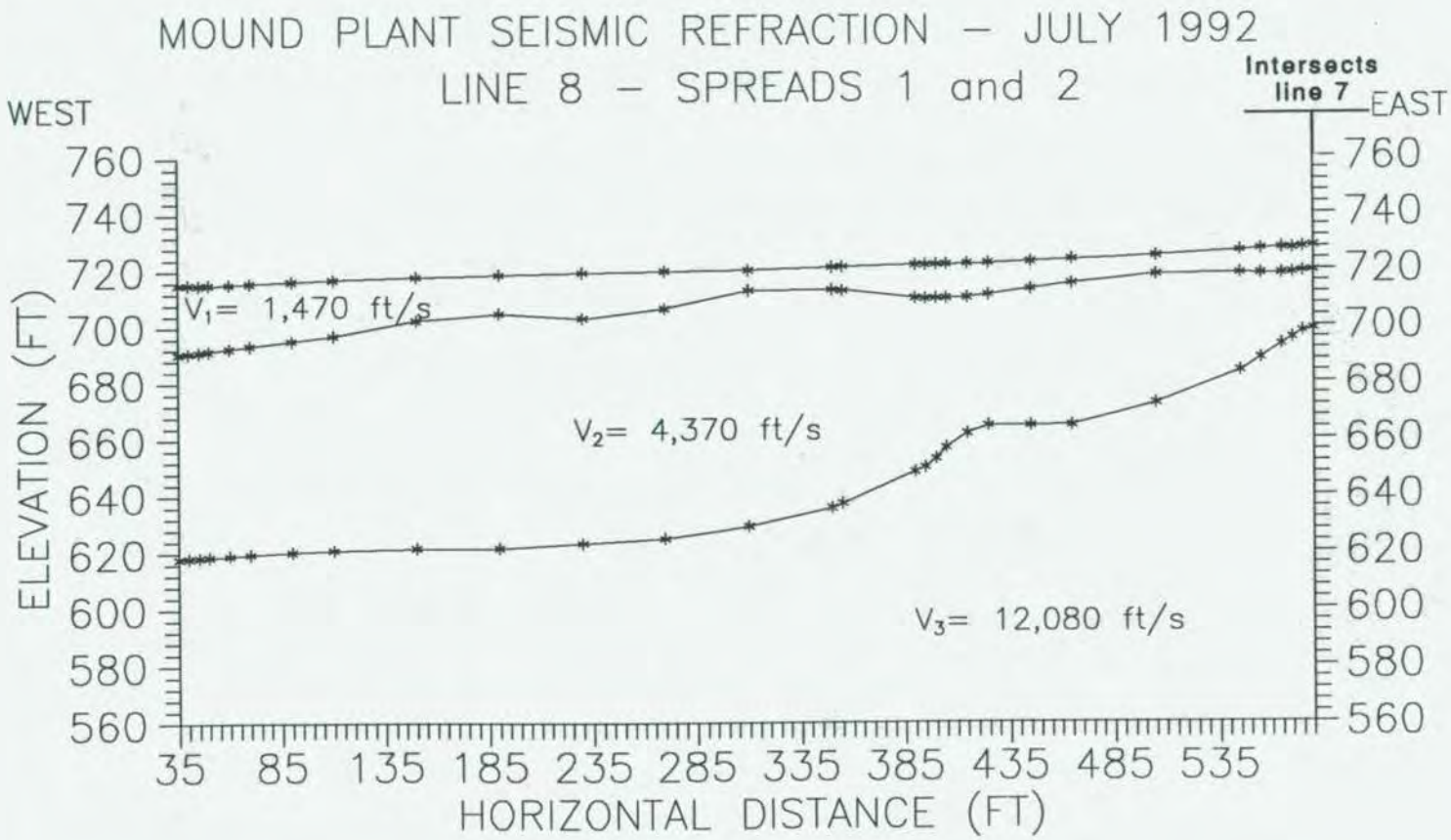

MOUND PLANT SEISMIC REFRACTION – JULY 1992
LINE 6 – SPREAD 3
SOUTH
NORTH
850
830
810
790
770
750
ELEVATION (FT)
V1= 1,300 ft/s
V2= 4,020 ft/s
V3= 8,170 ft/s
445
495
545
595
645
HORIZONTAL DISTANCE (FT)

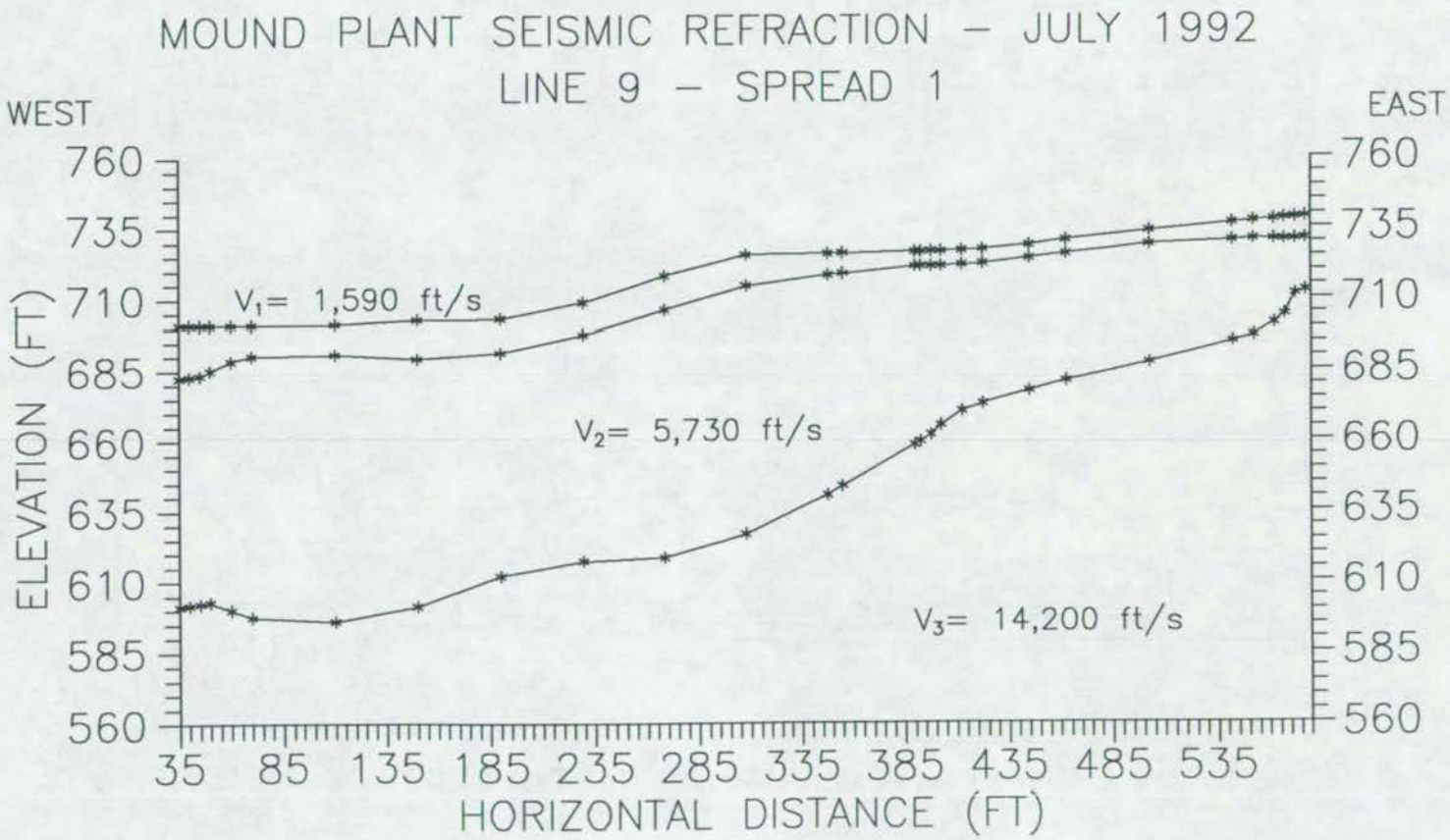

MOUND PLANT SEISMIC REFRACTION – JULY 1992
LINE 6 – SPREAD 4
SOUTH
NORTH
ELEVATION (FT)
900
880
860
840
820
800
660
710
760
810
860
HORIZONTAL DISTANCE (FT)
V1= 1,360 ft/s
V2= 3,450 ft/s
V3= 7,140 ft/s

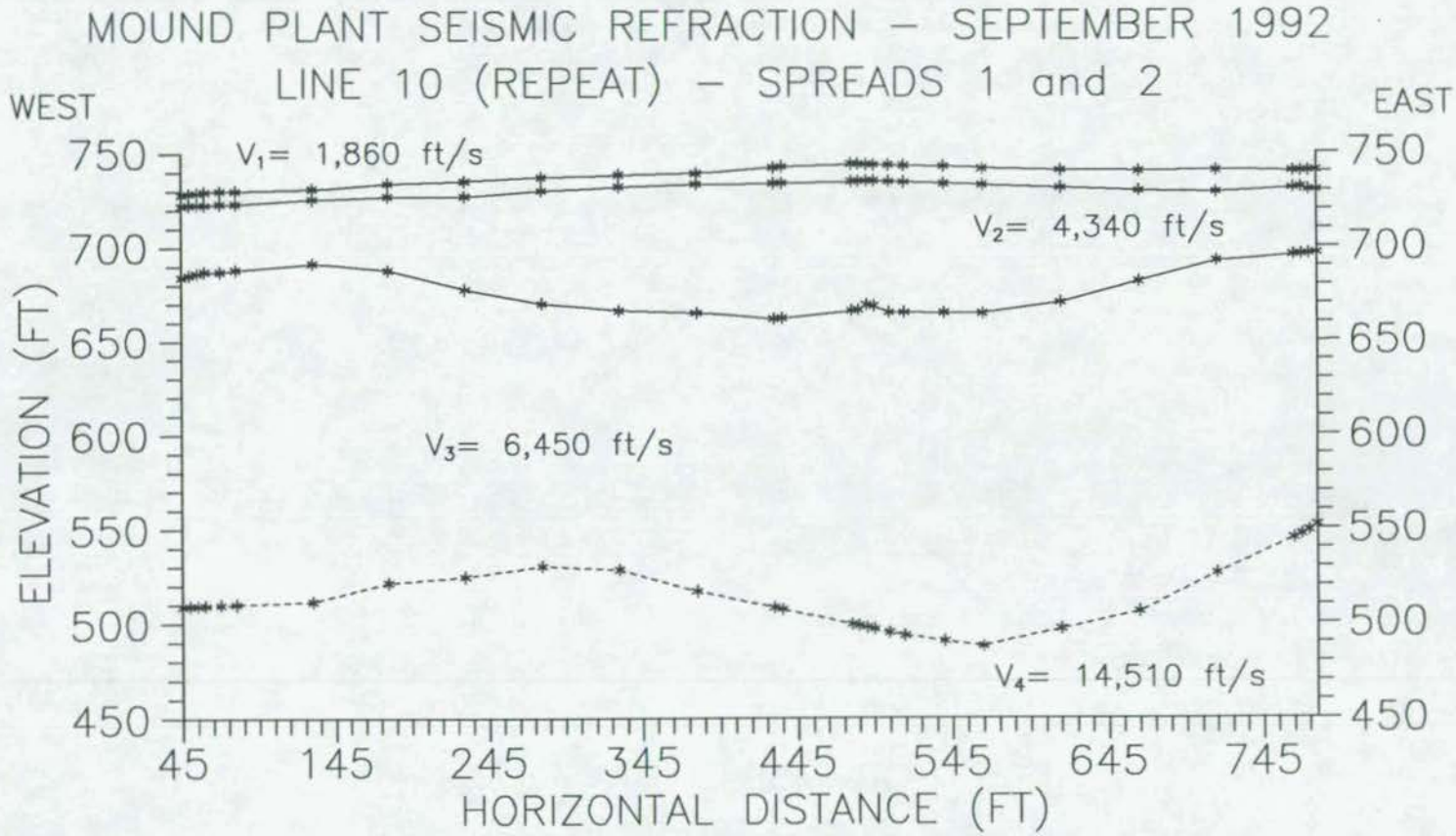

MOUND PLANT SEISMIC REFRACTION – JULY 1992
LINE 6 – SPREAD 5
SOUTH
NORTH
ELEVATION (FT)
900
880
860
840
820
800
875
925
975
1025
HORIZONTAL DISTANCE (FT)
V1= 1,450 ft/s
V2= 4,230 ft/s
V3= 7,700 ft/s

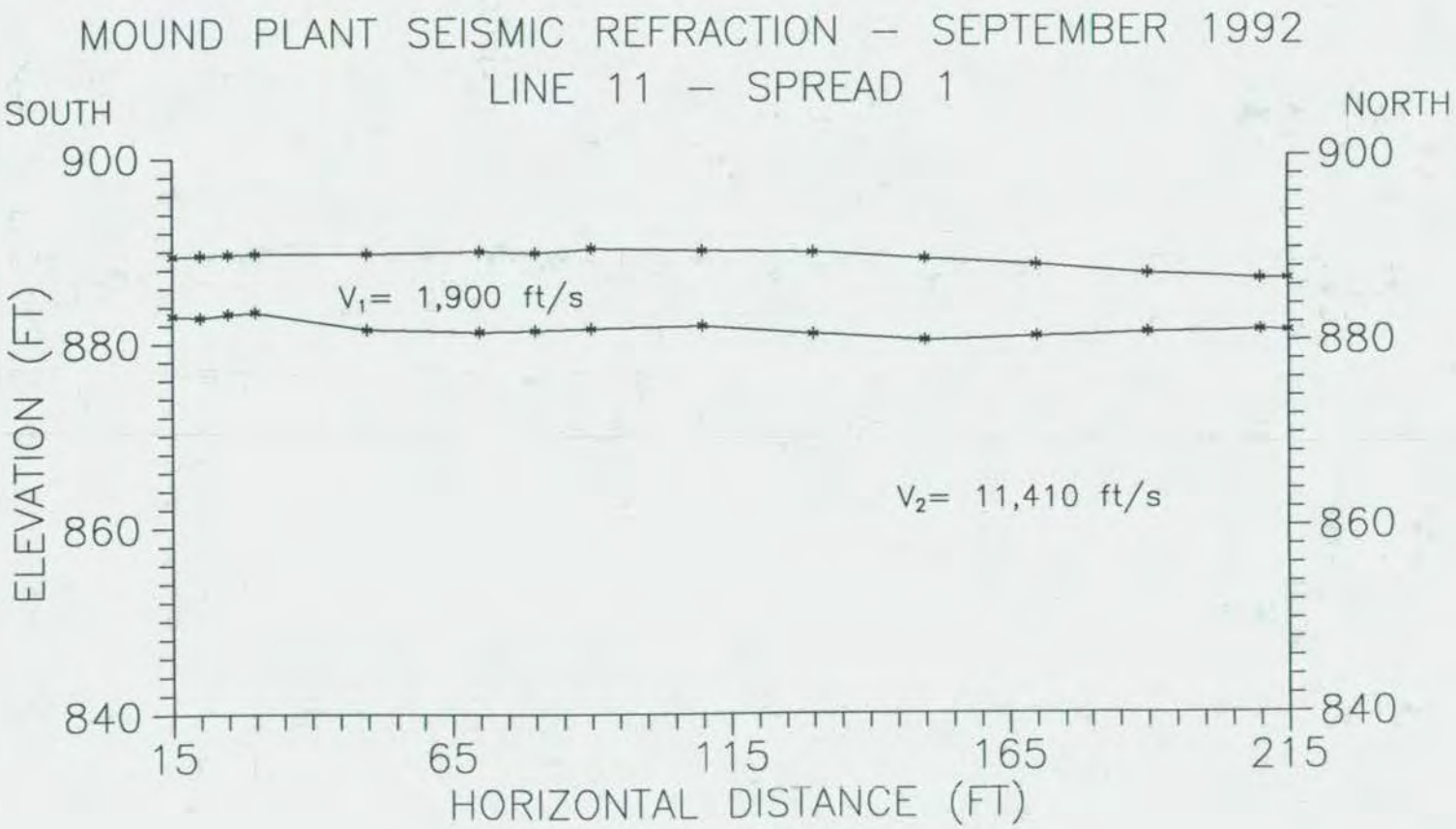

MOUND PLANT SEISMIC REFRACTION – JULY 1992
LINE 7 – SPREADS 3 and 4
SOUTH
NORTH
Intersects line 8
V_1= 1,160 ft/s
V_2= 3,840 ft/s
V_3= 10,200 ft/s
ELEVATION (FT)
780
760
740
720
700
680
745
795
845
895
945
995
1045
1095
1145
HORIZONTAL DISTANCE (FT)

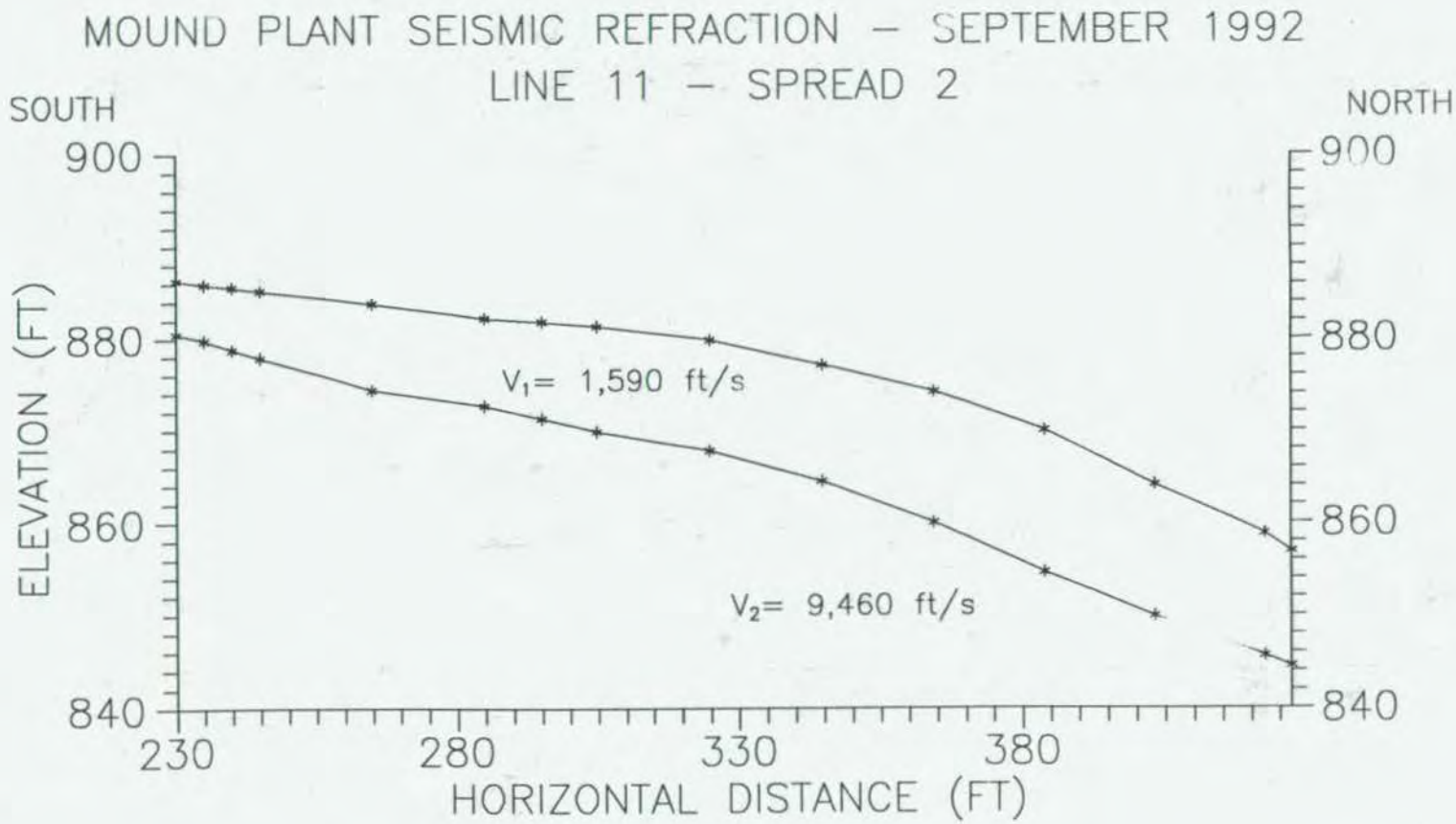

MOUND PLANT SEISMIC REFRACTION – JULY 1992
LINE 7 – SPREADS 5, 6, and 7
SOUTH
NORTH
ELEVATION (FT)
830
810
790
770
750
730
1175
1275
1375
1475
1575
1675
1775
HORIZONTAL DISTANCE (FT)
V1= 1,260 ft/s
V2= 3,621 ft/s
V3= 8,480 ft/s


MOUND PLANT SEISMIC REFRACTION – JULY 1992
LINE 8 – SPREADS 1 and 2
WEST
EAST
Intersects line 7
ELEVATION (FT)
760
740
720
700
680
660
640
620
600
580
560
V1= 1,470 ft/s
V2= 4,370 ft/s
V3= 12,080 ft/s
35 85 135 185 235 285 335 385 435 485 535
HORIZONTAL DISTANCE (FT)

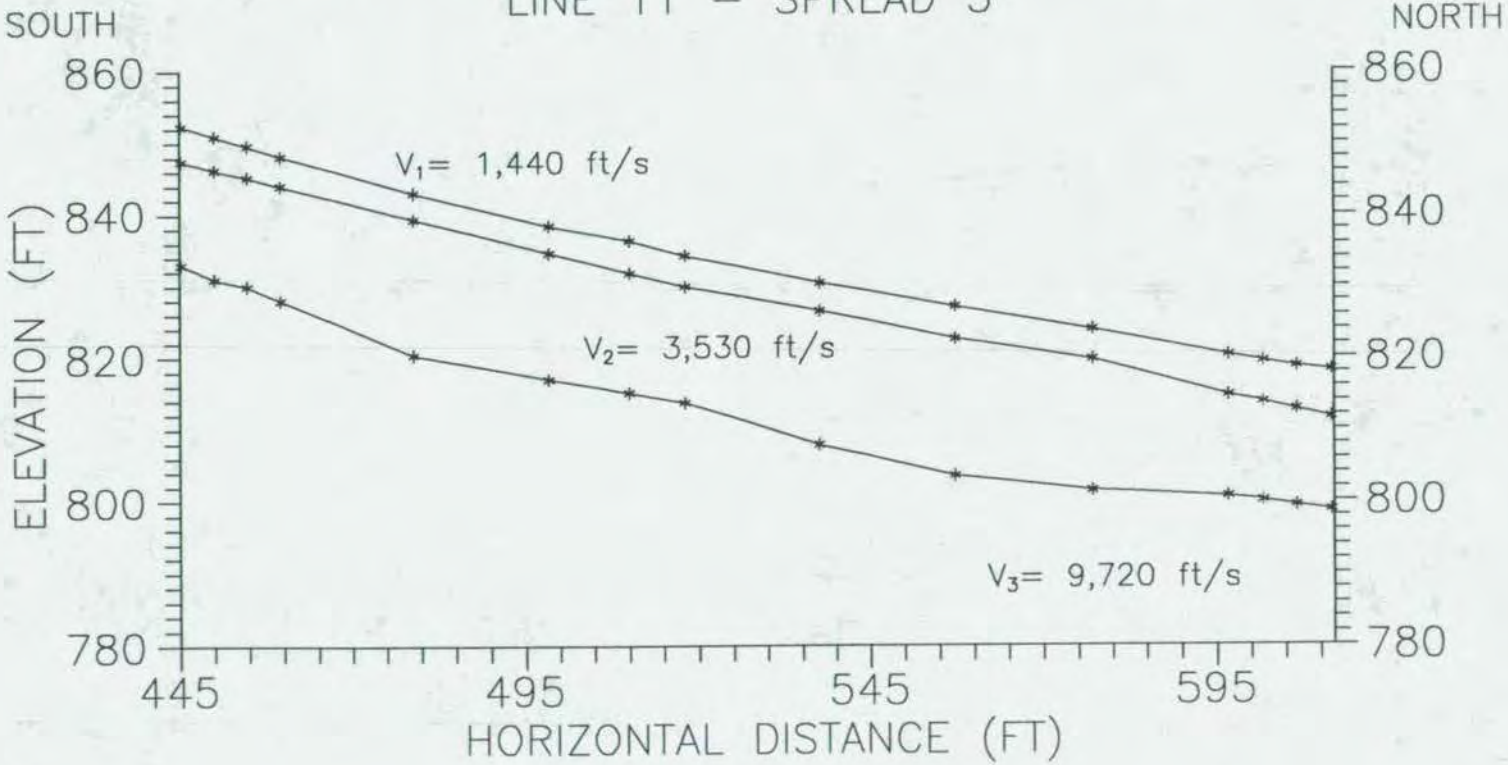

MOUND PLANT SEISMIC REFRACTION – JULY 1992
LINE 9 – SPREAD 1
WEST
EAST
ELEVATION (FT)
760
735
710
685
660
635
610
585
560
V1= 1,590 ft/s
V2= 5,730 ft/s
V3= 14,200 ft/s
35 85 135 185 235 285 335 385 435 485 535
HORIZONTAL DISTANCE (FT)

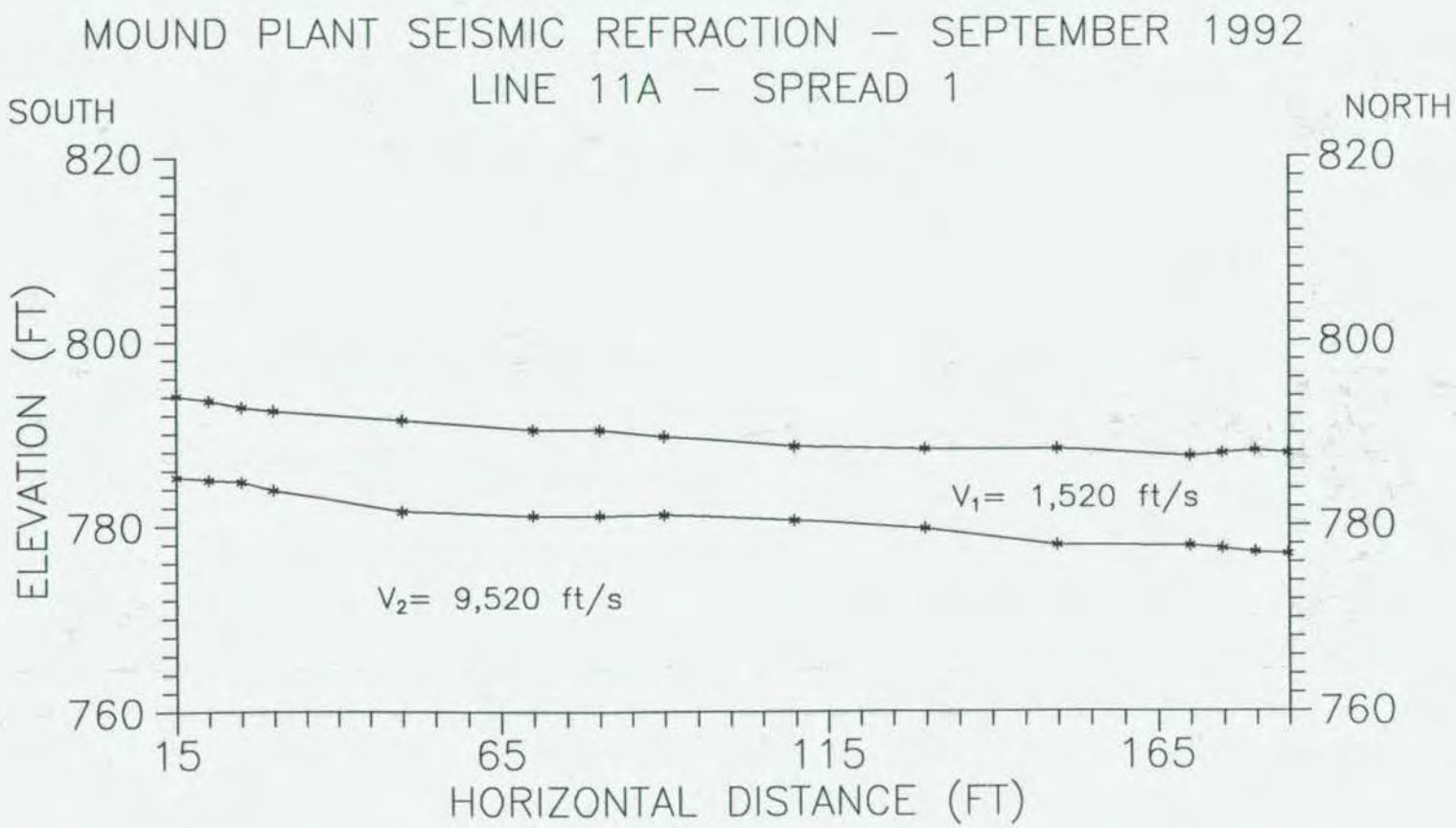

MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992
LINE 10 (REPEAT) – SPREADS 1 and 2
WEST
EAST
V1= 1,860 ft/s
V2= 4,340 ft/s
V3= 6,450 ft/s
V4= 14,510 ft/s
ELEVATION (FT)
750
700
650
600
550
500
450
45
145
245
345
445
545
645
745
HORIZONTAL DISTANCE (FT)


MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992
LINE 11 – SPREAD 1
SOUTH
NORTH
900
880
860
840
ELEVATION (FT)
V_1= 1,900 ft/s
V_2= 11,410 ft/s
15
65
115
165
215
HORIZONTAL DISTANCE (FT)


MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992
LINE 11 – SPREAD 2
SOUTH
NORTH
900
880
860
840
ELEVATION (FT)
V_1= 1,590 ft/s
V_2= 9,460 ft/s
230
280
330
380
HORIZONTAL DISTANCE (FT)

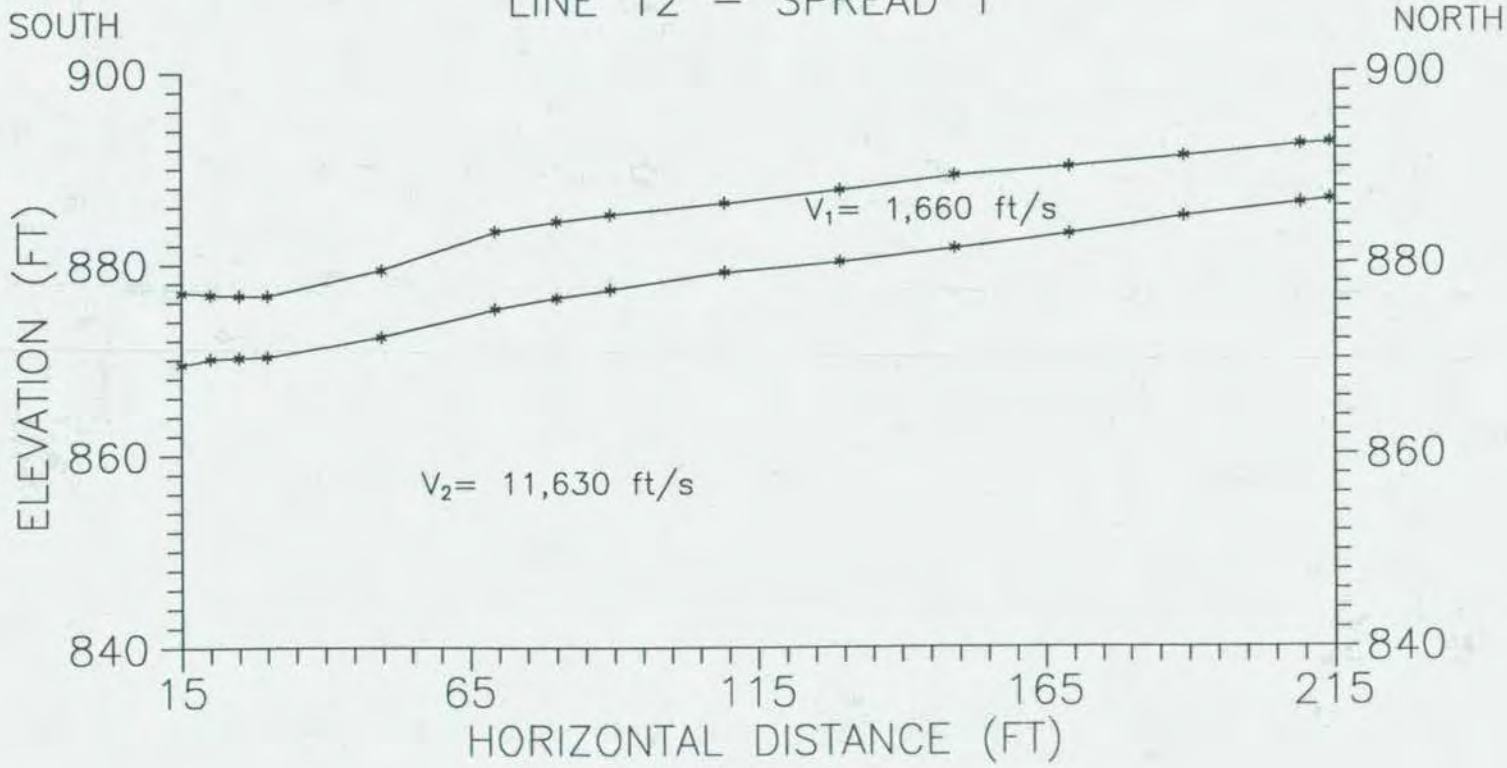
MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992
LINE 11 – SPREAD 3



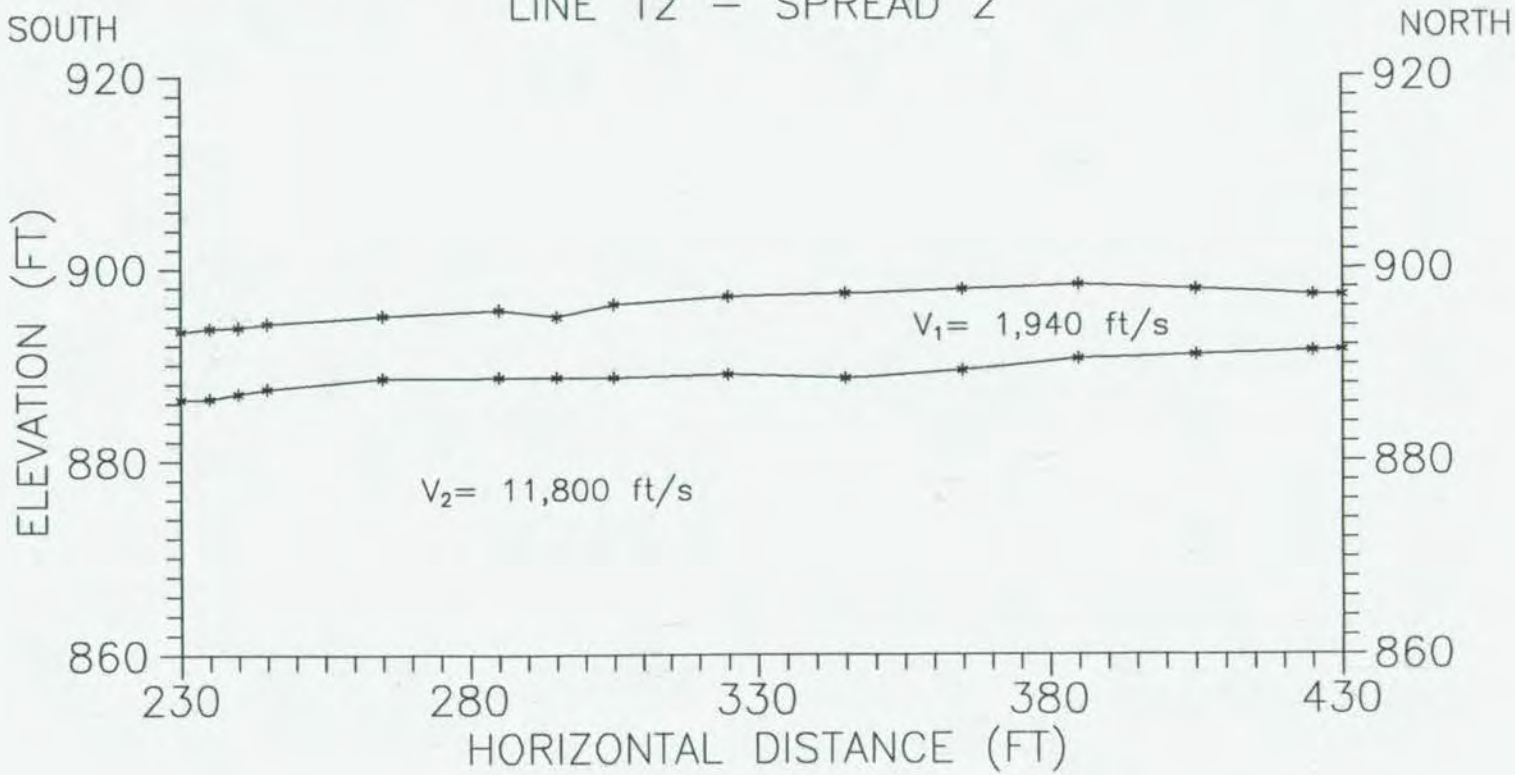

MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992
LINE 11A – SPREAD 1
SOUTH
NORTH
820
800
780
760
ELEVATION (FT)
V_1= 1,520 ft/s
V_2= 9,520 ft/s
15
65
115
165
HORIZONTAL DISTANCE (FT)

MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992

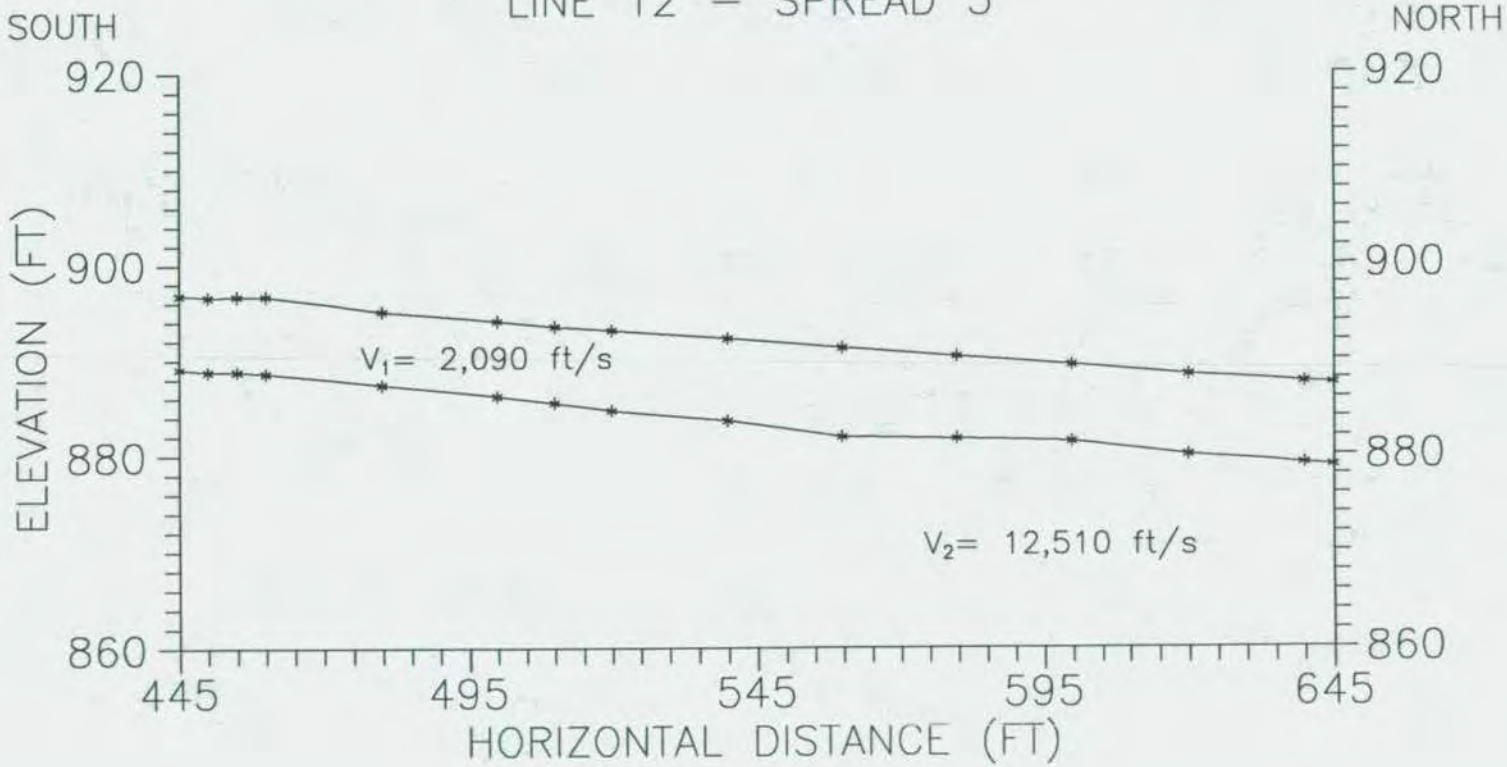
LINE 12 – SPREAD 1

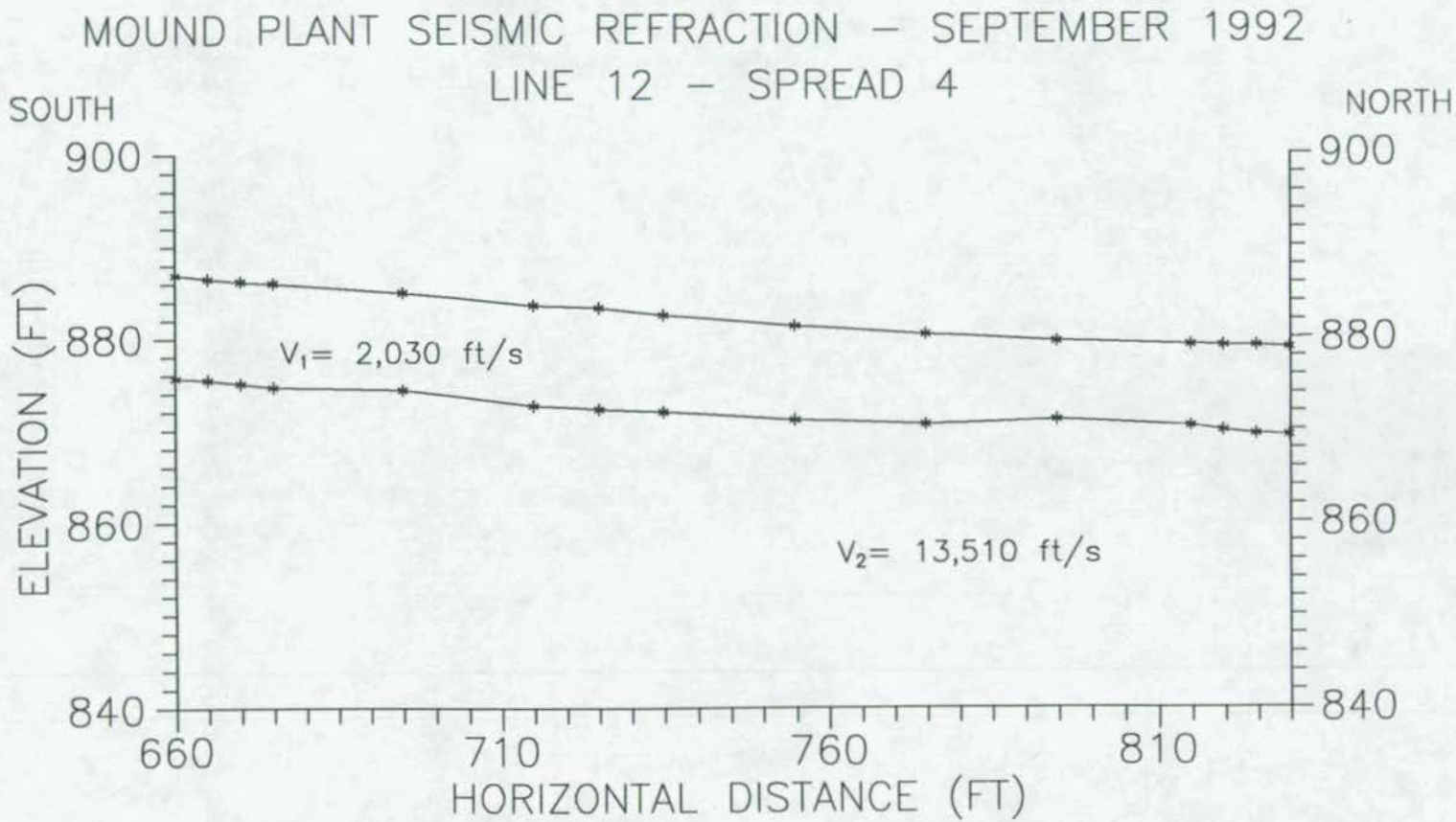


MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992
LINE 12 – SPREAD 2



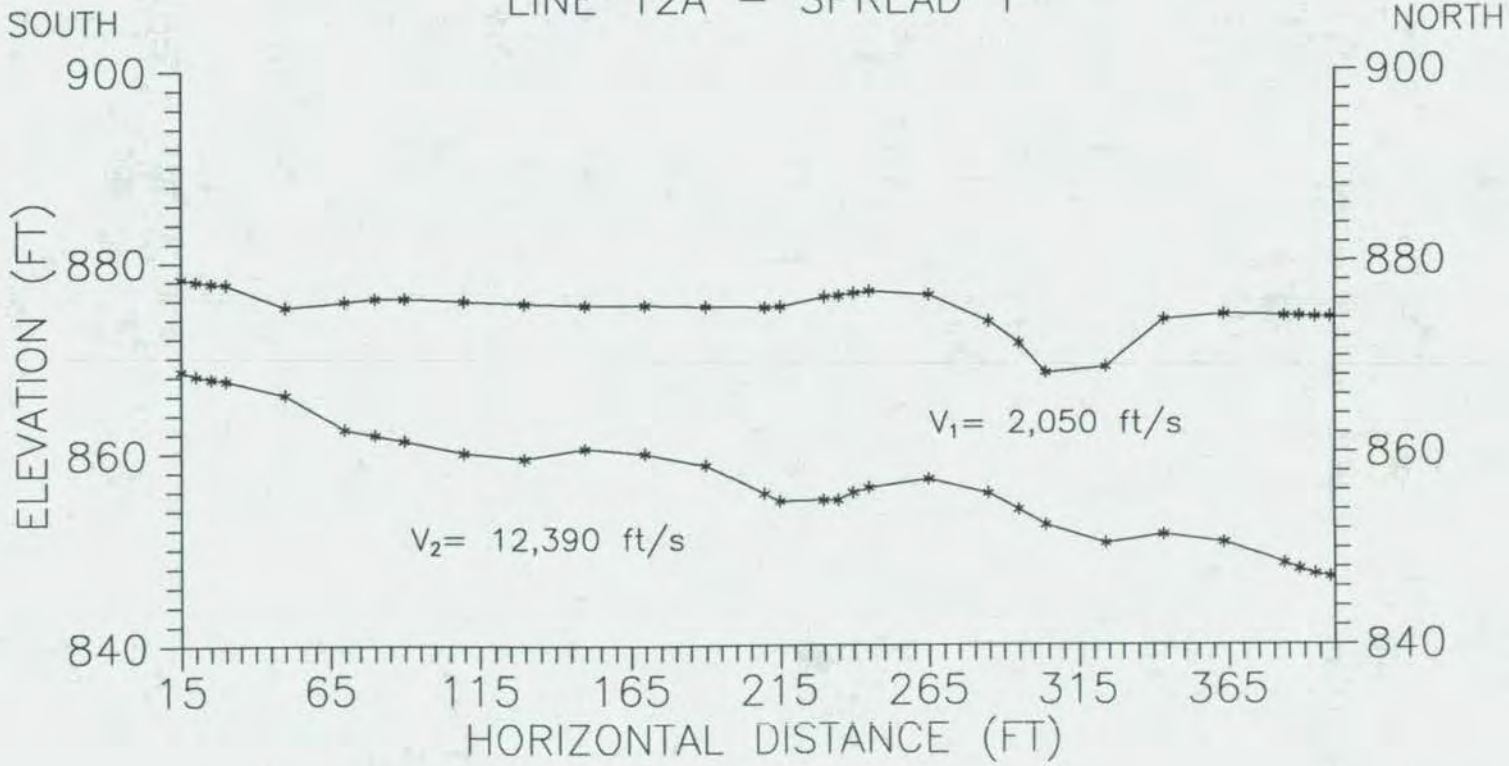
MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992
LINE 12 – SPREAD 3




MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992
LINE 12 – SPREAD 4
SOUTH
NORTH
900
880
860
840
ELEVATION (FT)
V1= 2,030 ft/s
V2= 13,510 ft/s
660
710
760
810
HORIZONTAL DISTANCE (FT)

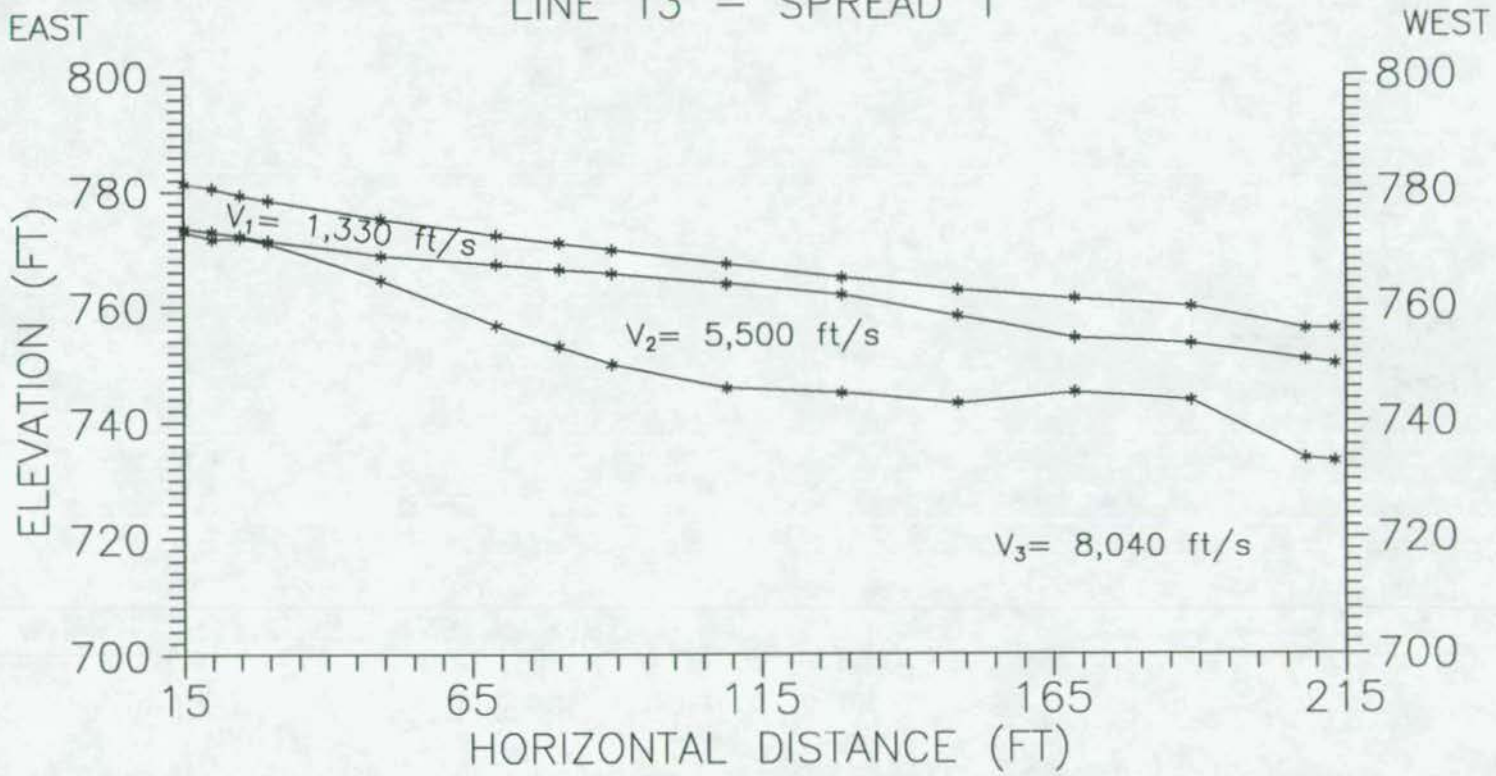
MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992

LINE 12A – SPREAD 1



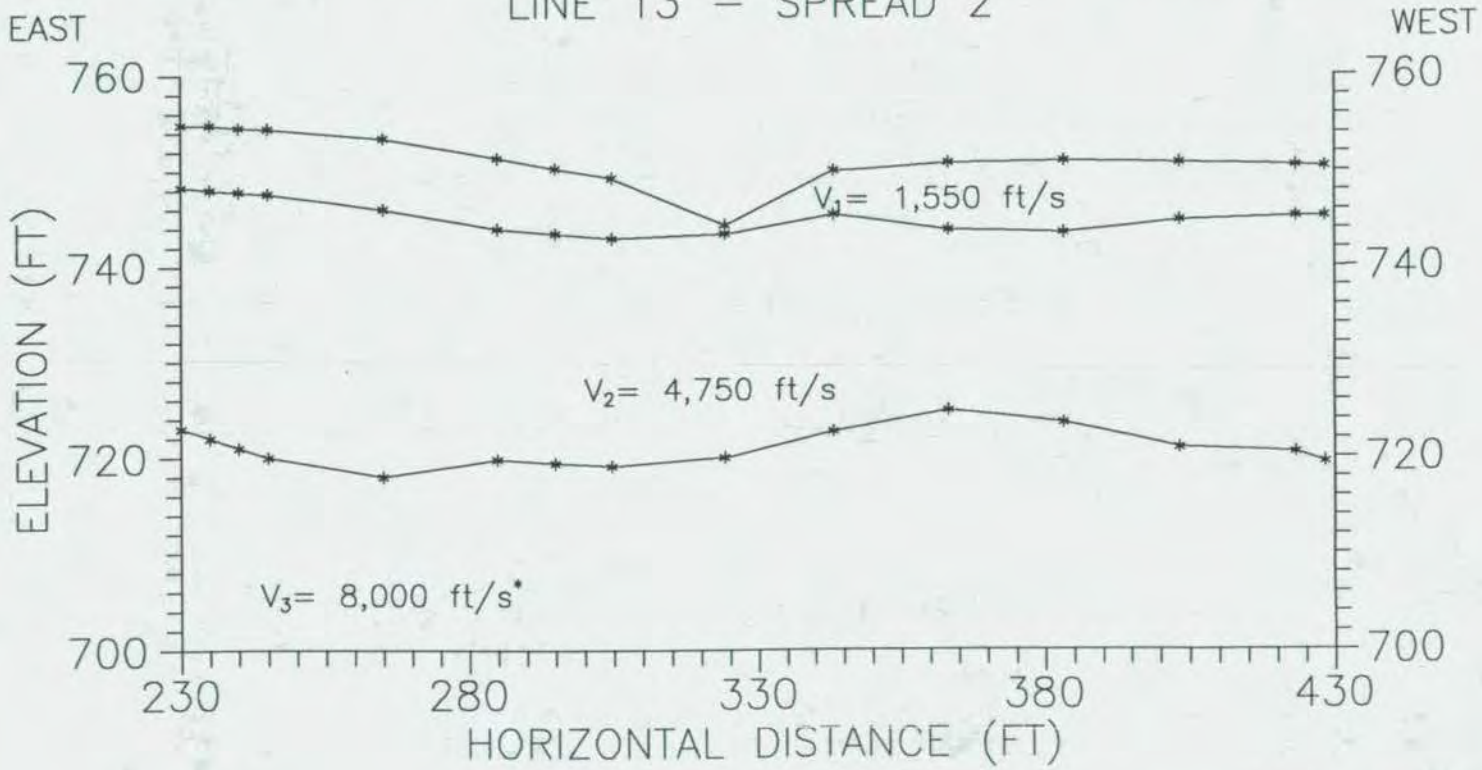
MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992

LINE 13 – SPREAD 1

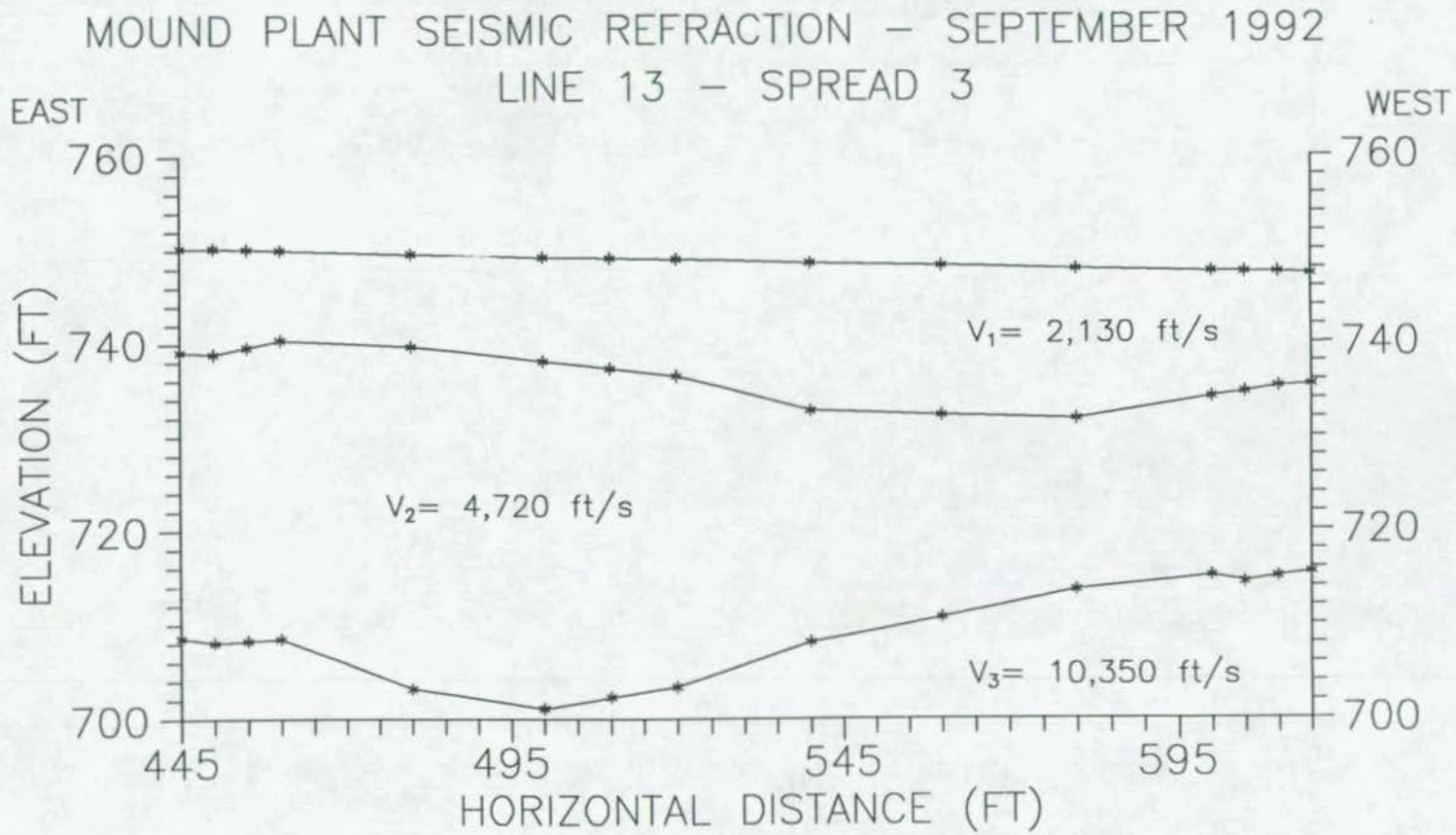


MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992

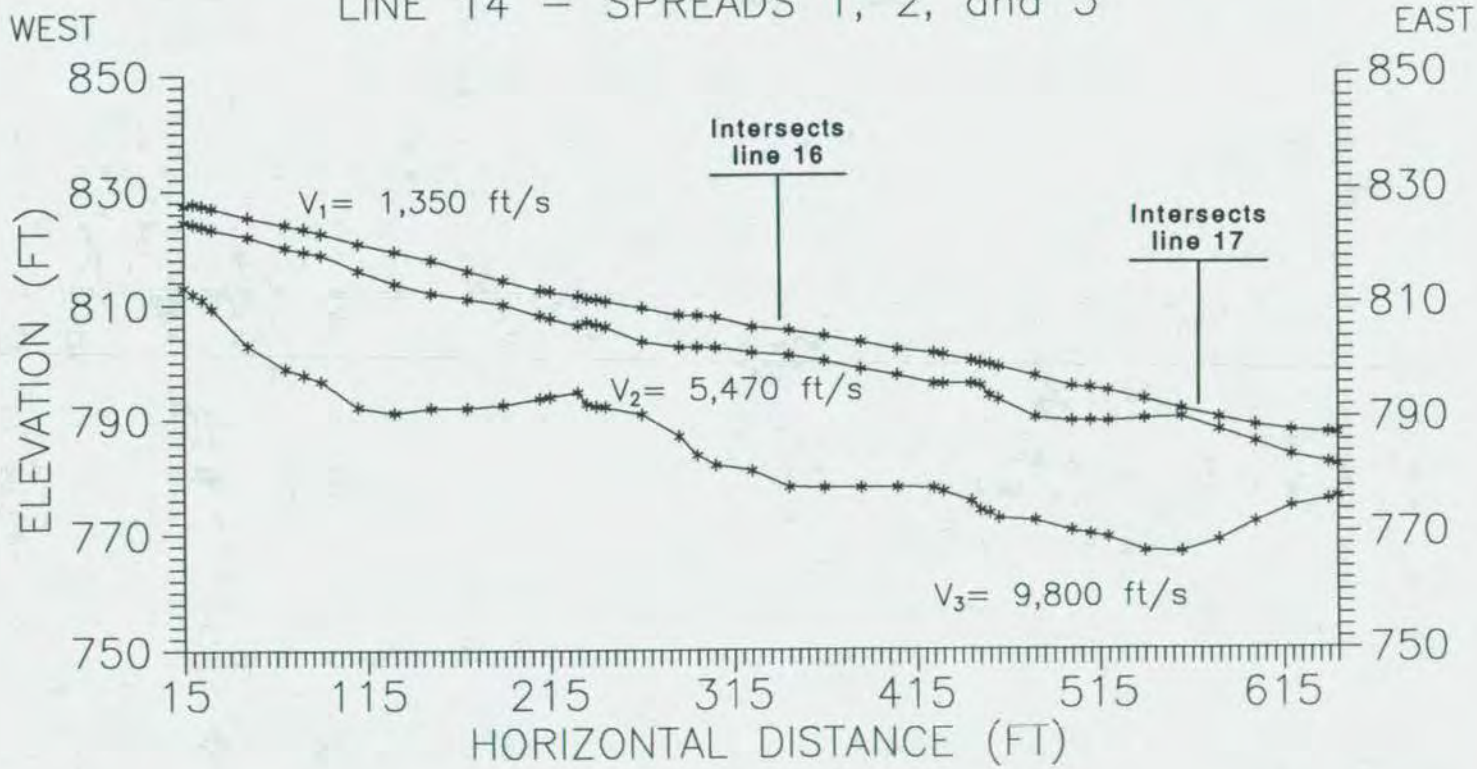
LINE 13 – SPREAD 2

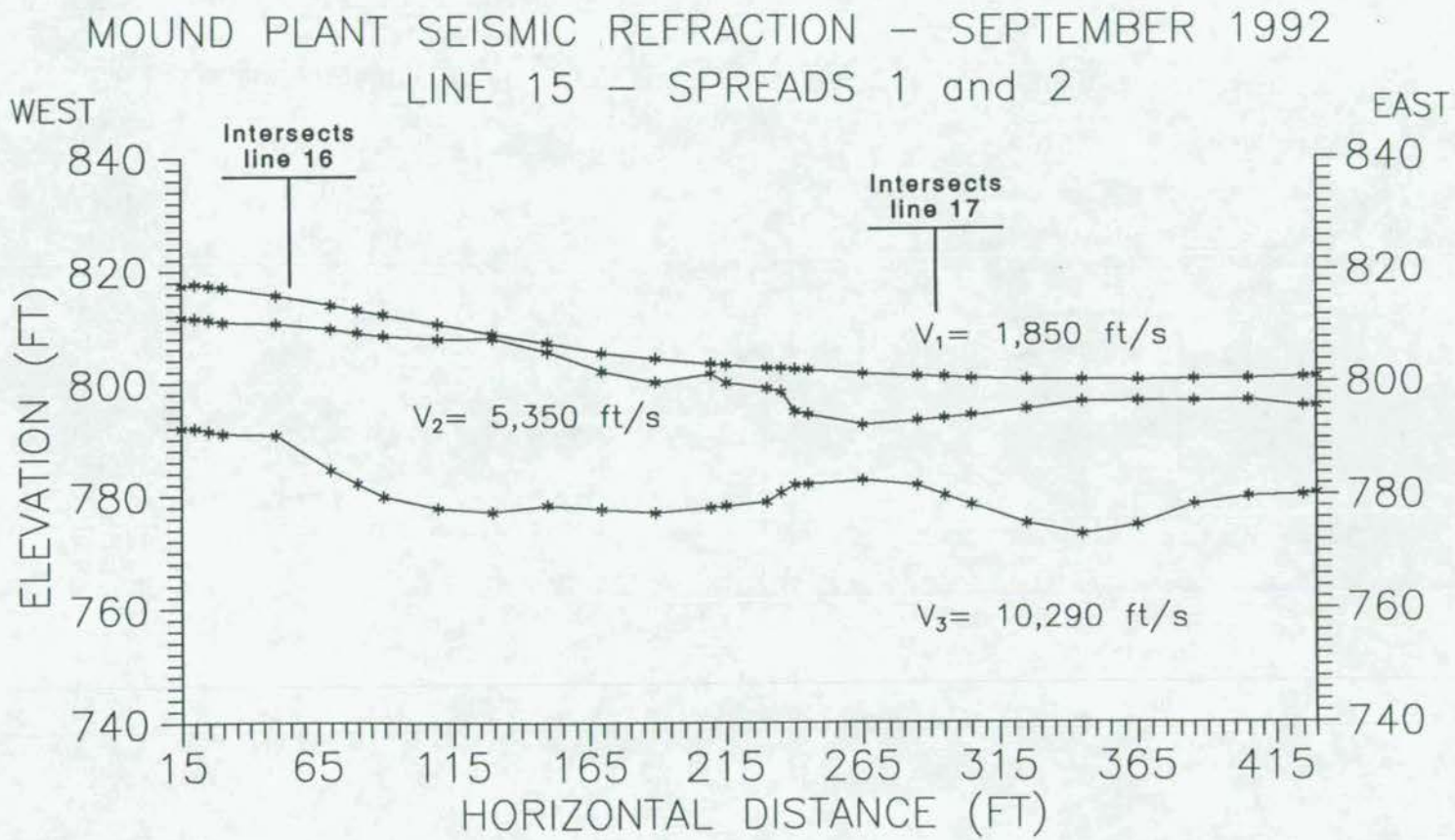


* = Velocity override value.


MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992
LINE 13 – SPREAD 3
EAST
WEST
760
740
720
700
ELEVATION (FT)
V1= 2,130 ft/s
V2= 4,720 ft/s
V3= 10,350 ft/s
445
495
545
595
HORIZONTAL DISTANCE (FT)

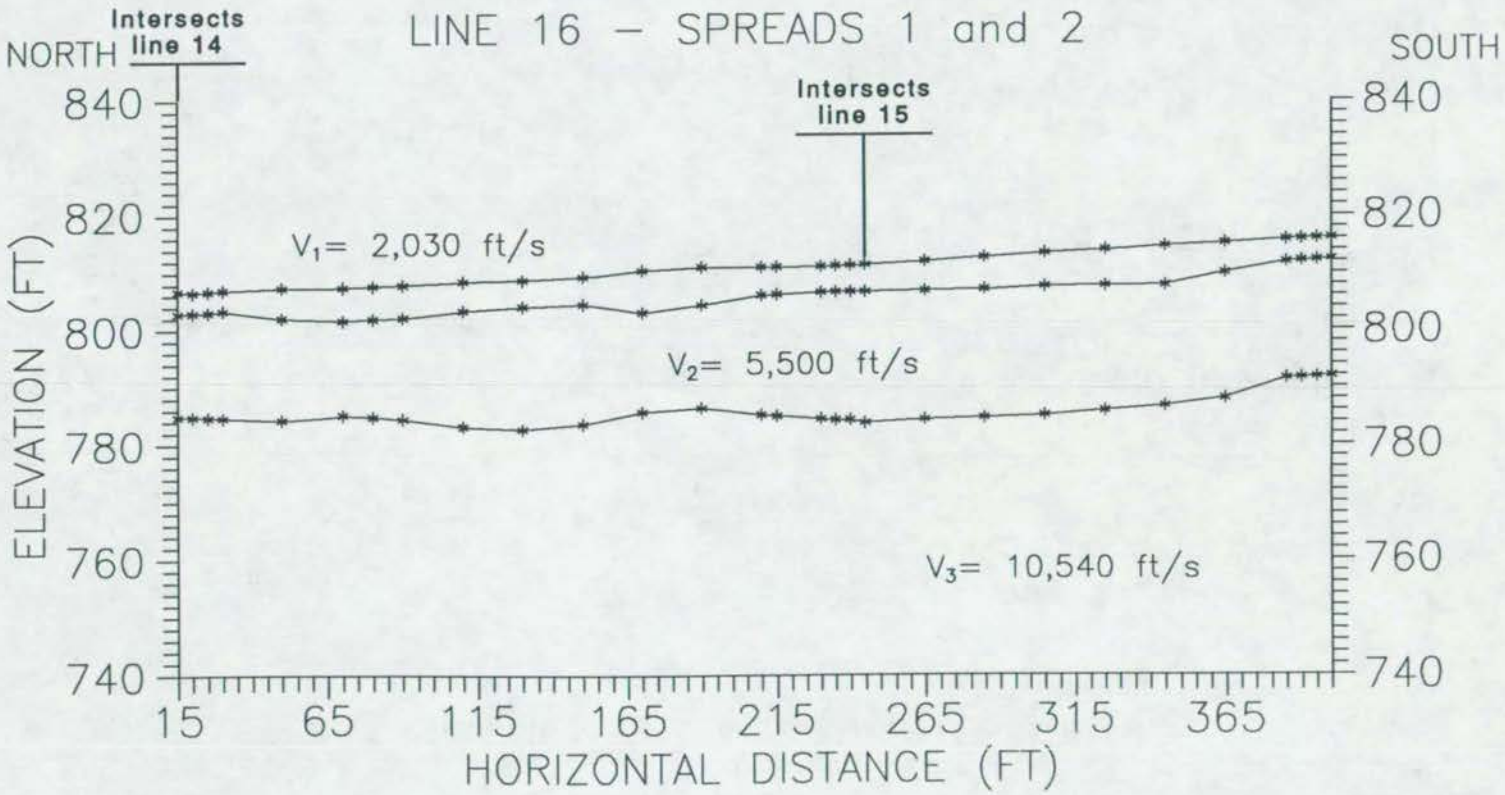
MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992
LINE 14 – SPREADS 1, 2, and 3

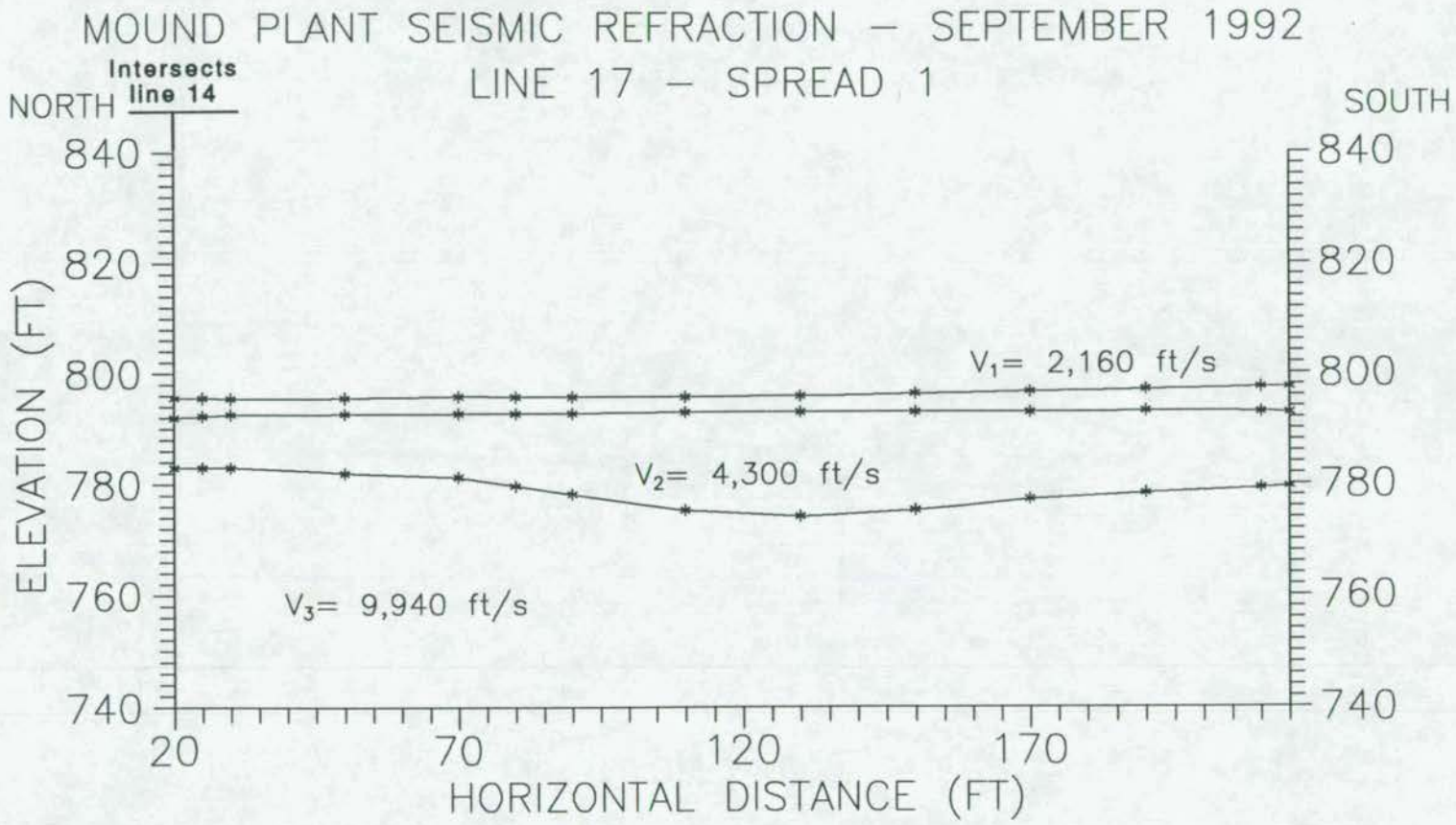



MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992
LINE 15 – SPREADS 1 and 2
WEST
EAST
Intersects line 16
Intersects line 17
V_1= 1,850 ft/s
V_2= 5,350 ft/s
V_3= 10,290 ft/s
ELEVATION (FT)
840
820
800
780
760
740
15
65
115
165
215
265
315
365
415
HORIZONTAL DISTANCE (FT)

MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992

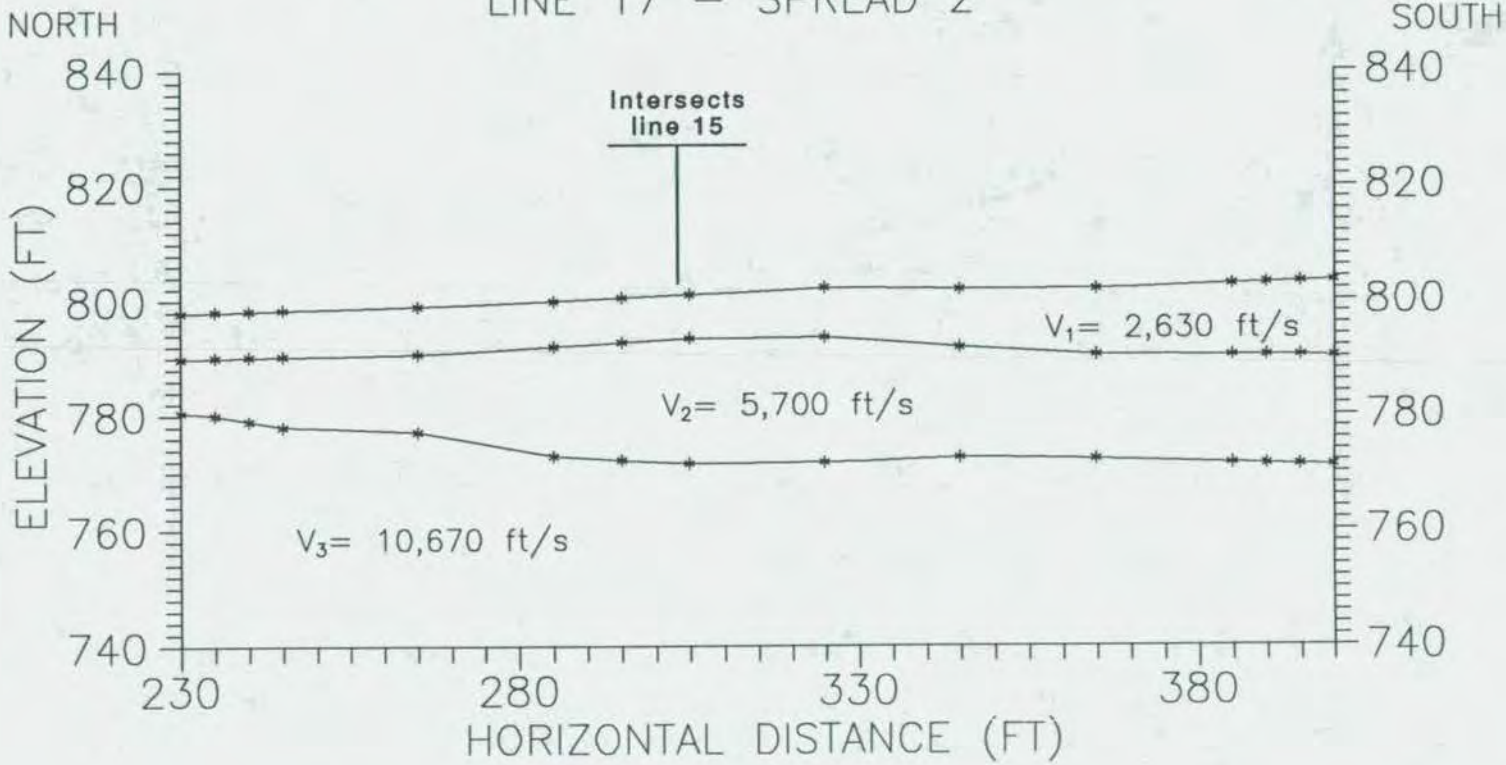
LINE 16 – SPREADS 1 and 2

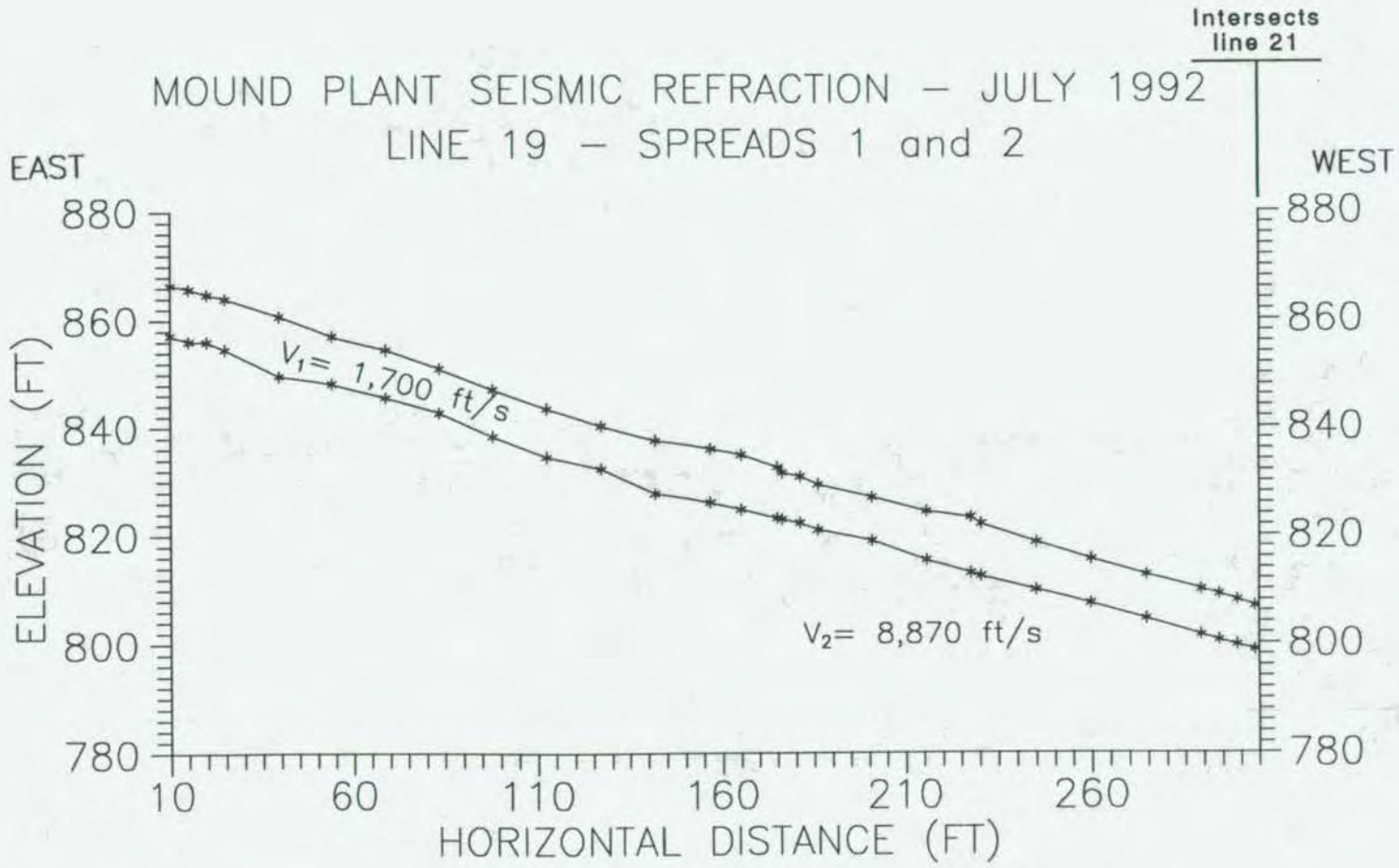



MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992
LINE 17 – SPREAD 1
Intersects line 14
NORTH
SOUTH
ELEVATION (FT)
840
820
800
780
760
740
V_1= 2,160 ft/s
V_2= 4,300 ft/s
V_3= 9,940 ft/s
20
70
120
170
HORIZONTAL DISTANCE (FT)

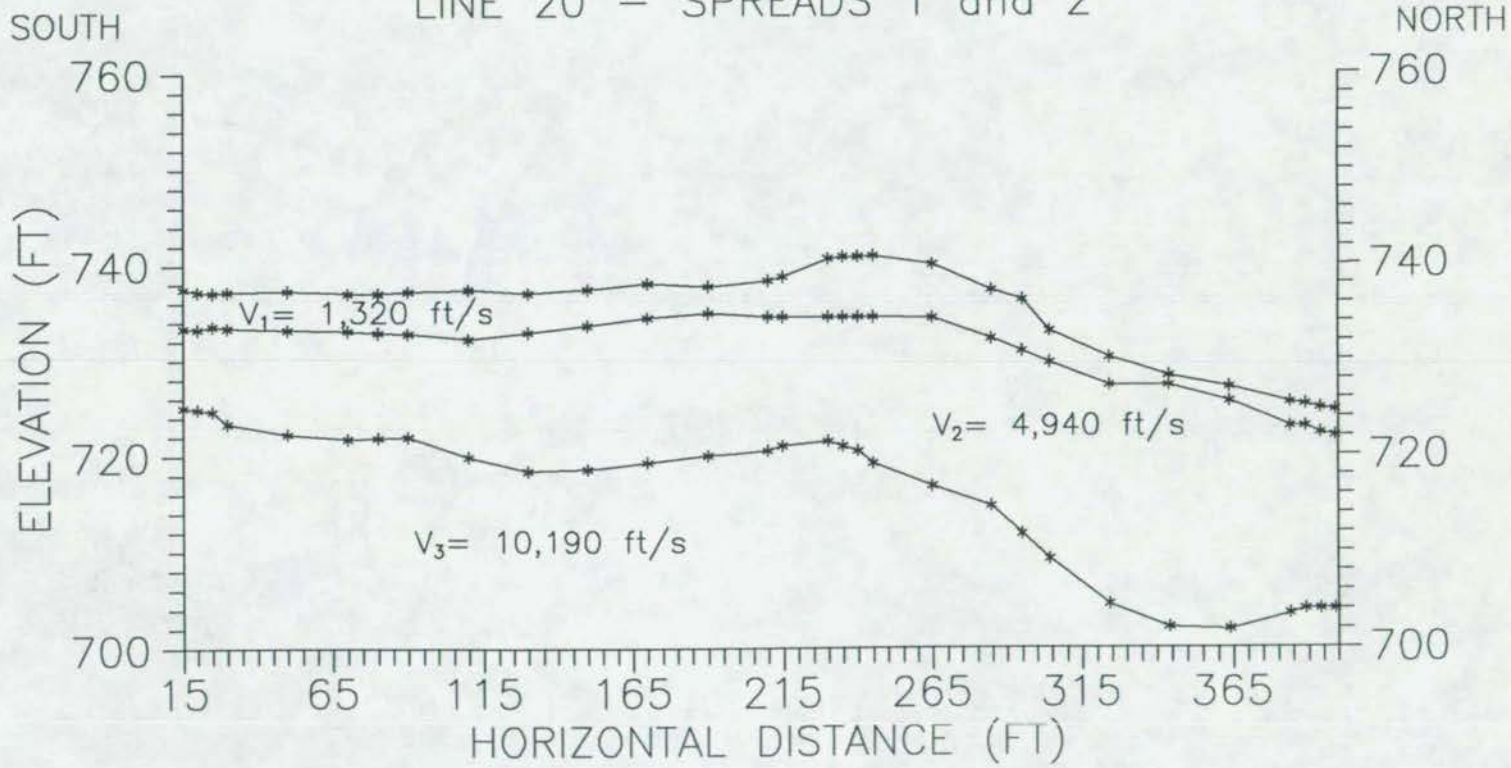
MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992

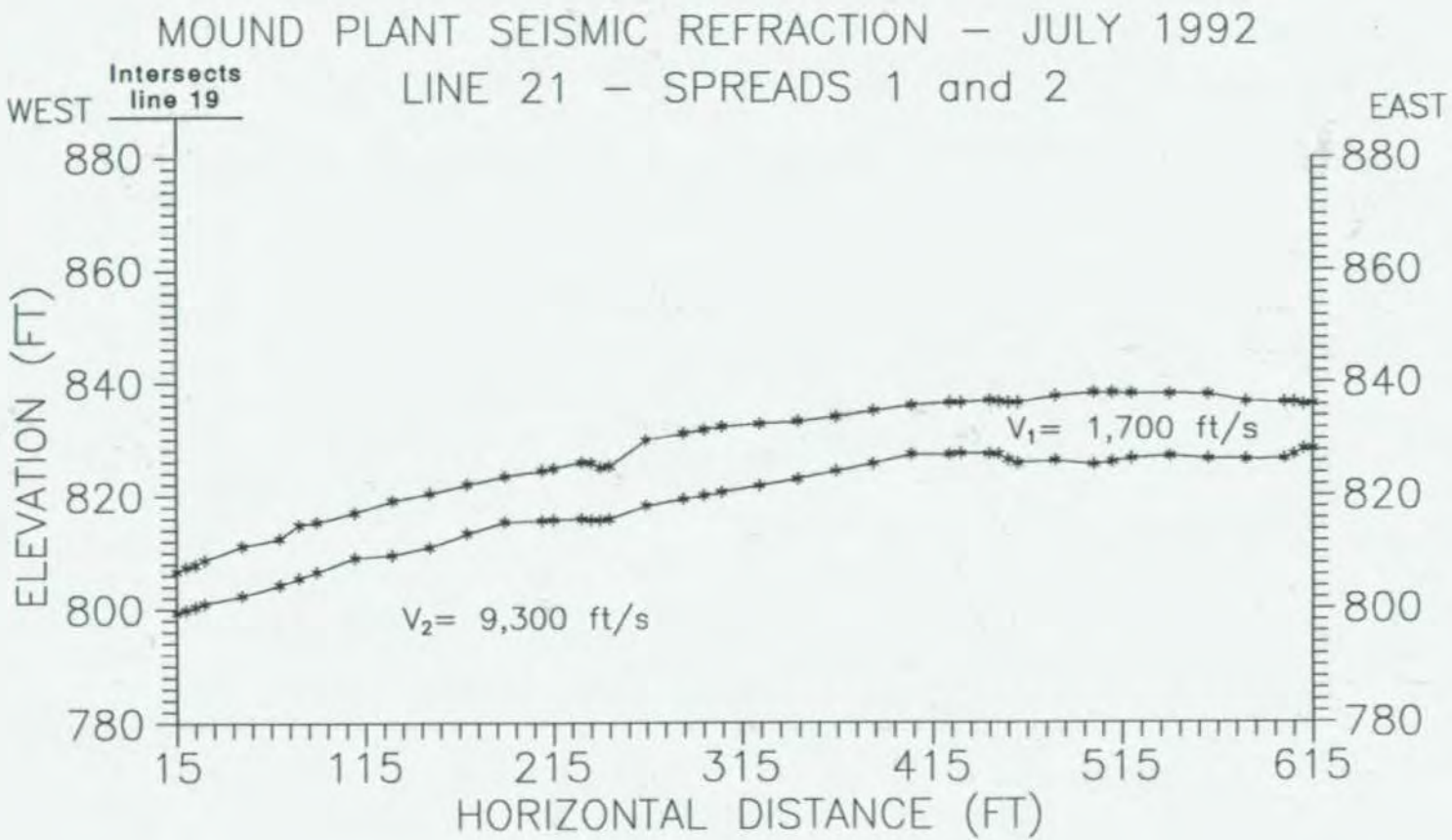
LINE 17 – SPREAD 2



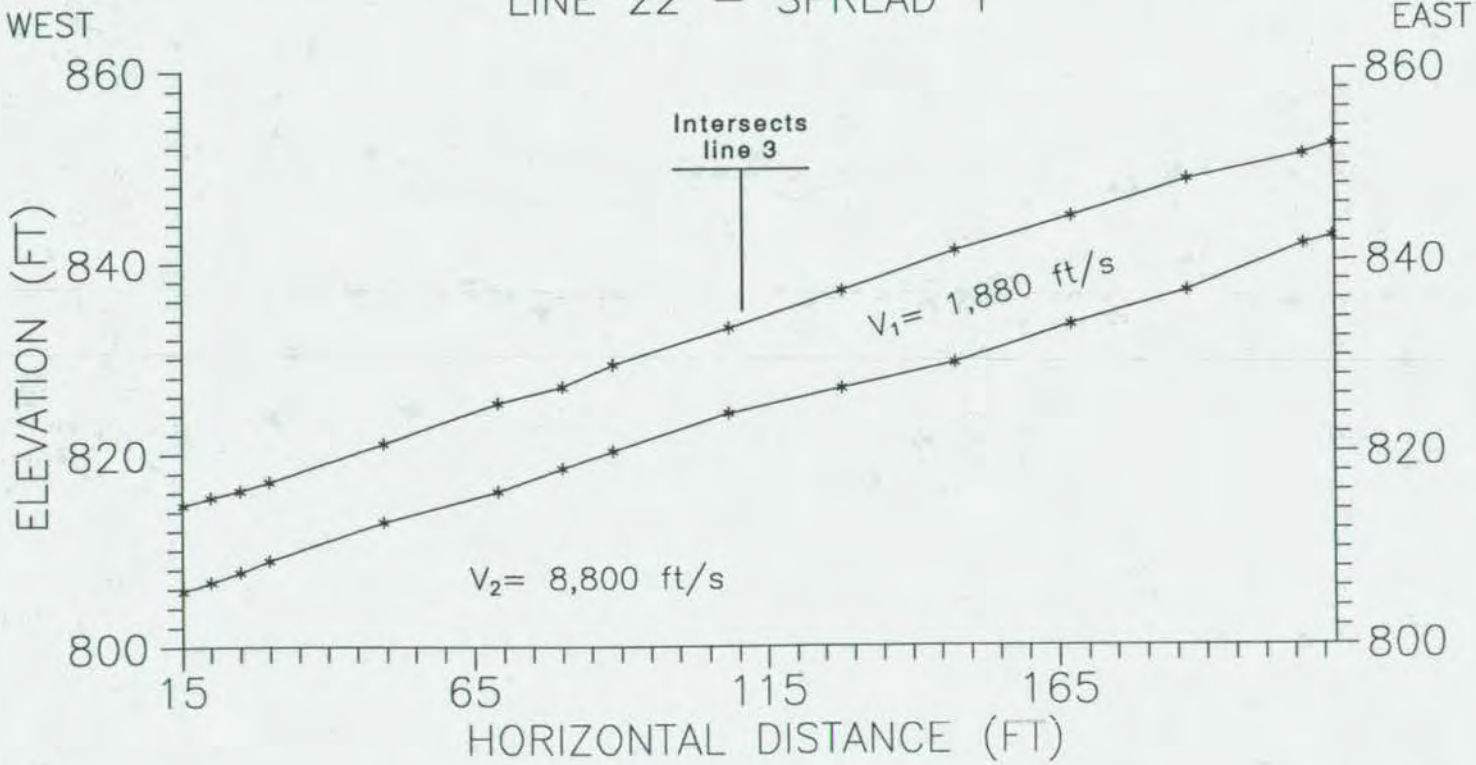

Intersects line 21
MOUND PLANT SEISMIC REFRACTION – JULY 1992
LINE 19 – SPREADS 1 and 2
EAST
WEST
880
860
840
820
800
780
ELEVATION (FT)
V_1= 1,700 ft/s
V_2= 8,870 ft/s
10
60
110
160
210
260
HORIZONTAL DISTANCE (FT)

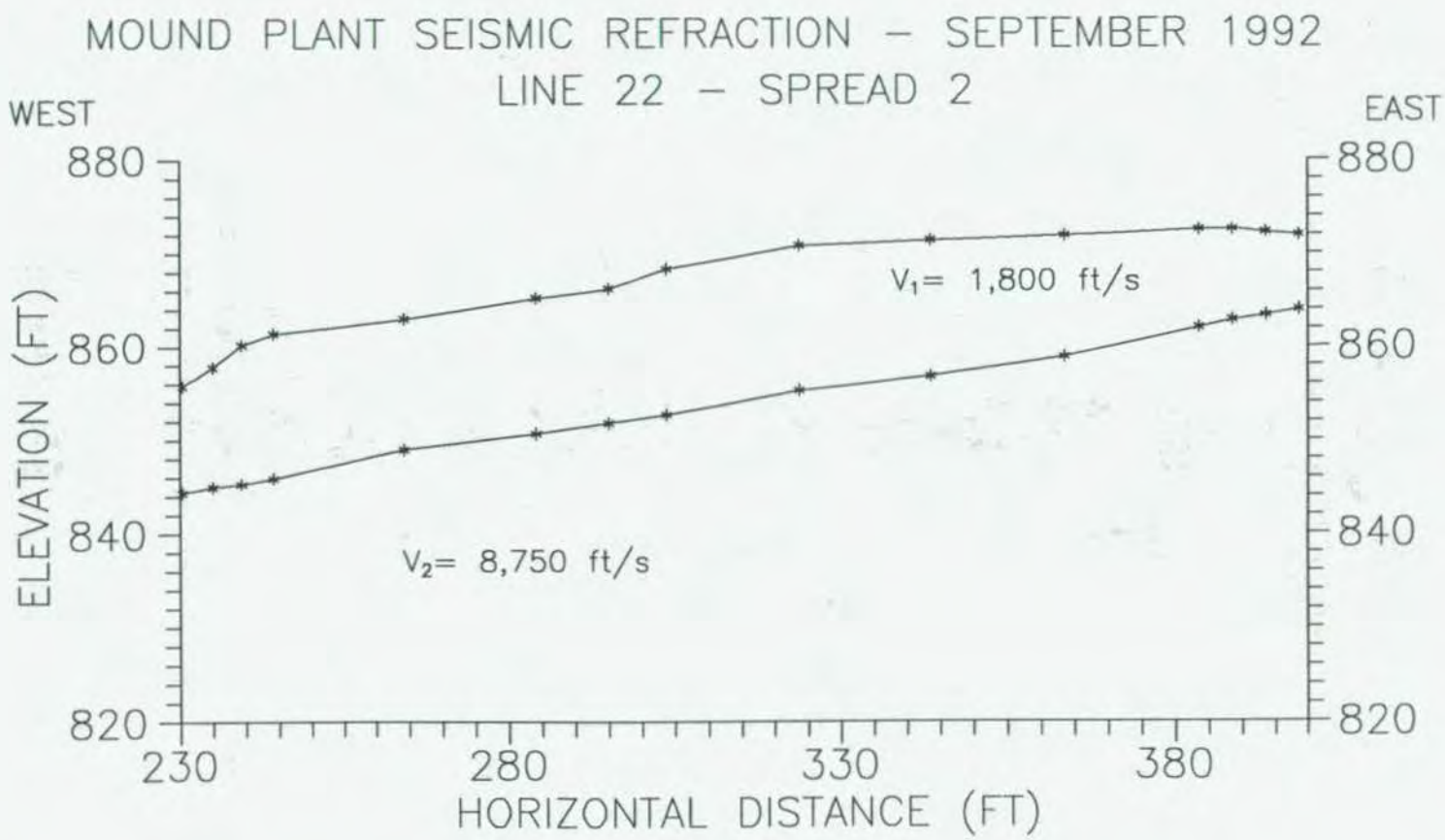
MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992
LINE 20 – SPREADS 1 and 2




MOUND PLANT SEISMIC REFRACTION – JULY 1992
LINE 21 – SPREADS 1 and 2
WEST
Intersects line 19
EAST
ELEVATION (FT)
880
860
840
820
800
780
V_1= 1,700 ft/s
V_2= 9,300 ft/s
15
115
215
315
415
515
615
HORIZONTAL DISTANCE (FT)

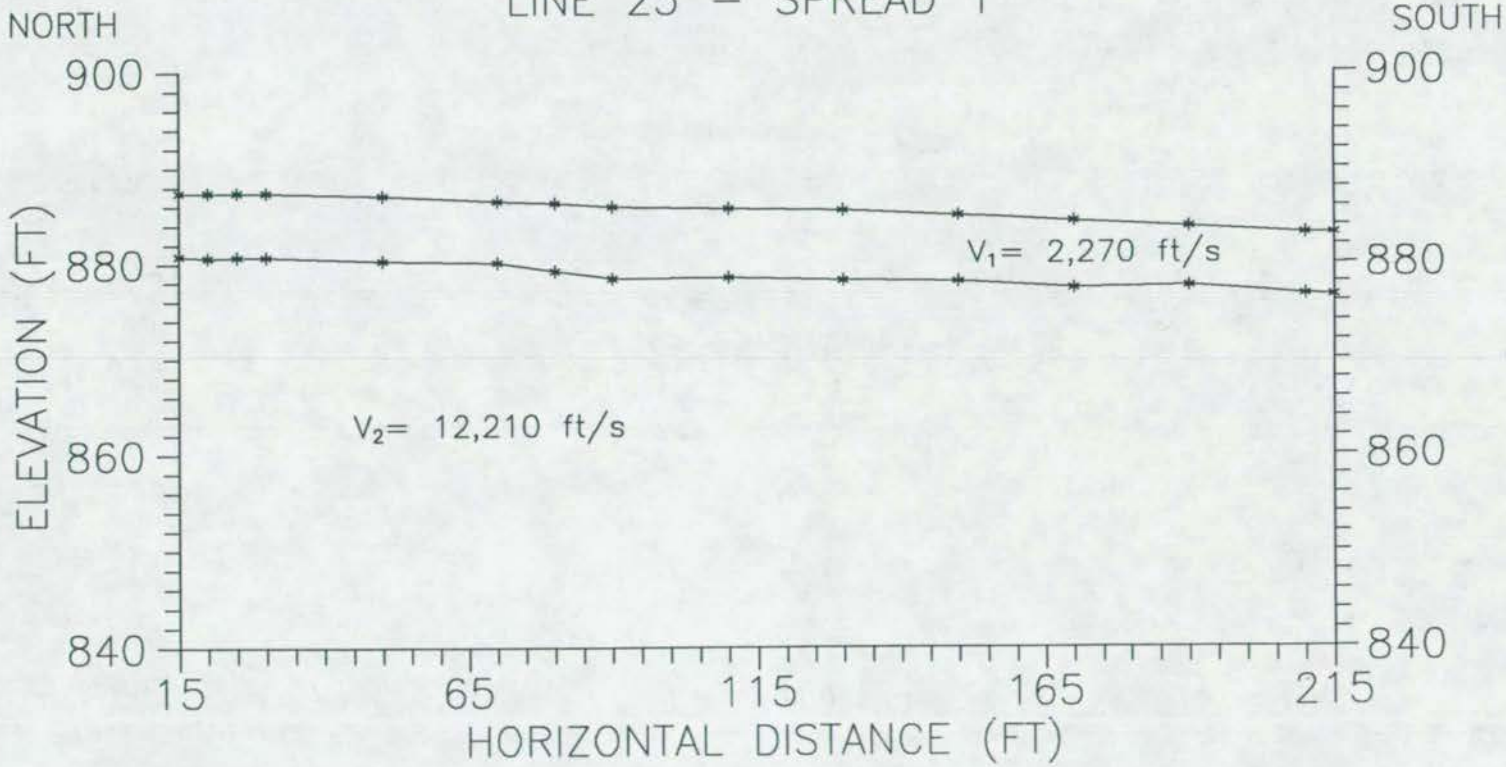
MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992
LINE 22 – SPREAD 1

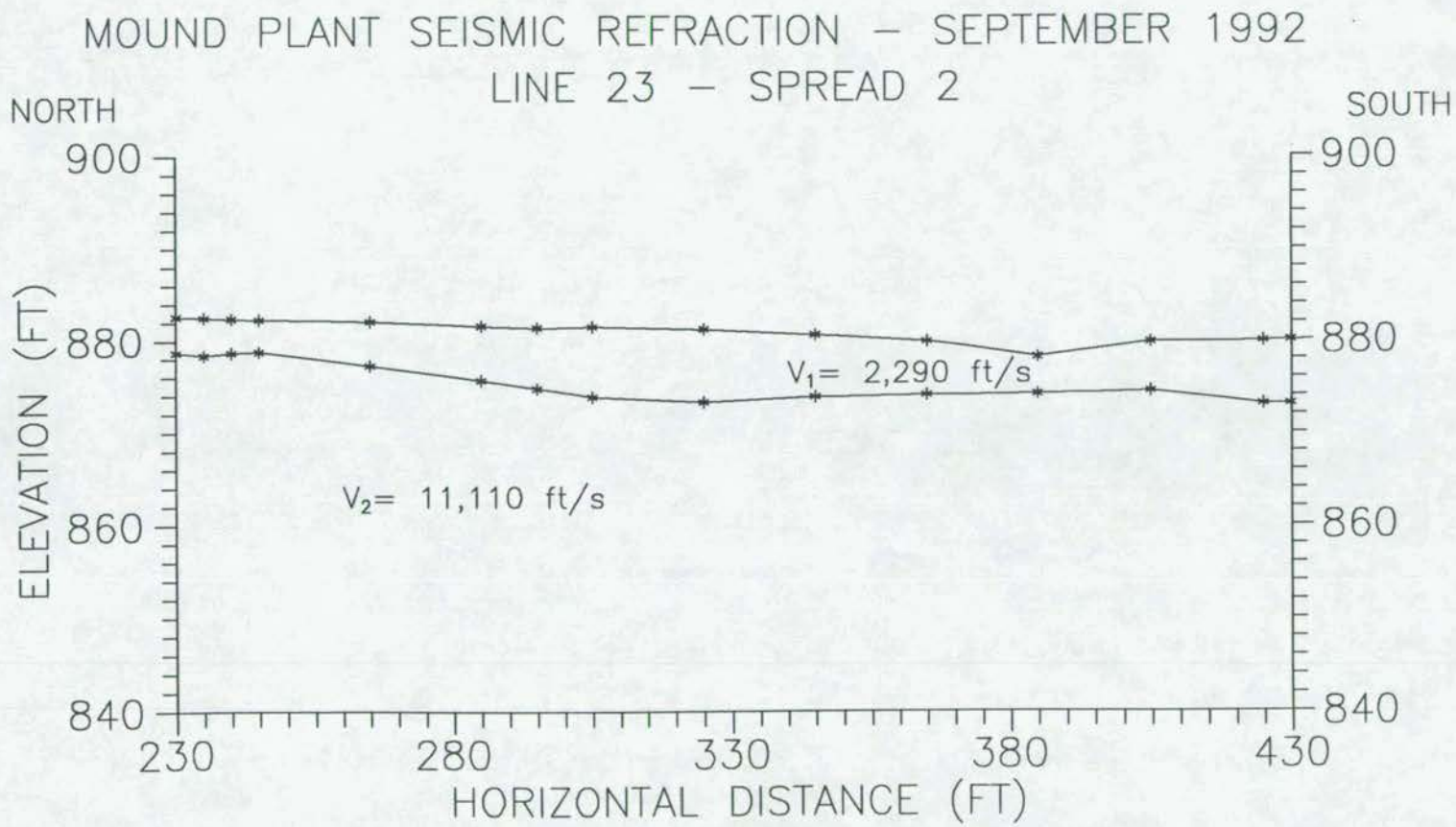



MOUND PLANT SEISMIC REFRACTION - SEPTEMBER 1992
LINE 22 - SPREAD 2
WEST
EAST
880
860
840
820
ELEVATION (FT)
V_1= 1,800 ft/s
V_2= 8,750 ft/s
230
280
330
380
HORIZONTAL DISTANCE (FT)

MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992

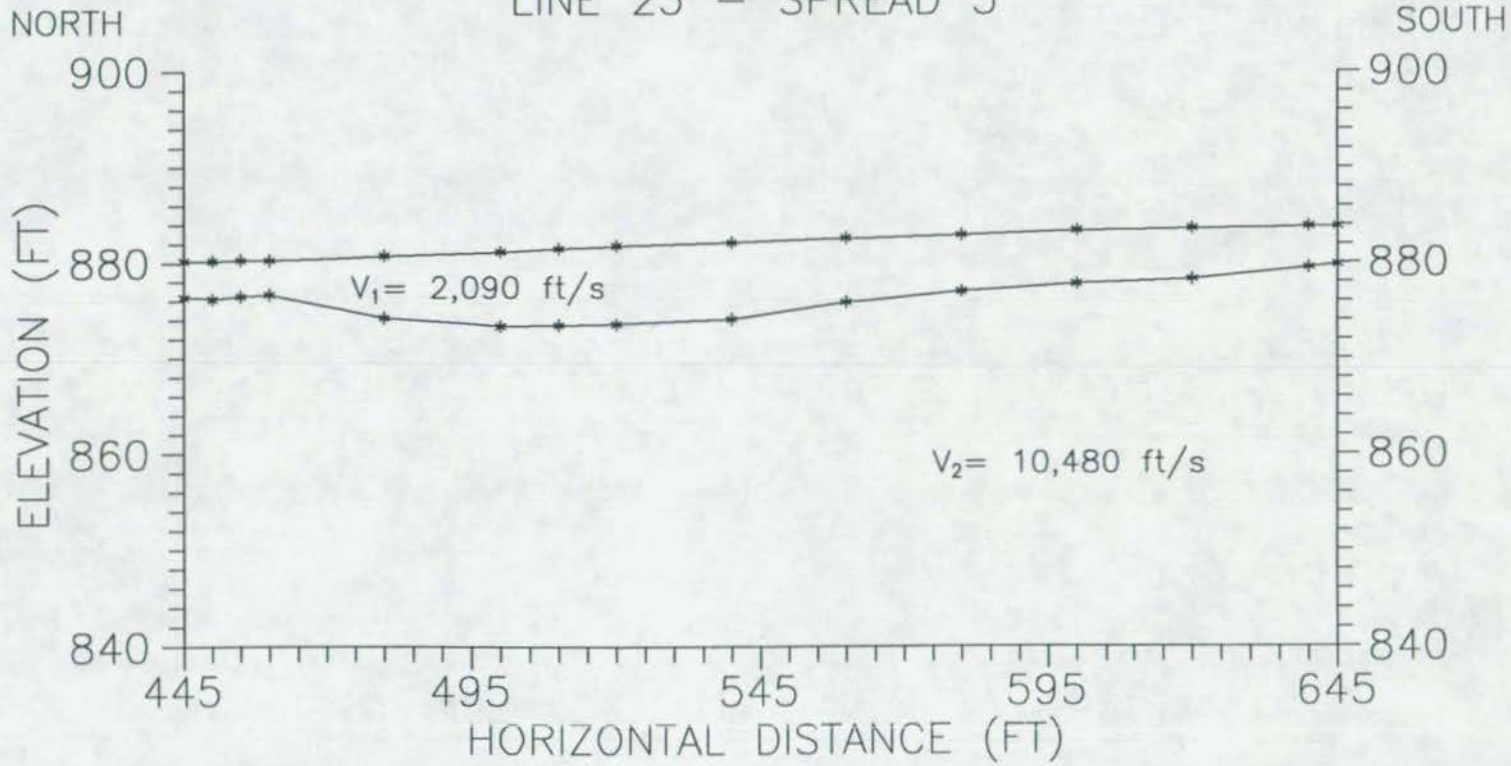
LINE 23 – SPREAD 1



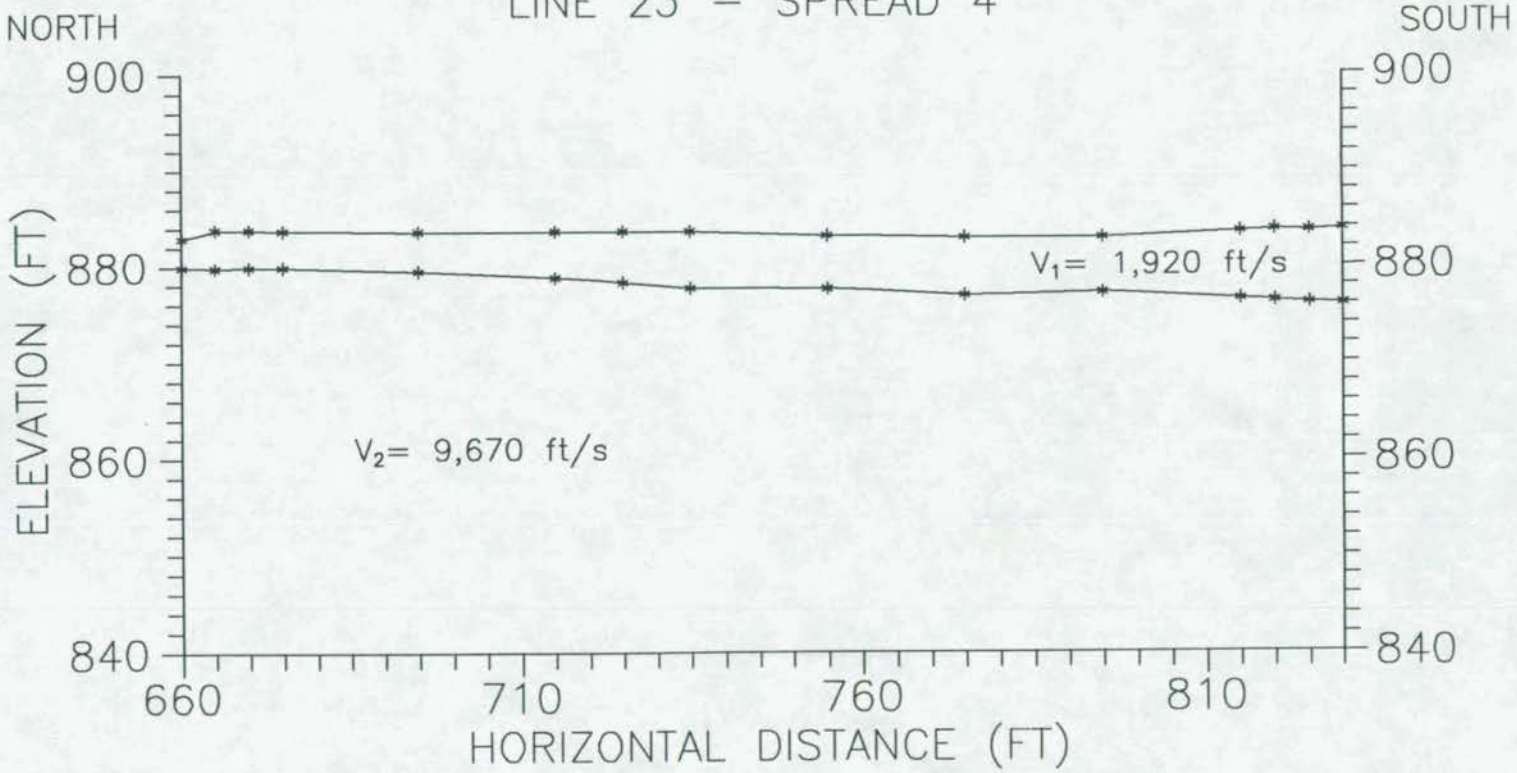

MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992
LINE 23 – SPREAD 2
NORTH
SOUTH
900
880
860
840
ELEVATION (FT)
V_1= 2,290 ft/s
V_2= 11,110 ft/s
230
280
330
380
430
HORIZONTAL DISTANCE (FT)

MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992

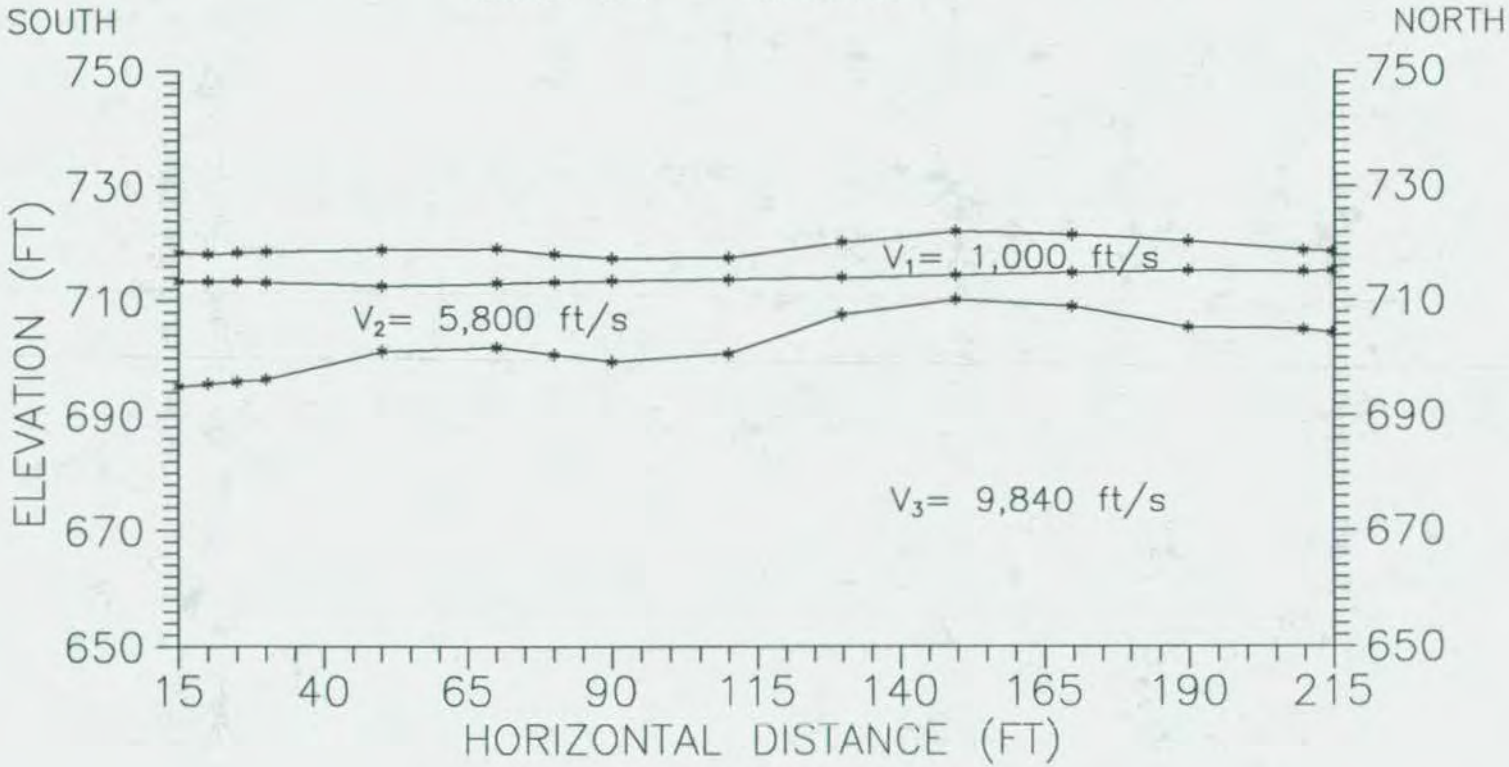
LINE 23 – SPREAD 3



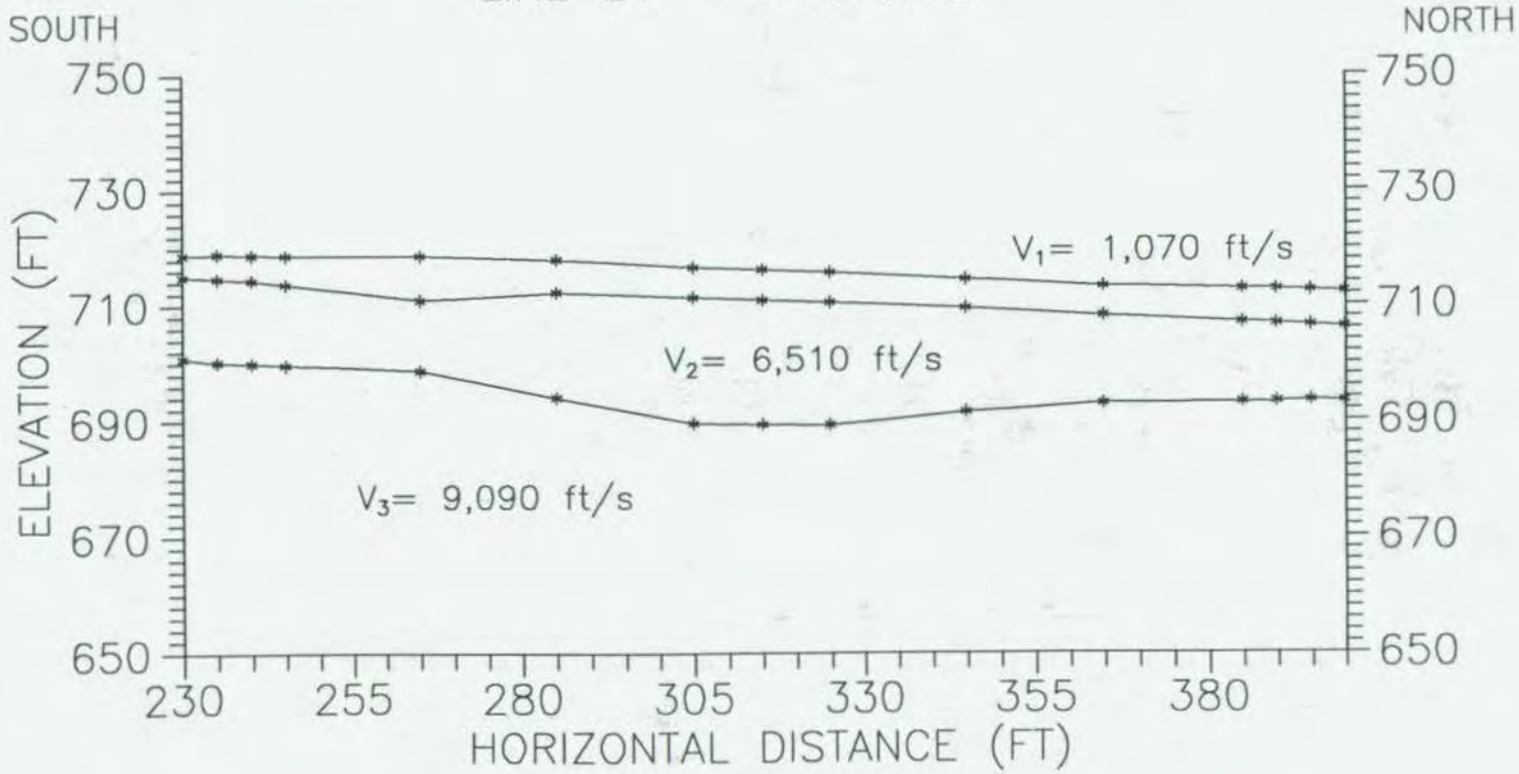
MOUND PLANT SEISMIC REFRACTION – SEPTEMBER 1992
LINE 23 – SPREAD 4



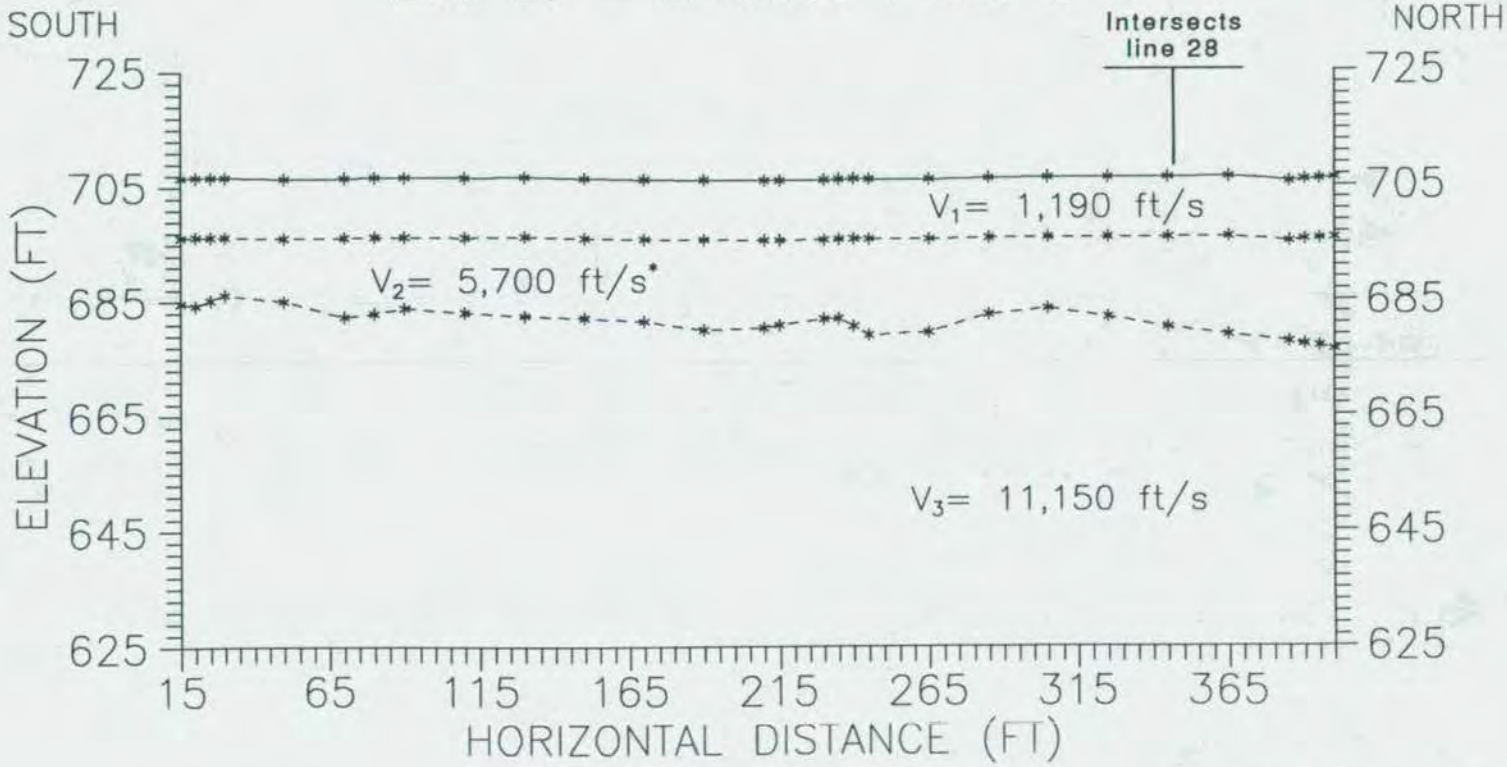
MOUND PLANT SEISMIC REFRACTION – FEBRUARY 1993
LINE 24 – SPREAD 1



MOUND PLANT SEISMIC REFRACTION – FEBRUARY 1993
LINE 24 – SPREAD 2

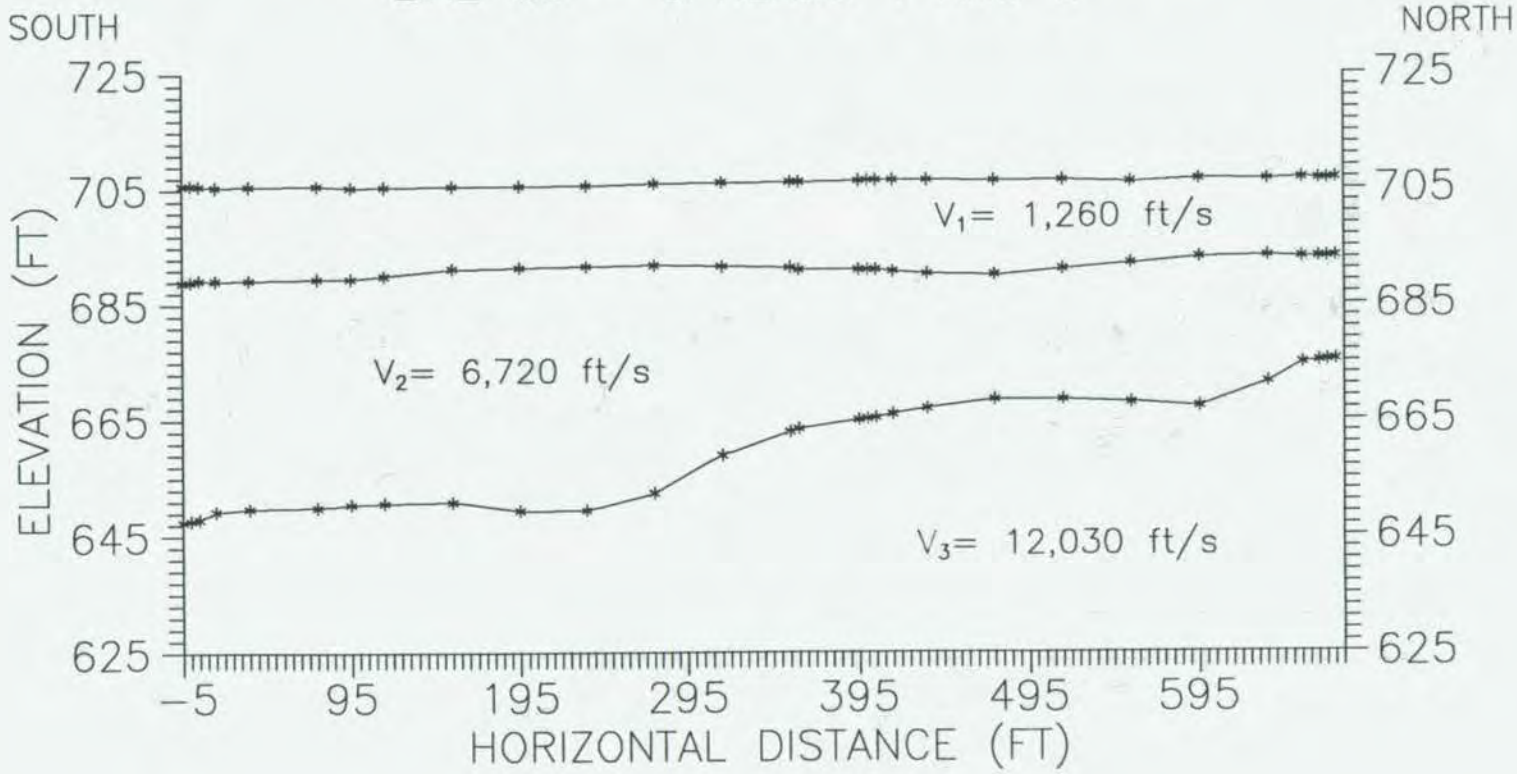


MOUND PLANT SEISMIC REFRACTION – FEBRUARY 1993
LINE 25 – SPREADS 1 AND 2

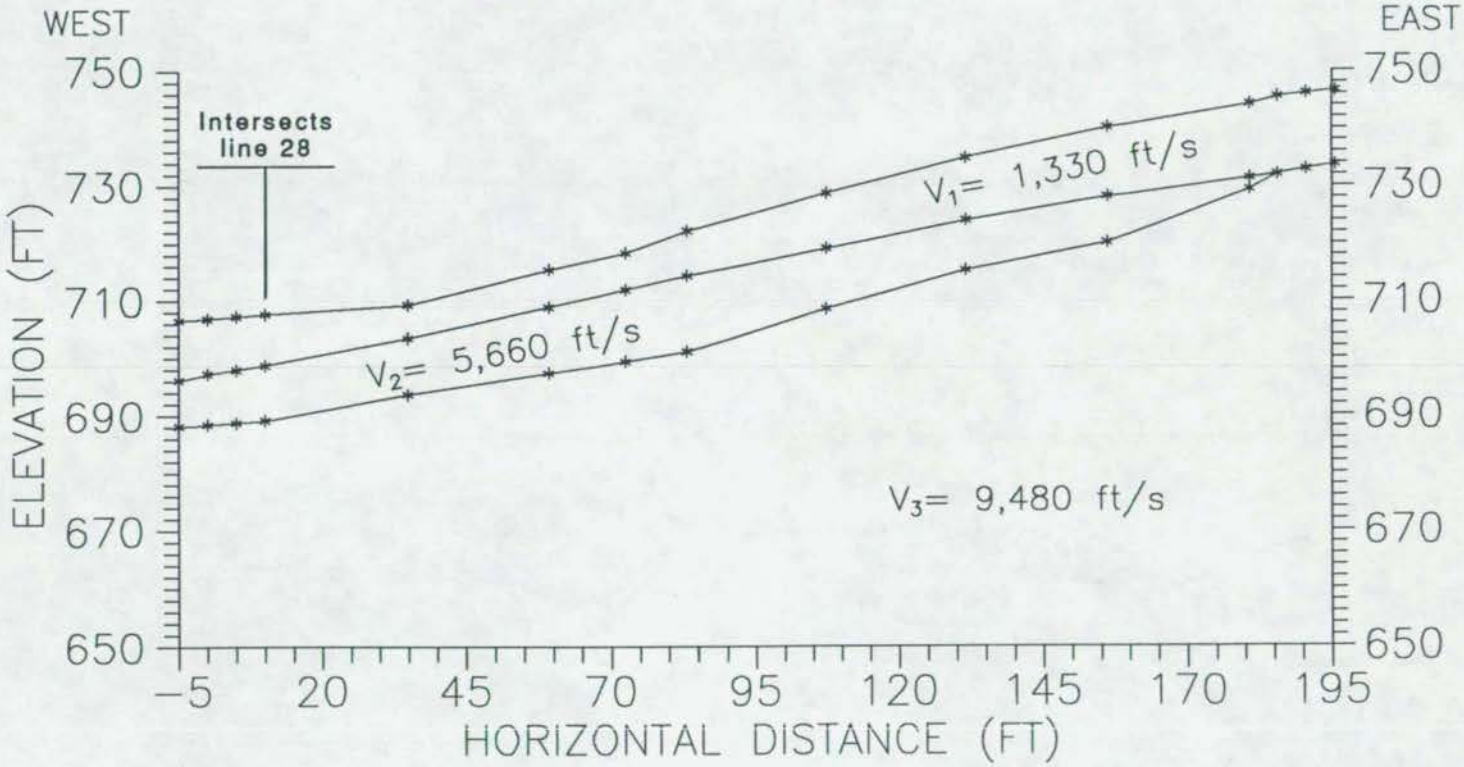


* = Velocity override value.

MOUND PLANT SEISMIC REFRACTION – FEBRUARY 1993
LINE 26 – SPREADS 1 AND 2



MOUND PLANT SEISMIC REFRACTION – FEBRUARY 1993
LINE 28 – SPREAD 1



APPENDIX B.2. SEISMIC REFRACTION TECHNIQUE

APPENDIX B.2
SEISMIC REFRACTION TECHNIQUE

Recent advances in electronics and in computer hardware and software make it possible to efficiently generate high-resolution elevation profiles from seismic refraction data. These advances greatly enhance application of the refraction technique to guide monitoring well placement where target refractors are relatively shallow. The technique is particularly effective for locating bedrock lows and channels that may concentrate or provide pathways for migration of groundwater contaminants.

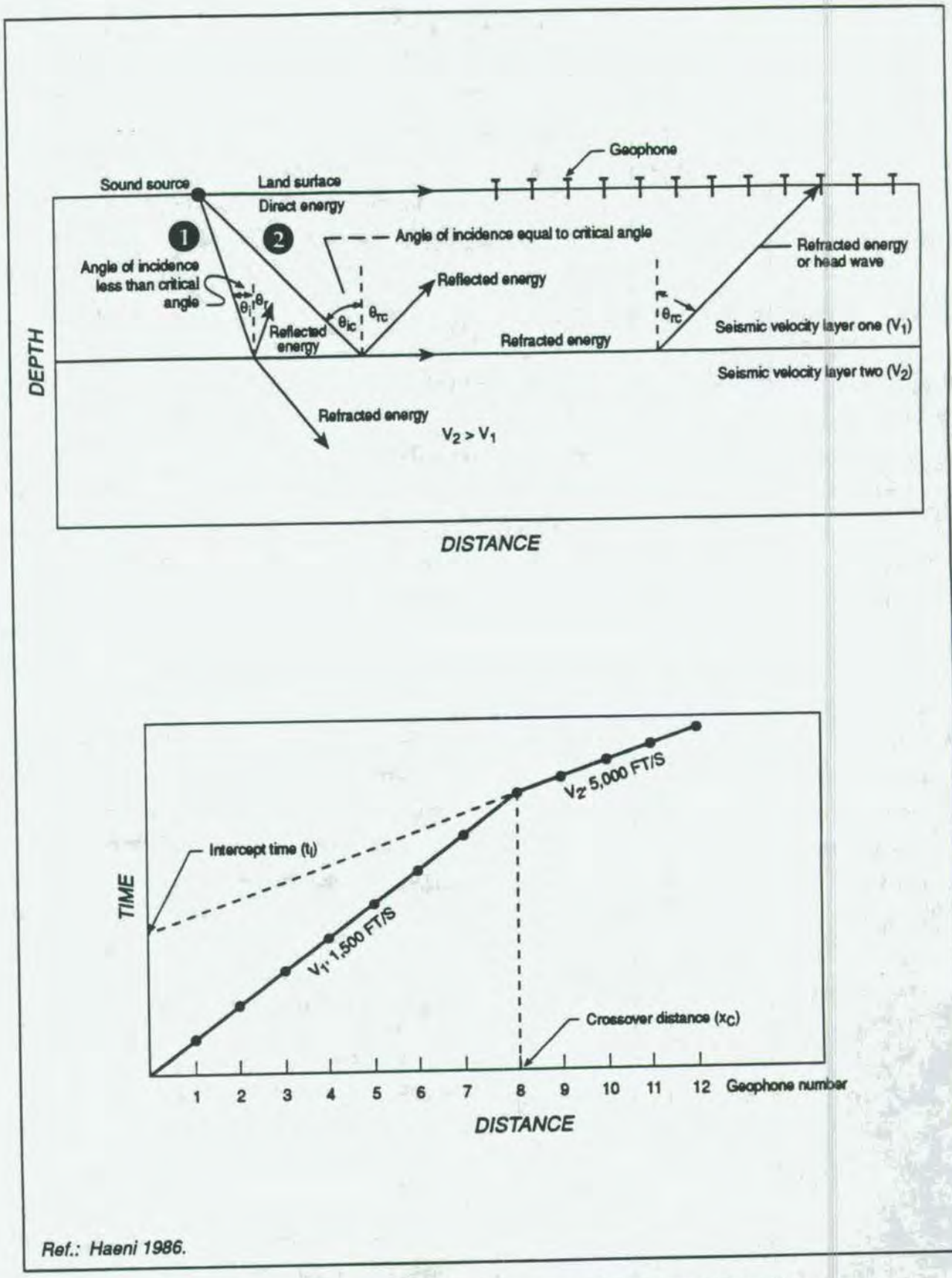
A.2.1. SEISMIC REFRACTION THEORY

According to Snell's Law, at an interface between two layers where the velocity of a compressional seismic wave that is not perpendicular to the interface increases, a portion of the wave is reflected and a portion is refracted toward the lower velocity layer (Figure B-1). At some critical angle (θ_{rc}), the refracted wave will propagate along the interface between the layers at the higher of the two velocities (V_2). The refracted wave acts as a point source, continually propagating sound back to the surface according to Huygen's Principle. At some distance from the shot, the energy from the refracted wave will reach the geophones before the slower wave traveling along the surface, despite the fact that the refracted wave has a longer distance to travel. The distance at which the refracted wave arrives first is called the crossover distance (Xc).

Based upon the first arrival of energy at each phone, a time-distance plot may be constructed, as shown in Figure B-1. There are two distinct line segments, indicating two layers with different velocities. The point at which the higher velocity segment (slope is the inverse of velocity in the figure) intersects the Y-axis is termed the intercept time (Ti). Using the velocities determined for the two layers, and the Xc or Ti, the depth to the interface below the shot may be calculated. In order to determine the slope of an interface, a reverse shot must also be included. Intercept time and crossover distance formulas may also be used to calculate depths to interfaces where there are more than two layers (Dobrin 1976).

While intercept time and crossover distance formulas provide information about subsurface interfaces, they only provide depths below each shot point. In addition, where the topography of the interface is not smooth (often the case for the bedrock surface), crossover distance and intercept time solutions may become difficult.

In addition to simple reverse solutions, the delay-time method may be incorporated to provide depth to interface below each geophone as described by Pakister and Black (Pakister and Black 1957), but



Ref.: Haeni 1986.

Figure B-1. Refraction of seismic energy and a resulting time-distance plot

the method is extremely labor intensive when performed manually. An important advance in the application of the refraction technique was the development of the SIPT1 computer program, which provides high resolution profiles of velocity interfaces in the subsurface from refraction data. This program provides delay-time solutions and also incorporates numeric ray path tracing to efficiently provide accurate depths to interfaces below each geophone and shot point.

Detailed discussions of the SIPT1 seismic interpretation program are presented in the literature (Scott et al. 1972; Scott 1977; Haeni et al. 1987), and the theoretical foundations and use of the program are not discussed here. Under ideal conditions, refraction profiles interpreted with the SIPT1 program are accurate to within 10 percent of the actual depths of subsurface interfaces (Scott 1977).

A seismic refraction system consists of a signal enhancing seismograph, a number of geophones, a spread cable with take-outs for each phone, and a sound source. The phones are laid out in a linear array at predetermined spacings, and shot points are placed along this line at known distances from the phones. The seismograph is triggered and begins recording when a sound is generated at a shot point by either an explosion or impact of a weight on the ground. The seismograph provides a record of time versus seismic signal for each geophone. Because the distance from the shot point to each geophone is known and the arrival time of the first wave is measured by the seismograph, the velocity of sound propagation may be calculated.

Several "stacks" may be made at the same shot point, where wave forms from successive shots are added together. Stacking often aids in the selection of first arrival times (first breaks) by reducing random noise and increasing the amplitude of the seismic signal.

A.2.2. LIMITATIONS

The conditions listed below must be satisfied for the seismic refraction technique to be effective:

- The velocity of sound propagation through earth materials must increase with depth; otherwise, seismic waves will not refract toward the surface. Low velocity layers underlying higher velocity layers (velocity inversions) are not detectable with the seismic refraction method and will lead to erroneous calculated depths.

- A sufficient velocity contrast (interface) must exist between layers in question to provide adequate refraction of sound energy.

- Interfaces between layers of interest must be distinct. Gradational contacts are likely to be missed with the seismic refraction method.

- Thin, undetectable layers with intermediate seismic velocities (blind zones) must not be present, or incorrect depth determinations will result.

In addition to these constraints there are other uncertainties. Lateral heterogeneity in earth materials may complicate interpretations of seismic data, and ambient noise may complicate application of the refraction technique.

APPENDIX B.3. STATE PLANE COORDINATES OF LINE END POINTS

MOUND PLANT SEISMIC REFRACTION
END–LINE COORDINATES

SEISMND.WK1

SEISMIC LINE	END–POINT DIRECTION	COORDINATES		ELEVATION FT, MSL
		NORTHING	EASTING	
1	North	594813.53	1495444.79	712.36
1	South	594120.39	1495515.78	718.72
2	East	594319.96	1497056.54	720.39
2	West	594491.89	1495463.07	794.49
3	South	594307.71	1497086.51	797.13
3	North	595302.17	1497140.02	828.9
5	East	596262.58	1497489.45	887.59
5	West	596545.46	1494945.32	702.59
7	South	594397.75	1496176.84	746.02
8	East	595207.10	1496260.67	728.98
9	East	595984.23	1495756.50	740.28
9	West	595869.57	1495150.83	700.04
10	East	594639.69	1496139.96	738.83
10	West	594676.70	1495400.25	721.51
11A	North	597603.05	1496765.36	786.6
11	North	597239.41	1496724.12	815.78
11A	South	597411.55	1496742.24	793.11
12A	North	597546.73	1497063.76	872.28
12A	South	597113.93	1497095.22	877.35
13	East	597631.90	1496754.00	783.17
14	East	599532.50	1497494.77	785.09
14	West	599569.75	1496838.23	827.82
16	North	599548.85	1497179.77	803.84
17	North	599537.83	1497408.36	788.17
18	North	597411.64	1495698.83	740.66
18	South	597101.68	1495618.50	737.63
20	South	596577.03	1495477.80	735.91
21(1)	West	598288.69	1496958.78	803.99
21	East	598588.25	1497509.81	834.67
22	West	595256.23	1497027.19	811.72
23	North	596064.77	1497617.83	886.13
23	South	595224.16	1497543.52	882.28
24	East	598620.32	1494784.92	715.96
25	North	598444.12	1494675.15	704.58
25	South	598021.46	1494645.17	705.19
28	West	598371.59	1494660.18	705.15
28	East	598284.19	1494886.90	747.51

(1) – This point is also the north end of seismic line #19.

APPENDIX B.4. DATA REDUCTION AND PROCESSING FLOW DIAGRAM AND EXAMPLES

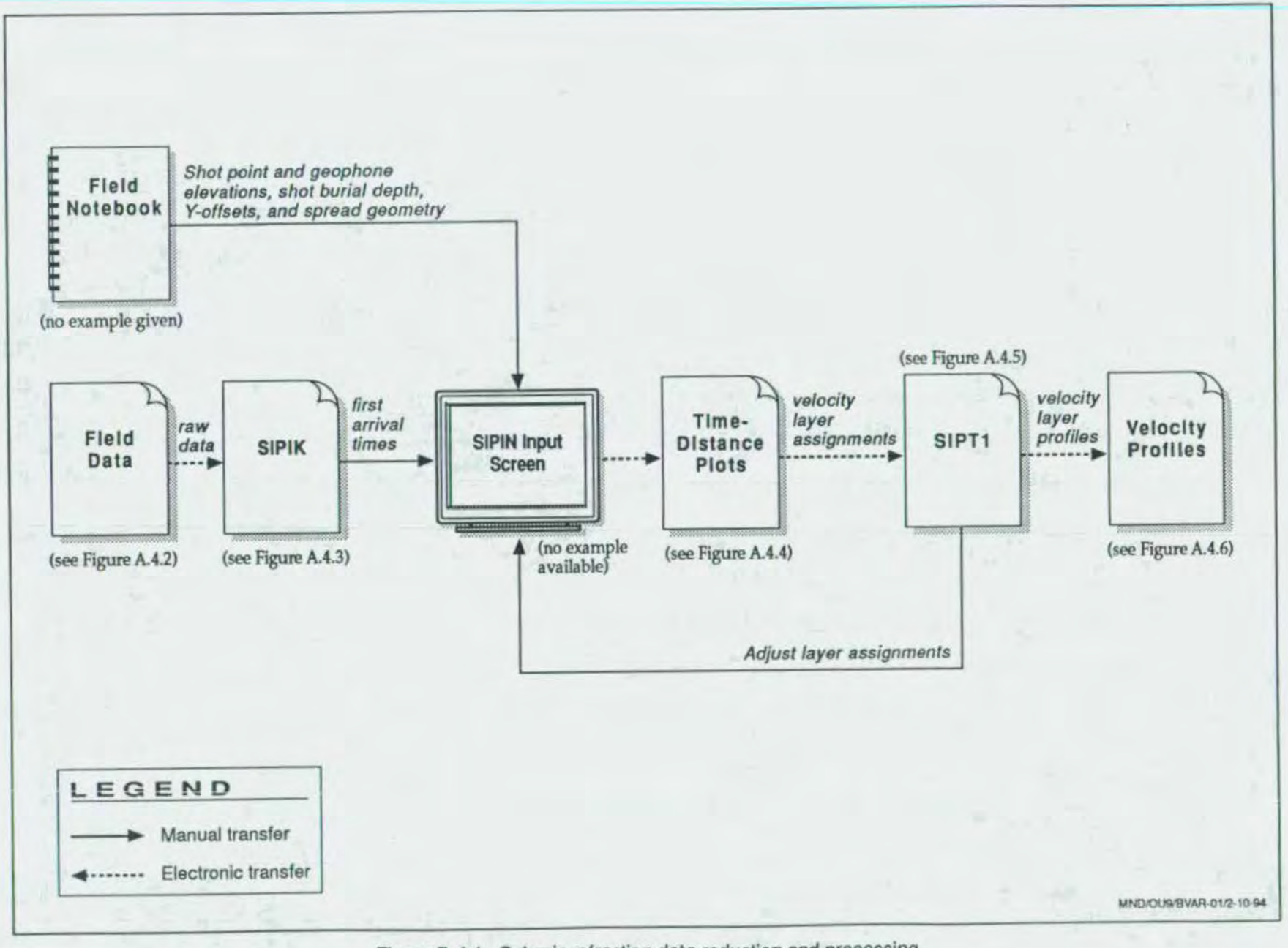
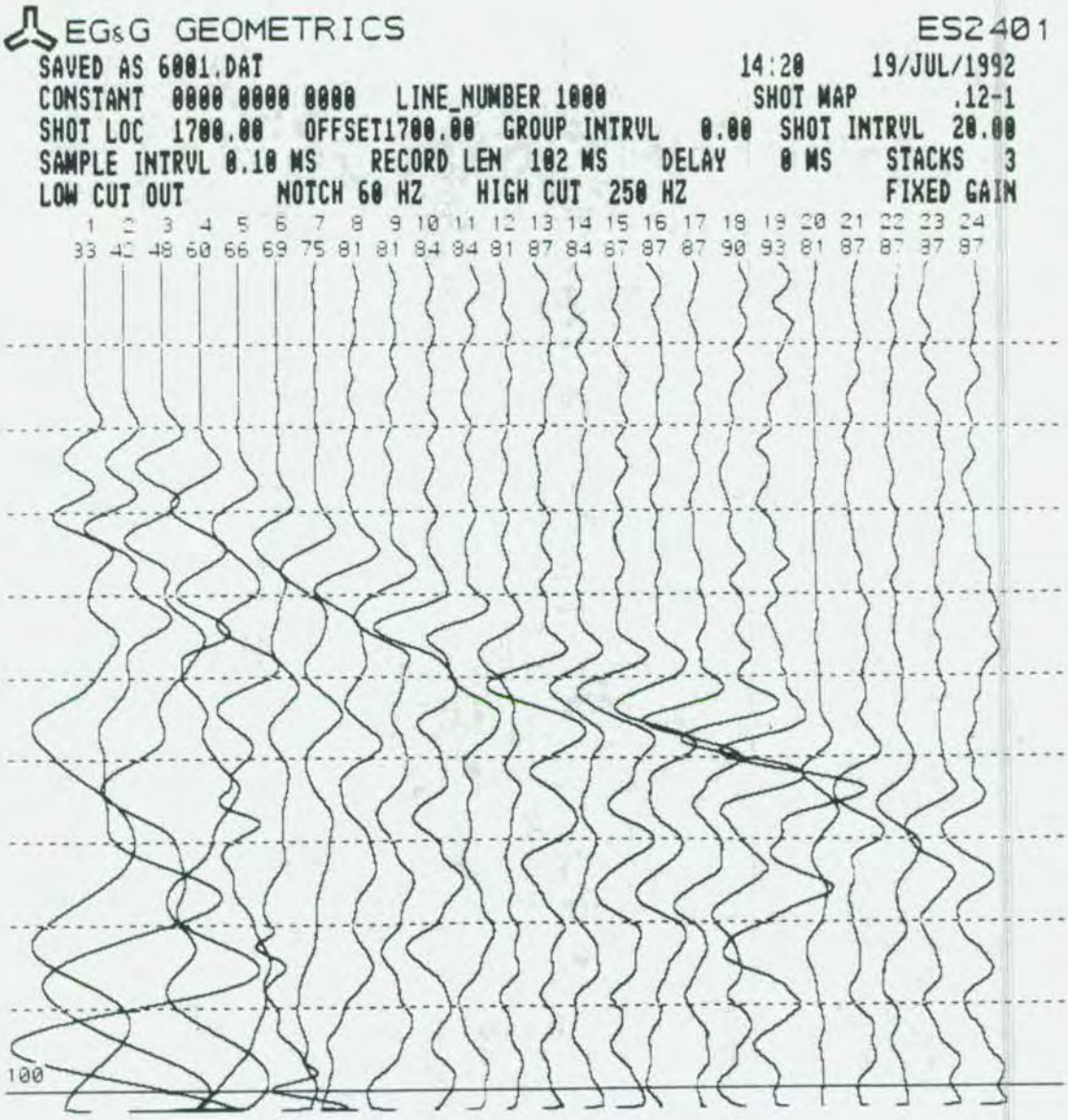


Figure B.4.1. Seismic refraction data reduction and processing.



MND/OU9/BVAR-02

Figure B.4.2. Field data output from seismograph (digital copy stored on floppy disk).

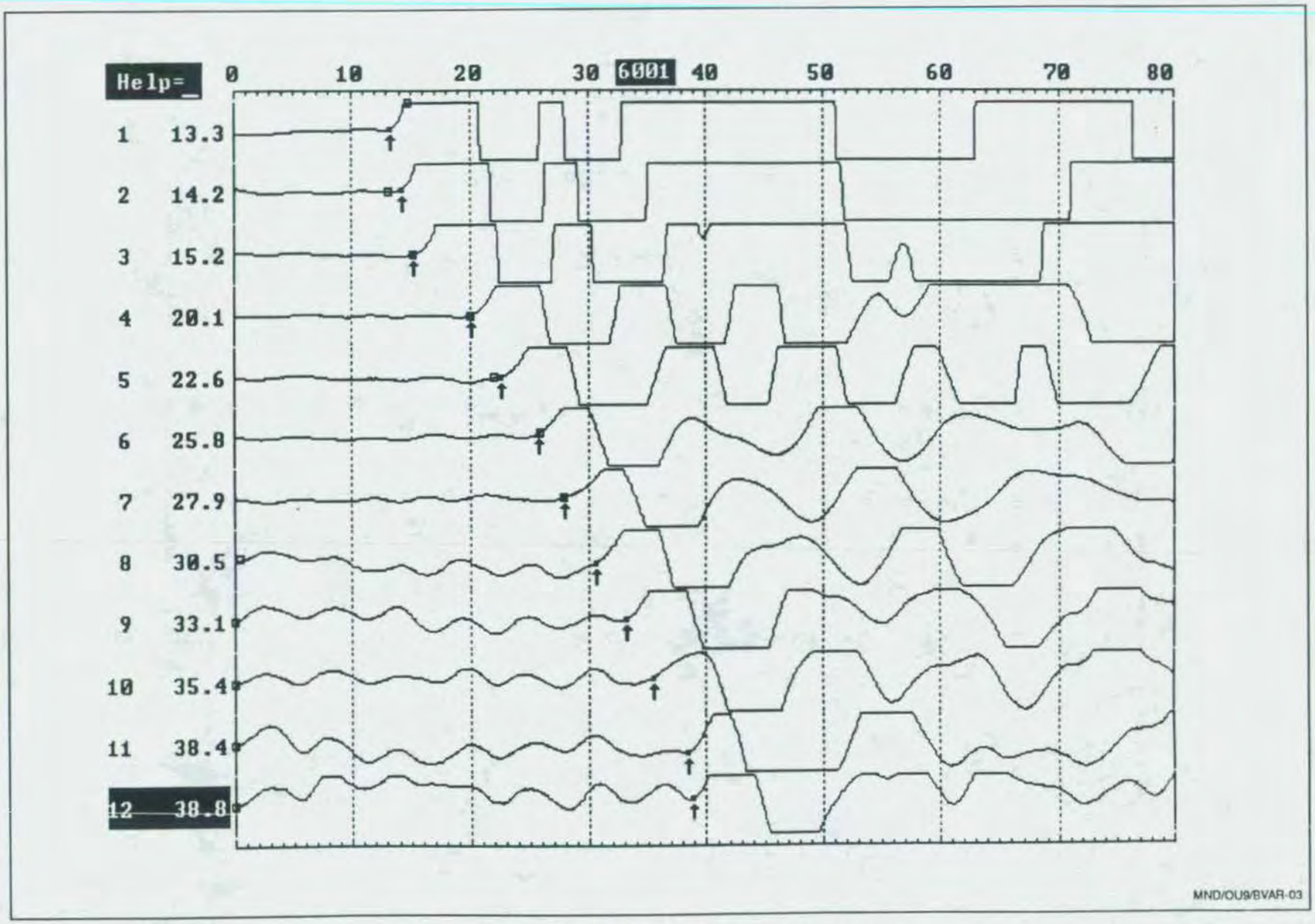


Figure B.4.3. SIPIK-generated first arrival time output.

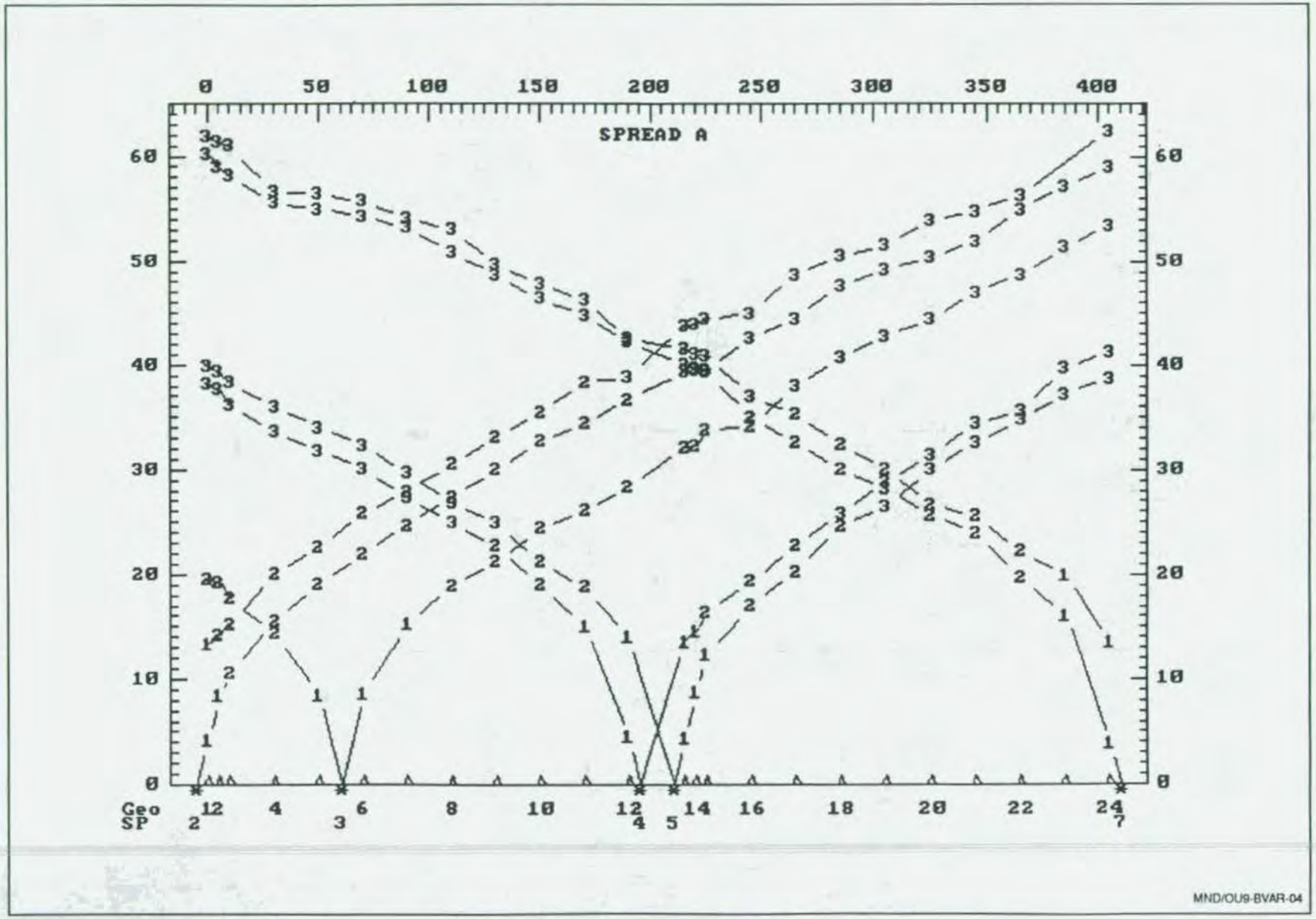


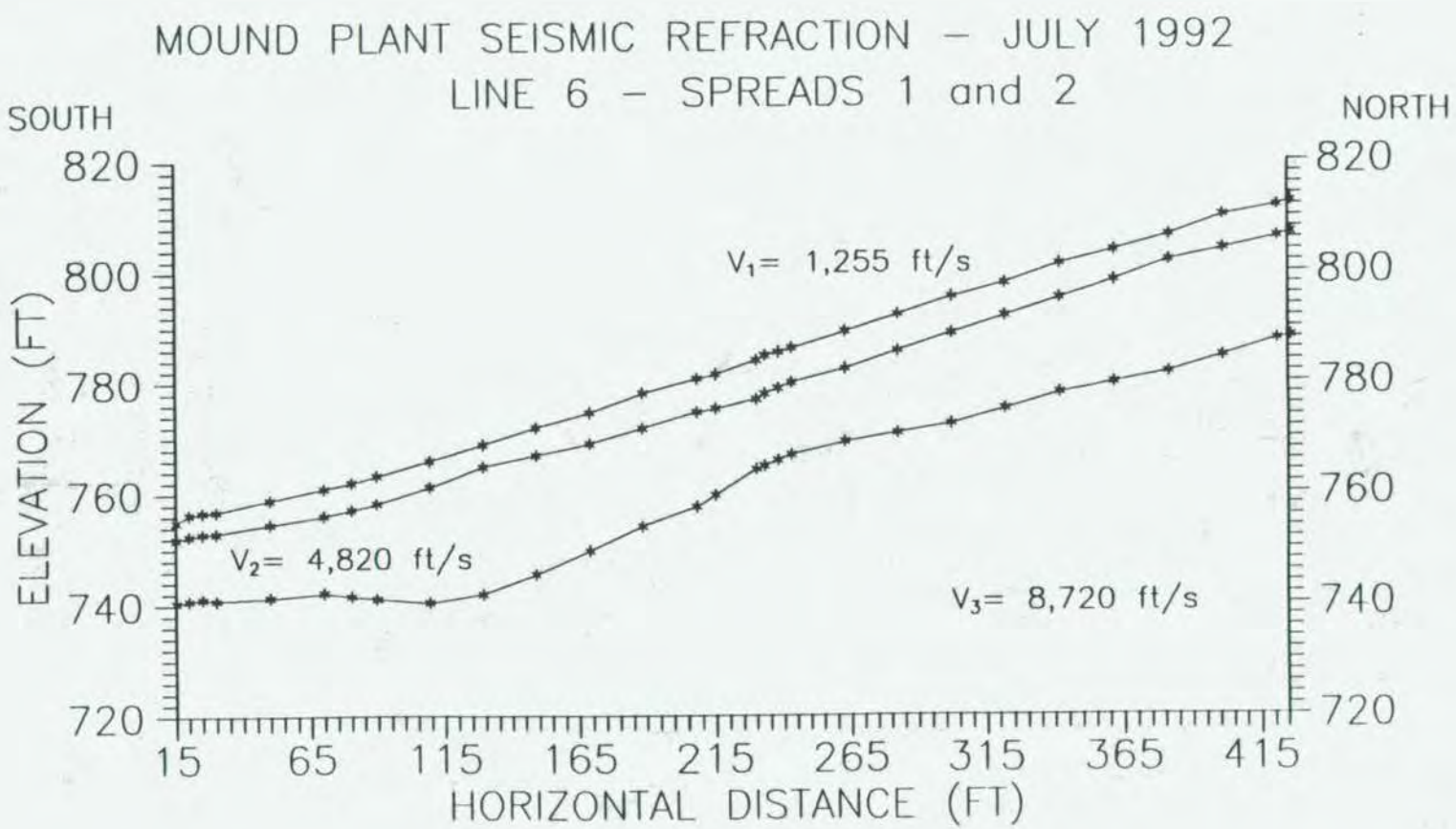
Figure B.4.4. SIPIN-generated time-distance plots.

```
velocities used, spread 1
        layer 1        layer 2        layer 3        layer
vertical  1401.          6917.
horizontal               6917.          9510.

                                                                    s
                                                                    p
                                                              g     r
                                                              e     e
 d                                                            o     a
 i                                                      s     d
 s              e l e v a t i o n   ( f e e t )         p
 t                                                              d
                                                                    A
   440        520        600        680        760        840
     +----------+----------+----------+----------+----------+
 -20. +          +          +          +     : s*+          +- 1      A
  -5. +          +          +          +     : s*+          +- 2      A
   0. -          +          +          +     # :##          +-    2   A
  10. -          +          +          +     :  3>          +-    3   A
  30. -          +          +          +    ##  #>          +-    4   A
     -                                       ##78::           -
  50. -          +          +          +     #  #>          +-    5   A
  60. +          +          +          +     :8 ##          +- 3      A
  70. -          +          +          +     #s #+>         +-    6   A
  89. -          +          +          +     :   #>         +-    7   A
     -                                       #   ::           -
 109. -          +          +          +    :    #>         +-    8   A
     -                                     #18#   ::           -
 129. -          +          +          +   2#45  # >        +-    9   A
 149. -          +          +          +    #    +#>        +-   10   A
     -                                      :     #:          -
 169. -          +          +          +    :    +# >       +-   11   A
     -                                    1 # 5   ::          -
 195. +          +          +          +     #   + #>       +- 4 12   A
     -                                     12     s:          -
 210. +          +          +          +     #   + ##       +- 5 14   A
 223. -          +          +          +    1 2  + : >      +-   15   A
 243. -          +          +          +     #83 +  #>      +-   16   A
     -                                      ##     7:         -
 262. -          +          +          +      #  +  #>      +-   17   A
     -                                      s#     ::         -
 282. -          +          +          +     ### +  # >     +-   18   A
     -                                      # :#   ::         -
 302. -          +          +          +       : +  :8>     +-   19   A
 322. -          +          +          +      4#3   #>      +-   20   A
     -                                        :   ::         -
 342. -          +          +          +        ##  # >     +-   21   A
     -                                        #3  ::         -
 361. -          +          +          +        +:  # >     +-   22   A
 381. -          +          +          +        +:   : >    +-   23   A
     -                                         ##  ::         -
 406. +          +          +          +        + s  s*>    +- 7 24   A
     -                                          :  ::         -
 421. +          +          +          +        +  : s *    +- 8      A
     +----------+----------+----------+----------+----------+
   440        520        600        680        760        840
```

MND/OUS/BVAR-05

Figure B.4.5. SIPT1-generated seismic refraction line profiles.



MND/OU9/BVAR-06

Figure B.4.6. Grapher-generated velocity profiles.

APPENDIX C

GEOTECHNICAL AND MINERALOGICAL DATA REPORTS

APPENDIX C

GEOTECHNICAL AND MINERALOGICAL DATA REPORTS

C.1. GEOTECHNICAL REPORT FROM BOWSER-MORNER

C.2. X-RAY DIFFRACTION REPORT FROM LAMDA RESEARCH

C.3. FIELD FORMS FOR pH MEASUREMENTS

C.1. GEOTECHNICAL REPORT FROM BOWSER-MORNER

BOWSER MORNER

COMMITTED TO EXCELLENCE SINCE 1911

4518 Taylorsville Road
P.O. Box 51
Dayton, OH 45401-0051
513-236-8805
513-233-2016 FAX

April 27, 1993

Roy F. Weston, Inc.
Attn: Ms. Tina Sanchez
6501 Americas Parkway, NE Suite 800
Albuquerque, New Mexico 87110

Re: Geotechnical Analyses of Soil Samples from the Mound Environmental Restoration Program
RFW W.O. No. 05376-039-006
Task Order No. 0005 (OU9)

Dear Ms. Sanchez:

This is our laboratory report of samples received February 15, 1993 through April 5, 1993. Testing was performed as specified in Subcontract Agreement No. M-0147-C1 and in accordance with the following procedures:

ASTM D422, "Particle-Size Analysis of Soils"

ASTM D854, "Specific Gravity of Soils"

ASTM D1557, "Laboratory Compaction Characteristics of Soil Using Modified Effort (12,400 ft.-lbf/ft^3 (600 kN-m/m^3))"

ASTM D2216, "Laboratory Determination of Water (Moisture) Content of Soil and Rock"

ASTM D2487, "Classification of Soils for Engineering Purposes"

ASTM D2974, "Moisture, Ash, Organic Matter of Peat and Other Organic Soils"

ASTM D4253, "Maximum Index Density and Unit Weight of Soils Using a Vibratory Table"

ASTM D4254, "Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density"

ASTM D5084, "Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter"

EPA Method 9081A, "Cation-Exchange Capacity of Soils (Sodium Acetate)"

Results are summarized on Table I and Table II and detailed on the attached data sheets.

Should you have any questions, or if we may be of further service, please contact us at (513) 236-8805.

Respectfully submitted,

BOWSER-MORNER, INC.

James W. Fletcher, Manager
Construction Materials and
Geotechnical Laboratories

JWF/cfw
000832C
1-Client
1-File

Roy F. Weston
Mound Environmental Restoration Program
W.O. No. 47894

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BOWSER MORNER

TABLE I

Summary of Physical Index Properties, Unit Weights, Hydraulic Conductivity

Roy F. Weston, Inc.- Mound Environmental Restoration Program - Task Order No. 0005 (OU9)
BMI Work Order No. 47894 - Report No. 000832C
April 27, 1993

Sample ID	As Rec'd. Moisture Content, %	C.E.C meq/100 gms	Specific Gravity	Particle Sizes, % Cobble	Gravel	Sand	Silt	Clay	L.O.I., %	Wet Unit Weight, pcf	Dry Unit Weight, pcf	Hydraulic Conductivity, cm/sec.
MND20-0341-0020	9.4	39.6	2.73	0	9	30	31	30	1.5	144.8	132.3	4.0×10^{-9}
MND20-0342-0010	8.5	37.6	2.75	0	56	35	5	4	0.8	134.7	130.7	4.4×10^{-5}
MND20-0342-0075	11.7	39.5	2.73	0	16	40	25	19	1.4	142.0	127.0	2.3×10^{-8}
MND20-0342-0095	22.8	40.6	2.71	0	3	84	7	6	1.2	124.8	111.5	3.5×10^{-5}
MND20-0343-0028	saturated	8.4	- - -	0	42	38	11	9	1.3	120.5	119.6	1.9×10^{-5}
MND20-0343-0037	saturated	3.0	- - -	0	38	49	7	6	1.1	133.0	132.4	3.3×10^{-4}
MND20-0343-0057	7.3	4.4	2.74	0	32	42	16	10	0.7	141.7	132.1	1.5×10^{-5}
MND20-0343-0067/0080	11.4	10.0	2.73	0	10	31	27	32	2.1	133.7	120.1	2.9×10^{-9}
MND20-0344-0018	9.9	3.48	2.74	0	48	42	10		0.8	147.6	133.7	5.0×10^{-6}
MND20-0344-0025	6.6	4.13	2.74	0	63	29	8		0.9	145.6	137.1	3.0×10^{-4}
MND20-0344-0030	5.8	1.20	2.72	0	28	47	15	10	0.7	140.0	133.2	1.1×10^{-6}
MND20-0344-0035	7.0	4.24	2.74	0	21	54	15	10	1.0	140.8	134.6	5.4×10^{-7}
MND20-0344-0040	8.6	9.24	2.71	0	23	43	19	15	1.2	136.2	127.6	4.2×10^{-5}
MND20-0344-0060	21.2	1.85	2.71	0	2	91	7		0.5	111.0	106.9	5.5×10^{-4}
MND20-0344-0065	22.5	1.85	2.69	0	0	85	15		0.8	105.2	103.2	3.3×10^{-4}
MND20-0344-0115	8.6	1.41	2.71	0	33	65	2		1.1	125.6	121.1	4.9×10^{-4}
MND20-0346-0025	9.7	44.9	2.73	0	13	31	29	27	1.3	139.3	127.0	2.5×10^{-9}
MND20-0346-0035	8.9	52.2	2.65	0	48	32	8	12	1.6	138.3	134.8	3.5×10^{-7}
MND20-0386-0033	6.6	2.6	2.76	0	47	32	11	10	1.9	148.5	139.3	7.3×10^{-8}
MND20-0386-0035	10.5	2.4	2.73	0	12	36	31	21	2.2	155.2	140.4	9.8×10^{-9}
MND20-0386-0055	10.0	4.0	2.80	23	43	21	9	4	0.8	136.4	133.8	4.7×10^{-7}
MND20-0386-0080	11.5	1.5	2.77	0	54	38	4	3	1.4	126.9	125.4	9.1×10^{-5}

TABLE II

Summary of Moisture-Density Relations, Maximum and Minimum Dry Density

Roy F. Weston, Inc.- Mound Environmental Restoration Program - Task Order No. 0005 (OU9)
BMI Work Order No. 47894 - Report No. 000832C
April 27, 1993

Sample ID	ASTM D1557 Maximum Dry Density, pcf	ASTM D1557 Optimum Moisture Content, %	ASTM D4253 Maximum Dry Density, pcf	ASTM D4254 Minimum Dry Density, pcf
MND20-0341-0020	141.8	5.6		
MND20-0342-0010			141.2	113.8
MND20-0342-0075	146.5	5.5		
MND20-0342-0095	123.3	11.1		
MND20-0343-0028			134.1	103.7
MND20-0343-0037			138.5	113.4
MND20-0343-0057	147.6	4.4		
MND20-0343-0067/0080	135.1	7.8		
MND20-0344-0018			135.2	117.8
MND20-0344-0025			137.7	114.3
MND20-0344-0030	146.4	5.0		
MND20-0344-0035	147.0	4.3		
MND20-0344-0040	145.2	5.2		
MND20-0344-0060			117.5	96.2
MND20-0344-0065	109.2	14.0		
MND20-0344-0115			135.7	118.9
MND20-0346-0025	141.7	6.6		
MND20-0346-0035			135.2	105.2
MND20-0386-0033	146.0	5.5		
MND20-0386-0035	141.5	5.8		
MND20-0386-0055			134.9	100.4
MND20-0386-0080			137.2	113.9

Section I

Hydraulic Conductivity Data

BOWSER MORNER

ASTM D5084
FALLING HEAD
PERMEABILITY TEST
UNDISTURBED

Date:	April 21, 1993
Project No.:	47894-Roy F. Weston
Project:	Mound Environmental Restoration Program
Location:	MND20-0341-0020
Material Description:	Gray Silt, Some Clay, Some Sand, Some Gravel (visual)

SPECIMEN DATA:

Dimension, Inches:	
Height:	1.959
Diameter:	4.226
Weight, lbs.:	2.302
Moisture Content, %:	9.4
Wet Unit Weight, pcf:	144.8
Dry Unit Weight, pcf:	132.3
Permeability, cm/sec.:	
k:	4.0×10^{-9}

ASTM D5084
FALLING HEAD
PERMEABILITY TEST
LABORATORY COMPACTED

Date:	April 15, 1993
Project No.:	47894-Roy F. Weston
Project:	Mound Environmental Restoration Program
Location:	MND20-0342-0010
Material Description:	"GW-GM" Brown Well-Graded Gravel With Silt and Sand

ASTM D4253, D4254, Relative Density	
Maximum Dry Density, pcf:	141.2
Minimum Dry Density, pcf:	113.8

SPECIMEN DATA:

Dimension, Inches:	
Height:	4.600
Diameter:	4.083
Weight, lbs.:	4.694
Moisture Content, %:	3.0
Wet Unit Weight, pcf:	134.7
Dry Unit Weight, pcf:	130.7
Compaction, %:	92.6
Permeability, cm/sec.:	
k:	4.4×10^{-5}

ASTM D5084
FALLING HEAD
PERMEABILITY TEST
UNDISTURBED

Date:	April 22, 1993
Project No.:	47894-Roy F. Weston
Project:	Mound Environmental Restoration Program
Location:	MND20-0342-0075
Material Description:	"SM" Gray Sand, Some Silt, Some Clay, Some Gravel

SPECIMEN DATA:

Dimension, Inches:	
Height:	2.358
Diameter:	3.991
Weight, lbs.:	2.424
Moisture Content, %:	11.7
Wet Unit Weight, pcf:	142.0
Dry Unit Weight, pcf:	127.0
Permeability, cm/sec.:	
k:	2.3×10^{-8}

ASTM D5084
FALLING HEAD
PERMEABILITY TEST
LABORATORY COMPACTED

Date:	April 20, 1993
Project No.:	47894-Roy F. Weston
Project:	Mound Environmental Restoration Program
Location:	MND20-0342-0095
Material Description:	"SM" Gray Silty Sand

ASTM D1557, Modified Proctor

Maximum Dry Density, pcf:	123.3
Optimum Moisture Content, %:	11.1

SPECIMEN DATA:

Dimension, Inches:	
Height:	4.171
Diameter:	4.104
Weight, lbs.:	3.985
Moisture Content, %:	12.0
Wet Unit Weight, pcf:	124.8
Dry Unit Weight, pcf:	111.5
Compaction, %:	90.4
Permeability, cm/sec.:	
k:	3.5×10^{-5}

ASTM D5084
FALLING HEAD
PERMEABILITY TEST
LABORATORY COMPACTED

Date:	March 24, 1993
Project No.:	47894-Roy F. Weston
Project:	Mound Environmental Restoration Program
Location:	MND20-0343-0028
Material Description:	"GM" Brown Silty Gravel With Sand
ASTM D4253, D4254, Relative Density	
Maximum Dry Density, pcf:	134.1
Minimum Dry Density, pcf:	103.7

SPECIMEN DATA:

Dimension, Inches:	
Height:	3.894
Diameter:	4.422
Weight, lbs.:	4.169
Moisture Content, %:	0.7
Wet Unit Weight, pcf:	120.5
Dry Unit Weight, pcf:	119.6
Compaction, %:	89.2
Permeability, cm/sec.:	
k:	1.9×10^{-5}

ASTM D5084
FALLING HEAD
PERMEABILITY TEST
LABORATORY COMPACTED

Date:	March 22, 1993
Project No.:	47894-Roy F. Weston
Project:	Mound Environmental Restoration Program
Location:	MND20-0343-0037
Material Description:	"SM" Brown Silty Sand With Gravel

ASTM D4253, D4254, Relative Density

Maximum Dry Density, pcf:	138.5
Minimum Dry Density, pcf:	113.4

SPECIMEN DATA:

Dimension, Inches:

Height:	4.395
Diameter:	3.898
Weight, lbs.:	4.037
Moisture Content, %:	0.5
Wet Unit Weight, pcf:	133.0
Dry Unit Weight, pcf:	132.4
Compaction, %:	95.6

Permeability, cm/sec.:

k: 3.3×10^{-4}

ASTM D5084
FALLING HEAD
PERMEABILITY TEST
LABORATORY COMPACTED

Date:	March 24, 1993
Project No.:	47894-Roy F. Weston
Project:	Mound Environmental Restoration Program
Location:	MND20-0343-0057
Material Description:	Gray Sand, Some Gravel, Some Silt, Trace Clay (visual)

<u>ASTM D1557, Modified Proctor</u>

Maximum Dry Density, pcf:	147.6
Optimum Moisture Content:	4.4

<u>SPECIMEN DATA:</u>

Dimension, Inches:	
Height:	4.584
Diameter:	3.915
Weight, lbs.:	4.526
Moisture Content, %:	7.3
Wet Unit Weight, pcf:	141.7
Dry Unit Weight, pcf:	132.1
Compaction, %:	89.5
Permeability, cm/sec.:	
k:	1.5×10^{-5}

ASTM D5084
FALLING HEAD
PERMEABILITY TEST
UNDISTURBED

Date:	March 22, 1993
Project No.:	47894-Roy F. Weston
Project:	Mound Environmental Restoration Program
Location:	MND20-0343-0067
Material Description:	Gray Clay, Some Sand, Some Silt, Trace Gravel (visual)

SPECIMEN DATA:

Dimension, Inches:	
Height:	2.598
Diameter:	4.123
Weight, lbs.:	2.685
Moisture Content, %:	11.4
Wet Unit Weight, pcf:	133.7
Dry Unit Weight, pcf:	120.1
Permeability, cm/sec.:	
k:	2.9×10^{-9}

ASTM D5084
FALLING HEAD
PERMEABILITY TEST
LABORATORY COMPACTED

Project No.:	47894-Roy F. Weston
Project:	Mound Environmental Restoration Program
Location:	MND20-0344-0018
Material Description:	"GW-GM" Brown Well Graded Gravel With Silt and Sand

ASTM D4253, D4254, Relative Density	
Maximum Dry Density, pcf:	135.2
Minimum Dry Density, pcf:	117.8

SPECIMEN DATA:

Dimension, Inches:	
Height:	4.302
Diameter:	3.870
Weight, lbs.:	4.322
Moisture Content, %:	10.4
Wet Unit Weight, pcf:	147.6
Dry Unit Weight, pcf:	133.7
Compaction, %:	98.9
Permeability, cm/sec.:	
k:	5.0×10^{-6}

ASTM D5084
FALLING HEAD
PERMEABILITY TEST
LABORATORY COMPACTED

Project No.:	47894-Roy F. Weston
Project:	Mound Environmental Restoration Program
Location:	MND20-0344-0025
Material Description:	"GP-GM" Brown Poorly Graded Gravel With Silt and Sand

ASTM D4253, D4254, Relative Density	
Maximum Dry Density, pcf:	137.7
Minimum Dry Density, pcf:	114.3

SPECIMEN DATA:

Dimension, Inches:	
Height:	4.368
Diameter:	3.843
Weight, lbs.:	4.269
Moisture Content, %:	6.2
Wet Unit Weight, pcf:	145.6
Dry Unit Weight, pcf:	137.1
Compaction, %:	99.6
Permeability, cm/sec.:	
k:	3.0×10^{-4}

ASTM D5084
FALLING HEAD
PERMEABILITY TEST
LABORATORY COMPACTED

Project No.:	47894-Roy F. Weston
Project:	Mound Environmental Restoration Program
Location:	MND20-0344-0030
Material Description:	"SM" Brown Silty Sand With Gravel
ASTM D1557, Modified Proctor	
Maximum Dry Density, pcf:	146.4
Optimum Moisture Content, %:	5.0

SPECIMEN DATA:

Dimension, Inches:	
Height:	4.598
Diameter:	3.909
Weight, lbs.:	4.471
Moisture Content, %:	5.1
Wet Unit Weight, pcf:	140.0
Dry Unit Weight, pcf:	133.2
Compaction, %:	91.0
Permeability, cm/sec.:	
k:	1.1×10^{-6}

ASTM D5084
FALLING HEAD
PERMEABILITY TEST
LABORATORY COMPACTED

Project No.:	47894-Roy F. Weston
Project:	Mound Environmental Restoration Program
Location:	MND20-0344-0035
Material Description:	"SM" Gray Silty Sand with Gravel
ASTM D1557, Modified Proctor	
Maximum Dry Density, pcf:	147.0
Optimum Moisture Content, %:	4.3

SPECIMEN DATA:

Dimension, Inches:	
Height:	4.492
Diameter:	3.939
Weight, lbs.:	4.460
Moisture Content, %:	4.6
Wet Unit Weight, pcf:	140.8
Dry Unit Weight, pcf:	134.6
Compaction, %:	91.6
Permeability, cm/sec.:	
k:	5.4×10^{-7}

ASTM D5084
FALLING HEAD
PERMEABILITY TEST
LABORATORY COMPACTED

Project No.:	47894-Roy F. Weston
Project:	Mound Environmental Restoration Program
Location:	MND20-0344-0040
Material Description:	Gray Sand, Some Gravel, Some Silt, Some Clay (Visual)

ASTM D1557, Modified Proctor

Maximum Dry Density, pcf:	145.2
Optimum Moisture Content, %:	5.2

SPECIMEN DATA:

Dimension, Inches:

Height:	4.639
Diameter:	3.933
Weight, lbs.:	4.443
Moisture Content, %:	6.7
Wet Unit Weight, pcf:	136.2
Dry Unit Weight, pcf:	127.6
Compaction, %:	87.9

Permeability, cm/sec.:

k: 4.2×10^{-5}

ASTM D5084
FALLING HEAD
PERMEABILITY TEST
LABORATORY COMPACTED

Project No.:	47894-Roy F. Weston
Project:	Mound Environmental Restoration Program
Location:	MND20-0344-0060
Material Description:	"SP-SM" Brown Poorly Graded Sand With Silt

ASTM D4253, D4254, Relative Density	
Maximum Dry Density, pcf:	117.5
Minimum Dry Density, pcf:	96.2

SPECIMEN DATA:

Dimension, Inches:	
Height:	3.807
Diameter:	2.816
Weight, lbs.:	1.522
Moisture Content, %:	3.8
Wet Unit Weight, pcf:	111.0
Dry Unit Weight, pcf:	106.9
Compaction, %:	91.0
Permeability, cm/sec.:	
k:	5.5×10^{-4}

ASTM D5084
FALLING HEAD
PERMEABILITY TEST
LABORATORY COMPACTED

Project No.:	47894-Roy F. Weston
Project:	Mound Environmental Restoration Program
Location:	MND20-0344-0065
Material Description:	"SM" Gray Silty Sand
ASTM D1557, Modified Proctor	
Maximum Dry Density, pcf:	109.2
Optimum Moisture Content, %:	14.0

SPECIMEN DATA:

Dimension, Inches:	
Height:	3.479
Diameter:	2.828
Weight, lbs.:	1.331
Moisture Content, %:	2.0
Wet Unit Weight, pcf:	105.2
Dry Unit Weight, pcf:	103.2
Compaction, %:	94.5
Permeability, cm/sec.:	
k:	3.3×10^{-4}

ASTM D5084
FALLING HEAD
PERMEABILITY TEST
LABORATORY COMPACTED

Project No.:	47894-Roy F. Weston
Project:	Mound Environmental Restoration Program
Location:	MND20-0344-0115
Material Description:	"SP" Gray Poorly Graded Sand With Gravel
ASTM D4253, D4254, Relative Density	
Maximum Dry Density, pcf:	135.7
Minimum Dry Density, pcf:	118.9

SPECIMEN DATA:

Dimension, Inches:	
Height:	3.531
Diameter:	2.795
Weight, lbs.:	1.575
Moisture Content, %:	3.7
Wet Unit Weight, pcf:	125.6
Dry Unit Weight, pcf:	121.1
Compaction, %:	89.3
Permeability, cm/sec.:	
k:	4.9×10^{-4}

ASTM D5084
FALLING HEAD
PERMEABILITY TEST
UNDISTURBED

Date:	April 22, 1993
Project No.:	47894-Roy F. Weston
Project:	Mound Environmental Restoration Program
Location:	MND20-0346-0025
Material Description:	Gray Sand, Some Clay, Some Silt, Some Gravel (Visual)

SPECIMEN DATA:

Dimension, Inches:	
Height:	2.804
Diameter:	4.175
Weight, lbs.:	3.095
Moisture Content, %:	9.7
Wet Unit Weight, pcf:	139.3
Dry Unit Weight, pcf:	127.0
Permeability, cm/sec.:	
k:	2.5×10^{-9}

ASTM D5084
FALLING HEAD
PERMEABILITY TEST
LABORATORY COMPACTED

Date:	April 22, 1993
Project No.:	47894-Roy F. Weston
Project:	Mound Environmental Restoration Program
Location:	MND20-0346-0035
Material Description:	"GM" Brown Silty Gravel With Sand

ASTM D4253, D4254, Relative Density

Maximum Dry Density, pcf:	135.2
Minimum Dry Density, pcf:	105.2

SPECIMEN DATA:

Dimension, Inches:	
Height:	4.595
Diameter:	4.060
Weight, lbs.:	4.762
Moisture Content, %:	2.6
Wet Unit Weight, pcf:	138.3
Dry Unit Weight, pcf:	134.8
Compaction, %:	99.7
Permeability, cm/sec.:	
k:	3.5×10^{-7}

ASTM D5084
FALLING HEAD
PERMEABILITY TEST
LABORATORY COMPACTED

Project No.:	47894-Roy F. Weston
Project:	Mound Environmental Restoration Program
Location:	MND20-0386-0033
Material Description:	Brown Gravel, Some Sand, Some Silt, Some Clay (visual)

ASTM D1557, Modified Proctor

Maximum Dry Density, pcf:	146.0
Optimum Moisture Content, %:	5.5

SPECIMEN DATA:

Dimension, Inches:	
Height:	4.643
Diameter:	4.016
Weight, lbs.:	5.053
Moisture Content, %:	6.6
Wet Unit Weight, pcf:	148.5
Dry Unit Weight, pcf:	139.3
Compaction, %:	95.4
Permeability, cm/sec.:	
k:	7.3×10^{-8}

ASTM D5084
FALLING HEAD
PERMEABILITY TEST
UNDISTURBED

Date:	April 8, 1993
Project No.:	47894-Roy F. Weston
Project:	Mound Environmental Restoration Program
Location:	MND20-0386-0035
Material Description:	Gray/Brown Sand, Some Silt, Some Clay, Some Gravel (visual)

SPECIMEN DATA:

Dimension, Inches:	
Height:	2.571
Diameter:	4.924
Weight, lbs.:	2.792
Moisture Content, %:	10.5
Wet Unit Weight, pcf:	155.2
Dry Unit Weight, pcf:	140.4
Permeability, cm/sec.:	
k:	9.8×10^{-9}

ASTM D5084
FALLING HEAD
PERMEABILITY TEST
LABORATORY COMPACTED

Date:	April 8, 1993
Project No.:	47894-Roy F. Weston
Project:	Mound Environmental Restoration Program
Location:	MND20-0386-0055
Material Description:	"GM" Brown Silty Gravel With Sand

ASTM D4253, D4254, Relative Density

Maximum Dry Density, pcf:	134.9
Minimum Dry Density, pcf:	100.4

SPECIMEN DATA:

Dimension, Inches:

Height:	4.204
Diameter:	3.908
Weight, lbs.:	3.979
Moisture Content, %:	1.9
Wet Unit Weight, pcf:	136.4
Dry Unit Weight, pcf:	133.8
Compaction, %:	99.2

Permeability, cm/sec.:

k: 4.7×10^{-7}

ASTM D5084
FALLING HEAD
PERMEABILITY TEST
LABORATORY COMPACTED

Date:	April 8, 1993
Project No.:	47894-Roy F. Weston
Project:	Mound Environmental Restoration Program
Location:	MND20-0386-0080
Material Description:	"GP-GM" Brown Poorly Graded Gravel with Silt and Sand

ASTM D4253, D4254, Relative Density

Maximum Dry Density, pcf:	137.2
Minimum Dry Density, pcf:	113.9

SPECIMEN DATA:

Dimension, Inches:	
Height:	4.144
Diameter:	4.091
Weight, lbs.:	3.999
Moisture Content, %:	1.2
Wet Unit Weight, pcf:	126.9
Dry Unit Weight, pcf:	125.4
Compaction, %:	91.4
Permeability, cm/sec.:	
k:	9.1×10^{-5}

Section II

Density Data

BOWSER MORNER

Section II

Density Data

BOWSER MORNER

BOWSER-MORNER, INC.

4518 Taylorsville Road • P. O. Box 51 • Dayton, Ohio 45401 • 513/236-8805

Graphical determination of relative density

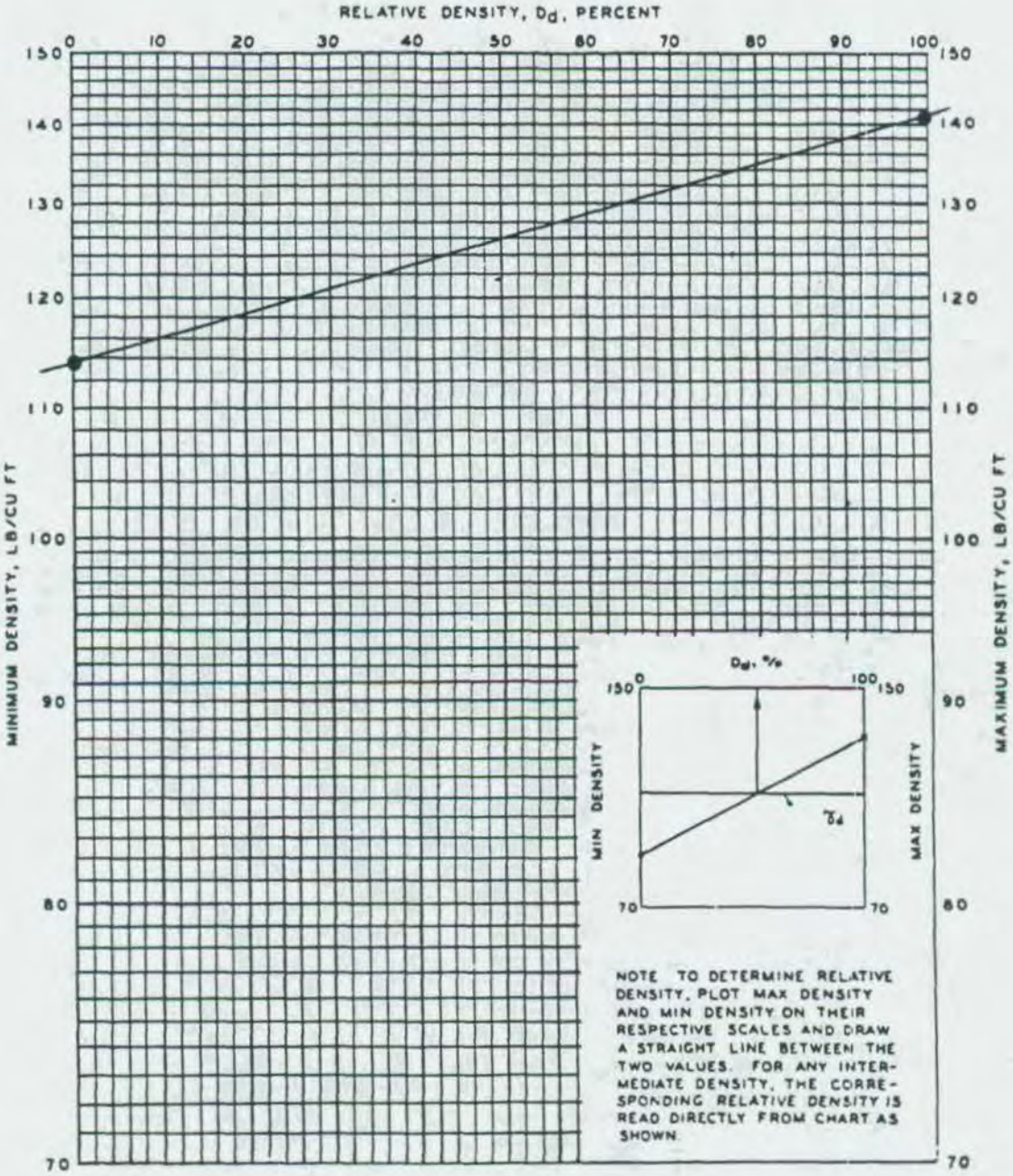
CLIENT: Roy F. Weston, Inc. DATE April 7, 1993

LAB NO. 47894

PROJECT: Mound Environmental Restoration Program

MATERIAL: "GW-GM" Brown well graded gravel with silt and sand Max. Dry Dens., pcf: 141.2

SOURCE OF MATERIAL: MND20-0342-0010 Min. Dry Dens., pcf: 113.8



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Graphical determination of relative density

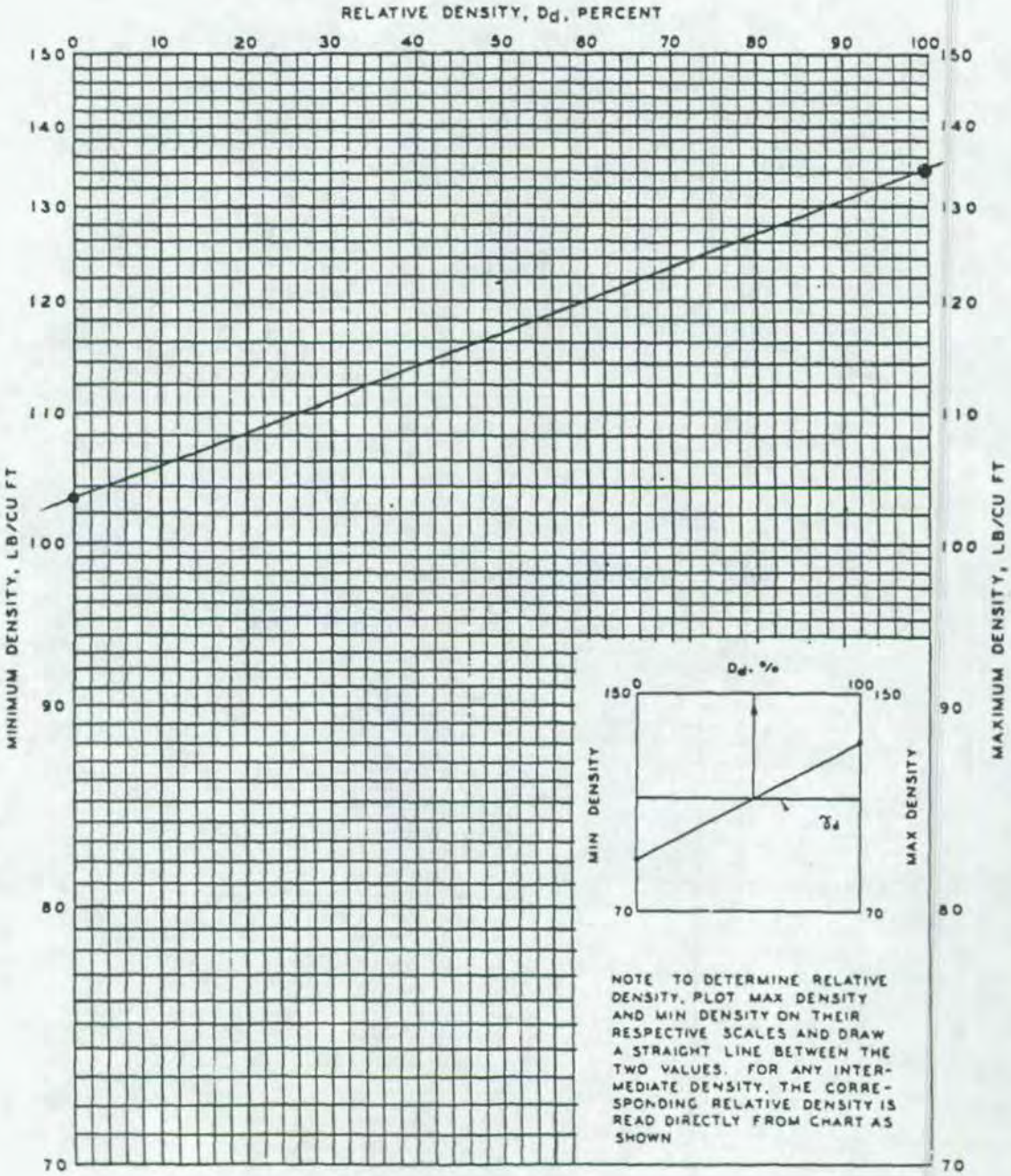
CLIENT: Roy F. Weston, Inc. DATE March 12, 1993

LAB NO. 47894

PROJECT: Mound Environmental Restoration Program

MATERIAL: Brown Silty Gravel With Sand Maximum Dry Density, pcf: 134.1

SOURCE OF MATERIAL: MND20-0343-0028 Minimum Dry Density, pcf: 103.7



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Graphical determination of relative density

CLIENT: Roy F. Weston, Inc

DATE March 12, 1993

LAB NO. 47894

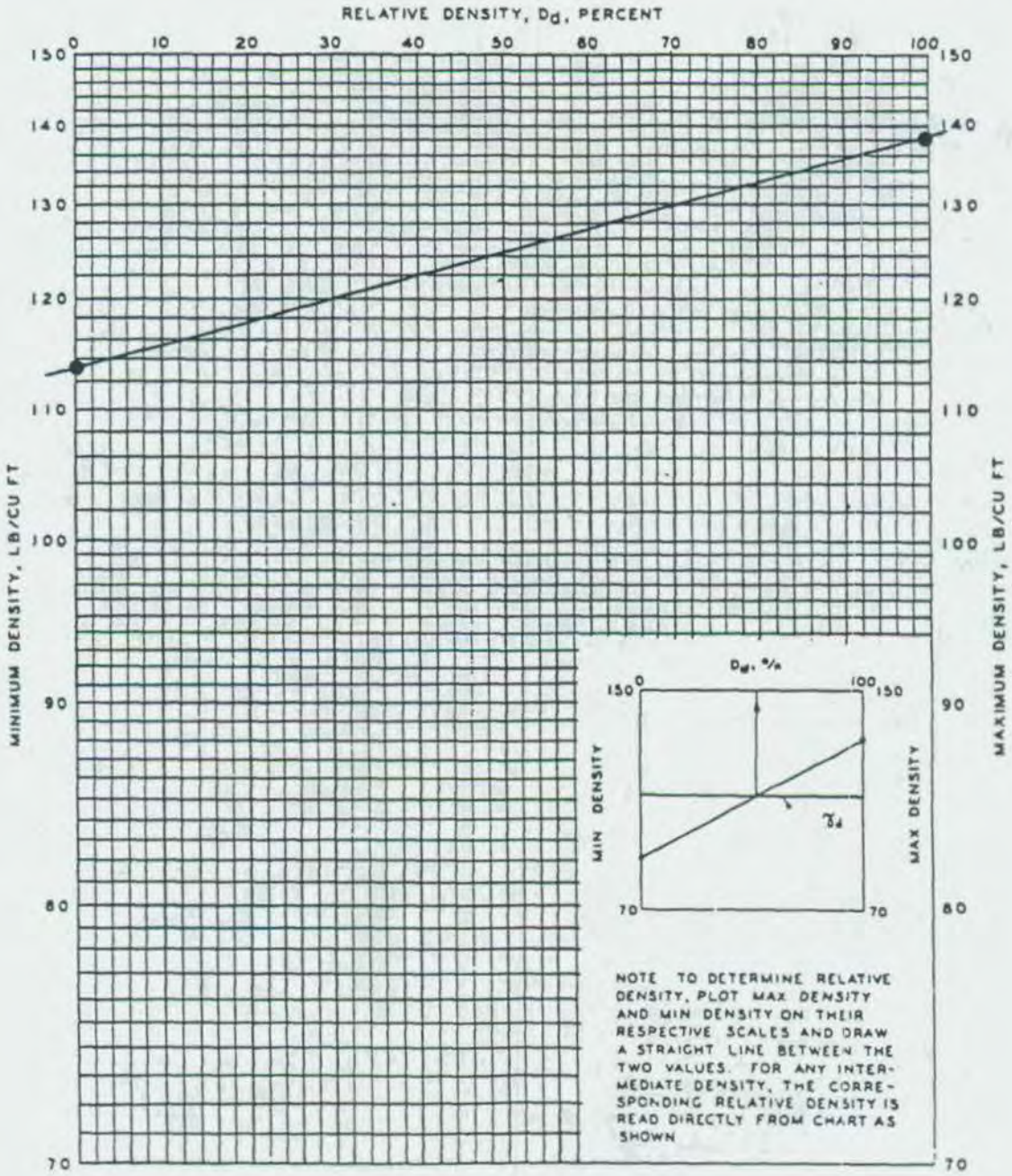
PROJECT: Mound Environmental Restoration Program

MATERIAL: Brown Silty Sand With Gravel

Maximum Dry Density, pcf: 138.5

SOURCE OF MATERIAL: MND20-0343-0037

Minimum Dry Density, pcf: 113.4



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Graphical determination of relative density

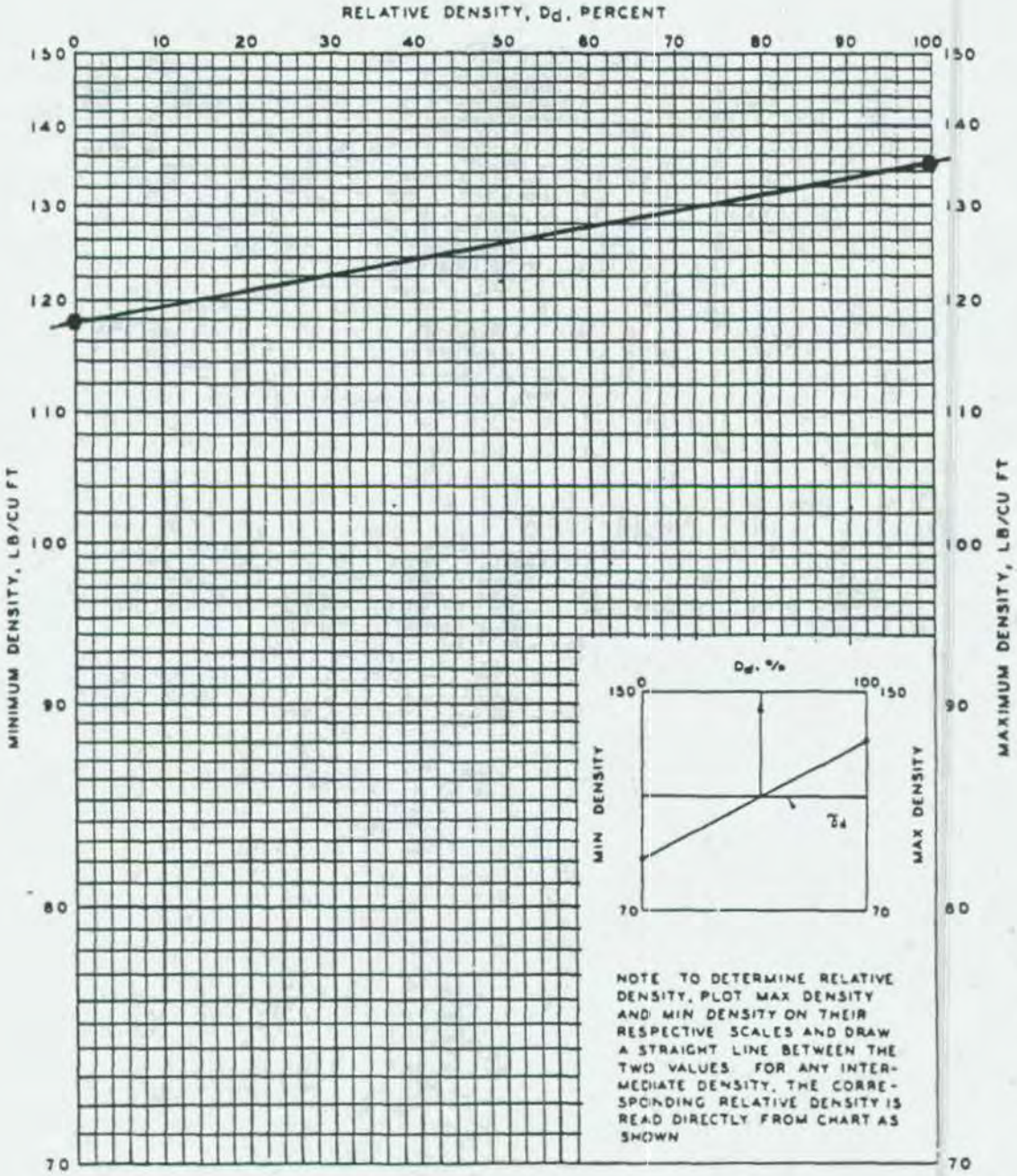
CLIENT: Roy F. Weston, Inc. DATE Feb. 22, 1993

LAB NO. 47894

PROJECT: Mound Environmental Restoration Program

MATERIAL: "GW-GM" Brown Well-Graded Gravel with Silt and Sand Max. Dry Density, pcf: 135.2

SOURCE OF MATERIAL: MND20-0344-0018 Min. Dry Density, pcf: 117.8



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Graphical determination of relative density

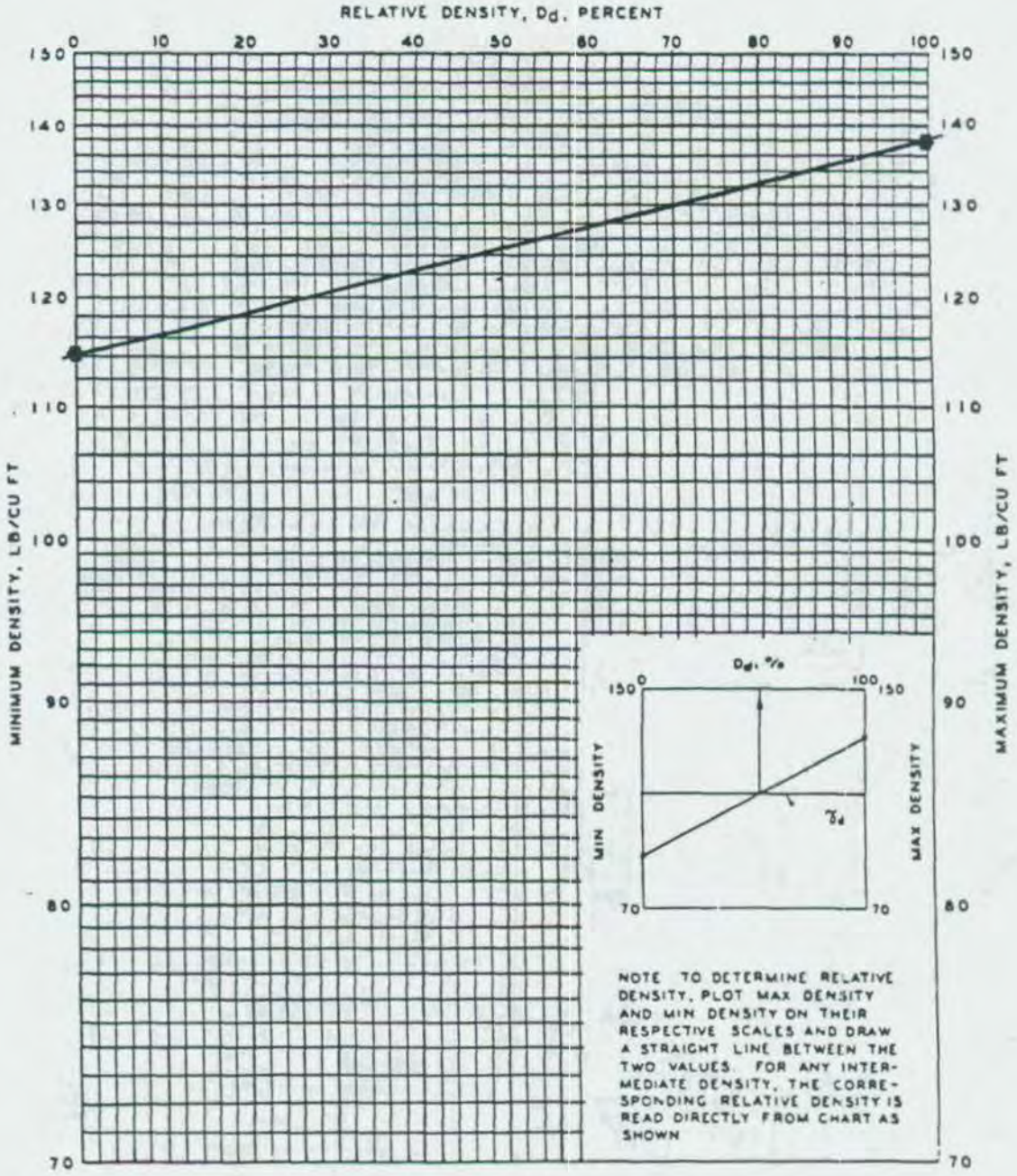
CLIENT: Roy F. Weston, Inc. DATE Feb. 22, 1993

LAB NO. 47894

PROJECT: Mound Environmental Restoration Program

MATERIAL: "GP-GM" Brown Poorly Graded Gravel with Silt and Sand Max. Dry Density, pcf: 137.7

SOURCE OF MATERIAL: MND20-0344-0025 Min. Dry Density, pcf: 114.3



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Graphical determination of relative density

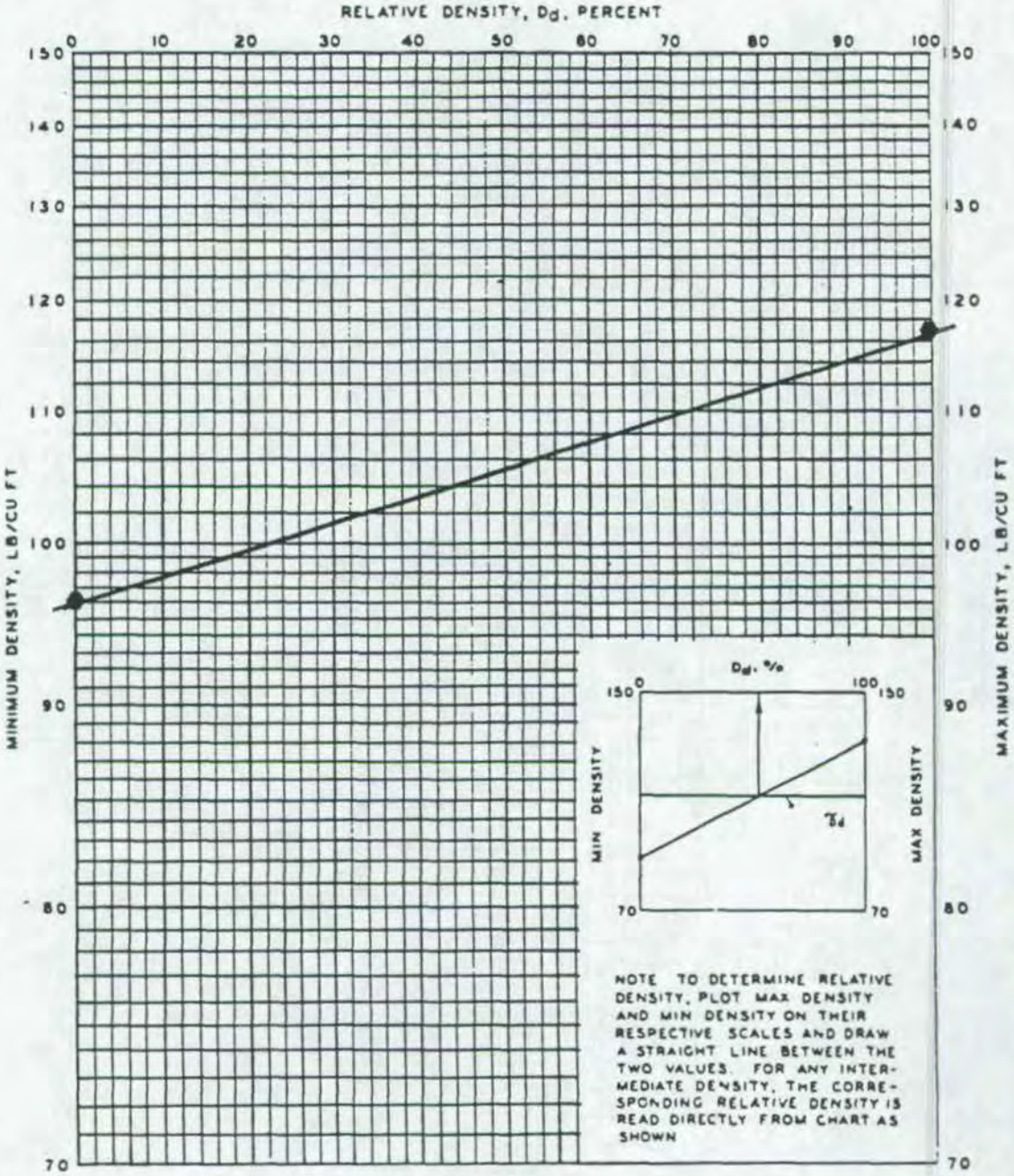
CLIENT: Roy F. Weston, Inc. DATE Feb. 22, 1993

LAB NO. 47894

PROJECT: Mound Environmental Restoration Program

MATERIAL: "SP-SM" Brown Poorly Graded Sand with Silt Max. Dry Density, pcf: 117.5

SOURCE OF MATERIAL: MND20-0344-0060 Min. Dry Density, pcf: 96.2



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Graphical determination of relative density

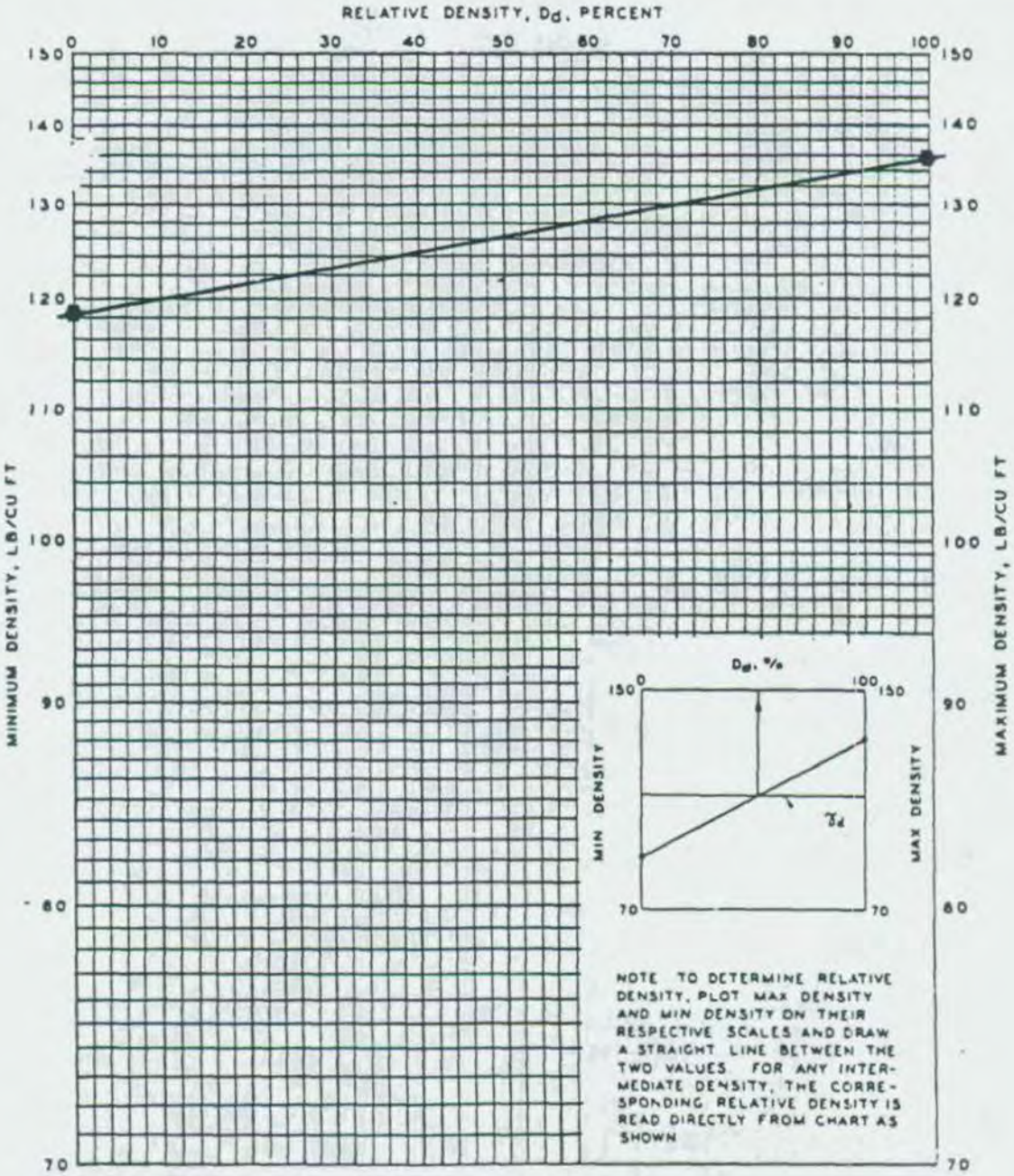
CLIENT: Roy F. Weston, Inc. DATE Feb. 22, 1993

LAB NO. 47894

PROJECT: Mound Environmental Restoration Program

MATERIAL: "SM" Gray Silty Sand Max. Dry Density, pcf: 135.7

SOURCE OF MATERIAL: MND20-0344-0115 Min. Dry Density, pcf: 118.9



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Graphical determination of relative density

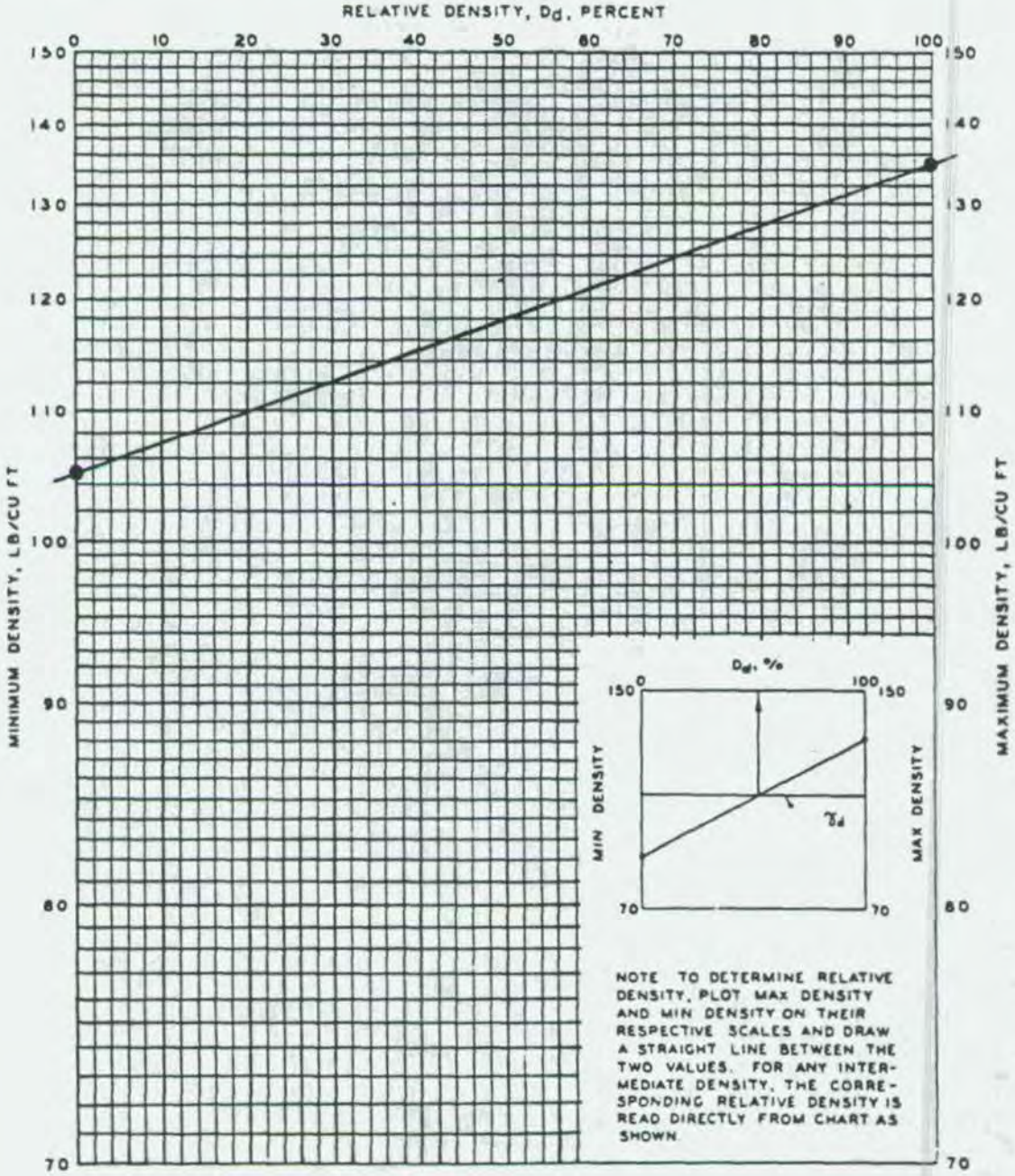
CLIENT: Roy F. Weston, Inc. DATE April 7, 1993

LAB NO. 47894

PROJECT: Mound Environmental Restoration Program

MATERIAL: "GM" Brown gravel, some sand, some clay, trace silt Max. Dry Dens., pcf: 135.2

SOURCE OF MATERIAL: MND20-0346-0035 Min. Dry Dens., pcf: 105.2



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Graphical determination of relative density

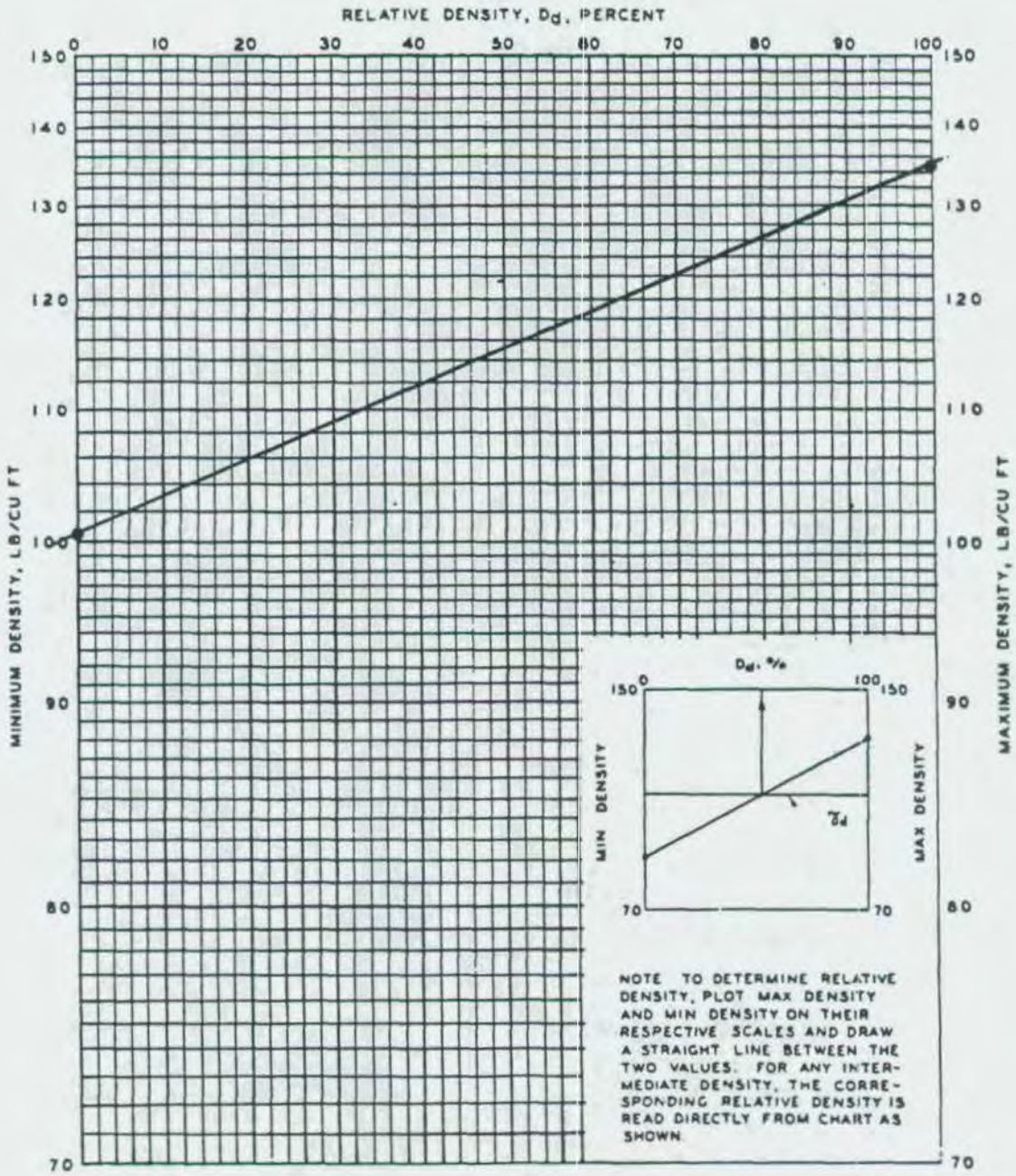
CLIENT: Roy F. Weston, Inc. DATE April 2, 1993

LAB NO. 47894

PROJECT: Mound Environmental Restoration Program

MATERIAL: "GM" Brown Silty Gravel with Sand Maximum Dry Density, pcf: 134.9

SOURCE OF MATERIAL: MND20-0386-0055 Minimum Dry Density, pcf: 100.4



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Graphical determination of relative density

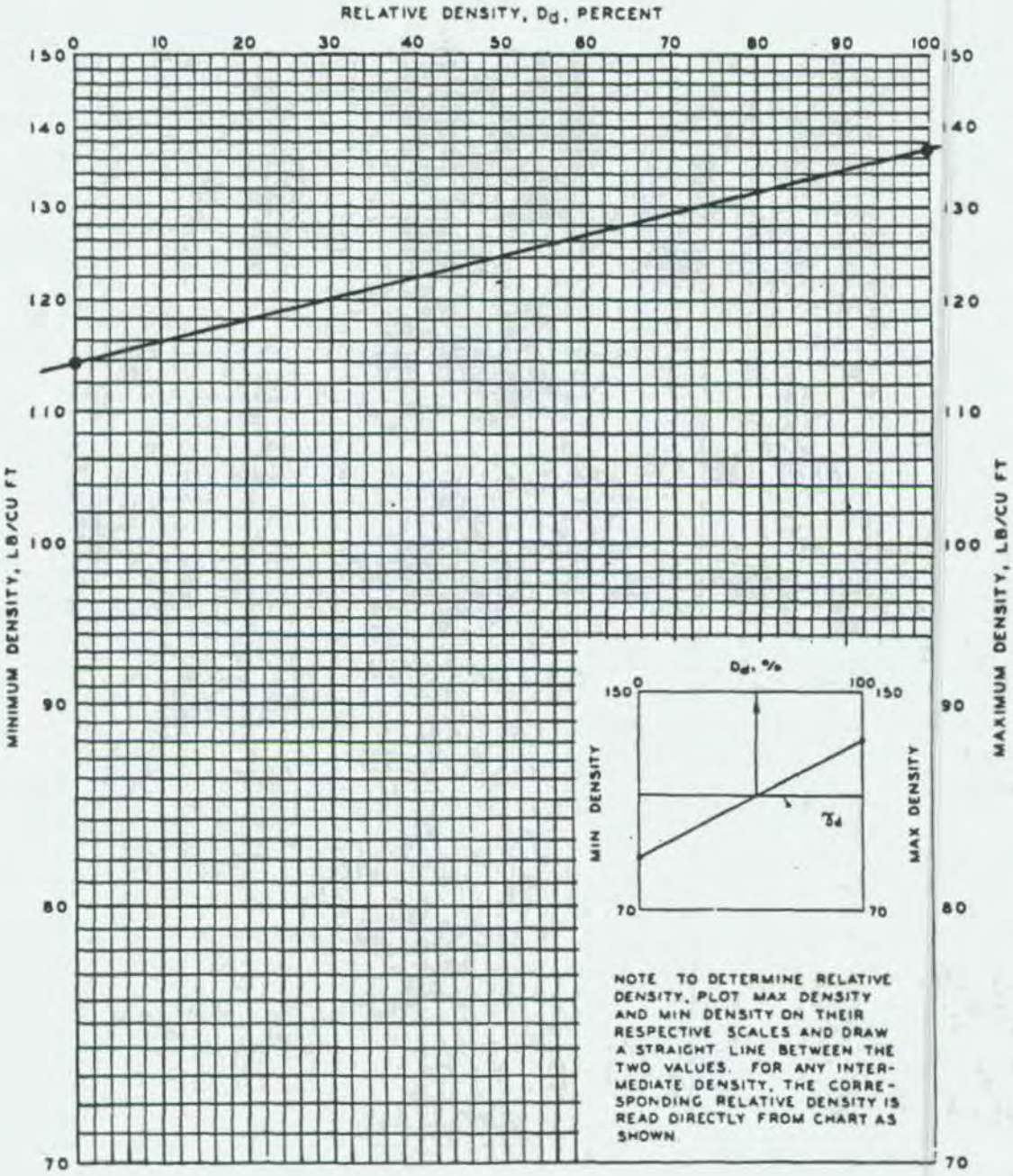
CLIENT: Roy F. Weston, Inc. DATE April 2, 1993

LAB NO. 47894

PROJECT: Mound Environmental Restoration Program

MATERIAL: "GP GM" Brown Poorly Graded Gravel w/silt and sand Max. Dry Dens., pcf: 137.2

SOURCE OF MATERIAL: MND20-0386-0080 Min. Dry Dens., pcf: 113.9



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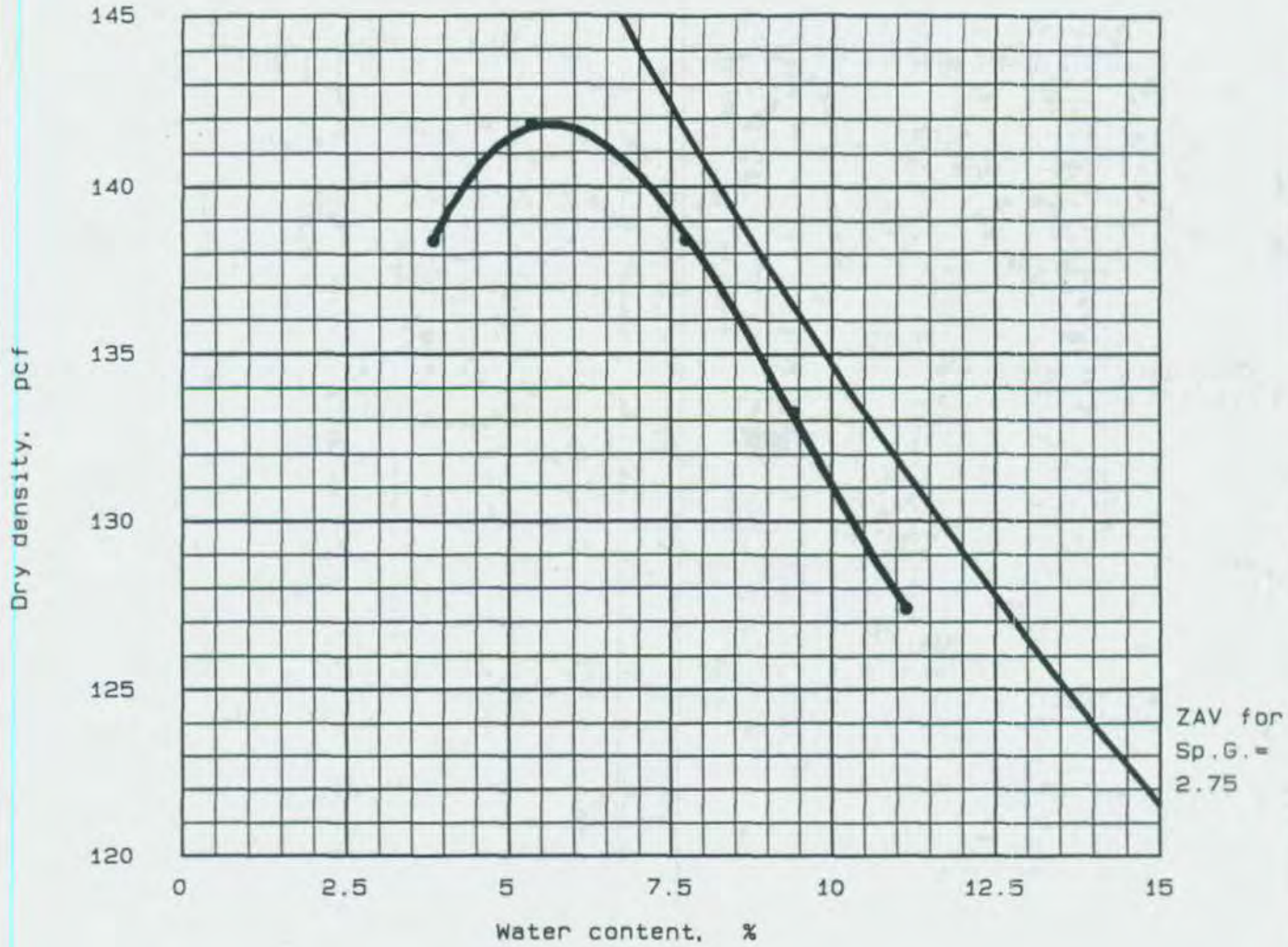
PROCTOR TEST REPORT

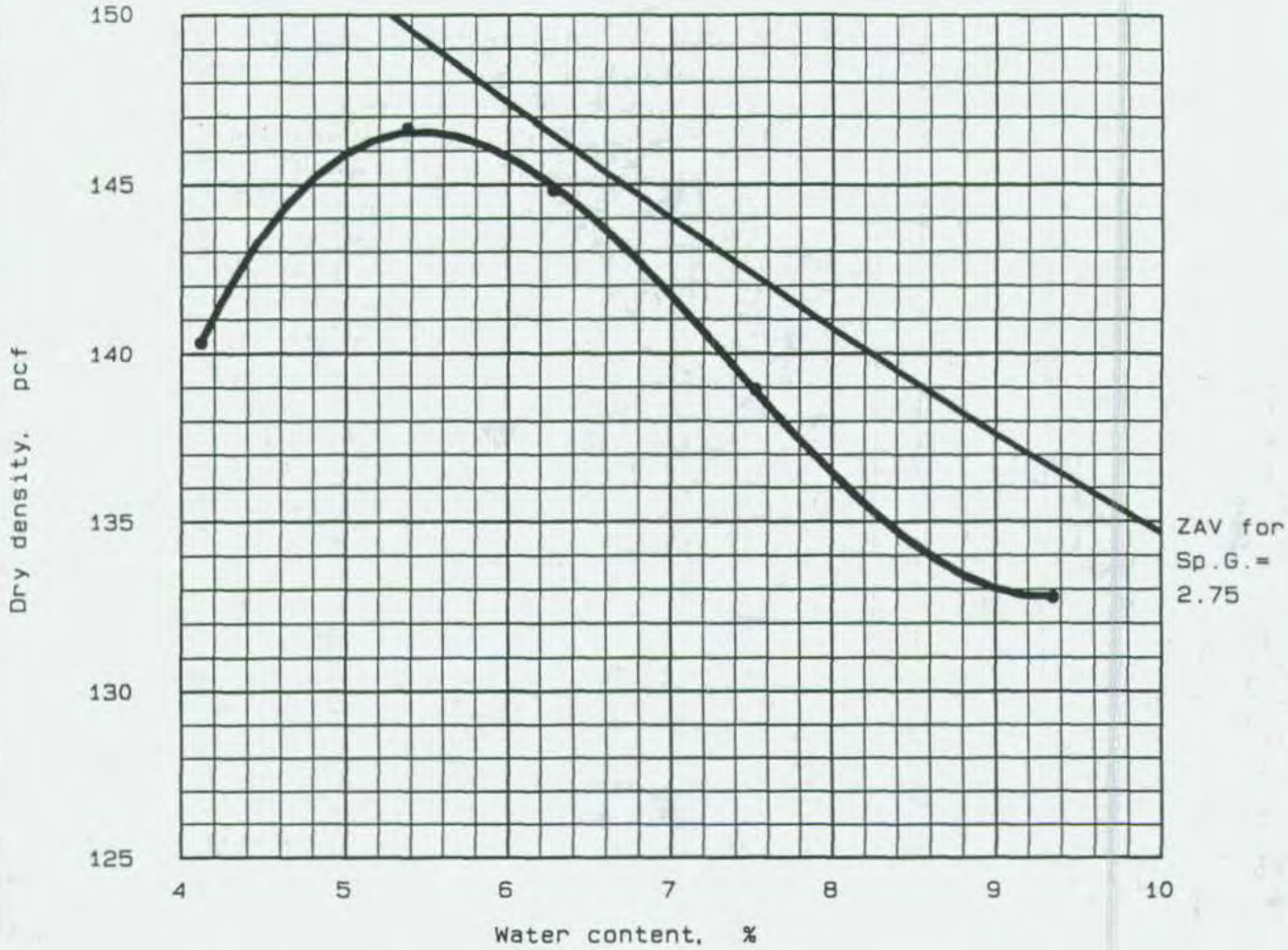


"Modified" Proctor, ASTM D 1557, Method A

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
							9 %	61 %

TEST RESULTS	MATERIAL DESCRIPTION
Optimum moisture = 5.6 % Maximum dry density = 141.8 pcf	GRAY SILT, SOME CLAY, SOME SAND, TRACE GRAVEL
Project No.: 47894 WESTON Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM Location: MND20-0341-0020 Date: 4-09-1993	Remarks: (visual) DATE SAMPLED: 03-29-93
PROCTOR TEST REPORT **BOWSER-MORNER, INC.**	Figure No. _____

PROCTOR TEST REPORT

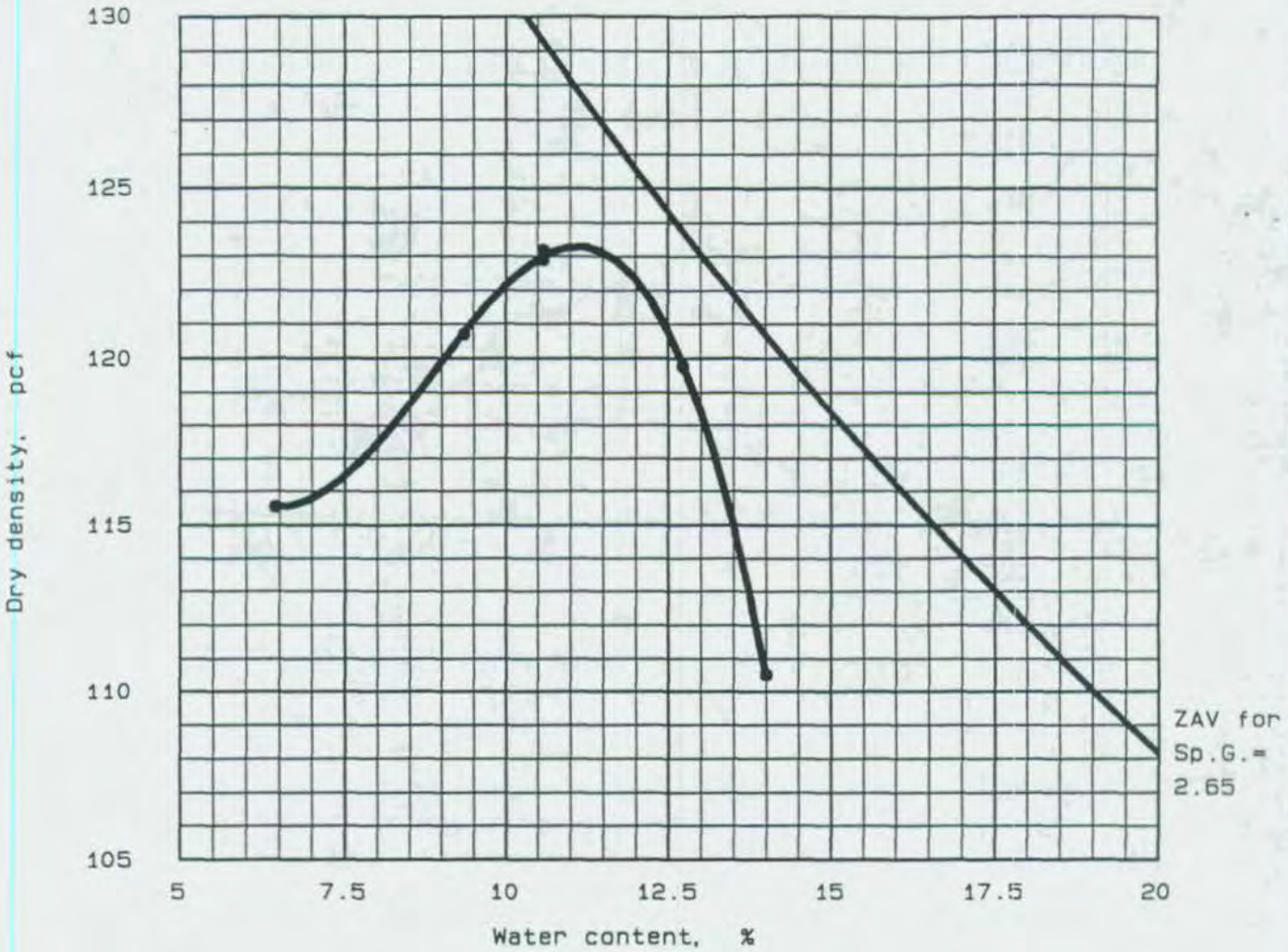


"Modified" Proctor, ASTM D 1557, Method A

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
							16 %	44 %

TEST RESULTS	MATERIAL DESCRIPTION
Optimum moisture = 5.5 % Maximum dry density = 146.5 pcf	BROWN SAND, SOME SILT, SOME CLAY, SOME GRAVEL
Project No.: 47894 WESTON Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM Location: MND20-0342-0075 Date: 4-09-1993	Remarks: (visual) DATE SAMPLED: 04-04-93
PROCTOR TEST REPORT **BOWSER-MORNER, INC.**	Figure No. _____

PROCTOR TEST REPORT



"Modified" Proctor, ASTM D 1557, Method A

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
	SM						3 %	13 %

TEST RESULTS	MATERIAL DESCRIPTION
Optimum moisture = 11.1 % Maximum dry density = 123.3 pcf	GRAY SILTY SAND

Project No.: 47894 WESTON

Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Location: MND20-0342-0095

Date: 4-08-1993

Remarks:

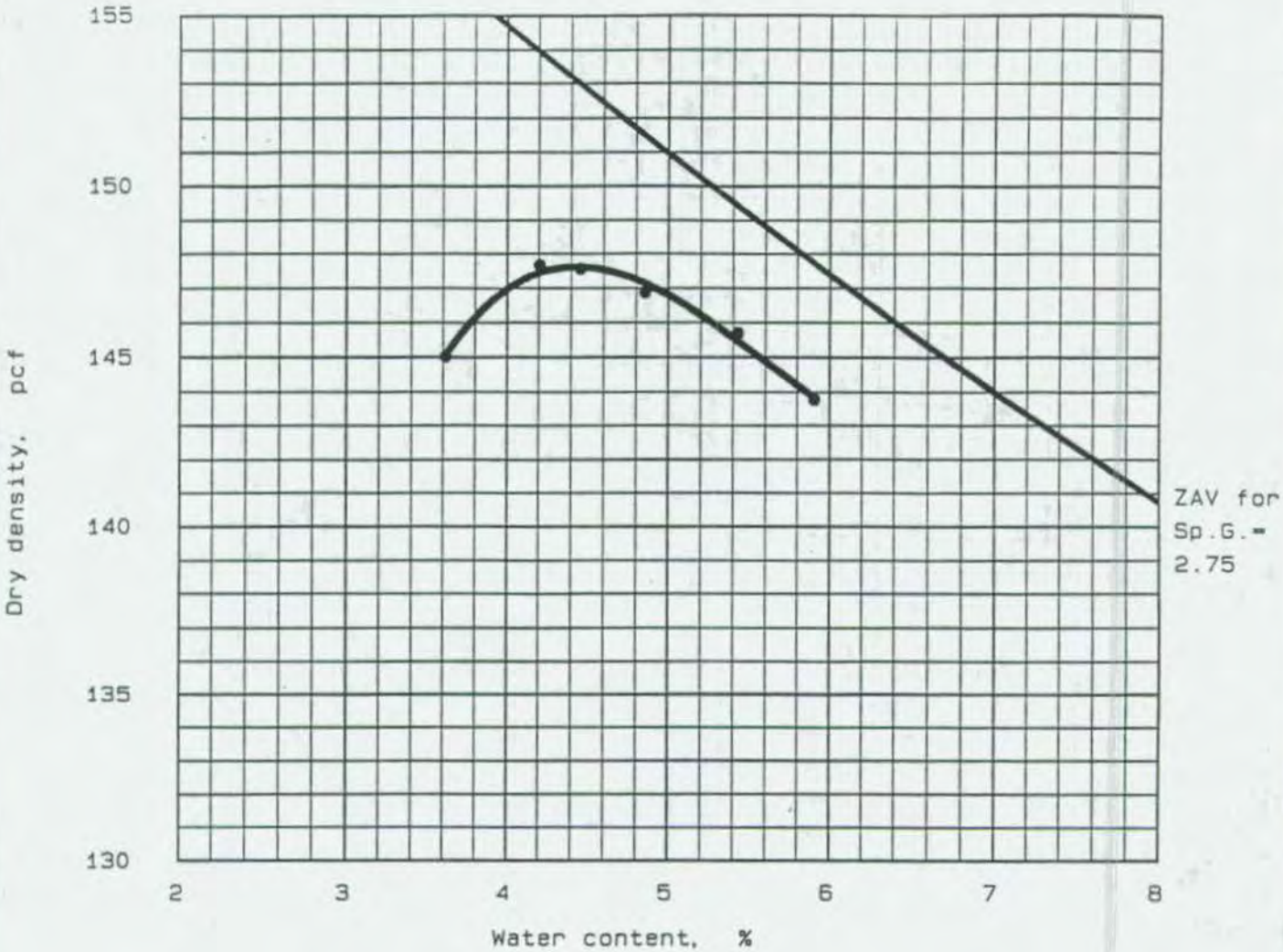
DATE SAMPLED: 04-04-93

PROCTOR TEST REPORT

BOWSER-MORNER, INC.

Figure No. _____

PROCTOR TEST REPORT



"Modified" Proctor, ASTM D 1557, Method C

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
							32 %	27 %

TEST RESULTS	MATERIAL DESCRIPTION
Optimum moisture = 4.4 % Maximum dry density = 147.6 pcf	GRAY SAND, SM GRAVEL, SM SILT, TR CLAY (VISUAL)
Project No.: 47894 WESTON Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM Location: MND20-0343-0057 Date: 3-15-1993	Remarks: BUCKET SAMPLED: 03-01-93
PROCTOR TEST REPORT BOWSER-MORNER, INC.	Figure No. _____

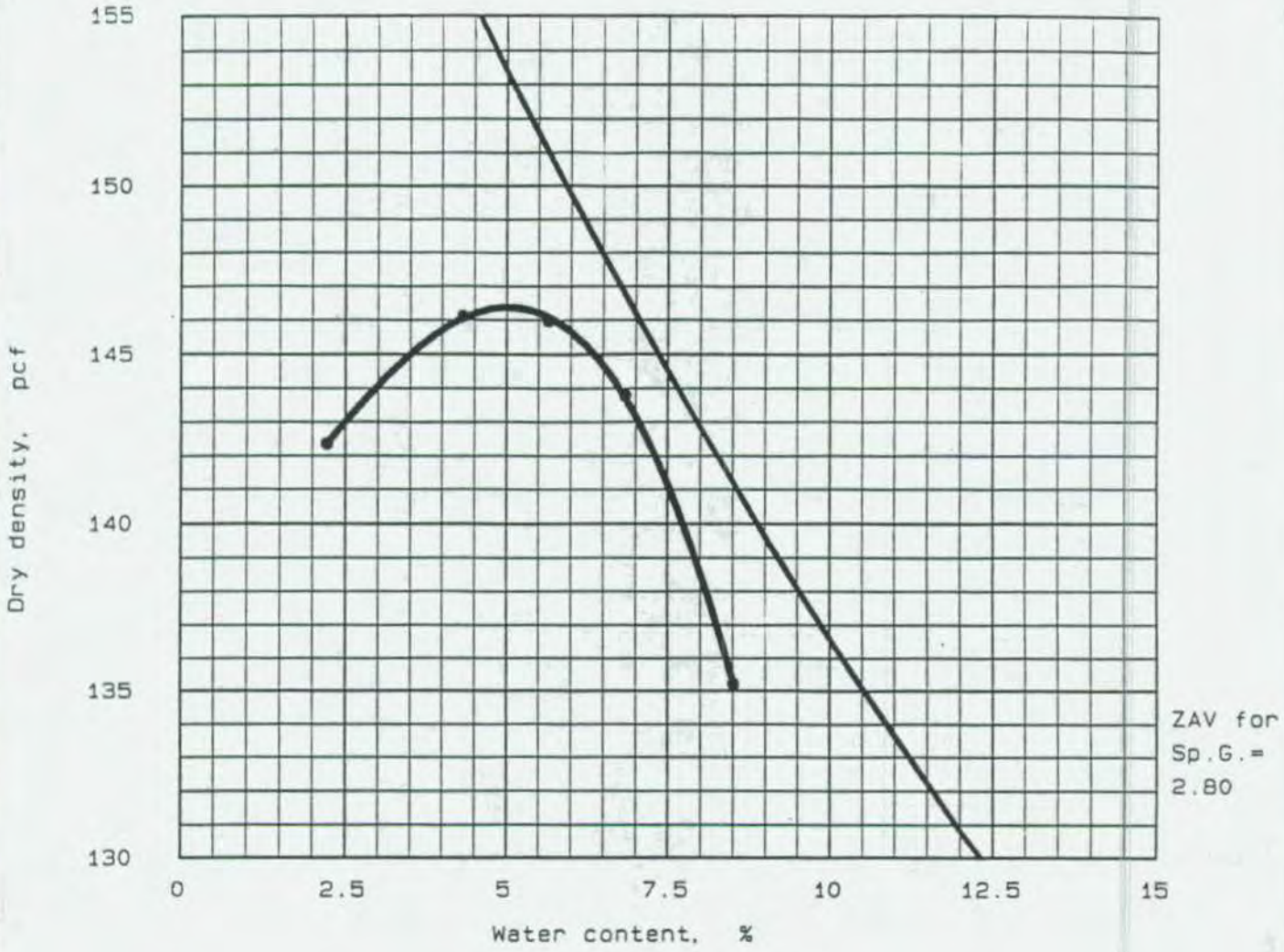
PROCTOR TEST REPORT

"Modified" Proctor, ASTM D 1557, Method A

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
				2.73			10 %	59 %

TEST RESULTS	MATERIAL DESCRIPTION
Optimum moisture = 7.8 % Maximum dry density = 135.1 pcf	GRAY CLAY, SM SAND, SM SILT, TR GRAVEL (VISUAL)
Project No.: 47894 WESTON Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM Location: MND20-0343-0067/0080 Date: 3-10-1993	Remarks: BUCKET SAMPLED: 03-01-93
PROCTOR TEST REPORT BOWSER-MORNER, INC.	Figure No. _____

PROCTOR TEST REPORT



"Modified" Proctor, ASTM D 1557, Method C

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
	SM						28 %	25 %

TEST RESULTS	MATERIAL DESCRIPTION
Optimum moisture = 5.0 % Maximum dry density = 146.4 pcf	BROWN SILTY SAND WITH GRAVEL

Project No.: 47894 WESTON

Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Location: MND20-0344-0030

Date: 2-19-1993

Remarks:

BUCKET SAMPLED: 01-25-93

PROCTOR TEST REPORT

BOWSER-MORNER, INC.

Figure No. _____

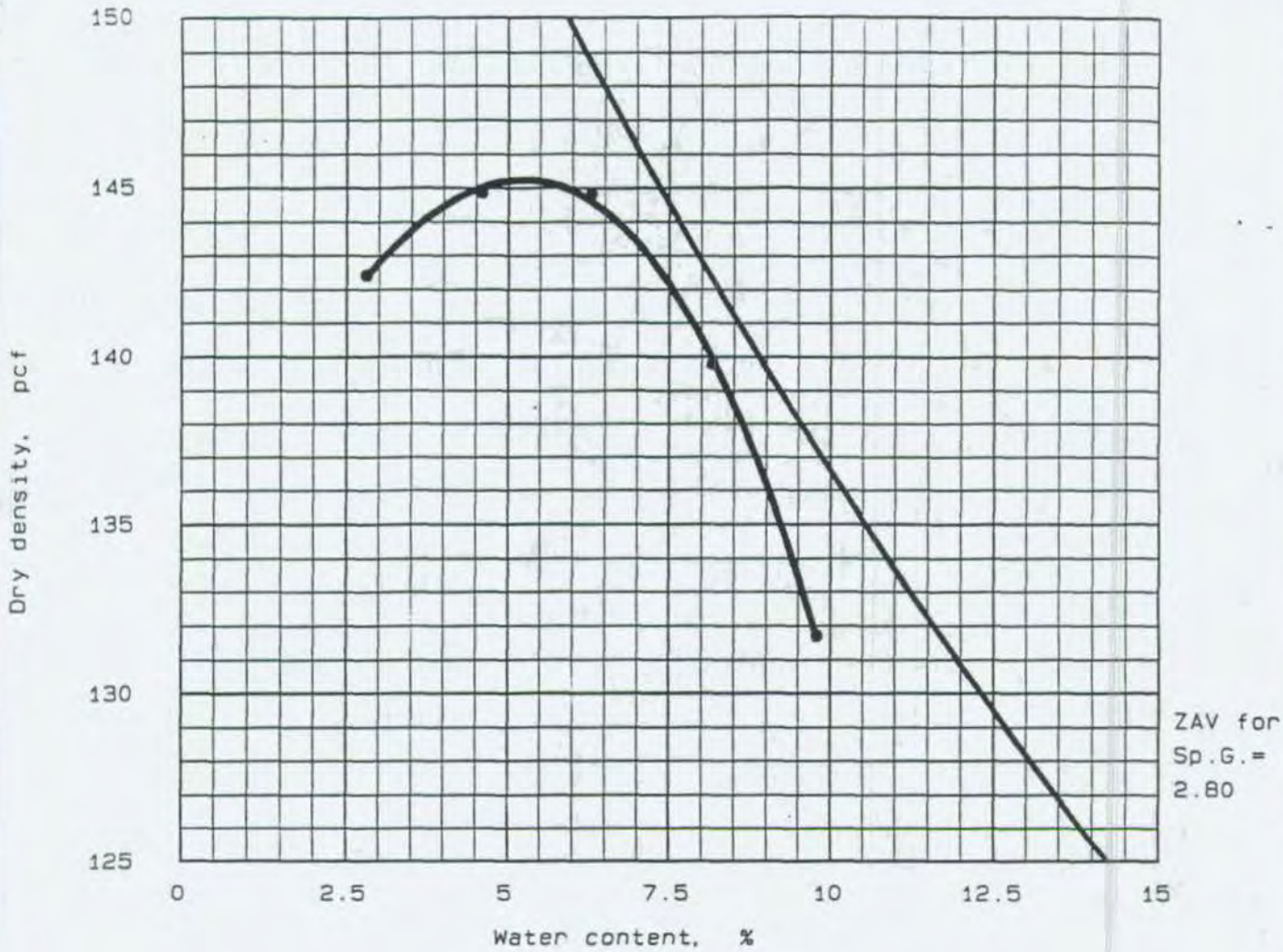
PROCTOR TEST REPORT

"Modified" Proctor, ASTM D 1557, Method C

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
	SM					NP	20 %	25 %

TEST RESULTS	MATERIAL DESCRIPTION
Optimum moisture = 4.3 % Maximum dry density = 147.0 pcf	GRAY SILTY SAND WITH GRAVEL
Project No.: 47894 WESTON Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM Location: MND20-0344-0035 Date: 2-19-1993	Remarks: BUCKET SAMPLED: 01-25-93
PROCTOR TEST REPORT BOWSER-MORNER, INC.	Figure No. _____

PROCTOR TEST REPORT

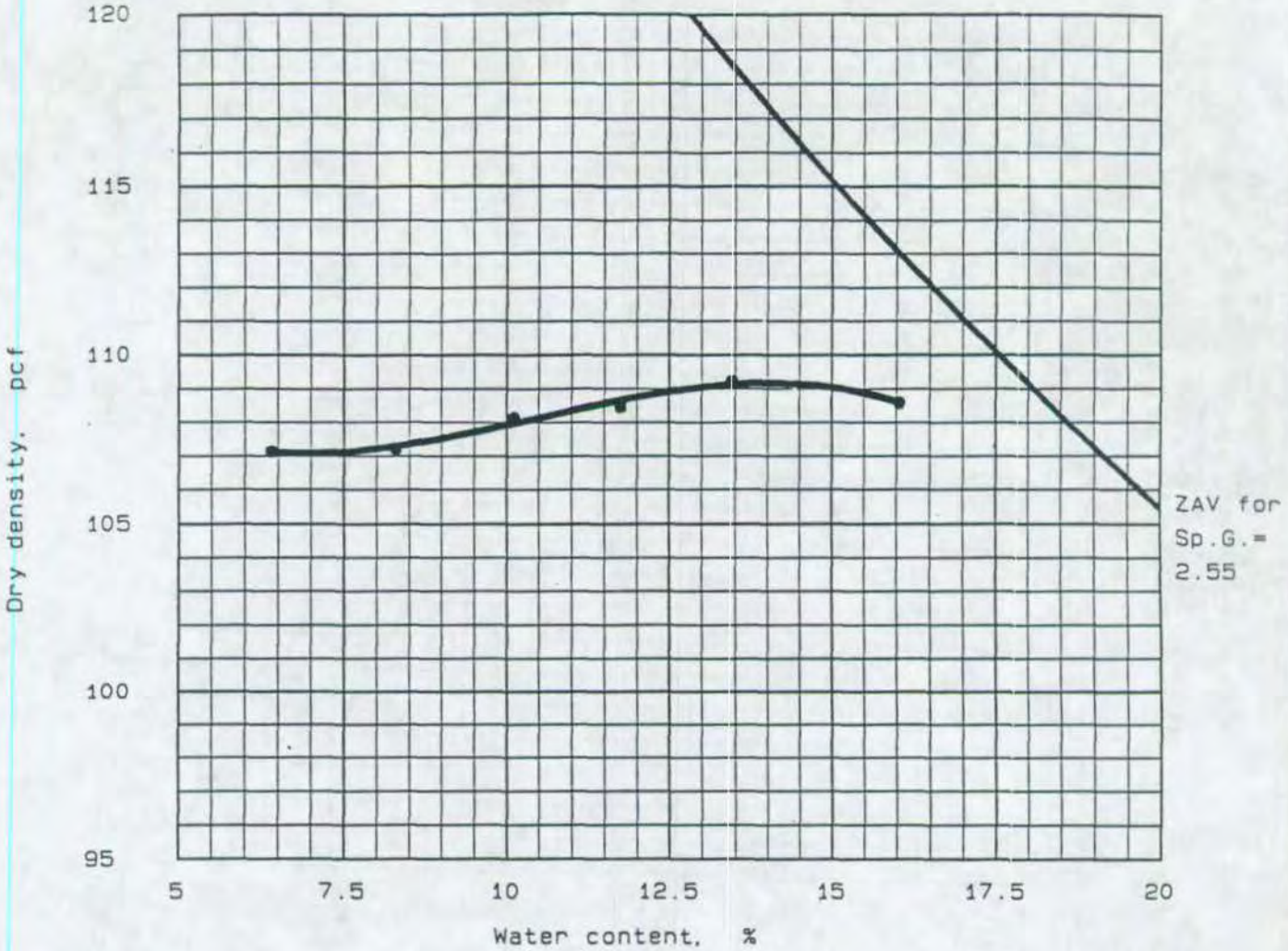


"Modified" Proctor, ASTM D 1557, Method A

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
							23 %	34 %

TEST RESULTS	MATERIAL DESCRIPTION
Optimum moisture = 5.2 % Maximum dry density = 145.2 pcf	GRAY SILTY SAND WITH GRAVEL
Project No.: 47894 WESTON Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM Location: MND20-0344-0040 Date: 2-19-1993	Remarks: BUCKET SAMPLED: 01-25-93
PROCTOR TEST REPORT BOWSER-MORNER, INC.	Figure No. _____

PROCTOR TEST REPORT

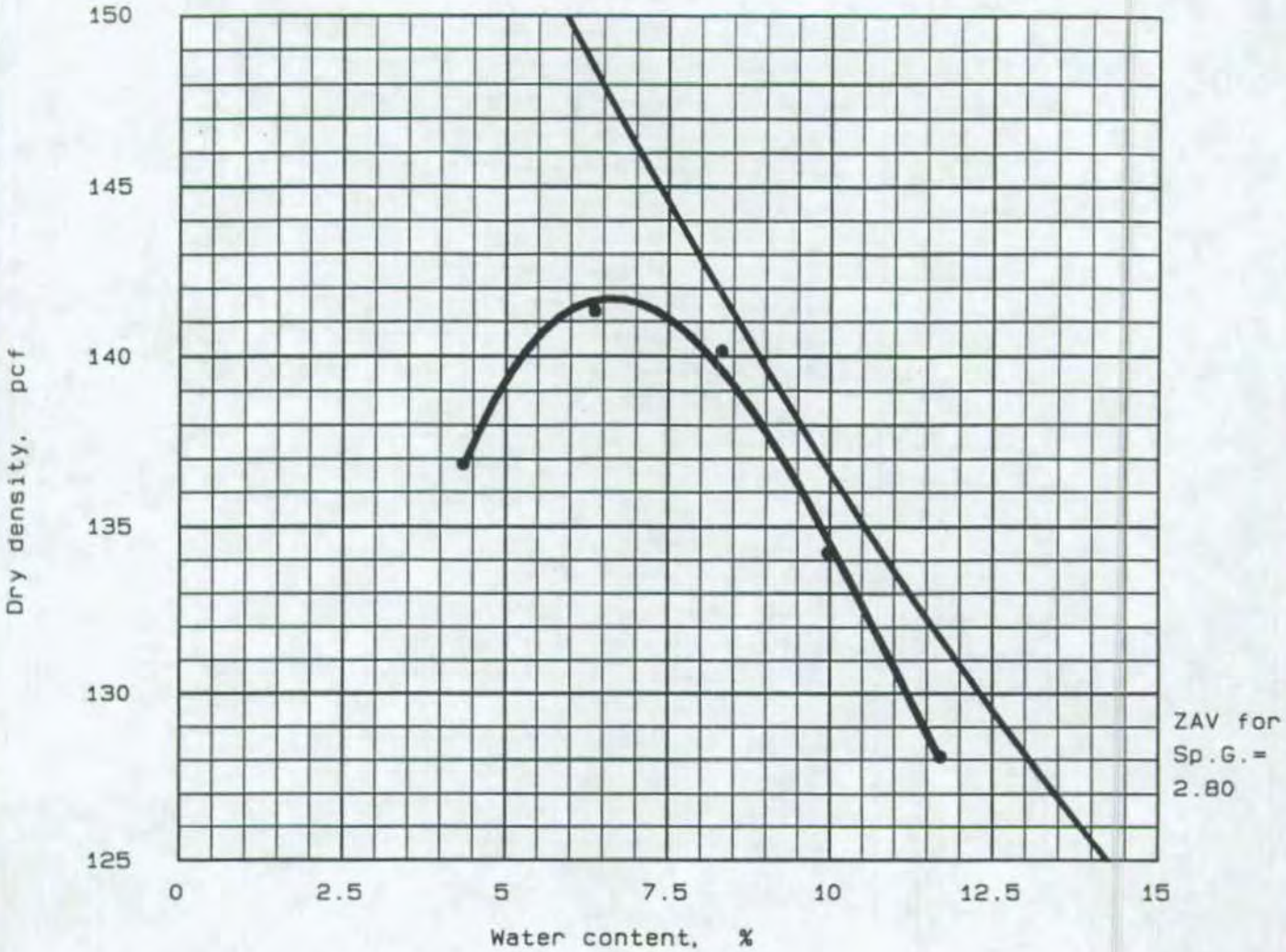


"Modified" Proctor, ASTM D 1557, Method A

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
	SM						0 %	14 %

TEST RESULTS	MATERIAL DESCRIPTION
Optimum moisture = 14.0 % Maximum dry density = 109.2 pcf	GRAY SILTY SAND
Project No.: 47894 WESTON Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM Location: MND20-0344-0065 Date: 2-18-1993	Remarks: BUCKET SAMPLED: 01-26-93
PROCTOR TEST REPORT BOWSER-MORNER, INC.	Figure No. _____

PROCTOR TEST REPORT

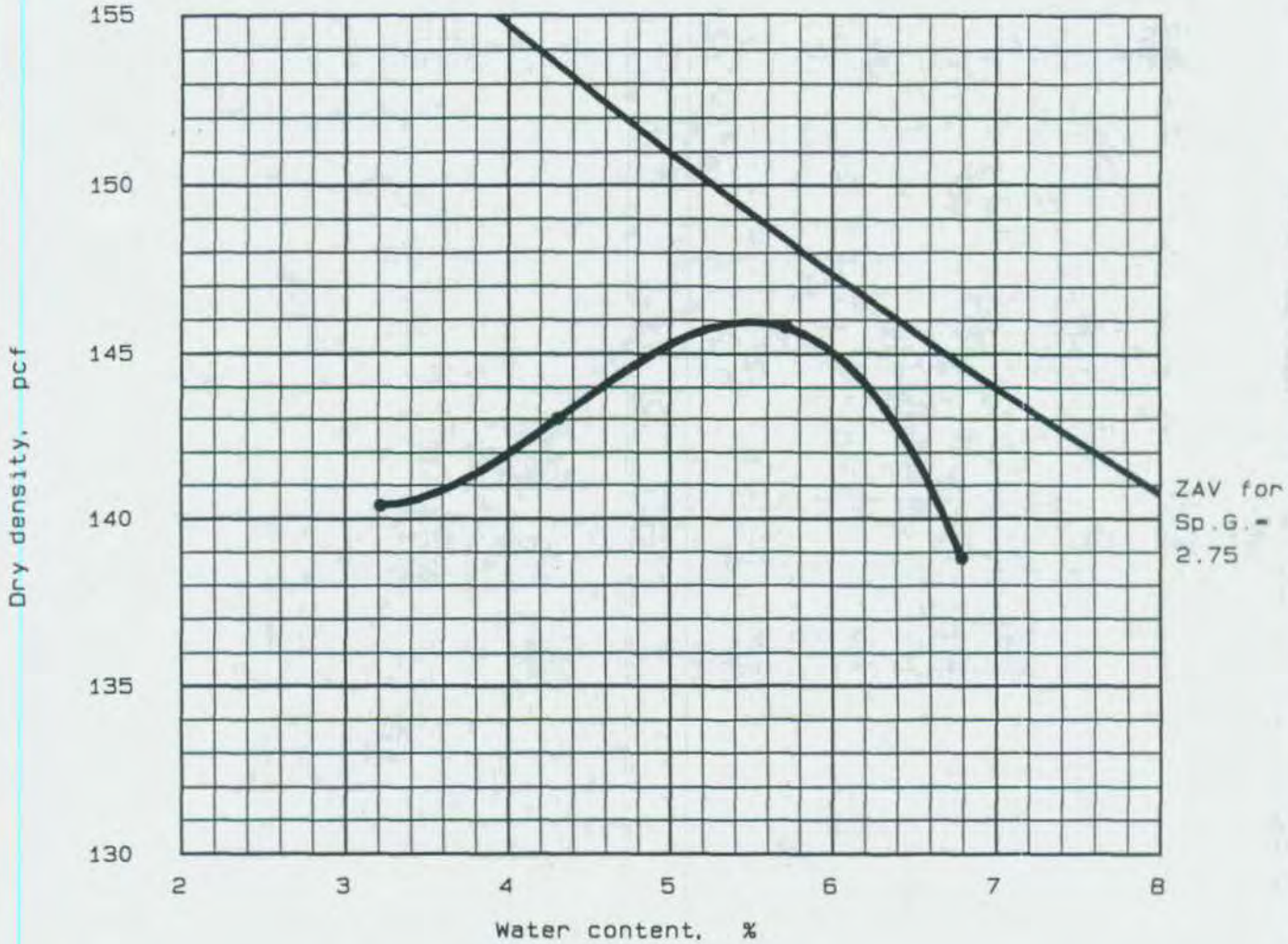


"Modified" Proctor, ASTM D 1557, Method A

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
							13 %	56 %

TEST RESULTS	MATERIAL DESCRIPTION
Optimum moisture = 6.6 % Maximum dry density = 141.7 pcf	GRAY SAND, SOME CLAY, SOME SILT, SOME GRAVEL
Project No.: 47894 WESTON Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM Location: MND20-0346-0025 Date: 4-09-1993	Remarks: (visual) DATE SAMPLED: 04-02-93
PROCTOR TEST REPORT **BOWSER-MORNER, INC.**	Figure No. _____

PROCTOR TEST REPORT



"Modified" Proctor, ASTM D 1557, Method C

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
							47 %	21 %

TEST RESULTS	MATERIAL DESCRIPTION
Optimum moisture = 5.5 % Maximum dry density = 146.0 pcf	BROWN GRAVEL, SOME SAND, SOME SILT, TRACE CLAY

Project No.: 47894 WESTON

Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Location: MND20-0386-0033

Date: 3-29-1993

Remarks: (visual)

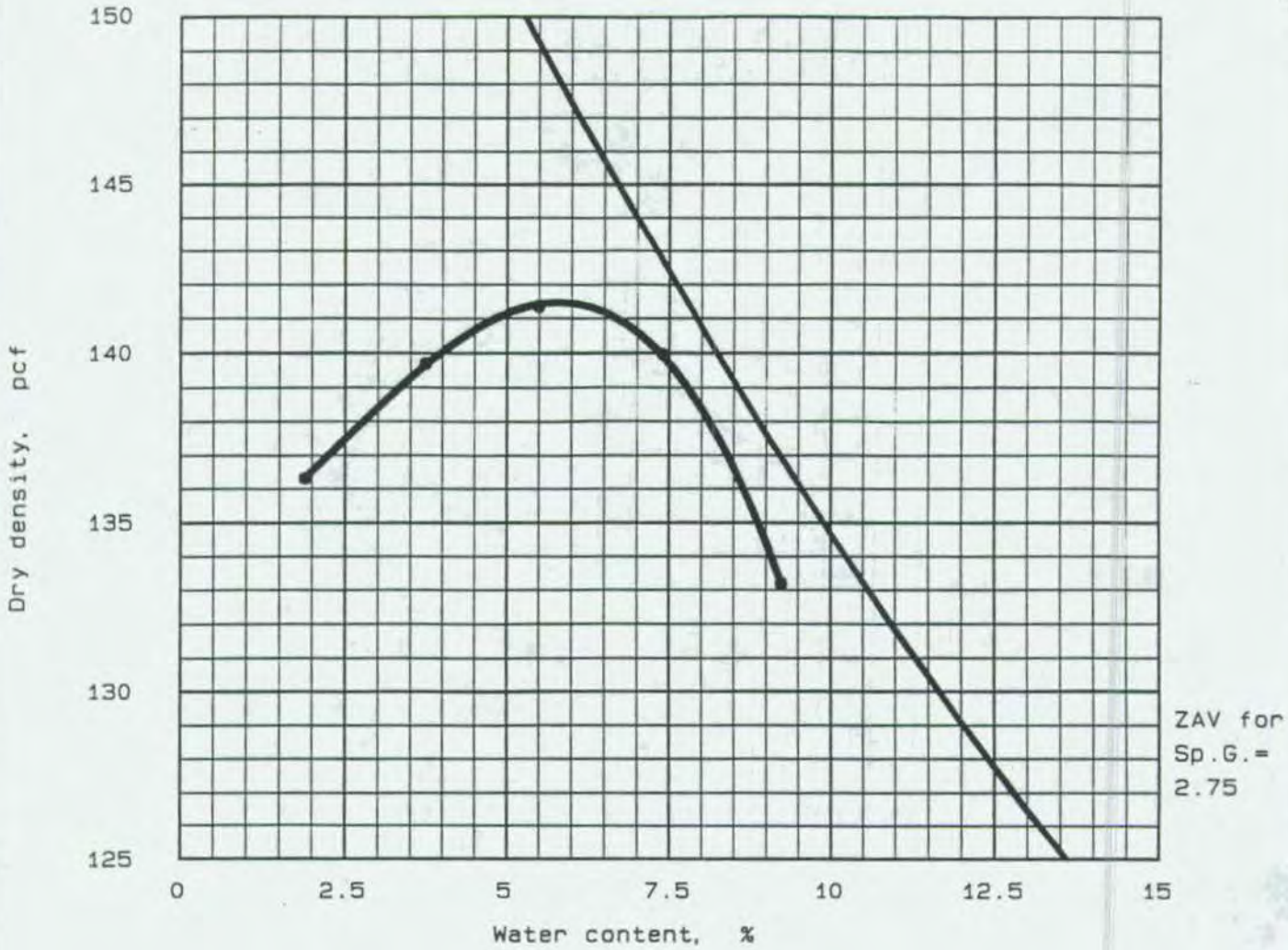
DATE SAMPLED: 03-22-93

PROCTOR TEST REPORT

BOWSER-MORNER, INC.

Figure No. _____

PROCTOR TEST REPORT



"Modified" Proctor, ASTM D 1557, Method A

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
							12 %	52 %

TEST RESULTS	MATERIAL DESCRIPTION
Optimum moisture = 5.8 % Maximum dry density = 141.5 pcf	GRAY/BROWN SAND, SOME SILT, SM CLAY, SM GRAVEL

Project No.: 47894 WESTON

Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Location: MND20-0386-0035

Date: 3-29-1993

Remarks: (visual)

DATE SAMPLED: 03-22-93

PROCTOR TEST REPORT

BOWSER-MORNER, INC.

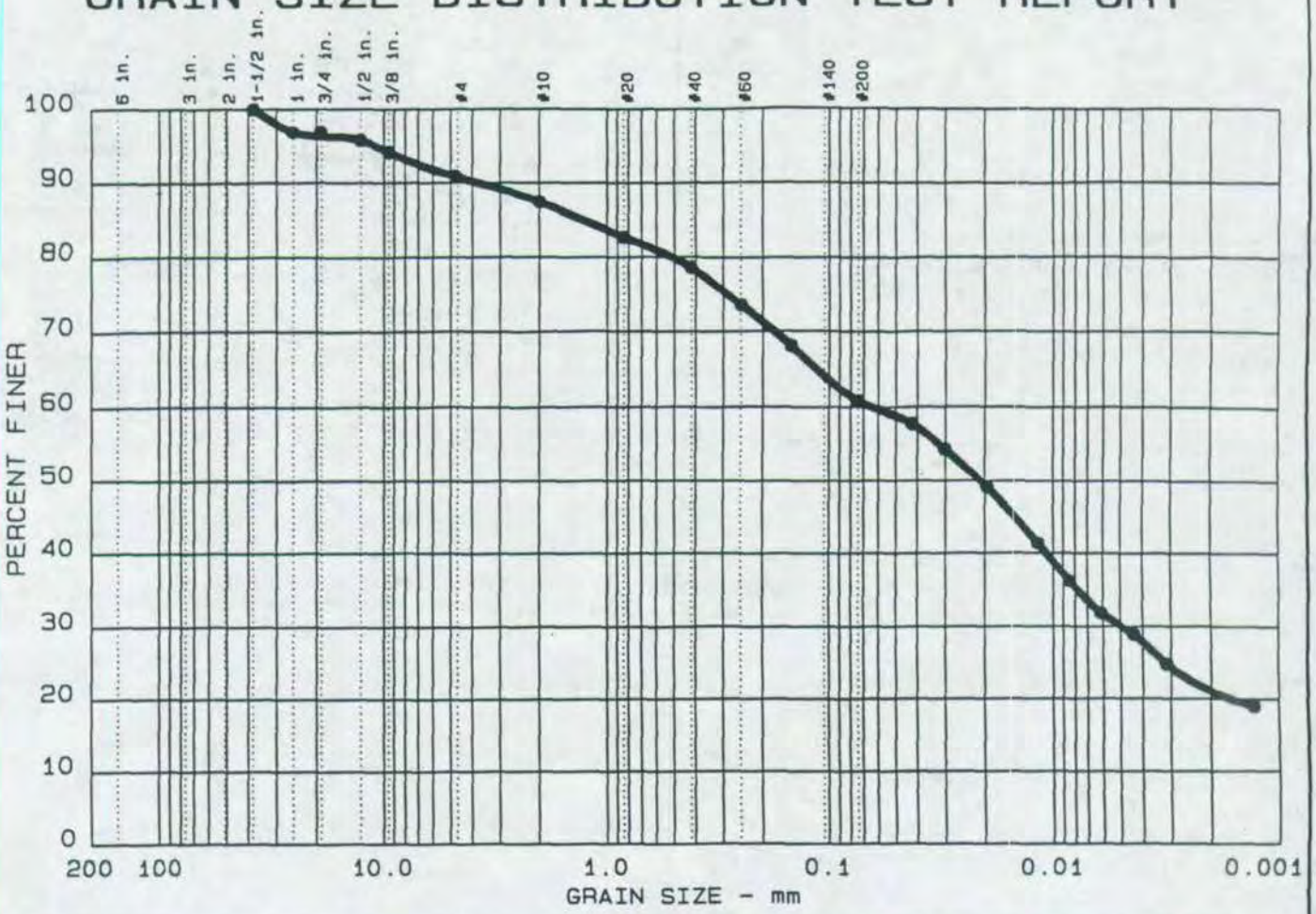
Figure No. _____

Section III

Grain Size Distribution Data

BOWSER MORNER

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	12	0.0	9.1	30.0	30.7	30.2

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.26		0.02	0.005				

MATERIAL DESCRIPTION	USCS	AASHTO
● GRAY SILT, SM CLAY, SM SAND, TR GRAVEL (VISUAL)		

Project No.: 47894 WESTON

Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

● Location: MND20-0341-0020

Date: 04-12-93

Remarks:

LOI, %: 1.5

BUCKET SAMPLED: 03-29-93

GRAIN SIZE DISTRIBUTION TEST REPORT

BOWSER-MORNER, INC.

Figure No. _____

GRAIN SIZE DISTRIBUTION TEST DATA Test No.: 12

Date: 04-12-93
Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Sample Data

Location of Sample: MND20-0341-0020
Sample Description: GRAY SILT, SM CLAY, SM SAND, TR GRAVEL (VISUAL)
USCS Class: Liquid limit:
AASHTO Class: Plasticity index:

Notes

Remarks: LOI, %: 1.5
BUCKET SAMPLED: 03-29-93
Fig. No.:

Mechanical Analysis Data

	Initial
Dry sample and tare=	2671.70
Tare =	200.20
Dry sample weight =	2471.50

Sample split on number 10 sieve
Split sample data:
Sample and tare = 50 Tare = 0 Sample weight = 50
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
1.5 inches	0.00	100.0
1 inches	76.52	96.9
0.75 inches	76.52	96.9
0.5 inches	103.77	95.8
0.375 inches	144.11	94.2
# 4	224.68	90.9
# 10	310.15	87.5
# 20	2.74	82.7
# 40	5.11	78.5
# 60	7.94	73.6
# 100	11.05	68.1
# 200	15.20	60.9

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 87.5
Weight of hydrometer sample: 50
Hygroscopic moisture correction:
  Moist weight & tare = 209.34
  Dry weight & tare = 208.79
  Tare = 98.66
  Hygroscopic moisture= 0.5 %
Calculated biased weight= 56.89
Automatic temperature correction
  Composite correction at 20 deg C =-4.5

Meniscus correction only= 0
Specific gravity of solids= 2.73
Specific gravity correction factor= 0.983
Hydrometer type: 152H Effective depth L= 16.294964 - 0.164 x Rm

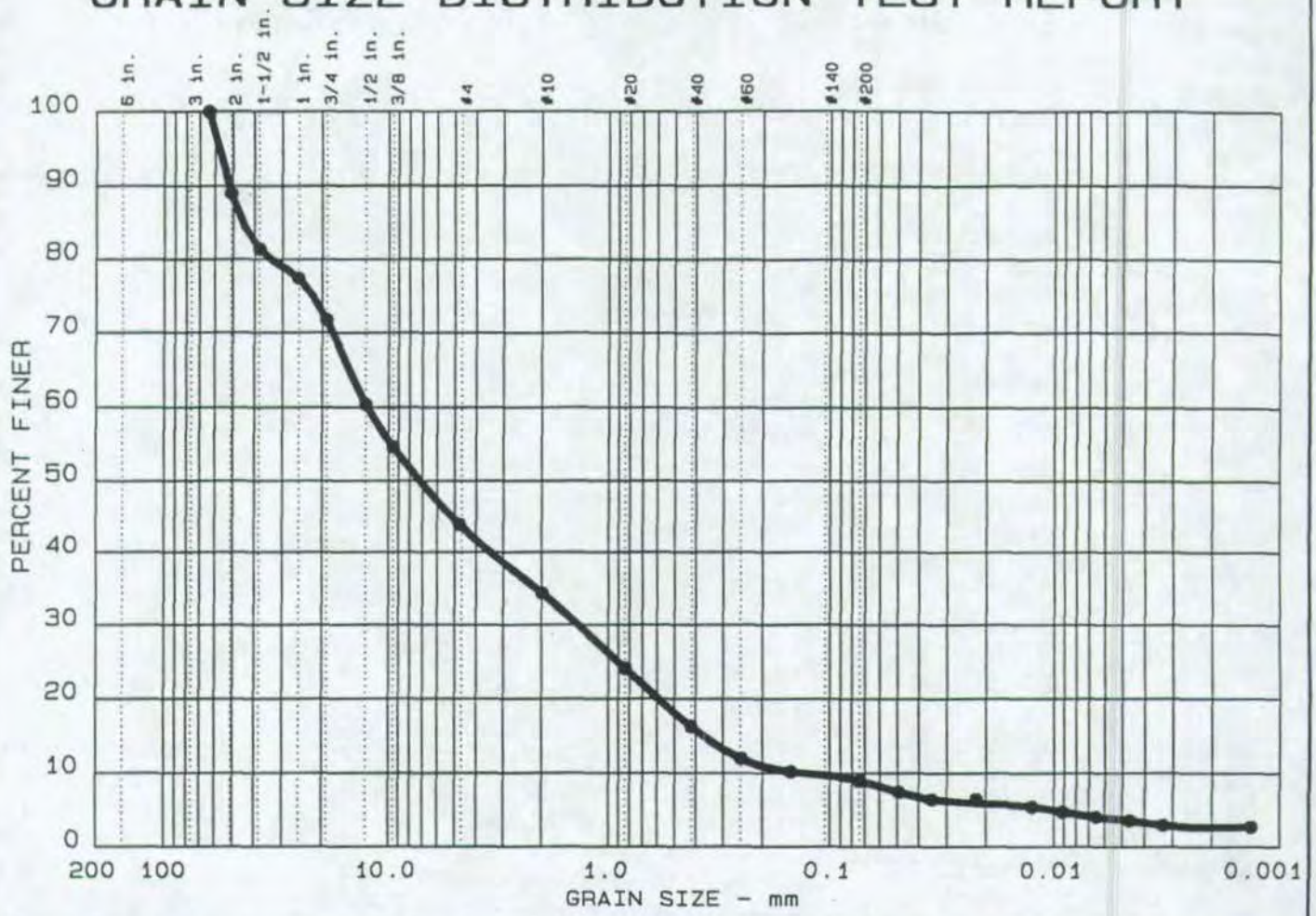
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1.0	20.0	38.0	33.5	0.0133	38.0	10.1	0.0423	57.8
2.0	20.1	36.0	31.5	0.0133	36.0	10.4	0.0303	54.4
5.0	20.1	33.0	28.5	0.0133	33.0	10.9	0.0196	49.2
15.0	20.1	28.5	24.0	0.0133	28.5	11.6	0.0117	41.4
30.0	20.1	25.5	21.0	0.0133	25.5	12.1	0.0085	36.2
60.0	20.1	23.0	18.5	0.0133	23.0	12.5	0.0061	31.9
120.0	19.1	21.5	16.8	0.0135	21.5	12.8	0.0044	29.0
240.0	19.6	19.0	14.4	0.0134	19.0	13.2	0.0031	24.8
1440.0	20.3	15.5	11.0	0.0133	15.5	13.8	0.0013	19.0

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 9.1 % SAND = 30.0
% SILT = 30.7 % CLAY = 30.2

D85= 1.26 D60= 0.063 D50= 0.021
D30= 0.0049

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	11	0.0	56.1	34.9	5.3	3.7

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			45.13	12.43	7.15	1.347	0.3669	0.1317	1.11	94.4

MATERIAL DESCRIPTION	USCS	AASHTO
● BROWN WELL-GRADED GRAVEL WITH SILT AND SAND	GW-GM	A-1-a

Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM
● Location: MND20-0342-0010

Date: 04-12-93

Remarks:
LOI, %: 0.8

BUCKET SAMPLED: 04-03-93

GRAIN SIZE DISTRIBUTION TEST REPORT
BOWSER-MORNER, INC.

Figure No. _____

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 11

Date: 04-12-93
Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Sample Data

Location of Sample: MND20-0342-0010
Sample Description: BROWN WELL-GRADED GRAVEL WITH SILT AND SAND
USCS Class: GW-GM Liquid limit:
AASHTO Class: A-1-a Plasticity index:

Notes

Remarks: LOI, %: 0.8
BUCKET SAMPLED: 04-03-93
Fig. No.:

Mechanical Analysis Data

Initial
Dry sample and tare= 4482.50
Tare = 210.30
Dry sample weight = 4272.20
Sample split on number 10 sieve
Split sample data:
Sample and tare = 50 Tare = 0 Sample weight = 50
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
2.5 inches	0.00	100.0
2 inches	469.18	89.0
1.5 inches	794.90	81.4
1 inches	965.20	77.4
0.75 inches	1206.00	71.8
0.5 inches	1691.00	60.4
0.375 inches	1937.00	54.7
# 4	2397.40	43.9
# 10	2802.39	34.4
# 20	14.96	24.1
# 40	26.36	16.3
# 60	32.59	12.0
# 100	35.18	10.2
# 200	36.99	9.0

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 34.4
Weight of hydrometer sample: 50
Hygroscopic moisture correction:
  Moist weight & tare = 204.84
  Dry weight & tare = 204.32
  Tare = 105.10
  Hygroscopic moisture= 0.5 %
Calculated biased weight= 144.57
Automatic temperature correction
  Composite correction at 20 deg C =-4.5

Meniscus correction only= 0
Specific gravity of solids= 2.75
Specific gravity correction factor= 0.978
Hydrometer type: 152H Effective depth L= 16.294964 - 0.164 x Rm

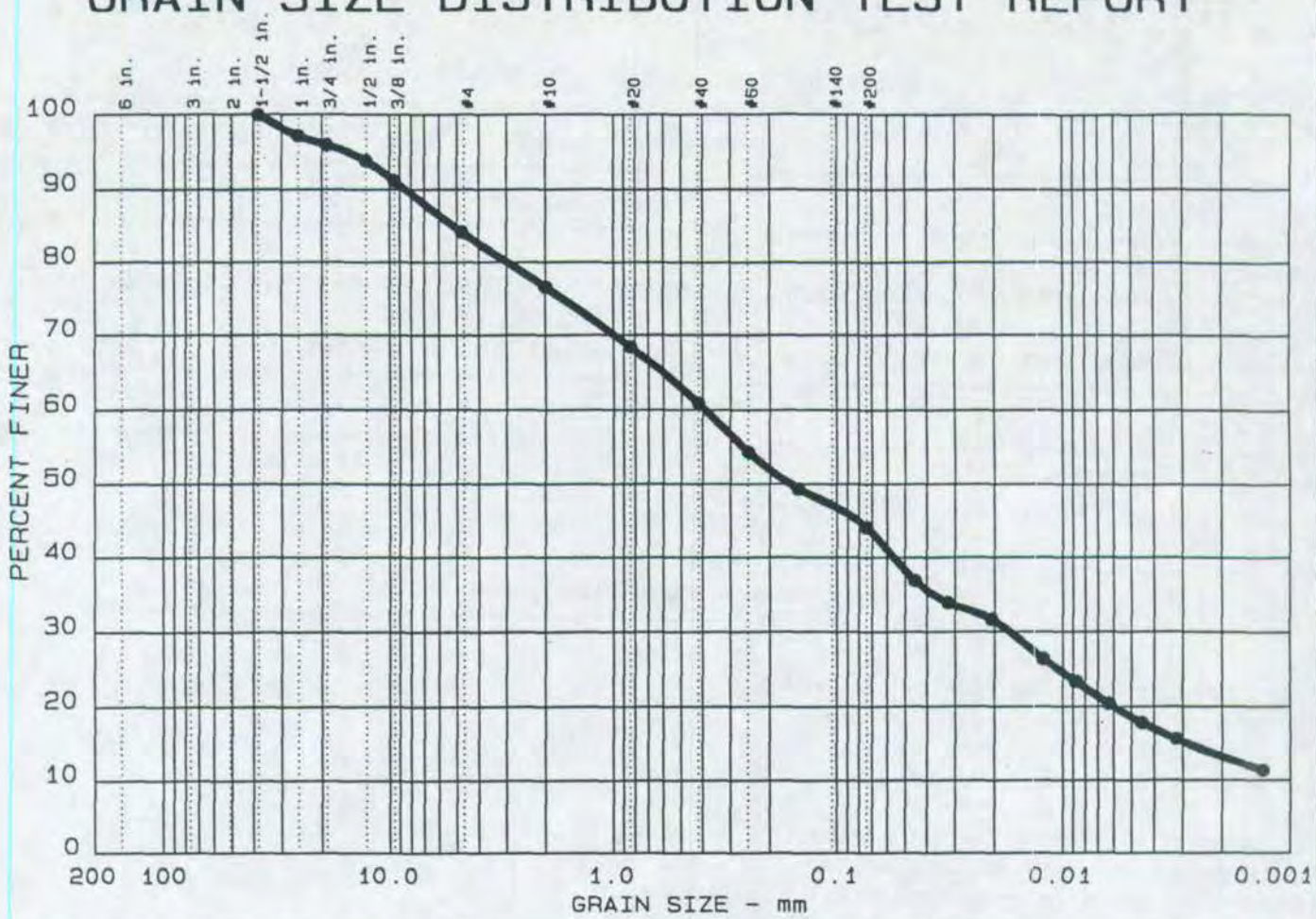
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1.0	20.0	15.5	11.0	0.0133	15.5	13.8	0.0491	7.4
2.0	20.1	14.0	9.5	0.0132	14.0	14.0	0.0350	6.4
5.0	20.1	14.0	9.5	0.0132	14.0	14.0	0.0221	6.4
16.0	20.1	12.5	8.0	0.0132	12.5	14.2	0.0125	5.4
30.0	20.1	11.5	7.0	0.0132	11.5	14.4	0.0092	4.7
60.0	20.1	10.5	6.0	0.0132	10.5	14.6	0.0065	4.0
122.0	19.1	10.0	5.3	0.0134	10.0	14.7	0.0046	3.6
240.0	19.6	9.0	4.4	0.0133	9.0	14.8	0.0033	3.0
1440.0	20.3	8.5	4.0	0.0132	8.5	14.9	0.0013	2.7

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 56.1 % SAND = 34.9
% SILT = 5.3 % CLAY = 3.7

D85= 45.13 D60= 12.431 D50= 7.153
D30= 1.3474 D15= 0.36686 D10= 0.13167
Cc = 1.1092 Cu = 94.4061

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	14	0.0	15.8	40.0	25.5	18.7

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			5.19	0.39	0.16	0.017	0.0028			

MATERIAL DESCRIPTION	USCS	AASHTO
● GRAY SAND, SM SILT, SM CLAY, SM GRAVEL (VISUAL)	SM	A-4

Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM
● Location: MND20-0342-0075

Date: 04-12-93

Remarks:
LOI, %: 1.4

BUCKET SAMPLED: 04-04-93

GRAIN SIZE DISTRIBUTION TEST REPORT
BOWSER-MORNER, INC.

Figure No. _____

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 14

Date: 04-12-93
Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Sample Data

Location of Sample: MND20-0342-0075
Sample Description: GRAY SAND, SM SILT, SM CLAY, SM GRAVEL (VISUAL)
USCS Class: SM Liquid limit:
AASHTO Class: A-4 Plasticity index:

Notes

Remarks: LOI, %: 1.4
BUCKET SAMPLED: 04-04-93
Fig. No.:

Mechanical Analysis Data

	Initial
Dry sample and tare=	2603.30
Tare =	216.90
Dry sample weight =	2386.40

Sample split on number 10 sieve
Split sample data:
Sample and tare = 50 Tare = 0 Sample weight = 50
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
1.5 inches	0.00	100.0
1 inches	67.13	97.2
0.75 inches	96.24	96.0
0.5 inches	146.30	93.9
0.375 inches	210.99	91.2
# 4	378.07	84.2
# 10	558.90	76.6
# 20	5.34	68.4
# 40	10.23	60.9
# 60	14.46	54.4
# 100	17.77	49.4
# 200	21.20	44.1

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 76.6
Weight of hydrometer sample: 50
Hygroscopic moisture correction:
  Moist weight & tare = 239.03
  Dry weight & tare = 238.47
  Tare = 115.17
  Hygroscopic moisture= 0.5 %
Calculated biased weight= 65.00
Automatic temperature correction
  Composite correction at 20 deg C =-4.5

Meniscus correction only= 0
Specific gravity of solids= 2.73
Specific gravity correction factor= 0.983
Hydrometer type: 152H Effective depth L= 16.294964 - 0.164 x Rm

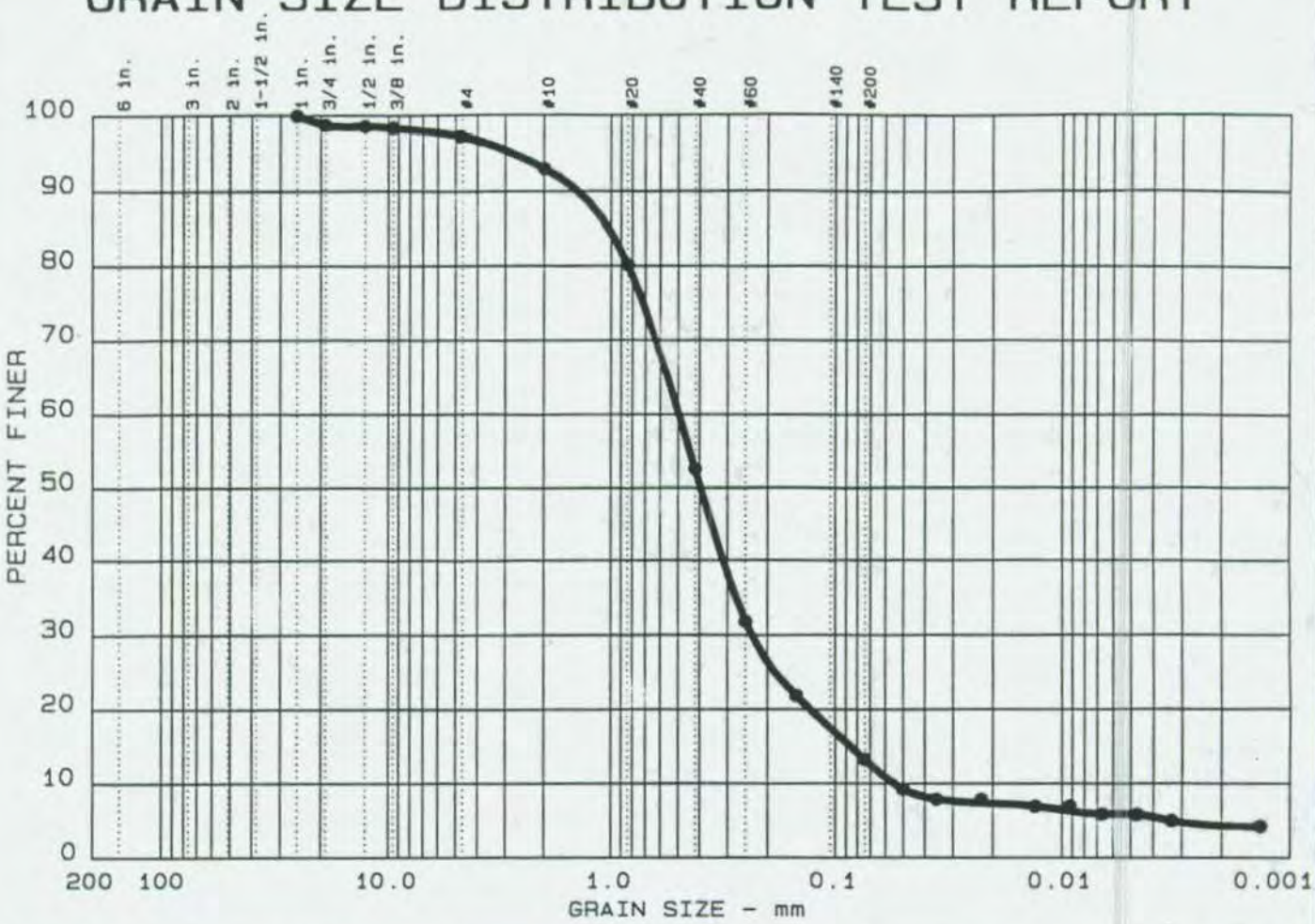
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1.0	20.1	29.0	24.5	0.0133	29.0	11.5	0.0452	37.0
2.0	20.1	27.0	22.5	0.0133	27.0	11.9	0.0324	34.0
5.0	20.1	25.5	21.0	0.0133	25.5	12.1	0.0207	31.7
15.0	20.1	22.0	17.5	0.0133	22.0	12.7	0.0122	26.4
30.0	20.1	20.0	15.5	0.0133	20.0	13.0	0.0088	23.4
60.0	20.1	18.0	13.5	0.0133	18.0	13.3	0.0063	20.4
120.0	19.3	16.5	11.8	0.0134	16.5	13.6	0.0045	17.9
240.0	19.6	15.0	10.4	0.0134	15.0	13.8	0.0032	15.7
1440.0	20.3	12.0	7.5	0.0133	12.0	14.3	0.0013	11.4

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 15.8 % SAND = 40.0
% SILT = 25.5 % CLAY = 18.7

D85= 5.19 D60= 0.389 D50= 0.160
D30= 0.0170 D15= 0.00282

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	15	0.0	2.7	84.0	7.4	5.9

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.02	0.49	0.40	0.234	0.0848	0.0548	2.02	9.0

MATERIAL DESCRIPTION	USCS	AASHTO
● GRAY SILTY SAND	SM	

Project No.: 47894 WESTON

Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

● Location: MND20-0342-0095

Date: 04-12-93

Remarks:

LOI, %: 1.2

BUCKET SAMPLED: 04-04-93

GRAIN SIZE DISTRIBUTION TEST REPORT

BOWSER-MORNER, INC.

Figure No. _____

GRAIN SIZE DISTRIBUTION TEST DATA Test No.: 15

Date: 04-12-93
Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Sample Data

Location of Sample: MND20-0342-0095
Sample Description: GRAY SILTY SAND
USCS Class: SM Liquid limit:
AASHTO Class: Plasticity index:

Notes

Remarks: LOI, %: 1.2
BUCKET SAMPLED: 04-04-93
Fig. No.:

Mechanical Analysis Data

Initial
Dry sample and tare= 3014.30
Tare = 230.30
Dry sample weight = 2784.00
Sample split on number 10 sieve
Split sample data:
Sample and tare = 100 Tare = 0 Sample weight = 100
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
1 inches	0.00	100.0
0.75 inches	34.12	98.8
0.5 inches	38.25	98.6
0.375 inches	44.62	98.4
# 4	76.12	97.3
# 10	193.66	93.0
# 20	13.86	80.1
# 40	43.55	52.5
# 60	65.73	31.9
# 100	76.51	21.9
# 200	85.73	13.3

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 93.0
Weight of hydrometer sample: 100
Hygroscopic moisture correction:
Moist weight & tare = 228.41

Dry weight & tare = 227.75
Tare = 104.54
Hygroscopic moisture= 0.5 %
Calculated biased weight= 106.90
Automatic temperature correction
Composite correction at 20 deg C =-4.5

Meniscus correction only= 0
Specific gravity of solids= 2.71
Specific gravity correction factor= 0.987
Hydrometer type: 152H Effective depth L= 16.294964 - 0.164 x Rm

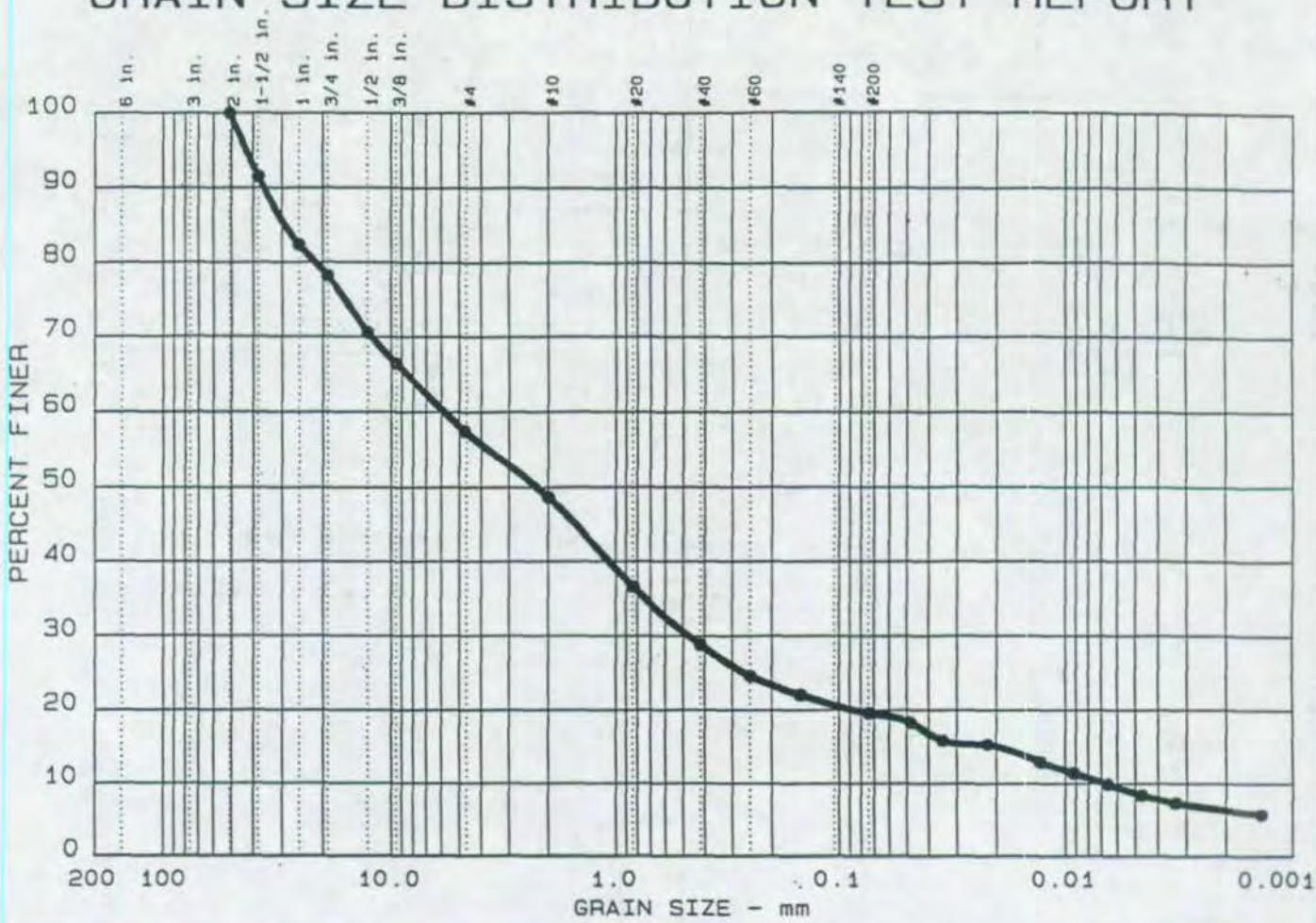
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1.0	20.1	14.5	10.0	0.0134	14.5	13.9	0.0499	9.2
2.0	20.1	13.0	8.5	0.0134	13.0	14.2	0.0356	7.8
5.0	20.1	13.0	8.5	0.0134	13.0	14.2	0.0225	7.8
15.0	20.1	12.0	7.5	0.0134	12.0	14.3	0.0131	6.9
30.0	20.1	12.0	7.5	0.0134	12.0	14.3	0.0093	6.9
60.0	19.3	11.0	6.3	0.0135	11.0	14.5	0.0066	5.8
120.0	19.2	11.0	6.3	0.0135	11.0	14.5	0.0047	5.8
240.0	19.6	10.0	5.4	0.0135	10.0	14.7	0.0033	5.0
1440.0	20.3	9.0	4.5	0.0134	9.0	14.8	0.0014	4.2

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 2.7 % SAND = 84.0
% SILT = 7.4 % CLAY = 5.9

D85= 1.02 D60= 0.494 D50= 0.397
D30= 0.2336 D15= 0.08482 D10= 0.05476
Cc = 2.0160 Cu = 9.0261

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	10	0.0	42.4	37.9	11.0	8.7

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			29.17	5.82	2.24	0.468	0.0193	0.0068	5.56	861.0

MATERIAL DESCRIPTION	USCS	AASHTO
● BROWN SILTY GRAVEL WITH SAND	GM	A-1-b

Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM
● Location: MND20-0343-0028

Date: 03-12-93

Remarks:
LOI, %: 1.3

BUCKET SAMPLED: 02-23-93

GRAIN SIZE DISTRIBUTION TEST REPORT
BOWSER-MORNER, INC.

Figure No. _____

GRAIN SIZE DISTRIBUTION TEST DATA — Test No.: 10

Date: 03-12-93
Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Sample Data

Location of Sample: MND20-0343-0028
Sample Description: BROWN SILTY GRAVEL WITH SAND
USCS Class: GM Liquid limit:
AASHTO Class: A-1-b Plasticity index:

Notes

Remarks: LOI, %: 1.3
BUCKET SAMPLED: 02-23-93
Fig. No.:

Mechanical Analysis Data

Initial
Dry sample and tare= 4621.10
Tare = 234.20
Dry sample weight = 4386.90
Sample split on number 10 sieve
Split sample data:
Sample and tare = 50 Tare = 0 Sample weight = 50
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
2 inches	0.00	100.0
1.5 inches	371.34	91.5
1 inches	776.00	82.3
0.75 inches	958.90	78.1
0.5 inches	1289.20	70.6
0.375 inches	1471.00	66.5
# 4	1861.40	57.6
# 10	2251.80	48.7
# 20	12.38	36.6
# 40	20.37	28.8
# 60	24.73	24.6
# 100	27.36	22.0
# 200	29.84	19.6

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 48.7
Weight of hydrometer sample: 50
Hygroscopic moisture correction:
  Moist weight & tare = 82.81
  Dry weight & tare = 82.53
  Tare = 30.17
  Hygroscopic moisture= 0.5 %
Calculated biased weight= 102.19
Automatic temperature correction
  Composite correction at 20 deg C =-2.5

Meniscus correction only= 0
Specific gravity of solids= 2.65
Specific gravity correction factor= 1.000
Hydrometer type: 152H Effective depth L= 16.294964 - 0.164 x Rm

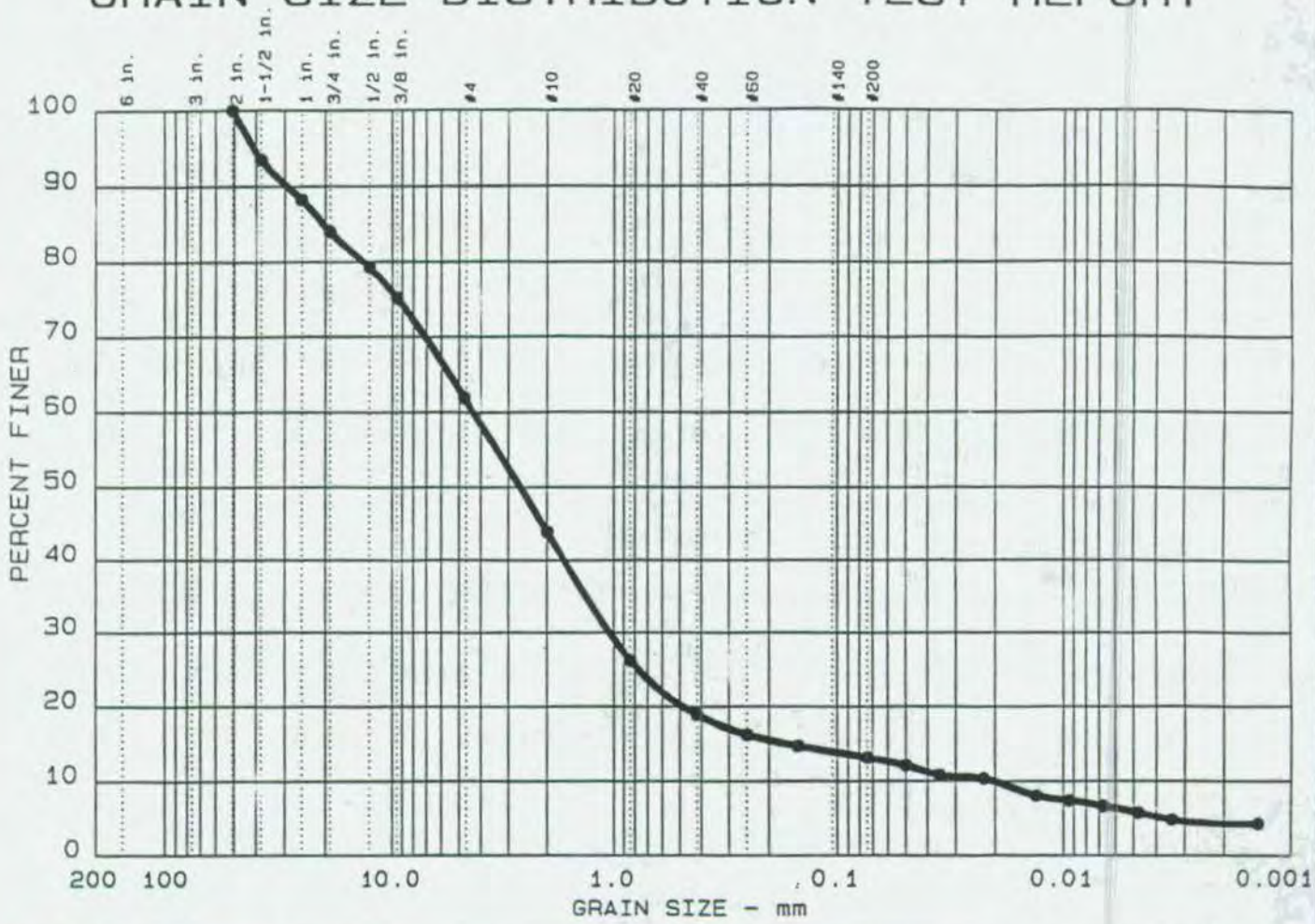
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1.0	21.2	21.0	18.7	0.0134	21.0	12.9	0.0482	18.3
2.0	21.2	18.5	16.2	0.0134	18.5	13.3	0.0346	15.9
5.0	21.1	18.0	15.7	0.0135	18.0	13.3	0.0220	15.4
15.0	21.0	15.5	13.2	0.0135	15.5	13.8	0.0129	12.9
30.0	20.9	14.0	11.7	0.0135	14.0	14.0	0.0092	11.4
60.0	20.6	12.5	10.1	0.0135	12.5	14.2	0.0066	9.9
120.0	20.4	11.0	8.5	0.0136	11.0	14.5	0.0047	8.4
240.0	20.3	10.0	7.5	0.0136	10.0	14.7	0.0034	7.4
1440.0	19.7	8.5	5.9	0.0137	8.5	14.9	0.0014	5.8

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 42.4 % SAND = 37.9
% SILT = 11.0 % CLAY = 8.7

D85= 29.17 D60= 5.821 D50= 2.239
D30= 0.4677 D15= 0.01928 D10= 0.00676
Cc = 5.5590 Cu = 860.9938

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	9	0.0	38.0	48.8	7.3	5.9

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			20.42	4.32	2.63	1.035	0.1567	0.0200	12.45	216.3

MATERIAL DESCRIPTION	USCS	AASHTO
● BROWN SILTY SAND WITH GRAVEL	SM	A-1-a

Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM
● Location: MND20-0343-0037

Date: 03-12-93

Remarks:
LOI, %: 1.1

BUCKET SAMPLED: 02-23-93

GRAIN SIZE DISTRIBUTION TEST REPORT
BOWSER-MORNER, INC.

Figure No. _____

GRAIN SIZE DISTRIBUTION TEST DATA Test No.: 9

Date: 03-12-93
Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Sample Data

Location of Sample: MND20-0343-0037
Sample Description: BROWN SILTY SAND WITH GRAVEL
USCS Class: SM Liquid limit:
AASHTO Class: A-1-a Plasticity index:

Notes

Remarks: LOI, %: 1.1
BUCKET SAMPLED: 02-23-93
Fig. No.:

Mechanical Analysis Data

Initial
Dry sample and tare= 4333.10
Tare = 207.70
Dry sample weight = 4125.40
Sample split on number 10 sieve
Split sample data:
Sample and tare = 50 Tare = 0 Sample weight = 50
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
2 inches	0.00	100.0
1.5 inches	265.34	93.6
1 inches	485.06	88.2
0.75 inches	660.30	84.0
0.5 inches	856.70	79.2
0.375 inches	1023.80	75.2
# 4	1569.40	62.0
# 10	2312.00	44.0
# 20	20.23	26.2
# 40	28.50	18.9
# 60	31.59	16.2
# 100	33.28	14.7
# 200	35.02	13.2

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 44.0
Weight of hydrometer sample: 50
Hygroscopic moisture correction:
  Moist weight & tare = 80.68
  Dry weight & tare = 80.48
  Tare = 27.68
  Hygroscopic moisture= 0.4 %
Calculated biased weight= 113.32
Automatic temperature correction
  Composite correction at 20 deg C =-1.5

Meniscus correction only= 0
Specific gravity of solids= 2.65
Specific gravity correction factor= 1.000
Hydrometer type: 152H Effective depth L= 16.294964 - 0.164 x Rm

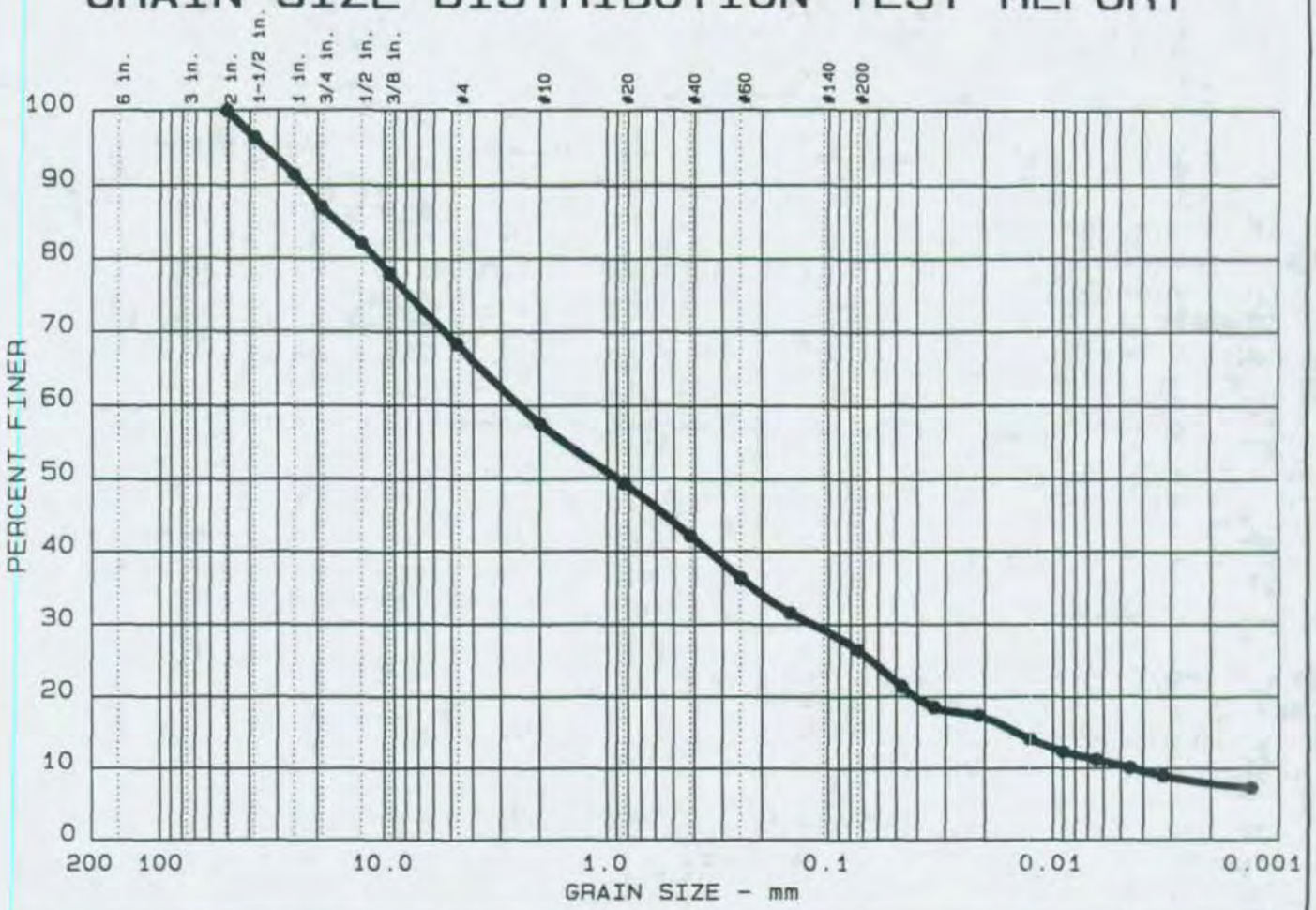
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1.0	21.1	15.0	13.7	0.0135	15.0	13.8	0.0501	12.1
2.0	21.5	13.5	12.3	0.0134	13.5	14.1	0.0356	10.8
5.0	21.3	13.0	11.7	0.0134	13.0	14.2	0.0226	10.4
15.0	20.9	10.5	9.2	0.0135	10.5	14.6	0.0133	8.1
30.0	20.8	9.8	8.4	0.0135	9.8	14.7	0.0095	7.4
60.0	20.6	9.0	7.6	0.0135	9.0	14.8	0.0067	6.7
120.0	20.5	8.0	6.6	0.0136	8.0	15.0	0.0048	5.8
240.0	20.3	7.0	5.5	0.0136	7.0	15.1	0.0034	4.9
1440.0	19.7	6.5	4.9	0.0137	6.5	15.2	0.0014	4.3

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 38.0 % SAND = 48.8
% SILT = 7.3 % CLAY = 5.9

D85= 20.42 D60= 4.315 D50= 2.630
D30= 1.0351 D15= 0.15668 D10= 0.01995
Cc = 12.4451 Cu = 216.2719

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	15	0.0	31.6	42.0	16.1	10.3

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			16.22	2.45	0.89	0.116	0.0143	0.0045	1.23	549.5

MATERIAL DESCRIPTION	USCS	AASHTO
● GRAY SAND, SM GRAVEL, SM SILT, TR CLAY (VISUAL)		

Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM
● Location: MND20-0343-0057

Date: 03-15-93

Remarks:
LOI, %: 0.7

BUCKET SAMPLED: 03-01-93

GRAIN SIZE DISTRIBUTION TEST REPORT
BOWSER-MORNER, INC.

Figure No. _____

GRAIN SIZE DISTRIBUTION TEST DATA — Test No.: 15

Date: 03-15-93
Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Sample Data

Location of Sample: MND20-0343-0057
Sample Description: GRAY SAND, SM GRAVEL, SM SILT, TR CLAY (VISUAL)
USCS Class: Liquid limit:
AASHTO Class: Plasticity index:

Notes

Remarks: LOI, %: 0.7
BUCKET SAMPLED: 03-01-93
Fig. No.:

Mechanical Analysis Data

Initial
Dry sample and tare= 4419.20
Tare = 213.20
Dry sample weight = 4206.00
Sample split on number 10 sieve
Split sample data:
Sample and tare = 50 Tare = 0 Sample weight = 50
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
2 inches	0.00	100.0
1.5 inches	153.12	96.4
1 inches	361.92	91.4
0.75 inches	546.18	87.0
0.5 inches	753.90	82.1
0.375 inches	927.90	77.9
# 4	1327.90	68.4
# 10	1785.64	57.5
# 20	7.09	49.4
# 40	13.35	42.2
# 60	18.37	36.4
# 100	22.49	31.7
# 200	27.00	26.5

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 57.5
Weight of hydrometer sample: 50
Hygroscopic moisture correction:
Moist weight & tare = 214.18
Dry weight & tare = 213.87
Tare = 106.02
Hygroscopic moisture= 0.3 %
Calculated biased weight= 86.64
Automatic temperature correction
Composite correction at 20 deg C =-4.5

Meniscus correction only= 0
Specific gravity of solids= 2.74
Specific gravity correction factor= 0.980
Hydrometer type: 152H Effective depth L= 16.294964 - 0.164 x Rm

Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1.0	19.7	23.5	18.9	0.0133	23.5	12.4	0.0470	21.4
2.0	19.7	21.0	16.4	0.0133	21.0	12.9	0.0338	18.6
5.0	19.7	20.0	15.4	0.0133	20.0	13.0	0.0215	17.4
15.0	20.0	17.0	12.5	0.0133	17.0	13.5	0.0126	14.1
30.0	19.8	15.5	10.9	0.0133	15.5	13.8	0.0090	12.4
60.0	19.8	14.5	9.9	0.0133	14.5	13.9	0.0064	11.2
120.0	19.7	13.5	8.9	0.0133	13.5	14.1	0.0046	10.1
240.0	19.7	12.5	7.9	0.0133	12.5	14.2	0.0032	8.9
1440.0	19.8	11.0	6.4	0.0133	11.0	14.5	0.0013	7.3

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 31.6 % SAND = 42.0
% SILT = 16.1 % CLAY = 10.3

D85= 16.22 D60= 2.455 D50= 0.891
D30= 0.1161 D15= 0.01429 D10= 0.00447
Cc = 1.2303 Cu = 549.5409

GRAIN SIZE DISTRIBUTION TEST REPORT

	Test	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	16	0.0	9.6	31.0	26.9	32.5

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			2.02	0.08	0.03	0.004				

MATERIAL DESCRIPTION	USCS	AASHTO
● GRAY CLAY, SM SAND, SM SILT, TR GRAVEL (VISUAL)		

Project No.: 47894 WESTON

Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

● Location: MND20-0343-0067/0080

Date: 03-15-93

Remarks:

LOI, %: 2.1

BUCKET SAMPLED: 03-01-93

GRAIN SIZE DISTRIBUTION TEST REPORT

BOWSER-MORNER, INC.

Figure No. _____

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 16

Date: 03-15-93
Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Sample Data

Location of Sample: MND20-0343-0067/0080
Sample Description: GRAY CLAY, SM SAND, SM SILT, TR GRAVEL (VISUAL)
USCS Class: Liquid limit:
AASHTO Class: Plasticity index:

Notes

Remarks: LOI, %: 2.1
BUCKET SAMPLED: 03-01-93
Fig. No.:

Mechanical Analysis Data

Initial
Dry sample and tare= 2309.40
Tare = 210.33
Dry sample weight = 2099.07
Sample split on number 10 sieve
Split sample data:
Sample and tare = 50 Tare = 0 Sample weight = 50
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
1 inches	0.00	100.0
0.75 inches	28.15	98.7
0.5 inches	82.17	96.1
0.375 inches	121.12	94.2
# 4	201.40	90.4
# 10	316.75	84.9
# 20	3.47	79.0
# 40	6.33	74.2
# 60	8.93	69.7
# 100	11.59	65.2
# 200	15.01	59.4

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 84.9
Weight of hydrometer sample: 50
Hygroscopic moisture correction:
Moist weight & tare = 192.55

Dry weight & tare = 191.81
Tare = 114.09
Hygroscopic moisture= 1.0 %
Calculated biased weight= 58.33
Automatic temperature correction
Composite correction at 20 deg C =-4.5

Meniscus correction only= 0
Specific gravity of solids= 2.73
Specific gravity correction factor= 0.983
Hydrometer type: 152H Effective depth L= 16.294964 - 0.164 x Rm

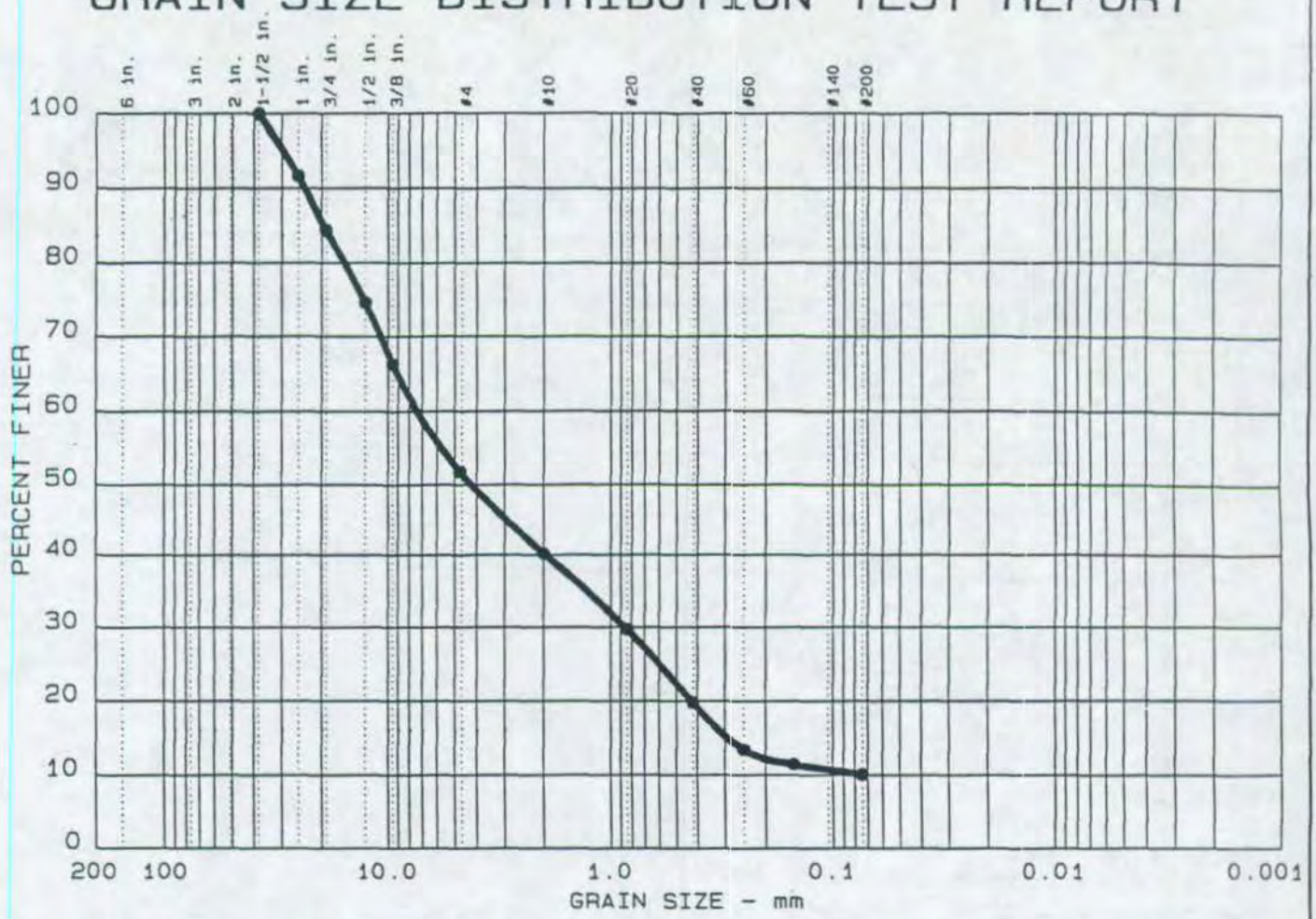
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1.0	19.7	36.0	31.4	0.0134	36.0	10.4	0.0431	52.9
2.0	19.7	33.5	28.9	0.0134	33.5	10.8	0.0311	48.7
5.0	19.7	32.0	27.4	0.0134	32.0	11.0	0.0199	46.1
15.0	19.9	29.0	24.4	0.0133	29.0	11.5	0.0117	41.2
30.0	19.8	26.5	21.9	0.0134	26.5	11.9	0.0084	36.9
60.0	19.8	25.0	20.4	0.0134	25.0	12.2	0.0060	34.4
120.0	19.7	23.0	18.4	0.0134	23.0	12.5	0.0043	31.0
240.0	19.7	21.5	16.9	0.0134	21.5	12.8	0.0031	28.5
1440.0	19.8	18.0	13.4	0.0134	18.0	13.3	0.0013	22.6

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 9.6 % SAND = 31.0
% SILT = 26.9 % CLAY = 32.5

D85= 2.02 D60= 0.079 D50= 0.035
D30= 0.0038

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	14	0.0	48.2	41.8	10.0	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			19.50	7.33	4.22	0.851	0.2917	0.0741	1.33	98.9

MATERIAL DESCRIPTION	USCS	AASHTO
● BROWN WELL-GRADED GRAVEL WITH SILT AND SAND	GW-GM	A-1-a

Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM
● Location: MND20-0344-0018

Date: 02-24-93

Remarks:
LOI, %: 0.8

BUCKET SAMPLED: 01-25-93

GRAIN SIZE DISTRIBUTION TEST REPORT
BOWSER-MORNER, INC.

Figure No. _____

GRAIN SIZE DISTRIBUTION TEST DATA — Test No.: 14

Date: 02-24-93
Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Sample Data

Location of Sample: MND20-0344-0018
Sample Description: BROWN WELL-GRADED GRAVEL WITH SILT AND SAND
USCS Class: GW-GM Liquid limit:
AASHTO Class: A-1-a Plasticity index:

Notes

Remarks: LOI, %: 0.8
BUCKET SAMPLED: 01-25-93
Fig. No.:

Mechanical Analysis Data

Initial
Dry sample and tare= 2324.30
Tare = 214.70
Dry sample weight = 2109.60
Sample split on number 10 sieve
Split sample data:
Sample and tare = 50 Tare = 0 Sample weight = 50
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
1.5 inches	0.00	100.0
1 inches	175.22	91.7
0.75 inches	329.51	84.4
0.5 inches	534.58	74.7
0.375 inches	710.30	66.3
# 4	1016.10	51.8
# 10	1259.80	40.3
# 20	13.10	29.7
# 40	25.43	19.8
# 60	33.30	13.5
# 100	35.77	11.5
# 200	37.60	10.0

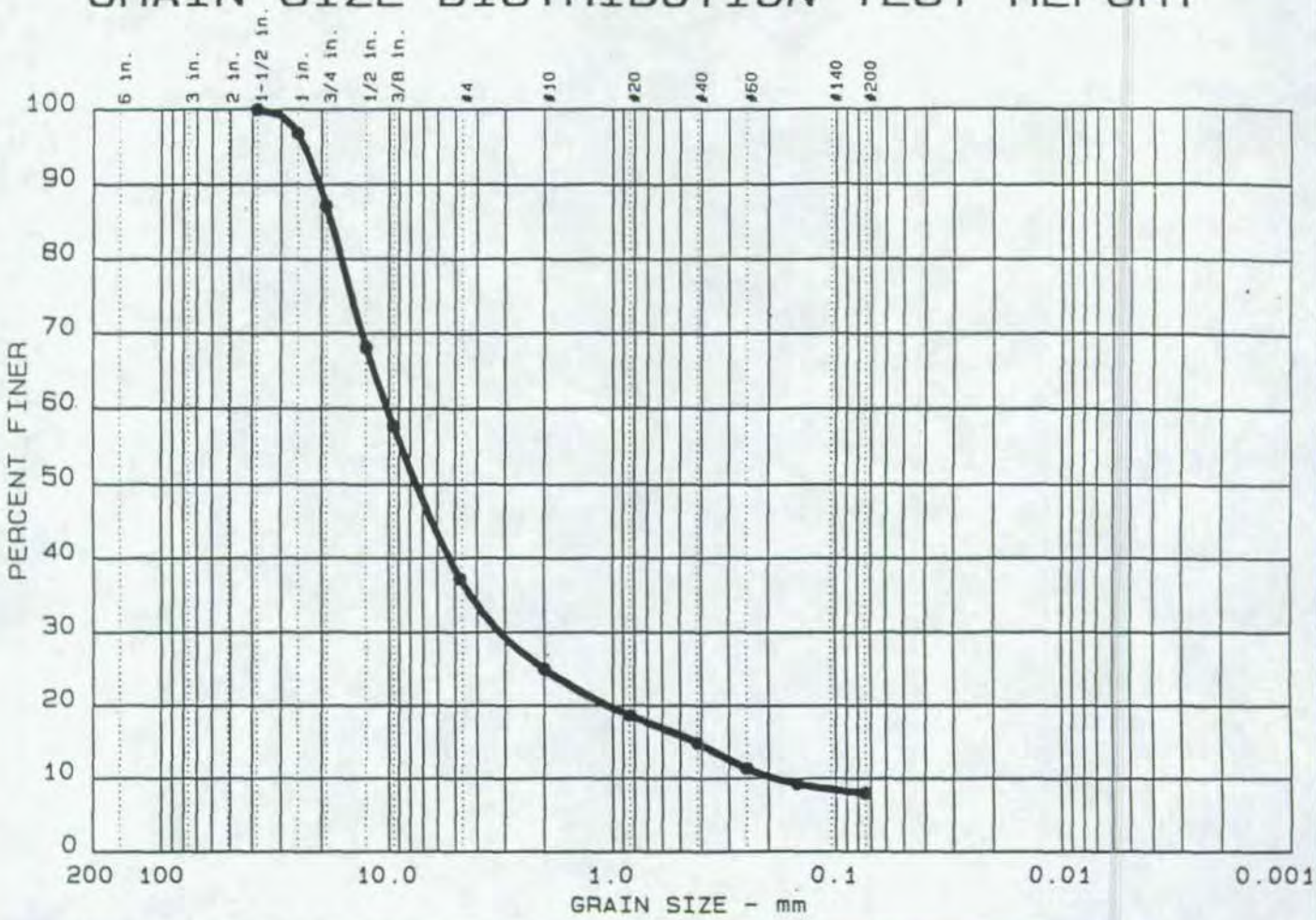
Fractional Components

% + 3 in. = 0.0 % GRAVEL = 48.2 % SAND = 41.8
% FINES = 10.0

D85= 19.50 D60= 7.328 D50= 4.217

D30= 0.8511 D15= 0.29174 D10= 0.07413
Cc = 1.3335 Cu = 98.8553

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	15	0.0	62.7	29.3	8.0	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			18.13	10.20	7.47	3.151	0.4202	0.1877	5.19	54.3

MATERIAL DESCRIPTION	USCS	AASHTO
● BROWN POORLY GRADED GRAVEL WITH SILT AND SAND	GP-GM	A-1-a

Project No.: 47894 WESTON

Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

● Location: MND20-0344-0025

Date: 02-24-93

Remarks:

LOI, %: 0.9

BUCKET SAMPLED: 01-25-93

GRAIN SIZE DISTRIBUTION TEST REPORT

BOWSER-MORNER, INC.

Figure No. _____

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 15

Date: 02-24-93
Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Sample Data

Location of Sample: MND20-0344-0025
Sample Description: BROWN POORLY GRADED GRAVEL WITH SILT AND SAND
USCS Class: GP-GM Liquid limit:
AASHTO Class: A-1-a Plasticity index:

Notes

Remarks: LOI, %: 0.9
BUCKET SAMPLED: 01-25-93
Fig. No.:

Mechanical Analysis Data

Initial
Dry sample and tare= 1832.90
Tare = 213.00
Dry sample weight = 1619.90
Sample split on number 10 sieve
Split sample data:
Sample and tare = 50 Tare = 0 Sample weight = 50
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
1.5 inches	0.00	100.0
1 inches	51.27	96.8
0.75 inches	207.89	87.2
0.5 inches	515.34	68.2
0.375 inches	685.00	57.7
# 4	1015.50	37.3
# 10	1215.10	25.0
# 20	12.77	18.6
# 40	20.30	14.8
# 60	27.33	11.3
# 100	31.54	9.2
# 200	34.05	8.0

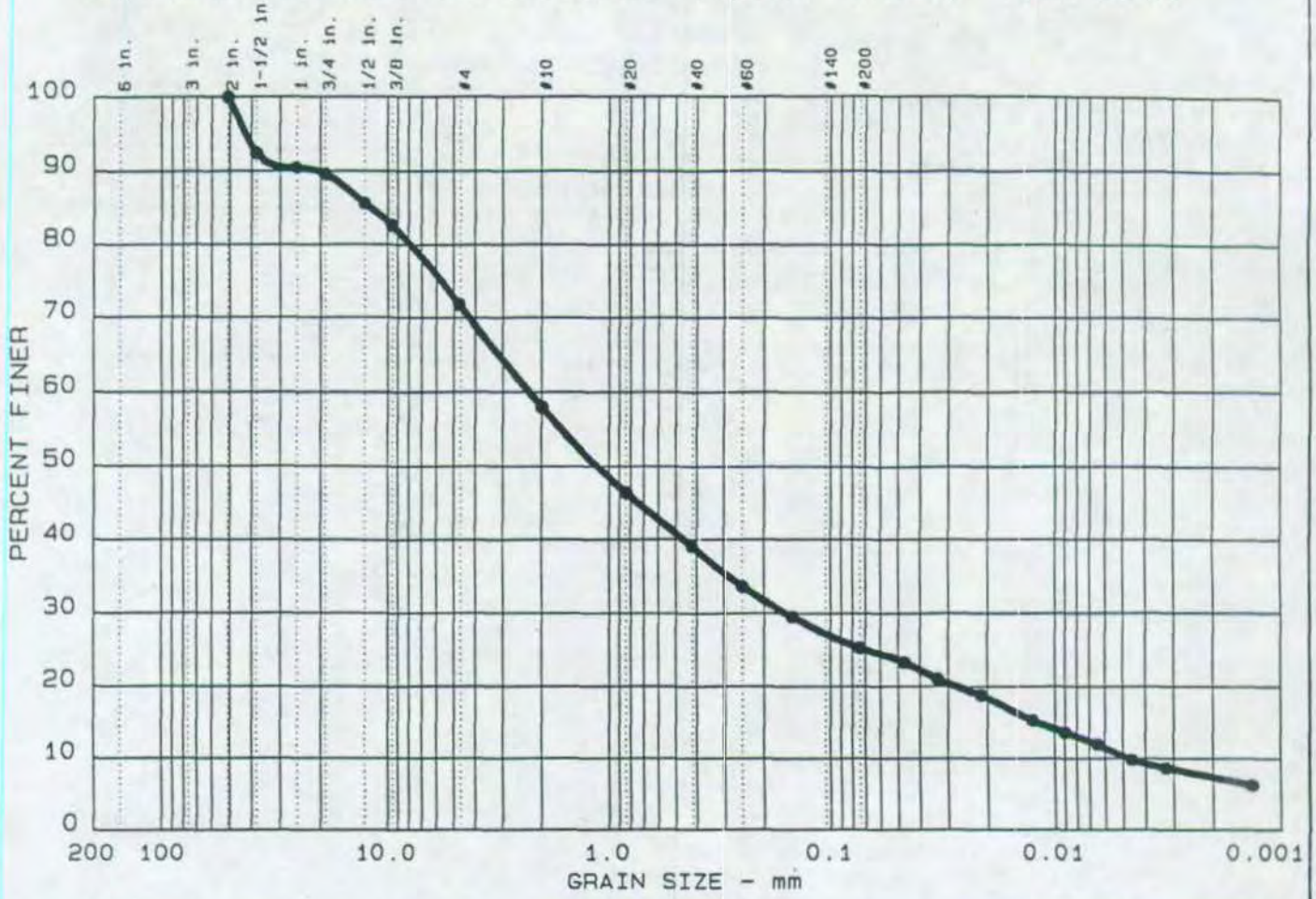
Fractional Components

% + 3 in. = 0.0 % GRAVEL = 62.7 % SAND = 29.3
% FINES = 8.0

D85= 18.13 D60= 10.198 D50= 7.473

D30= 3.1514 D15= 0.42024 D10= 0.18772
Cc = 5.1880 Cu = 54.3250

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	16	0.0	28.1	46.6	15.0	10.3

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			11.89	2.26	1.12	0.157	0.0117	0.0047	2.29	478.6

MATERIAL DESCRIPTION	USCS	AASHTO
● BROWN SILTY SAND WITH GRAVEL	SM	A-1-b

Project No.: 47894 WESTON

Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

● Location: MND20-0344-0030

Date: 02-23-93

Remarks:

LOI, %: 0.7

BUCKET SAMPLED: 01-25-93

GRAIN SIZE DISTRIBUTION TEST REPORT

BOWSER-MORNER, INC.

Figure No. _____

GRAIN SIZE DISTRIBUTION TEST DATA — Test No.: 16

Date: 02-23-93
Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Sample Data

Location of Sample: MND20-0344-0030
Sample Description: BROWN SILTY SAND WITH GRAVEL
USCS Class: SM — Liquid limit:
AASHTO Class: A-1-b — Plasticity index:

Notes

Remarks: LOI, %: 0.7
BUCKET SAMPLED: 01-25-93
Fig. No.:

Mechanical Analysis Data

	Initial
Dry sample and tare=	1850.60
Tare =	204.80
Dry sample weight =	1645.80

Sample split on number 10 sieve
Split sample data:
Sample and tare = 50 Tare = 0 Sample weight = 50
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
2 inches	0.00	100.0
1.5 inches	123.84	92.5
1 inches	156.44	90.5
0.75 inches	170.14	89.7
0.5 inches	236.69	85.6
0.375 inches	287.04	82.6
# 4	462.16	71.9
# 10	690.60	58.0
# 20	10.05	46.4
# 40	16.33	39.1
# 60	21.03	33.6
# 100	24.53	29.6
# 200	28.19	25.3

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 58.0
Weight of hydrometer sample: 50
Hygroscopic moisture correction:
  Moist weight & tare = 174.04
  Dry weight & tare = 173.91
  Tare = 98.96
  Hygroscopic moisture= 0.2 %
Calculated biased weight= 86.00
Automatic temperature correction
  Composite correction at 20 deg C =-4.5

Meniscus correction only= 0
Specific gravity of solids= 2.72
Specific gravity correction factor= 0.985
Hydrometer type: 152H Effective depth L= 16.294964 - 0.164 x Rm

Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1.0	19.7	25.0	20.4	0.0134	25.0	12.2	0.0468	23.4
2.0	19.7	23.0	18.4	0.0134	23.0	12.5	0.0336	21.1
5.0	19.8	21.0	16.4	0.0134	21.0	12.9	0.0215	18.8
15.0	19.8	18.0	13.4	0.0134	18.0	13.3	0.0126	15.4
30.0	20.0	16.5	12.0	0.0134	16.5	13.6	0.0090	13.7
60.0	20.1	15.0	10.5	0.0133	15.0	13.8	0.0064	12.0
120.0	20.3	13.0	8.5	0.0133	13.0	14.2	0.0046	9.8
240.0	20.4	12.0	7.5	0.0133	12.0	14.3	0.0032	8.6
1440.0	20.1	10.0	5.5	0.0133	10.0	14.7	0.0013	6.3

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 28.1 % SAND = 46.6
% SILT = 15.0 % CLAY = 10.3

D85= 11.89 D60= 2.265 D50= 1.122
D30= 0.1567 D15= 0.01175 D10= 0.00473
Cc = 2.2909 Cu = 478.6301

GRAIN SIZE DISTRIBUTION TEST REPORT

	Test	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	17	0.0	20.4	54.4	15.0	10.2

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			6.76	1.26	0.56	0.117	0.0145	0.0048	2.29	263.0

MATERIAL DESCRIPTION	USCS	AASHTO
● GRAY SILTY SAND WITH GRAVEL	SM	A-1-b

Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM
● Location: MND20-0344-0035

Date: 02-23-93

Remarks:
LOI, %: 1.0

BUCKET SAMPLED: 01-25-93

GRAIN SIZE DISTRIBUTION TEST REPORT
BOWSER-MORNER, INC.

Figure No. _____

GRAIN SIZE DISTRIBUTION TEST DATA — Test No.: 17

Date: 02-23-93
Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Sample Data

Location of Sample: MND20-0344-0035
Sample Description: GRAY SILTY SAND WITH GRAVEL
USCS Class: SM — Liquid limit:
AASHTO Class: A-1-b — Plasticity index:

Notes

Remarks: LOI, %: 1.0
BUCKET SAMPLED: 01-25-93
Fig. No.:

Mechanical Analysis Data

Initial
Dry sample and tare= 1332.20
Tare = 207.80
Dry sample weight = 1124.40
Sample split on number 10 sieve
Split sample data:
Sample and tare = 50 Tare = 0 Sample weight = 50
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
1 inches	0.00	100.0
0.75 inches	10.24	99.1
0.5 inches	70.21	93.8
0.375 inches	114.20	89.8
# 4	229.76	79.6
# 10	378.05	66.4
# 20	8.70	54.8
# 40	14.95	46.5
# 60	20.45	39.2
# 100	25.60	32.4
# 200	31.06	25.1

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 66.4
Weight of hydrometer sample: 50
Hygroscopic moisture correction:
Moist weight & tare = 171.05

Dry weight & tare = 170.95
Tare = 106.28
Hygroscopic moisture= 0.2 %
Calculated biased weight= 75.21
Automatic temperature correction
Composite correction at 20 deg C =-4

Meniscus correction only= 0
Specific gravity of solids= 2.75
Specific gravity correction factor= 0.978
Hydrometer type: 152H Effective depth L= 16.294964 - 0.164 x Rm

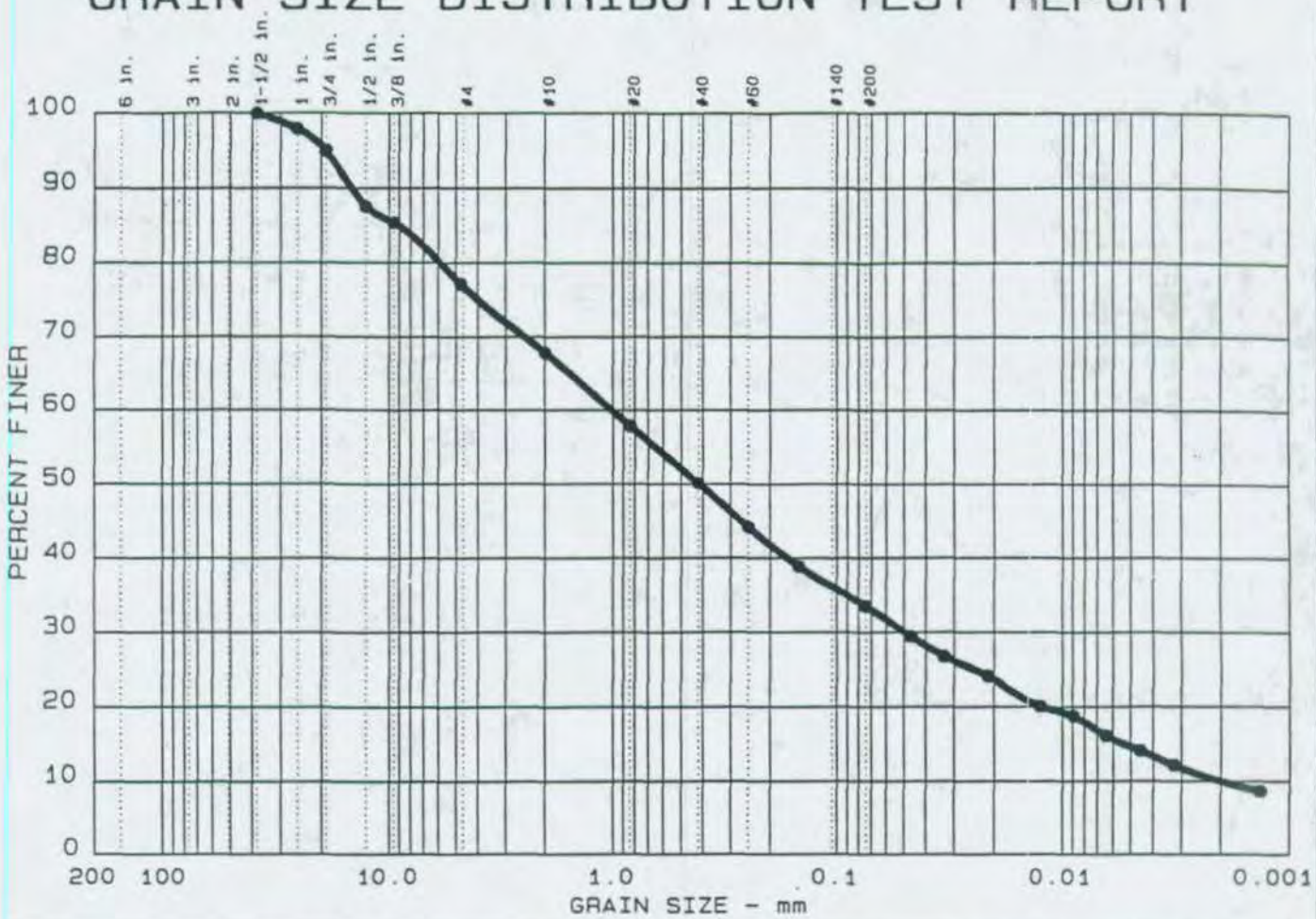
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1.0	19.8	20.0	15.9	0.0133	20.0	13.0	0.0479	20.7
2.0	19.8	18.5	14.4	0.0133	18.5	13.3	0.0342	18.8
5.0	19.8	17.0	12.9	0.0133	17.0	13.5	0.0218	16.8
15.0	20.0	15.0	11.0	0.0133	15.0	13.8	0.0127	14.3
30.0	20.0	13.5	9.5	0.0133	13.5	14.1	0.0091	12.3
60.0	20.1	12.5	8.5	0.0132	12.5	14.2	0.0064	11.0
120.0	20.4	11.5	7.5	0.0132	11.5	14.4	0.0046	9.8
240.0	20.4	10.5	6.5	0.0132	10.5	14.6	0.0032	8.5
1440.0	20.1	9.0	5.0	0.0132	9.0	14.8	0.0013	6.5

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 20.4 % SAND = 54.4
% SILT = 15.0 % CLAY = 10.2

D85= 6.76 D60= 1.259 D50= 0.556
D30= 0.1175 D15= 0.01445 D10= 0.00479
Cc = 2.2909 Cu = 263.0268

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	18	0.0	22.8	43.6	18.9	14.7

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			9.02	1.00	0.41	0.049	0.0053	0.0020	1.20	501.2

MATERIAL DESCRIPTION	USCS	AASHTO
● GRAY SAND, SM GRAVEL, SM SILT, SM CLAY (VISUAL)		

Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM
● Location: MND20-0344-0040

Date: 02-23-93

Remarks:
LOI, %: 1.2

BUCKET SAMPLED: 01-25-93

GRAIN SIZE DISTRIBUTION TEST REPORT
BOWSER-MORNER, INC.

Figure No. _____

GRAIN SIZE DISTRIBUTION TEST DATA — Test No.: 18

Date: 02-23-93
Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Sample Data

Location of Sample: MND20-0344-0040
Sample Description: GRAY SAND, SM GRAVEL, SM SILT, SM CLAY (VISUAL)
USCS Class: Liquid limit:
AASHTO Class: Plasticity index:

Notes

Remarks: LOI, %: 1.2
BUCKET SAMPLED: 01-25-93
Fig. No.:

Mechanical Analysis Data

Initial
Dry sample and tare= 1446.80
Tare = 203.70
Dry sample weight = 1243.10
Sample split on number 10 sieve
Split sample data:
Sample and tare = 50 Tare = 0 Sample weight = 50
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
1.5 inches	0.00	100.0
1 inches	25.96	97.9
0.75 inches	61.91	95.0
0.5 inches	154.53	87.6
0.375 inches	181.49	85.4
# 4	284.02	77.2
# 10	399.19	67.9
# 20	7.38	57.9
# 40	13.06	50.2
# 60	17.43	44.2
# 100	21.31	39.0
# 200	25.27	33.6

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 67.9
Weight of hydrometer sample: 50
Hygroscopic moisture correction:
  Moist weight & tare = 154.20
  Dry weight & tare = 154.07
  Tare = 104.54
  Hygroscopic moisture= 0.3 %
Calculated biased weight= 73.46
Automatic temperature correction
  Composite correction at 20 deg C =-4

Meniscus correction only= 0
Specific gravity of solids= 2.71
Specific gravity correction factor= 0.987
Hydrometer type: 152H Effective depth L= 16.294964 - 0.164 x Rm

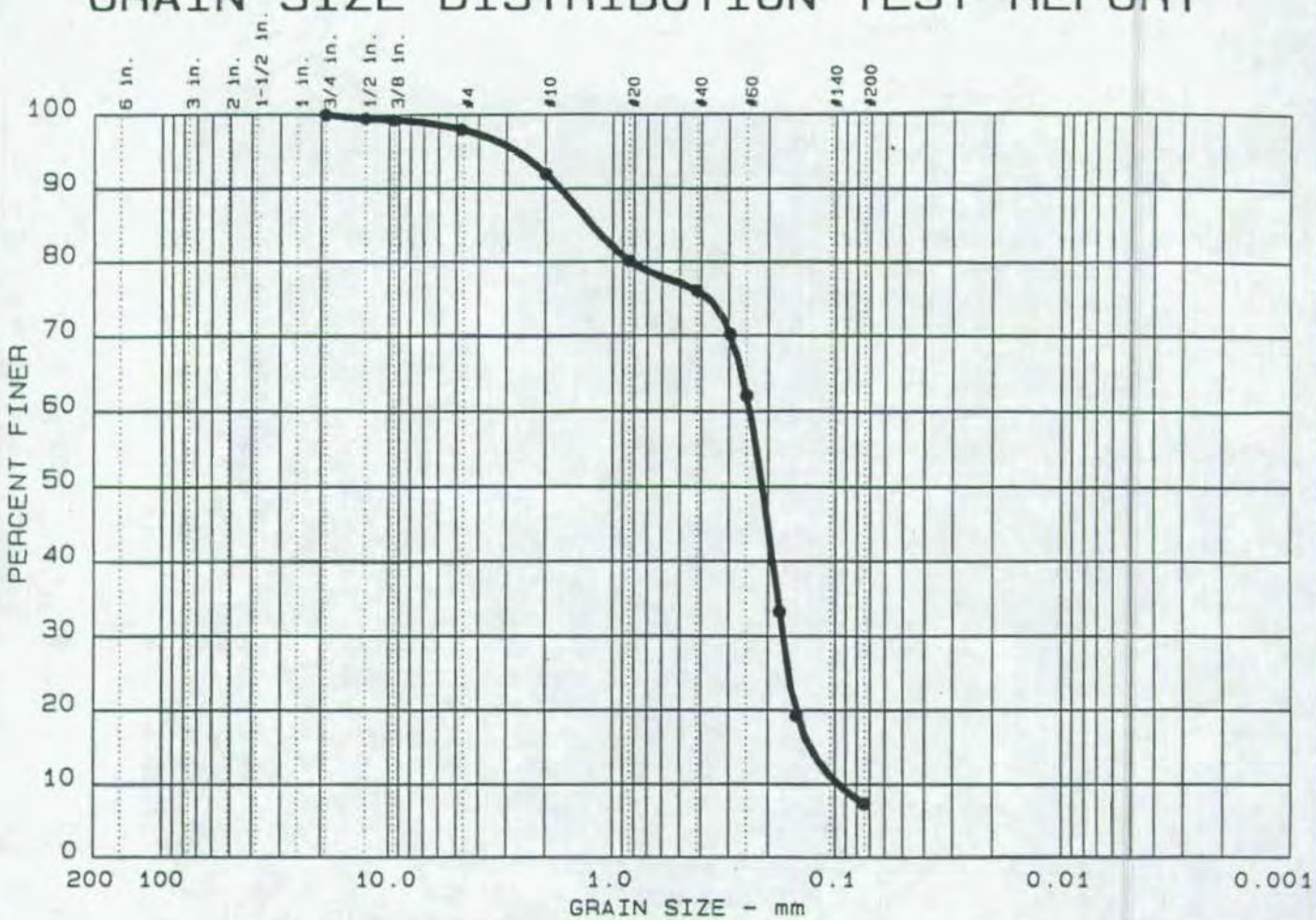
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1.0	20.0	26.0	22.0	0.0134	26.0	12.0	0.0465	29.5
2.0	19.9	24.0	19.9	0.0134	24.0	12.4	0.0334	26.8
5.0	20.0	22.0	18.0	0.0134	22.0	12.7	0.0214	24.1
15.0	19.8	19.0	14.9	0.0134	19.0	13.2	0.0126	20.0
30.0	20.0	18.0	14.0	0.0134	18.0	13.3	0.0089	18.8
60.0	20.1	16.0	12.0	0.0134	16.0	13.7	0.0064	16.1
120.0	20.3	14.5	10.5	0.0134	14.5	13.9	0.0045	14.1
240.0	20.4	13.0	9.0	0.0133	13.0	14.2	0.0032	12.1
1440.0	20.1	10.5	6.5	0.0134	10.5	14.6	0.0013	8.7

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 22.8 % SAND = 43.6
% SILT = 18.9 % CLAY = 14.7

D85= 9.02 D60= 1.000 D50= 0.412
D30= 0.0490 D15= 0.00531 D10= 0.00200
Cc = 1.2023 Cu = 501.1872

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	19	0.0	2.0	90.6	7.4	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.23	0.24	0.21	0.171	0.1282	0.0962	1.26	2.5

MATERIAL DESCRIPTION	USCS	AASHTO
● BROWN POORLY GRADED SAND WITH SILT	SP-SM	A-3

Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM
● Location: MND20-0344-0060

Date: 02-24-93

Remarks:
LOI, %: 0.5

BUCKET SAMPLED: 01-26-93

GRAIN SIZE DISTRIBUTION TEST REPORT
BOWSER-MORNER, INC.

Figure No. _____

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 19

Date: 02-24-93
Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Sample Data

Location of Sample: MND20-0344-0060
Sample Description: BROWN POORLY GRADED SAND WITH SILT
USCS Class: SP-SM Liquid limit:
AASHTO Class: A-3 Plasticity index:

Notes

Remarks: LOI, %: 0.5
BUCKET SAMPLED: 01-26-93
Fig. No.:

Mechanical Analysis Data

	Initial
Dry sample and tare=	996.50
Tare =	208.30
Dry sample weight =	788.20

Sample split on number 10 sieve
Split sample data:
Sample and tare = 100 Tare = 0 Sample weight = 100
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
0.75 inches	0.00	100.0
0.5 inches	3.64	99.5
0.375 inches	5.02	99.4
# 4	15.55	98.0
# 10	62.97	92.0
# 20	12.94	80.1
# 40	17.25	76.1
# 50	23.65	70.3
# 60	32.56	62.1
# 80	63.84	33.3
# 100	79.06	19.3
# 200	91.97	7.4

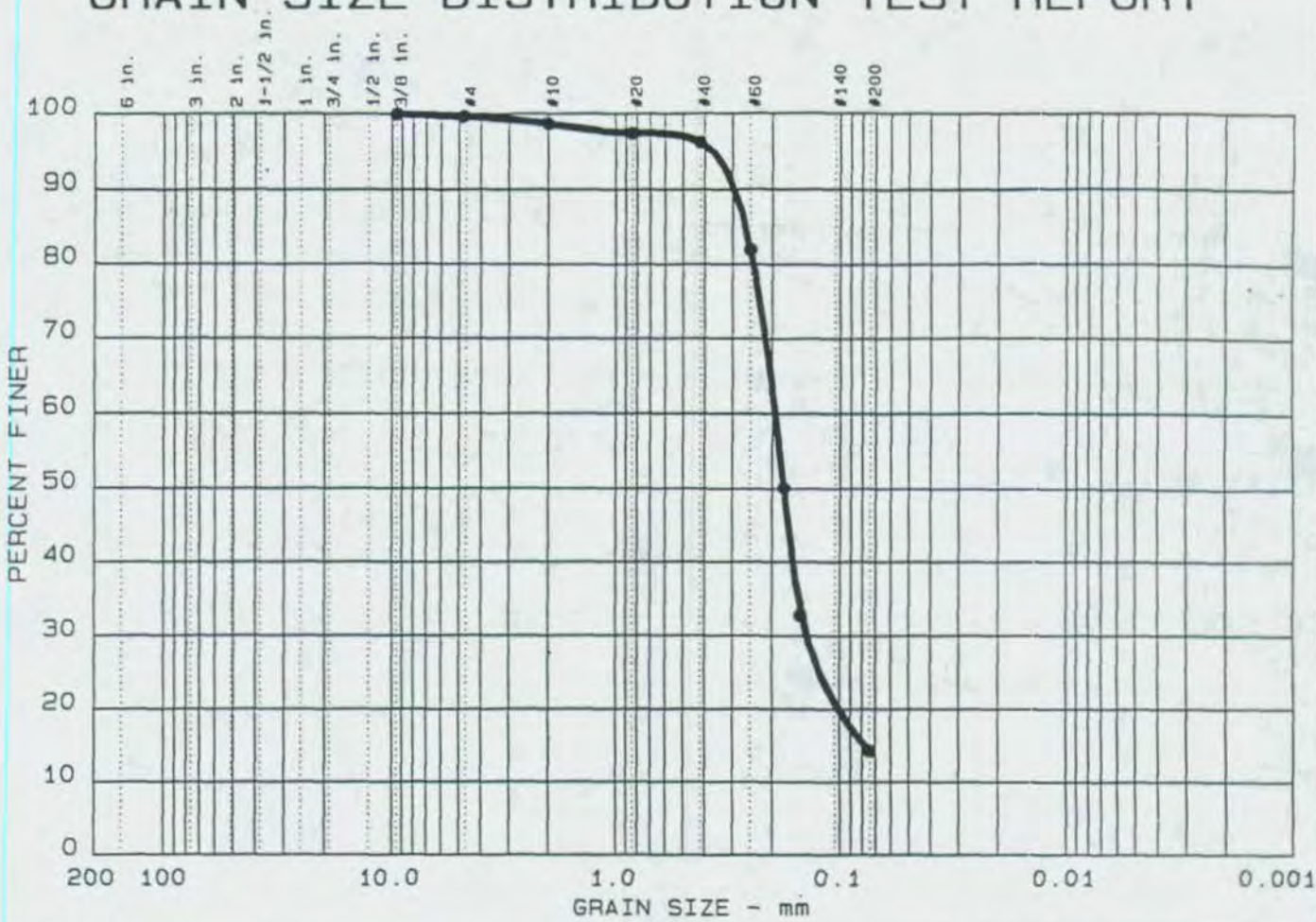
Fractional Components

% + 3 in. = 0.0 % GRAVEL = 2.0 % SAND = 90.6
% FINES = 7.4

D85= 1.23 D60= 0.242 D50= 0.212

D30= 0.1710 D15= 0.12823 D10= 0.09616
Cc = 1.2560 Cu = 2.5177

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	4	0.0	0.3	85.3	14.4	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.26	0.19	0.18	0.140	0.0762			

MATERIAL DESCRIPTION	USCS	AASHTO
● GRAY SILTY SAND	SM	

Project No.: 47894 WESTON

Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

● Location: MND20-0344-0065

Date: 02-24-93

Remarks:

LOI, %: 0.8

BUCKET SAMPLED: 01-26-93

GRAIN SIZE DISTRIBUTION TEST REPORT

BOWSER-MORNER, INC.

Figure No. _____

GRAIN SIZE DISTRIBUTION TEST DATA — Test No.: 4

Date: 02-24-93
Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Sample Data

Location of Sample: MND20-0344-0065
Sample Description: GRAY SILTY SAND
USCS Class: SM — Liquid limit:
AASHTO Class: — Plasticity index:

Notes

Remarks: LOI, %: 0.8
BUCKET SAMPLED: 01-26-93
Fig. No.:

Mechanical Analysis Data

	Initial
Dry sample and tare=	778.80
Tare =	213.40
Dry sample weight =	565.40

Sample split on number 10 sieve
Split sample data:
Sample and tare = 100 Tare = 0 Sample weight = 100
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
0.375 inches	0.00	100.0
# 4	1.82	99.7
# 10	7.05	98.8
# 20	1.30	97.5
# 40	2.48	96.3
# 60	17.05	81.9
# 80	49.24	50.1
# 100	66.77	32.8
# 200	85.46	14.4

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 0.3 % SAND = 85.3
% FINES = 14.4

D85= 0.26 D60= 0.193 D50= 0.177
D30= 0.1403 D15= 0.07621

GRAIN SIZE DISTRIBUTION TEST REPORT

	Test	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	3	0.0	32.9	64.7	2.4	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			10.00	3.43	2.11	0.716	0.3660	0.2941	0.51	11.7

MATERIAL DESCRIPTION	USCS	AASHTO
● GRAY POORLY GRADED SAND WITH GRAVEL	SP	A-1-a

Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM
● Location: MND20-0344-0115

Date: 02-24-93

Remarks:
LOI, %: 1.1

BUCKET SAMPLED: 01-26-93

GRAIN SIZE DISTRIBUTION TEST REPORT
BOWSER-MORNER, INC.

Figure No. _____

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 3

Date: 02-24-93
Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Sample Data

Location of Sample: MND20-0344-0115
Sample Description: GRAY POORLY GRADED SAND WITH GRAVEL
USCS Class: SP Liquid limit:
AASHTO Class: A-1-a Plasticity index:

Notes

Remarks: LOI, %: 1.1
BUCKET SAMPLED: 01-26-93
Fig. No.:

Mechanical Analysis Data

	Initial
Dry sample and tare=	1363.20
Tare =	212.00
Dry sample weight =	1151.20

Sample split on number 10 sieve
Split sample data:
Sample and tare = 100 Tare = 0 Sample weight = 100
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

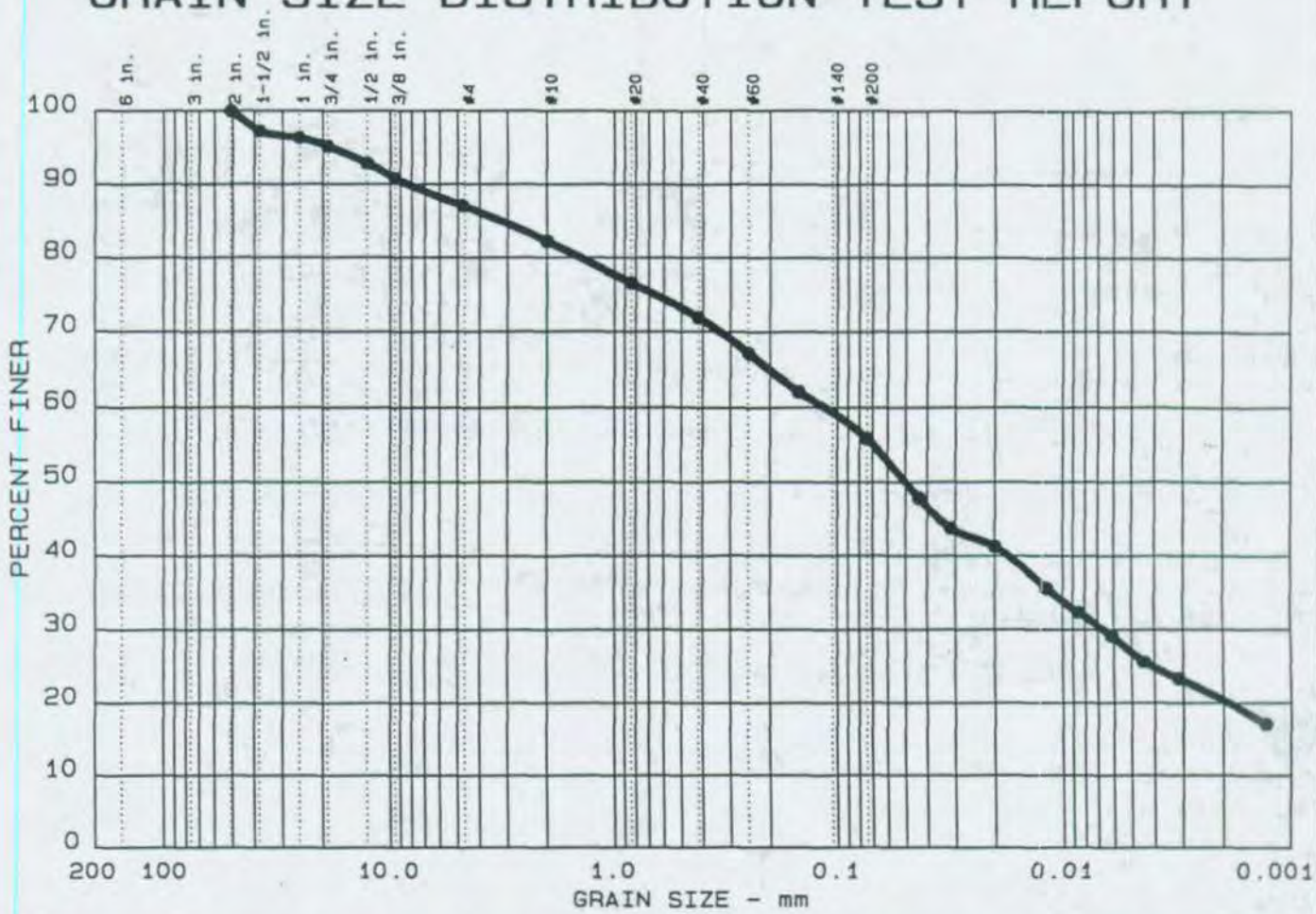
Sieve	Cumul. Wt. retained	Percent finer
1 inches	0.00	100.0
0.75 inches	47.52	95.9
0.5 inches	109.86	90.5
0.375 inches	188.33	83.6
# 4	378.88	67.1
# 10	588.84	48.8
# 20	32.48	33.0
# 40	62.44	18.3
# 60	85.71	7.0
# 100	92.67	3.6
# 200	95.02	2.4

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 32.9 % SAND = 64.7
% FINES = 2.4

D85= 10.00 D60= 3.428 D50= 2.113
D30= 0.7161 D15= 0.36602 D10= 0.29410

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	13	0.0	13.0	31.1	29.1	26.8

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			3.24	0.11	0.05	0.007				

MATERIAL DESCRIPTION	USCS	AASHTO
● GRAY SAND, SM CLAY, SM SILT, SM GRAVEL (VISUAL)		

Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM
● Location: MND20-0346-0025

Date: 04-12-93

Remarks:
LOI, %: 1.3

BUCKET SAMPLED: 04-02-93

GRAIN SIZE DISTRIBUTION TEST REPORT
BOWSER-MORNER, INC.

Figure No. _____

GRAIN SIZE DISTRIBUTION TEST DATA Test No.: 13

Date: 04-12-93
Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Sample Data

Location of Sample: MND20-0346-0025
Sample Description: GRAY SAND, SM CLAY, SM SILT, SM GRAVEL (VISUAL)
USCS Class: Liquid limit:
AASHTO Class: Plasticity index:

Notes

Remarks: LOI, %: 1.3
BUCKET SAMPLED: 04-02-93
Fig. No.:

Mechanical Analysis Data

Initial
Dry sample and tare= 3404.90
Tare = 219.80
Dry sample weight = 3185.10
Sample split on number 10 sieve
Split sample data:
Sample and tare = 50 Tare = 0 Sample weight = 50
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
2 inches	0.00	100.0
1.5 inches	86.45	97.3
1 inches	116.26	96.3
0.75 inches	152.22	95.2
0.5 inches	225.54	92.9
0.375 inches	291.24	90.9
# 4	413.18	87.0
# 10	567.90	82.2
# 20	3.44	76.5
# 40	6.26	71.9
# 60	9.08	67.2
# 100	12.20	62.1
# 200	15.96	55.9

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 82.2
Weight of hydrometer sample: 50
Hygroscopic moisture correction:
  Moist weight & tare = 281.33
  Dry weight & tare = 280.29
  Tare = 99.77
  Hygroscopic moisture= 0.6 %
Calculated biased weight= 60.50
Automatic temperature correction
  Composite correction at 20 deg C =-4.5

Meniscus correction only= 0
Specific gravity of solids= 2.73
Specific gravity correction factor= 0.983
Hydrometer type: 152H Effective depth L= 16.294964 - 0.164 x Rm

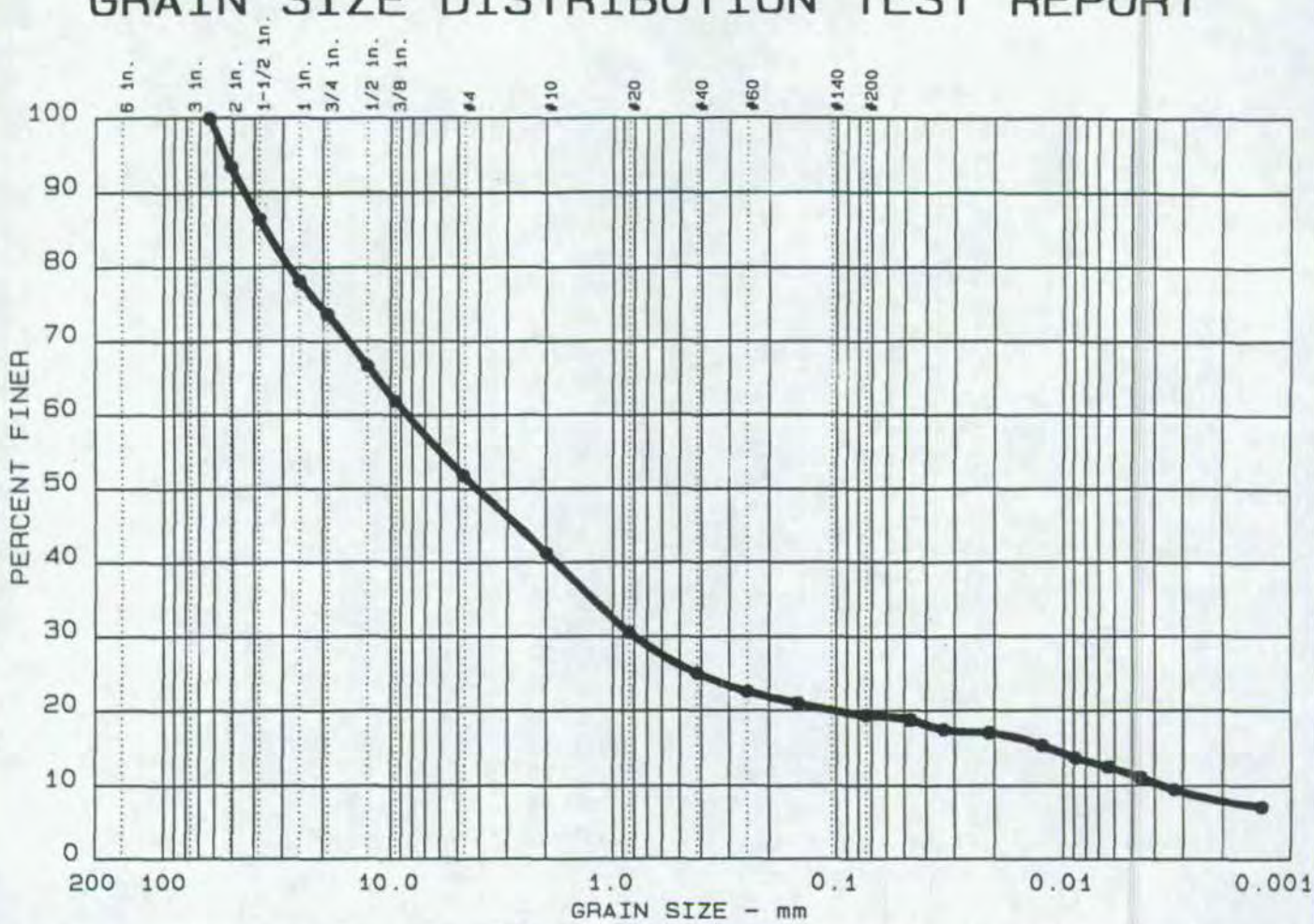
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1.0	20.1	34.0	29.5	0.0133	34.0	10.7	0.0436	47.9
2.0	20.1	31.5	27.0	0.0133	31.5	11.1	0.0314	43.8
5.0	20.1	30.0	25.5	0.0133	30.0	11.4	0.0201	41.4
15.0	20.1	26.5	22.0	0.0133	26.5	11.9	0.0119	35.7
30.0	20.1	24.5	20.0	0.0133	24.5	12.3	0.0085	32.4
60.0	20.1	22.5	18.0	0.0133	22.5	12.6	0.0061	29.2
120.0	19.1	20.5	15.8	0.0135	20.5	12.9	0.0044	25.6
240.0	19.6	19.0	14.4	0.0134	19.0	13.2	0.0031	23.3
1440.0	20.3	15.0	10.5	0.0133	15.0	13.8	0.0013	17.1

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 13.0 % SAND = 31.1
% SILT = 29.1 % CLAY = 26.8

D85= 3.24 D60= 0.114 D50= 0.050
D30= 0.0065

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	16	0.0	48.1	32.5	7.9	11.5

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			35.48	8.32	4.07	0.794	0.0111	0.0036	20.89	2290.9

MATERIAL DESCRIPTION	USCS	AASHTO
● BROWN SILTY GRAVEL WITH SAND	GM	

Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM
● Location: MND20-0346-0035

Date: 04-12-93

Remarks:
LOI, %: 1.6

BUCKET SAMPLED: 04-02-93

GRAIN SIZE DISTRIBUTION TEST REPORT
BOWSER-MORNER, INC.

Figure No. _____

GRAIN SIZE DISTRIBUTION TEST DATA

Test No.: 16

Date: 04-12-93
Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Sample Data

Location of Sample: MND20-0346-0035
Sample Description: BROWN SILTY GRAVEL WITH SAND
USCS Class: GM Liquid limit:
AASHTO Class: Plasticity index:

Notes

Remarks: LOI, %: 1.6
BUCKET SAMPLED: 04-02-93
Fig. No.:

Mechanical Analysis Data

	Initial
Dry sample and tare=	4771.50
Tare =	221.20
Dry sample weight =	4550.30

Sample split on number 10 sieve
Split sample data:
Sample and tare = 50 Tare = 0 Sample weight = 50
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
2.5 inches	0.00	100.0
2 inches	293.40	93.6
1.5 inches	613.60	86.5
1 inches	999.10	78.0
0.75 inches	1198.80	73.7
0.5 inches	1515.40	66.7
0.375 inches	1731.20	62.0
# 4	2190.00	51.9
# 10	2670.50	41.3
# 20	13.02	30.6
# 40	19.65	25.1
# 60	22.67	22.6
# 100	24.56	21.0
# 200	26.53	19.4

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 41.3
Weight of hydrometer sample: 50
Hygroscopic moisture correction:
  Moist weight & tare = 244.99
  Dry weight & tare = 243.83
  Tare = 106.02
  Hygroscopic moisture= 0.8 %
Calculated biased weight= 120.02
Automatic temperature correction
  Composite correction at 20 deg C =-4.5

Meniscus correction only= 0
Specific gravity of solids= 2.65
Specific gravity correction factor= 1.000
Hydrometer type: 152H Effective depth L= 16.294964 - 0.164 x Rm

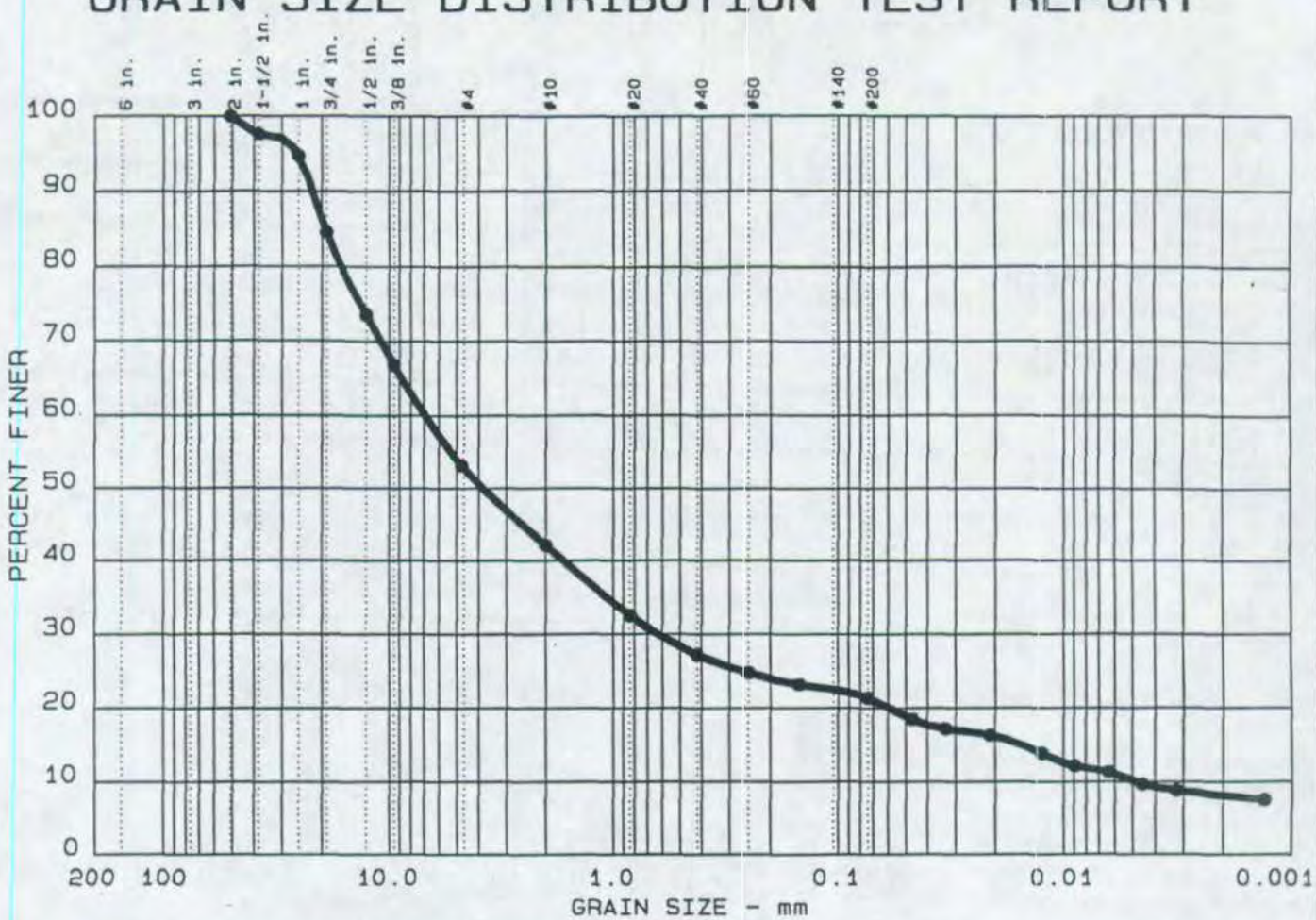
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1.0	20.1	27.0	22.5	0.0136	27.0	11.9	0.0470	18.7
2.0	20.1	25.5	21.0	0.0136	25.5	12.1	0.0335	17.5
5.0	20.1	25.0	20.5	0.0136	25.0	12.2	0.0213	17.1
15.0	20.1	23.0	18.5	0.0136	23.0	12.5	0.0125	15.4
30.0	20.1	21.0	16.5	0.0136	21.0	12.9	0.0089	13.7
60.0	20.1	19.5	15.0	0.0136	19.5	13.1	0.0064	12.5
120.0	19.2	18.0	13.3	0.0138	18.0	13.3	0.0046	11.1
240.0	19.6	16.0	11.4	0.0137	16.0	13.7	0.0033	9.5
1440.0	20.3	13.0	8.5	0.0136	13.0	14.2	0.0013	7.1

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 48.1 % SAND = 32.5
% SILT = 7.9 % CLAY = 11.5

D85= 35.48 D60= 8.318 D50= 4.074
D30= 0.7943 D15= 0.01109 D10= 0.00363
Cc = 20.8930 Cu =2290.8677

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	20	0.0	46.8	31.9	11.3	10.0

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			19.23	6.90	3.79	0.622	0.0149	0.0049	11.48	1412.5

MATERIAL DESCRIPTION	USCS	AASHTO
● BROWN GRAVEL, SOME SAND, SOME SILT, SOME CLAY (visual)		

Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM
● Location: MND20-0386-0033

Date: 04-05-93

Remarks:
LOI, %: 1.9

BUCKET SAMPLED: 03-22-93

GRAIN SIZE DISTRIBUTION TEST REPORT
BOWSER-MORNER, INC.

Figure No. _____

GRAIN SIZE DISTRIBUTION TEST DATA Test No.: 20

Date: 04-05-93
Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Sample Data

Location of Sample: MND20-0386-0033
Sample Description: BROWN GRAVEL, SOME SAND, SOME SILT, SOME CLAY
USCS Class: Liquid limit:
AASHTO Class: Plasticity index:

Notes

Remarks: LOI, %: 1.9
BUCKET SAMPLED: 03-22-93
Fig. No.:

Mechanical Analysis Data

	Initial
Dry sample and tare=	4118.80
Tare =	356.50
Dry sample weight =	3762.30

Sample split on number 10 sieve
Split sample data:
Sample and tare = 50 Tare = 0 Sample weight = 50
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
2 inches	0.00	100.0
1.5 inches	89.46	97.6
1 inches	196.31	94.8
0.75 inches	578.33	84.6
0.5 inches	992.20	73.6
0.375 inches	1247.20	66.9
# 4	1759.10	53.2
# 10	2174.30	42.2
# 20	11.44	32.6
# 40	17.68	27.3
# 60	20.59	24.8
# 100	22.56	23.2
# 200	24.68	21.4

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 42.2
Weight of hydrometer sample: 50
Hygroscopic moisture correction:
  Moist weight & tare = 81.88
  Dry weight & tare = 80.77
  Tare = 28.24
  Hygroscopic moisture= 2.1 %
Calculated biased weight= 116.01
Automatic temperature correction
  Composite correction at 20 deg C =-1.5

Meniscus correction only= 0
Specific gravity of solids= 2.76
Specific gravity correction factor= 0.976
Hydrometer type: 152H Effective depth L= 16.294964 - 0.164 x Rm

Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1.0	20.0	23.5	22.0	0.0132	23.5	12.4	0.0466	18.5
2.0	20.0	22.0	20.5	0.0132	22.0	12.7	0.0333	17.2
5.0	20.0	21.0	19.5	0.0132	21.0	12.9	0.0212	16.4
15.0	20.0	18.0	16.5	0.0132	18.0	13.3	0.0125	13.9
30.0	20.0	16.0	14.5	0.0132	16.0	13.7	0.0089	12.2
60.0	20.0	15.0	13.5	0.0132	15.0	13.8	0.0063	11.3
120.0	20.0	13.0	11.5	0.0132	13.0	14.2	0.0045	9.6
240.0	20.1	12.0	10.5	0.0132	12.0	14.3	0.0032	8.8
1440.0	20.1	10.5	9.0	0.0132	10.5	14.6	0.0013	7.6

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 46.8 % SAND = 31.9
% SILT = 11.3 % CLAY = 10.0

D85= 19.23 D60= 6.902 D50= 3.793
D30= 0.6223 D15= 0.01493 D10= 0.00489
Cc = 11.4815 Cu =1412.5375

GRAIN SIZE DISTRIBUTION TEST REPORT

	Test	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	2	0.0	11.6	36.5	31.4	20.5

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			2.51	0.15	0.07	0.014	0.0016			

MATERIAL DESCRIPTION	USCS	AASHTO
● GRY/BRN SAND, SOME SILT, SOME CLAY, SOME GRAVEL (visual)		

Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM
● Location: MND20-0386-0035

Date: 04-05-93

Remarks:
LOI, %: 2.2

BUCKET SAMPLED: 03-22-93

GRAIN SIZE DISTRIBUTION TEST REPORT
BOWSER-MORNER, INC.

Figure No. _____

GRAIN SIZE DISTRIBUTION TEST DATA Test No.: 2

Date: 04-05-93
Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Sample Data

Location of Sample: MND20-0386-0035
Sample Description: GRY/BRN SAND, SOME SILT, SOME CLAY, SOME GRAVEL
USCS Class: Liquid limit:
AASHTO Class: Plasticity index:

Notes

Remarks: LOI, %: 2.2
BUCKET SAMPLED: 03-22-93
Fig. No.:

Mechanical Analysis Data

	Initial
Dry sample and tare=	3169.20
Tare =	217.80
Dry sample weight =	2951.40

Sample split on number 10 sieve
Split sample data:
Sample and tare = 50 Tare = 0 Sample weight = 50
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve	Cumul. Wt. retained	Percent finer
1 inches	0.00	100.0
0.75 inches	119.60	95.9
0.5 inches	192.44	93.5
0.375 inches	240.78	91.8
# 4	341.55	88.4
# 10	483.35	83.6
# 20	3.43	77.9
# 40	6.72	72.4
# 60	10.14	66.7
# 100	14.14	60.0
# 200	18.94	51.9

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 83.6
Weight of hydrometer sample: 50
Hygroscopic moisture correction:
Moist weight & tare = 84.04

Dry weight & tare = 83.73
Tare = 28.61
Hygroscopic moisture= 0.6 %
Calculated biased weight= 59.46
Automatic temperature correction
Composite correction at 20 deg C =-2.5

Meniscus correction only= 0
Specific gravity of solids= 2.73
Specific gravity correction factor= 0.983
Hydrometer type: 152H Effective depth L= 16.294964 - 0.164 x Rm

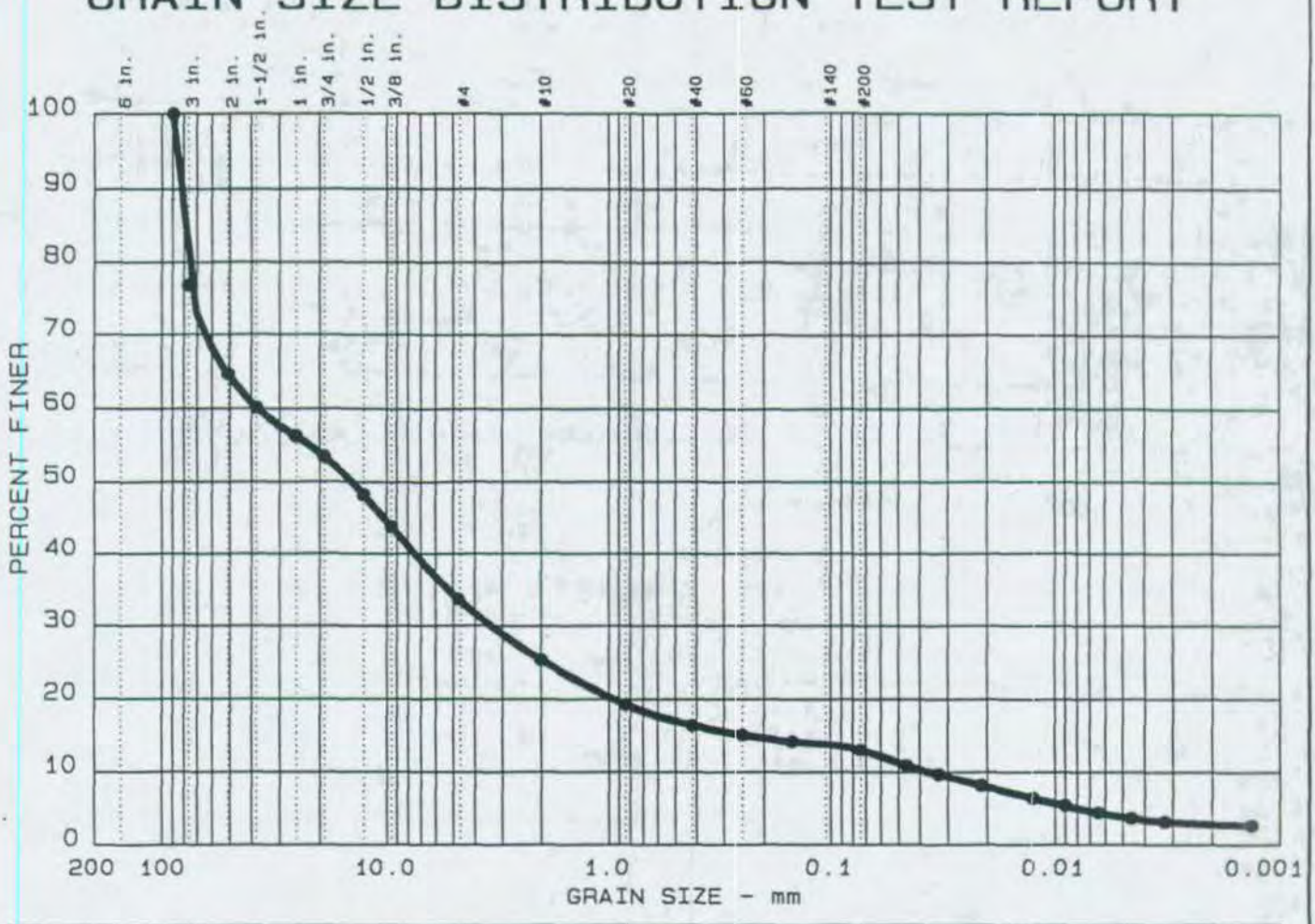
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1.0	20.0	28.0	25.5	0.0133	28.0	11.7	0.0456	42.1
2.0	20.0	25.5	23.0	0.0133	25.5	12.1	0.0328	37.9
5.0	20.0	23.5	21.0	0.0133	23.5	12.4	0.0210	34.6
15.0	20.0	20.0	17.5	0.0133	20.0	13.0	0.0124	28.9
30.0	20.0	18.5	16.0	0.0133	18.5	13.3	0.0089	26.4
60.0	20.1	16.5	14.0	0.0133	16.5	13.6	0.0063	23.1
120.0	20.0	14.5	12.0	0.0133	14.5	13.9	0.0045	19.8
240.0	20.1	13.5	11.0	0.0133	13.5	14.1	0.0032	18.1
1440.0	20.1	11.0	8.5	0.0133	11.0	14.5	0.0013	14.0

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 11.6 % SAND = 36.5
% SILT = 31.4 % CLAY = 20.5

D85= 2.51 D60= 0.148 D50= 0.067
D30= 0.0138 D15= 0.00160

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	3	23.2	43.1	20.7	9.2	3.8

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			81.66	37.33	14.35	3.365	0.2223	0.0361	8.41	1035.1

MATERIAL DESCRIPTION	USCS	AASHTO
● BROWN SILTY GRAVEL WITH SAND	GM	

Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM
● Location: MND20-0386-0055

Date: 04-05-93

Remarks:
LOI, %: 0.8

BUCKET SAMPLED: 03-22-93

GRAIN SIZE DISTRIBUTION TEST REPORT
BOWSER-MORNER, INC.

Figure No. _____

GRAIN SIZE DISTRIBUTION TEST DATA — Test No.: 3

Date: 04-05-93
Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Sample Data

Location of Sample: MND20-0386-0055
Sample Description: BROWN SILTY GRAVEL WITH SAND
USCS Class: GM
Liquid limit:
AASHTO Class:
Plasticity index:

Notes

Remarks: LOI, %: 0.8
BUCKET SAMPLED: 03-22-93
Fig. No.:

Mechanical Analysis Data

Initial
Dry sample and tare= 4138.70
Tare = 363.40
Dry sample weight = 3775.30
Sample split on number 10 sieve
Split sample data:
Sample and tare = 50 Tare = 0 Sample weight = 50
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve		Cumul. Wt. retained	Percent finer
3.5	inches	0.00	100.0
3	inches	874.30	76.8
3	inches	874.30	76.8
2	inches	1333.20	64.7
1.5	inches	1505.20	60.1
1	inches	1649.00	56.3
0.75	inches	1754.60	53.5
0.5	inches	1954.10	48.2
0.375	inches	2121.30	43.8
# 4		2500.30	33.8
# 10		2815.00	25.4
# 20		12.13	19.3
# 40		17.63	16.5
# 60		20.25	15.1
# 100		22.00	14.2
# 200		24.37	13.0

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 25.4
Weight of hydrometer sample: 50
Hygroscopic moisture correction:
  Moist weight & tare = 80.23
  Dry weight & tare = 79.86
  Tare = 29.50
  Hygroscopic moisture= 0.7 %
Calculated biased weight= 195.14
Automatic temperature correction
  Composite correction at 20 deg C =-1.5

Meniscus correction only= 0
Specific gravity of solids= 2.8
Specific gravity correction factor= 0.969
Hydrometer type: 152H Effective depth L= 16.294964 - 0.164 x Rm

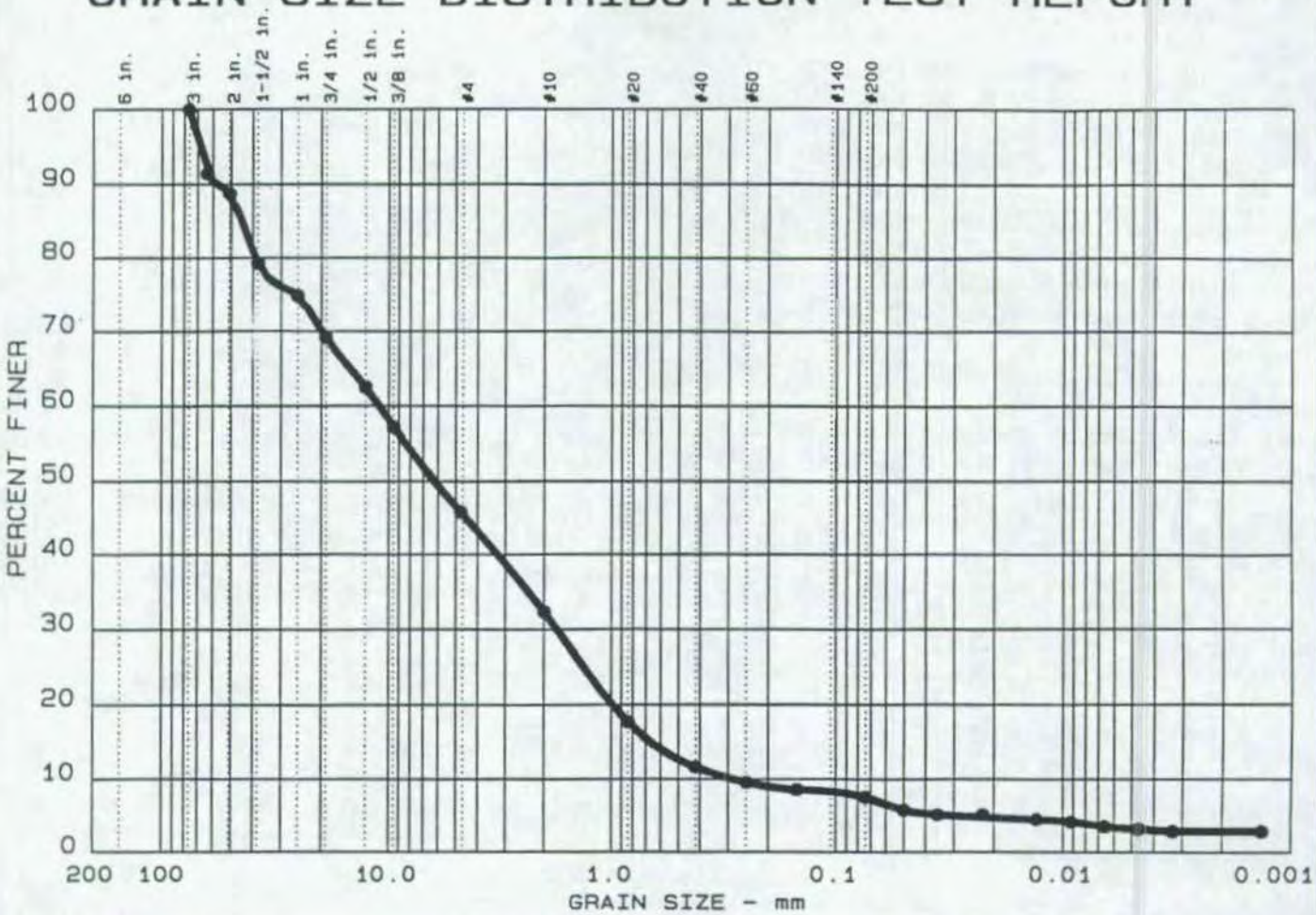
Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1.0	20.1	23.5	22.0	0.0130	23.5	12.4	0.0460	10.9
2.0	20.1	21.0	19.5	0.0130	21.0	12.9	0.0331	9.7
5.0	20.0	18.0	16.5	0.0131	18.0	13.3	0.0213	8.2
15.0	20.1	14.5	13.0	0.0130	14.5	13.9	0.0126	6.4
30.0	20.0	12.5	11.0	0.0131	12.5	14.2	0.0090	5.4
60.0	20.1	10.5	9.0	0.0130	10.5	14.6	0.0064	4.5
120.0	20.0	9.0	7.5	0.0131	9.0	14.8	0.0046	3.7
240.0	20.1	8.0	6.5	0.0130	8.0	15.0	0.0033	3.2
1440.0	20.1	7.0	5.5	0.0130	7.0	15.1	0.0013	2.7

Fractional Components

% + 3 in. = 23.2 % GRAVEL = 43.1 % SAND = 20.7
% SILT = 9.2 % CLAY = 3.8

D85= 81.66 D60= 37.325 D50= 14.355
D30= 3.3651 D15= 0.22233 D10= 0.03606
Cc = 8.4140 Cu =1035.1422

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	1	0.0	54.2	38.2	4.3	3.3

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_C	C_U
●			44.67	10.96	6.24	1.738	0.6607	0.2884	0.95	38.0

MATERIAL DESCRIPTION	USCS	AASHTO
● BROWN POORLY GRADED GRAVEL WITH SILT AND SAND	GP-GM	

Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM
● Location: MND20-0386-0080

Date: 04-05-93

Remarks:
LOI, %: 1.4

BUCKET SAMPLED: 03-22-93

GRAIN SIZE DISTRIBUTION TEST REPORT
BOWSER-MORNER, INC.

Figure No. _____

GRAIN SIZE DISTRIBUTION TEST DATA Test No.: 1

Date: 04-05-93
Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM

Sample Data

Location of Sample: MND20-0386-0080
Sample Description: BROWN POORLY GRADED GRAVEL WITH SILT AND SAND
USCS Class: GP-GM Liquid limit:
AASHTO Class: Plasticity index:

Notes

Remarks: LOI, %: 1.4
BUCKET SAMPLED: 03-22-93
Fig. No.:

Mechanical Analysis Data

	Initial
Dry sample and tare=	6509.30
Tare =	362.40
Dry sample weight =	6146.90

Sample split on number 10 sieve
Split sample data:
Sample and tare = 50 Tare = 0 Sample weight = 50
Cumulative weight retained tare= 0
Tare for cumulative weight retained= 0

Sieve		Cumul. Wt. retained	Percent finer
3	inches	0.00	100.0
2.5	inches	522.96	91.5
2	inches	692.30	88.7
1.5	inches	1274.50	79.3
1	inches	1548.50	74.8
0.75	inches	1892.50	69.2
0.5	inches	2304.60	62.5
0.375	inches	2629.00	57.2
# 4		3333.60	45.8
# 10		4156.40	32.4
# 20		22.69	17.7
# 40		32.07	11.6
# 60		35.29	9.5
# 100		36.84	8.5
# 200		38.39	7.5

Hydrometer Analysis Data

Separation sieve is number 10
Percent -# 10 based on complete sample= 32.4
Weight of hydrometer sample: 50
Hygroscopic moisture correction:
  Moist weight & tare = 87.32
  Dry weight & tare = 86.30
  Tare = 28.21
  Hygroscopic moisture= 1.8 %
Calculated biased weight= 151.74
Automatic temperature correction
  Composite correction at 20 deg C =-2.5

Meniscus correction only= 0
Specific gravity of solids= 2.77
Specific gravity correction factor= 0.974
Hydrometer type: 152H Effective depth L= 16.294964 - 0.164 x Rm

Elapsed time, min	Temp, deg C	Actual reading	Corrected reading	K	Rm	Eff. depth	Diameter mm	Percent finer
1.0	20.1	11.5	9.0	0.0132	11.5	14.4	0.0500	5.8
2.0	20.0	10.5	8.0	0.0132	10.5	14.6	0.0356	5.1
5.0	20.0	10.5	8.0	0.0132	10.5	14.6	0.0225	5.1
15.0	20.1	9.5	7.0	0.0132	9.5	14.7	0.0130	4.5
30.0	20.0	9.0	6.5	0.0132	9.0	14.8	0.0093	4.1
60.0	20.0	8.0	5.5	0.0132	8.0	15.0	0.0066	3.5
120.0	20.0	7.5	5.0	0.0132	7.5	15.1	0.0047	3.2
240.0	20.1	7.0	4.5	0.0132	7.0	15.1	0.0033	2.9
1440.0	20.1	7.0	4.5	0.0132	7.0	15.1	0.0013	2.9

Fractional Components

% + 3 in. = 0.0 % GRAVEL = 54.2 % SAND = 38.2
% SILT = 4.3 % CLAY = 3.3

D85= 44.67 D60= 10.965 D50= 6.237
D30= 1.7378 D15= 0.66069 D10= 0.28840
Cc = 0.9550 Cu = 38.0189

BOWSER MORNER
COMMITTED TO EXCELLENCE SINCE 1911

4518 Taylorsville Road
P.O. Box 51
Dayton, OH 45401-0051
513-236-8805
513-233-2016 FAX

July 1, 1993

Roy F. Weston, Inc.
Attn: Mr. Paul Darr Fax (505) 884-5388
Mr. Craig Stohl Fax (513) 825-3336
6501 Americas Parkway N.E., Suite 800
Albuquerque, New Mexico 87110

RE: Review Questions: Geotechnical Analyses of Soil Samples
Mound Environmental Restoration Program
RFW W.O. No. 05376-039-006
Task Order No. 0005 (OU9)
BMI Report 000832D, Dated May 13, 1993

Dear Mr. Darr,

This is our response to the review of the geotechnical laboratory data for the above referenced project. An in-house audit of the data file has been completed as specified in our initial letter of response dated June 8, 1993. Additionally, specific samples which were identified as having questionable results were retested. Those results are presented as follows:

1. Cation Exchange Capacity (CEC)

Quality control measures employed during CEC testing indicate that the results reported are valid. Quality control in this case involved the analysis of check standards associated with both the exchange procedure and the instrumental analysis of the final exchange solutions for sodium by ICP spectroscopy and the analysis of one sample replicate.

A known reference standard, a Kansas soil of mixed mineralogy (montmorillonite, illite, chlorite, vermiculite) was tested along with the site samples. Analyzed in duplicate, the reference standard with a true value of 23.5 meq/100 g resulted in test values of 24.1 and 25.9 meq/100 g. These recoveries of 103% and 110% are within acceptable limits.

In addition to accessing accuracy by analysis of the reference standard, some assessment of method precision was determined by selecting one sample for duplicate analysis. The resulting duplicate values were 17.3 and 17.6 meq/100 g with a very low %RSD of 1.7.

Although the above is true, Mr. Randall Warden, Assistant Director of our Analytical Sciences Division, agrees that the results are not consistent with the apparent soil mineralogy. It has been noted by the chemical laboratory that all of the seven samples associated with this analytical batch appear high for CEC.

We request additional time to further investigate this matter. We are in the process of re analyzing the samples in question and are willing to send a representative split to another laboratory of your choice for comparison as part of this investigation. Of course, this would be at our expense.

2. Unit Weight - Sample MND20-0386-0035

Original measurements for this sample were taken from a trimmed (cylindrical) specimen at its as-received moisture content. The oven-dried test specimen was remeasured and weighed to check the previously reported result.

Note the following:

TABLE I

	Original Result	Retest Result
Height, in.	2.571	2.588
Diameter, in.	3.924	3.983
Wet Weight, g	1266.4	1146.3*
Moisture Content, %	10.5	0.0
Volume, ft^3	0.017993	0.018661
Wet Unit Weight, pcf	155.2	---
Dry Unit Weight, pcf	140.4	135.4

*Oven dried specimen.

From the data collected it is shown that a difference of 5.0 pcf is detected between the original test and the retest of the same specimen. It is reasonable to assume that some change in dimensions occurred during oven drying which would affect the volume measurements. The dry weight of solids for both tests are nearly identical, i.e., 1146.1 g versus 1146.3 g.

An additional undisturbed portion of this sample was also tested with results as follows:

TABLE II

Height, in.	1.993
Diameter, in.	3.985
Wet Weight, g	937.6
Moisture Content, %	8.9
Volume, ft^3	0.01438
Wet Unit Weight, pcf	143.7
Dry Unit Weight, pcf	131.9

We believe the above stated result of 131.9 pcf dry density to be valid and it is reported on the resubmitted hydraulic conductivity data summary sheet.

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3. Moisture-Density (Proctor) - Sample MND20-0342-0095

This sample was retested to establish maximum dry density and optimum moisture content (modified proctor, D1557). Results are as follows:

TABLE III

	Original Result	Retest Result	Difference
Maximum Dry Density, pcf	123.3	124.1	0.8
Optimum Moisture Content, %	11.1	10.4	0.7

Proctor curves from both tests are provided plotted on the sample graph for comparison.

Recent AMRL proficiency sample reports indicate that one standard deviation for these parameters average about 2.1 pcf and 0.9% for maximum dry density and optimum moisture content respectively. Our retest results are within that range.

4. Hydraulic Conductivity (Permeability)

Additional specimens were tested for hydraulic conductivity to confirm original results. Another undisturbed specimen was used from the same sample where possible. A test specimen was reconstituted in cases where an undisturbed specimen was not available. Remolding was performed to achieve a similar density and moisture content as the original undisturbed specimen. It should be acknowledged that remolded specimens can have a much different particle structure than the original in-situ state which may affect the hydraulic conductivity result.

Results are as follows:

TABLE IV

Sample ID	Original Result, cm/sec.	Retest Result, cm/sec.
MND20-0341-0020	4.0×10^{-9}	7.0×10^{-9}
MND20-0343-0067	2.9×10^{-9}	2.5×10^{-9}
MND20-0344-0115	4.9×10^{-4}*	3.5×10^{-4}*
MND20-0386-0033	7.3×10^{-8}*	1.9×10^{-8}**
MND20-0386-0035	9.8×10^{-9}	9.2×10^{-9}

* Remolded specimen.

** Remolded specimen from oven dry material.

Table V details dimensions and other pertinent values, i.e., void ratios, percent saturation, etc., for the retest specimens.

I believe the retest of these five samples compare very well with the original test results. Admittedly, a greater volume of permeant was run through these specimens. Note that B-coefficients prior to initiating flow through the specimen is greater than 0.95 in all five cases. Further, inflow equaled outflow at test equilibrium indicating a steady-state condition.

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The four cohesive materials remain in the flex-wall permeameter with multiple readings taken daily. We can continue to monitor flow through these specimens per your instructions. Please advise us as to your evaluation of the data presented.

TABLE V

	0341-0020	0343-0067	0344-0115	0386-0033	0386-0035
Height, in.	4.573	1.102	3.345	4.587	1.993
Diameter, in.	4.022	4.166	2.892	4.024	3.985
Weight, g	2209.7	541.8	720.0	2278.2	937.6
Specific Gravity	2.73	2.73	2.71	2.76	2.73
Moisture, %	9.1	12.6	2.3	7.5	8.9
Volume, ft^3	0.03362	0.008693	0.01272	0.03376	0.01438
Wet Density, pcf	144.9	137.4	124.8	148.8	143.7
Dry Density, pcf	132.8	122.0	122.0	138.4	131.9
Dry Solids, cm^3	2025.4	481.2	703.8	2119.3	861.0
Volume of Solids, cm^3	741.9	176.2	259.7	767.8	315.4
Volume of Voids, cm^3	210.2	70.0	100.4	188.1	91.9
Void Ratio	0.2833	0.3973	0.3866	0.2450	0.2914
Porosity, %	22.1	28.4	27.9	19.7	22.6
B Value	0.97	0.99	1.00	1.00	1.00
k, cm/sec.	7.0×10^{-9}	2.5×10^{-9}	3.5×10^{-4}	1.9×10^{-8}	9.2×10^{-9}
Vol. perm as of last reading, cm	61	44	300	124	72
Vol. perm as of last reading, pore vol., %	29	63	300	66	78
Initial Saturation, %	87.8	86.8	16.1	84.7	83.3

Please advise us of your review of this information.

Should you have any questions, or if we may be of further service, please contact us at (513) 236-8805.

Respectfully submitted,

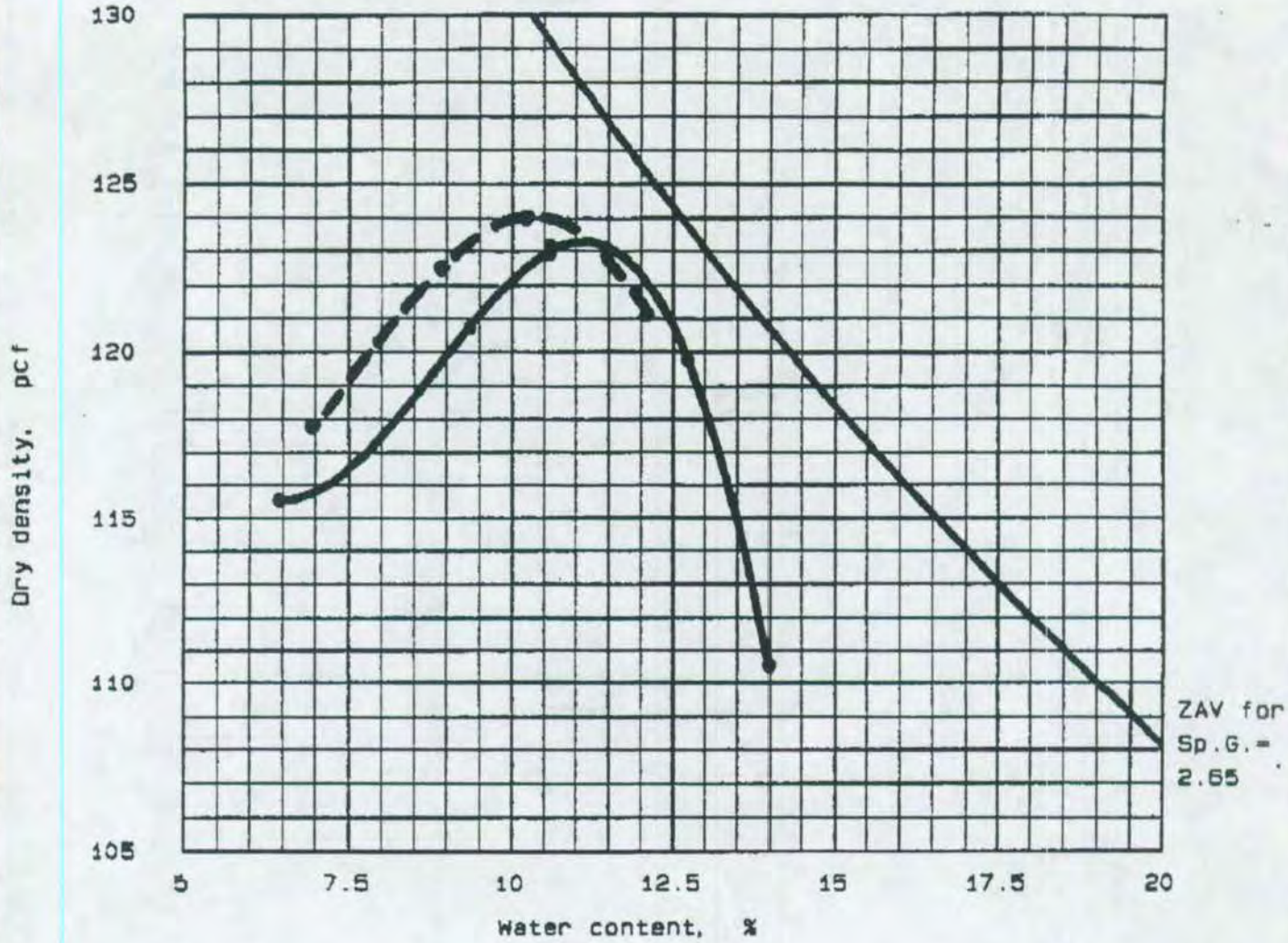
BOWSER-MORNER, INC.

James W. Fletcher, Manager
Construction Materials and
Geotechnical Laboratories

JWF/cfw
001760
1-Client
1-File
1-Mark Bingman, BMI QA/QC

BOWSER MORNER

PROCTOR TEST REPORT

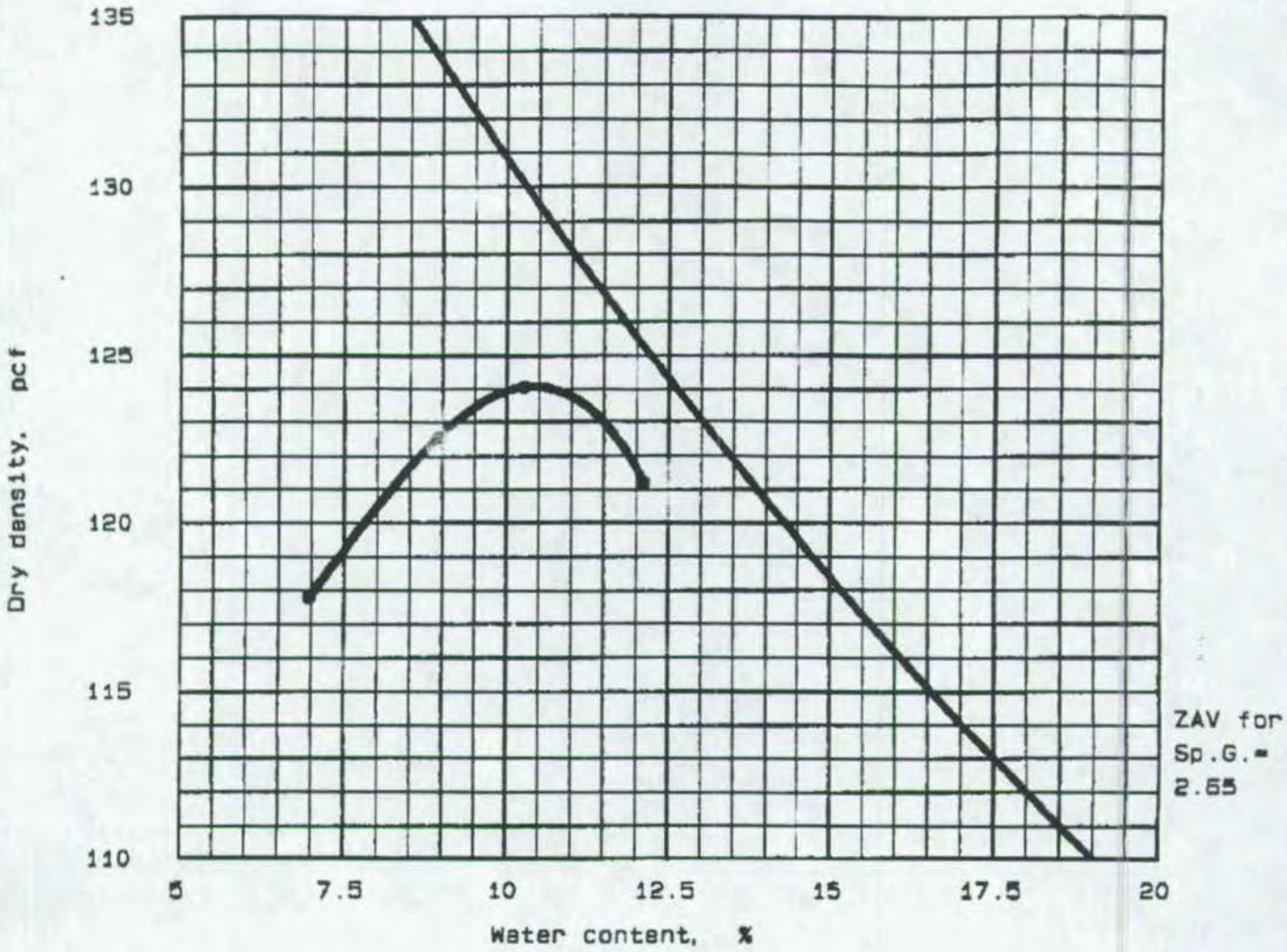


"Modified" Proctor, ASTM D 1557, Method A

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
	SM						3 %	13 %

TEST RESULTS	MATERIAL DESCRIPTION
Optimum moisture = 11.1 % Retest 10.4 % Maximum dry density = 123.3 pcf 124.1 pcf	GRAY SILTY SAND
Project No.: 47894 WESTON Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM Location: MND20-0342-0095 Date: 4-08-1993	Remarks: DATE SAMPLED: 04-04-93
PROCTOR TEST REPORT **BOWSER-MORNER, INC.**	Figure No. _____

PROCTOR TEST REPORT



"Modified" Proctor, ASTM D 1557, Method A

Elev/ Depth	Classification USCS	Classification AASHTO	Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200

TEST RESULTS	MATERIAL DESCRIPTION
Optimum moisture = 10.4 % Maximum dry density = 124.1 pcf	GRAY SILTY SAND

Project No.: 47894 WESTON
Project: MOUND ENVIRONMENTAL RESTORATION PROGRAM
Location: MND20-0342-0095

Date: 6-14-1993

Remarks:
-IN HOUSE AUDIT-

PROCTOR TEST REPORT

BOWSER-MORNER, INC.

Figure No. _____

ASTM D5084
FALLING HEAD
PERMEABILITY TEST
UNDISTURBED

Date:	July 1, 1993
Project No.:	47894-Roy F. Weston
Project:	Mound Environmental Restoration Program
Location:	MND20-0386-0035
Material Description:	Gray/Brown Sand, Some Silt, Some Clay, Some Gravel (visual)

SPECIMEN DATA:

Dimension, Inches:	
Height:	1.993
Diameter:	3.985
Weight, lbs.:	2.067
Moisture Content, %:	8.9
Wet Unit Weight, pcf:	143.7
Dry Unit Weight, pcf:	131.9
Permeability, cm/sec.:	
k:	9.2×10^{-9}

C.2. X-RAY DIFFRACTION REPORT FROM LAMDA RESEARCH

LAMBDA
RESEARCH
5521 FAIR LANE CINCINNATI, OHIO 45227 PHONE: 513/561-0883 FAX: 513/561-0886

Roy F. Weston, Inc.
11840-D Kemper Springs Dr.
Cincinnati, Ohio 45240-1640

SEMI-QUANTITATIVE PHASE ANALYSIS OF FIVE SOIL SAMPLES USING THE EXTERNAL STANDARD METHOD

REPORT: 624-0-001-A
DATE: 06/14/93

ATTN: Mr. Craig Stoll
AUTHORIZATION: Subcontract No. LL-1434-C1
RFW W.O. No. 05376-039-006
Task Order No. 0002

INTRODUCTION

Five soil samples were received from Roy F. Weston, Inc. for the purpose of semi-quantitative phase analysis by x-ray diffraction. The samples are identified as MND20-0342-0010, MND20-0342-0075, MND20-0342-0095, MND20-0343-0037, and MND20-0343-0057

Laboratory Technician:
Atul C. Paradkar
Quality Assurance:
Marie Marawi
Director of Research:
Paul S. Prevey

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TECHNIQUE

Each sample was wet sieved using a 200 mesh screen. A -200 mesh fraction was collected in a beaker. The sample was filtered using filter paper to remove excess water. The wet sample was then removed from the filter paper and was collected in a petri dish. A sufficient amount of ethylene glycol was added to the wet sample which was in the form of a paste. The sample was then thoroughly mixed and allowed to dry in air. The dry sample was ground for two minutes in a ball mill using plastic vials and balls to get a fine powder. A quantity of powder was packed into a 2.8 in. by 0.6 in. by 0.15 in. powder tray using a back packing method. The back packing method was used to minimize preferred orientation. The sample was placed in a flat sample holder to obtain a diffraction pattern.

Diffraction patterns were obtained using graphite monochromated copper K-alpha radiation on a computer-controlled, Bragg-Brentano focusing geometry horizontal diffractometer. The incident slit used was 1 deg. and the receiving slit was 0.1 deg. The angular range, step increment, and counting time for each data set are shown at the top of the corresponding table of reduced diffraction data. The suffix "EG" is added after sample identification to indicate that the sample was solvated using ethylene glycol. Original field identifications are used as laboratory identifications.

NIST standard reference material No. 640, "Silicon Powder for X-ray Diffraction," [1] was employed to correct systematic error in the diffraction angle caused by instrument misalignment and aberrations due to defocusing, beam divergence, etc.

A technique was developed for analyzing the system of phases using published reference intensity ratios (RIR values) [2] for each candidate phase in the mixture, and the relative intensities of the peaks of each phase.

Integrated intensities were obtained by utilizing one or more methods, as follows.

Integrated intensities were calculated assuming that the K-alpha 1 and K-alpha 2 peak components were closely approximated by a summation of Pearson VII functions fitted by regression while assuming a linear background under the peak group. Once the parameters of the function describing the peaks were known, the area under each peak, corresponding to the integrated intensity, was calculated.

Direct integration was performed assuming a Pearson VII functional form of surrounding peak profiles, fitting the surrounding peaks, integrating the total counts collected over a range that included the peak(s) of interest, and

subtracting the neighboring fitted peak profiles. The background was approximated by either linear or quadratic functions, as appropriate.

Qualitative energy dispersive x-ray fluorescence analysis was performed to aid in the analysis of the x-ray diffraction data. Qualitative energy dispersive x-ray fluorescence analysis, capable of identifying elemental constituents from Al to U, provided the elemental analysis shown in Table II. The elements are shown in order of total fluorescent intensity (which is not simply related to the weight fraction of the elements present).

The external standard method [3] was used to quantify the relative weight fractions of the phases present in the soil samples: quartz (Q), montmorillonite (M), illite (I), stilbite (S), hydrosodalite (H), kaolinite (K), anorthite (A), calcite (C), and dolomite (D). The external standard method allows the weight percent of crystalline phases present in a mixture to be determined with reference to a single diffraction peak obtained from a fully dense reference standard. Each sample has been assumed to have the same packing factor as was measured from a sample of pure quartz prepared in the same manner. All the phases are assumed to have the same mass absorption coefficient as that of alpha quartz.

RESULTS AND DISCUSSION

The x-ray diffraction patterns are shown graphically in Figures 1 through 9 and are tabulated in Tables III through XI. The results are summarized in Tables I and II. The results of the quantitative analyses are presented in Tables XII through XVII.

The figures present the raw data as a plot of x-ray intensity versus the diffraction angle. The diffracted intensity, measured at each step scanning increment, is plotted individually.

For the tables of data generated on the diffractometer, detectable peaks are identified by an assigned number at the left of the table. The next two columns show the diffraction angle, "2-theta," and interplanar spacing, "d," after correction for systematic angular error using the NBS silicon standard. In the fourth column, "I/Io," the net peak maximum intensities are listed on a relative scale, with the most intense peak given a value of 100. The fifth column, "Net I % S.D.," displays the percentage standard deviation of the net peak intensity. Peaks with a standard deviation above 50% are not reported.

The absolute intensities, in counts per second, are presented in the next three columns under the headings "Peak,"

"B.G." (background), and "Net." The last column contains an estimate of the nominal diffraction peak width between inflection points.

CONCLUSIONS

Table I is the summary table showing the results of the semi-quantitative phase analysis. Table II shows the x-ray fluorescence analysis of the clay samples.

Figures 1 through 6 show the diffraction patterns of the clay samples. The absolute intensity, relative intensity, angle, d-spacing and half width for peaks in the diffraction patterns are shown in Tables III through VIII. The diffraction pattern and peak information for the calibration sample is included in Figures 7 through 9 and Tables VIII through XI. Tables XII through XVII show the output from the quantitative analysis program.

The -200 mesh fraction of the samples seem to contain more minerals than actual clay. The minerals identified are quartz, calcite, dolomite, stilbite, anorthite and hydrosodalite. The clays are identified as montmorillonite, illite and kaolinite.

The major constituents in most samples are quartz, calcite and dolomite. Anorthite, montmorillonite and illite could be considered as secondary phases while kaolinite, stilbite and hydrosodalite could form the minor phases.

Montmorillonite and illite are the major clay phases present while kaolinite could be considered as a secondary clay phase.

In some cases, the total percentage of crystalline phases exceeds one hundred. This is attributed to the use of RIR values for the phases identified, obtained from the literature, which could lead to a small error in the final analysis. Also, the packing factor for the clays is not rigorously determined which could also lead to a small error in the final analysis. Hence the results are termed as semi-quantitative and the numbers give the approximate amount of the phases present, rather than exact amounts.

REFERENCES:

(1) Hubbard, C., NIST Publication 567 (1980)

(2) Snyder, R.L. and Bish, D.L., Modern Powder Diffraction, Volume 20, 1989, pp. 101-141.

(3) Cullity, B.D., Elements of X-ray Diffraction, 1978, pp. 407-419.

LAMBDA RESEARCH, INC.
CINCINNATI, OH

X-RAY DIFFRACTION SEMI-QUANTITATIVE PHASE ANALYSIS

	WEIGHT PERCENT									
Sample	Mont.	Ill.	Stilb.	Kao	Hydro	Quartz	Anor	Calc	Dolo	%Cryst.
MND20-0342-0095	7	5	3	4	0	24	10	5	38	96
MND20-0343-0057	4	6	0	5	1	18	4	15	40	94
MND20-0343-0037	20	13	0	5	0	16	6	22	21	103
MND20-0342-0010	12	8	2	3	0	16	4	7	48	99
MND20-0342-0075	6	8	2	6	0	15	8	27	26	98
MND20-0342-0075[a]	6	7	0	6	0	17	6	30	34	107

(a) Repeat measurement

TABLE I

Legend:

Mont. : Montmorillonite
Ill. : Illite
Stilb.: Stilbite
Kao : Kaolinite
Hydro.: Hydrosodalite
Anor. : Anorthite
Calc. : Calcite
Dolo. : Dolomite
Cryst.: Crystallinity

LAMBDA RESEARCH, INC.
CINCINNATI, OH

X-RAY FLUORESCENCE ANALYSIS

Sample	Elements
MND20-0342-0095	Fe, Ca, Si, Ti
MND20-0343-0057	K, Cr, Ca, Al, Si
MND20-0343-0037	Fe, Ca, Si, Cl, Al
MND20-0342-0010	Fe, Ca, Si, K, Ti, Al
MND20-0342-0075	Ca, Fe, Cl, Si, P, Al

TABLE II

LAMBDA RESEARCH INC.
CINCINNATI OHIO

QUALITATIVE PHASE ANALYSIS

MND20-0342-0095 EG 1/.1MRLS/M
Data File: 624001.q51 9306E07AC Wavelength = 1.54178 (A)
Corrected Using NBS SRM 640 Maximum Intensity = 2684 cps

Range No 1 3.00 --> 54.00 deg. at .02 deg. steps for 2.0 s

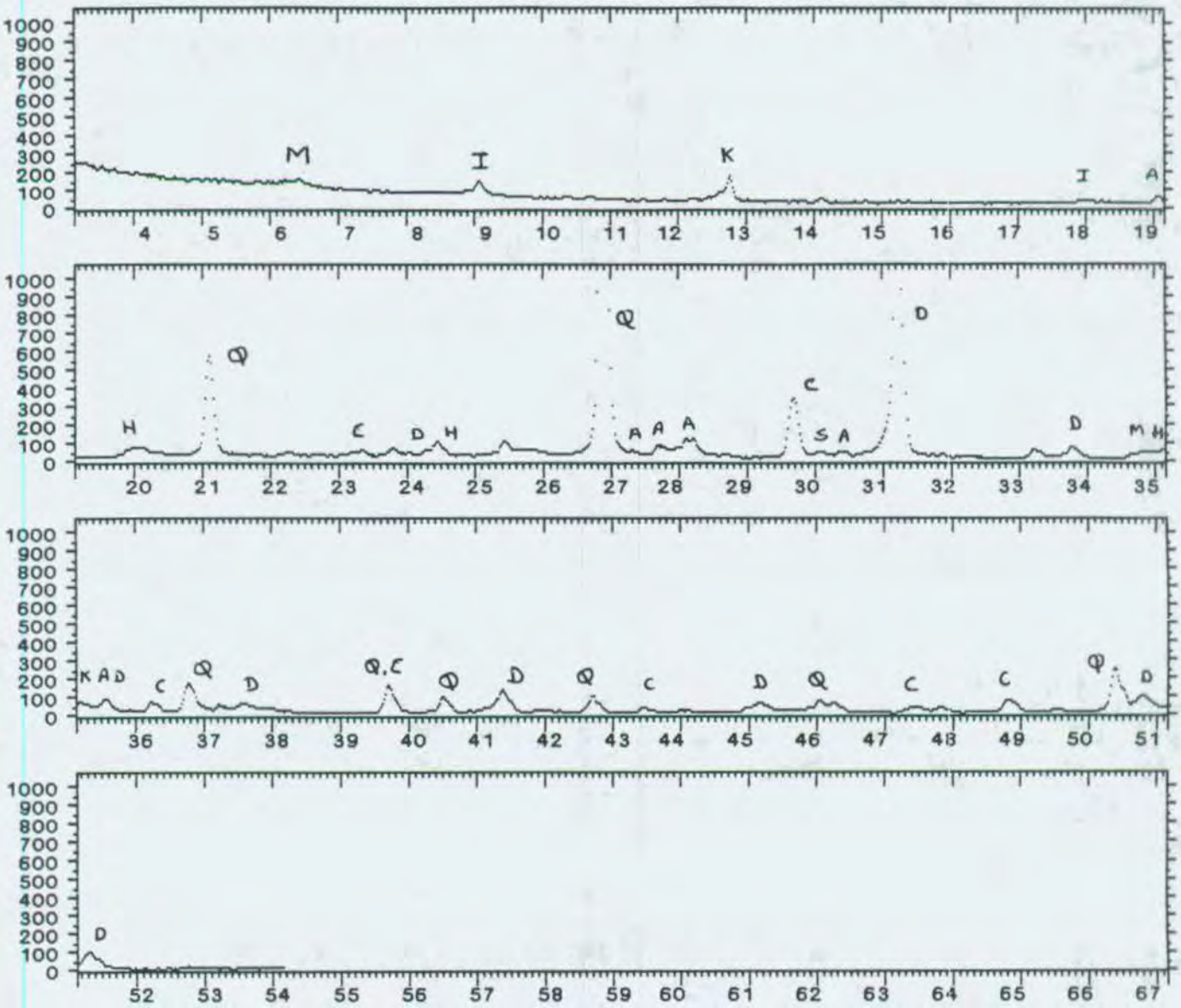

FIGURE 1

Lambda Research, Inc.

624001.q51 QUALTAB3.05.FOR 06/07/93

QUALITATIVE PHASE ANALYSIS

MND20-0342-0095 EG 1/.1MRLS/M

Data File: 624001.q51 9306E07AC Wavelength = 1.54178 (A)

Alignment Correction Using NBS SRM 640 Maximum Intensity = 2684 cps

Peak No.	2-Theta (deg.)	d(A)	I/Io	Net I %S.D.	Intensity (cps) Peak	B.G.	Net	Width (deg.)
Range No: 1	3.00 -->	54.00	deg. using	.02 deg. steps for			2.0 s	
1	6.46	13.682	2	38	175	128	46	.26
2	9.08	9.739	3	23	161	93	68	.24
3	12.76	6.938	5	12	182	56	126	.22
4	18.03	4.920	1	33	52	25	27	.18
5	19.02	4.666	2	18	78	21	57	.20
6	19.96	4.448	3	14	92	18	74	.32
7	21.05	4.220	22	4	586	15	571	.22
8	22.23	3.999	2	17	63	12	51	.22
9	22.69	3.919	1	20	49	11	38	.16
10	23.29	3.819	2	14	73	10	64	.23
11	23.74	3.748	3	13	82	9	73	.22
12	24.38	3.651	4	10	120	8	112	.24
13	25.36	3.512	5	10	125	7	118	.22
14	25.80	3.453	3	13	79	6	73	.24
15	26.81	3.325	100	2	2600	5	2595	.22
16	27.67	3.224	3	11	94	4	90	.18
17	28.15	3.170	5	9	141	4	137	.24
18	29.62	3.016	13	5	351	3	348	.22
19	30.30	2.950	2	13	62	3	60	.16
20	31.14	2.872	53	3	1383	2	1381	.24
21	33.14	2.703	3	12	74	2	72	.20
22	33.71	2.659	3	11	84	2	82	.24
23	35.11	2.556	3	11	84	2	82	.20
24	35.47	2.531	4	10	102	2	100	.20
25	36.15	2.485	3	11	85	2	83	.20
26	36.69	2.449	7	8	182	2	181	.22
27	37.49	2.399	3	12	71	2	70	.20
28	39.60	2.276	7	8	171	2	169	.24
29	40.42	2.232	4	10	109	2	107	.22
30	41.28	2.187	5	9	144	2	142	.26
31	41.92	2.155	1	18	39	3	36	.28
32	42.60	2.122	4	10	110	3	107	.24
33	43.36	2.087	2	16	50	3	46	.22
34	43.92	2.061	1	20	35	4	31	.26
35	44.40	2.040	1	23	28	4	24	.14
36	45.06	2.012	3	13	75	5	71	.34
37	45.94	1.975	3	12	88	5	82	.44
38	47.36	1.919	2	18	50	7	43	.24
39	47.72	1.906	1	19	46	7	38	.22
40	48.72	1.869	3	12	91	9	82	.24
41	49.46	1.843	1	26	36	10	26	.20

TABLE III

QUALITATIVE PHASE ANALYSIS

MND20-0342-0095 EG 1/.1MRLS/M

Peak No.	2-Theta (deg.)	d(A)	I/Io	Net I %S.D.	Intensity (cps) Peak	B.G.	Net	Width (deg.)
42	50.27	1.815	10	7	261	12	249	.22
43	50.65	1.802	4	11	113	13	100	.18
44	51.21	1.784	4	11	118	14	103	.24

TABLE III (cont.)

LAMBDA RESEARCH INC.
CINCINNATI OHIO

QUALITATIVE PHASE ANALYSIS

MND20-0343-0057 EG 1/.1MRLS/M
Data File: 624001.q08 9305E14AC Wavelength = 1.54178 (A)
Corrected Using NBS SRM 640 Maximum Intensity = 1849 cps

Range No 1 3.00 --> 40.00 deg. at .02 deg. steps for 2.0 s

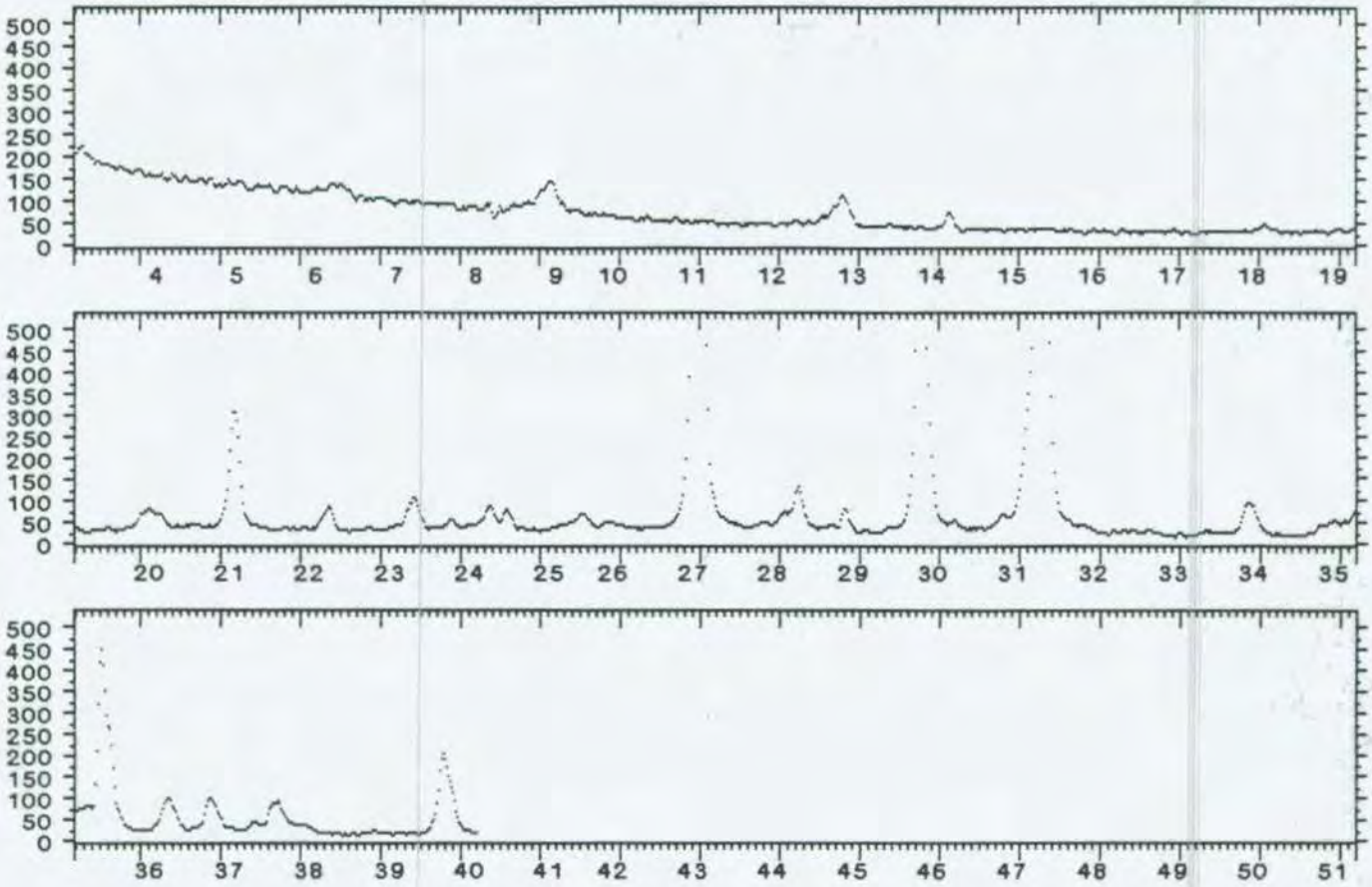

FIGURE 2

Lambda Research, Inc.

624001.q08 QUALTAB3.05.FOR 05/17/93

QUALITATIVE PHASE ANALYSIS

MND20-0343-0057 EG 1/.1MRLS/M

Data File: 624001.q08 9305E14AC Wavelength = 1.54178 (A)

Alignment Correction Using NBS SRM 640 Maximum Intensity = 1849 cps

Peak No.	2-Theta (deg.)	d(A)	I/Io	Net I %S.D.	Intensity (cps) Peak	B.G.	Net	Width (deg.)
Range No: 1	3.00 --> 40.00 deg. using .02 deg. steps for 2.0 s							
1	9.14	9.675	4	20	152	77	75	.24
2	12.76	6.938	4	18	120	48	72	.25
3	14.07	6.294	2	29	81	42	39	.22
4	20.04	4.431	3	23	86	37	49	.32
5	21.09	4.212	15	7	315	39	276	.22
6	22.27	3.992	3	25	90	43	46	.22
7	23.32	3.814	4	20	112	48	64	.21
8	24.28	3.666	2	30	93	53	40	.46
9	26.87	3.318	100	2	1889	75	1814	.22
10	28.13	3.172	2	34	134	91	44	.24
11	29.64	3.014	33	5	707	114	594	.22
12	31.16	2.870	50	4	1056	144	912	.26
13	35.39	2.536	10	14	462	273	189	.22

TABLE IV

LAMBDA RESEARCH INC.
CINCINNATI OHIO

QUALITATIVE PHASE ANALYSIS

MND20-0343-0037 EG 1/.1MRLS/M
Data File: 624001.q15 9305E18AC Wavelength = 1.54178 (A)
Corrected Using NBS SRM 640 Maximum Intensity = 1517 cps

Range No 1 3.00 --> 40.00 deg. at .02 deg. steps for 2.0 s

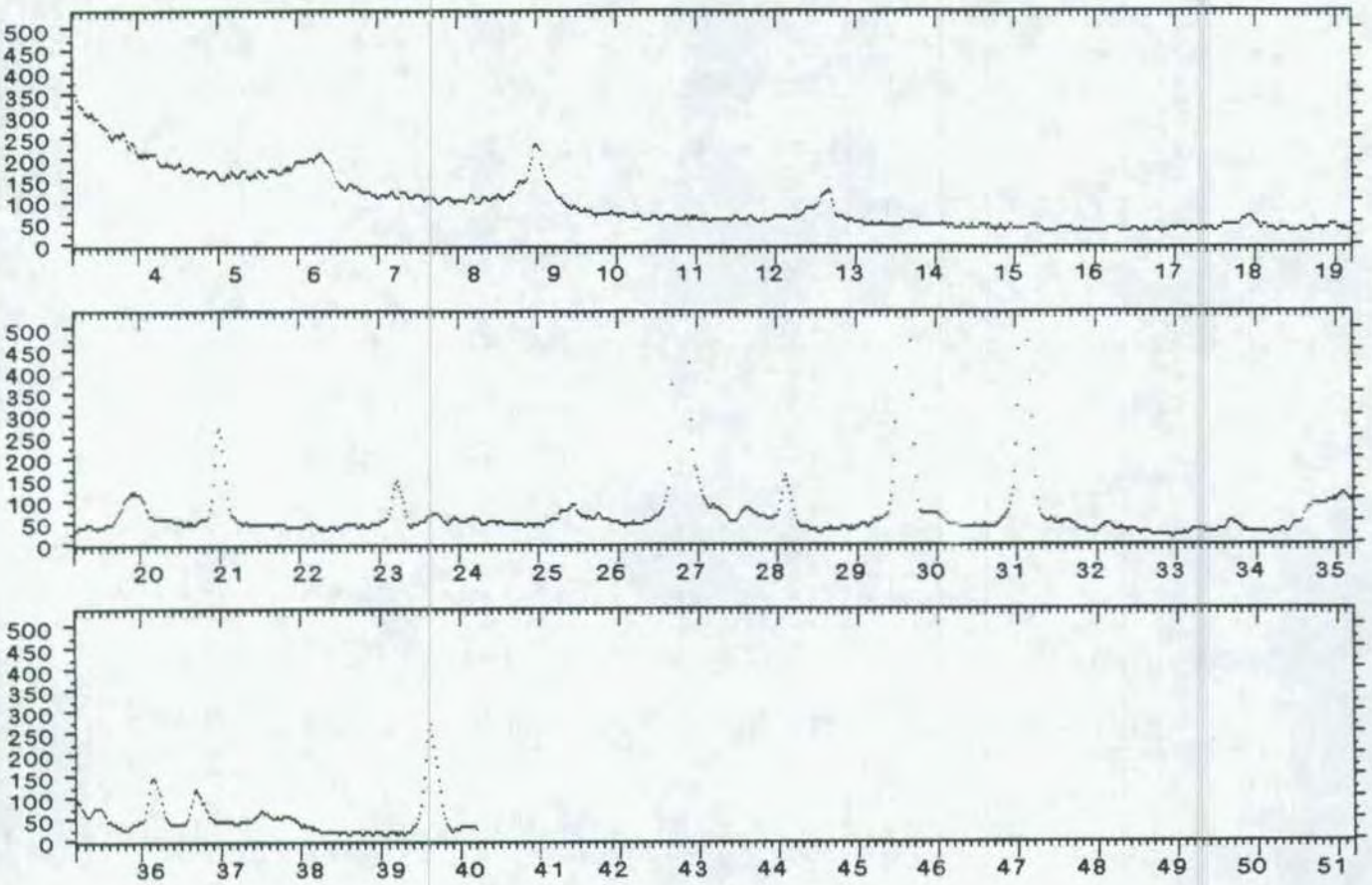

FIGURE 3

Lambda Research, Inc.

624001.q15 QUALTAB3.05.FOR 05/25/93

QUALITATIVE PHASE ANALYSIS

MND20-0343-0037 EG 1/.1MRLS/M

Data File: 624001.q15 9305E18AC Wavelength = 1.54178 (A)

Alignment Correction Using NBS SRM 640 Maximum Intensity = 1517 cps

Peak No.	2-Theta (deg.)	d(A)	I/Io	Net I %S.D.	Intensity (cps) Peak	B.G.	Net	Width (deg.)
Range No: 1	3.00 -->	40.00	deg. using	.02 deg.	steps for	2.0 s		
1	6.28	14.074	6	22	215	131	84	.52
2	8.96	9.869	10	13	238	94	143	.24
3	12.62	7.014	5	20	129	59	69	.24
4	17.83	4.975	3	26	68	30	38	.24
5	18.90	4.695	2	35	51	26	25	.22
6	19.86	4.470	7	12	122	24	99	.30
7	20.91	4.248	17	7	277	21	256	.20
8	22.07	4.028	2	24	53	18	35	.18
9	22.57	3.939	2	25	51	17	33	.20
10	23.13	3.845	9	10	147	17	131	.20
11	23.60	3.770	4	17	72	16	56	.20
12	24.08	3.696	3	18	65	15	50	.20
13	25.32	3.517	5	13	94	14	80	.28
14	26.69	3.340	100	3	1491	13	1478	.22
15	27.51	3.242	5	14	85	12	73	.20
16	27.99	3.188	10	9	160	12	148	.22
17	29.46	3.032	65	3	972	12	960	.22
18	30.98	2.887	47	4	702	12	690	.24
19	33.20	2.698	2	29	38	13	25	.20
20	33.55	2.671	3	20	57	14	43	.22
21	34.93	2.569	7	11	115	15	100	.26
22	36.01	2.494	9	10	152	17	135	.24
23	36.55	2.458	7	11	124	17	106	.22
24	37.39	2.405	4	18	72	19	53	.22
25	39.48	2.282	17	7	272	24	248	.24

TABLE V

LAMBDA RESEARCH INC.
CINCINNATI OHIO

QUALITATIVE PHASE ANALYSIS

MND20-0342-0010 EG 1/.1MRLS/M
Data File: 624001.q18 9305E18AC Wavelength = 1.54178 (A)
Corrected Using NBS SRM 640 Maximum Intensity = 1312 cps

Range No 1 3.00 --> 40.00 deg. at .02 deg. steps for 2.0 s

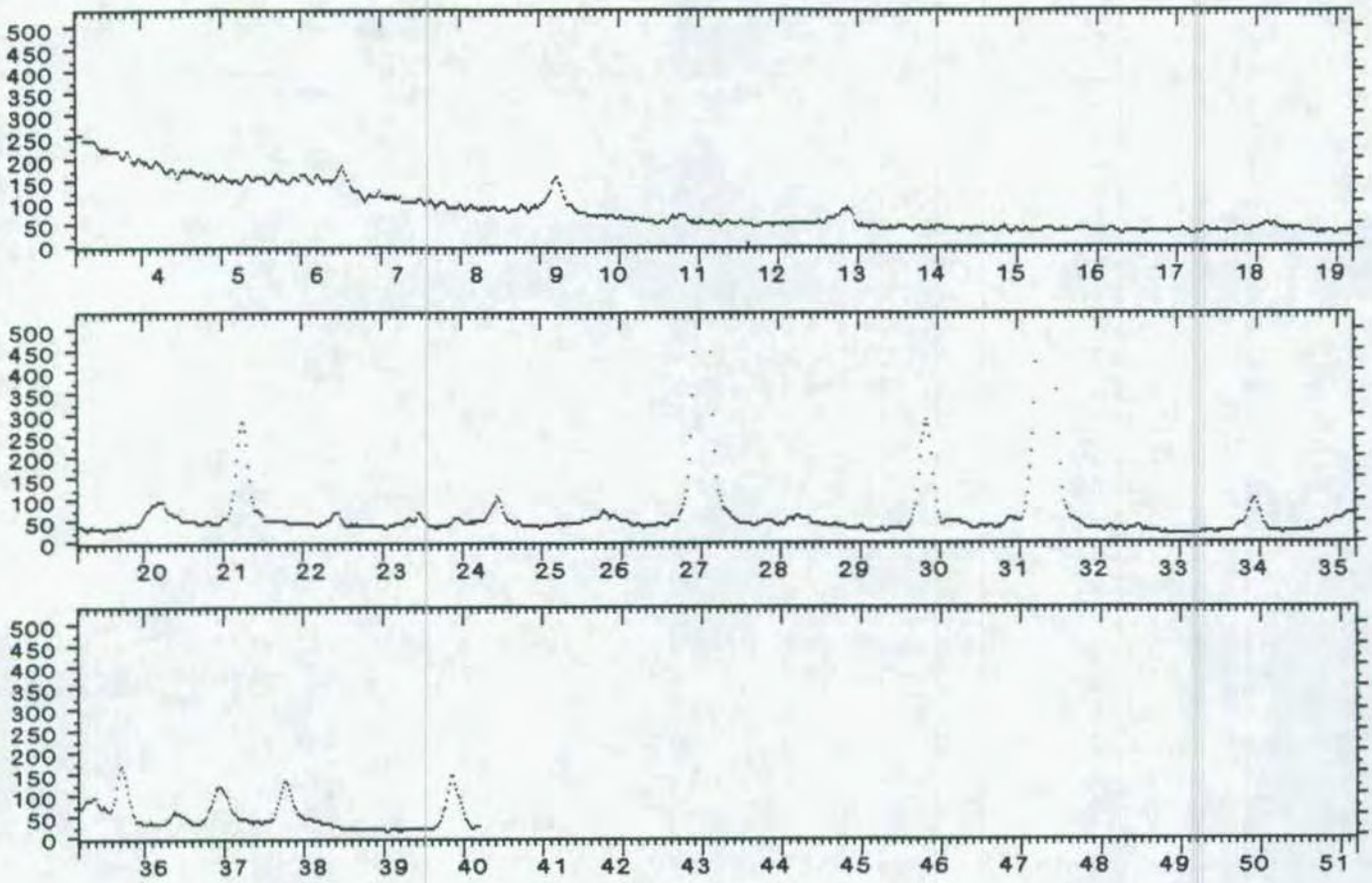

FIGURE 4

Lambda Research, Inc.

624001.q18 QUALTAB3.05.FOR 05/19/93

QUALITATIVE PHASE ANALYSIS page 1

MND20-0342-0010 EG 1/.1MRLS/M

Data File: 624001.q18 9305E18AC Wavelength = 1.54178 (A)

Alignment Correction Using NBS SRM 640 Maximum Intensity = 1312 cps

Peak No.	2-Theta (deg.)	d(A)	I/Io	Net I %S.D.	Intensity (cps) Peak	B.G.	Net	Width (deg.)
Range No: 1	3.00 --> 40.00 deg. using .02 deg. steps for 2.0 s							
1	6.52	13.556	6	25	191	119	72	.22
2	9.18	9.633	7	18	164	79	86	.24
3	12.82	6.905	4	28	90	48	42	.23
4	18.05	4.914	2	49	54	35	19	.24
5	20.14	4.409	5	19	100	37	62	.32
6	21.15	4.201	21	7	287	40	247	.22
7	22.33	3.981	3	33	77	44	33	.20
8	23.34	3.811	2	47	73	49	23	.35
9	24.34	3.657	5	24	109	56	54	.22
10	26.93	3.311	97	3	1216	80	1135	.24
11	29.72	3.006	14	12	291	124	166	.22
12	31.22	2.865	100	3	1328	158	1171	.26

TABLE VI

LAMBDA RESEARCH INC.
CINCINNATI OHIO

QUALITATIVE PHASE ANALYSIS

MND20-0342-0075 EG 1/.1MRLS/M
Data File: 624001.q20 9305E19AC Wavelength = 1.54178 (A)
Corrected Using NBS SRM 640 Maximum Intensity = 1568 cps

Range No 1 3.00 --> 40.00 deg. at .02 deg. steps for 2.0 s

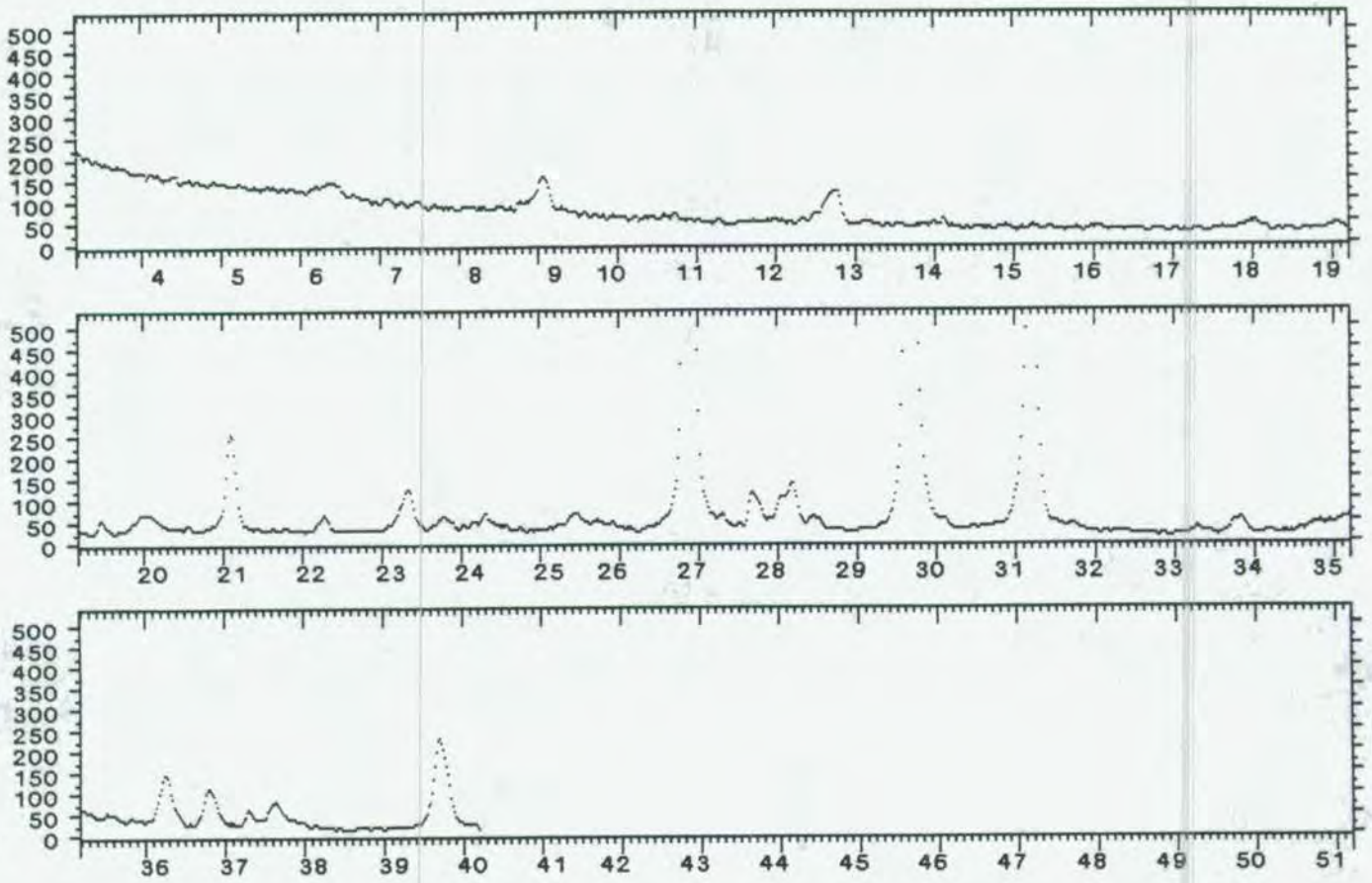

FIGURE 5

Lambda Research, Inc.

624001.q20 QUALTAB3.05.FOR 05/19/93

QUALITATIVE PHASE ANALYSIS

MND20-0342-0075 EG 1/.1MRLS/M

Data File: 624001.q20 9305E19AC Wavelength = 1.54178 (A)

Alignment Correction Using NBS SRM 640 Maximum Intensity = 1568 cps

Peak No.	2-Theta (deg.)	d(A)	I/Io	Net I %S.D.	Intensity (cps) Peak	B.G.	Net	Width (deg.)
Range No: 1	3.00 -->	40.00	deg. using	.02 deg. steps for	2.0 s			
1	9.04	9.782	5	20	164	85	79	.22
2	12.72	6.959	5	18	126	53	73	.26
3	17.97	4.936	2	34	53	27	27	.22
4	18.98	4.676	2	32	51	24	27	.24
5	19.40	4.575	3	22	64	23	42	.20
6	19.96	4.448	4	18	76	21	55	.30
7	21.01	4.228	16	7	265	19	246	.22
8	22.19	4.006	4	17	73	17	56	.22
9	23.25	3.826	8	10	134	15	119	.21
10	23.66	3.760	4	17	67	15	53	.20
11	24.22	3.675	4	16	71	14	58	.28
12	25.34	3.515	4	15	76	13	63	.22
13	26.77	3.330	100	3	1512	12	1500	.24
14	27.57	3.235	8	10	124	12	113	.20
15	28.09	3.177	9	10	142	12	130	.24
16	29.56	3.022	72	3	1097	12	1085	.24
17	31.08	2.877	45	4	686	12	674	.24
18	33.16	2.702	2	27	41	13	27	.24
19	33.71	2.659	3	18	62	14	48	.22
20	35.09	2.557	3	17	67	15	52	.24
21	36.13	2.486	9	10	149	17	132	.24
22	36.67	2.451	6	12	115	18	97	.22
23	37.51	2.398	4	16	84	19	65	.20
24	39.56	2.278	14	8	238	25	213	.26

TABLE VII

LAMBDA RESEARCH INC.
CINCINNATI OHIO

QUALITATIVE PHASE ANALYSIS

MND20-0342-0075 EG rpt 1/.1MRLS/M
Data File: 624001.q21 9305E19AC Wavelength = 1.54178 (A)
Corrected Using NBS SRM 640 Maximum Intensity = 1935 cps

Range No 1 3.00 --> 40.00 deg. at .02 deg. steps for 2.0 s

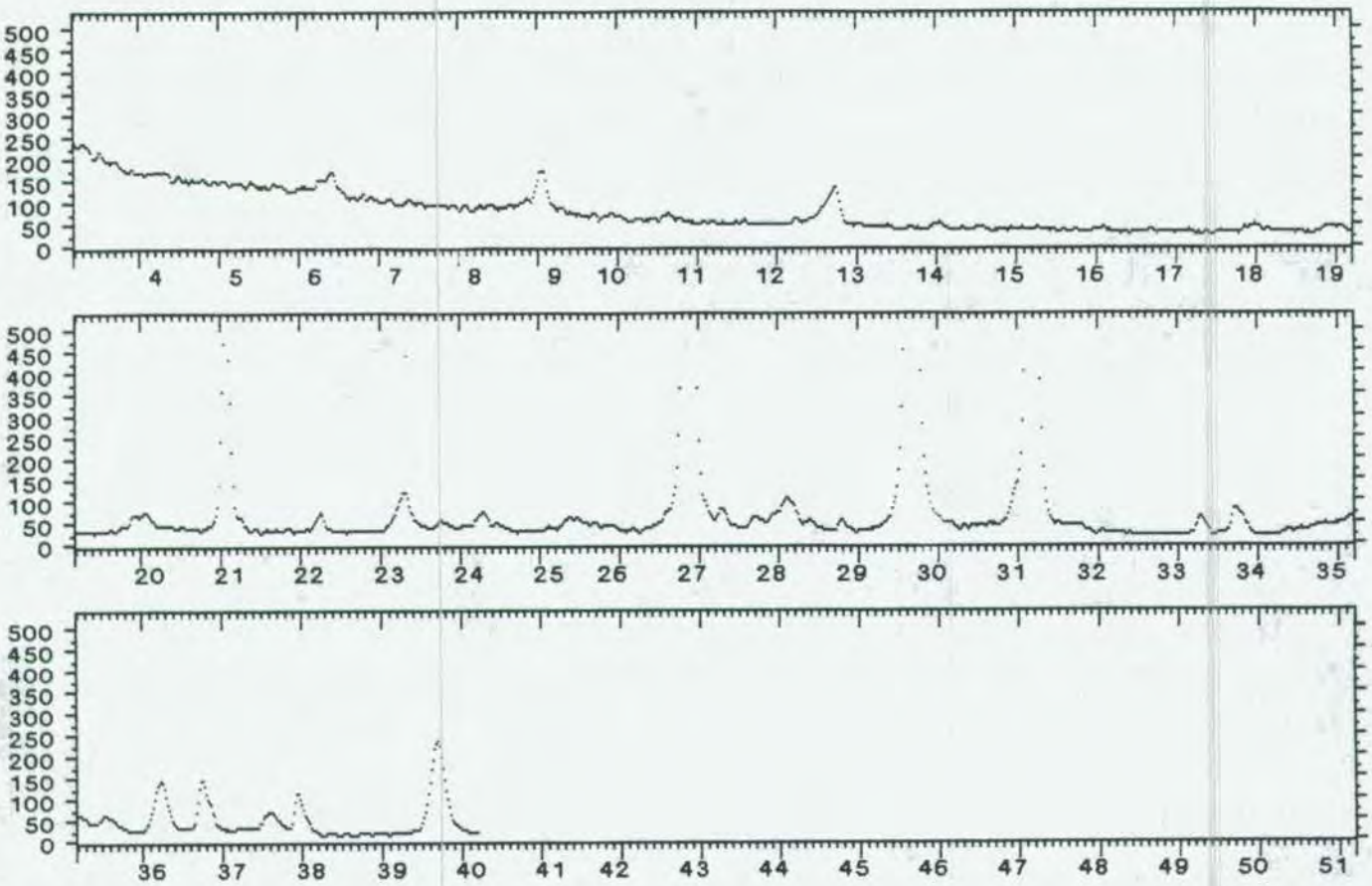

FIGURE 6

Lambda Research, Inc.

624001.q21 QUALTAB3.05.FOR 05/19/93

QUALITATIVE PHASE ANALYSIS page 1

MND20-0342-0075 EG rpt 1/.1MRLS/M

Data File: 624001.q21 9305E19AC Wavelength = 1.54178 (A)

Alignment Correction Using NBS SRM 640 Maximum Intensity = 1935 cps

Peak No.	2-Theta (deg.)	d(A)	I/Io	Net I %S.D.	Intensity (cps) Peak	B.G.	Net	Width (deg.)
Range No: 1	3.00 --> 40.00 deg. using .02 deg. steps for 2.0 s							
1	6.40	13.810	3	32	175	122	54	.24
2	9.04	9.782	5	16	179	81	98	.22
3	12.68	6.981	5	16	138	50	88	.24
4	19.98	4.444	3	24	83	37	46	.30
5	20.97	4.236	28	5	540	39	501	.22
6	22.17	4.010	2	32	78	43	35	.22
7	23.23	3.829	4	17	123	48	76	.23
8	24.18 Kb	3.330	1	46	78	53	25	.24
9	26.77	3.330	100	2	1890	76	1814	.22
10	29.54	3.024	64	3	1272	115	1157	.24
11	31.06	2.879	44	4	951	146	806	.24

TABLE VIII

LAMBDA RESEARCH INC.
CINCINNATI OHIO

QUALITATIVE PHASE ANALYSIS

Novaculite Std 1/.1MRLS/M
Data File: 624001.q12 9305E17AC Wavelength = 1.54178 (A)
Corrected Using NBS SRM 640 Maximum Intensity = 12492 cps

Range No 1 25.00 --> 30.00 deg. at .02 deg. steps for 2.0 s

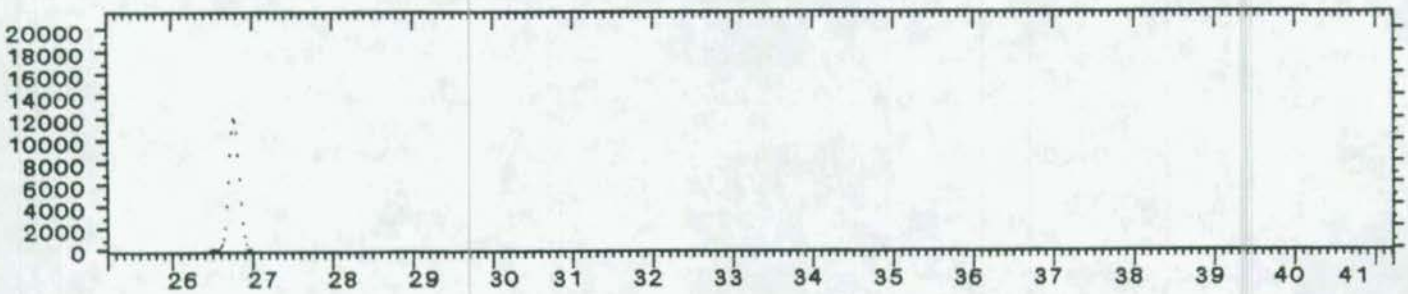

FIGURE 7

Lambda Research, Inc.

624001.q12 QUALTAB3.05.FOR 06/04/93

QUALITATIVE PHASE ANALYSIS page 1

Novaculite Std 1/.1MRLS/M

Data File: 624001.q12 9305E17AC Wavelength = 1.54178 (A)

Alignment Correction Using NBS SRM 640 Maximum Intensity = 12492 cps

Peak No.	2-Theta (deg.)	d(A)	I/Io	Net I %S.D.	Intensity (cps) Peak	B.G.	Net	Width (deg.)
Range No: 1	25.00 --> 30.00 deg. using .02 deg. steps for 2.0 s							
1	26.63	3.347	100	1	12315	20	12295	.22

TABLE IX

LAMBDA RESEARCH INC.
CINCINNATI OHIO

QUALITATIVE PHASE ANALYSIS

novaculite std 1/.1MRLS/M
Data File: 624001.q16 9305E18AC Wavelength = 1.54178 (A)
Corrected Using NBS SRM 640 Maximum Intensity = 12551 cps

Range No 1 25.00 --> 30.00 deg. at .02 deg. steps for 2.0 s

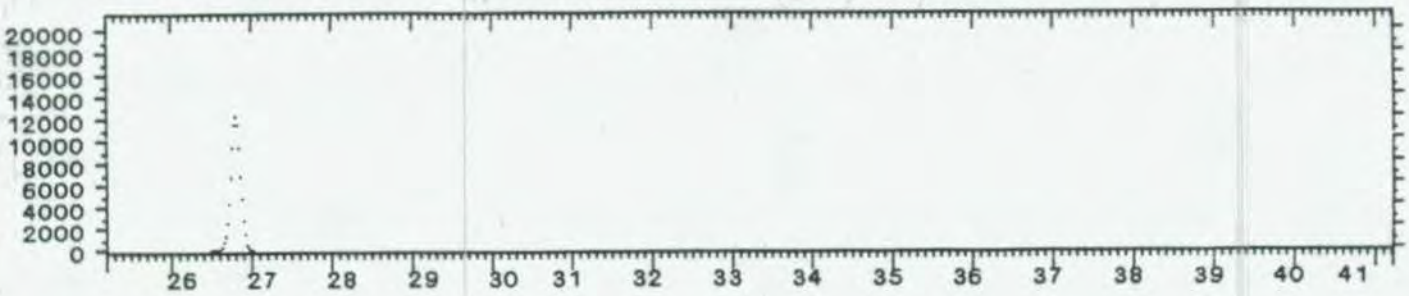

FIGURE 8

Lambda Research, Inc.

624001.q16 QUALTAB3.05.FOR 06/04/93

QUALITATIVE PHASE ANALYSIS page 1

novaculite std 1/.1MRLS/M

Data File: 624001.q16 9305E18AC Wavelength = 1.54178 (A)

Alignment Correction Using NBS SRM 640 Maximum Intensity = 12551 cps

Peak No.	2-Theta (deg.)	d(A)	I/Io	Net I %S.D.	Intensity (cps) Peak	B.G.	Net	Width (deg.)
Range No: 1	25.00 --> 30.00 deg. using .02 deg. steps for 2.0 s							
1	26.67	3.342	100	1	12595	24	12571	.24

TABLE X

LAMBDA RESEARCH INC.
CINCINNATI OHIO

QUALITATIVE PHASE ANALYSIS

novaculite std
Data File: 624001.q22 9305E19AC
Corrected Using NBS SRM 640

1/.1MRLS/M
Wavelength = 1.54178 (A)
Maximum Intensity = 12715 cps

Range No 1 25.00 --> 30.00 deg. at .02 deg. steps for 2.0 s

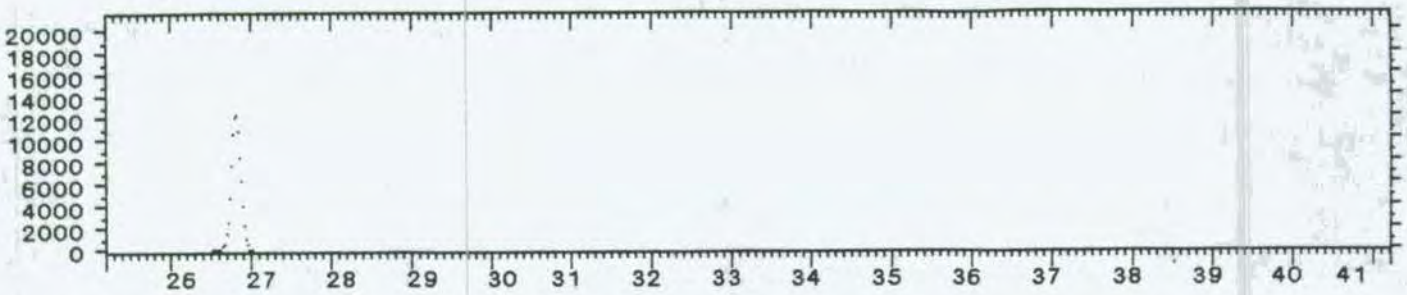

FIGURE 9

Lambda Research, Inc.

624001.q22 QUALTAB3.05.FOR 06/04/93

QUALITATIVE PHASE ANALYSIS page 1

novaculite std 1/.1MRLS/M

Data File: 624001.q22 9305E19AC Wavelength = 1.54178 (A)

Alignment Correction Using NBS SRM 640 Maximum Intensity = 12715 cps

Peak No.	2-Theta (deg.)	d(A)	I/Io	Net I %S.D.	Intensity (cps) Peak	B.G.	Net	Width (deg.)

Range No: 1 25.00 --> 30.00 deg. using .02 deg. steps for 2.0 s

TABLE XI

Lambda Research, Inc.

624001.q07 QUANT2.30 06/01/93

QUANTITATIVE PHASE ANALYSIS
EXTERNAL STANDARD METHOD

MND20-0342-0095 EG 1/.1MRLS/M

PHASE	WEIGHT %		ERROR
Montmorillonite	7.10	+-	.96
Illite	5.31	+-	.37
Stilbite	2.87	+-	.54
Kaolinite	4.40	+-	.36
Hydrosodalite	.24	+-	.70
Quartz	23.78	+-	.13
Anorthite	9.94	+-	.18
Calcite	4.82	+-	.07
Dolomite	37.69	+-	.26
PERCENT CRYSTALLINITY	96.14	+-	1.44

External Standard Data File: 624001.q12

Technique File: clay_ext.tec

TABLE XII

Lambda Research, Inc.

624001.q08 QUANT2.30 06/01/93

QUANTITATIVE PHASE ANALYSIS
EXTERNAL STANDARD METHOD

MND20-0343-0057 EG 1/.1MRLS/M

PHASE	WEIGHT %		ERROR
Montmorillonite	4.43	+-	.87
Illite	6.37	+-	.36
Stilbite	.30	+-	.51
Kaolinite	5.07	+-	.35
Hydrosodalite	.80	+-	.67
Quartz	17.69	+-	.11
Anorthite	4.42	+-	.15
Calcite	15.33	+-	.13
Dolomite	39.65	+-	.26
PERCENT CRYSTALLINITY	94.04	+-	1.36

External Standard Data File: 624001.q12

Technique File: clay_ext.tec

TABLE XIII

Lambda Research, Inc.

624001.q15 QUANT2.30 06/01/93

QUANTITATIVE PHASE ANALYSIS
EXTERNAL STANDARD METHOD

MND20-0343-0037 EG 1/.1MRLS/M

PHASE	WEIGHT %		ERROR
Montmorillonite	19.73	+-	.97
Illite	13.32	+-	.39
Stilbite	.00	+-	.52
Kaolinite	5.23	+-	.36
Hydrosodalite	.00	+-	.69
Quartz	15.76	+-	.10
Anorthite	6.26	+-	.16
Calcite	21.49	+-	.16
Dolomite	21.19	+-	.19
PERCENT CRYSTALLINITY	102.99	+-	1.44

External Standard Data File: 624001.q12

Technique File: clay_ext.tec

TABLE XIV

624001.q18 Lambda Research, Inc. QUANT2.30 06/01/93

QUANTITATIVE PHASE ANALYSIS
EXTERNAL STANDARD METHOD

MND20-0342-0010 EG 1/.1MRLS/M

PHASE	WEIGHT %		ERROR
Montmorillonite	12.02	+-	.99
Illite	7.51	+-	.37
Stilbite	1.84	+-	.53
Kaolinite	2.54	+-	.36
Hydrosodalite	.00	+-	.69
Quartz	16.01	+-	.10
Anorthite	4.04	+-	.16
Calcite	6.76	+-	.09
Dolomite	48.36	+-	.30
PERCENT CRYSTALLINITY	99.07	+-	1.46

External Standard Data File: 624001.q16

Technique File: clay_ext.tec

TABLE XV

Lambda Research, Inc.

624001.q20 QUANT2.30 06/01/93

QUANTITATIVE PHASE ANALYSIS
EXTERNAL STANDARD METHOD

MND20-0342-0075 EG 1/.1MRLS/M

PHASE	WEIGHT %		ERROR
Montmorillonite	6.36	+-	.93
Illite	8.37	+-	.37
Stilbite	2.06	+-	.52
Kaolinite	5.61	+-	.37
Hydrosodalite	.00	+-	.70
Quartz	15.03	+-	.10
Anorthite	8.30	+-	.17
Calcite	26.55	+-	.19
Dolomite	25.79	+-	.22
PERCENT CRYSTALLINITY	98.06	+-	1.43

External Standard Data File: 624001.q22

Technique File: clay_ext.tec

TABLE XVI

624001.q21 Lambda Research, Inc. QUANT2.30 06/01/93

QUANTITATIVE PHASE ANALYSIS
EXTERNAL STANDARD METHOD

MND20-0342-0075 EG rpt 1/.1MRLS/M

PHASE	WEIGHT %		ERROR
Montmorillonite	6.32	+-	.95
Illite	7.27	+-	.38
Stilbite	.25	+-	.55
Kaolinite	5.90	+-	.38
Hydrosodalite	.00	+-	.71
Quartz	16.79	+-	.11
Anorthite	6.31	+-	.16
Calcite	30.29	+-	.20
Dolomite	33.51	+-	.25
PERCENT CRYSTALLINITY	106.66	+-	1.46

TABLE XVII

External Standard Data File: 624001.q22

Technique File: clay_ext.tec

C.3. FIELD FORMS FOR pH MEASUREMENTS

WESTON

pH DATA
(Soil pH, Aqueous pH, Corrosivity by pH)

Batch : 03

Test Soil pH

Worksheet : 01

RFW #/Standard	pH < 7.00	pH > 7.00	SOLID PREP/ COMMENT
MNA20-0344-0018		7.3	
MNA20-0344-0025.		7.4	
MNA20-0344-0030	6.9		
MNA20-0344-0035	6.2		
MNA20-0344-0040		7.8	
MNA20-0344-0060		7.7	
MNA20-0344-0065		8.0	
MNA20-0344-0115		7.3	

Logbook : NA

pH meter ID : RF0004884

Date: 1/26/93

Analyst: M. [illegible]

Time: 1715

Reviewed by:

Date:

RFW 21-21-016/F-12/89

WESTON

pH DATA
(Soil pH, Aqueous pH, Corrosivity by pH)

Batch # 06

Test Soil pH

Worksheet # 02

RFW #/Standard	pH < 7.00	pH > 7.00	SOLID PREP/ COMMENT
MND20-0343-0028	6.9		
MND20-0343-0057	7.0		

Logbook # NA

pH meter ID # RFW04884

Date: 2/24/93

Analyst: MJWinch

Time: ~~1415~~ ~~09~~ 1350

Reviewed by:

Date:

RFW 21-21-016/F-12/89

WESTON

pH DATA
(Soil pH, Aqueous pH, Corrosivity by pH)

Batch # 06

Test Soil pH

Worksheet # 03

RFW #/Standard	pH < 7.00	pH > 7.00	SOLID PREP/ COMMENT
MNDZO-0343-0057	--	7.3	
MNDZO-0343-~~8~~0080		7.1	

Logbook # NA

pH meter ID # RFW04884

Date: 3/2/93

Analyst: [illegible]

Time: 900

Reviewed by:

Date:

RFW 21-21-016/F-12/89

WESTON

pH DATA
(Soil pH, Aqueous pH, Corrosivity by pH)

Batch # 07

Test Soil pH

Worksheet # D4

RFW #/Standard	pH < 7.00	pH > 7.00	SOLID PREP/ COMMENT
MNA20-0386-0033	7.0		
MNA20-0386-0035		7.4	
MNA20-0386-0055		7.7	
MNA20-0386-0080		7.8	

Logbook # NA

pH meter ID # RFW04884

Date: 3/23/93

Analyst: [illegible]

Time: 13:15

Reviewed by:

Date:

RFW 21-21-016/F-12/89

WESTON

pH DATA
(Soil pH, Aqueous pH, Corrosivity by pH)

Batch # D8

Test Soil pH

Worksheet # 05

RFW #/Standard	pH < 7.00	pH > 7.00	SOLID PREP/ COMMENT
MNDX0-0341-0000		7.1	

Logbook # N/A

pH meter ID # RFW04884

Date: 3/30/93

Analyst: MJWrack

Time: 1845

Reviewed by:

Date:

RFW 21-21-016/F-12/89

WESTON

pH DATA
(Soil pH, Aqueous pH, Corrosivity by pH)

Batch # 08

Test Soil pH

Worksheet # 06

RFW #/Standard	pH < 7.00	pH > 7.00	SOLID PREP/ COMMENT
MND20-0346-0025	7.0		
MND20-0346-0035	7.0		

Logbook # NA

pH meter ID # RFW04884

Date: 4/3/93

Analyst: M Jarnes

Time: 1140

Reviewed by:

Date:

RFW 21-21-016/F-12/89

WESTON

pH DATA
(Soil pH, Aqueous pH, Corrosivity by pH)

Batch # 09

Test Soil pH

Worksheet # 07

RFW #/Standard	pH < 7.00	pH > 7.00	SOLID PREP/ COMMENT
MNDZ0-0342-0010	6.8		
MNDZ0-0342-0075	7.0		
MNDZ0-0342-0095	7.1		

Logbook # NA

pH meter ID # RFW04884

Date: 4/4/93

Analyst: [illegible]

Time: 1730

Reviewed by:

Date:

RFW 21-21-016/F-12/89

WESTON

pH DATA
(Soil pH, Aqueous pH, Corrosivity by pH)

Batch # 0

Test Soil pH

Worksheet # 08

RFW #/Standard	pH < 7.00	pH > 7.00	SOLID PREP/ COMMENT
MND2C PC26-0048		7.2	
MND2CPC26-0083		7.2	

Logbook # NA

pH meter ID # RF-00484

Date: 4/21/93

Analyst: MJ Dunn

Time: 1140

Reviewed by:

Date:

RFW 21-21-016/F-12/89

APPENDIX D

HYDROLOGY DATA

APPENDIX D

HYDROLOGY DATA

D.1. SUMMARY OF AQUIFER PARAMETERS FROM AQUIFER TESTS FROM OU 1 REMEDIAL INVESTIGATION REPORT

D.2. SUMMARY DATA OF WATER LEVEL MONITORING

D.2.1. SUMMARY TABLE, HYDROGRAPHS OF MONTHLY MEASURED MONITORING WELLS AND PIEZOMETERS, AND GROUNDWATER ELEVATION MAPS APRIL TO DECEMBER 1993

D.2.2. CALIBRATIONS AND HYDROGRAPHS OF CONTINUOUSLY MONITORED WELLS AND PIEZOMETERS, 1 JULY TO 31 DECEMBER 1993

D.2.3 CALCULATIONS OF VERTICAL GRADIENTS

D.2.4 PUMPING TEST DATA FROM BOREHOLE 0352

D.3. ESTIMATES OF GROUNDWATER BUDGET

D.4. PRECIPITATION DATA

D.4.1. PRECIPITATION DATA FROM MOUND PLANT

D.4.2. PRECIPITATION FROM USGS GAUGE

D.5. INDUSTRIAL AND MUNICIPAL PUMPING RATES

D.5.1. 1992 PUMPING RATES FOR MOUND PLANT PRODUCTION WELLS FROM OU 1 REMEDIAL INVESTIGATION REPORT

D.5.2. 1992 PUMPING RATES FOR MIAMISBURG AND DAYTON POWER AND LIGHT COMPANY PRODUCTION WELLS

D.1. SUMMARY OF AQUIFER PARAMETERS FROM AQUIFER TESTS FROM OU 1 REMEDIAL INVESTIGATION REPORT

Table IV.5. Comparison of Aquifer Parameters Calculated from May 1993 Aquifer Test

Well Number	Complete Test							20,000 Minutes into the Test			
	Theis		Neuman			Hantush		Neuman			
	Transmissivity (ft^2/day)	S	Transmissivity (ft^2/day)	S	Sy	Transmissivity (ft^2/day)	Sy	Transmissivity (ft^2/day)	Conductivity (ft/day*)	S	Sy
0912	35,800	0.23	36,000		0.23	18,500	0.15	27,500	460	0.11	0.12
P018	45,700	0.13	45,700		0.14			49,100	820	0.06	0.07
P009	54,300	0.11	49,100		0.13			47,500	800	0.004	0.13
P013	58,300	0.13	47,900		0.1			30,200	500	0.03	0.1
P029	55,800	0.09	57,800		0.08			50,900	850	0.009	0.10
0156	46,400	0.15	50,500		0.13			52,200	870	0.001	0.14
0304						17,900	0.06	54,100	900	0.14	0.27
0393	29,800	0.27	27,700		0.21	14,700	0.17	32,600	550	0.1	0.14
P005			39,100		0.05			36,400	600	0.01	0.05
0309						30,500	0.33	30,800	500	0.28	0.34
0394	58,400	0.01	39,600		0.04			38,700	650	0.01	0.04
P027			33,900		0.11			32,300	550	0.1	0.17
P032			53,300		0.09	44,900	0.09	55,200	900	0.001	0.07
P006			35,500		0.06			34,300	600	0.02	0.06

*Transmissivity divided by Well 0071 thickness (60 ft) values are rounded.

Table IV.3. Factors Affecting Measured Drawdown in Monitoring Wells

Well Number	Formation of Completion	Filter Pack Interval (FPI)	Saturated Thickness (ft)	Aquifer Unit	Measurement Method	Fine Grained Unit above FPI	Partially Penetrating	Barometric Pressure	River Stage	0076 Pumping	0071 Pumping
P035	GP	18.0-25.0	93	UBVA	Telog	N	Y	Y	Y		N
P036	GP	46.0-55.0	93	UBVA	Telog	N	Y	Y	Y		N
P037	GP/SP/GP	78.0-85.0	93	LBVA	Telog	N	Y	Y	Y		N
P038	GP/SP/TI	90.0-98.0	93	LBVA	Telog	N	Y	Y	Y		N
P039	GP	13.0-20.0	45	UBVA	Telog	N	Y	Y	Y		N
P040	GP/SP	35.0-42.0	45	UBVA	Telog	N	Y	Y	Y		N
P041	GP/SP	45.0-52.0	45	LBVA	Telog	N	Y	Y	Y		N
P042	ST	59.0-68.5	Bedrock	Bedrock	Telog	N	N	Y	Y		N
0118	SM-SP	27.5-41.5	92	UBVA	Hand	Y	Y	h	h	h	h
0152	SP/CL/GP/GC/SH	22.0-47.0	18	UBVA	Hand	Y	N	h	h	h	h
0313	CL/GW	30.5-41.5	13(e)	UBVA	Hand	Y	N	h	h	h	h
0320	CL/SW/SP-SW	27.0-43.5	160(e)	UBVA	Hand	Y	Y	h	h	h	h
0344	GP	162.0-175.5	156	LBVA	Hand	N	N	h	h	h	h
0354	CL/ST-LS	11.0-23.0	Bedrock	Bedrock	Hand	Y	N	h	h	h	h
0129	SM-SP	28.5-41.5	31(e)	UBVA	Hand	N	Y	h	h	h	h
P017	GP/SP/GP	17.0-25.0	152(e)	UBVA	Telog	N	Y	U	U		U
0130	SP	22.5-35.5	148(e)	UBVA	Telog	N	Y	Y	Y		Y
0156	SM-SP/ML-GM/SP	23.0-36.5	149(e)	UBVA	Telog	N	Y		Y		Y
0157	GP/SP/GP	48.3-61.8	149(e)	UBVA	Telog	N	Y		Y		Y
0159	SP/GP	17.0-32.0	43(e)	UBVA	Telog	N	N		Y		Y
0302	GC-GM/SP	105.0-120.6	118(e)	LBVA	Telog	Y	N		Y		Y
0304	CL/SP-GP-GM	87.5-103.9	150(e)	LBVA	Telog	Y	Y		Y		Y
0333	GP/SP-GP	63.0-75.0	143	LBVA	Telog	Y	Y	Y	Y		N
0334	GP	16.0-29.0	143(e)	UBVA	Telog	N	Y	Y	Y		N

Table IV.3. (page 2 of 3)

Well Number	Formation of Completion	Filter Pack Interval (FPI)	Saturated Thickness (ft)	Aquifer Unit	Measurement Method	Fine Grained Unit above FPI	Partially Penetrating	Barometric Pressure	River Stage	0076 Pumping	0071 Pumping
0342	SP-GP	145.0-160.0	150	LBVA	Telog	Y	N		Y		Y
0343	ML/SM/SP	80.0-90.0	80	LBVA	Telog	Y	N		Y		Y
0353	TI/SH-LS	10.0-18.0	16	Bedrock	Telog	Y	N	Y	Y		Y
0377	SP/SM-SP/GP	11.0-25.0	63(e)	UBVA	Telog	N	N		Y		Y
0380	SH-LS	48.0-61.0	Bedrock	Bedrock	Telog	Y	N	Y	Y		Y
0381	ST-LS/ST-SH/ST-LS	26.0-37.0	Bedrock	Bedrock	Telog	N	N				
P006	GP/SM-SP	19.5-31.8	9	UBVA	*IN SITU*	N	N		Y		Y
P007	SP/SM/SC/GP/SH/TI	17.5-30.5	16	UBVA	*IN SITU*	N	N	Y	Y		Y
P025	GP	17.0-24.5	40(e)	UBVA	*IN SITU*	N	N		U		Y
P027	SP/ML/SP	27.0-35.0	40(e)	UBVA	*IN SITU*	N	N	Y	Y		Y
P028	CL/SW	21.0-28.0	51(e)	LBVA	*IN SITU*	Y	Y		U		U
P031	SM/GP	22.0-30.0	74(e)	LBVA	*IN SITU*	M	Y	Y	Y	Y	Y
P032	TI/GP	27.0-34.0	123(e)	LBVA	*IN SITU*	Y	Y		Y		Y
P033	GP/SP/GP/SP	17.0-25.0	83(e)	UBVA	*IN SITU*	N	Y		Y	Y	Y
0071	GP/GC/GW/GC	2.0-53.5	27(e)	UBVA	*IN SITU*	Y	N		Y		Y
0076	TS/GP/GM/CL/GW/SP	2.0-64.0	86(e)	UNK	*IN SITU*	Y	N		U	Y	U
0155	GM/SP/SW	19.0-32.7	32(e)	UBVA	*IN SITU*	N	Y	Y	Y		Y
0276	UNK	UNK	UNK	UNK	*IN SITU*	U	U		U		U
0309	SH	43.5-53.0	Bedrock	Bedrock	*IN SITU*	Y	N	Y	Y		Y
0317	SP\SM\SC-SM	47.5-63.5	40	UBVA	*IN SITU*	N	N	Y	Y		Y
0393	ST-LS	42.0-50.0	Bedrock	Bedrock	*IN SITU*	N	N	Y	Y		Y
0382	SH/LS/SH	22.0-35.0	Bedrock	Bedrock	Telog	Y	N	Y			N
0912	UNK	UNK	UNK	UNK	Telog	U	U		Y		Y
P008	GP	13.0-25.0	40	UBVA	Telog	N	Y		Y		Y

Table IV.3. (page 3 of 3)

Well Number	Formation of Completion	Filter Pack Interval (FPI)	Saturated Thickness (ft)	Aquifer Unit	Measurement Method	Fine Grained Unit above FPI	Partially Penetrating	Barometric Pressure	River Stage	0076 Pumping	0071 Pumping
P009	SP-GP	53.5-57.0	61	UBVA	Telog	N	N		Y		Y
P013	GP	12.0-24.0	94	UBVA	Telog	N	Y		Y		Y
P014	TI/GP	27.5-40.5	7	LBVA	Telog	Y	N		Y		Y
P015	GM-GP/SP/GM-GP	42.0-55.0	8	UBVA	Telog	N	N		U		Y
P018	ML/GM/GP/SP	11.5-24.0	145	UBVA	Telog	N	Y	Y	Y		Y
P024	TI/LS	33.0-44.0	25	Bedrock	Telog	Y	N	Y			N
P029	SM/GP	20.0-28.0	154(e)	UBVA	Telog	N	Y		Y		Y
P030	SP-GP/SP	80.0-89.0	154	LBVA	Telog	N	Y		Y		Y
P001	GP	33.0-45.0	11	UBVA	*IN SITU*[a]	N	N	Y	Y		Y
P003	TI/SP-GP/ST	21.6-39.0	12	LBVA	*IN SITU*[a]	Y	N	Y	Y		Y
P004	LS/ST-SH/SH/SH-LS/SH	51.0-62.3	Bedrock	Bedrock	*IN SITU*[a]	N	N	Y			N
P005	FL/GM-GP	49.5-63.0	6	UBVA	*IN SITU*[a]	N	N	Y	Y		Y
0394	LS/GP/ST-LS	52.5-60.0	Bedrock	Bedrock	*IN SITU*[a]	N	N	Y	Y		Y
0306	GC/GC-GP/GC-SH	30.5-41.0	18	UBVA	*IN SITU*[a]	N	N	Y	Y		Y

(e) - Estimated
CL - Lean clays, sandy or silty clays, or gravelly clays
FL - Fill material
GC - Clayey gravel or clayey sandy gravel soils
GM - Silty gravel or silty soils
GP - Gravel or sandy gravel, poorly graded
h - Hand measured, not analyzed
LBVA - Lower Buried Valley aquifer
LS - Limestone
ML - Silts, sands or clayey fine sands
N - No
SH - Shale
SM - Silty sand or sand-silt mixtures
SP - Sand or gravelly sand, poorly graded
ST - Siltstone
SW - Sand or gravelly sand, well graded
TI - Till
TS - Topsoil, undifferentiated
U - Unknown
UBVA - Upper Buried Valley aquifer
Y - Yes
UNK - Unknown

Table G5a. Previous Pump Test Data - May 1990 Aquifer Test

- data set generated by pressure transducers
+ - data set generated by sounder measurement

WELL	DISTANCE FROM PROD. WELL 71-1 (feet)	SCREENED INTERVAL (ft below TOC)	SCREENED LITHOLOGY	DRAWDOWN T (ft^2/day)	DRAWDOWN S *
0063	255.04'	34' - 37'	GC, GP Clay and gravel, gravel over shale	NA #	*NA #*
				67,000 +	*0.05 +*
0071	NA	44' - 53.5'	GW Sand and gravel	71,000 #	*0.20 #*
				63,000 +	*0.19 +*
0271	168.35'	43' - 59'	GW, GC, GP Gravel, sand and gravel with clay, sand and gravel	76,000 #	*0.08 #*
				NA +	*NA +*
0076	462.85'	47' - 62'	GW, SP, GW Sand and gravel, fine sand, sand and gravel	72,000 #	*0.13 #*
				83,000 +	*0.10 +*
0152	659.10'	27' - 47'	CL, GP, GC, SH Dry dense clay, sand and gravel with small clay lenses, clayey sand and gravel, dry weathered shale	NA #	*NA #*
				37,000 +	*0.09 +*
0153	369.49'	21.5' - 41.5'	CL, SC, GC, GW, SH Moist silty clay with trace gravel, clayey gravelly (1") sand, clayey gravel (2"), clean sand and gravel, hard shale	53,000 #	*0.11 #*
				47,000 +	*0.12 +*

Table G5a. (page 2 of 3)

- data set generated by pressure transducers
+ - data set generated by sounder measurement

WELL	DISTANCE FROM PROD. WELL 71-1 (feet)	SCREENED INTERVAL (ft below TOC)	SCREENED LITHOLOGY	DRAWDOWN	
				T (ft^2/day)	S *
0154	98.90'	37' - 47'	GP, CL Sandy gravel (medium grained, subrounded), silty clay (stiff, homogeneous)	74,000 #	*0.04 #*
				64,000 +	*0.06 +*
0155	87.77'	22.7' - 32.7'	SP, SW Sand (medium grained, homogeneous), gravelly sand (30% gravel, subrounded)	62,000 #	*0.08 #*
				52,000 +	*0.15 +*
0305	187.80'	33.7' - 38.7'	GC, GM, CL Gravel with silt, clay, and sand, and clay with gravel, sand, and silt	43,000 #	*0.07 #*
				42,000 +	*0.09 +*
0306	351.04'	34.4' - 39.4'	GC Clayey, sandy gravel over shale	51,000 #	*0.11 #*
				46,000 +	*0.12 +*
0307	524.57'	45.5' - 49.5'	GW, SH Sandy gravel, weathered shale	NA #	*NA #*
				45,000 +	*0.06 +*

Table G5a. (page 3 of 3)

- data set generated by pressure transducers
+ - data set generated by sounder measurement

WELL	DISTANCE FROM PROD. WELL 71-1 (feet)	SCREENED INTERVAL (ft below TOC)	SCREENED LITHOLOGY	DRAWDOWN	
				T (ft^2/day)	S *
0309	202.63'	45.7' - 50.7'	SH	37,000 #	*0.24 #*
			Blue shale	42,000 +	*0.19 +*
0310	360.87'	49.2' - 54.2'	LS	55,000 #	*0.11 #*
			Limestone	50,000 +	*0.10 +*
0313	525.77'	34.5' - 39.5'	CL, GW Silty clay trace gravel, sandy gravel trace clay	NA #	*NA #*
				61,000 +	*0.08 +*
0317	120.59'	50.8' - 60.8'	GM, SC, SM, SP Gravel (up to .3'), clayey fine silty sand to coarse gravel	37,000 #	*0.09 #*
				NA +	*NA +*

* *The calculated storage values shown are best approximation values. Calculations for the storage coefficient are sensitive to the curve matching technique used to model the data and the time frame from which the analyzed data was taken.*

Table G5b. Previous Pump Test Data

04/13/61 - 04/14/61

Pumped Well:	Pumping Rate:
0271	400 - 1075 gpm

Observation Well ID	Distance From Pumped Well (feet)	Screened Interval (ft below TOC)	Screened Lithology	Transmissivity (ft^2/d)	Storage	Method of Analysis
0271	NA	43' - 59'	GW, GC, GP Gravel, sand and gravel with clay, sand and gravel	78,000	NA	Theis Distance - Drawdown
				46,000	0.002	WHIP
0371	94.54	UNK	UNK	64,000	0.0006	WHIP
0471	163.17	UNK	UNK	71,000	0.003	WHIP
0571	350.12	UNK	UNK	96,000	0.04	WHIP
0276	45.64	UNK	UNK	NA	NA	NA
0076	904.45	47' - 62'	GW, SP Sand and gravel, fine sand	27,000	NA	Theis Distance - Drawdown

Note: WHIP data analyzed by WESTON in 1990.

Reference: Earth Science Laboratories, Inc., 1961

09/09/76 - 09/13/76

Poor data quality, no analysis performed

Reference: Dames and Moore 1976

10/11/76 - 11/03/76

Pumped Well:	Pumping Rate:
0912	510 - 525 gpm

Observation Well ID	Distance From Pumped Well (feet)	Screened Interval (ft below TOC)	Screened Lithology	Transmissivity (ft^2/d)	Storage	Method of Analysis
0101	31.62	43' - 45'	GW	13,000	0.7	Modified Theis
			Sand and gravel	13,000	0.8	Theis
0002	190.01	47' - 62'	GW Sand and gravel	13,000	0.9	Modified Theis
		65' - 67'	TI Till	11,000	0.2	Theis
0003	327.71	32' - 34'	GW	16,000	0.03	Modified Theis
			Sand and gravel	13,000	0.04	Theis
0004	217.43	57' - 59'	GW	19,000	0.02	Modified Theis
			Sand and gravel	17,000	0.02	Theis
0005	516.21	53.5' - 55.5'	GW	24,000	0.09	Modified Theis
			Sand and gravel	23,000	0.1	Theis
0008	1465.01	140.5'-142.5'	GW, SH Sand and gravel, shale	NA	NA	NA
0106	816.37	48' - 50'	GW	27,000	0.06	Modified Theis
			Sand and gravel	20,000	0.08	Theis
0137	396.04	73' - 75'	GW	16,000	0.01	Modified Theis
			Sand and gravel	8,000	0.02	Theis
0904	614.59	50' - 53'	GW Sand and gravel	NA	NA	NA

Reference: Dames and Moore 1976

12/29/86 - 01/05/87

Pumped Well:	Pumping Rate:
0071	@ 600 gpm

Observation Well ID	Distance From Pumped Well (feet)	Screened Interval (ft below TOC)	Screened Lithology	Transmissivity (ft^2/d)	Storage	Method of Analysis
0071	NA	44' - 53.5'	GW Sand and gravel	5,300	NA	Cooper - Jacob
0063	160.87	34' - 37'	GC, GP Clay and gravel over shale	25,000	0.05	Cooper - Jacob
0471	159.46	UNK	UNK	28,000	0.03	Cooper - Jacob
				25,000	0.04	Theis
0063 0271 0371 0471	160.87 410.56 228.64 159.46	34' - 37' 43' - 59' UNK UNK	GC, GP GW, GC, GP UNK UNK	31,000	0.03	Cooper - Jacob Distance - Drawdown (4 wells)

Reference: Terran Corporation 1987

Table G5b. (page 4 of 5)

11/03/87 - 11/05/87

Pumped Well:	Pumping Rate:
0912	584 - 603 gpm

Observation Well ID	Distance from Pumped Well (feet)	Screened Interval (ft below TOC)	Screened Lithology	Transmissivity (ft^2/d)	Storage	Method of Analysis
0912	NA	UNK	UNK	NA	NA	NA
0004	217.43	57' - 59'	GW Sand and gravel	57,000 - 76,000	0.1 - 0.3*	Theis
				52,000	0.5	Cooper - Jacob
0123	319.09	50' - 56'	GW Dense sand and gravel, rock fragments	11,00	0.1*	Theis
				16,000	0.05	Cooper - Jacob
0124	192.34	45' - 55'	SM, SP, GP Silty, gravelly sand, sandy gravel	13,000	0.09*	Theis
				27,000	.2	Cooper - Jacob
0126	17.32	44' - 53.5'	SM, SP, GM Silty gravelly sand, silty, sandy gravel	60,000	.013*	Neuman
				13,000	0.4	Cooper - Jacob
0004	217.43	57' - 59'	GW	12,000	NA	Theis Distance - Drawdown
0123	319.09	50' - 56'	GW			
0124	192.34	45' - 55'	SM, SP, GP			
0126	17.32	44' - 53.5'	SM SP, GM			

*Calculated from early time confined storage.

References: DOE 1989

12/16/87 - 11/18/87

Pumped Well:	Pumping Rate:
0913	1252 - 1280 gpm

Observation Well ID	Distance from Pumped Well (feet)	Screened Interval (ft below TOC)	Screened Lithology	Transmissivity (ft^2/d)	Storage	Method of Analysis
0913	NA	UNK	UNK	27,000	NA	Theis Recovery
0118	602.70	30.63'- 40.63'	SM, SP Silty, gravelly sand	48,000 -	0.007	Theis
				52,000	NA	Theis Recovery
0138	93.27	31' - 41'	SP Gravelly sand (up to 1.5 in)	27,000		Theis Recovery
				40,000	.0034*	Neuman

*Calculated from early time confined storage.

Abreviations: NA - not applicable or not analyzed
UNK - unknown

Method References:

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Theis, C. V. 1935. "The Lowering of the Piezometric Surface and the Rate and Discharge of a Well Using Ground-Water Storage." *Transactions of the American Geophysical Union* 16:519-24.

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D.2. SUMMARY DATA OF WATER LEVEL MONITORING

D.2.1. SUMMARY TABLE, HYDROGRAPHS OF MONTHLY MEASURED MONITORING WELLS AND PIEZOMETERS, AND GROUNDWATER ELEVATION MAPS APRIL TO DECEMBER 1993

14-Mar-94

Well	A 04/21/93	B 04/28/93	C 05/05/93	D 05/12/93	E 05/19/93	F 05/26/93	G 06/02/93	H 06/09/93	I 06/23/93	J 09/02/93	K 10/06/93	L 11/02/93	M 12/14/93
0005	684.94	684.87	684.14	683.55	682.76	682.06	681.58	681.42	681.39	680.8	680.64	680.77	684.5
0007	694.9	693.67				682.93	682.34	681.97	681.62	681.62	680.67	680.96	685.12
0033	758.82	758.79	758.78	758.77	758.75	758.73	758.76	758.75	758.74	758.56	758.56	758.53	758.65
0034					802.26	802.19	802.06	802.05	802.07		801.42	801.6	802.63
0042	738.86	738.55	738.88	738.88	738.88	738.87	738.86	738.86	738.87	738.82	738.87	738.83	738.83
0046	684.99	683.82	684.09	683.42	682.43	707.71	681.19	680.88			680.51	680.61	684.34
0063	684.71	684.58	683.83	683.22	681.5		680.14		680.84	680.21	680.16	680.26	684.09
0071			683.42	682.87	673.66	672.85	672.4	671.98	680.45				
0076			673.1	672.7	671.68	672.1	668.36	675.99	679.3	672.69	678.66	672.11	677.88
0101	673.47	673.06	682.42	671.99	672.26	672.46	672.65	672.41	671.77	672.99	672.33	672.94	673.73
0106	685.06	684.93	684.19	683.63	682.9	682.23	681.74	681.55	681.48	680.9	680.78	680.88	684.61
0108		684.99	684.55	683.87	683.4	682.69	682.16	681.86	681.61	681.24	680.87	681.05	685.11
0118	686.01	685.9	685.06	684.53	684.29	683.94	683.5	683.7	683.3	682.39	682.44	682.51	685.29
0119	721.86	722.22	722.5	722.71	722.6	722.37	722.23		718.73	719.65	719.03	718.03	718.77
0122	720.2	719.32	720.19	720.07	720.19								
0123	685.01	684.81	684.12	683.61	682.62	682.94	681.36	681.14	681.24	680.77	680.53	680.7	684.46
0124	684.97	684.82	684.12	683.52	682.6	681.91	681.37	681.12	681.27	680.76	680.54	680.7	684.49
0125	708.85	708.83	708.83	708.7	708.59	708.39	708.2	708.03	707.76	707.23	693.16	697.37	704.95
0126	684.94	684.8	685	683.48	682.52	681.89	681.28	681.08	681.24	680.72	682.51	680.64	684.48
0127	685	684.92	684.16	683.66	682.89	682.21	681.71	681.56	681.47	680.94	680.71	680.85	684.54
0128	684.99	684.93	684.23	683.62	682.89	682.21	681.74	681.53	681.48	680.89	680.71	680.85	684.52
0129	684.82	684.72	683.95	683.35	682.14	681.38	680.87	680.58	681.03	680.74	680.29	680.42	684.32
0130	684.8	684.64	684.05	683.45	682.7	682.05	681.54	681.3	681.26	680.64	680.32	680.45	684.27
0137	683.46	683.53	683.56	683.52	683.53	683.48	683.37	683.28	683.07	682.95	679.22	680.6	685.44
0138		685.57	684.76	684.4	682.71	683.46	681.9	683.25	682.7	682.07	682.15	682.23	685.1
0151	695.24	695.48	695.45	695.48	695.43	695.41	695.38	695.38	695.34	695.23	695.31	695.2	695.3
0152	684.87	684.74	684.01	683.41	682.25	681.5	680.98	660.7	681.09	680.64	680.37	680.5	684.23
0153	684.8	684.65	683.94	683.34	681.89	681.2	680.59	680.23		680.48	680.31	680.39	684.24
0154	684.56	684.41	683.68	683.16	681.11	680.25	679.72	679.35		680.27	680.04	680.14	684
0155	683.89	683.76	683.3	682.51	680.4	679.53	679	678.63	680.08	679.55	679.33	679.42	683.29
0156	684.47	684.52	683.75	683.1	681.97	681.19	680.68	680.36	680.8	680.19	679.87	679.97	683.95
0157	684.47	684.53	683.76	683.13	681.97	681.21	680.7	680.39	680.81	680.27	679.94	680.06	683.99
0158	684.38	684.31	683.57	682.92	682.26	681.56	681.05	680.79	680.51	679.81	679.66	679.73	683.63
0159	684.37	684.34	683.72	683.11	682.46	681.8	681.26	681.02	680.82	680.19	679.78	679.89	683.76
0160	684.51	684.47	683.7	683.12	682.45	681.74	681.26	681	680.81	680.15	679.95	680.08	683.94
0227			770.01		769.88	769.72	769.51	769.55		768.85	769.01	769.22	769.13
0236		735.93	735.92	735.93	735.95	735.93	735.93	735.91	735.92	735.59	735.44	735.37	735.54
0242	739.59	739.61	739.61	739.6	739.61	739.6	739.58	739.57	739.56	739.42	739.43	739.42	739.46
0271											679.26		683.3
0301	684.88	684.8	684.16	683.68	683.17	682.68	682.15	682.03		681.43	681.12	681.25	684.51
0302	684.84	684.76	684.12	683.53	682.81	682.14	681.65	681.44	681.37	680.84	680.59	680.7	684.47
0303	684.85	684.75	684.02	683.41	681.64	681.94	681.43	681.2	681.18	680.67	680.41	680.51	684.33
0304	684.44	684.47	683.75	683.11	682.22	681.58	680.99	680.67	680.79	680.15	679.86	679.97	683.94

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Well	A 04/21/93	B 04/28/93	C 05/05/93	D 05/12/93	E 05/19/93	F 05/26/93	G 06/02/93	H 06/09/93	I 06/23/93	J 09/02/93	K 10/06/93	L 11/02/93	M 12/14/93
0305	684.57	684.44	683.9	683.53	681.27	680.43	679.91	679.55	680.75	680.34	680.08	680.19	684.06
0306	684.77	684.63	683.99	683.3	681.85	681.06	680.56	680.23	680.93	680.46	680.26	680.35	684.13
0307	684.86	684.7	683.99	683.25	682.07	681.32	685.81	680.5	680.99	680.62	680.38	680.46	684.3
0308	684.76	684.57	684.13	683.64	683.06	682.72	682.55						684.21
0311	684.85	684.77	684.55	683.67	683.17	682.63	682.21	682.11		681.25	681.34	681.34	684.64
0313	684.84	684.7	683.97	683.33	682.08	681.32	680.8	680.49	680.98	680.6	680.38	680.44	684.21
0315	684.96	684.82	684.21	683.52	682.33	681.8	681.29	681.07	681.19	680.77	680.48	680.77	684.42
0316	694.19	694.24	694.28	694.32	694.36	694.38	694.4	694.57	694.55	694.8	694.99	695.11	695.33
0317	684.34	684.2		683.45	680.99	680.11	679.61	679.13	681.48	679.98	679.77	679.83	683.78
0319	684.43	684.27	683.54	682.87	682.06	681.25	680.72	680.41	680.51	680.03	678.89	679.81	683.76
0320	684.51	684.43	683.77	682.97	682.33	681.58	681.07	680.79	680.59	679.99	679.82	679.89	683.81
0327			684.72	684.82	684.14	682.78	683.76	683.94		682.67	682.84	682.8	684.86
0328			684.71	684.75	684.12	683.81	683.71	684.01		682.75	682.77	682.84	684.94
0329			688.38	688.38	688.28	688.23	688.31	693.3	688.16	687.97	688	688.14	688.29
0330			685.18	684.91	684.38	684.1	683.8	684	683.7	683.32	682.85	682.9	685.35
0333		685.42	684.55	684.21	683.77	683.33	683.13	683.12	682.84	682	681.95	682.06	684.68
0334		685.45	684.62	684.26	683.84	683.4	683.14	683.19	682.9	681.96	682.07	682.14	684.85
0336			685.22	684.68	684.52	684.2	683.77	683.87	683.54	682.56	682.57	682.62	685.4
0337			685.23	684.67	684.46	684.03	683.72	683.82	683.49	682.5	682.53	682.59	685.42
0340									706.17	691.67	691.87	691.98	692.01
0342	684.6	684.53	683.75	683.11	682.41	681.68	681.18	680.89	680.82	680.41	679.94	680.06	684.16
0343		684.9	684.01	683.38	682.65	681.94	681.43	681.19	681.15	680.62	680.37	680.48	684.34
0344	684.52	684.44	683.71	683.03	682.35	681.58	681.08	680.82	680.65	680.25	679.87	679.93	683.8
0345	730.05	730.43	730.66	730.72	730.63	730.46	727.24	730.02	729.58	726.8	725.47	724.46	725.43
0346				730.55	730.64	730.38	730.16	729.96	729.46	726.72	725.13	724.33	725.41
0347	684.96	684.83	684.12	683.62	682.5	681.92	681.28	681.05	681.2	680.79	680.52	680.64	684.32
0356	684.52	684.46	683.83	683.03	682.38	681.63	681.12	680.87	680.68	680.04	679.78	679.84	683.75
0370	684.83	684.68	684.07	683.38	682.03	681.89	680.75	680.53	681	680.55	680.43	680.52	684.29
0371	684.76	684.64	684	683.34	681.8	680.99			680.89	680.48	680.38	680.34	684.14
0373	684.74	684.71	683.89	688.76	681.73	680.95	680.59	680.28	681.13	680.53		680.31	684.13
0374			683.92	683.25	681.38		680.07	679.65	680.81	680.35	680.13	680.21	684.06
0375			684.1	683.46	682.42	681.67	681.16	681.01	681.16	680.73	680.52	680.62	684.32
0376			683.86	683.36	681.95	681.2	680.66	680.37	681.44	680.35	680.19	680.3	684.22
0377	684.63	684.47	683.82	683.22	681.8	681.02	680.51	680.19	680.87	680.19	680.06	680.18	684.11
0378	684.63	684.48	683.75	683.13	681.62	680.84	680.33	680	678.76	680.14	680.03	680.1	684.08
0379	684.98	684.83	684.21	683.72	682.49	681.82	681.25	680.98	681.26	680.79	680.58	680.76	684.47
0380	684.95	684.77	684.13	683.58	682.53	681.79	681.23	681	681.18	680.68	680.51	680.56	684.27
0383		684.85	650.72	683.54	682.63	681.88	681.38	681.12	681.3	680.73	680.53	680.64	684.44
0386			684.13	693.49	682.52	681.81	681.3	709.74	681.26	680.79	680.47	680.61	684.42
0387			680.27	679.78	682.51	681.78	681.29	680.98	681.2	680.76	680.46	680.61	684.43
0388	684.77	684.61	683.9	683.29	682.05	681.3	680.75	680.6	680.98	680.4	680.21	680.45	684.25
0389				691.8	682.51	681.85	681.26	681.01	681.2	680.79	680.46	680.71	684.43
0390			687.77	687.19	691.76	681.77	691.75	691.78	691.8	691.83	691.76	691.78	691.82

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Well	A 04/21/93	B 04/28/93	C 05/05/93	D 05/12/93	E 05/19/93	F 05/26/93	G 06/02/93	H 06/09/93	I 06/23/93	J 09/02/93	K 10/06/93	L 11/02/93	M 12/14/93
0392			686.8	684.11	682.48	681.92	681.23	681	681.2	680.75	680.45	680.58	684.42
0395	734.36	734.36	734.39	734.38	734.38	734.39	734.37	734.35	742.4	734.29	734.35	734.35	734.4
0471			683.24	682.62	680.91	680.04	679.54	679.12	680.65	679.95	680.09	680.1	684.27
0571			682.47	683.02	682.93	682.9	676.08			682.41	682.1	681.71	682.2
0832	685.29	685.17											
P001	684.76	684.63	683.9	683.28	681.77	680.97	680.46	680.14	680.93	680.48	680.18	680.36	684.14
P003	684.79	684.64	683.9	684.28	681.83	681.03	680.53	680.2	681.01	680.49	680.27	680.35	684.14
P005	684.82	684.64	683.85	688.7	681.75	680.97	680.47	680.12	681	680.64	680.3	680.32	684.12
P006	684.71	684.56	683.81	683.2	681.42	680.66	680.12	679.74	680.82	680.35	680.16	680.25	684.08
P007	684.94	684.8	684.06	683.95	682.42	681.7	681.18	680.9	681.15	680.71	680.5	680.62	684.32
P008	684.74	684.57	683.88	683.24	681.93	681.16	680.65	680.35	680.91	680.34	680.18	680.29	684.22
P009	684.69	684.54	683.83	683.21	681.84	681.06	680.54	680.23	680.87	680.25	680.15	680.23	684.2
P013	684.64	684.48	683.75	683.13	681.63	680.83	680.33	679.99	680.77	680.23	680.05	680.13	684.11
P014	684.99	684.82	684.14	683.53		681.79	681.23	681	681.25	680.78	680.49	684.72	684.35
P015		684.27	683.62	683.02	681.22	680.4	679.82	679.4	680.49	680.12	679.84	672.05	676.06
P016	685.02	684.91	684.22	683.68	682.2	682.36	681.89	681.72	681.57	681.08	680.81	680.95	684.58
P017	684.92	684.8	684.08	683.49	682.79	682.11	681.62	681.41	681.31	680.8	680.52	680.65	684.45
P018	684.78	684.62	683.92	683.32	682.29	681.58	681.07	680.79	681.03	680.6	680.27	680.44	684.29
P019			684.29	683.75	683.26	682.62	682.18	682.08	681.81	681.14	681.04	681.17	684.69
P020			684.26	683.69	683.09	682.46	682.05	681.85	681.6	680.99	680.85	680.97	684.61
P021	730.03	730.36	730.58	730.8	730.58	730.42	730.22	730.04	729.52	726.86	725.42	724.67	725.58
P023			686.04	686.11	686.3	686.18	686.16	686.19	686.18	686.13	686.18	686.24	
P025	684.46	684.24	683.49	682.9	681.59	680.09	680.02	680.02	680.48	680.01	680.03	680.05	683.82
P026	684.66	684.83	684.15	683.53	682.66	681.96	681.46	681.24	681.33	680.82	680.57	680.69	684.46
P027	684.44	684.31	683.59	682.94	681.01	680.13	679.6	679.18	680.47	679.99	679.8	679.89	683.84
P028	684.31	684.08	683.37	682.73	681.83	681.84	681.83	681.83	681.85	681.78	681.8	681.77	683.68
P029	684.39	684.16	683.46	682.84	681.64	680.82	680.36	679.96	680.42	679.89	679.77	679.81	683.87
P030	684.48	684.34	683.54	682.93	681.78	680.98	680.48	680.17	680.51	680.02	679.84	679.88	683.92
P031	684.19	684.01	683.2	682.53	681.13	680.29	679.69	679.44	680.32	679.72	679.51	679.59	683.6
P032	684.4	684.25	683.47	682.82	681.91	681.2	680.62	680.25	680.46	679.98	679.75	679.82	683.78
P033		684.17	683.44	682.3	681.69	680.82	680.29	679.86	680.25	679.83	679.53	679.61	683.71
P034				683.05	682.15	681.4	680.9	680.59	680.7	680.27	679.93	680.04	684.03
P035			684.27	683.76	683.18	682.6	682.15	682.05	681.83	681.25	681.09	681.19	684.62
P036			684.27	683.75	683.19	682.59	682.13	682.03	681.79	681.24	681.04	681.16	684.65
P037			684.17	683.61	683	682.38	681.91	681.76	681.56	681.07	680.89	681.01	684.58
P038			684.72	683.53	682.89	682.25	681.77	681.59	681.41	680.82	680.6	680.72	684.45
P039			683.86	683.22	682.52	681.81	681.33	681.09	680.96	680.47	680.12	679.23	684.16
P040			683.86	683.26	682.46	681.74	681.25	681.02	680.87	680.36	680.08	680.18	684.09
P041			683.85	683.24	682.6	681.87	681.39	681.16	681.04	680.53	680.22	680.33	684.26

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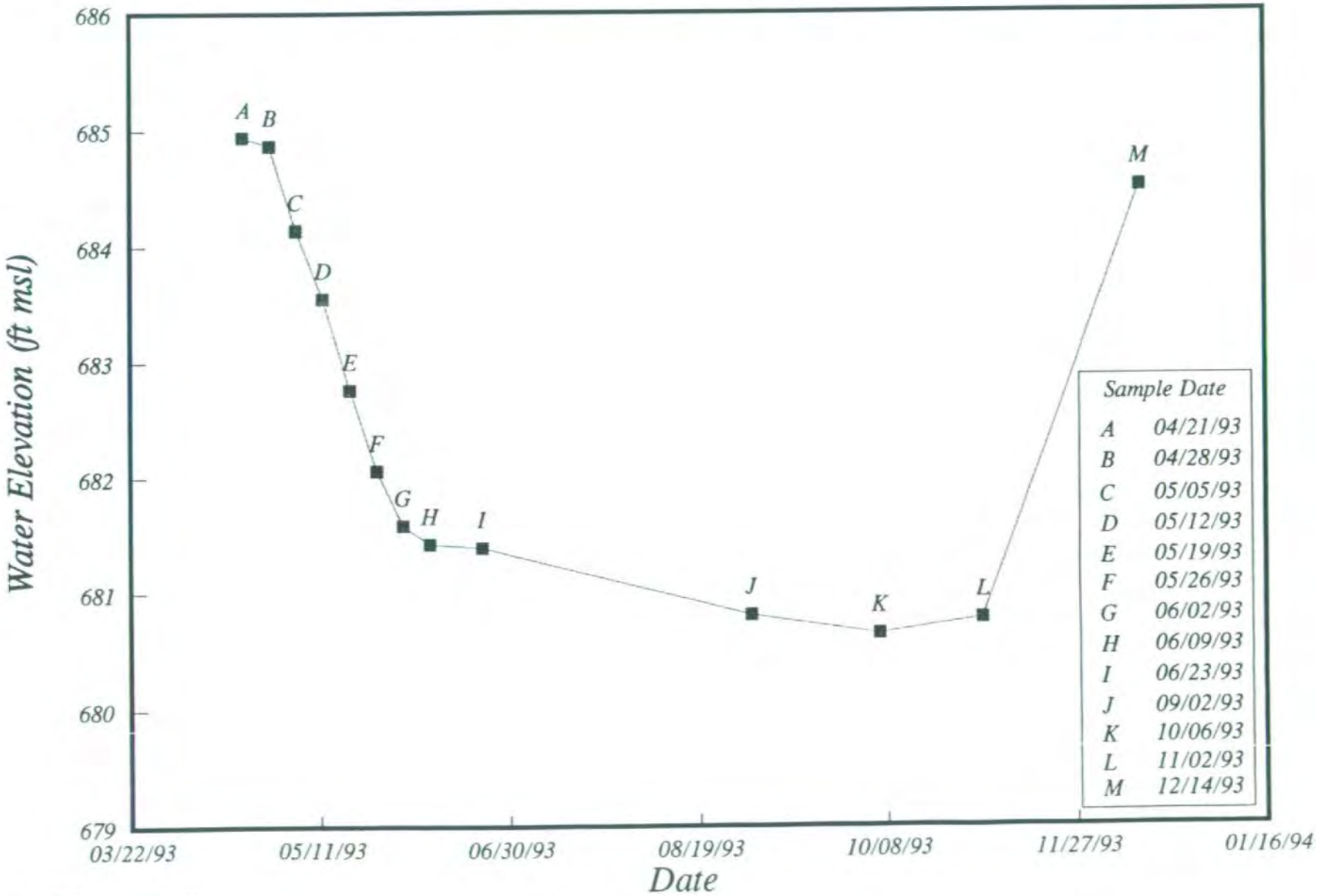

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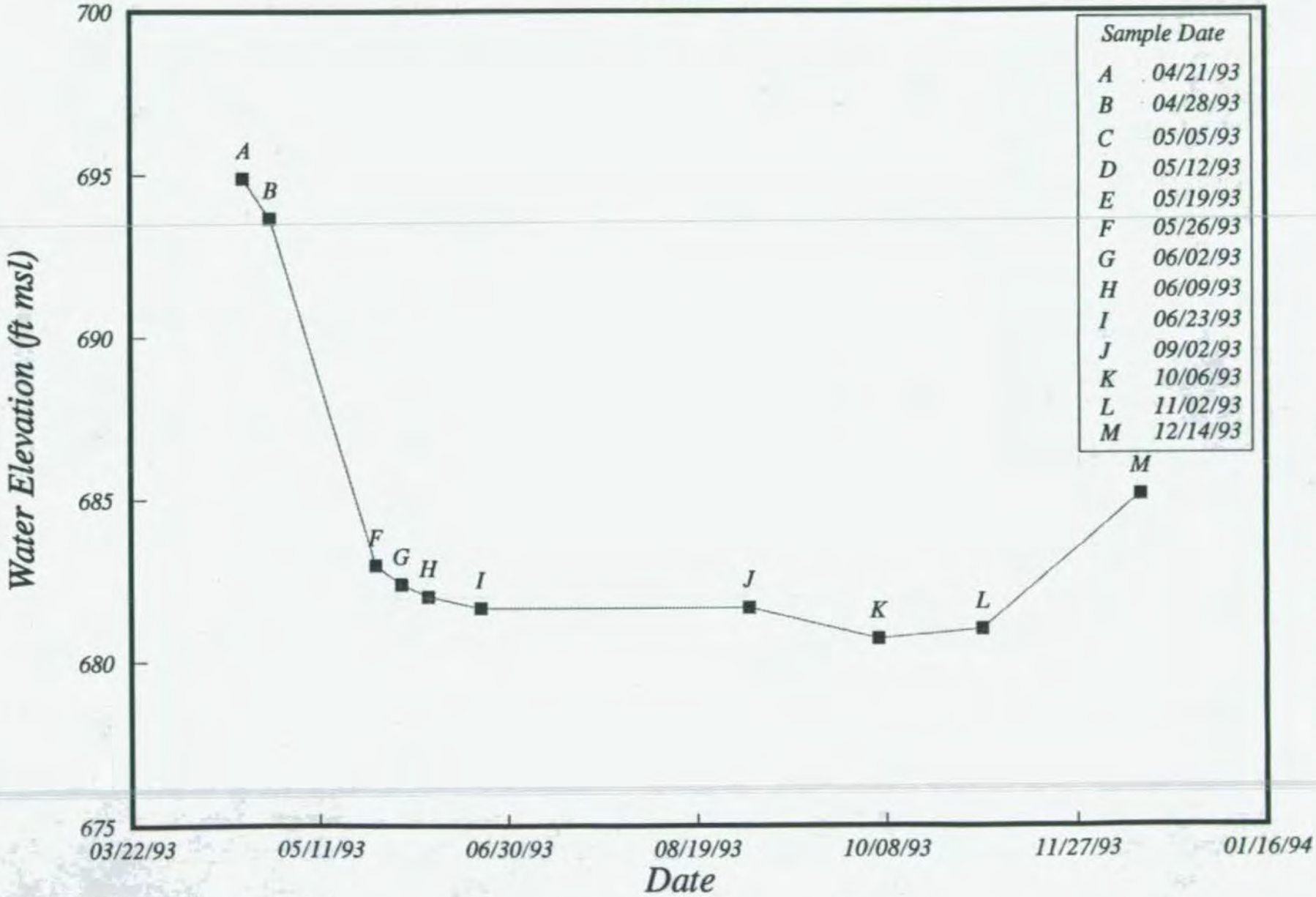

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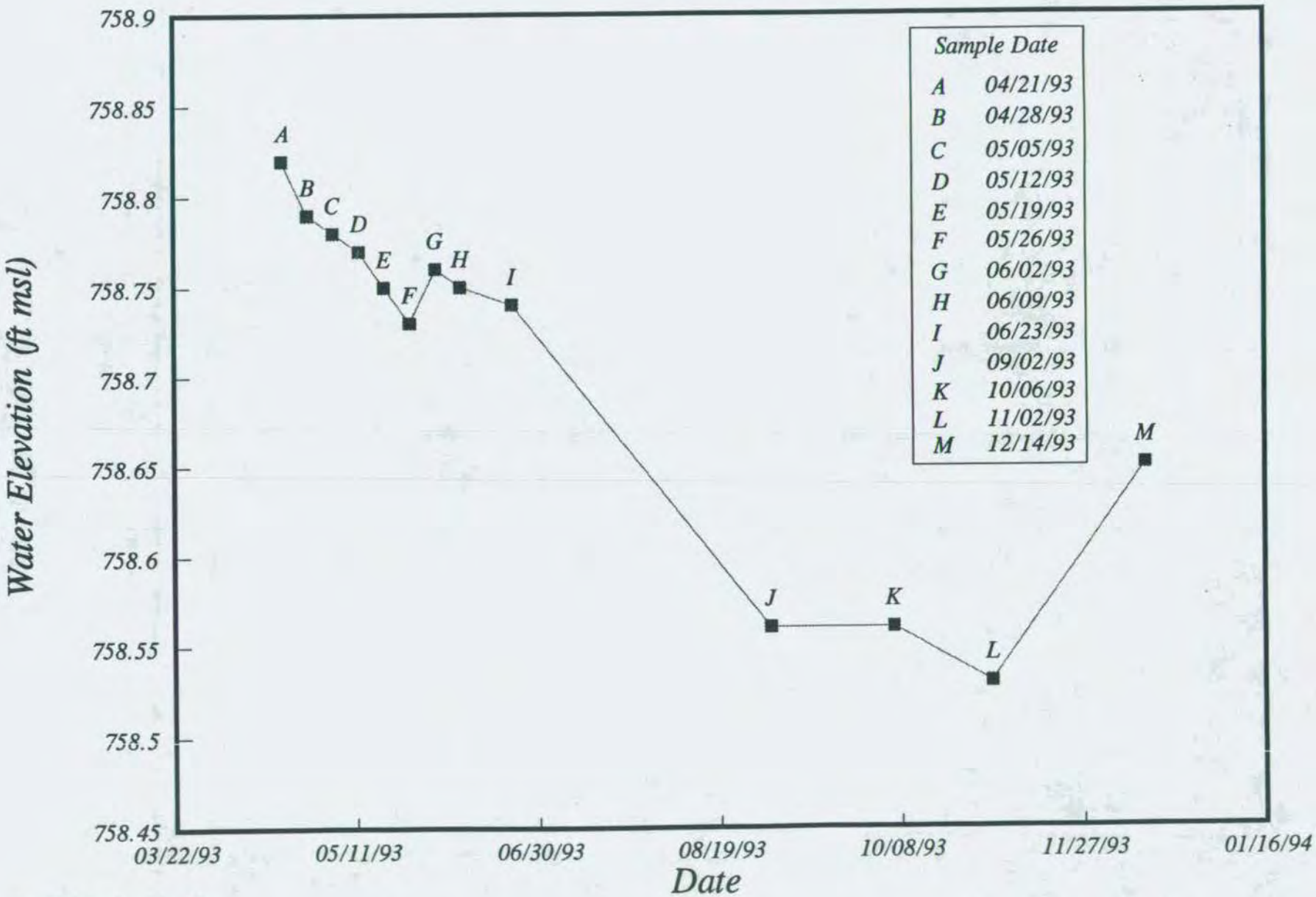

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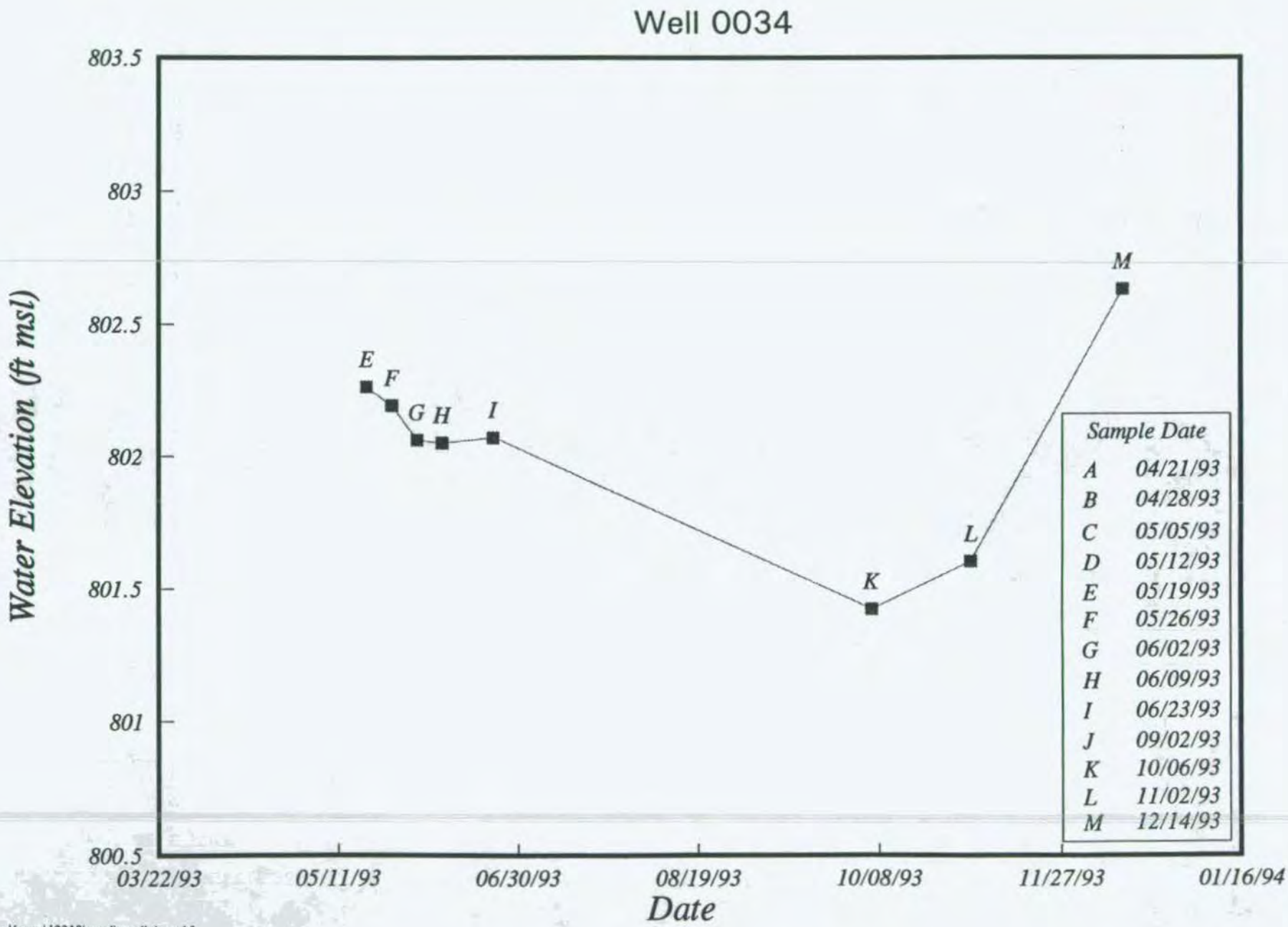

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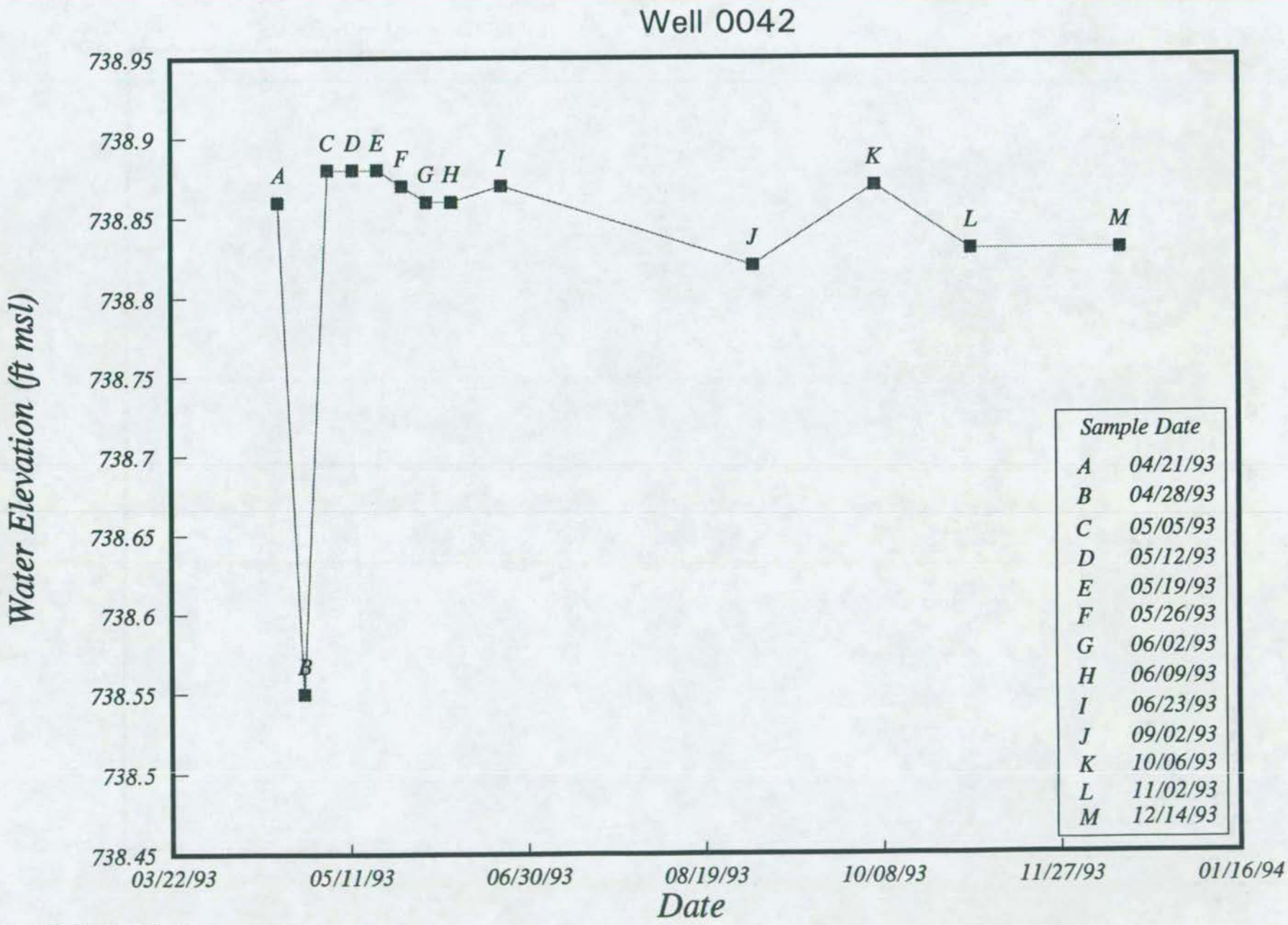

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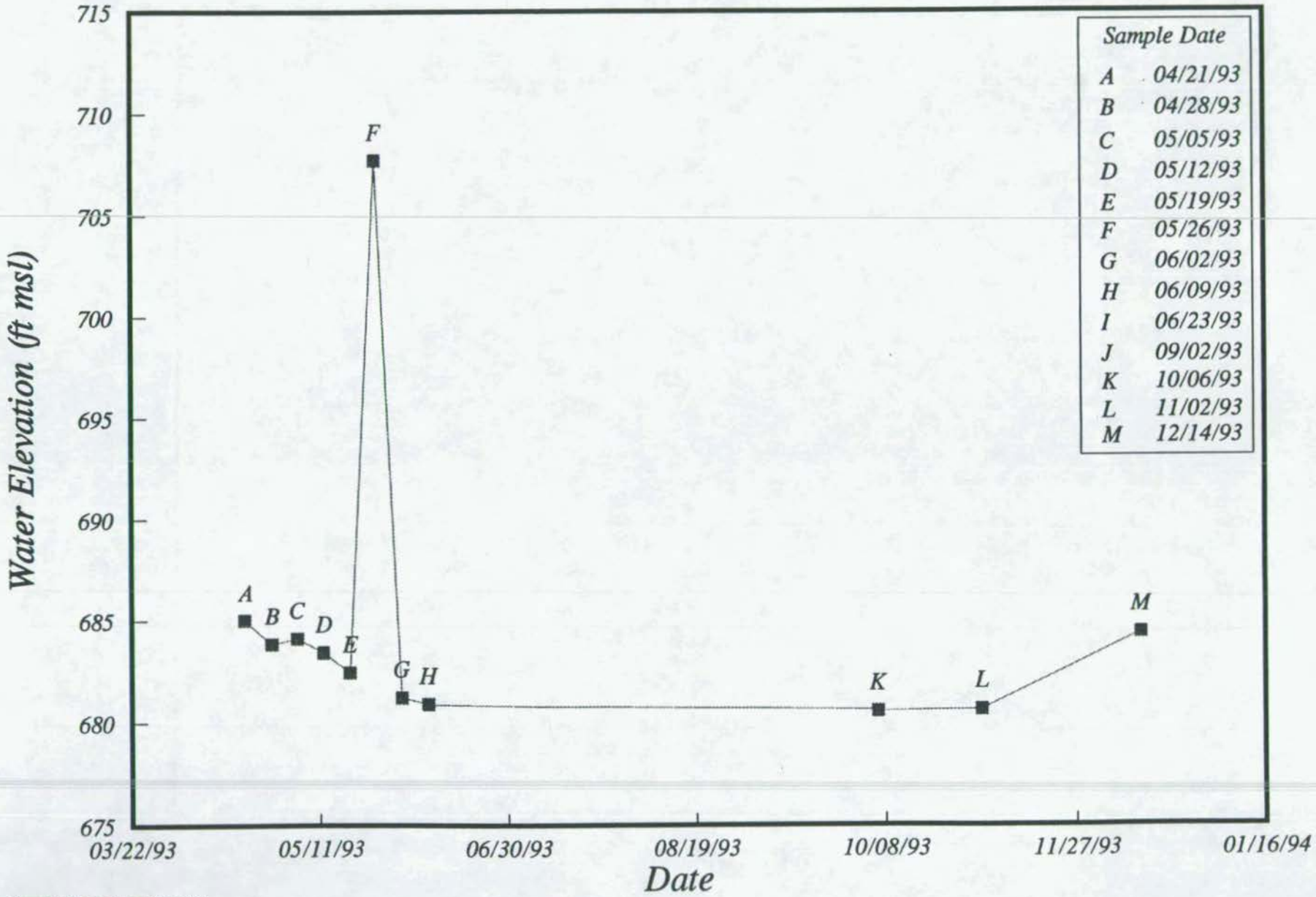

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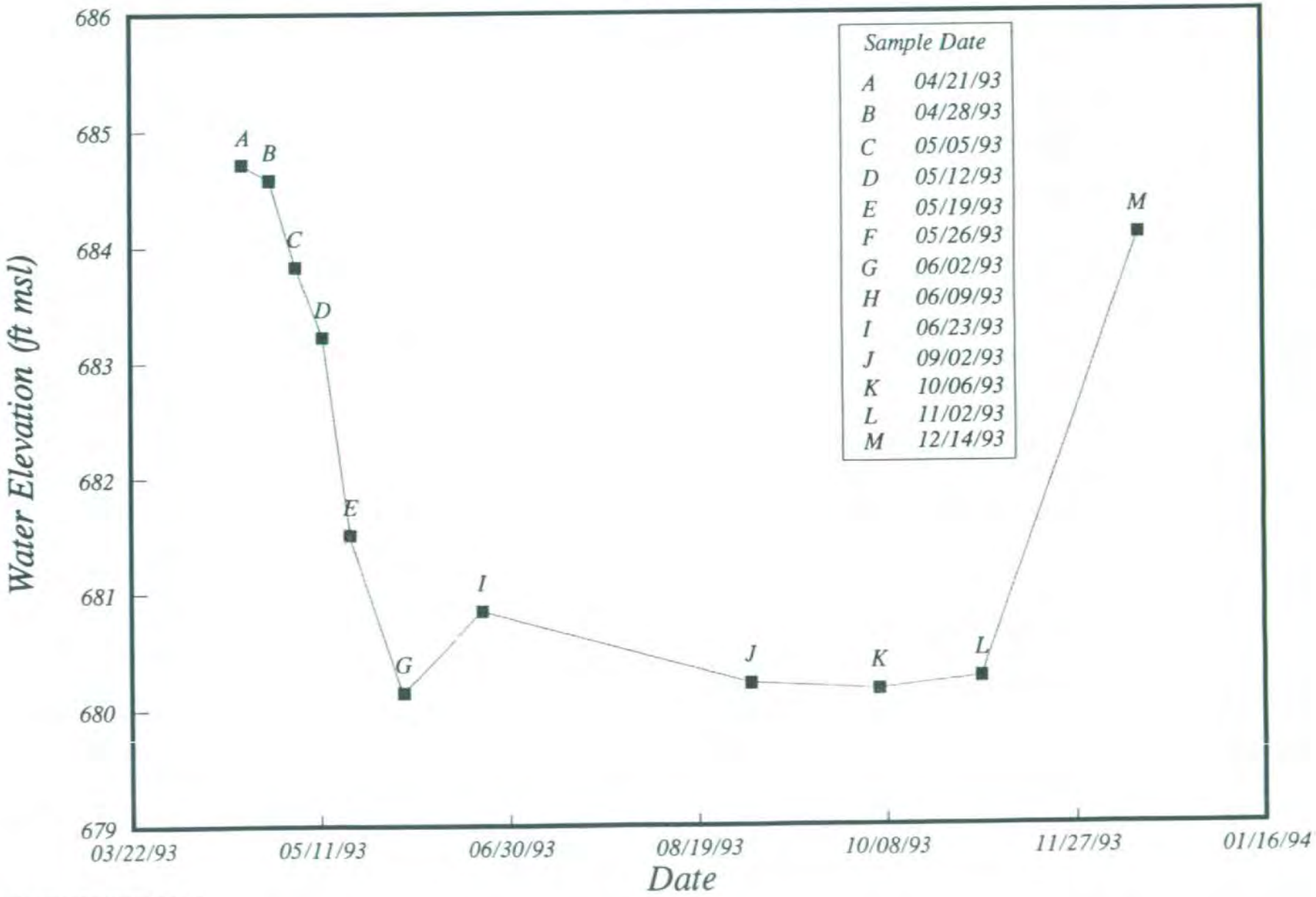

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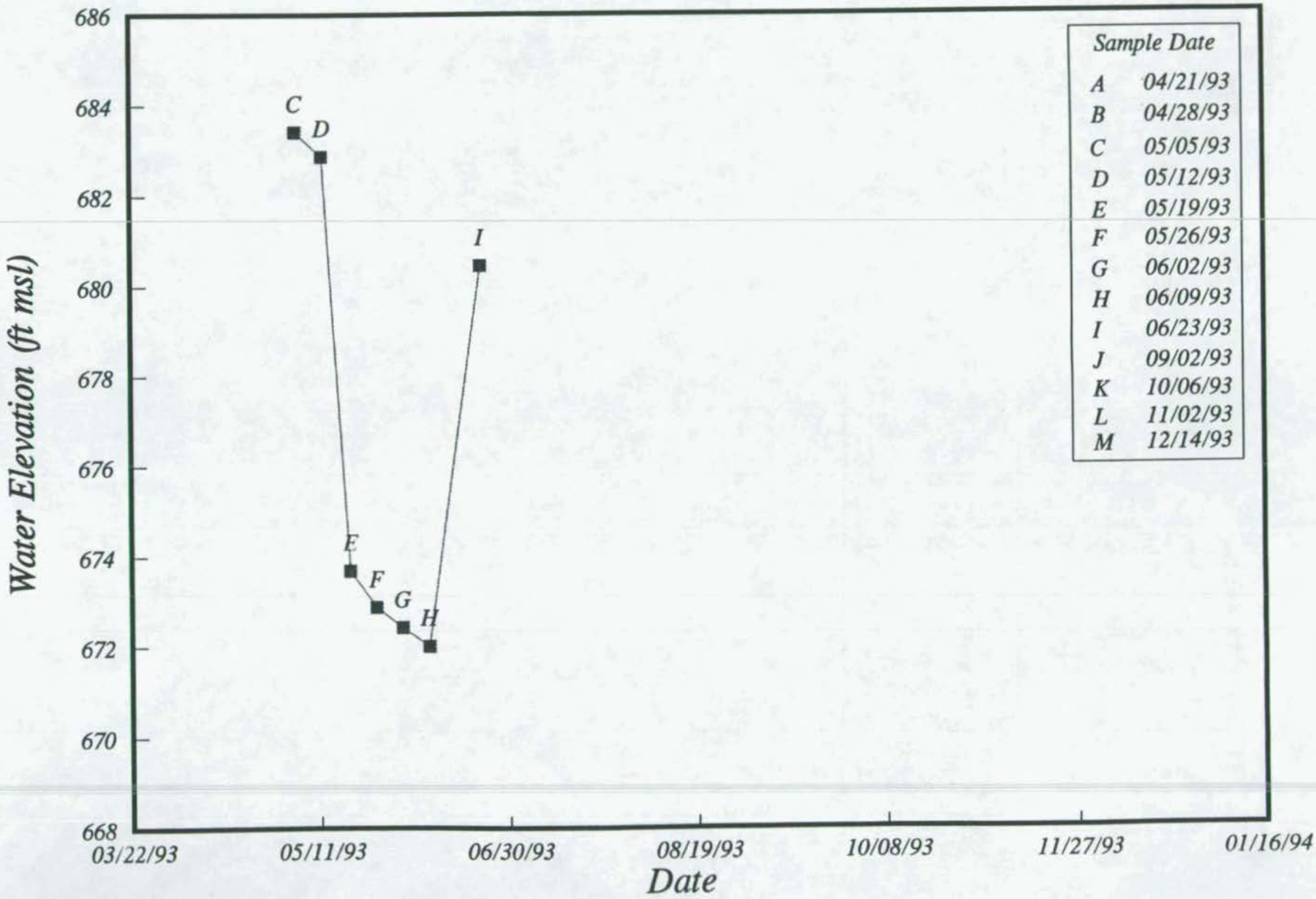

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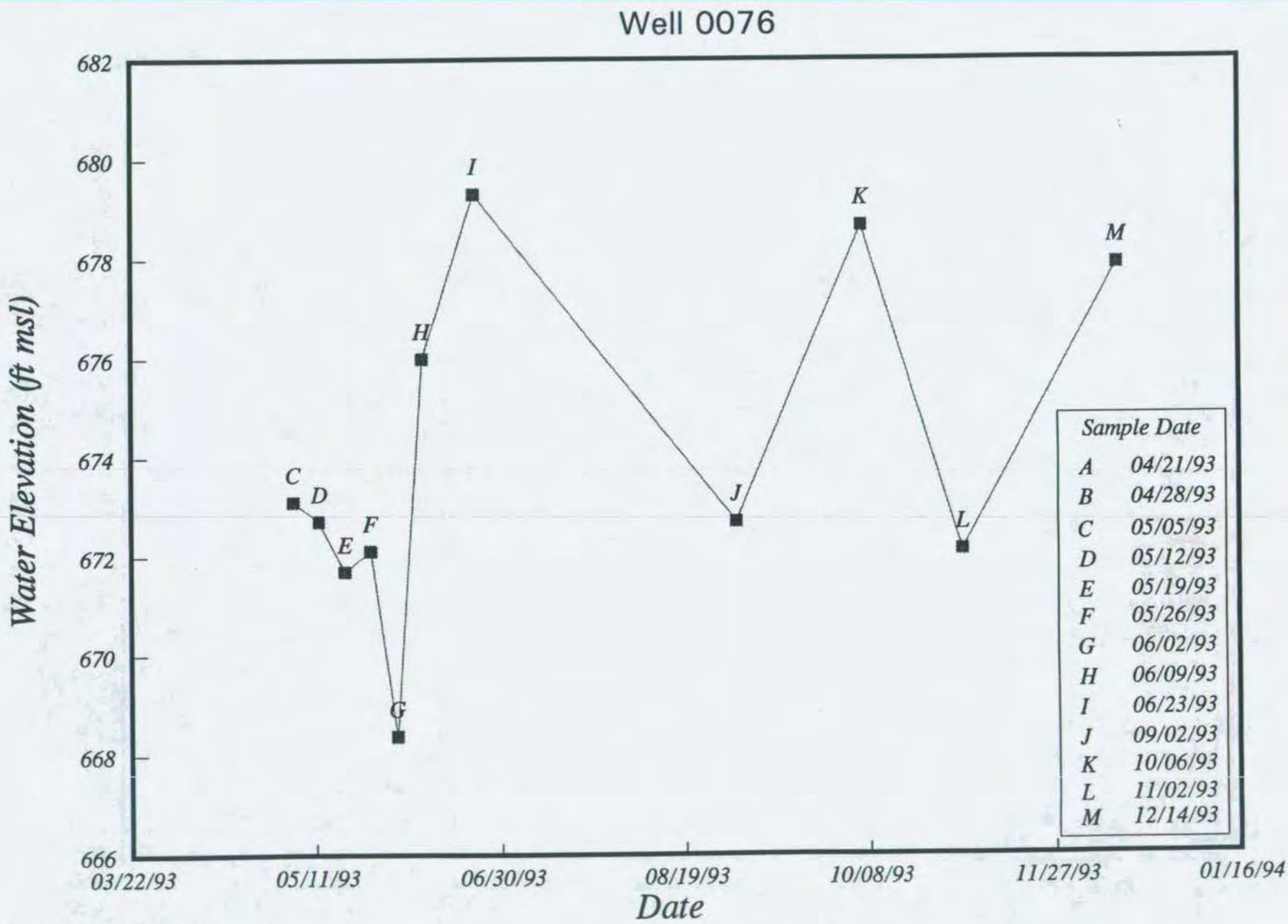

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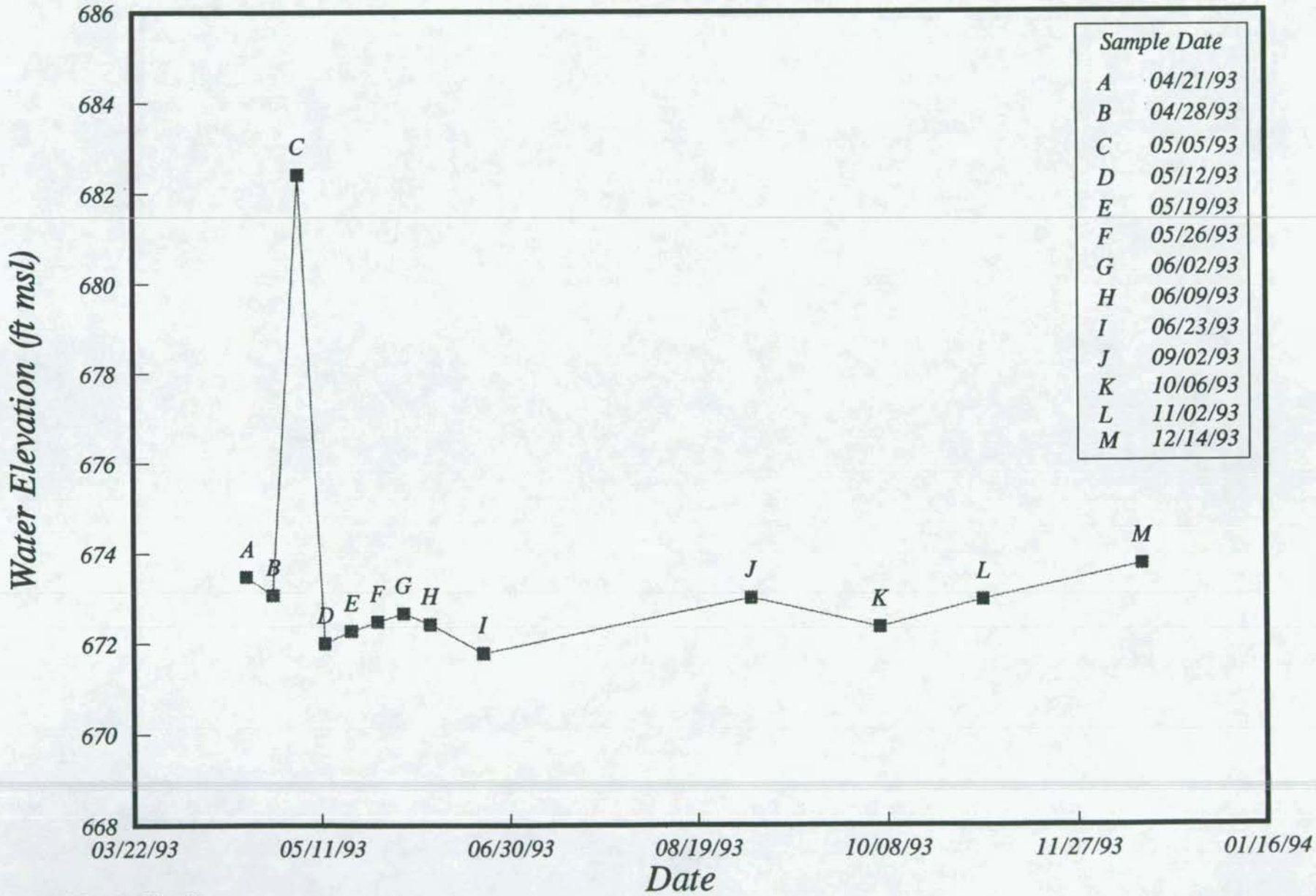

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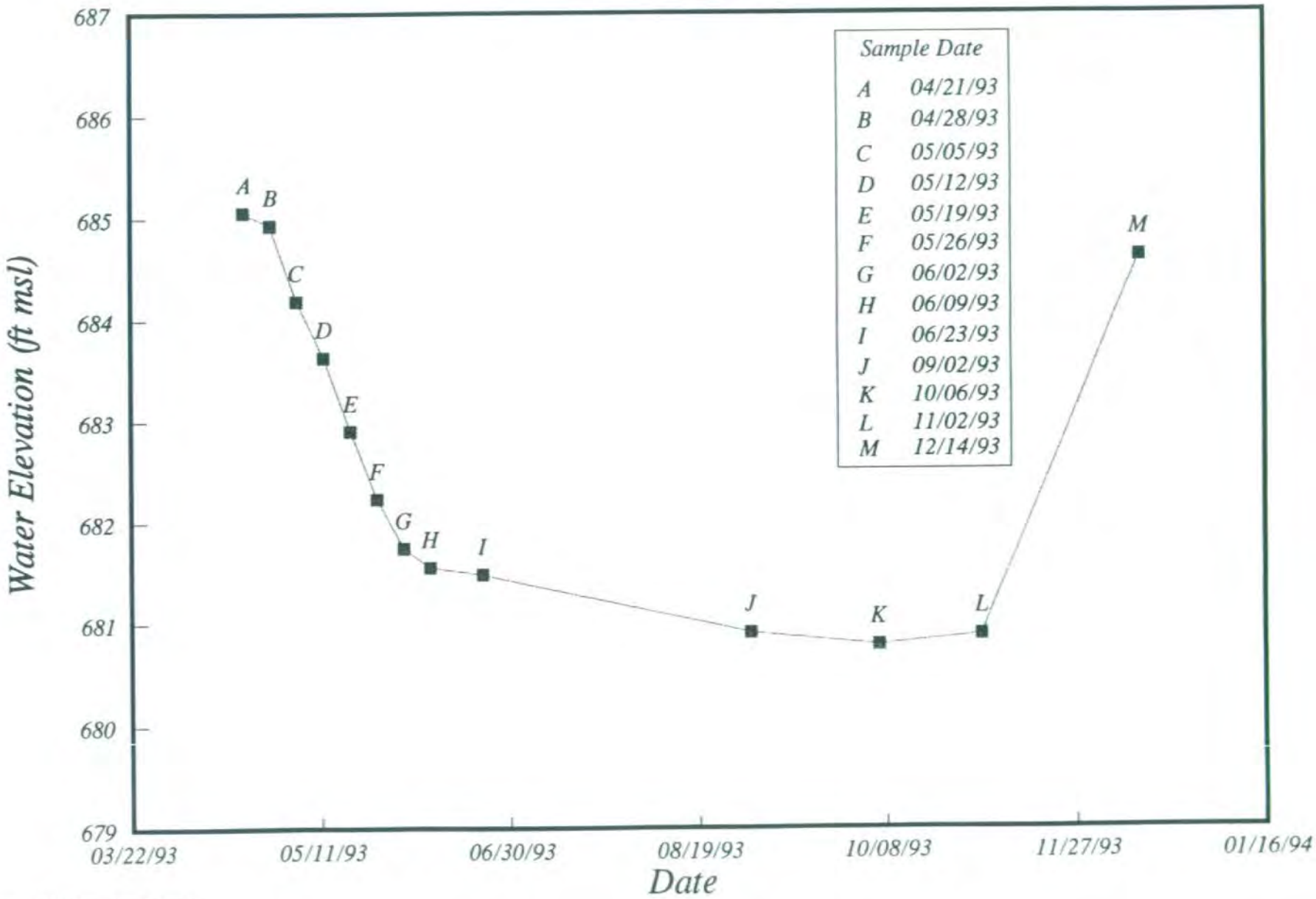

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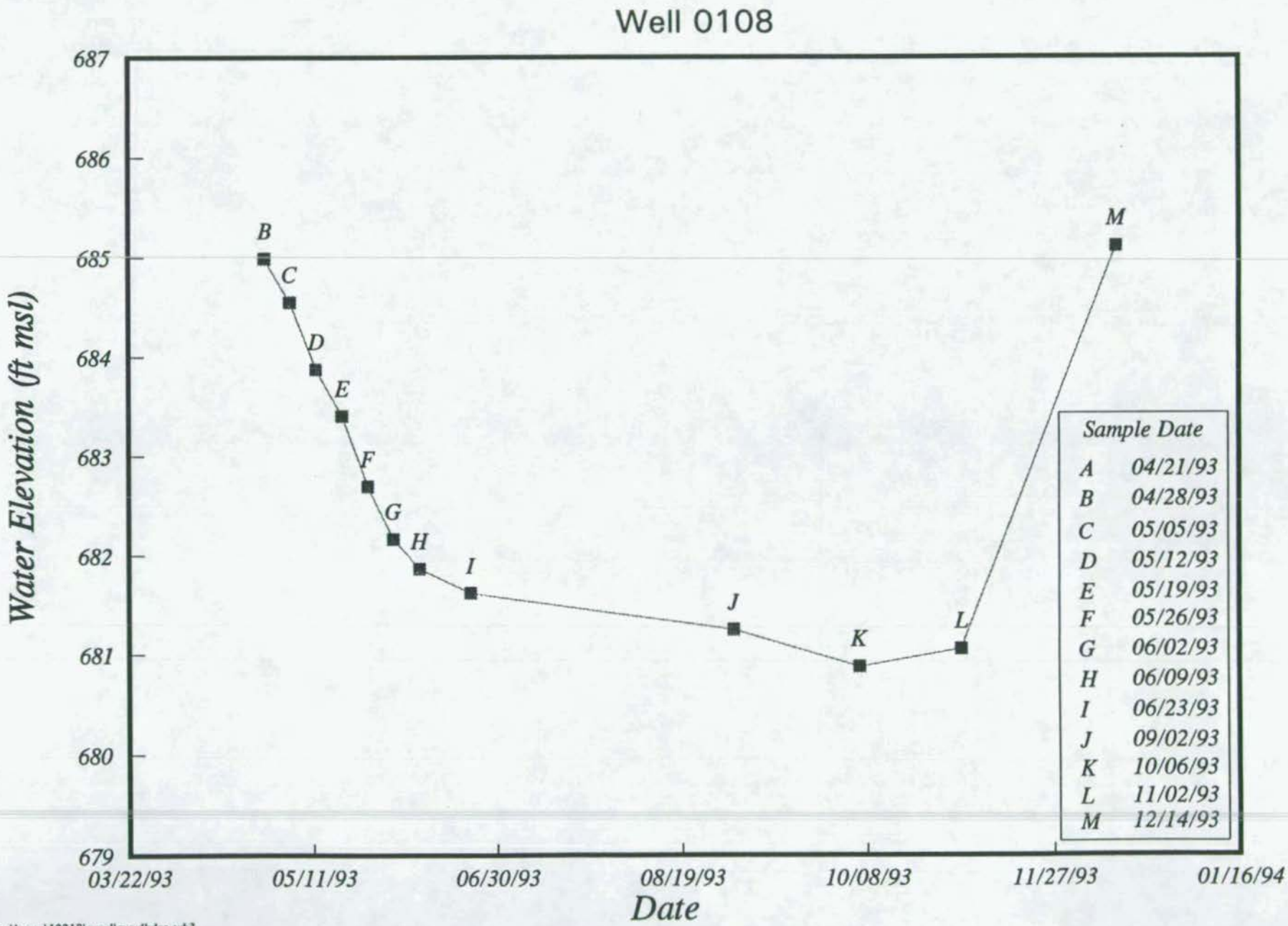

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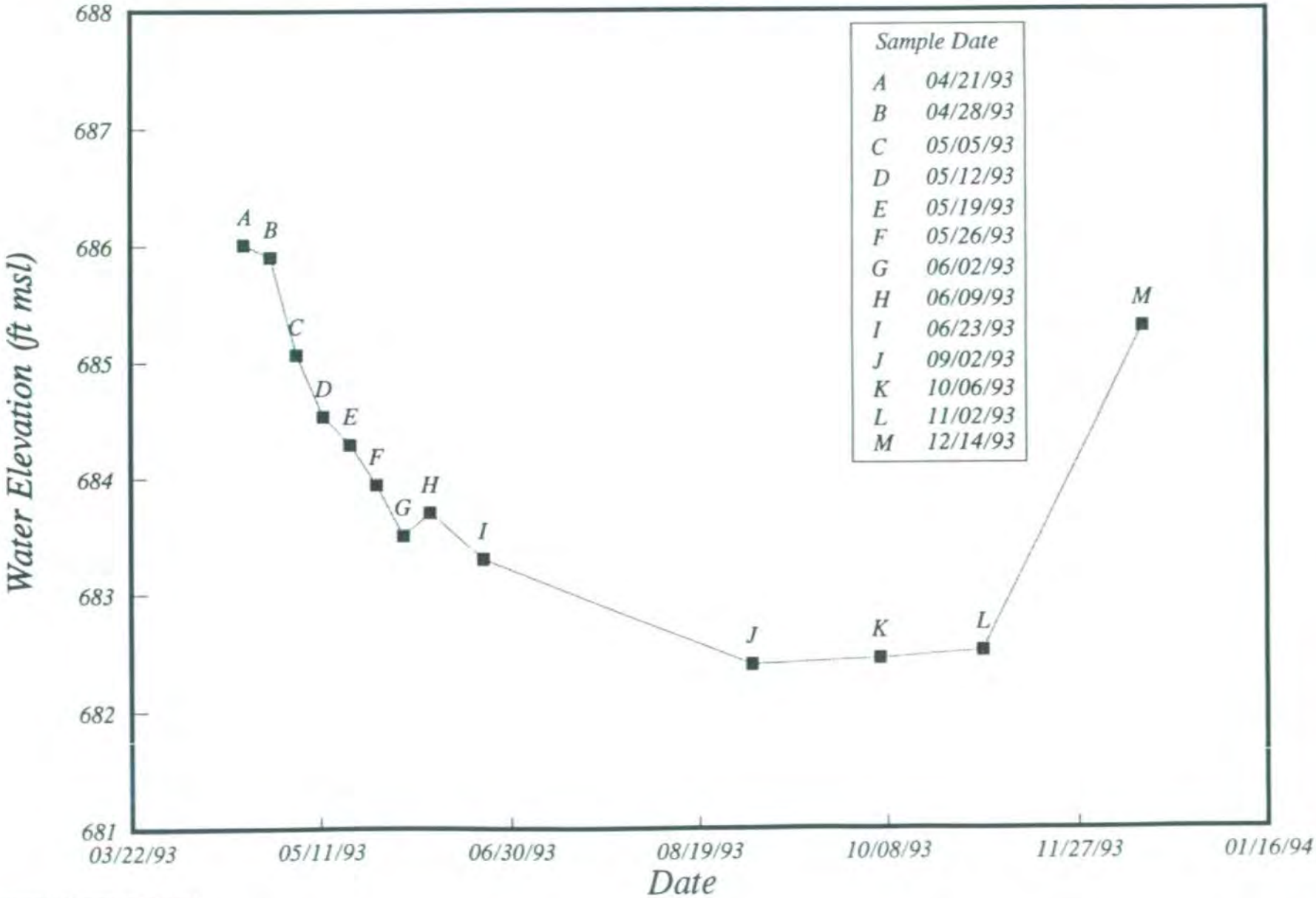

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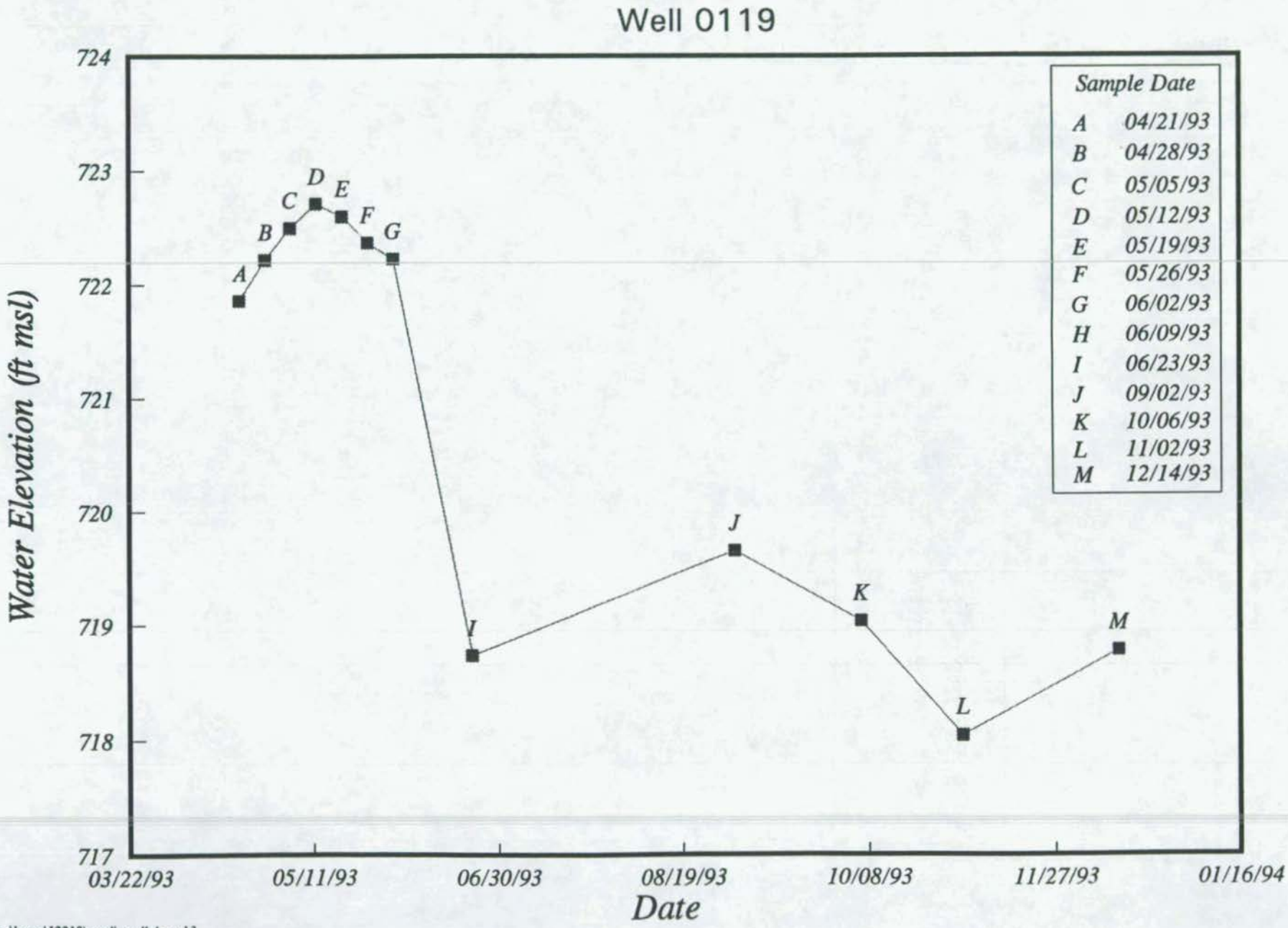

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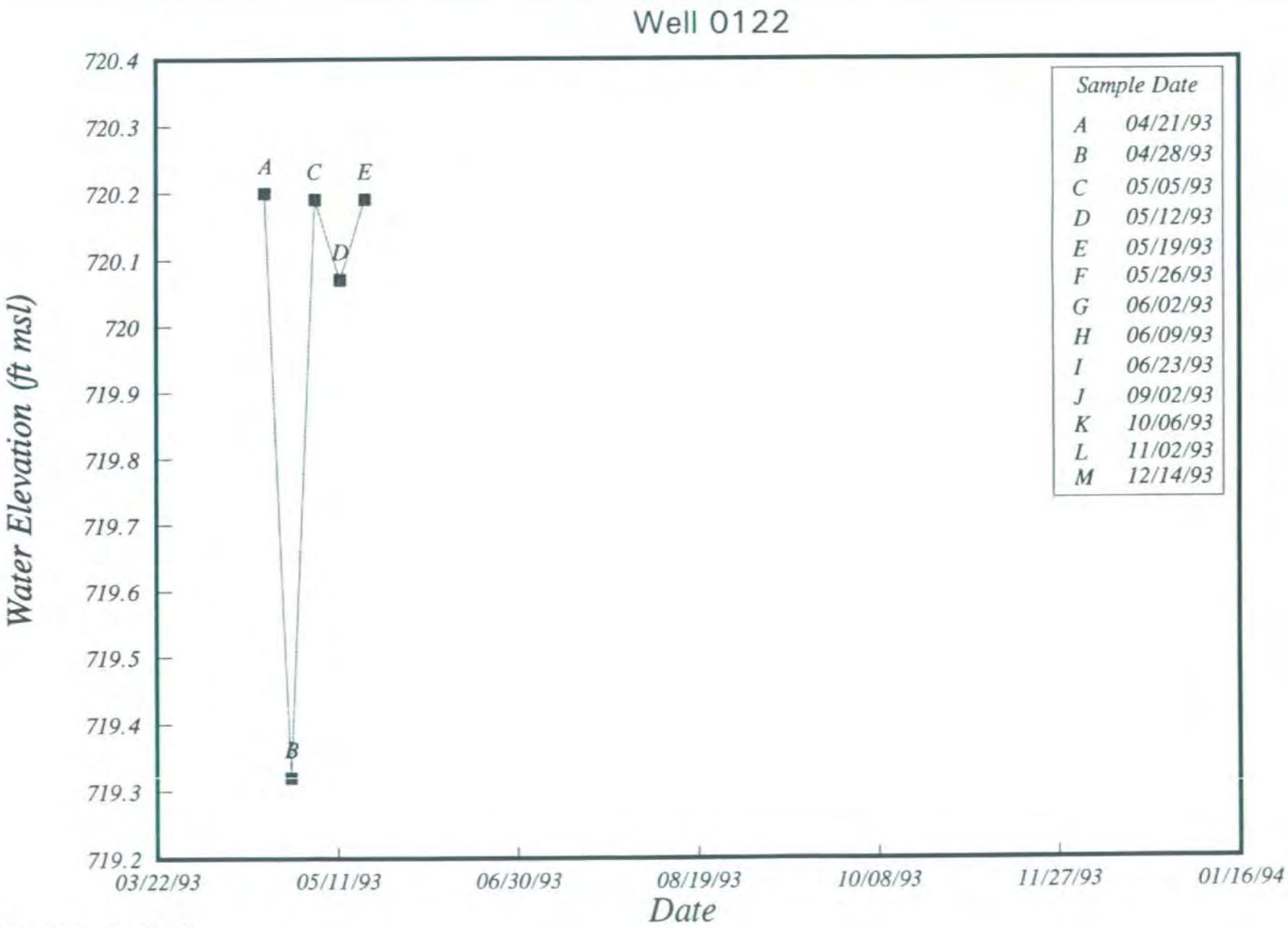

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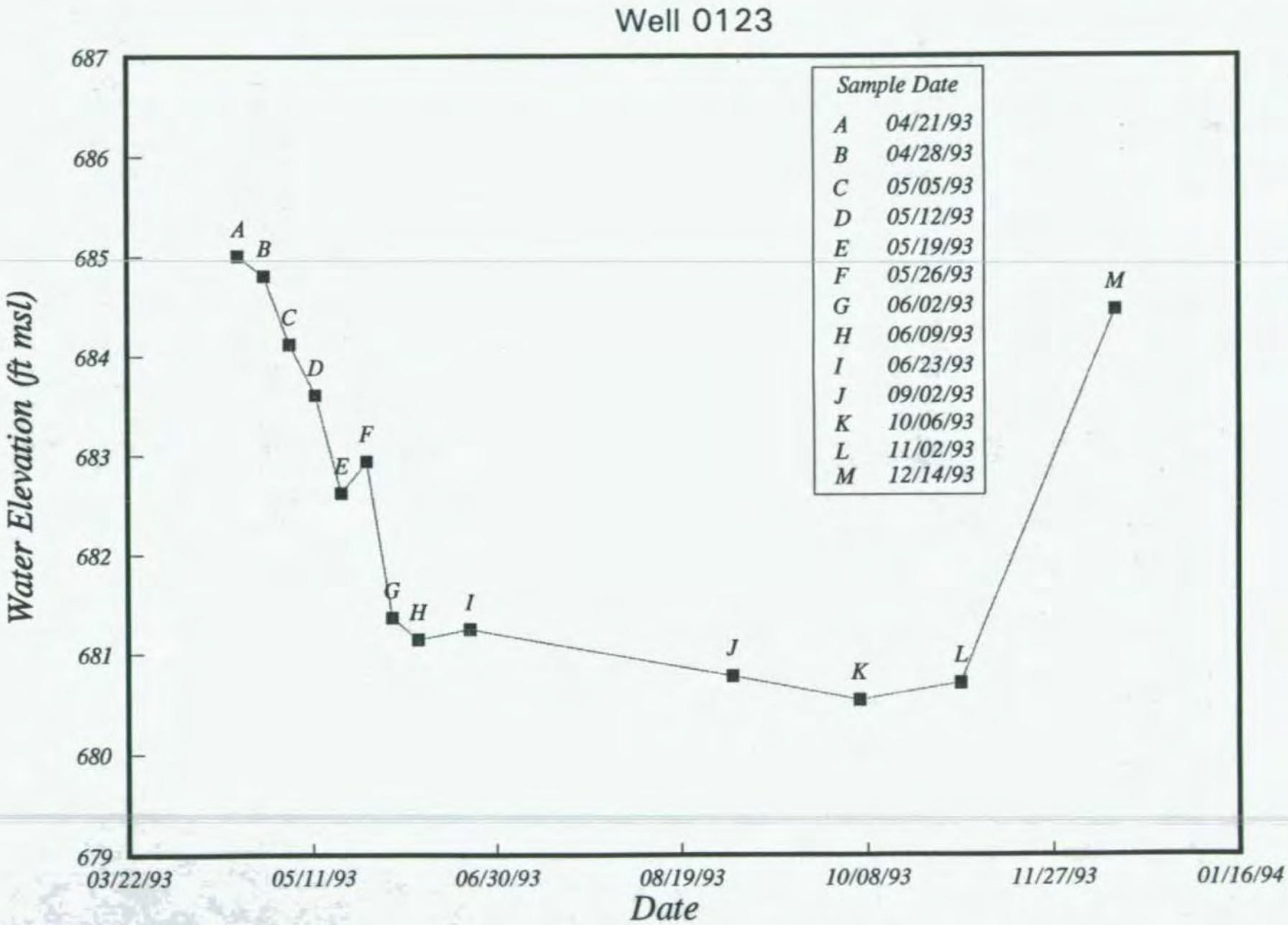

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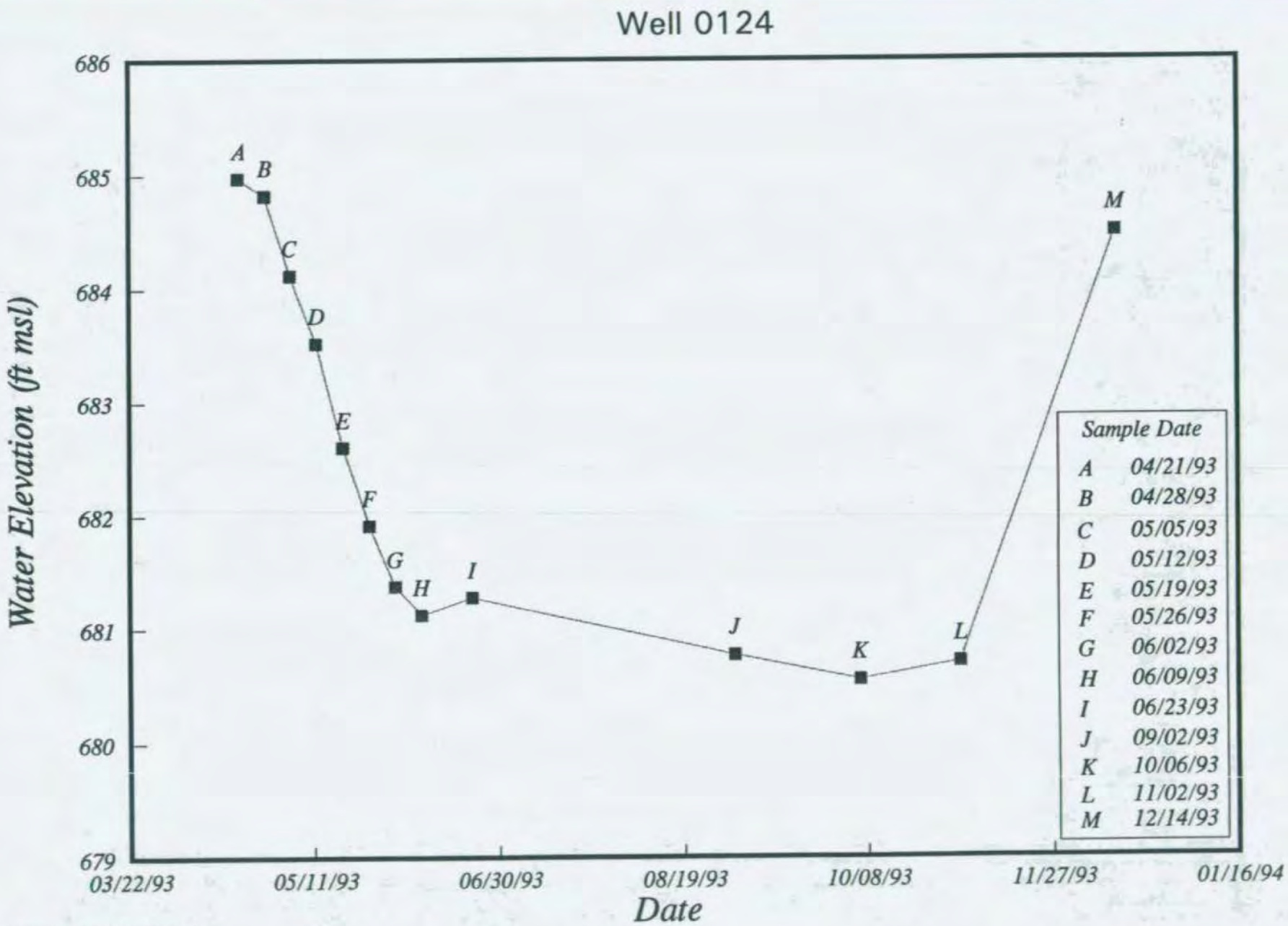

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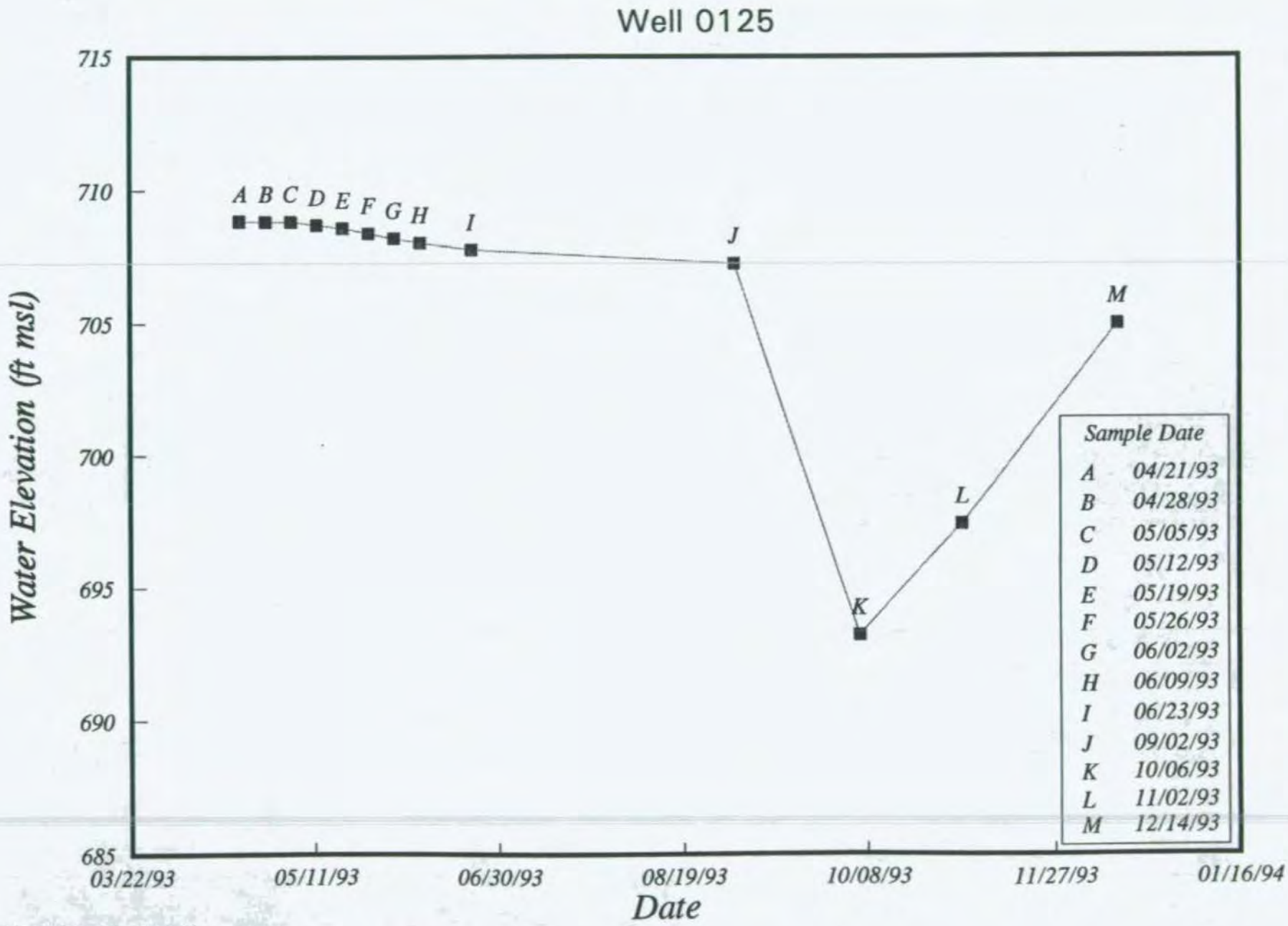

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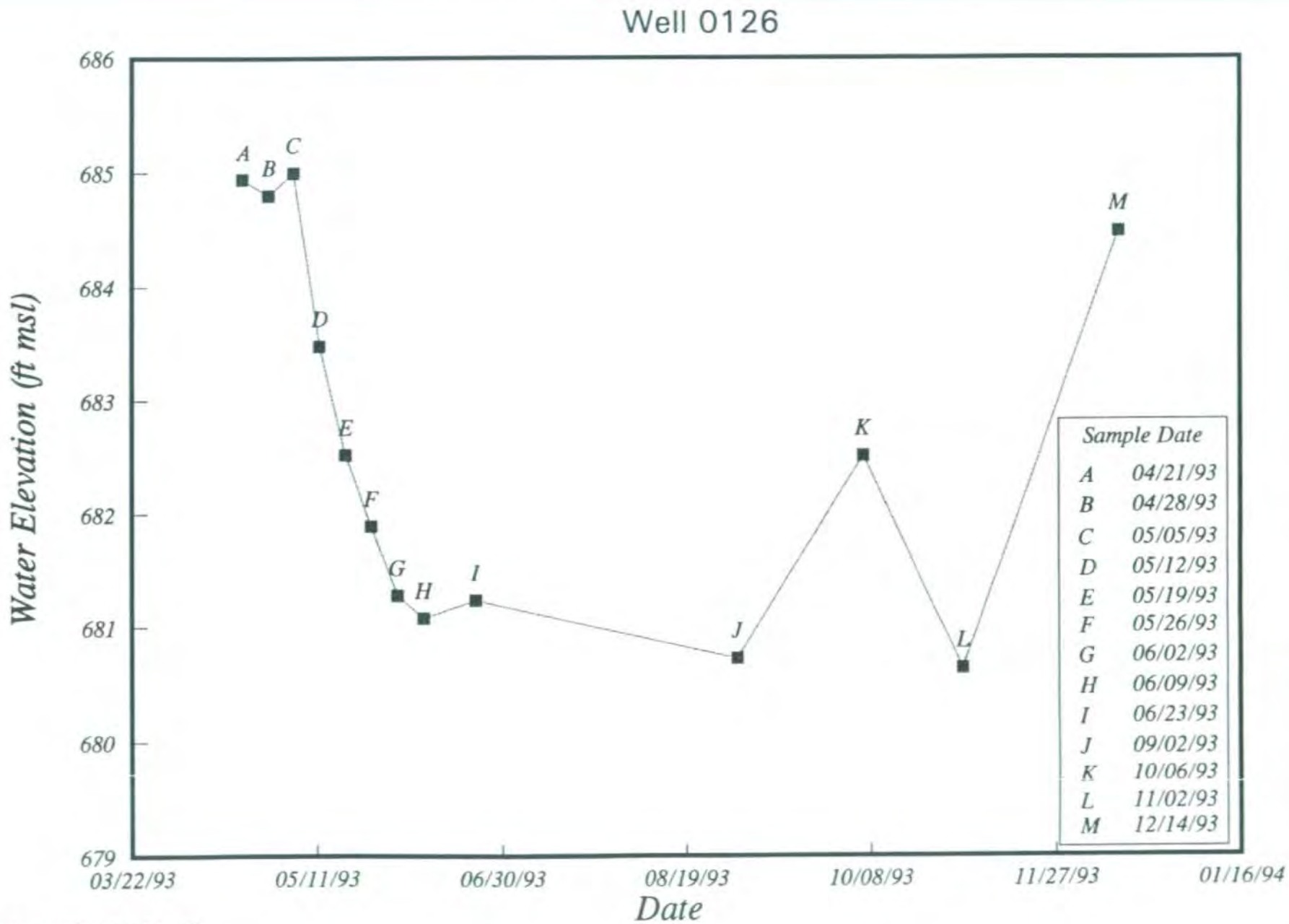

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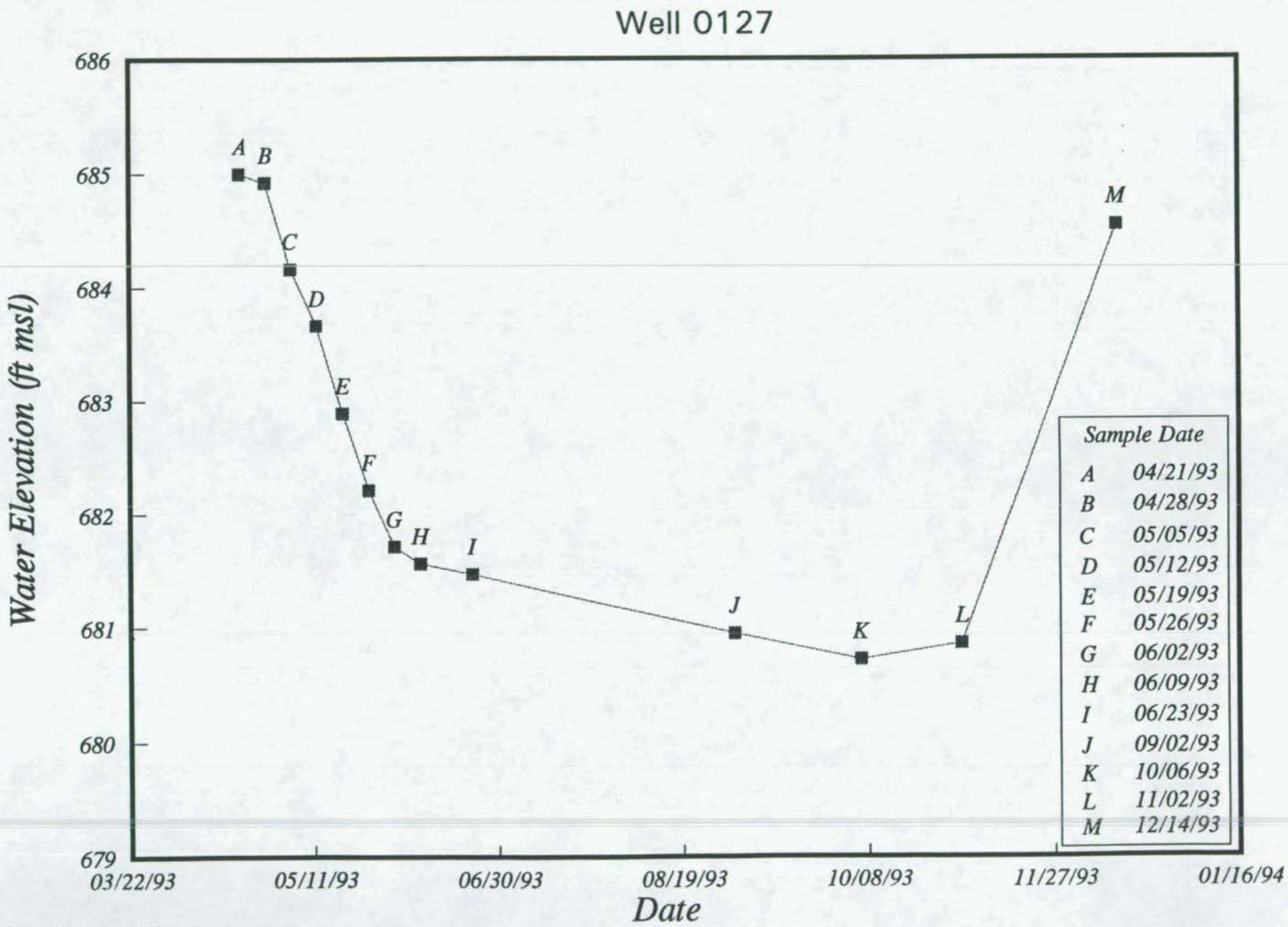

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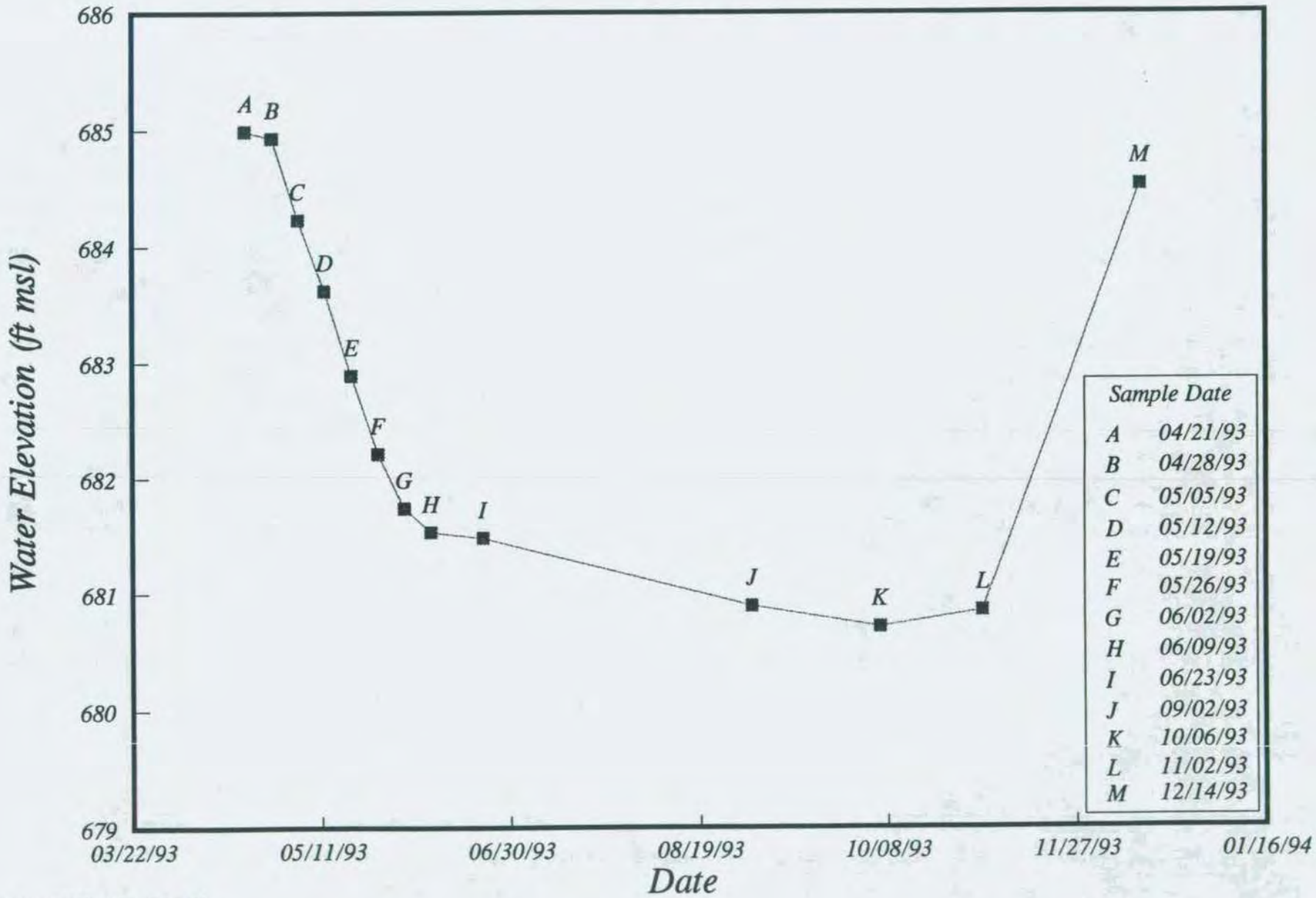

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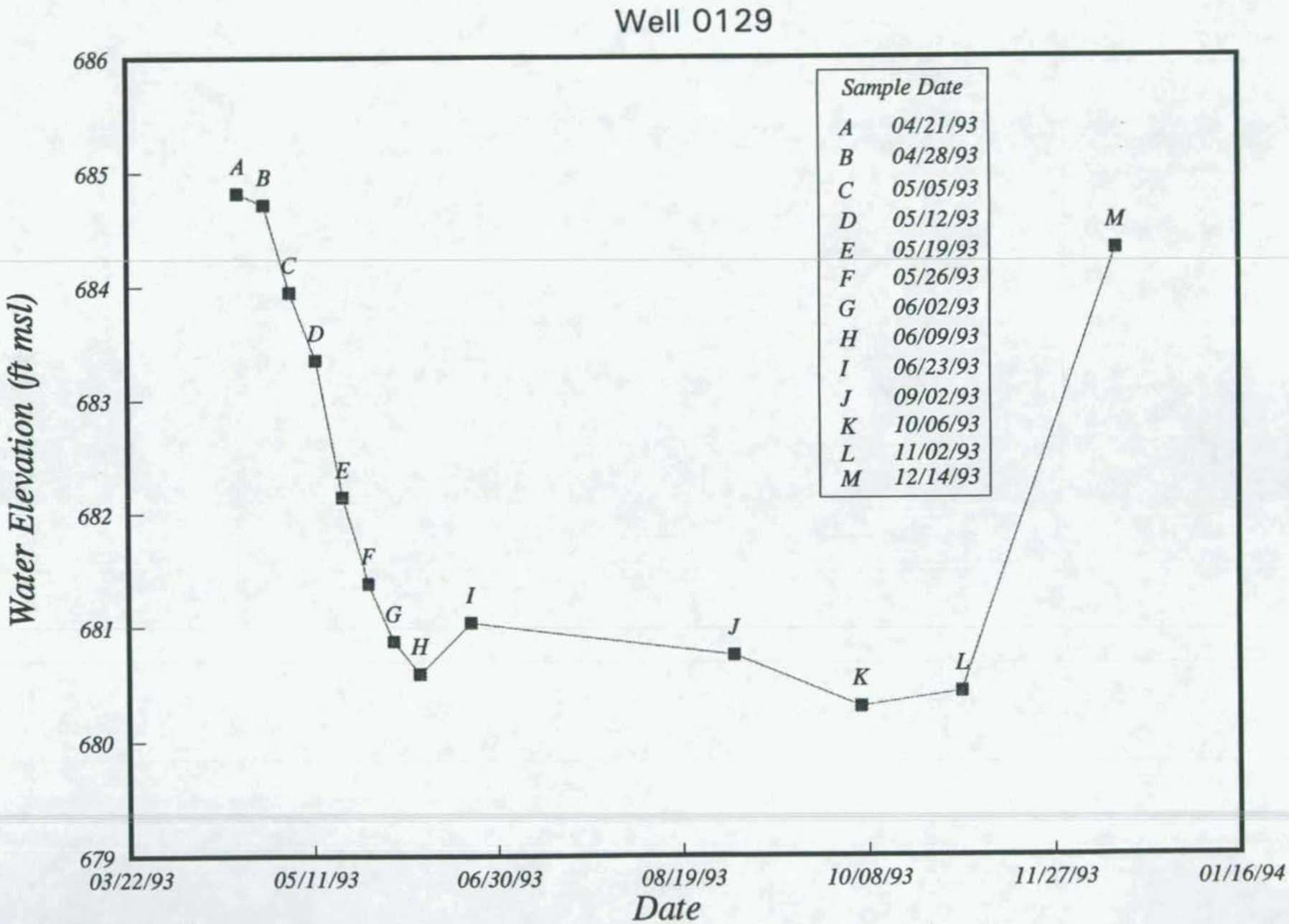

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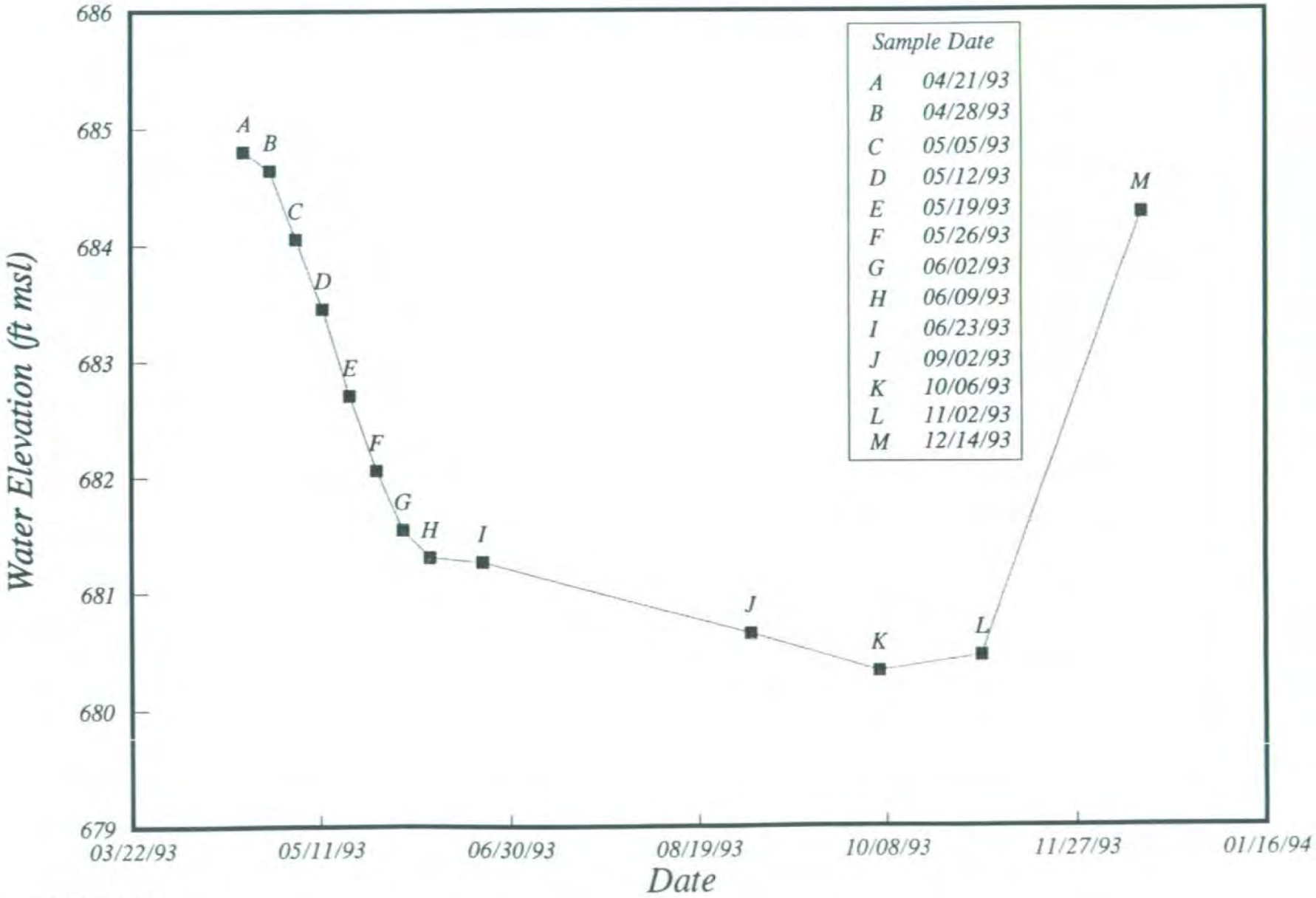

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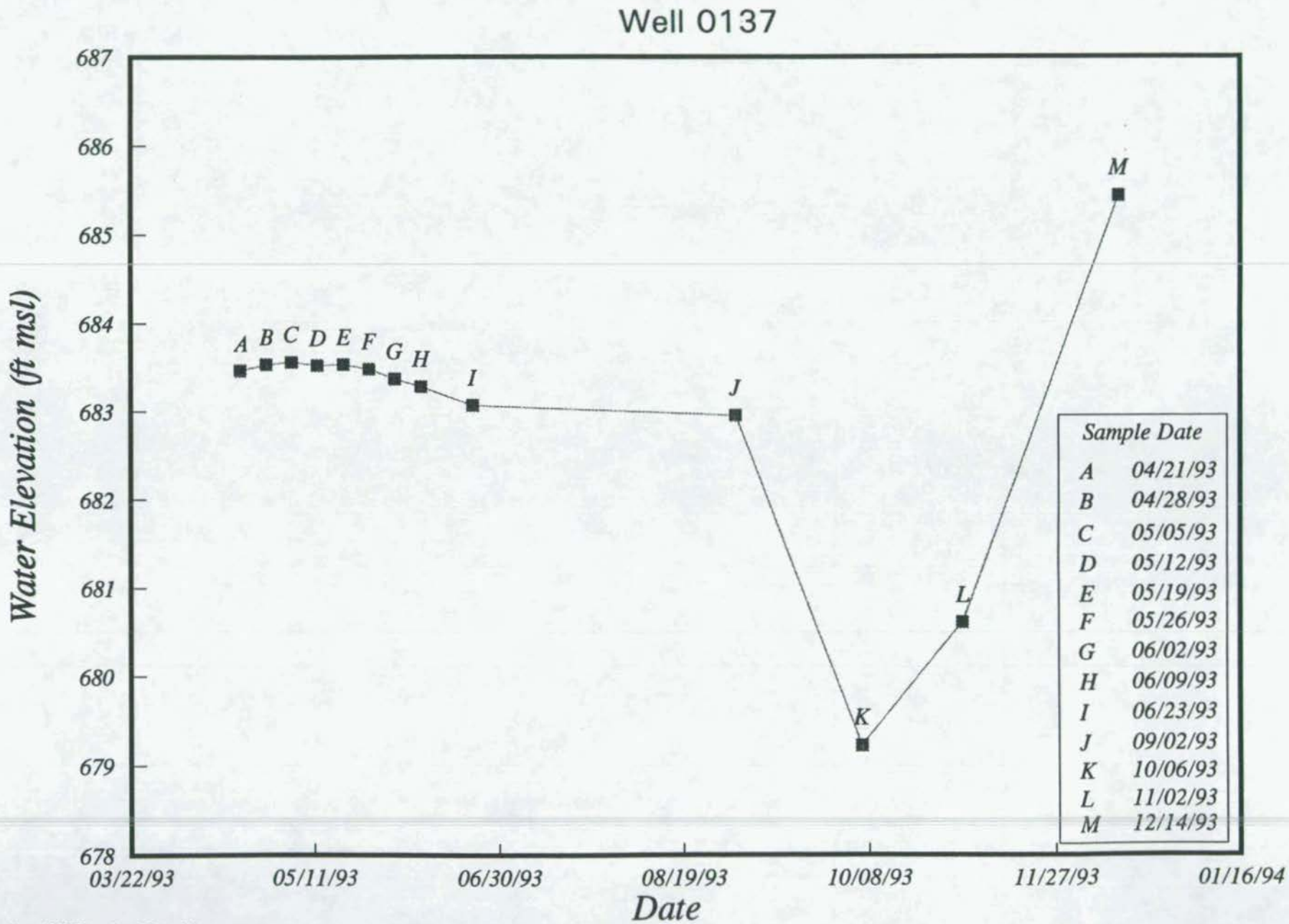

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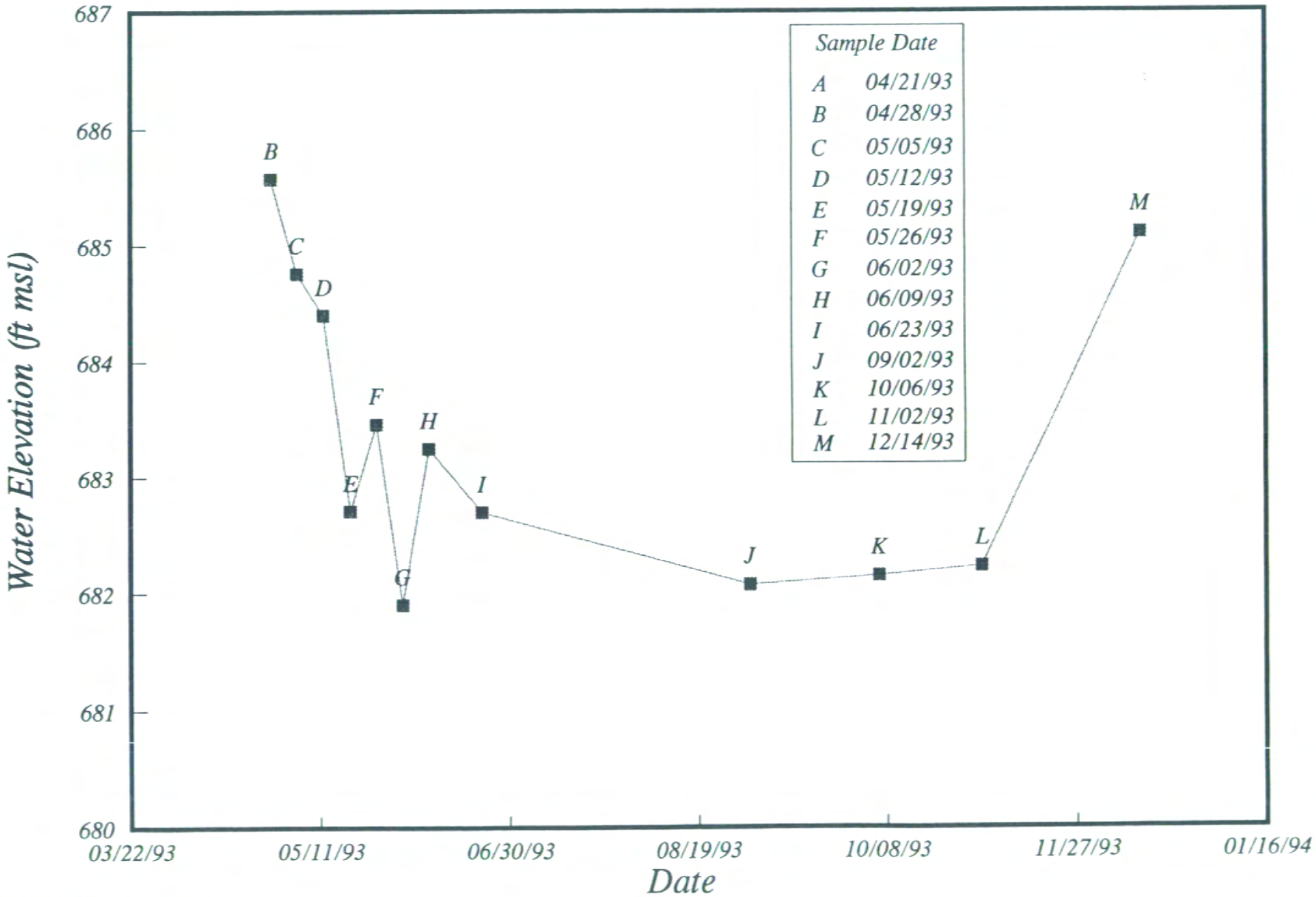

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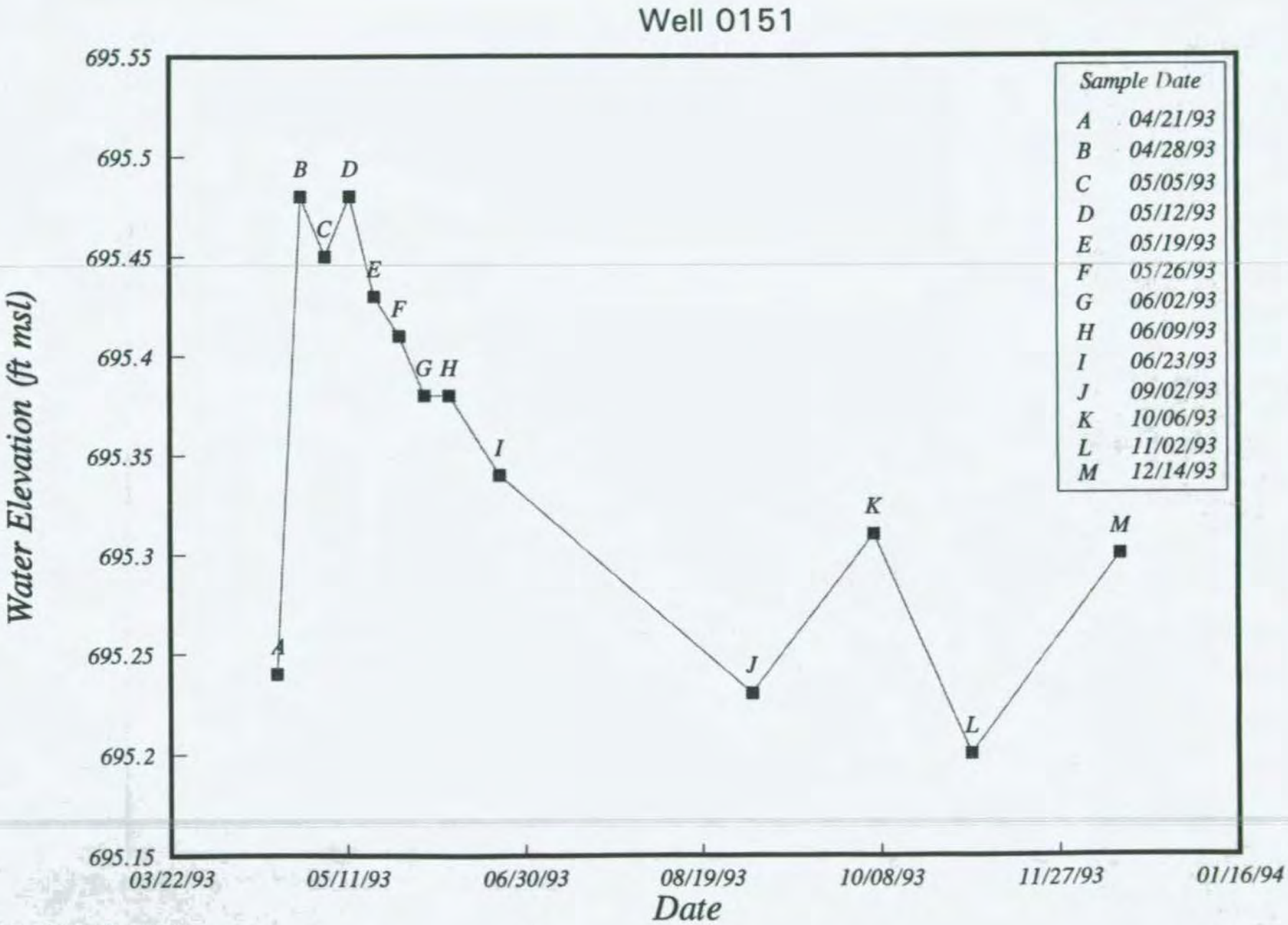

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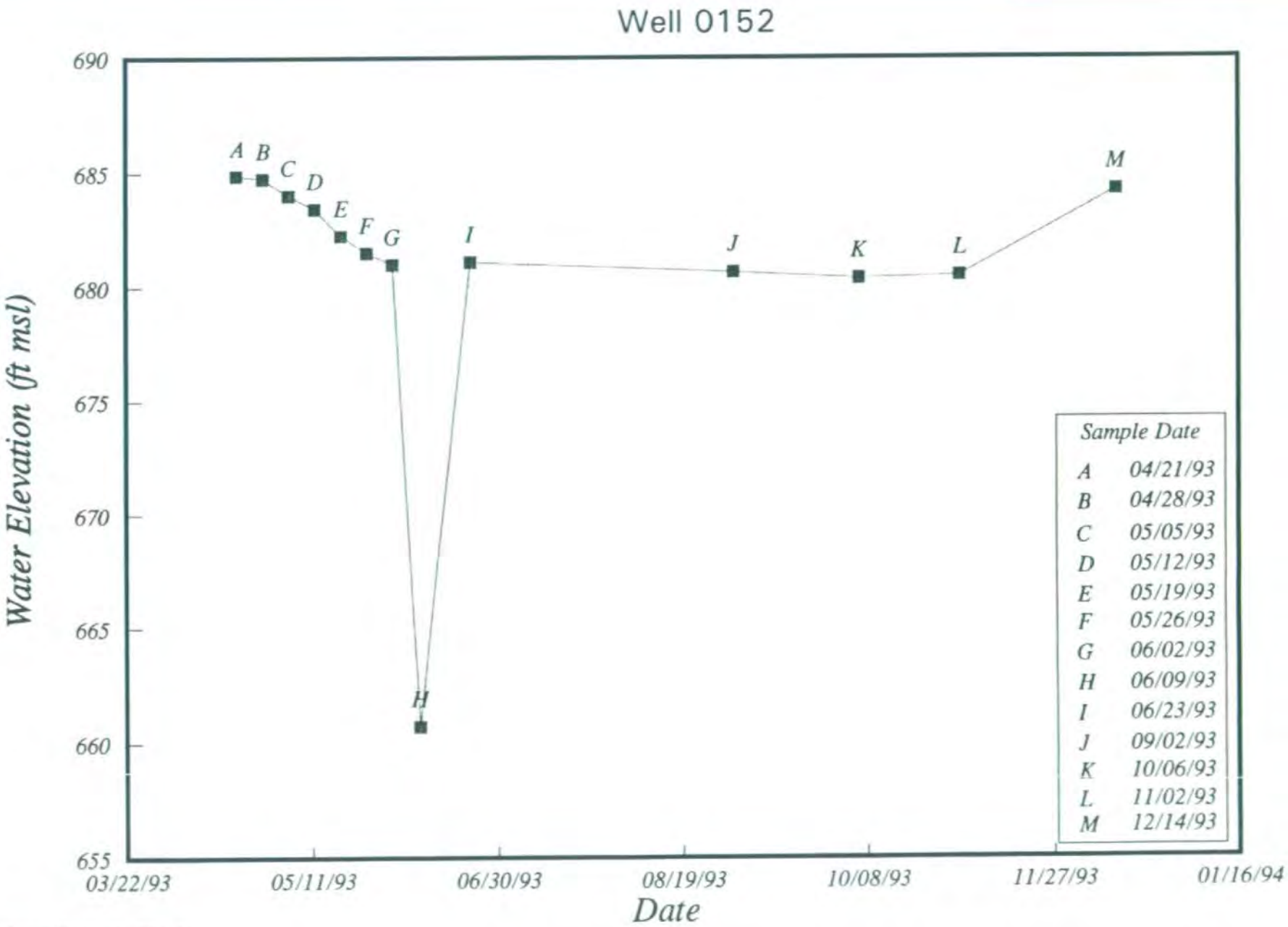

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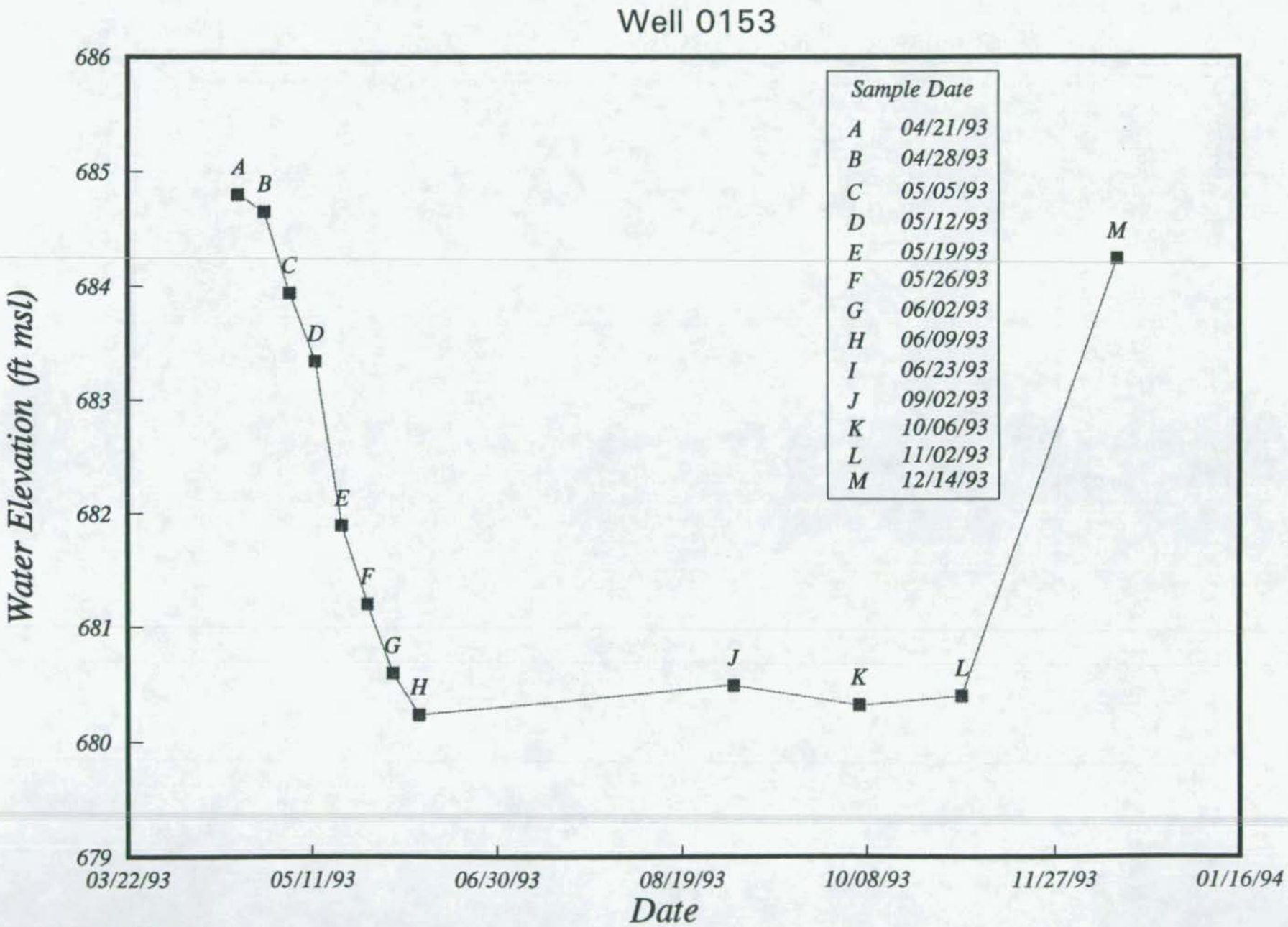

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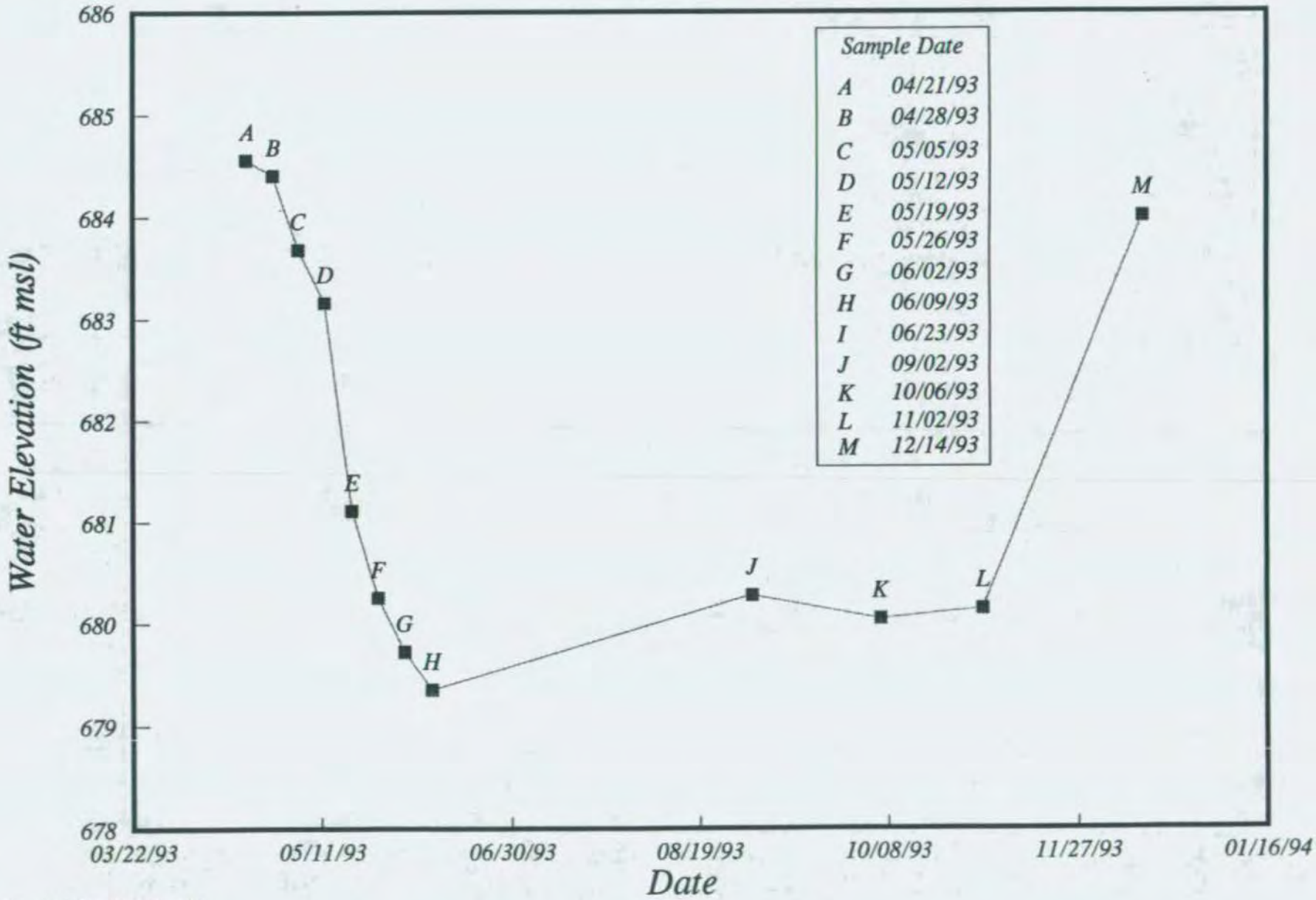

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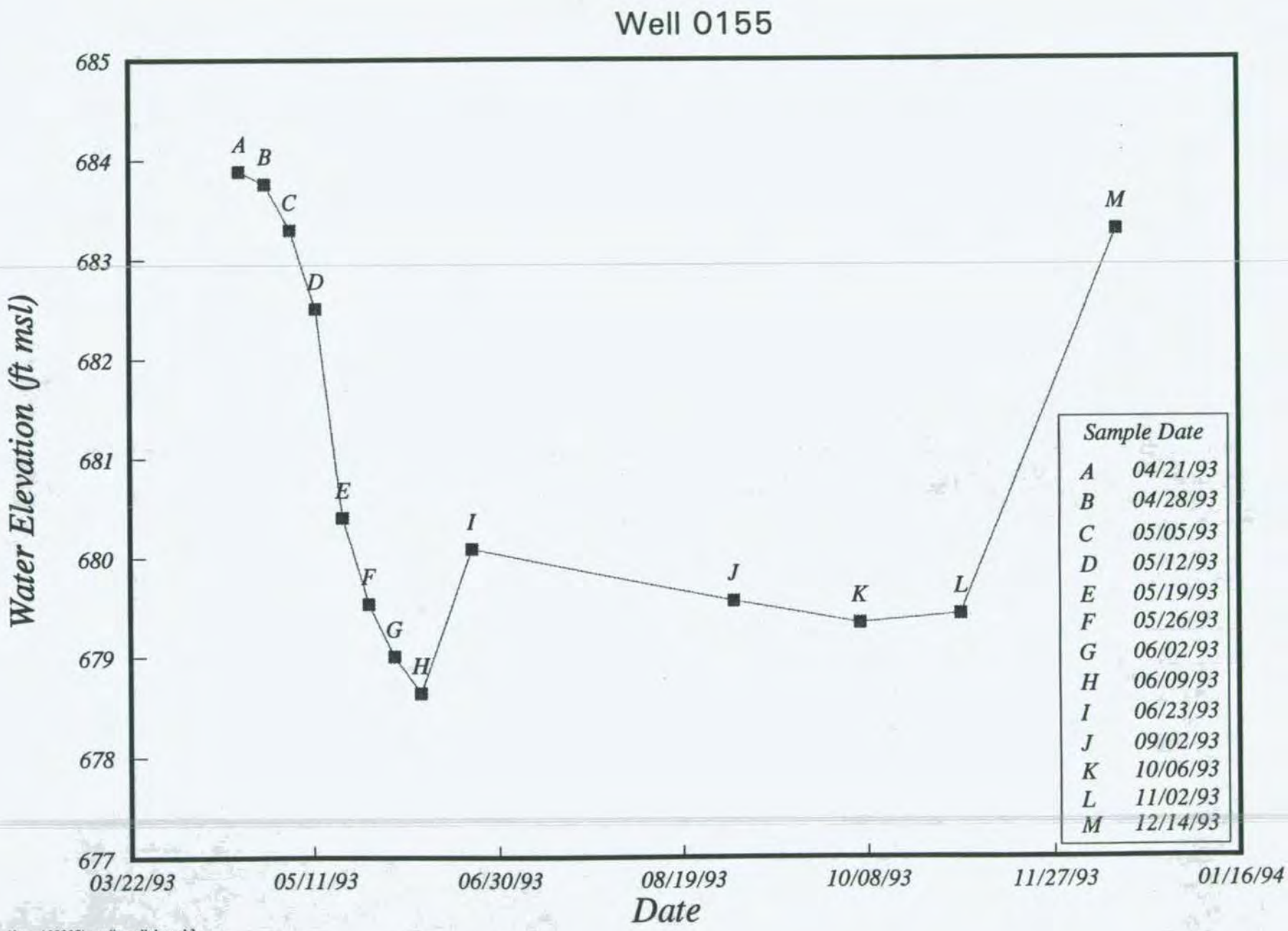

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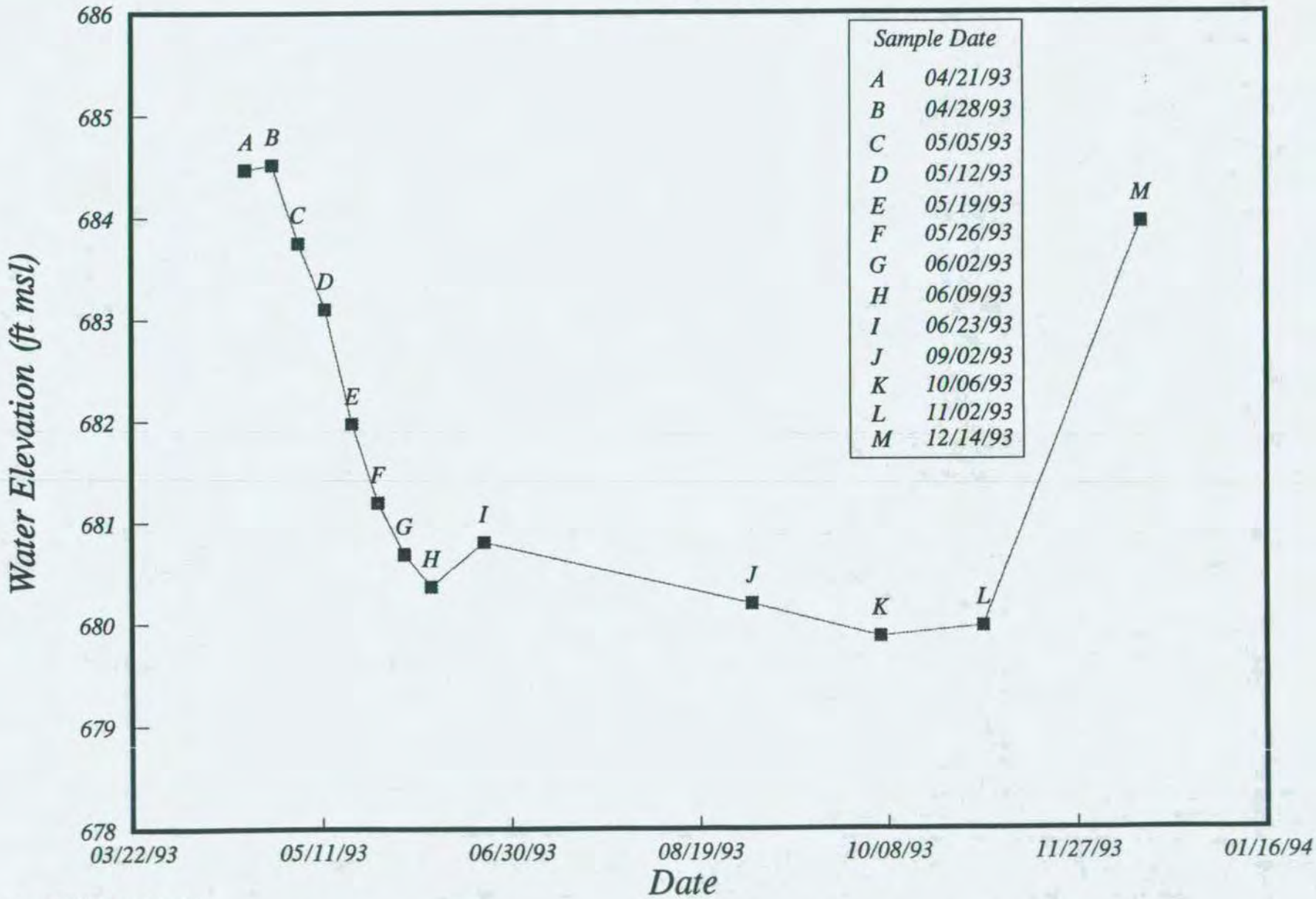

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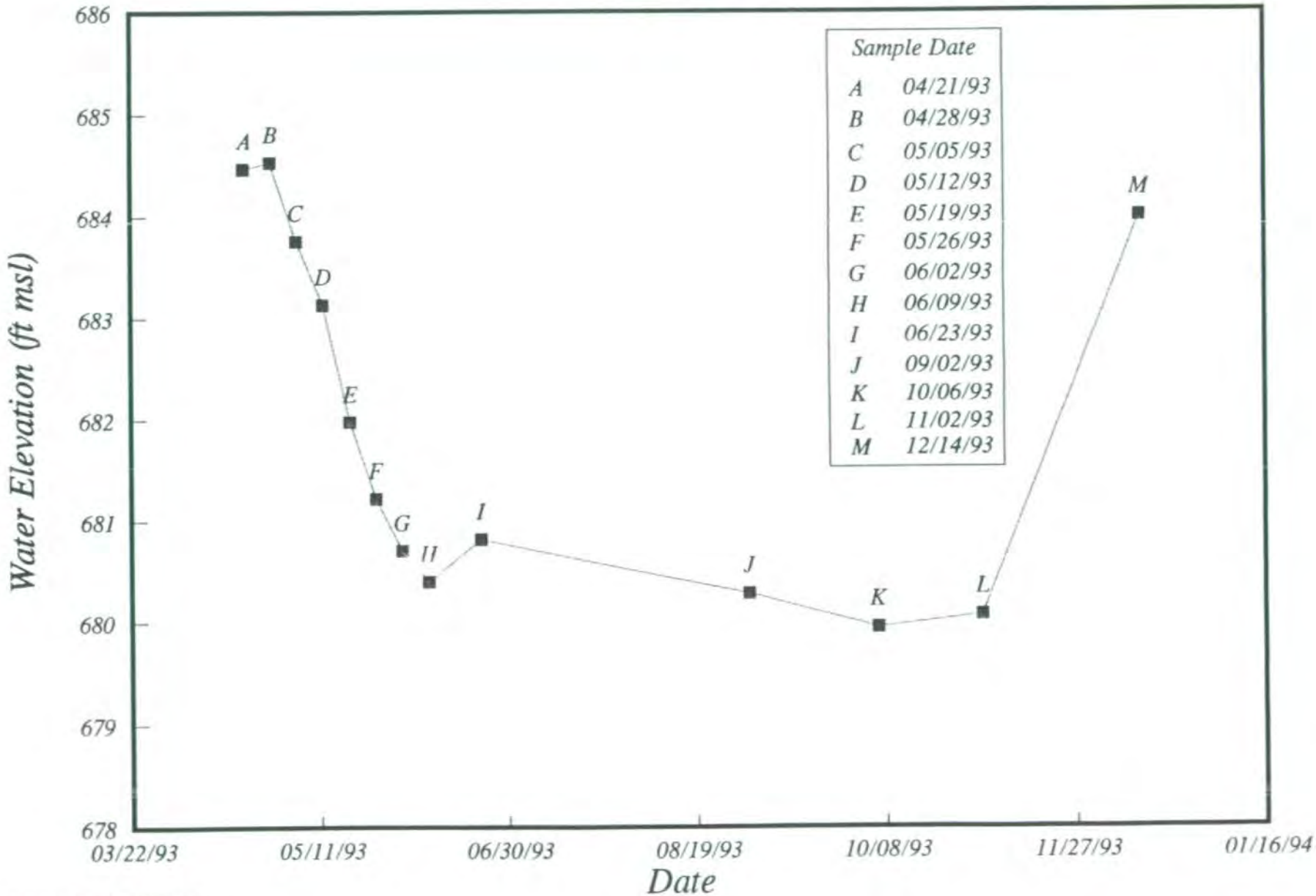

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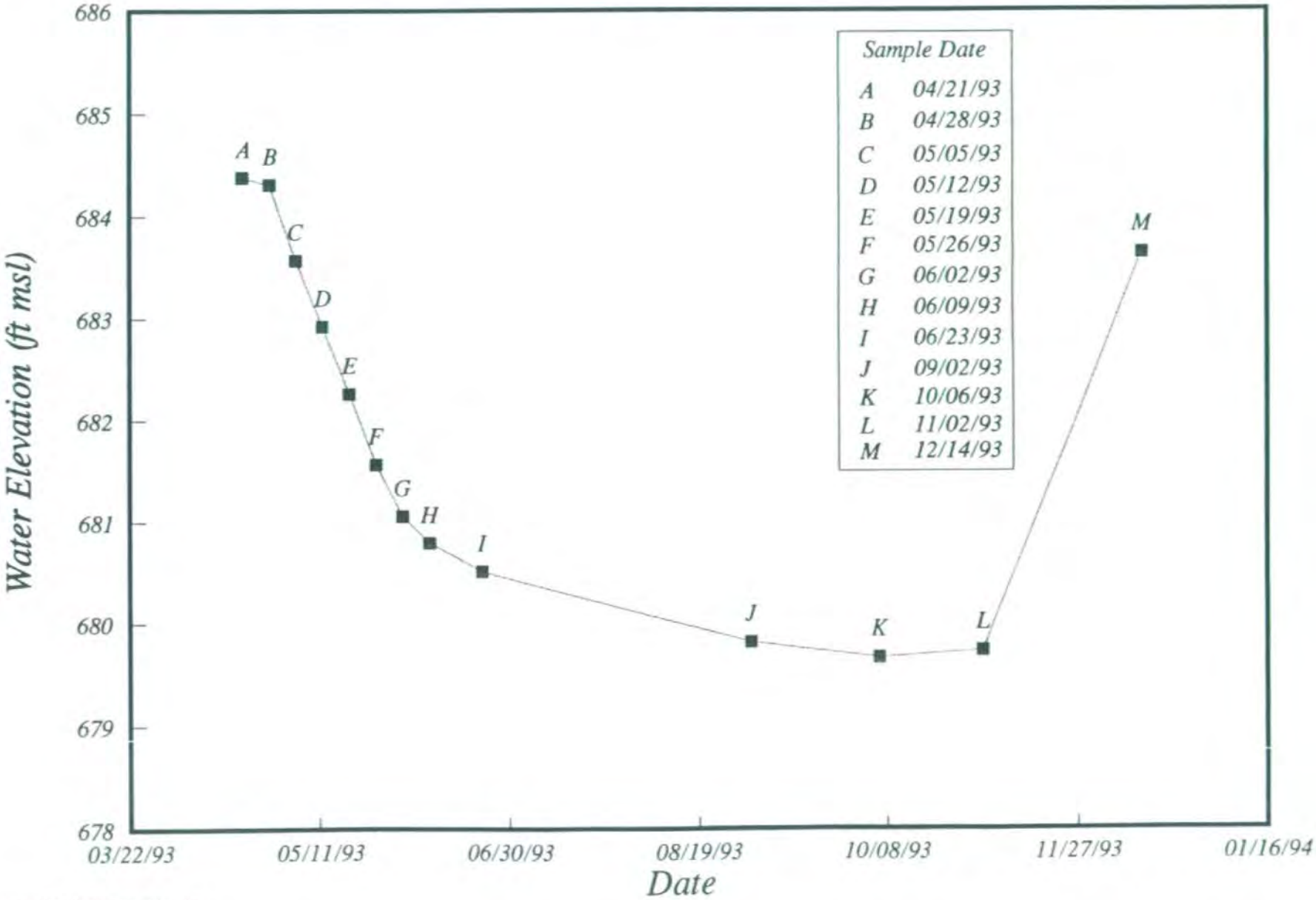

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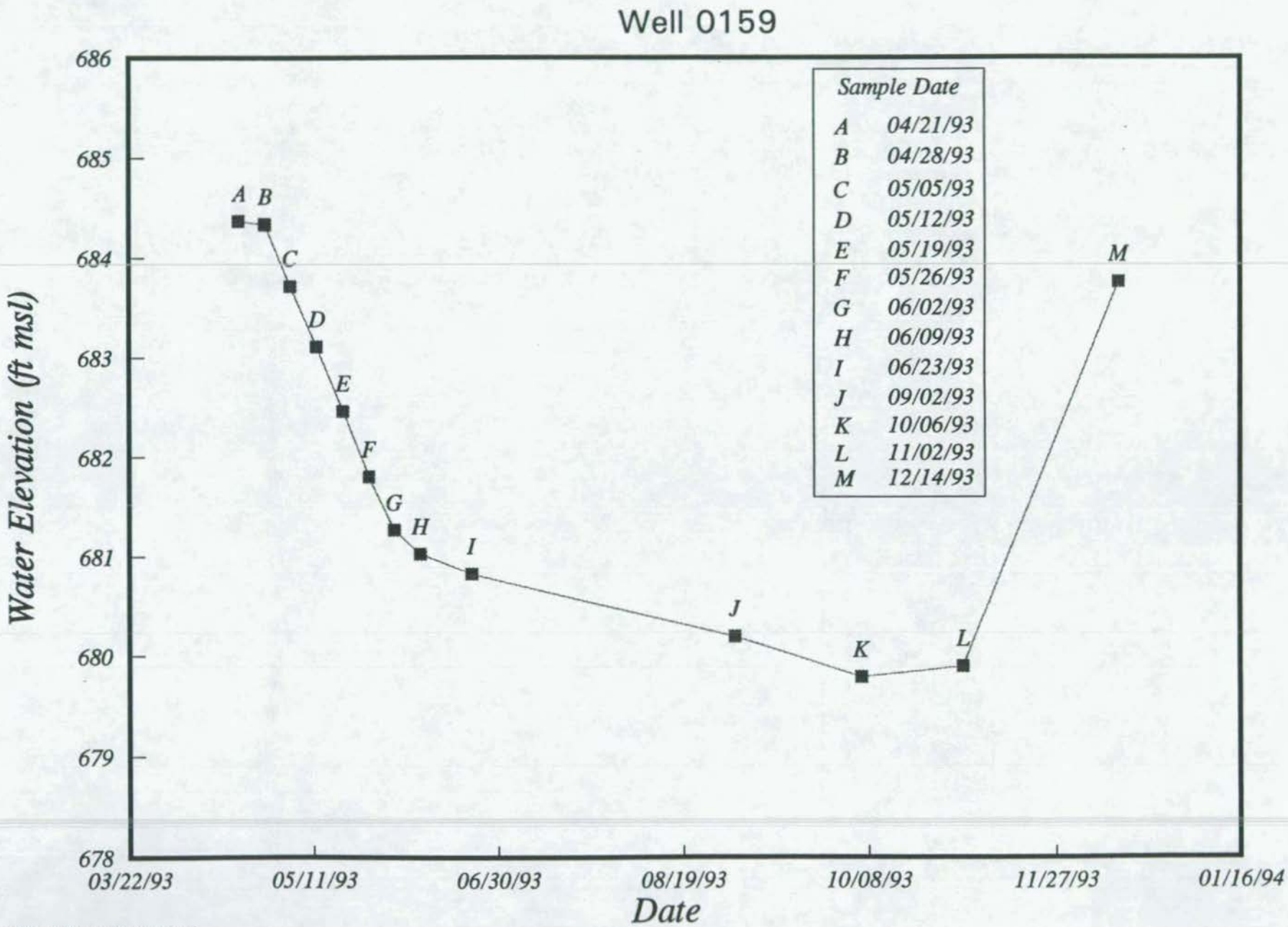

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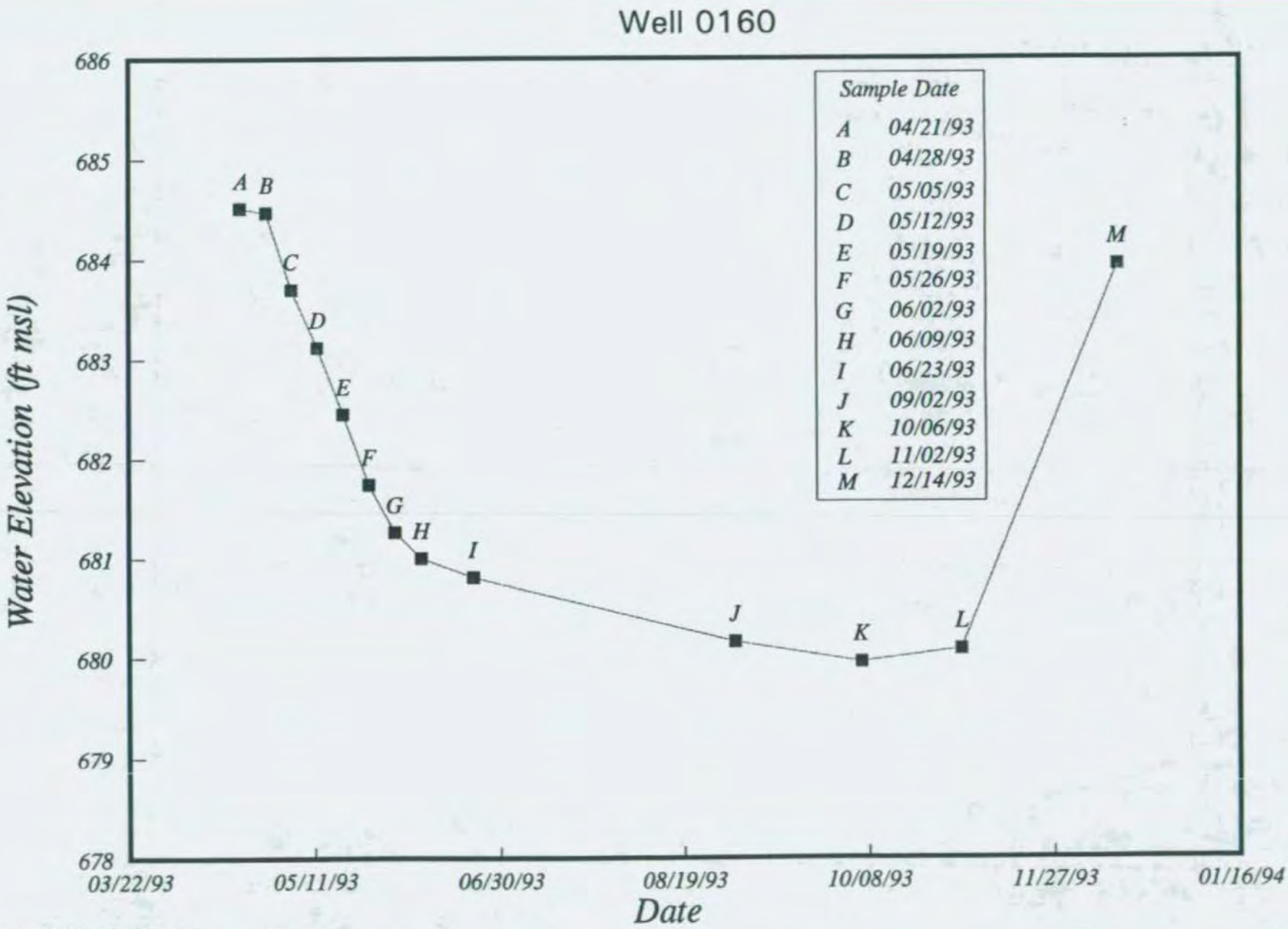

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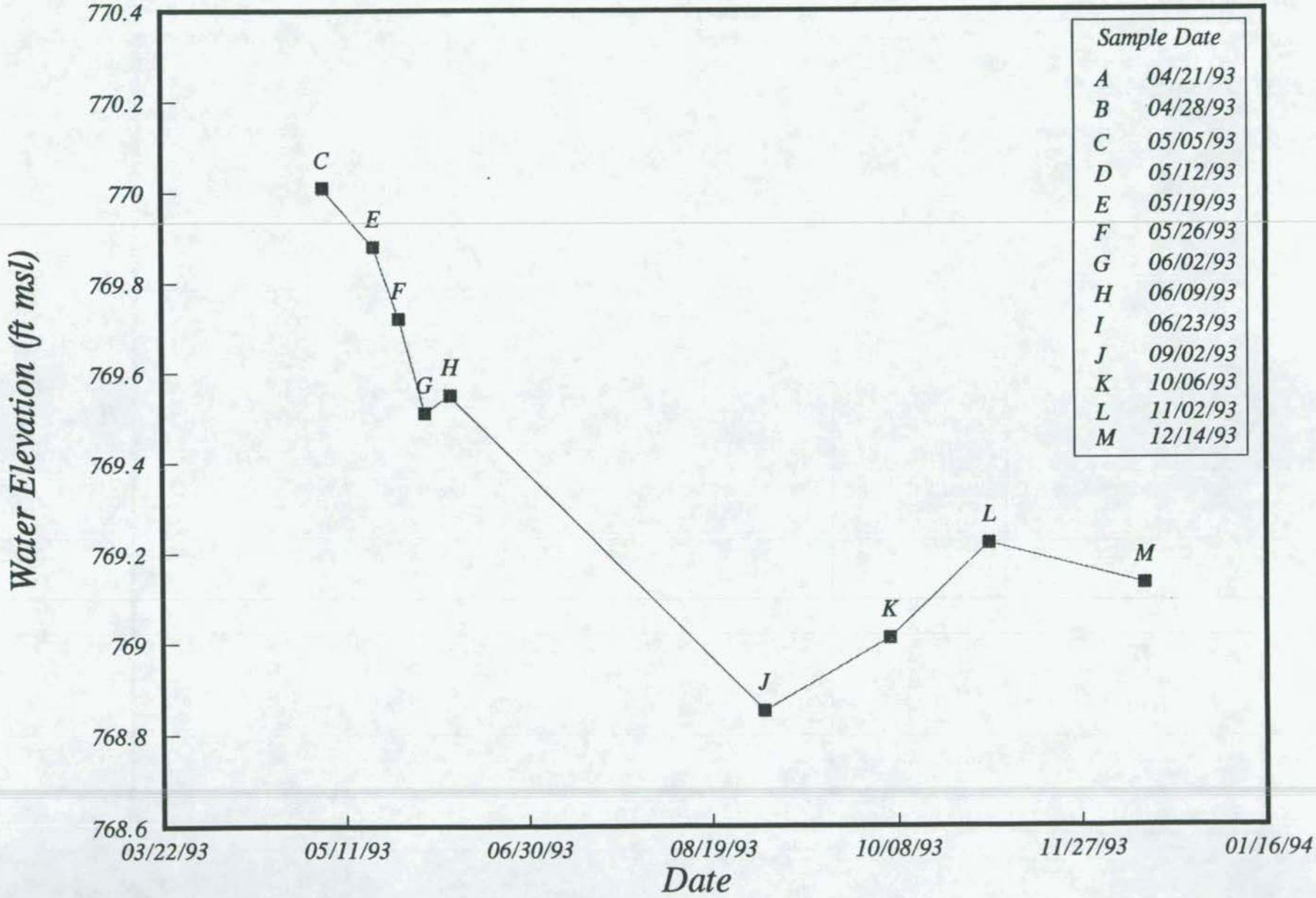

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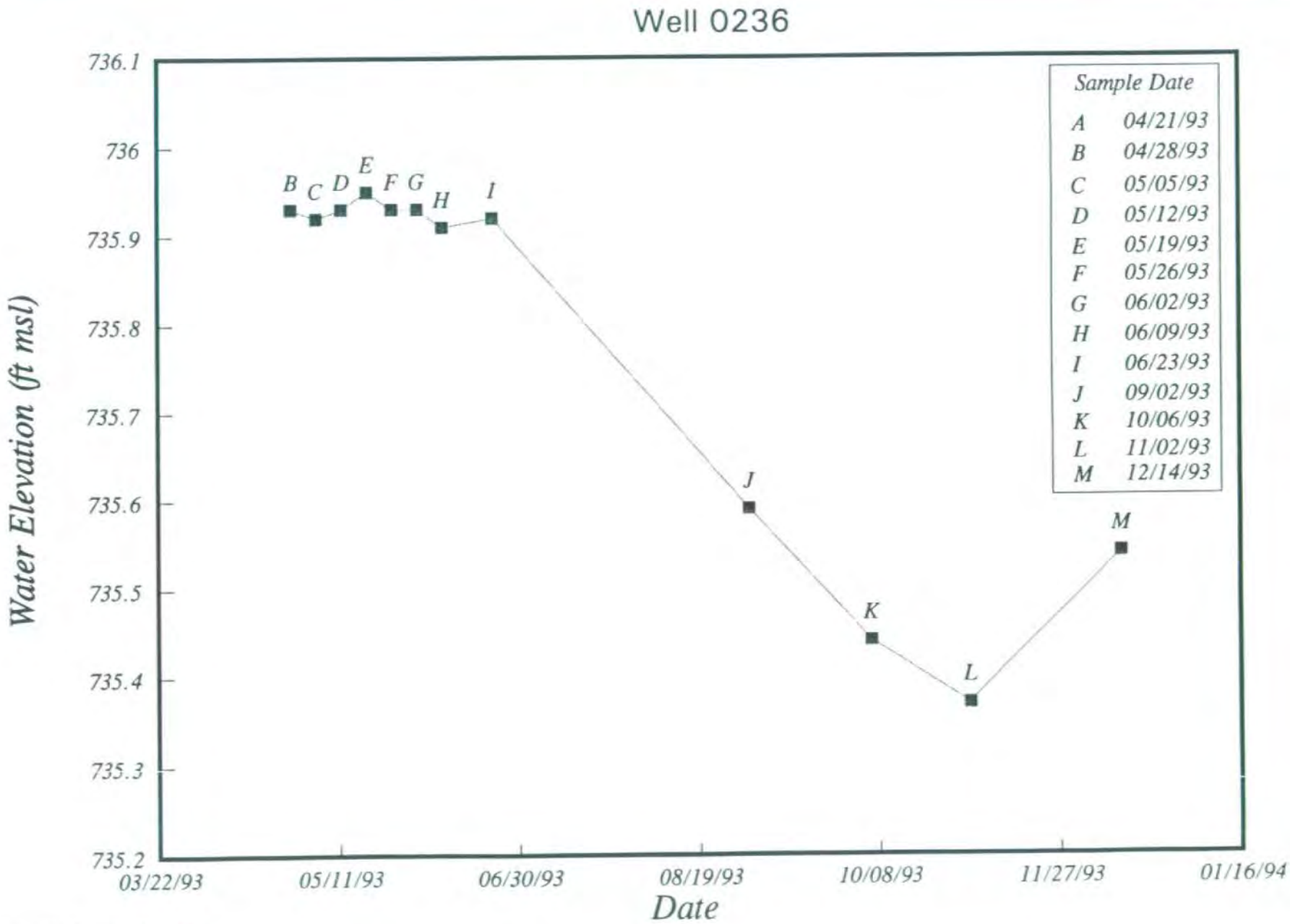

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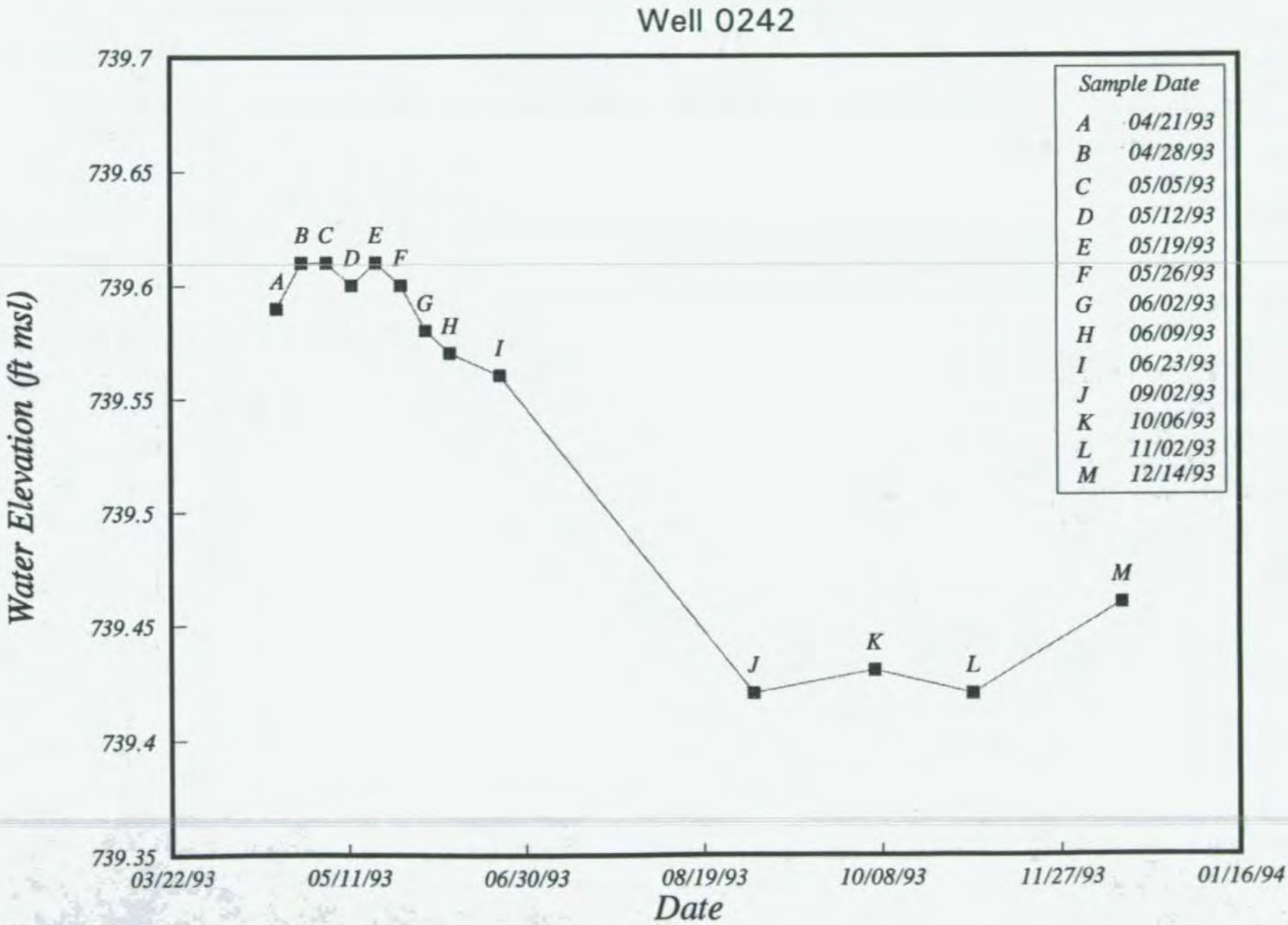

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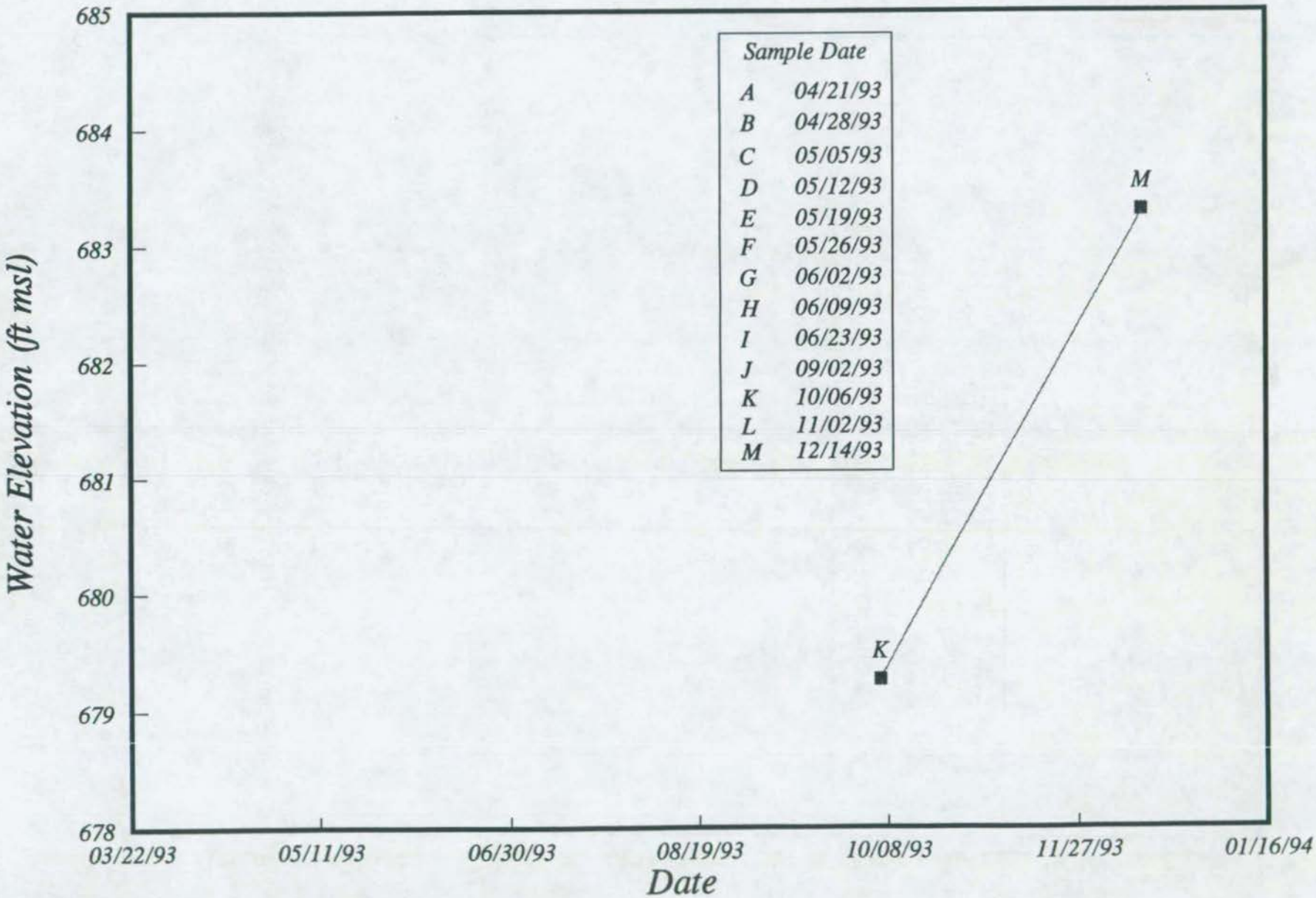

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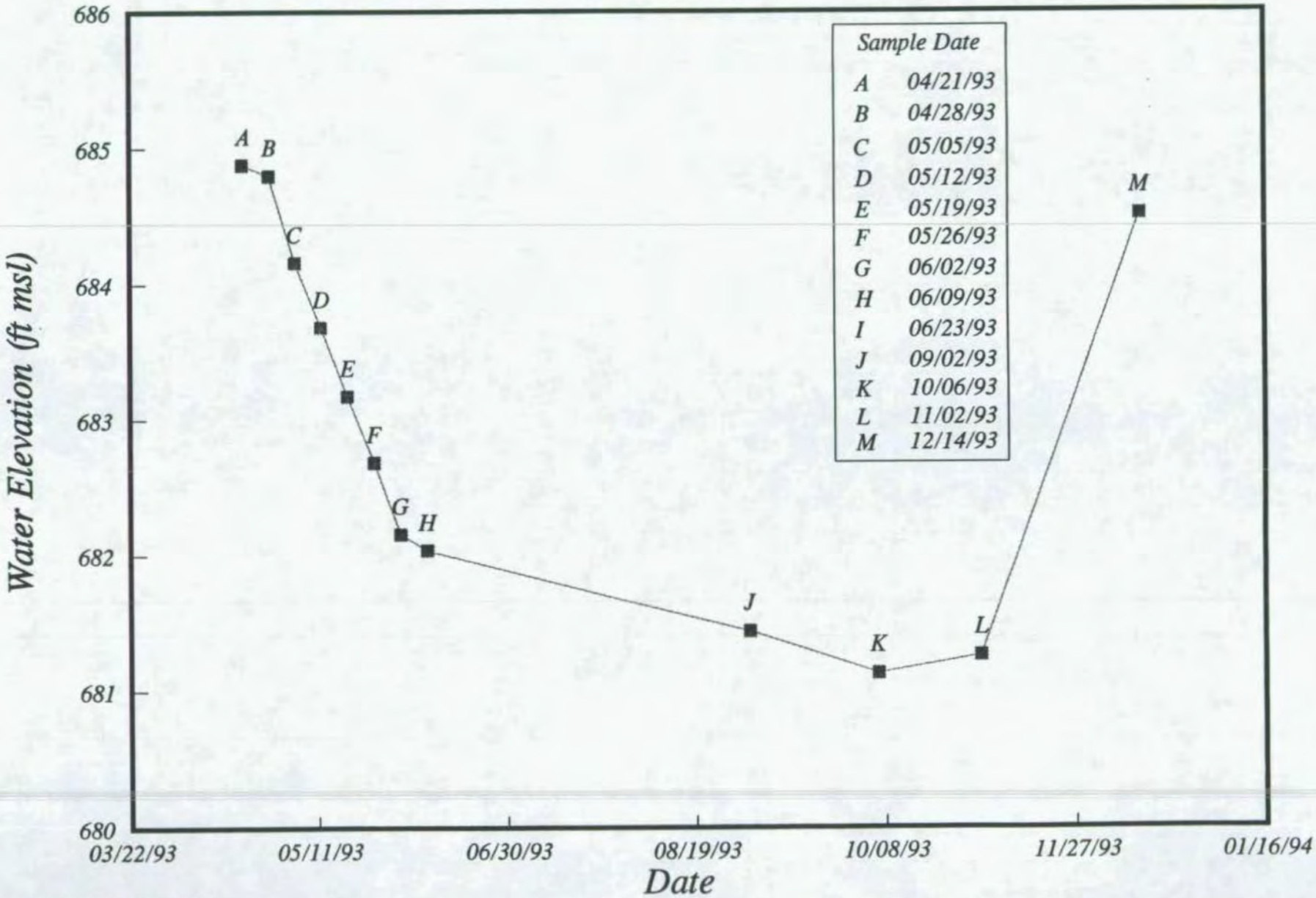

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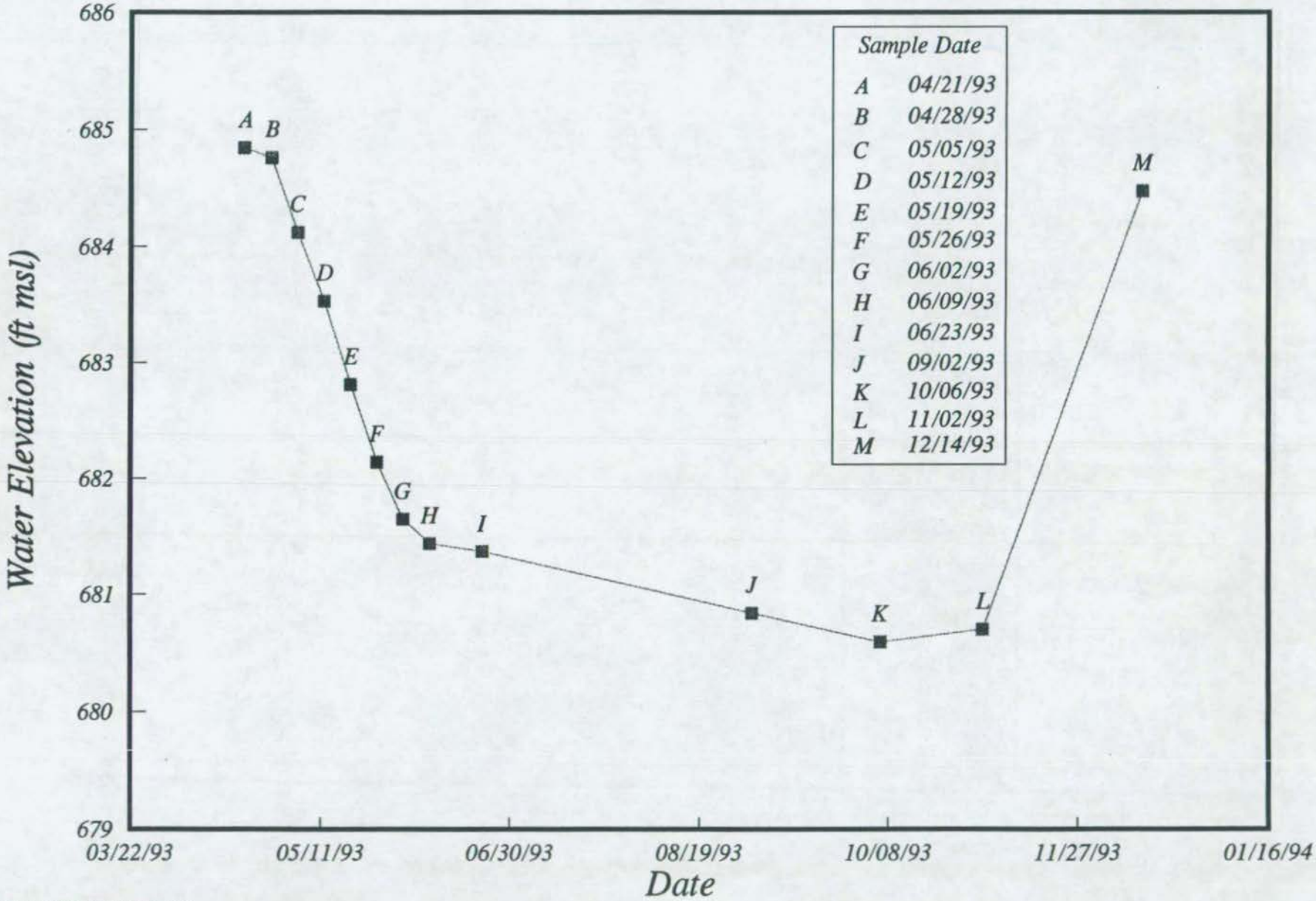

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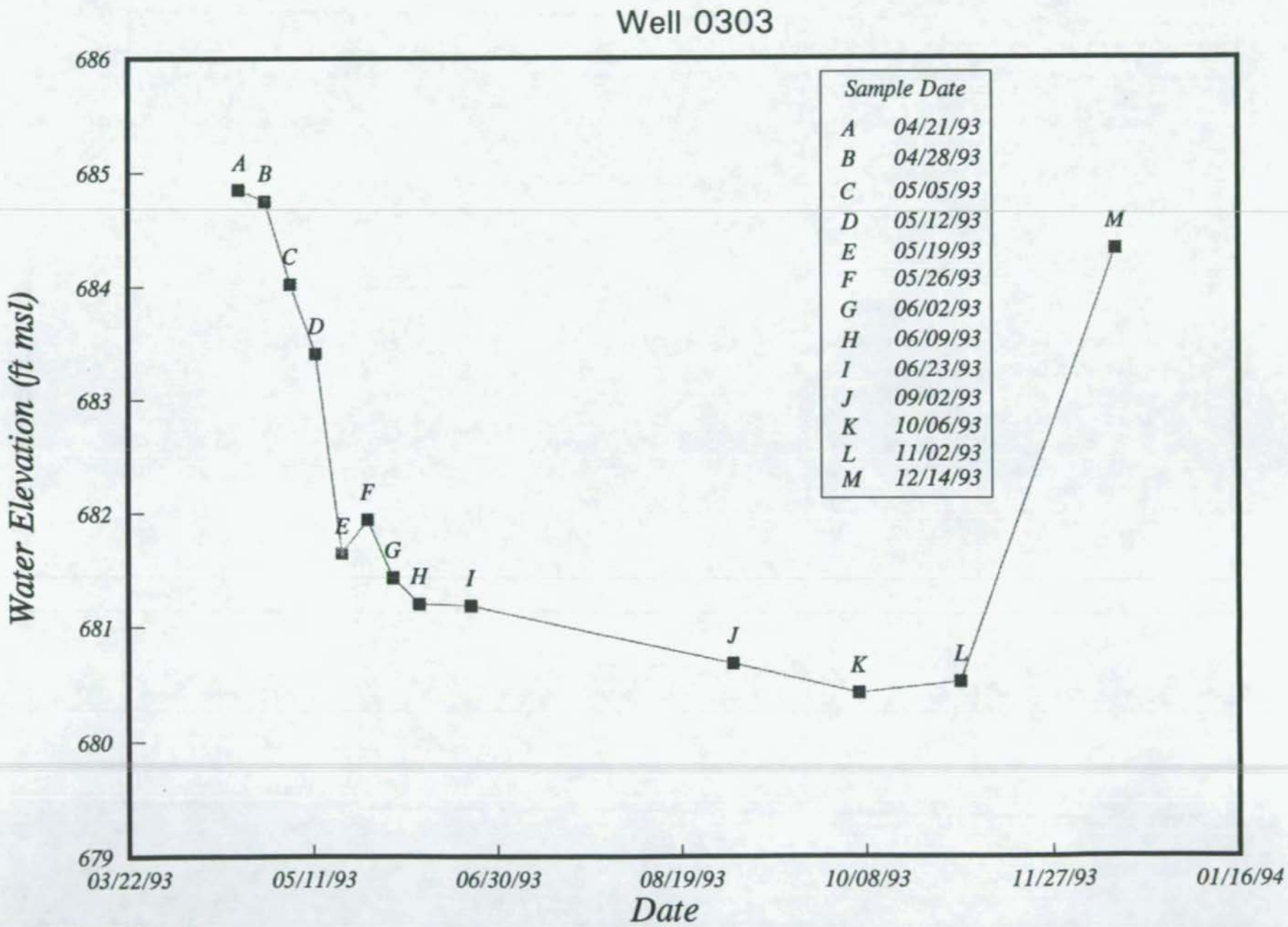

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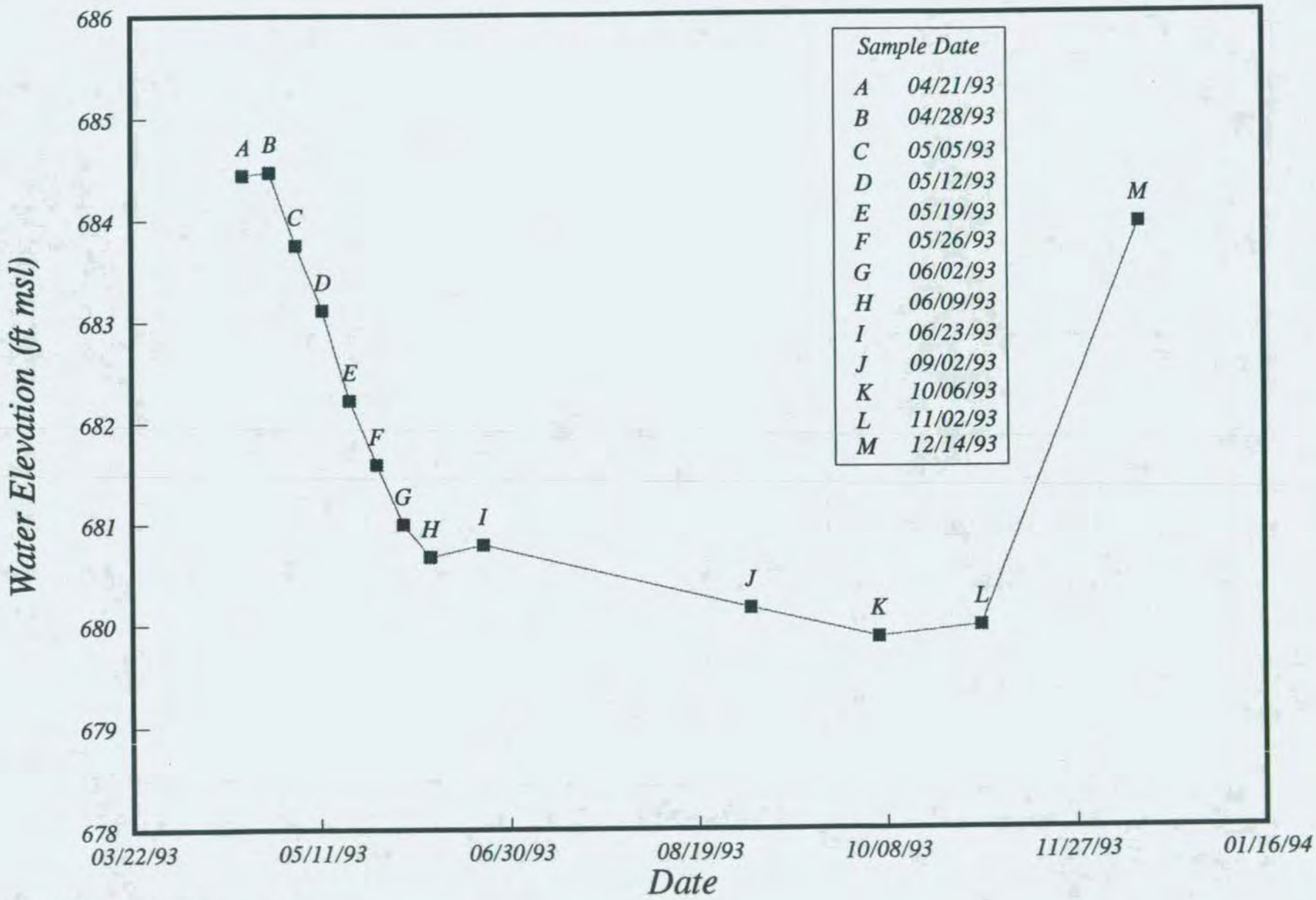

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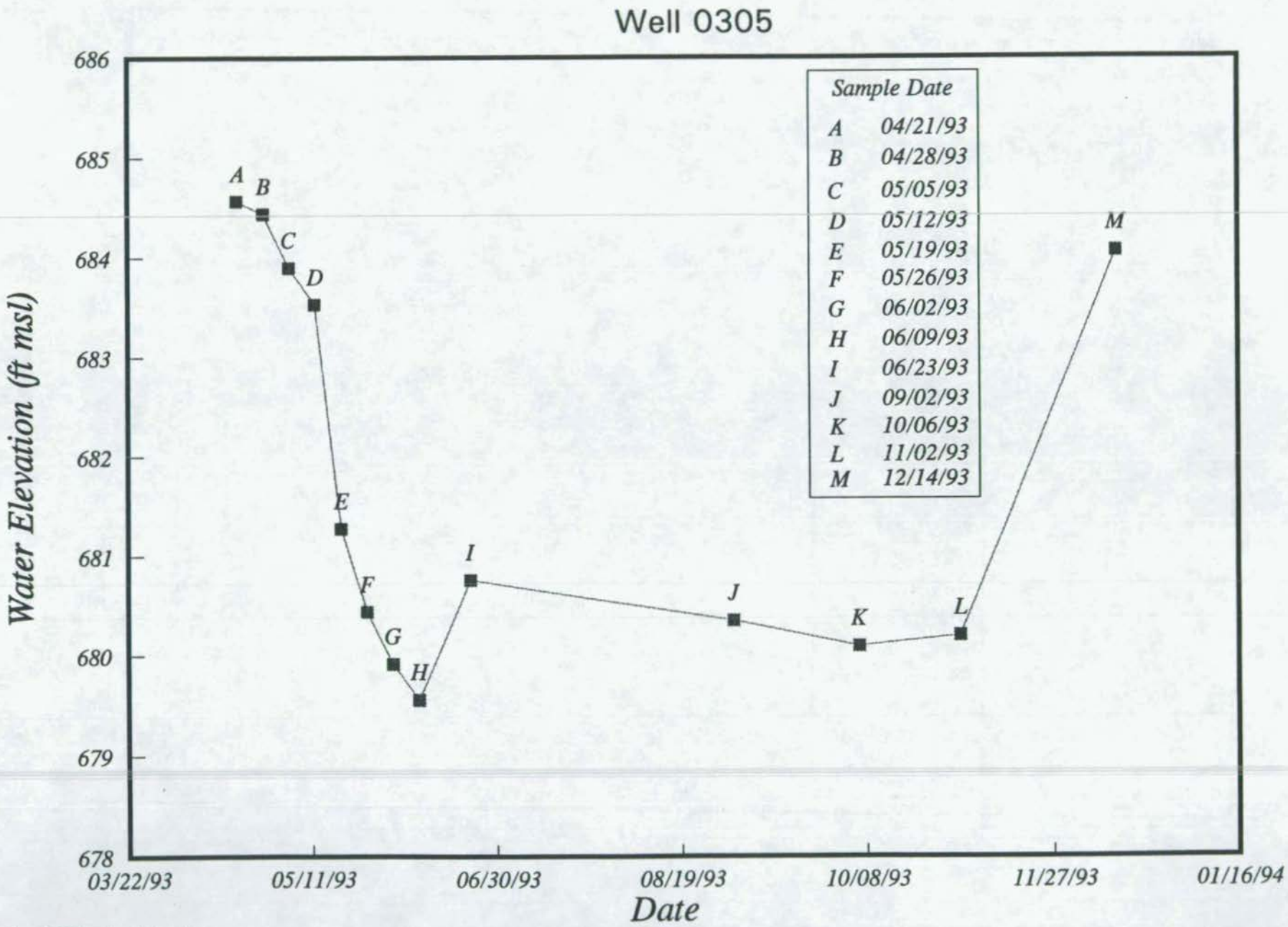

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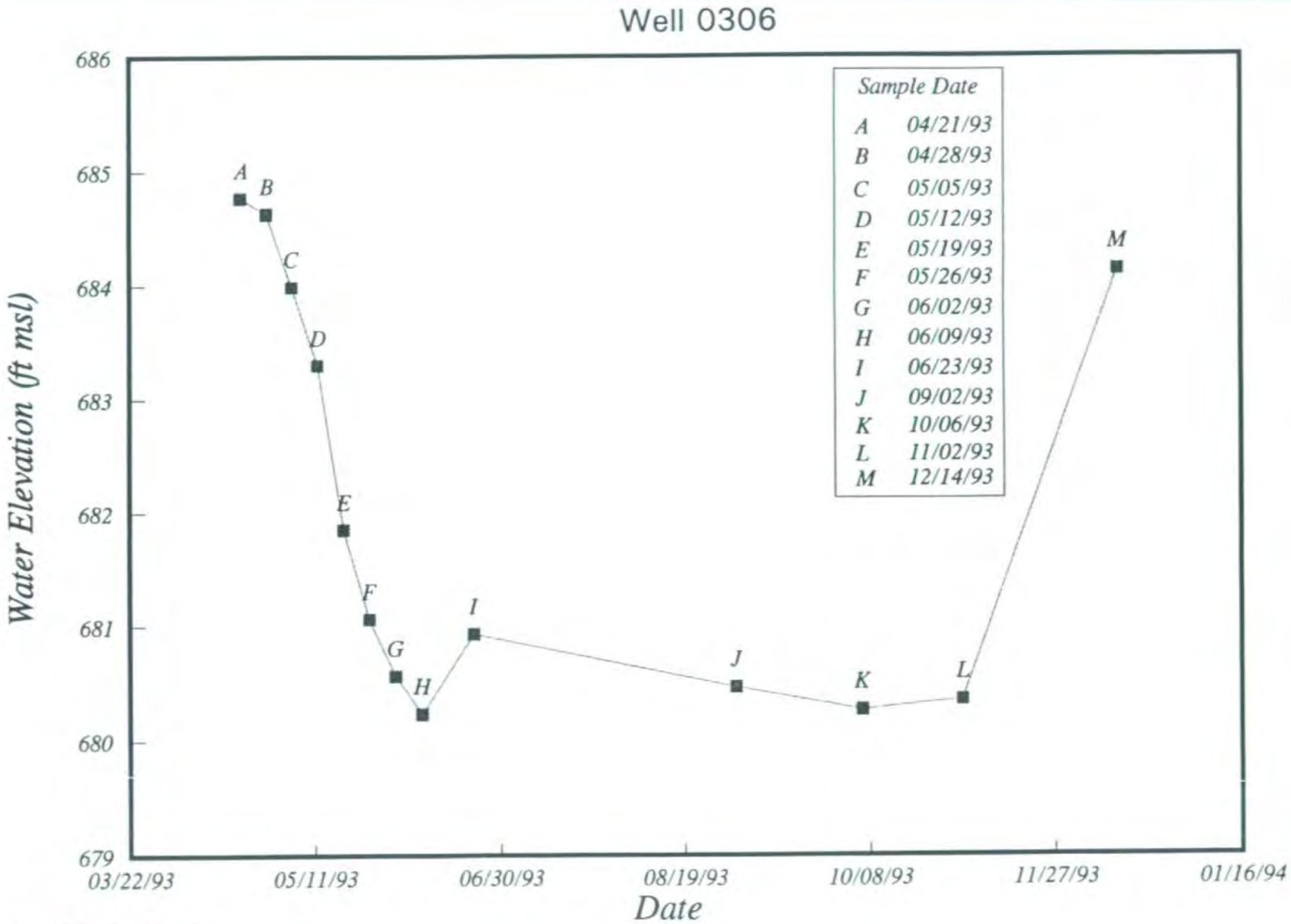

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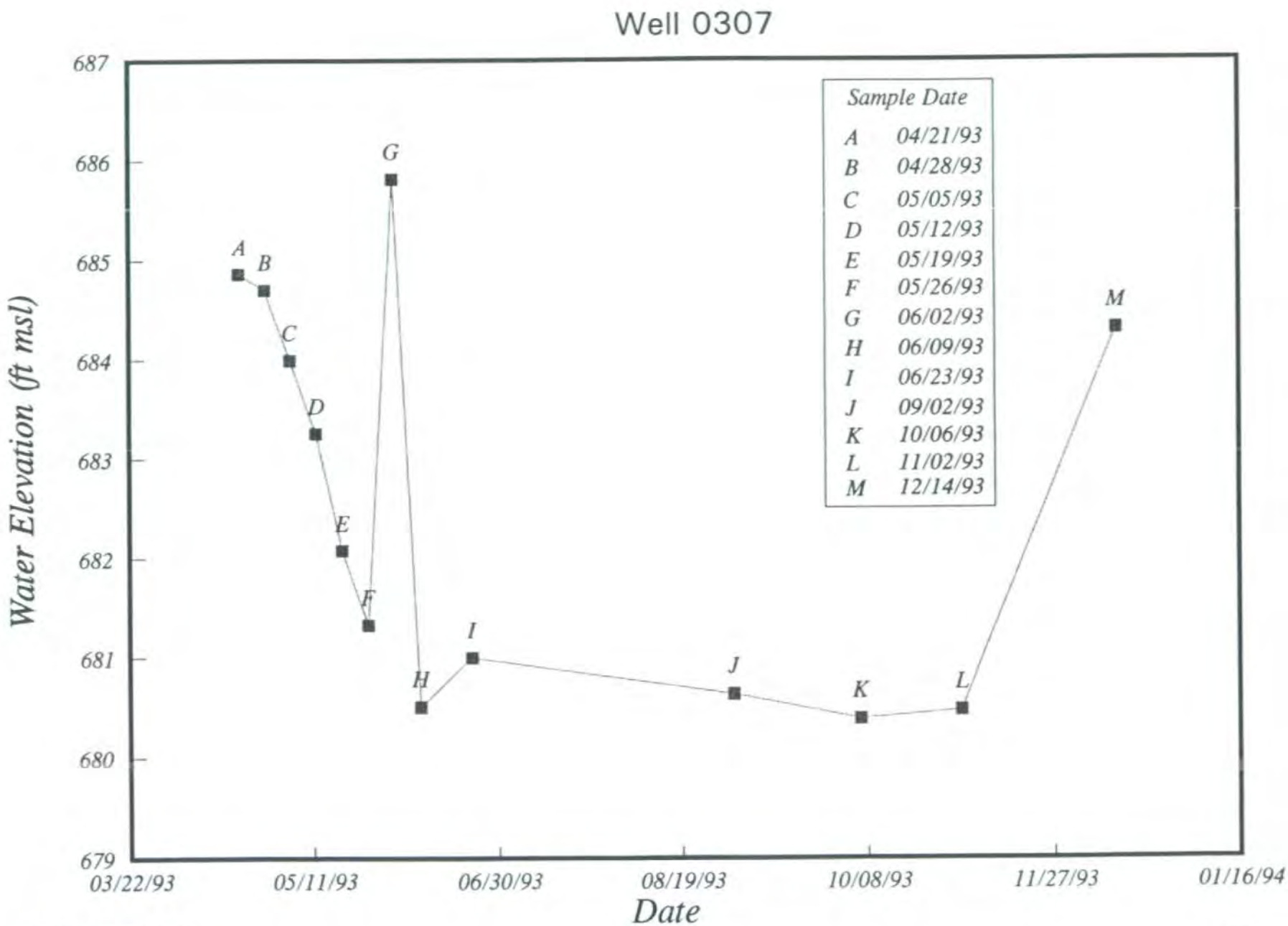

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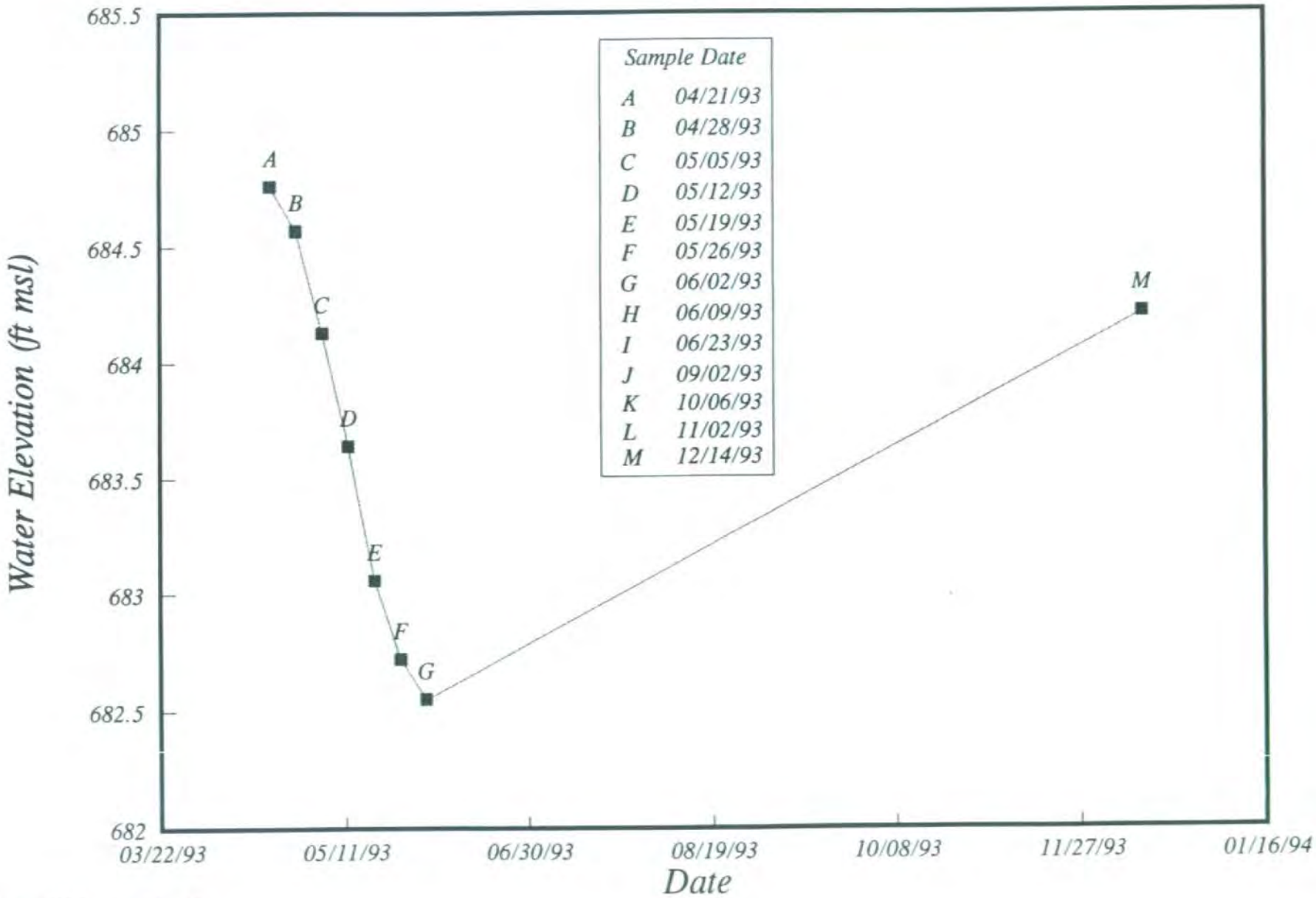

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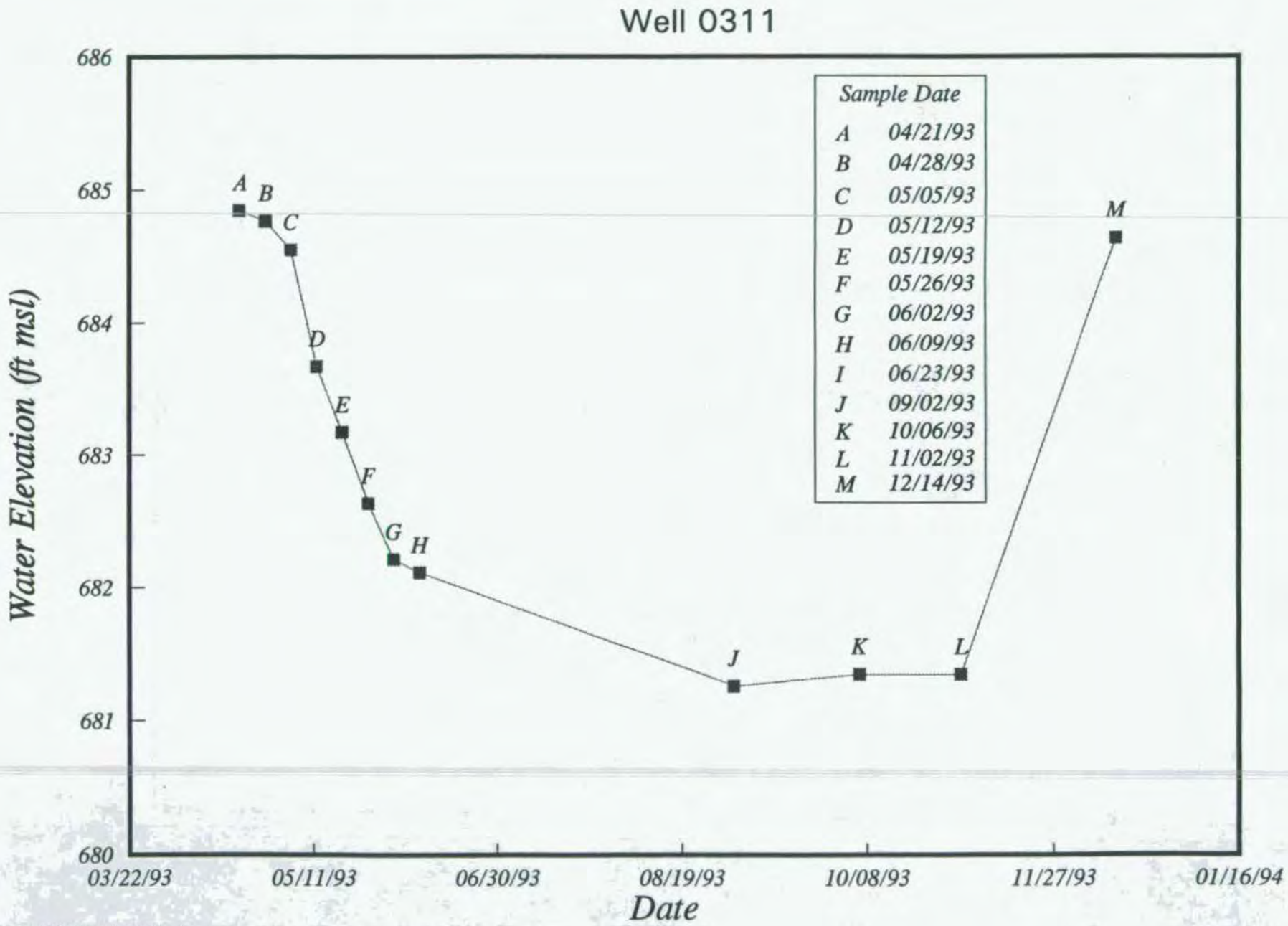

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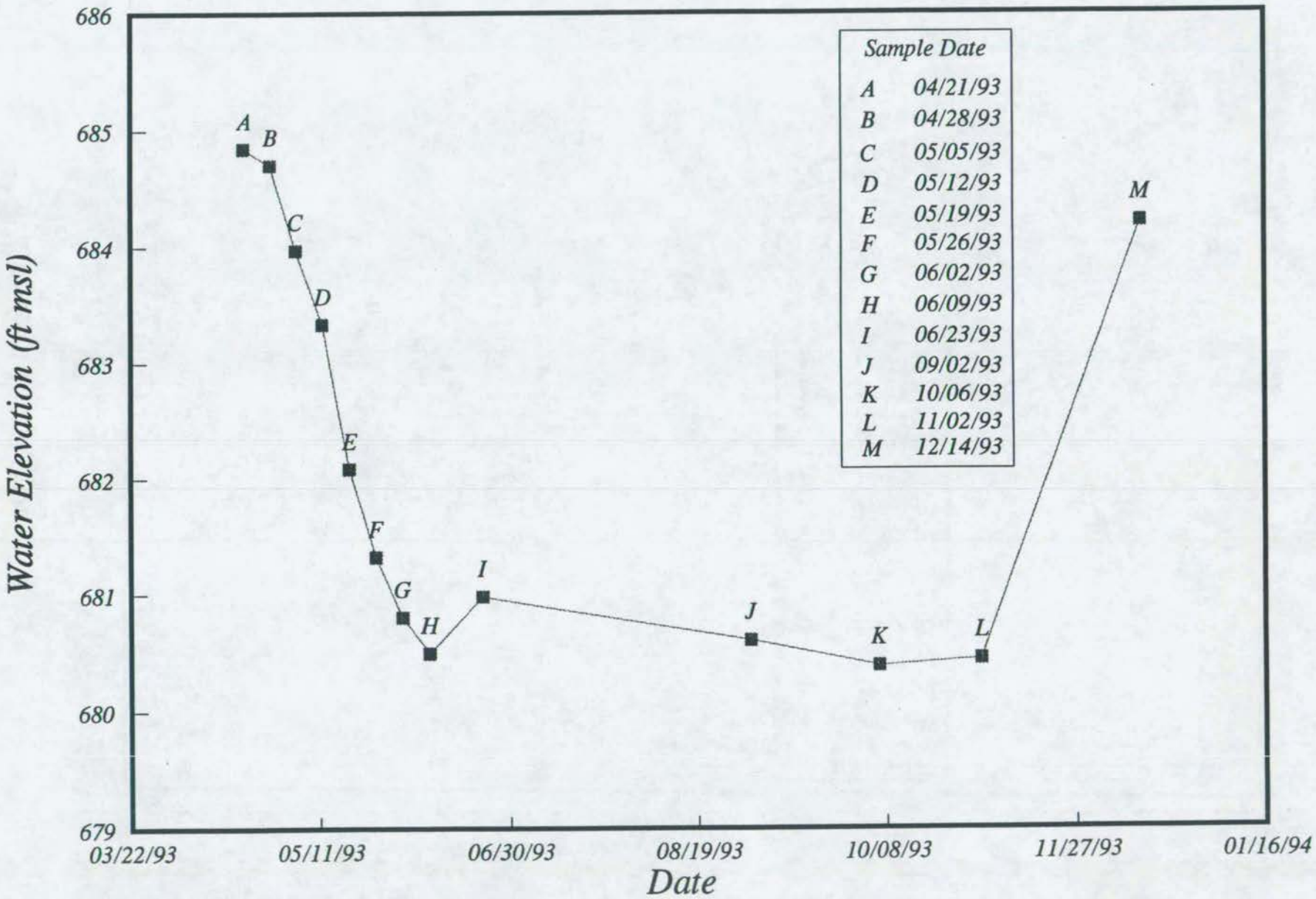

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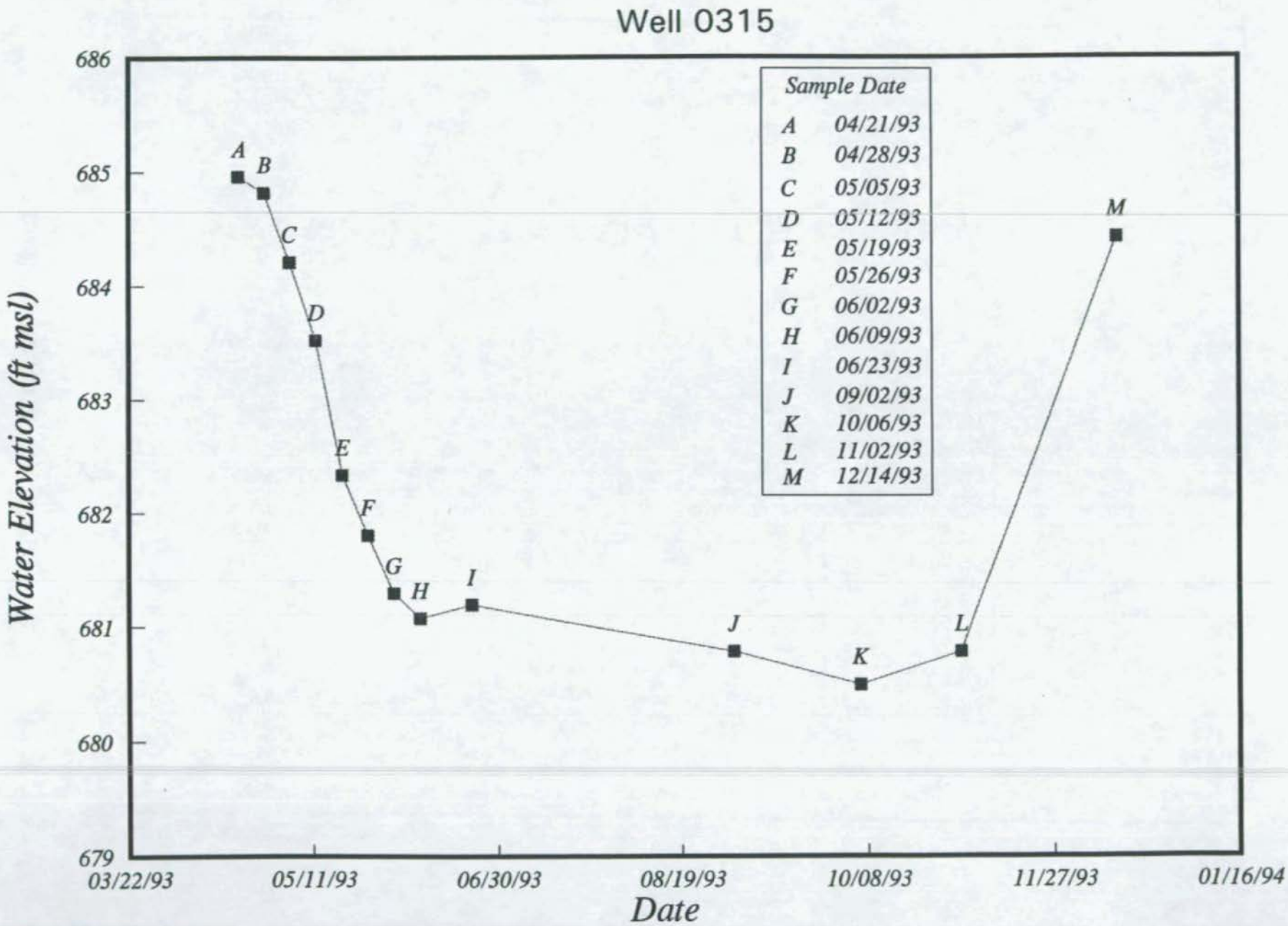

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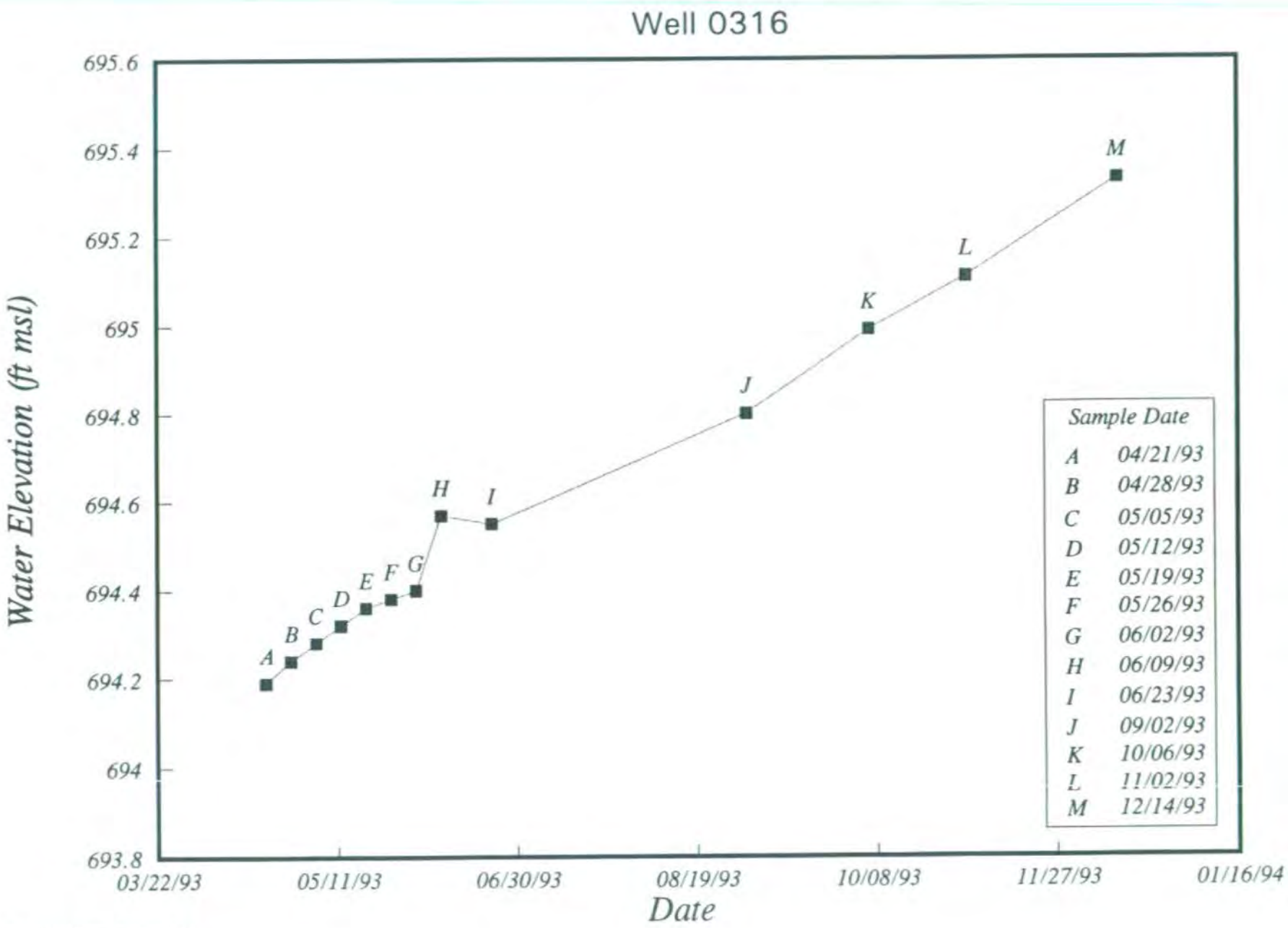

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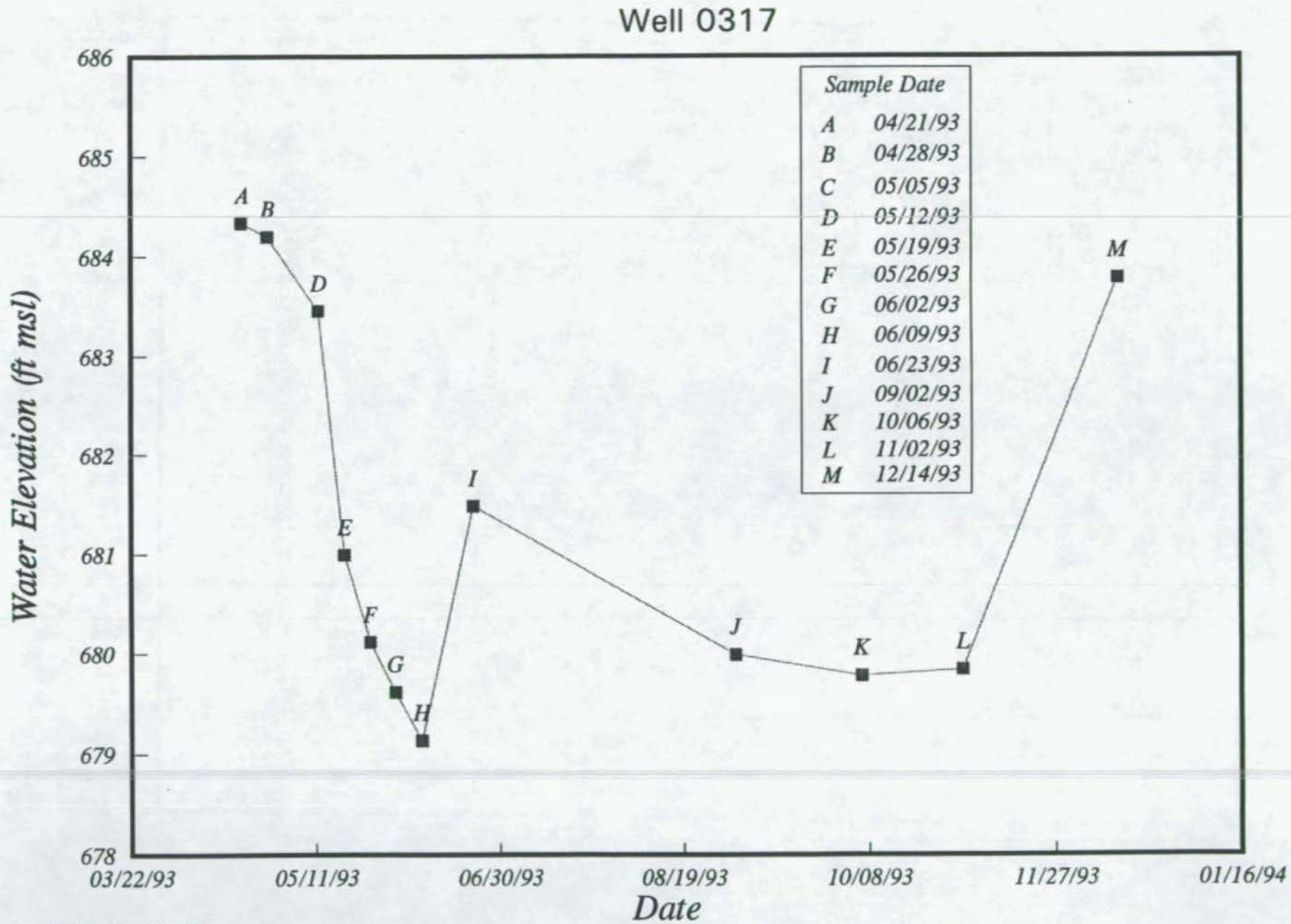

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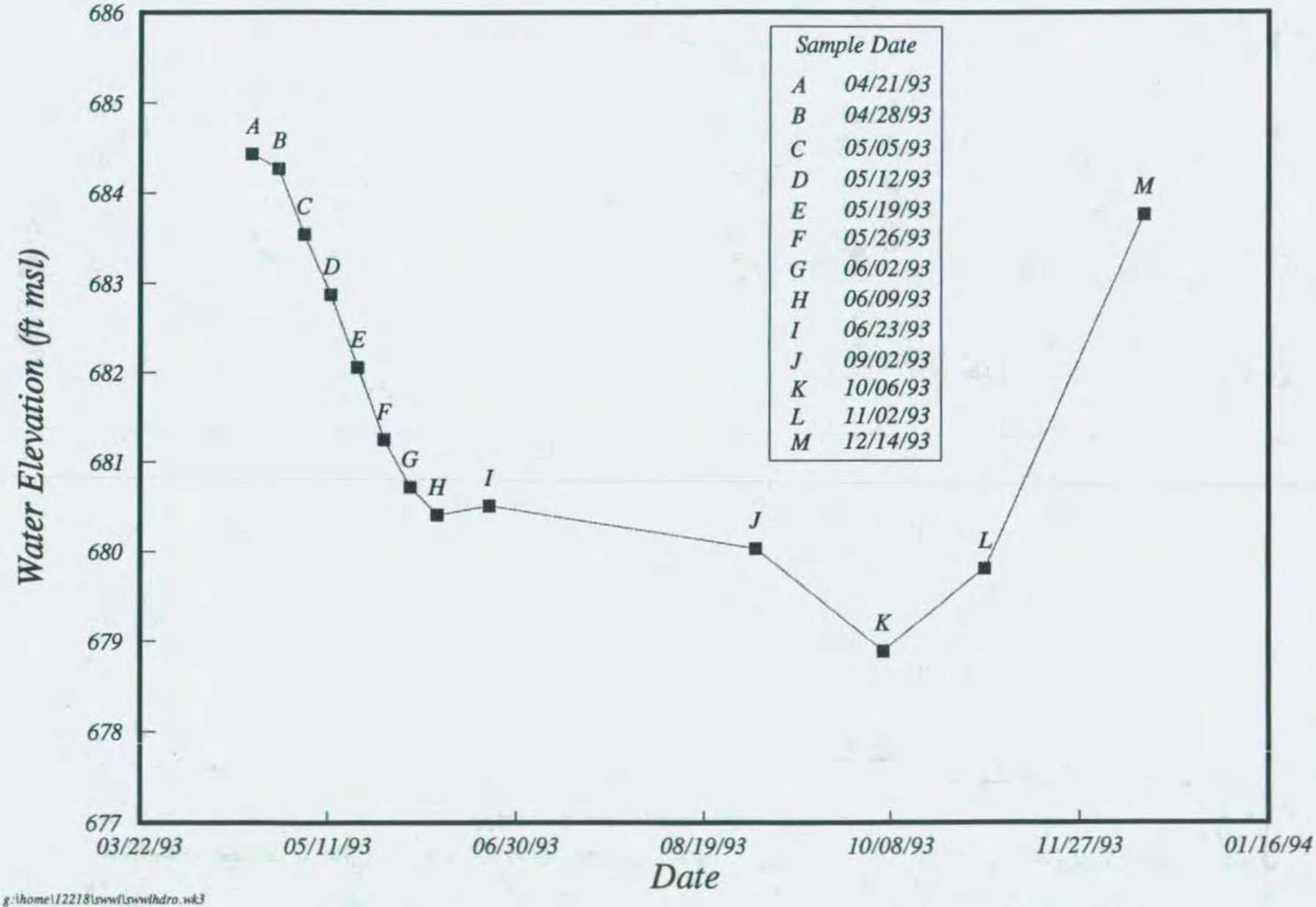

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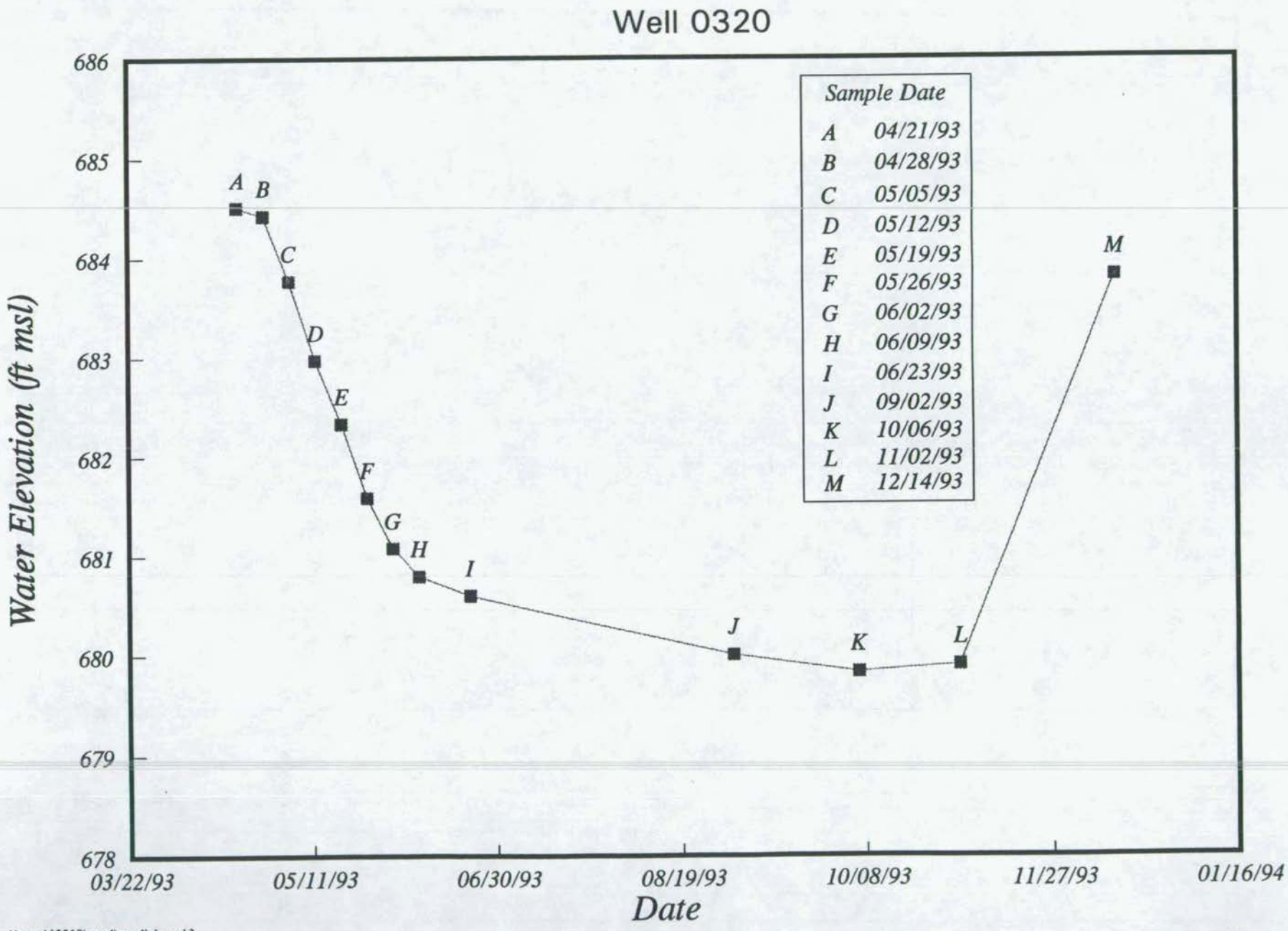

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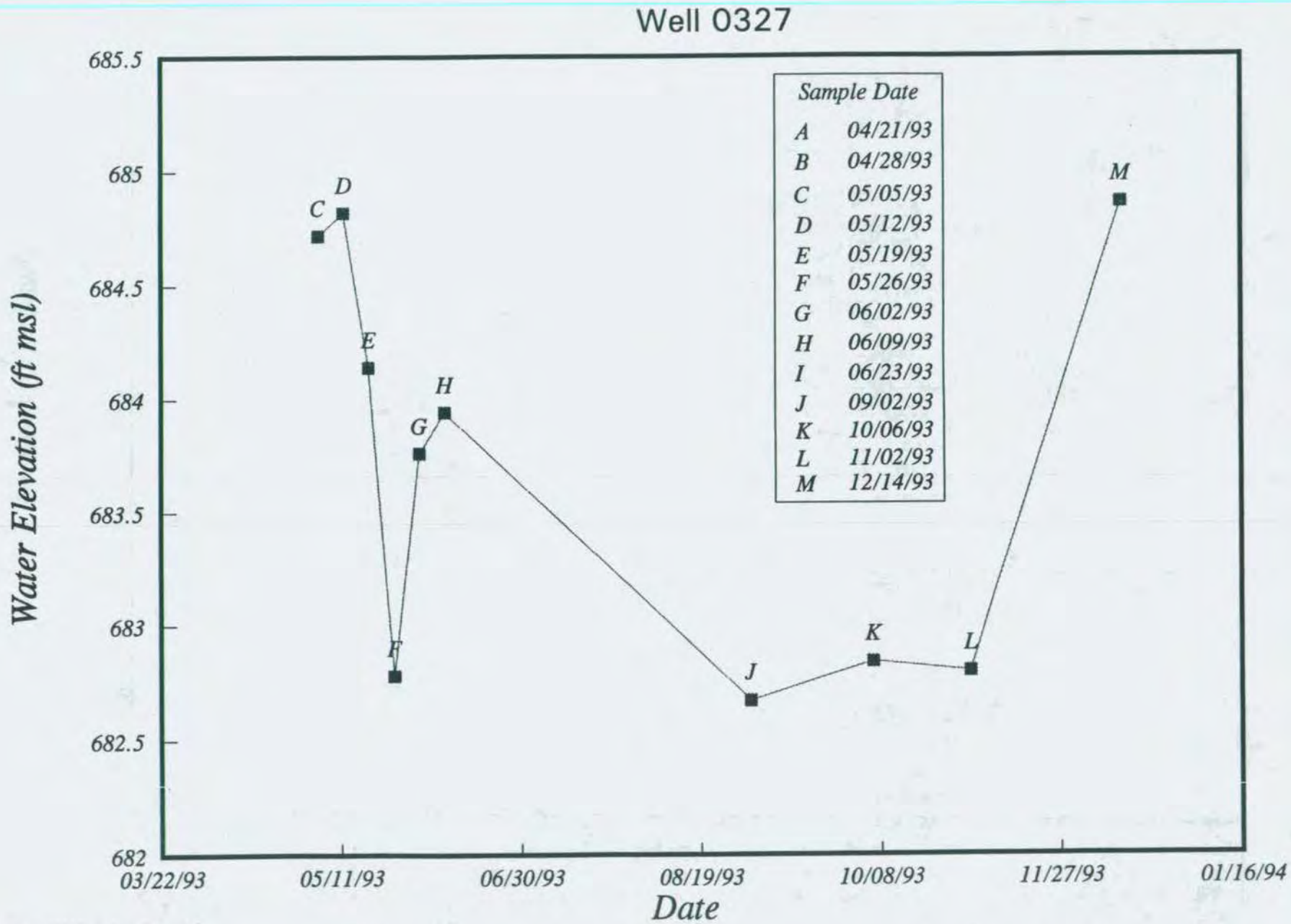

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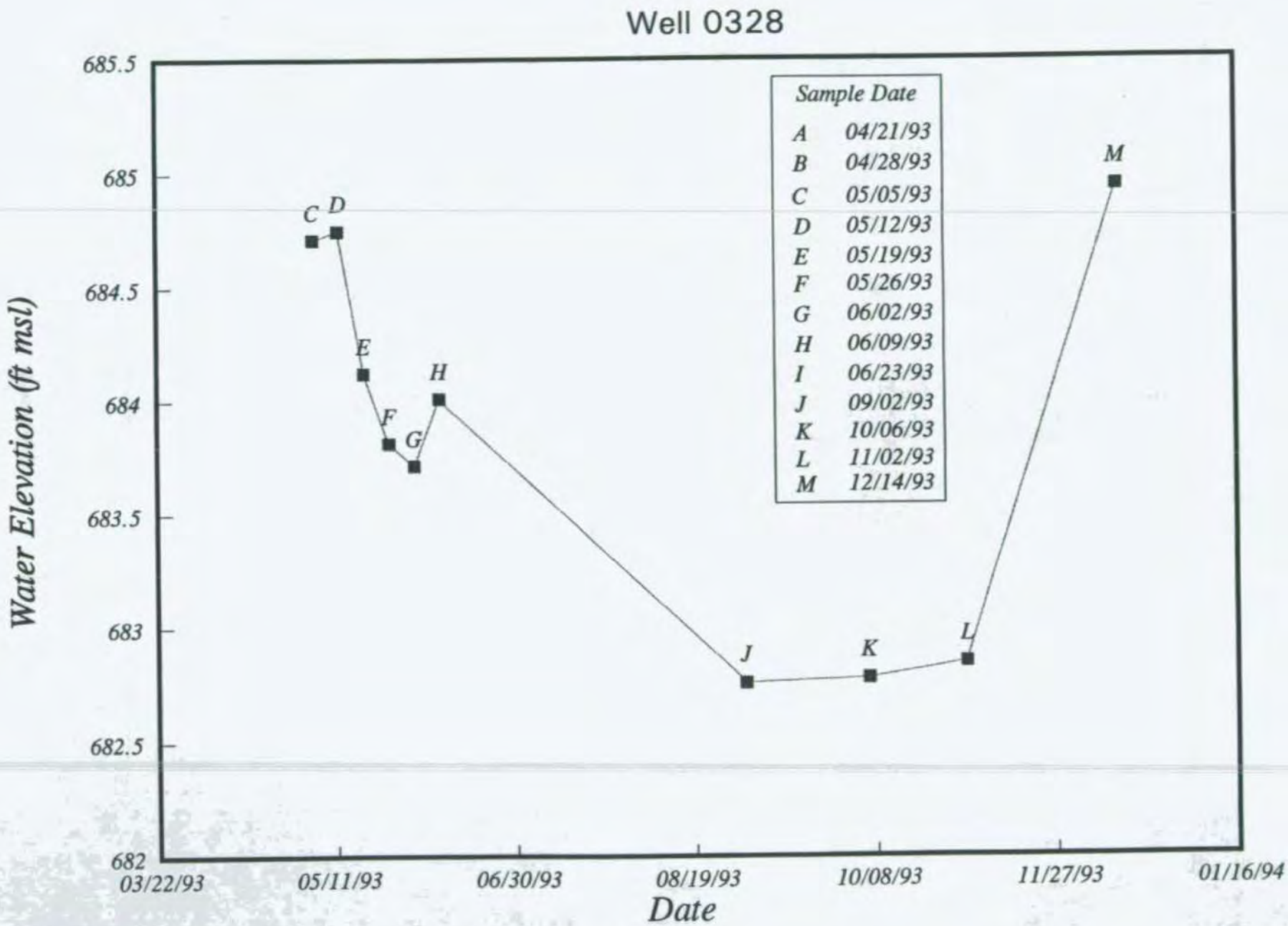

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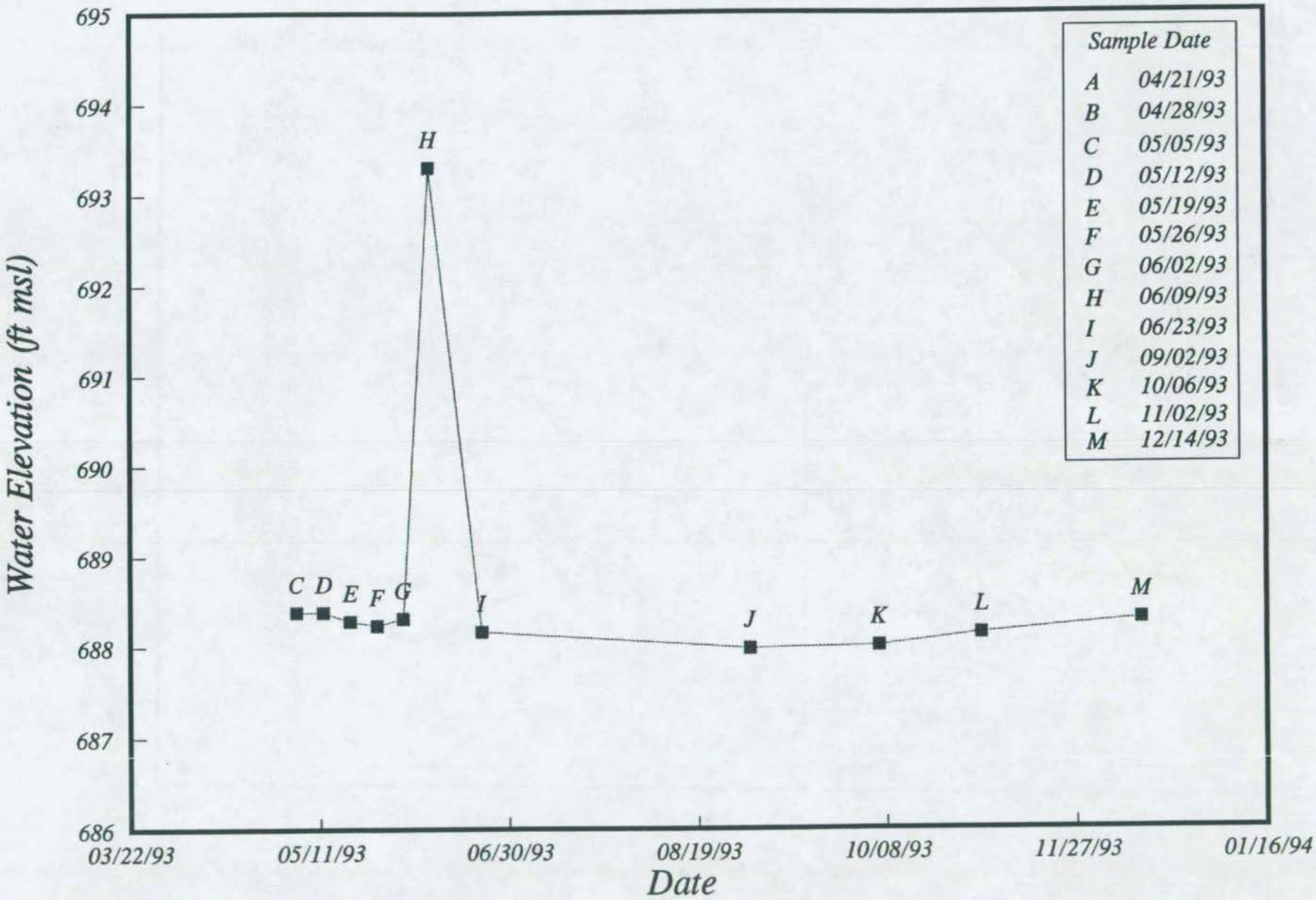

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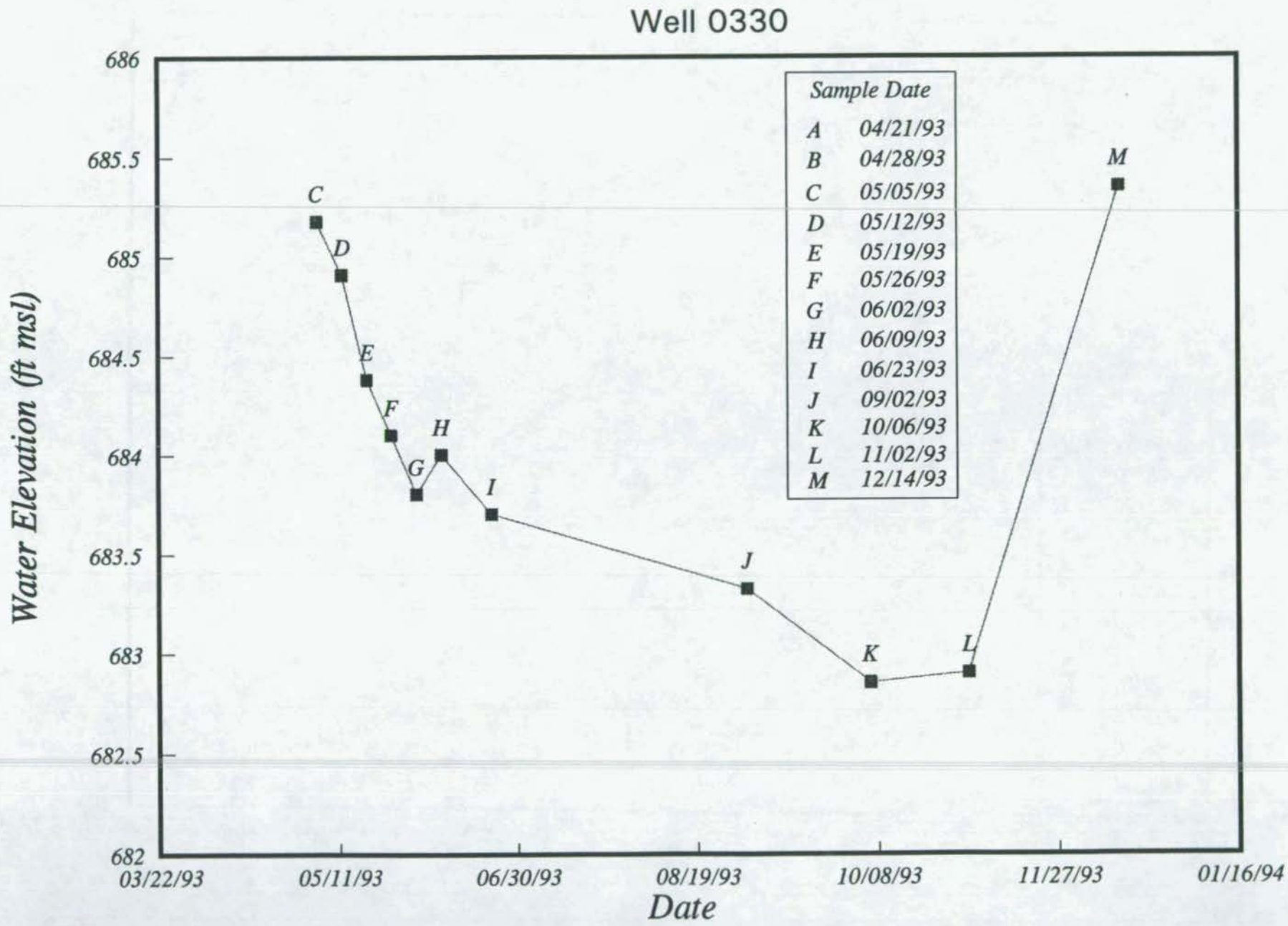

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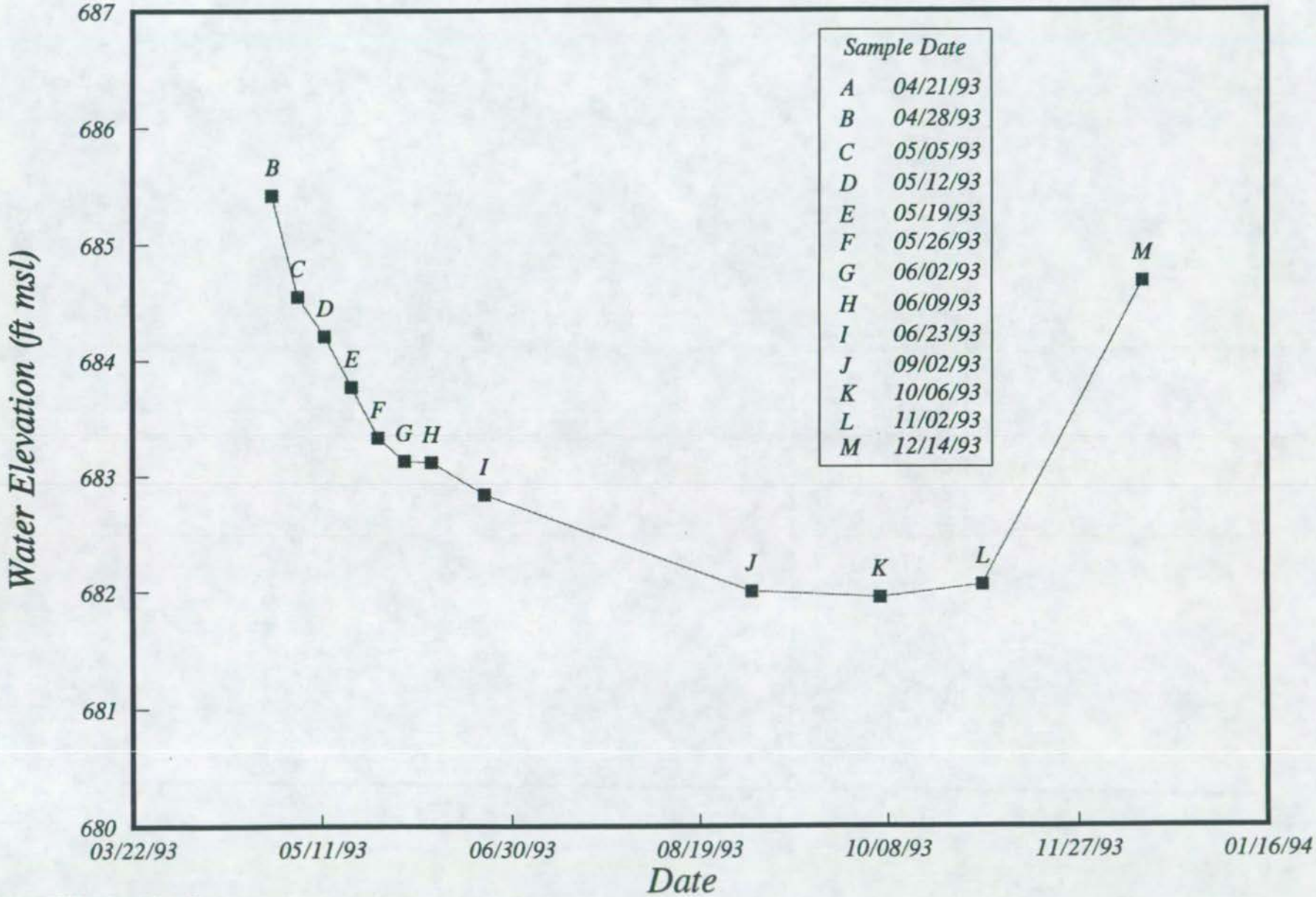

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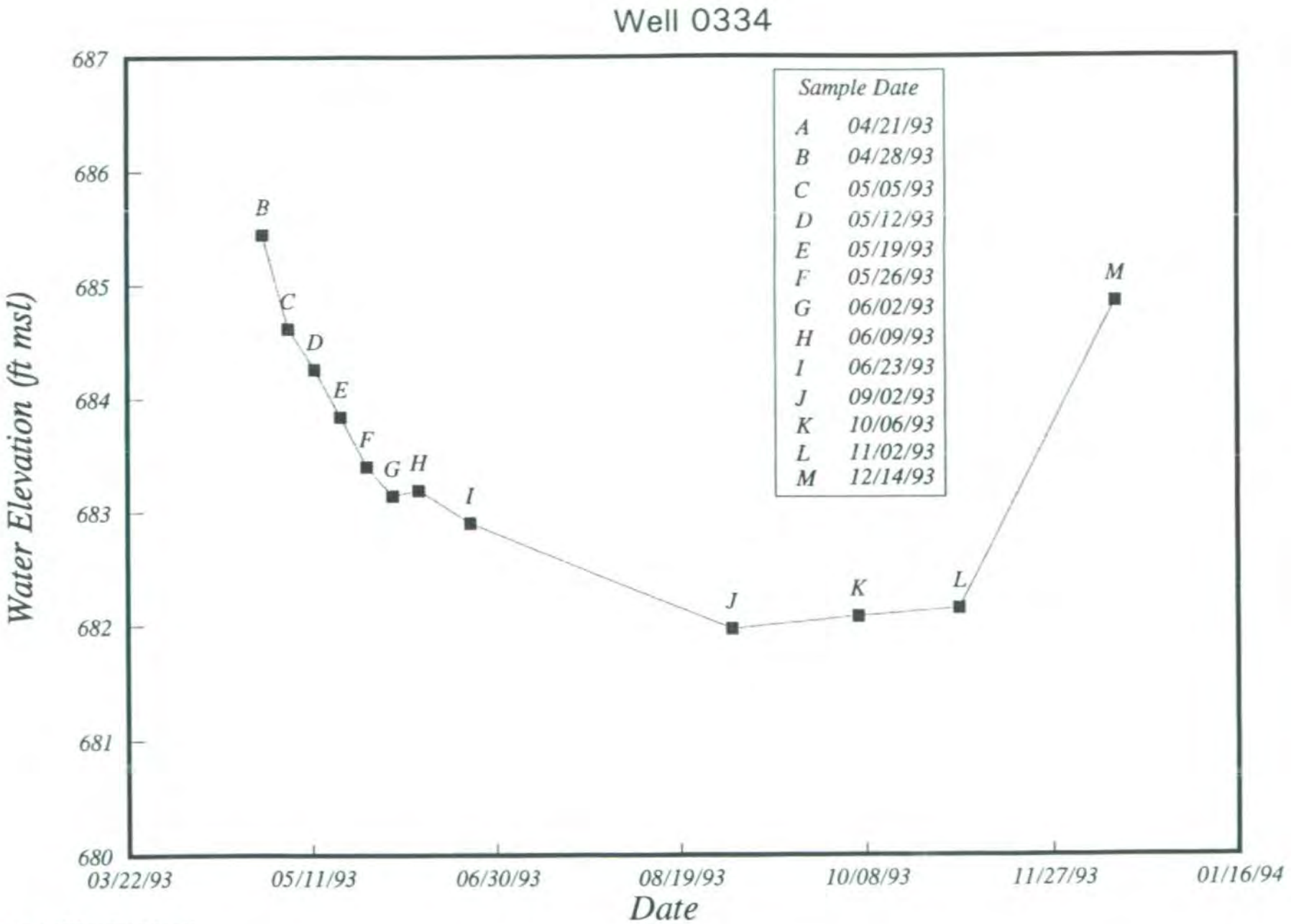

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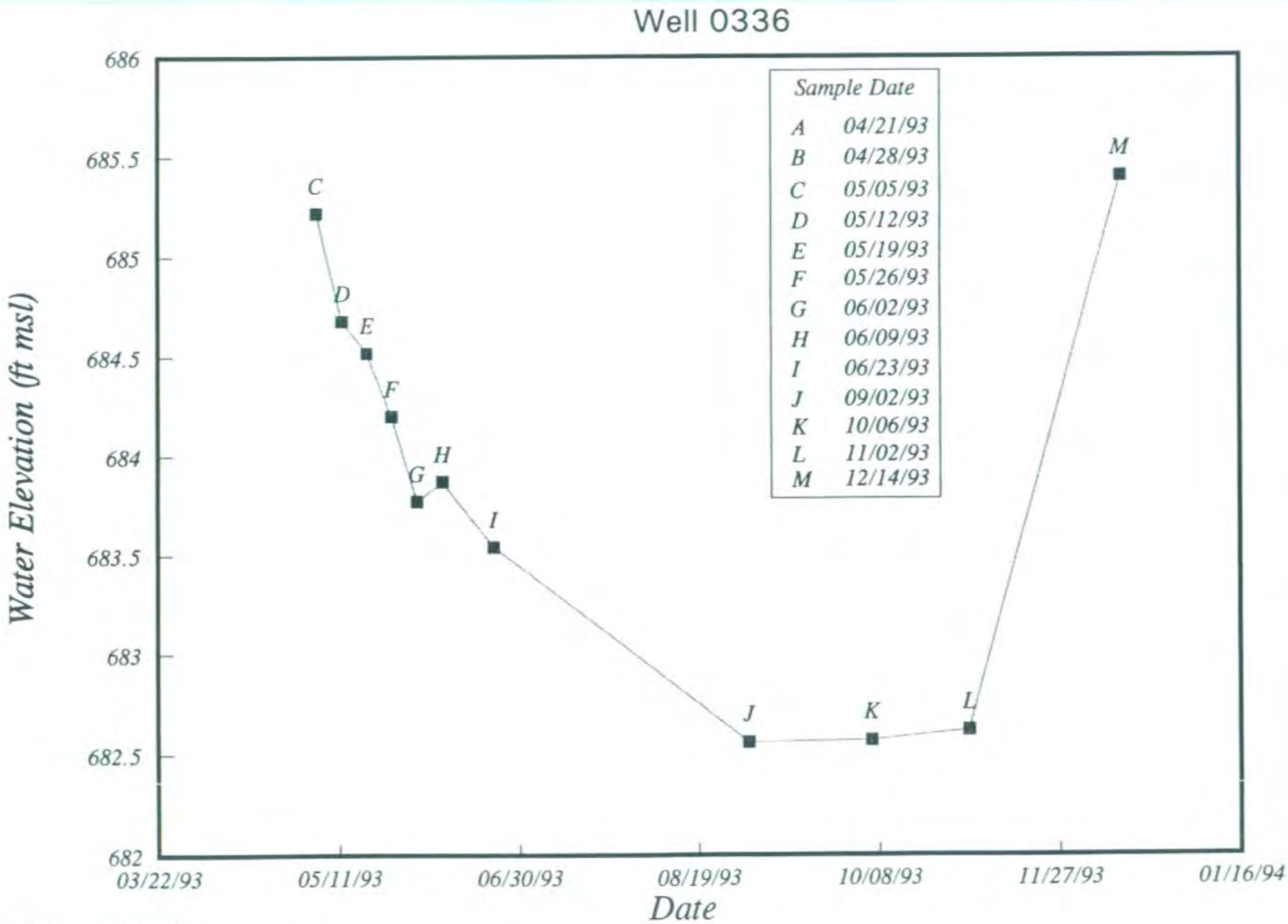

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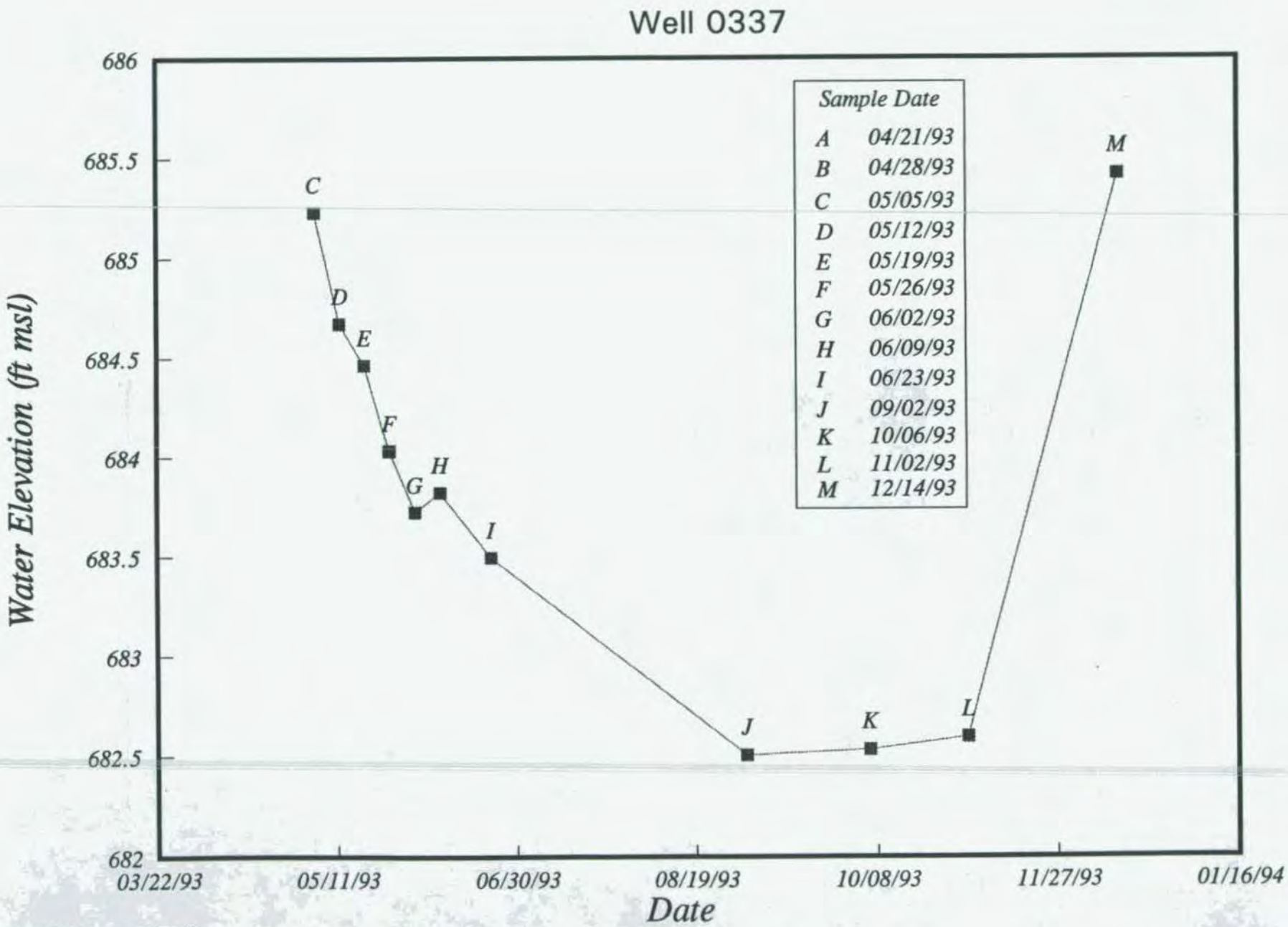

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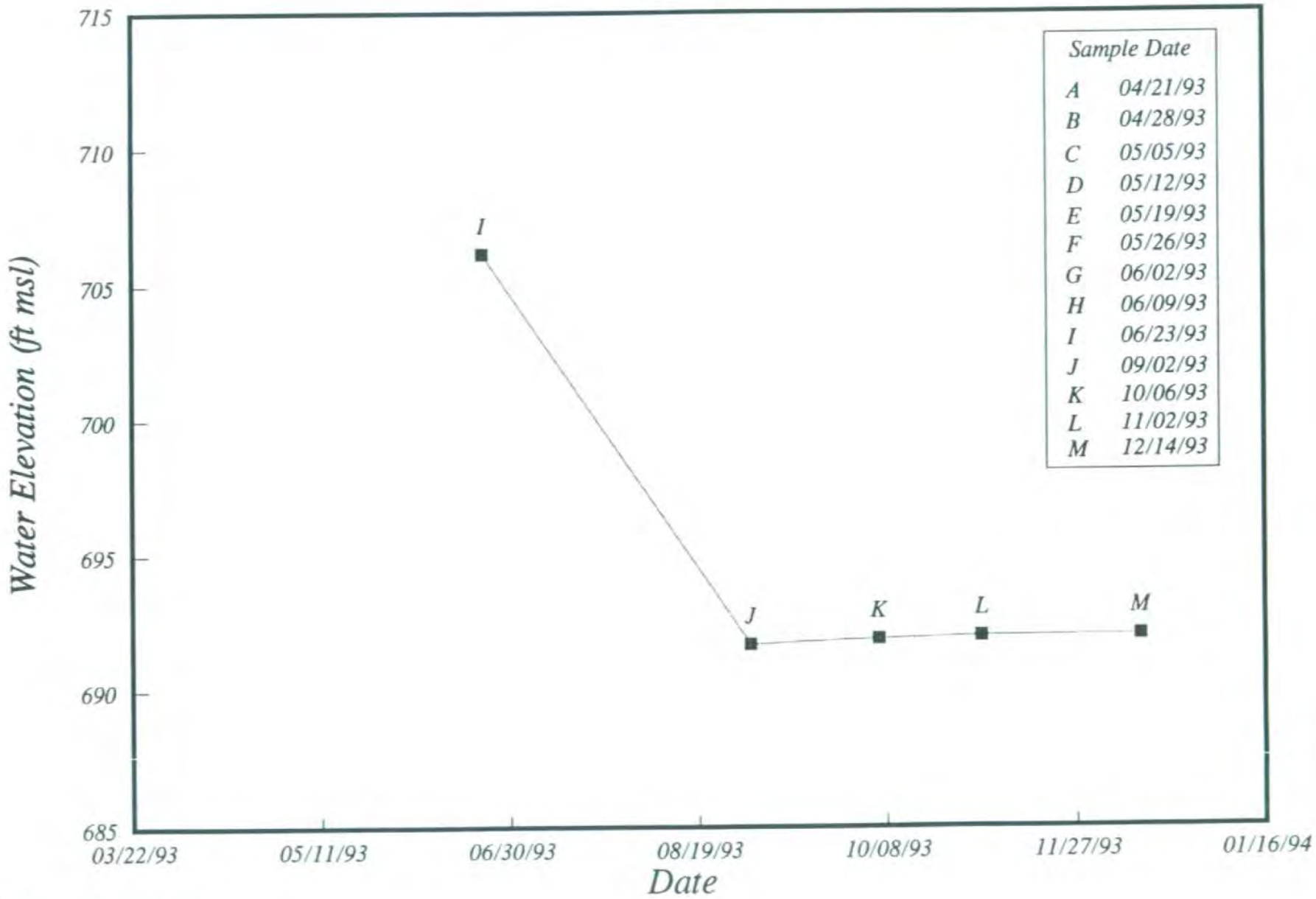

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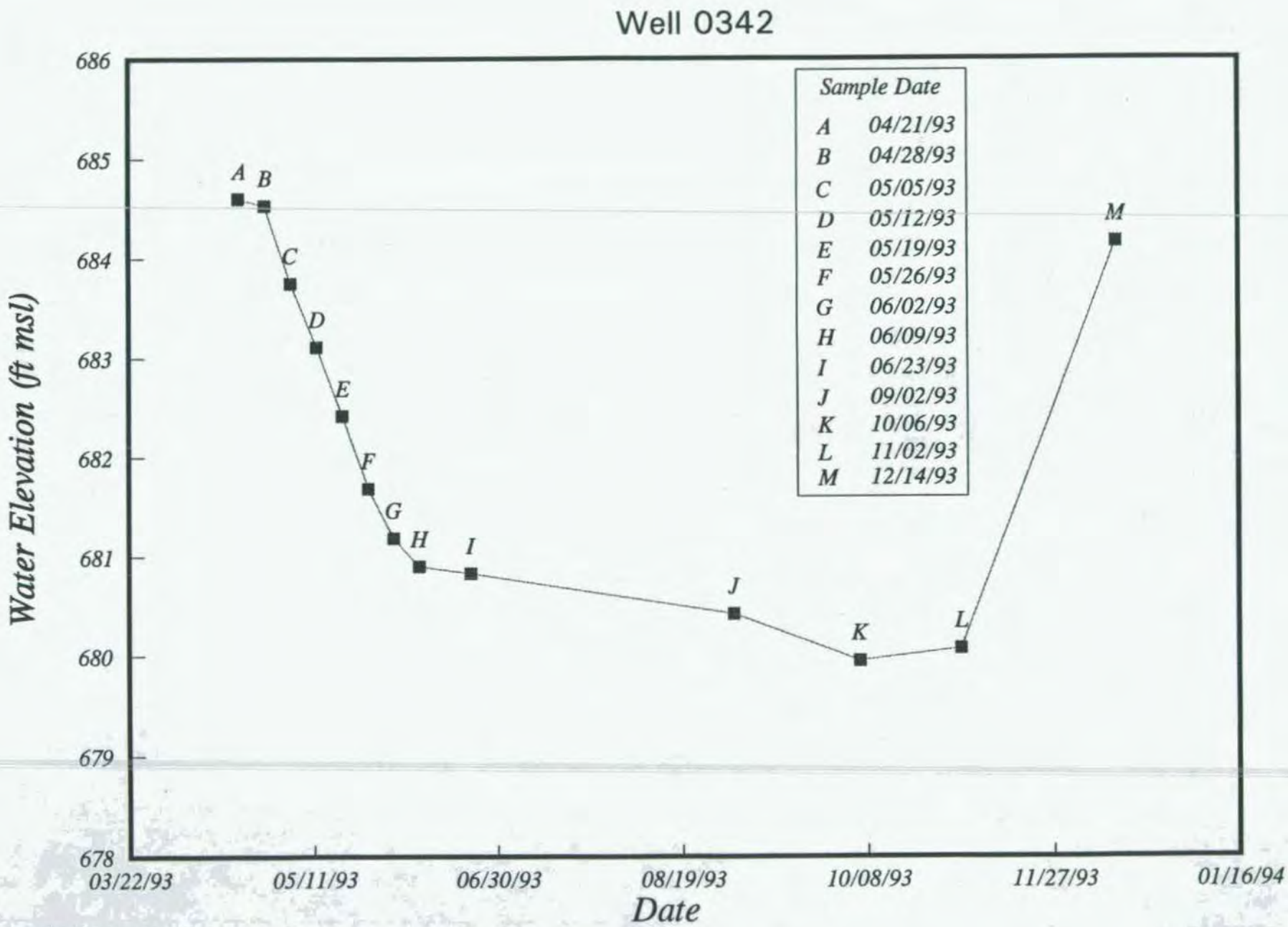

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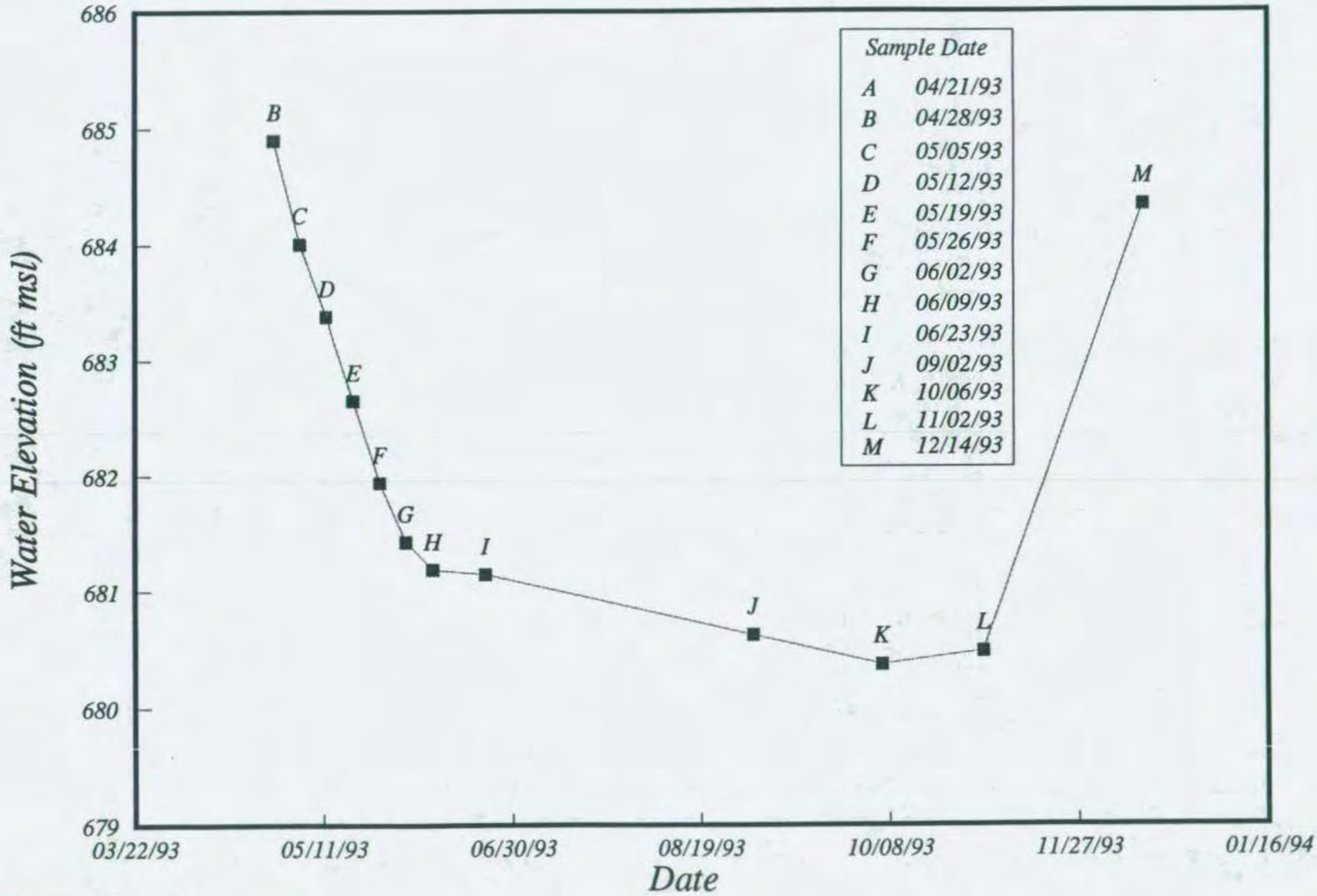

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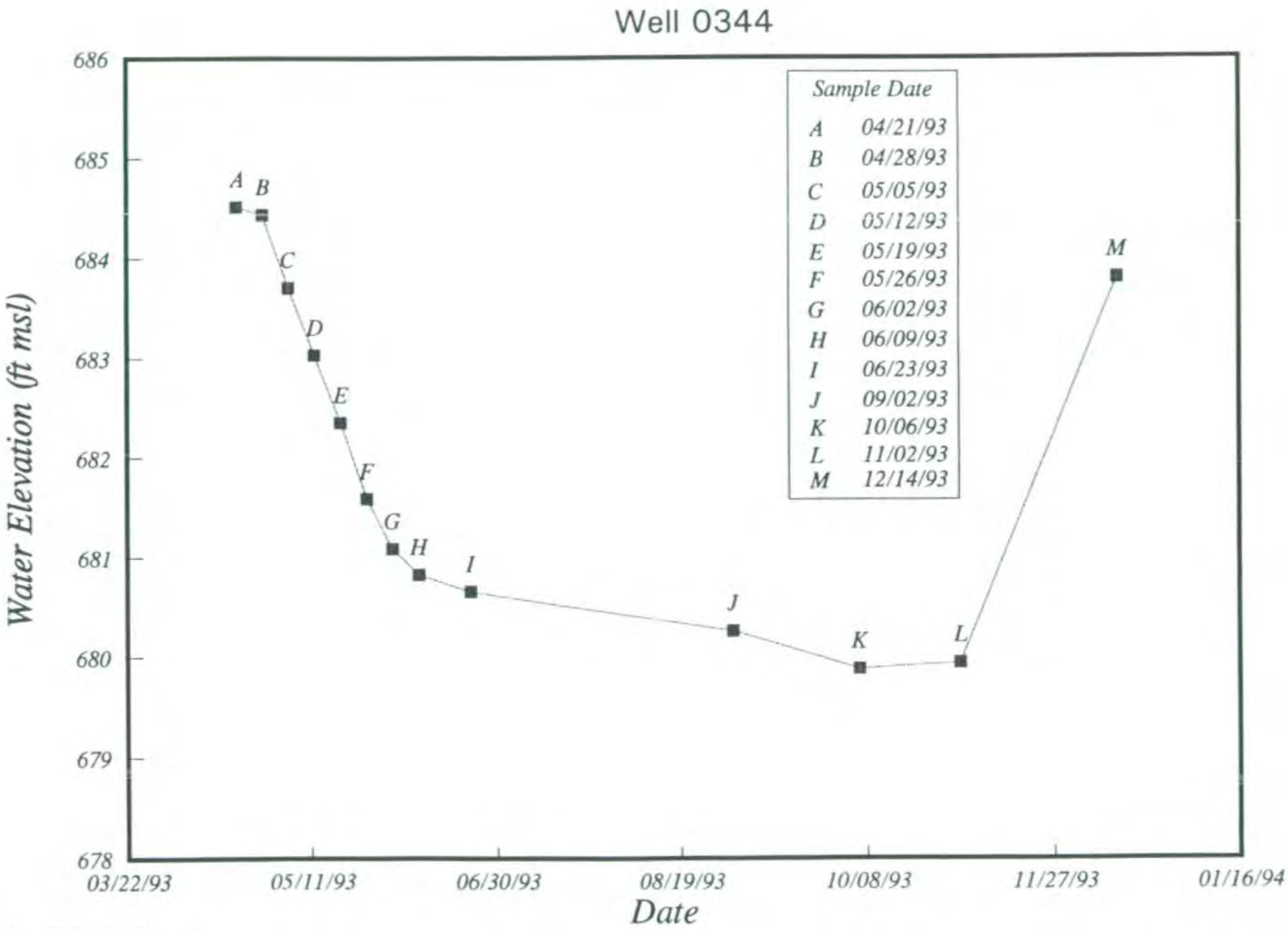

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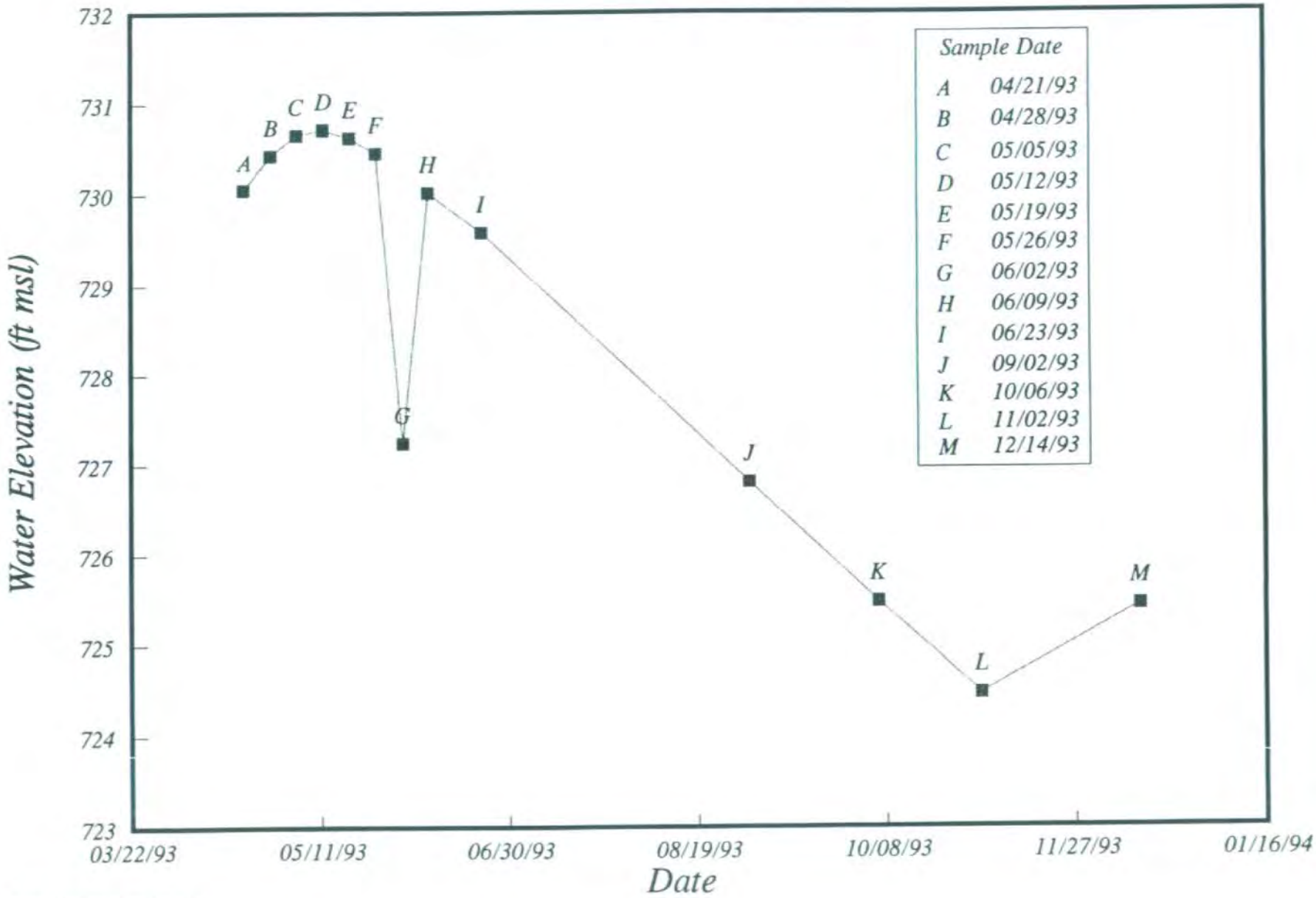

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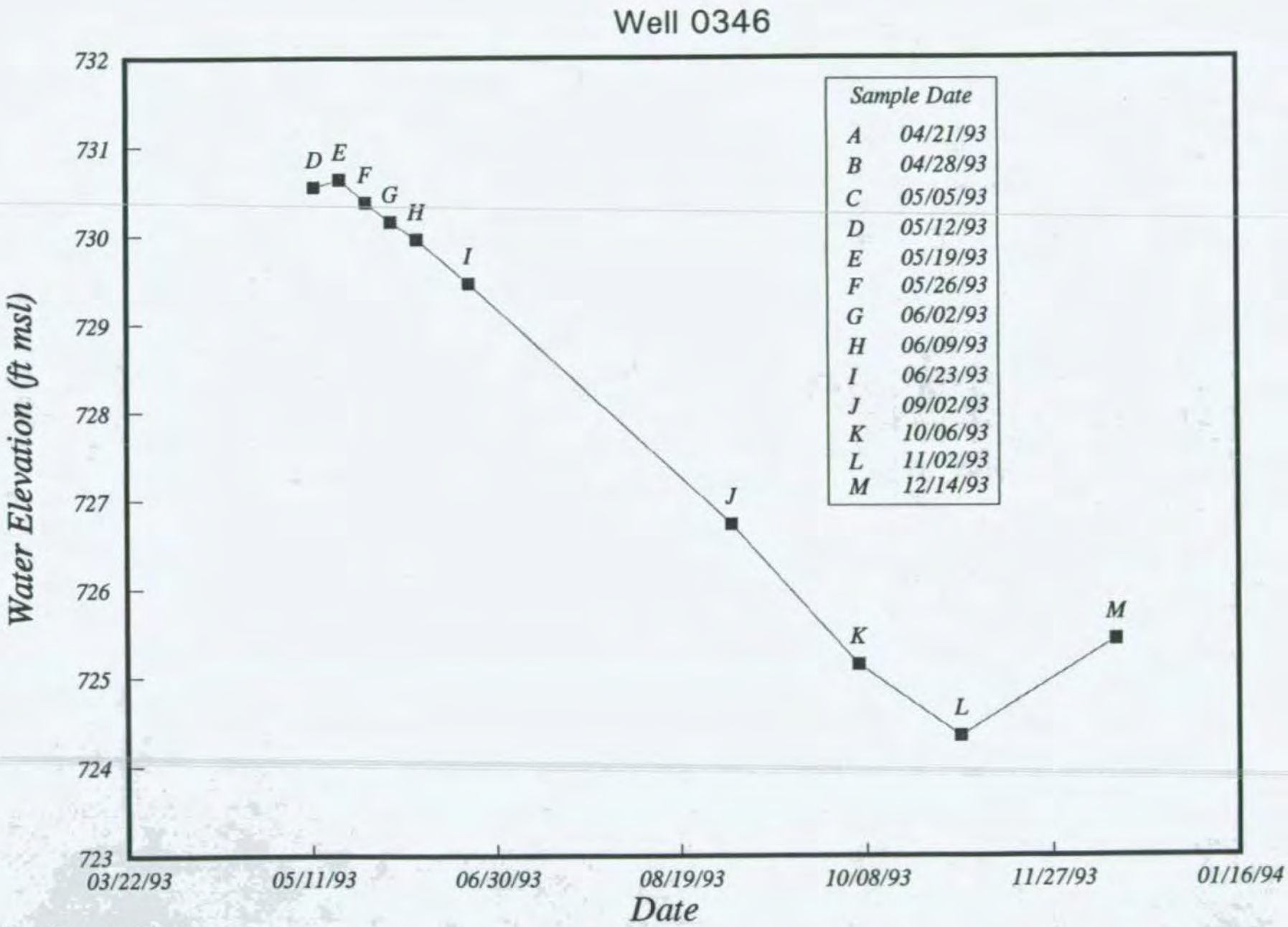

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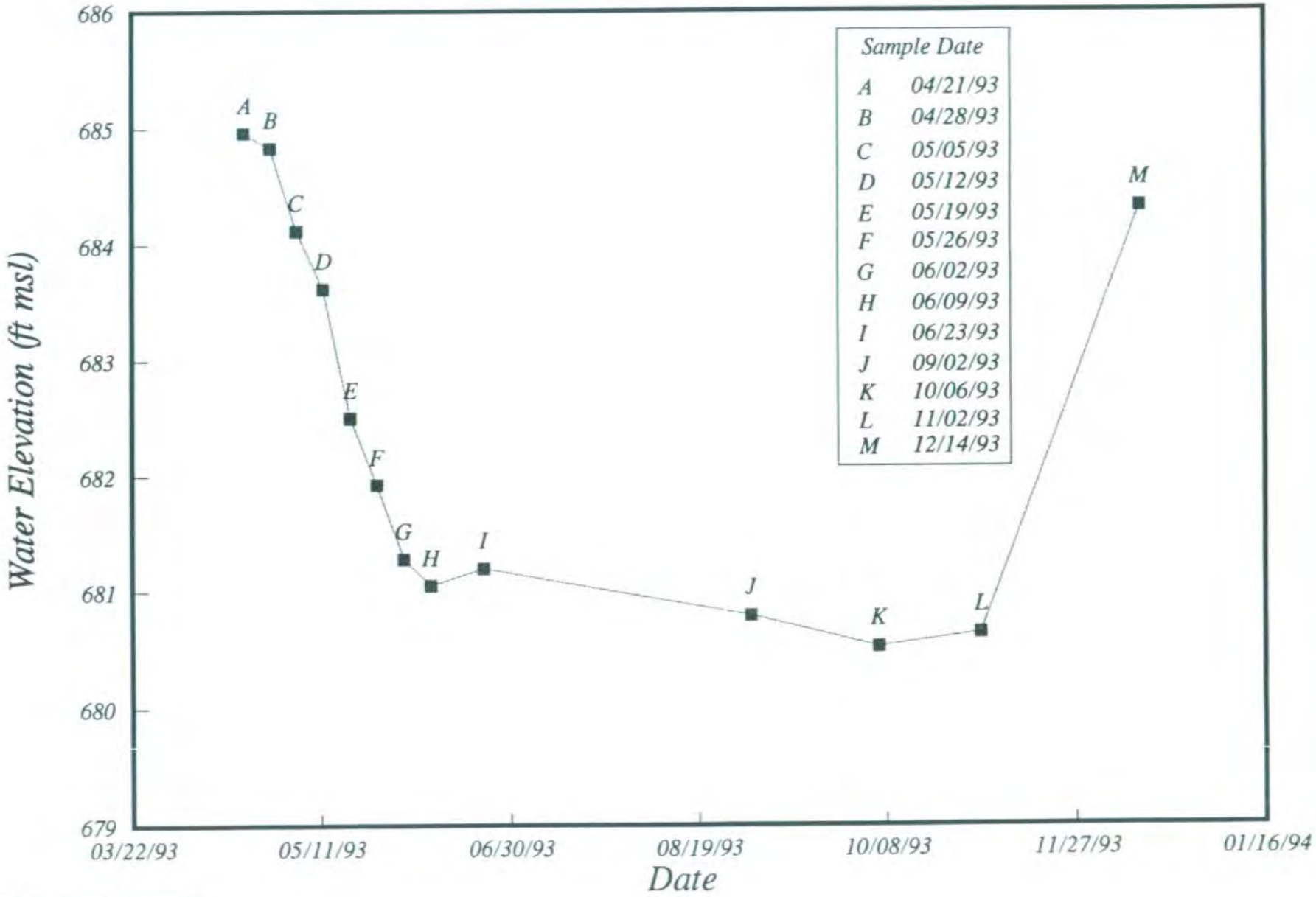

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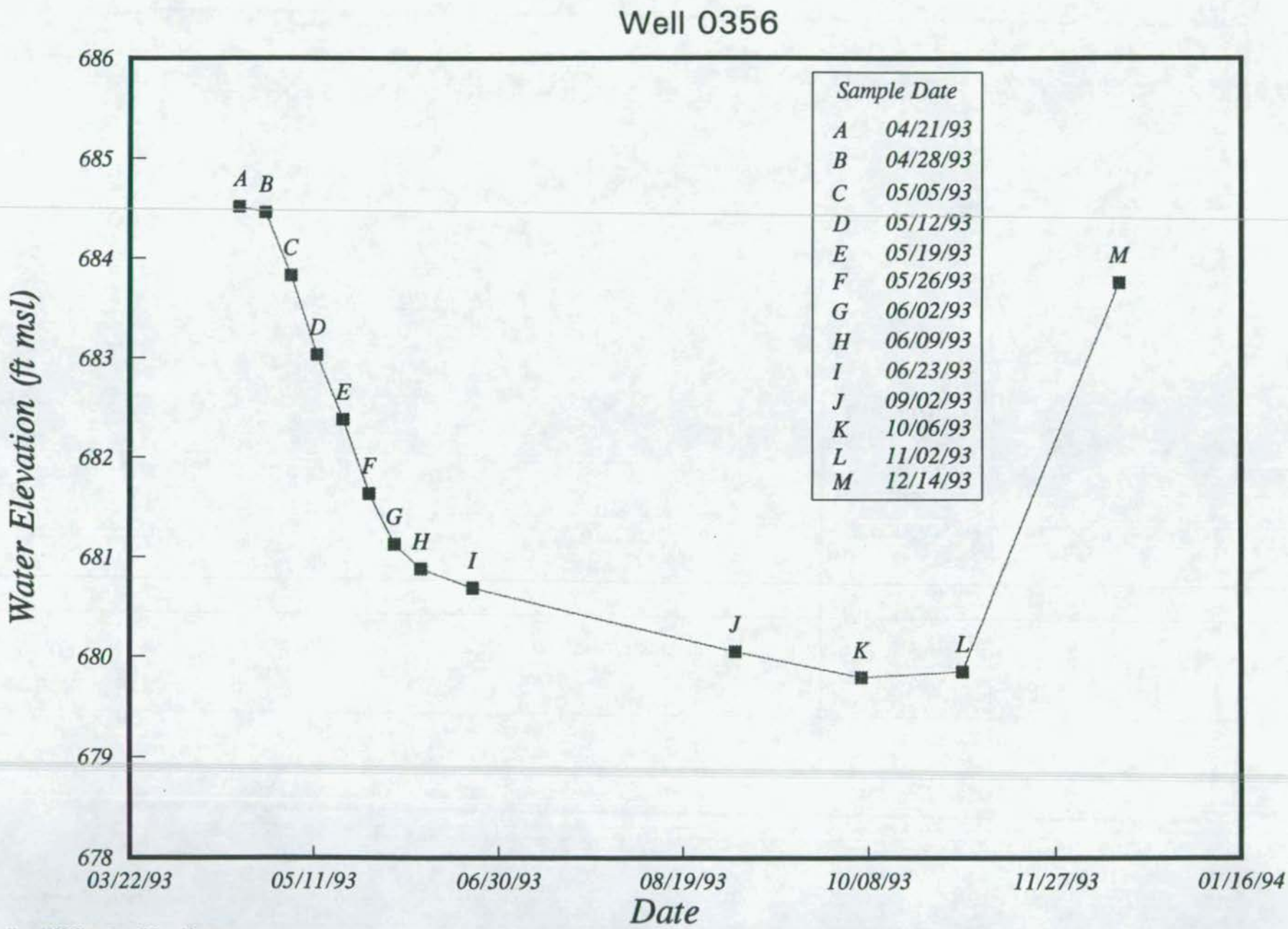

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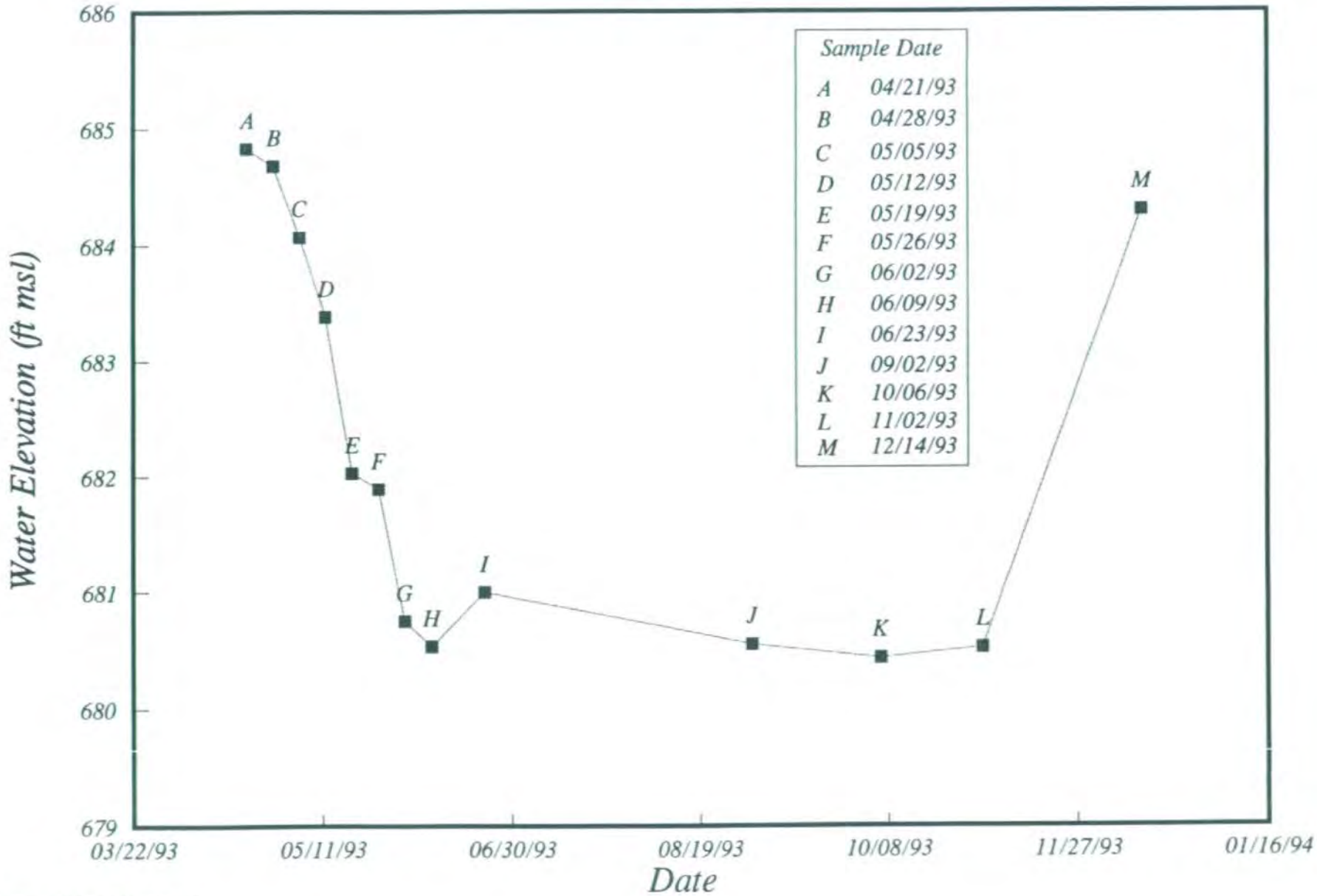

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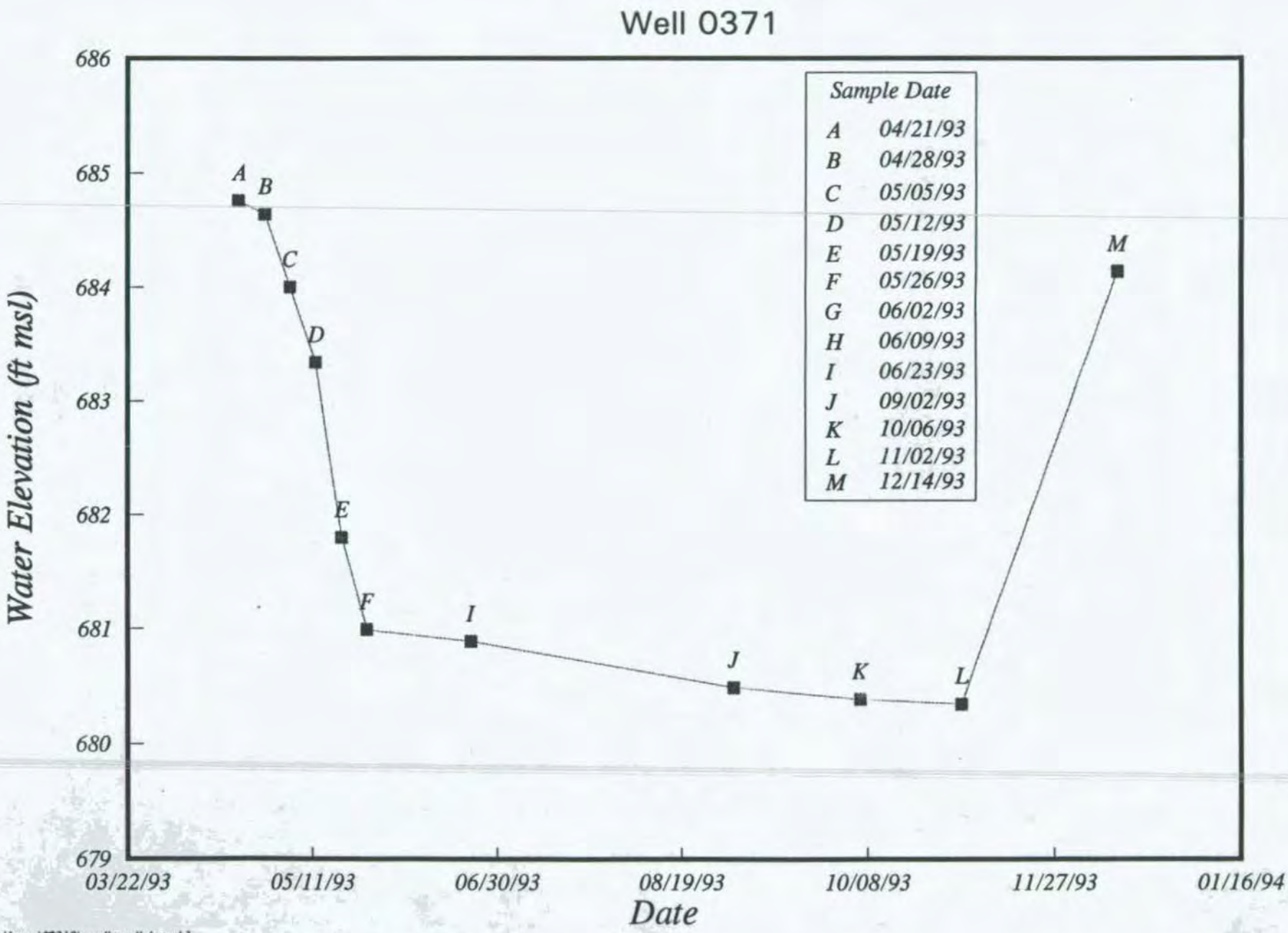

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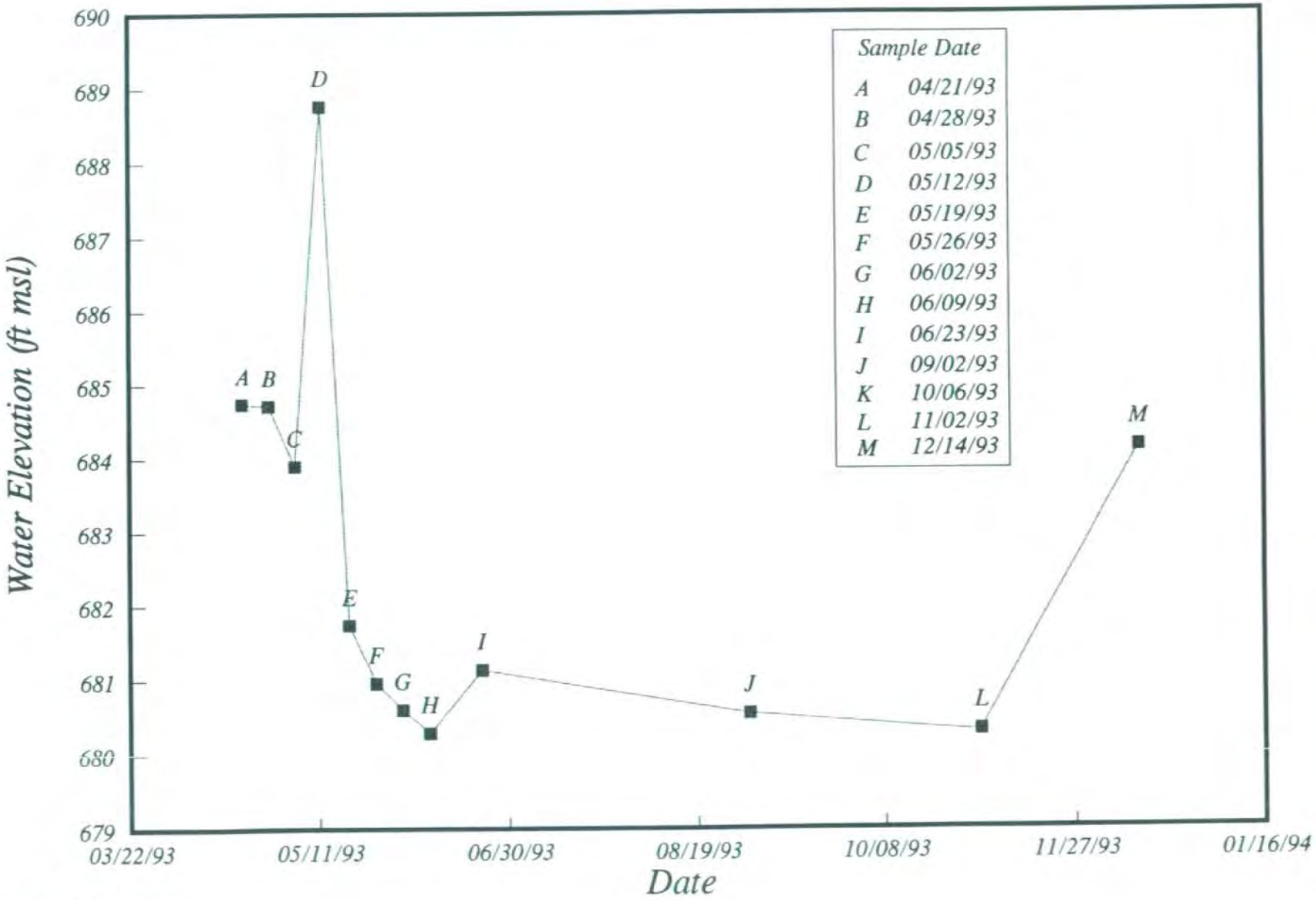

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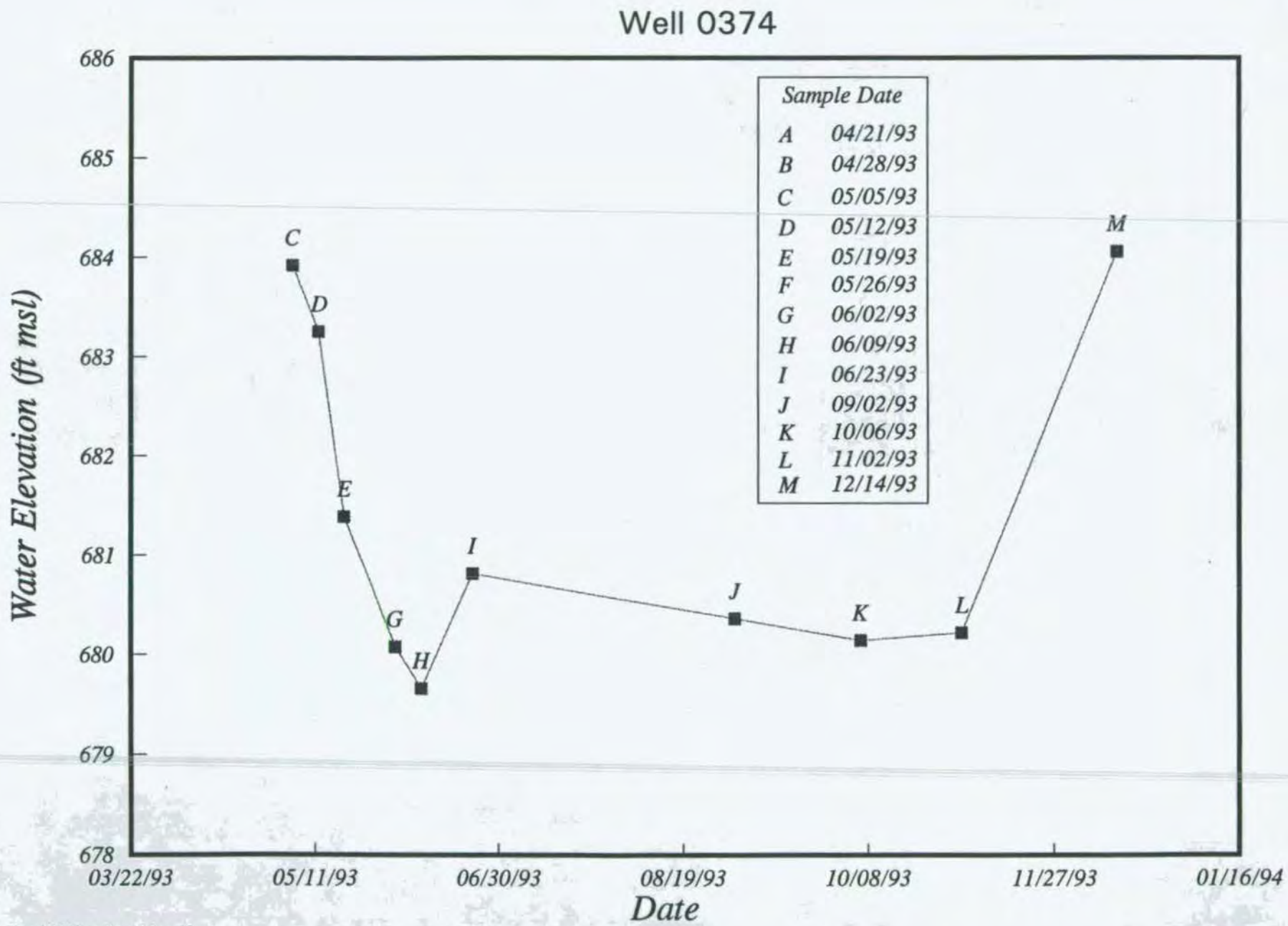

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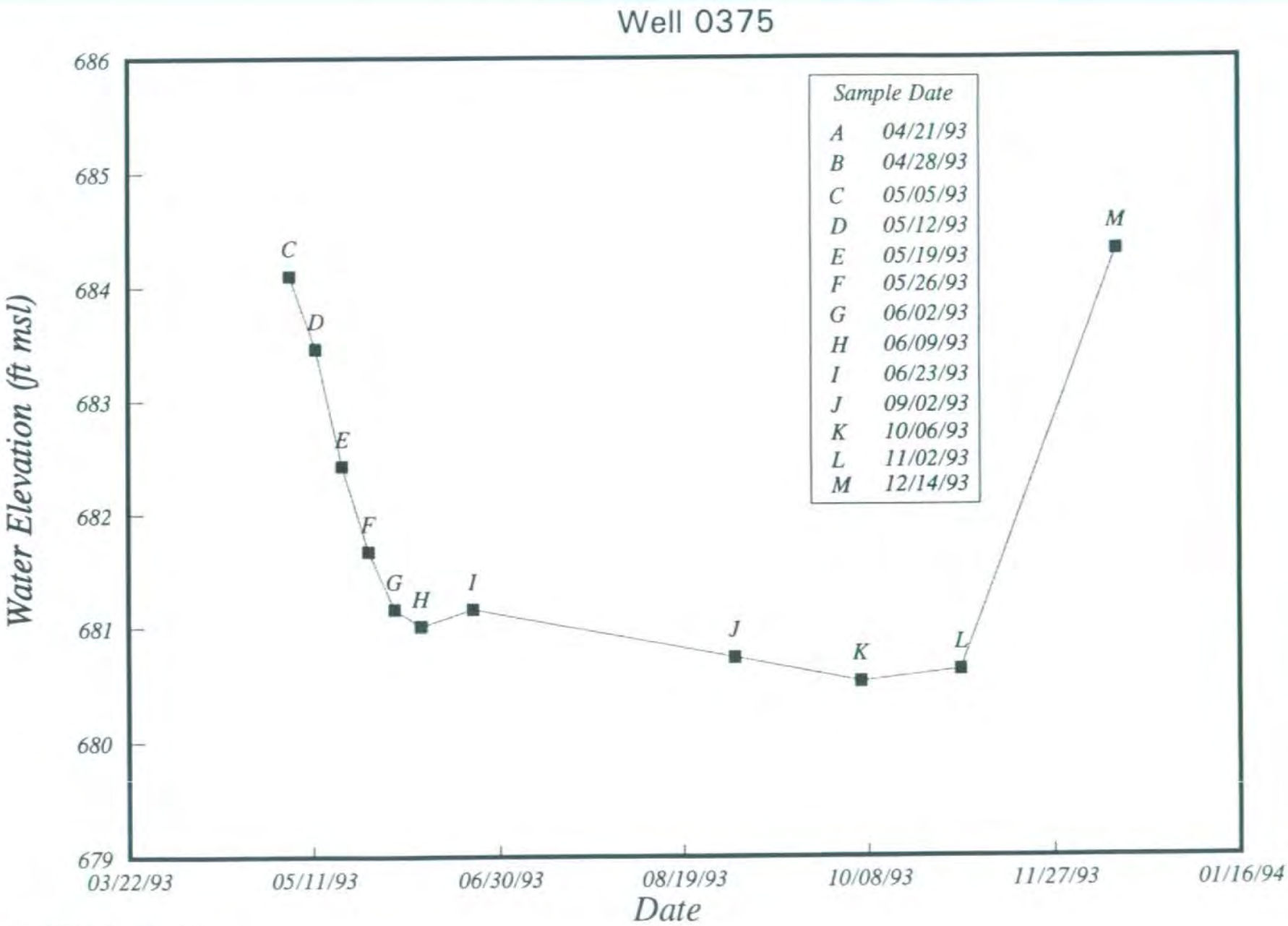

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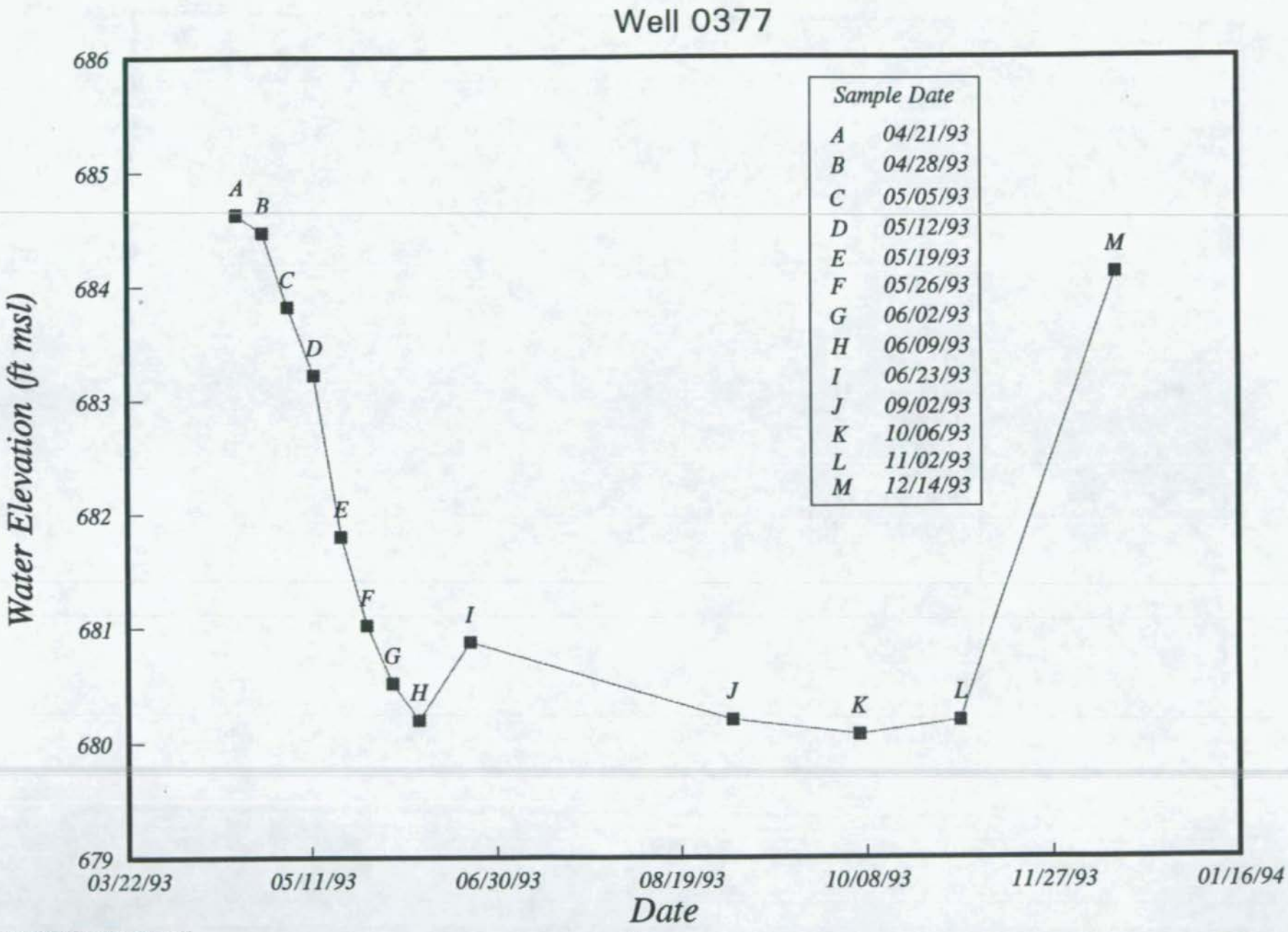

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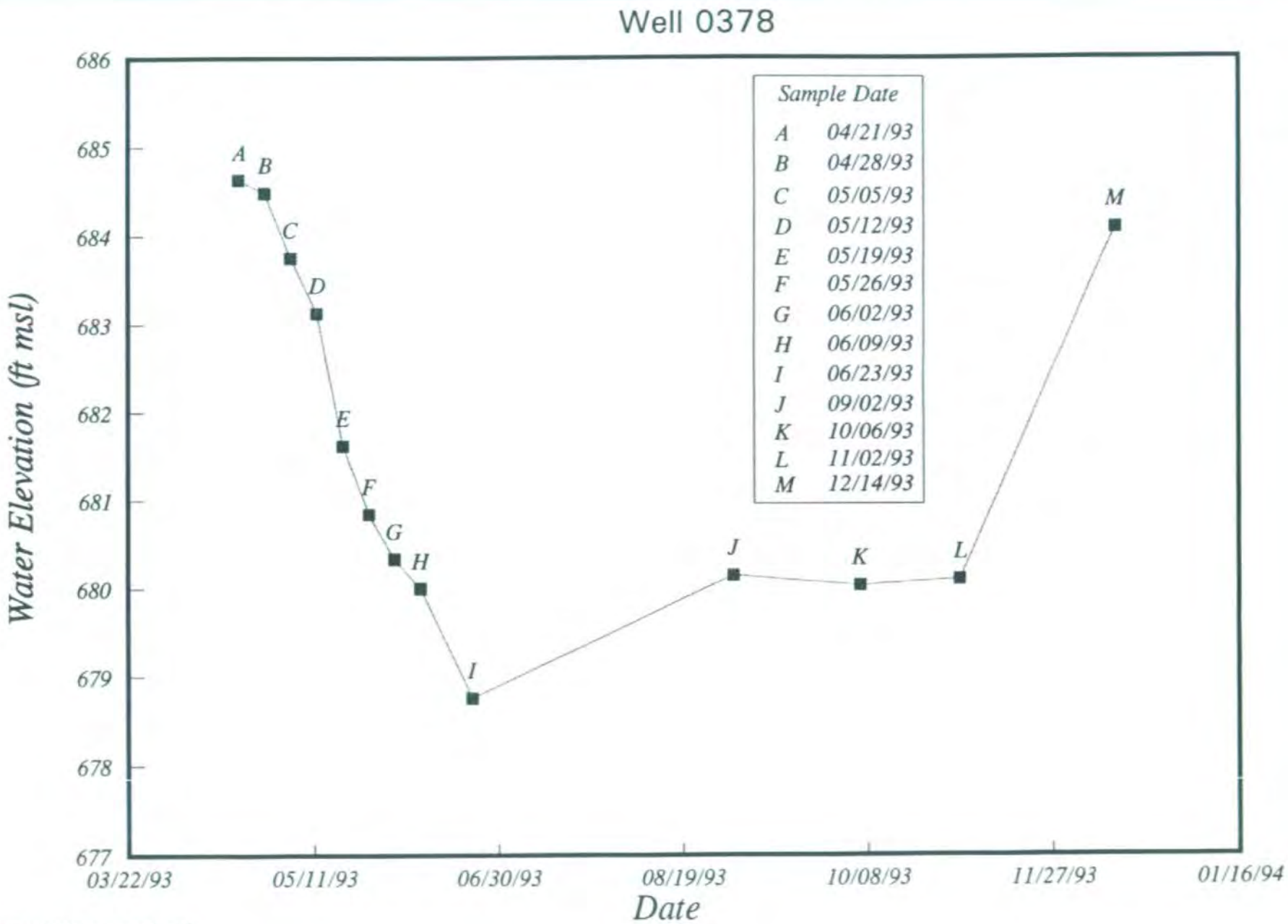

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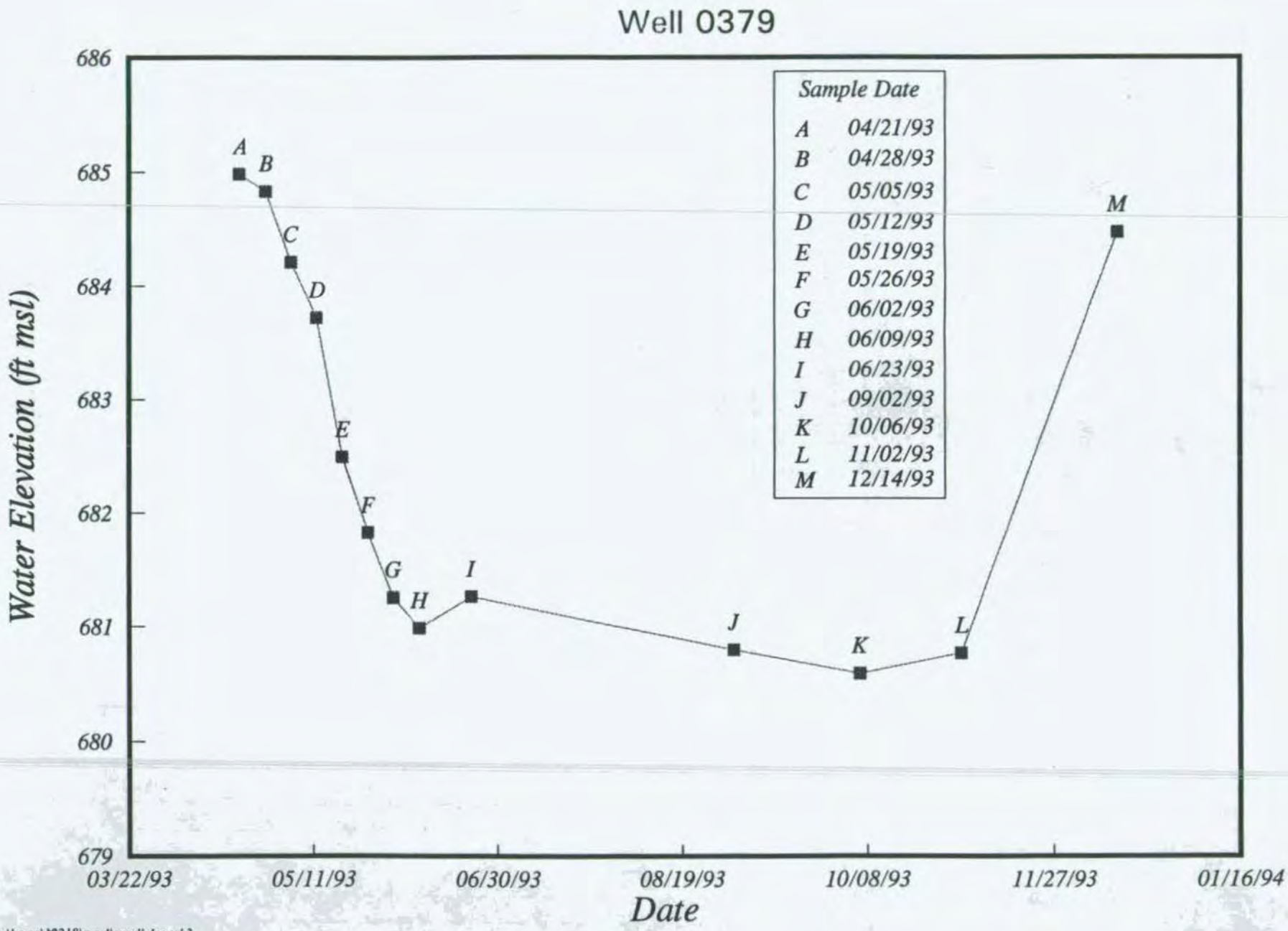

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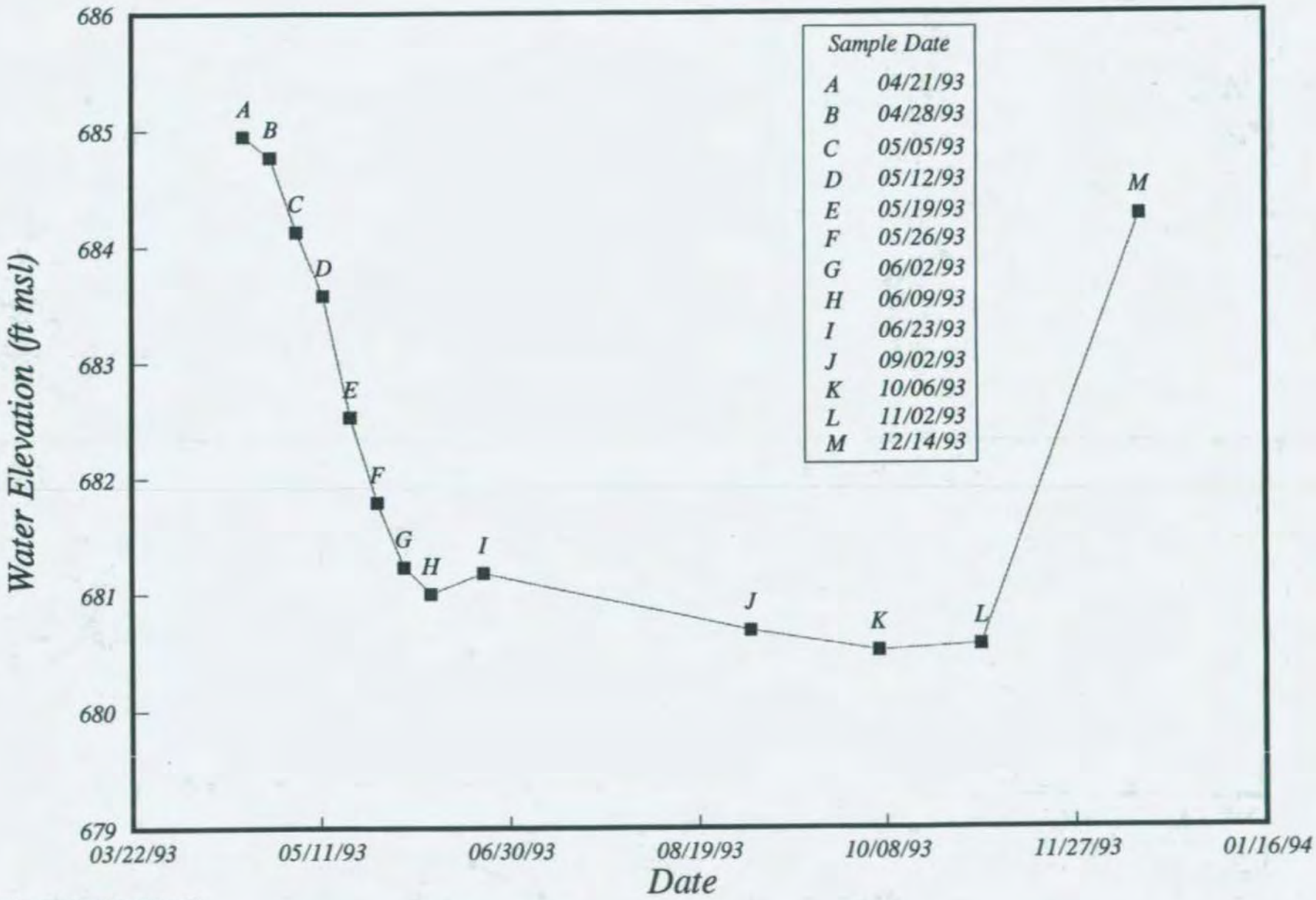

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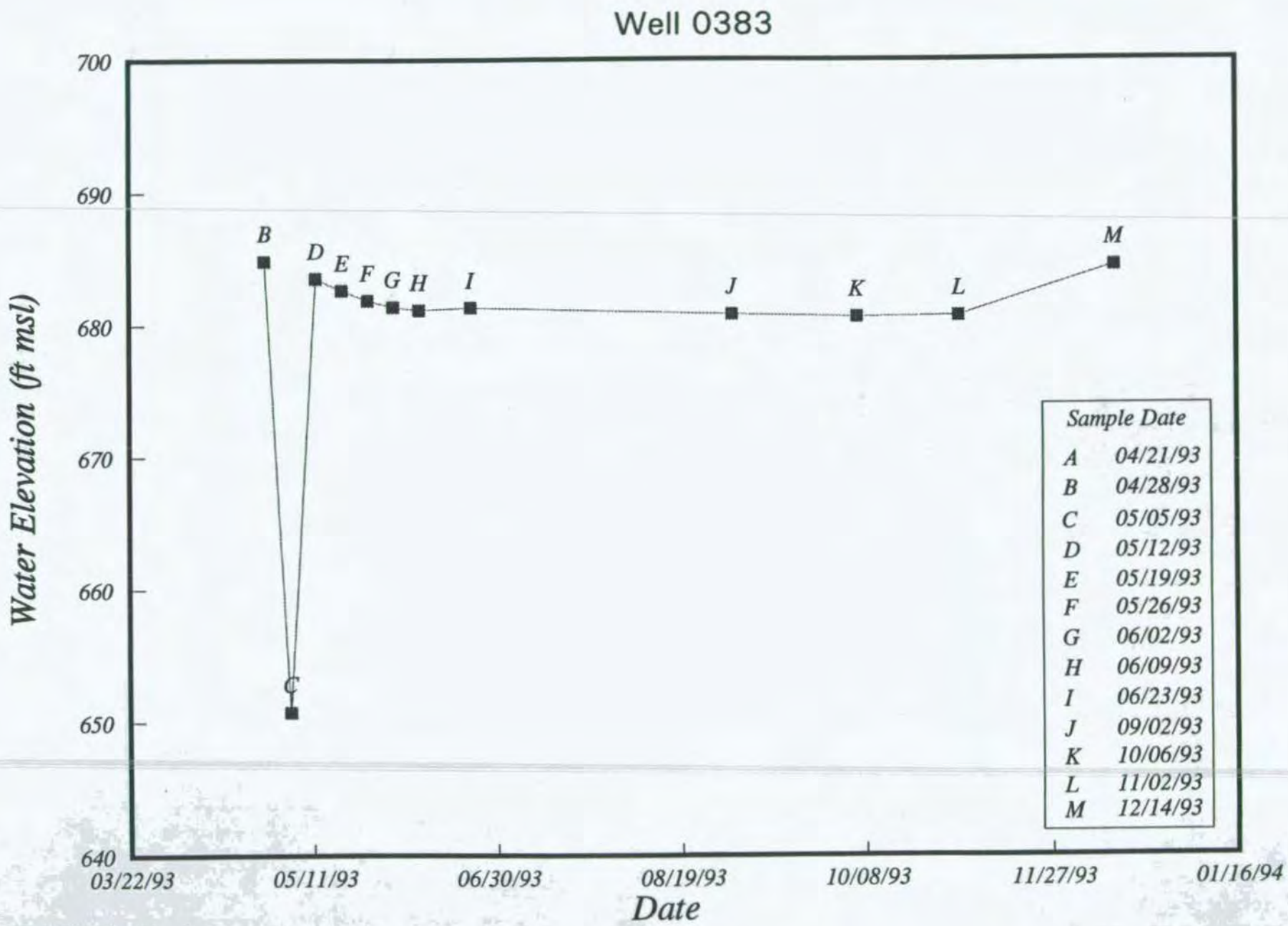

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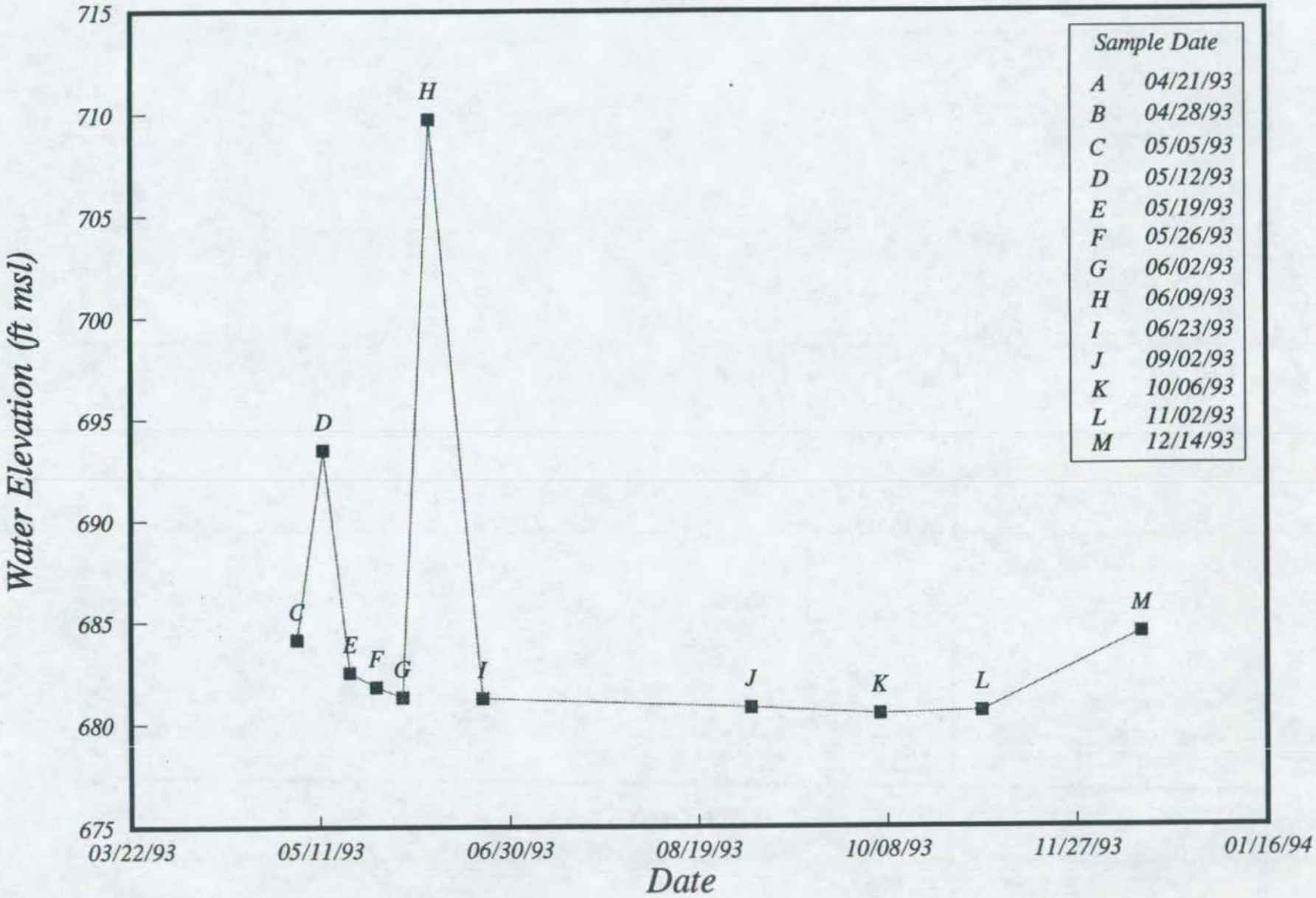

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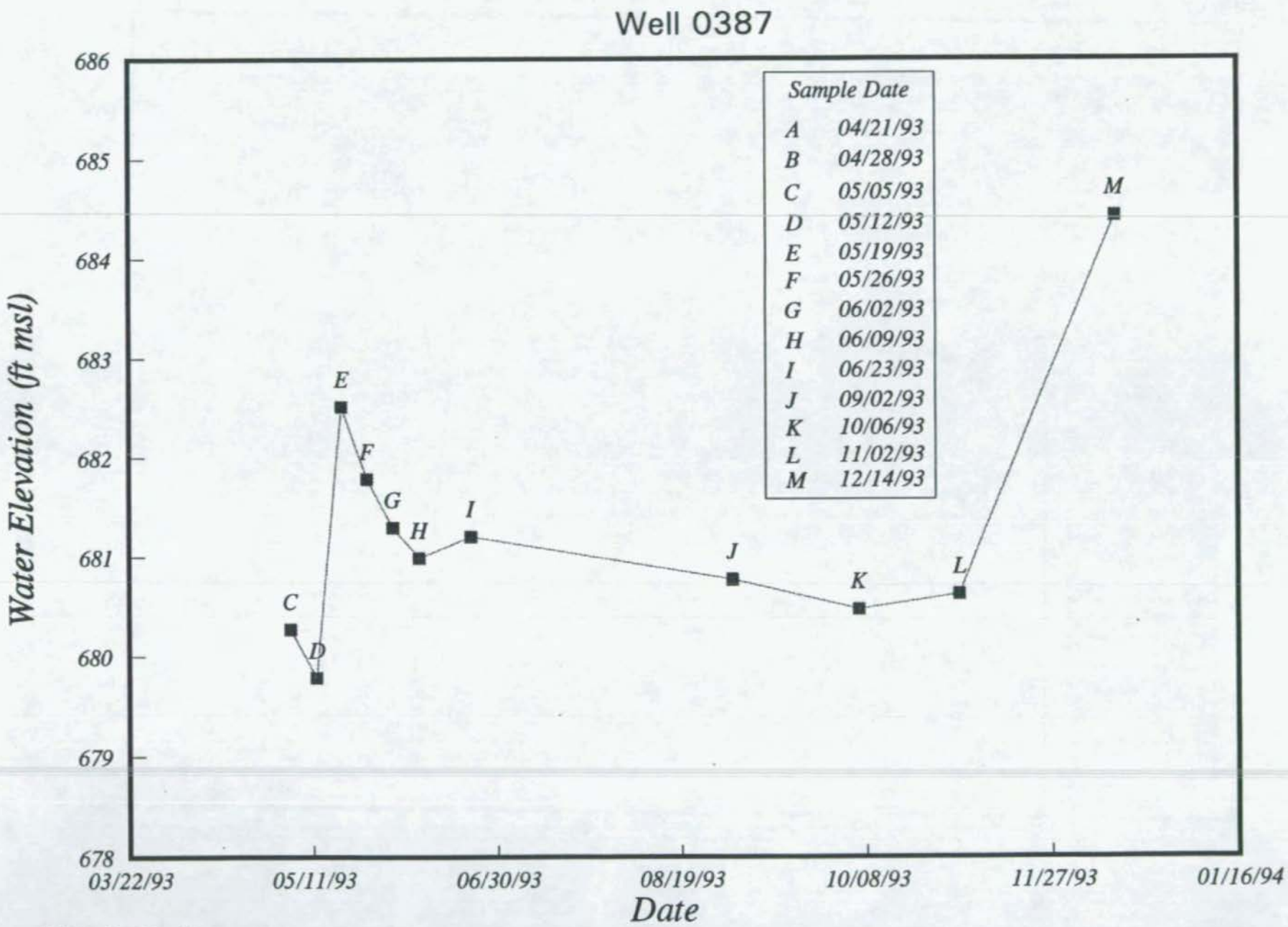

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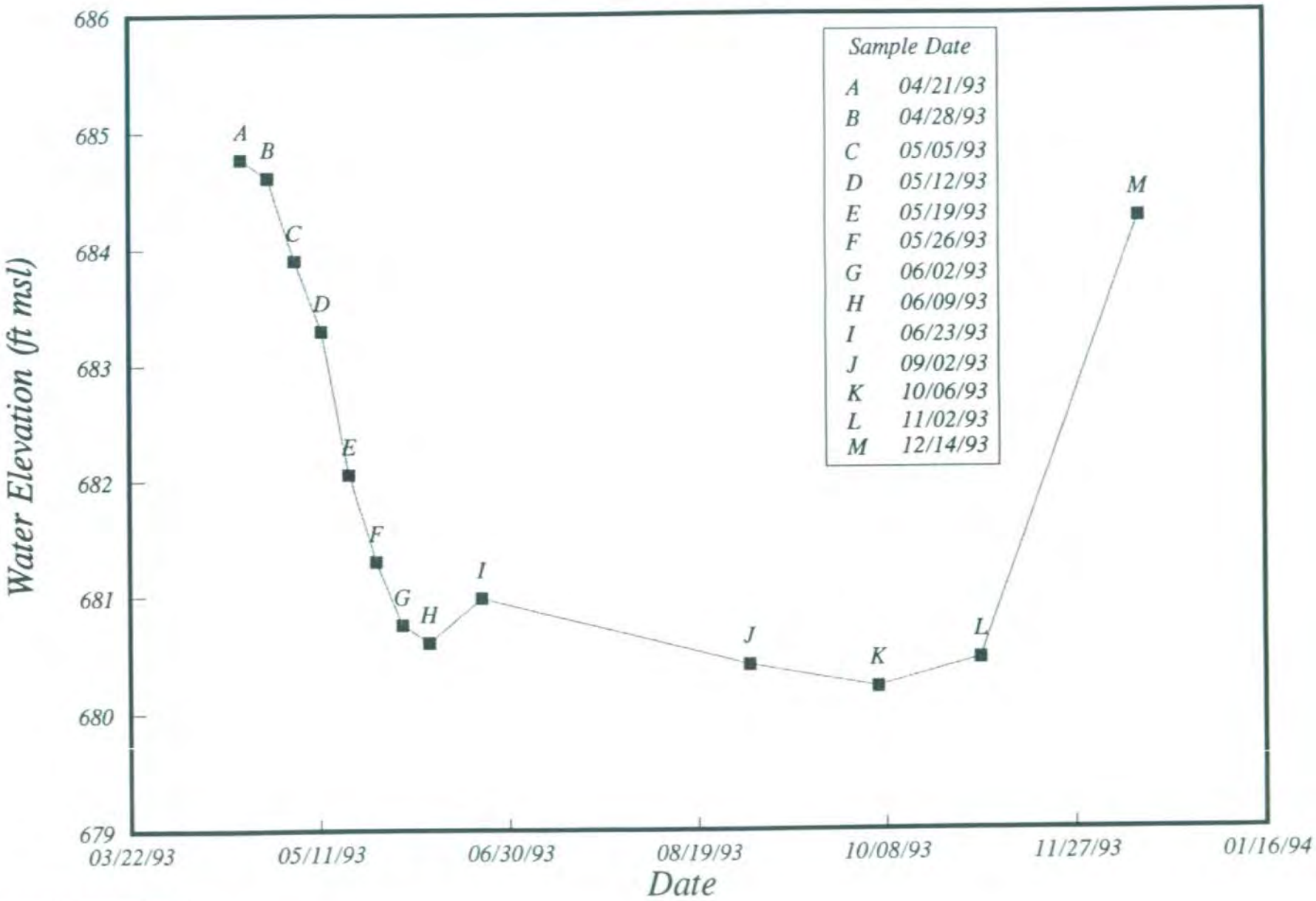

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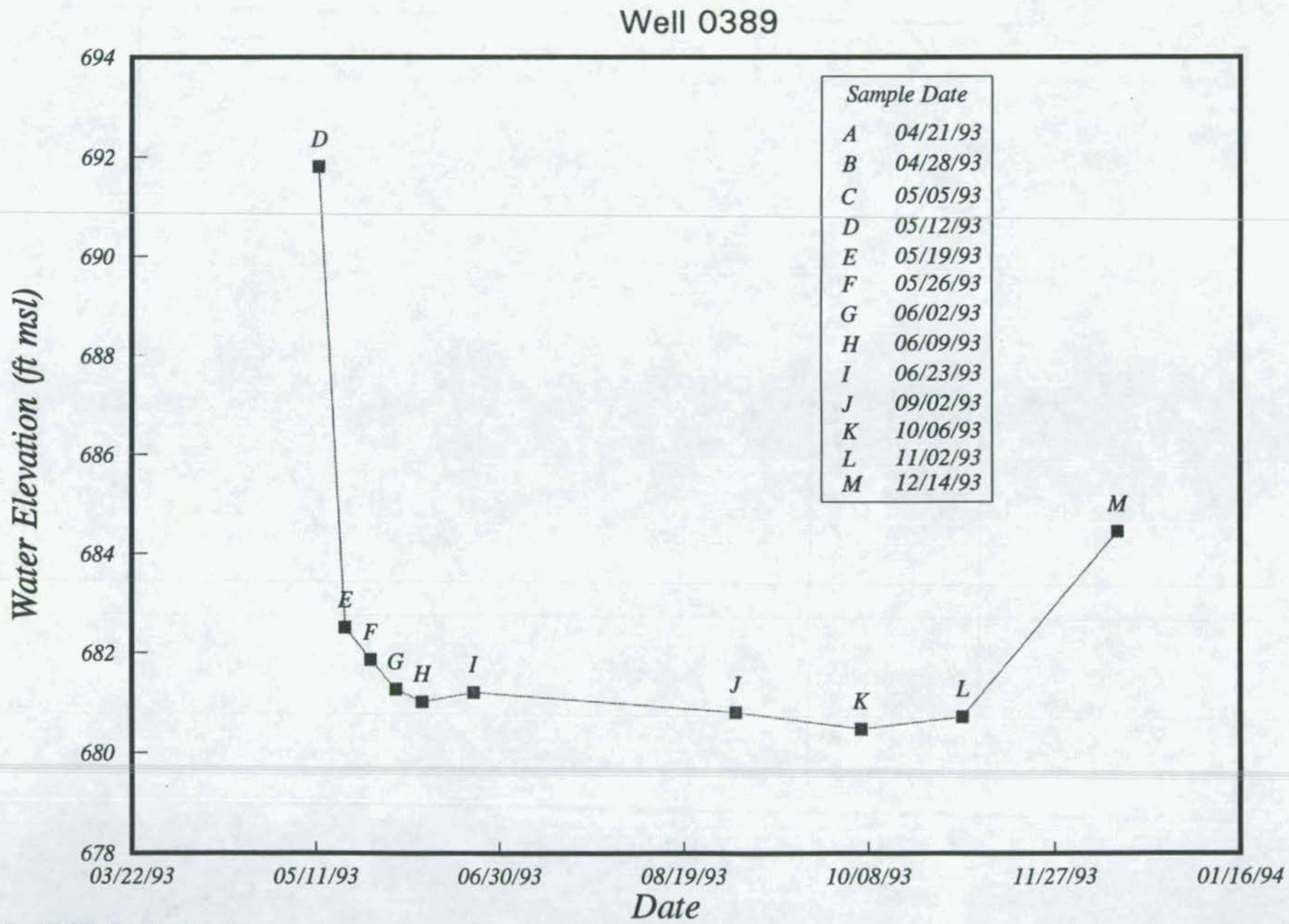

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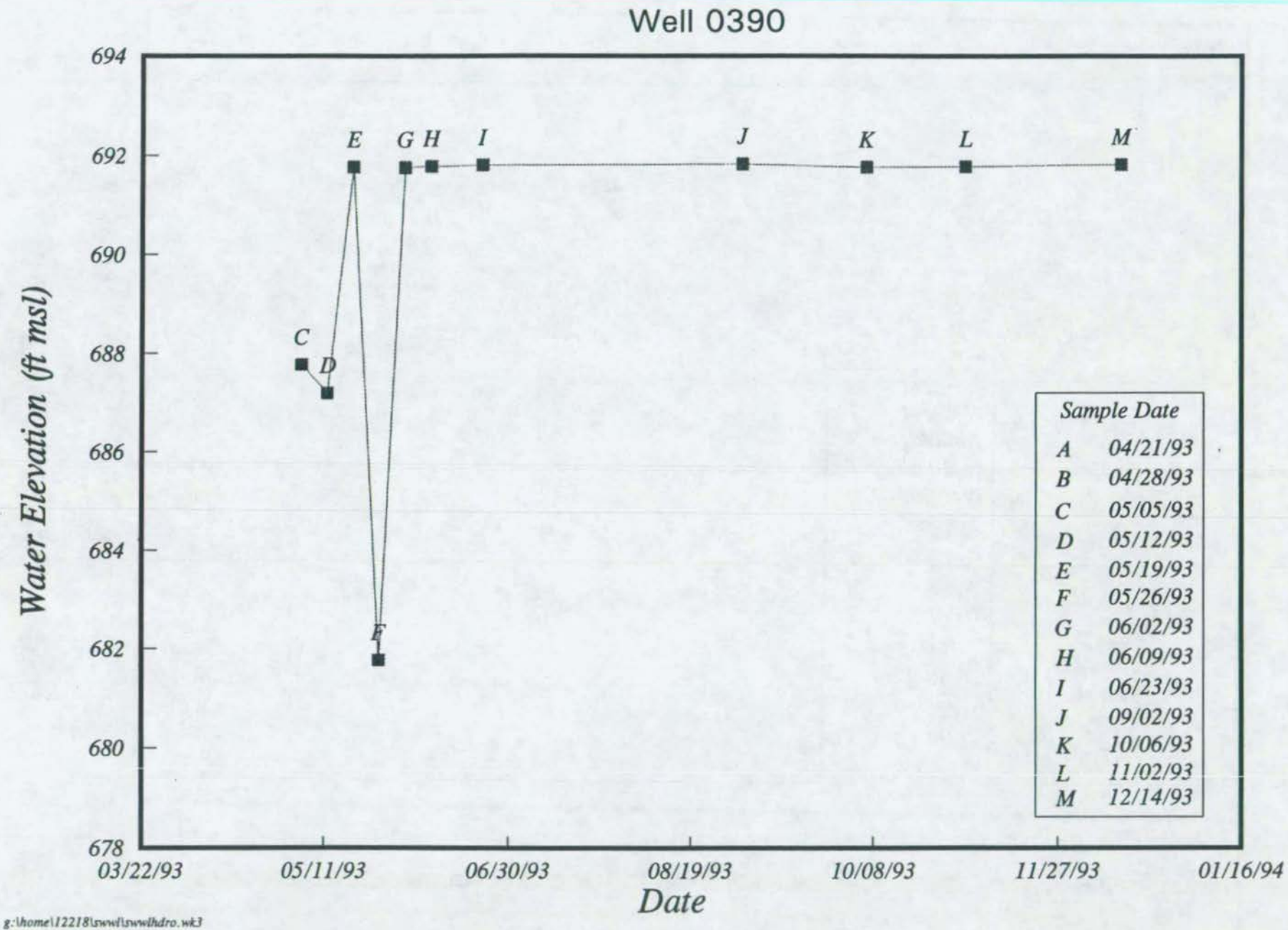

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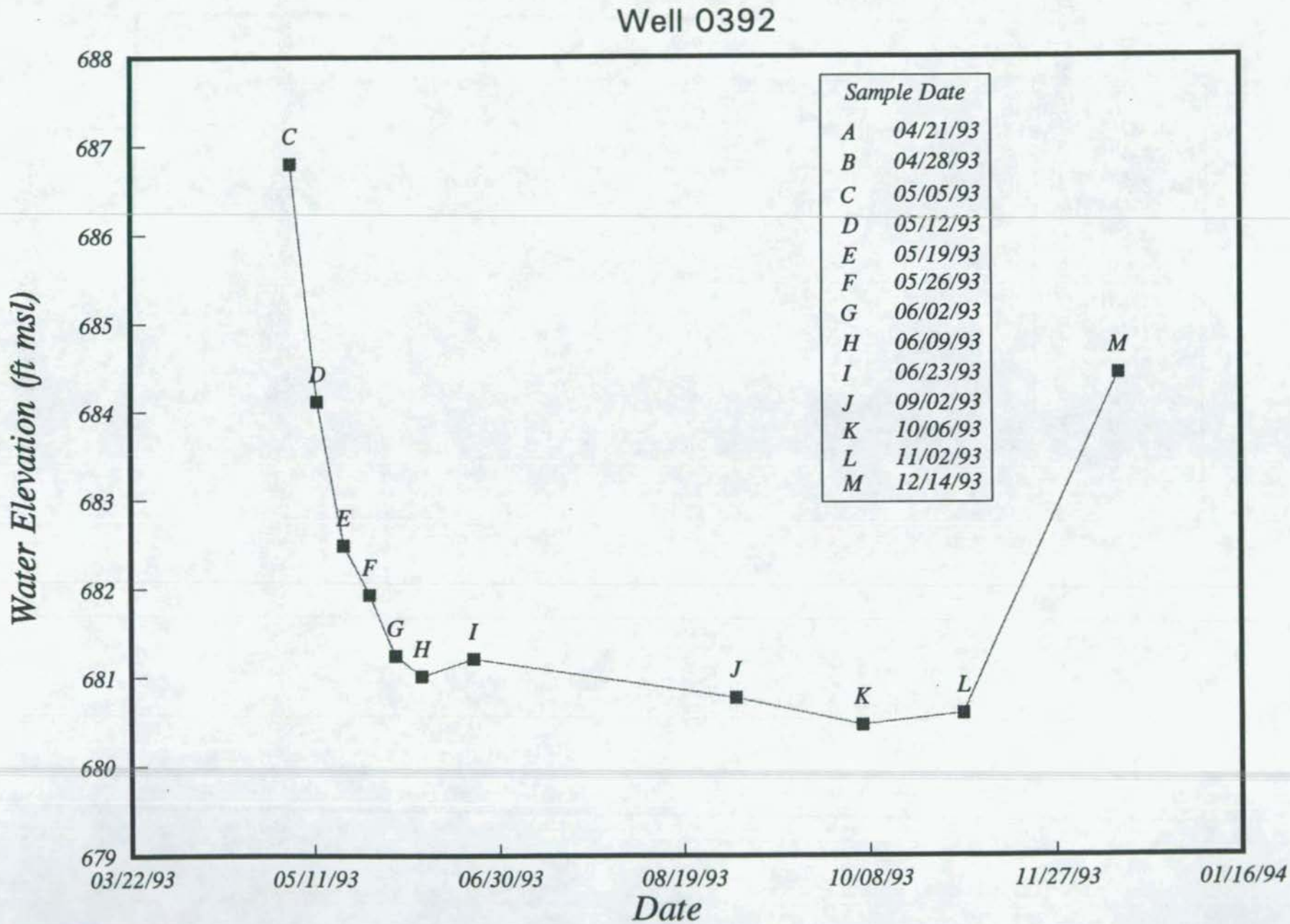

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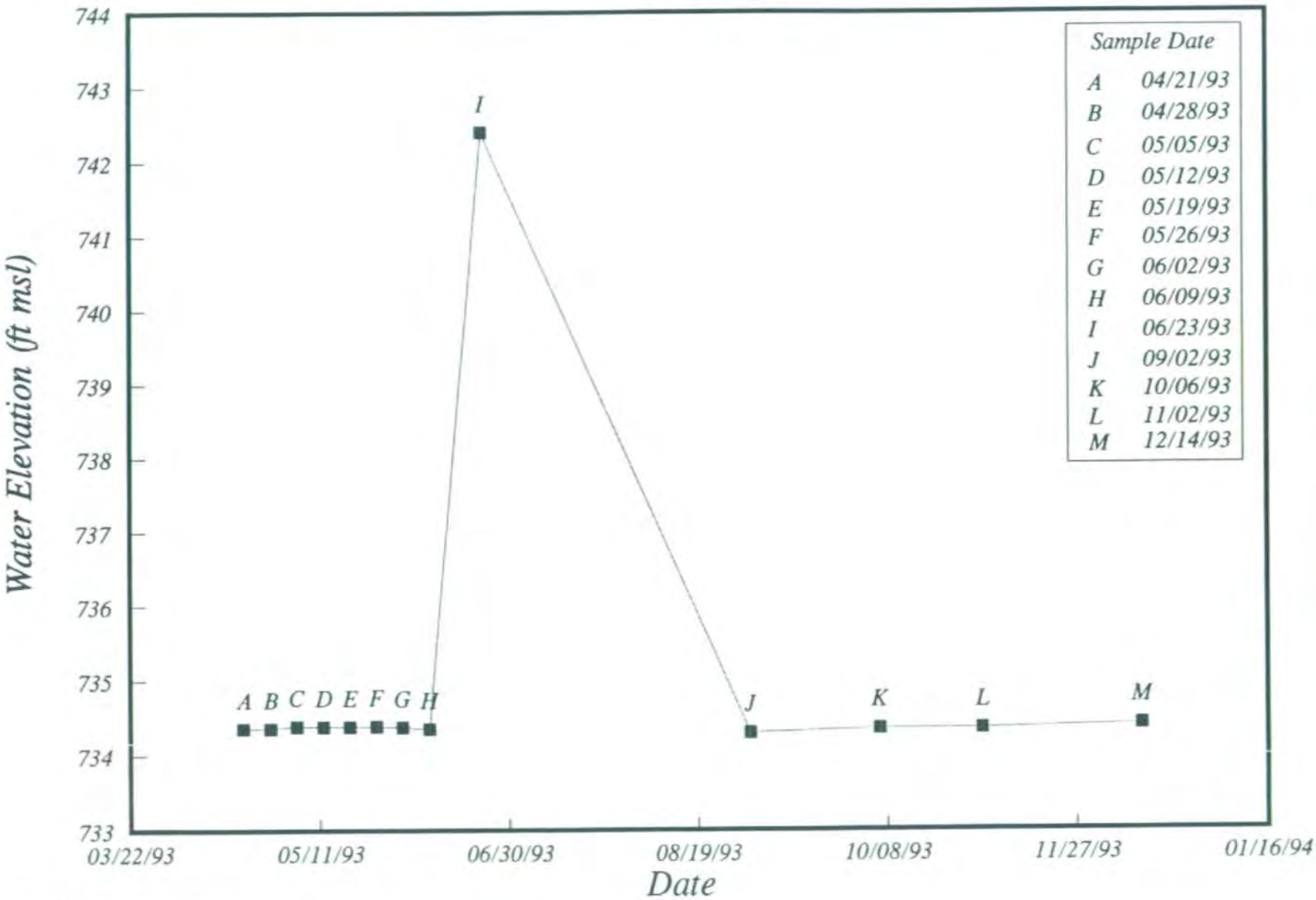

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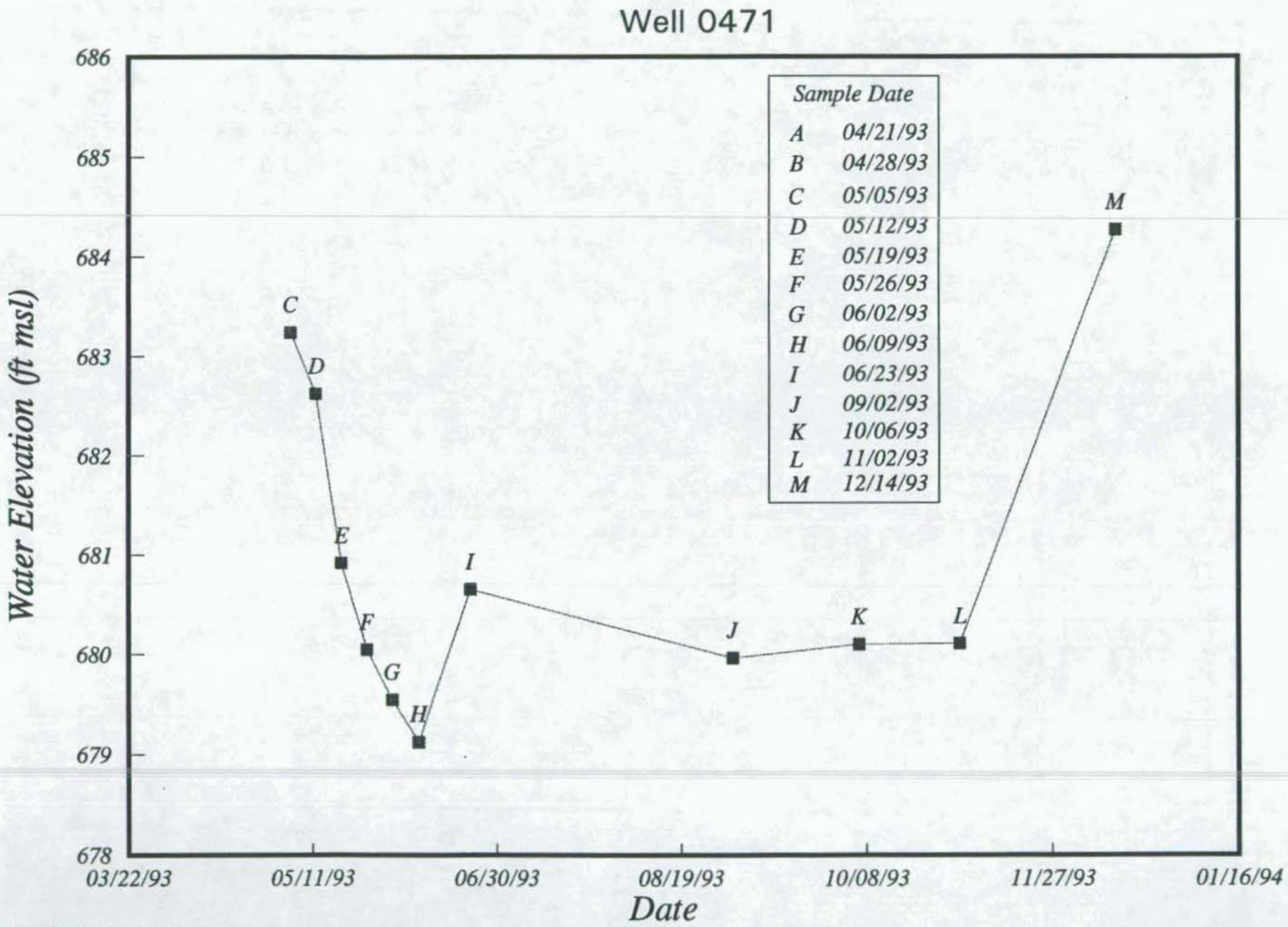

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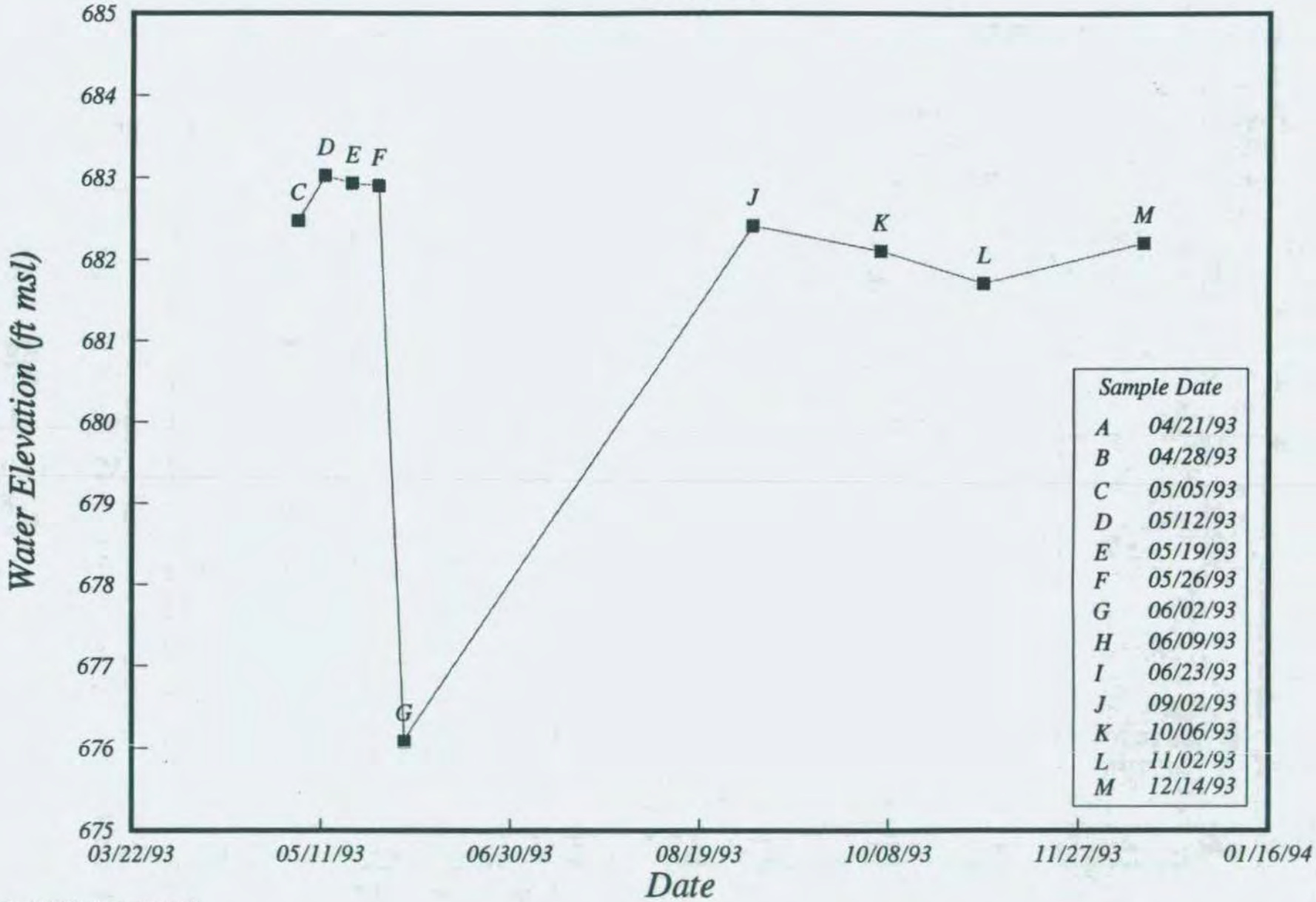

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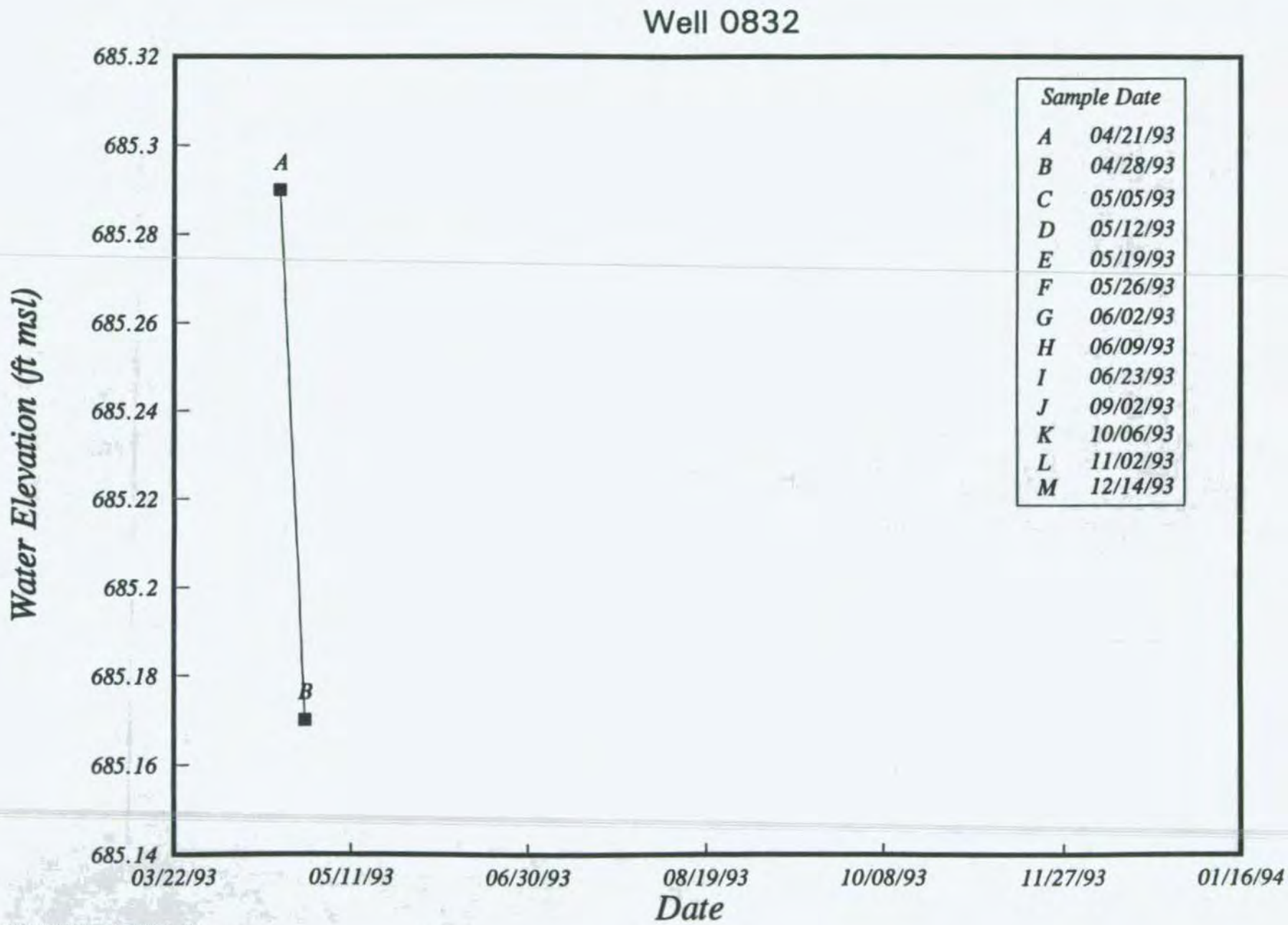

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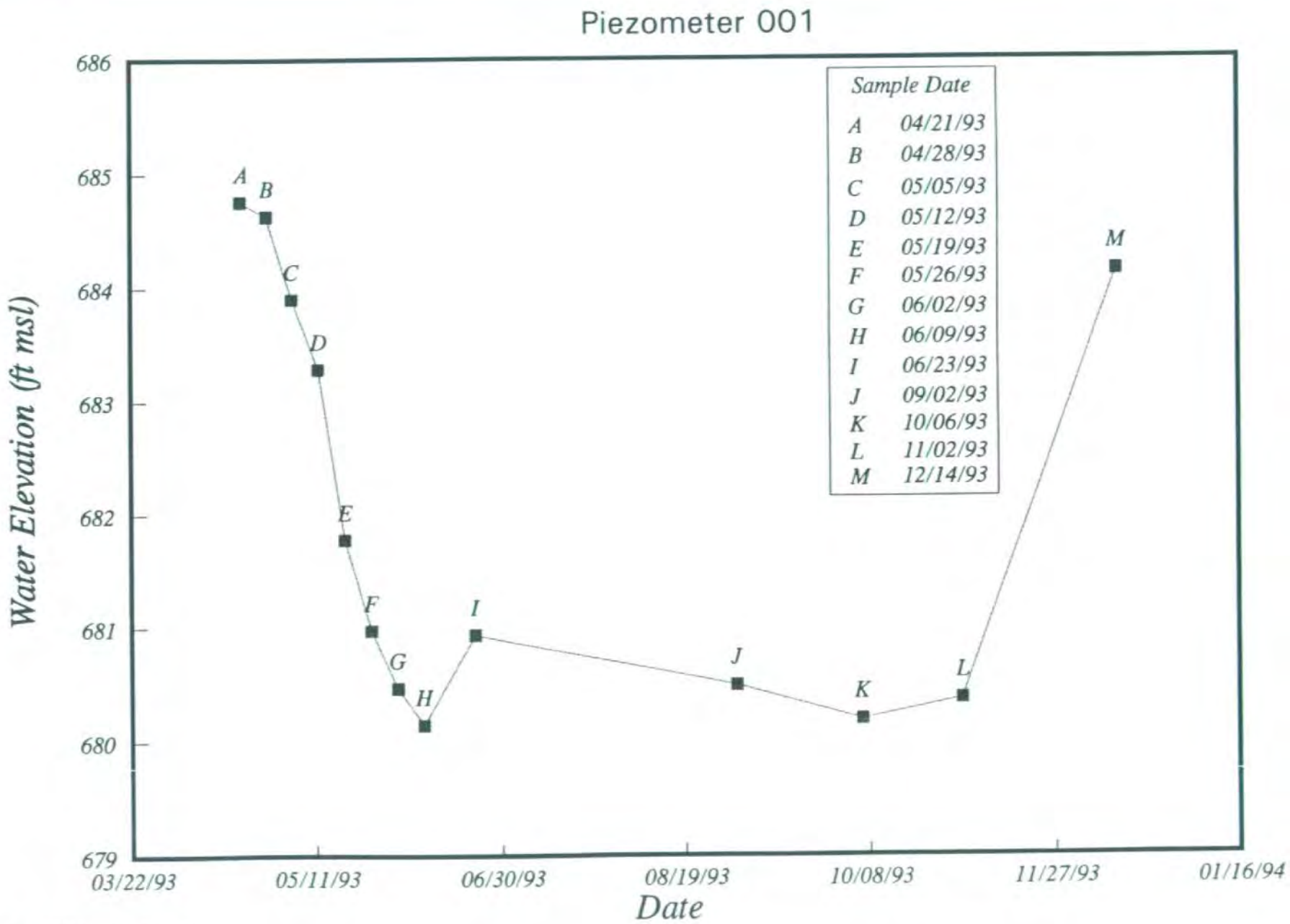

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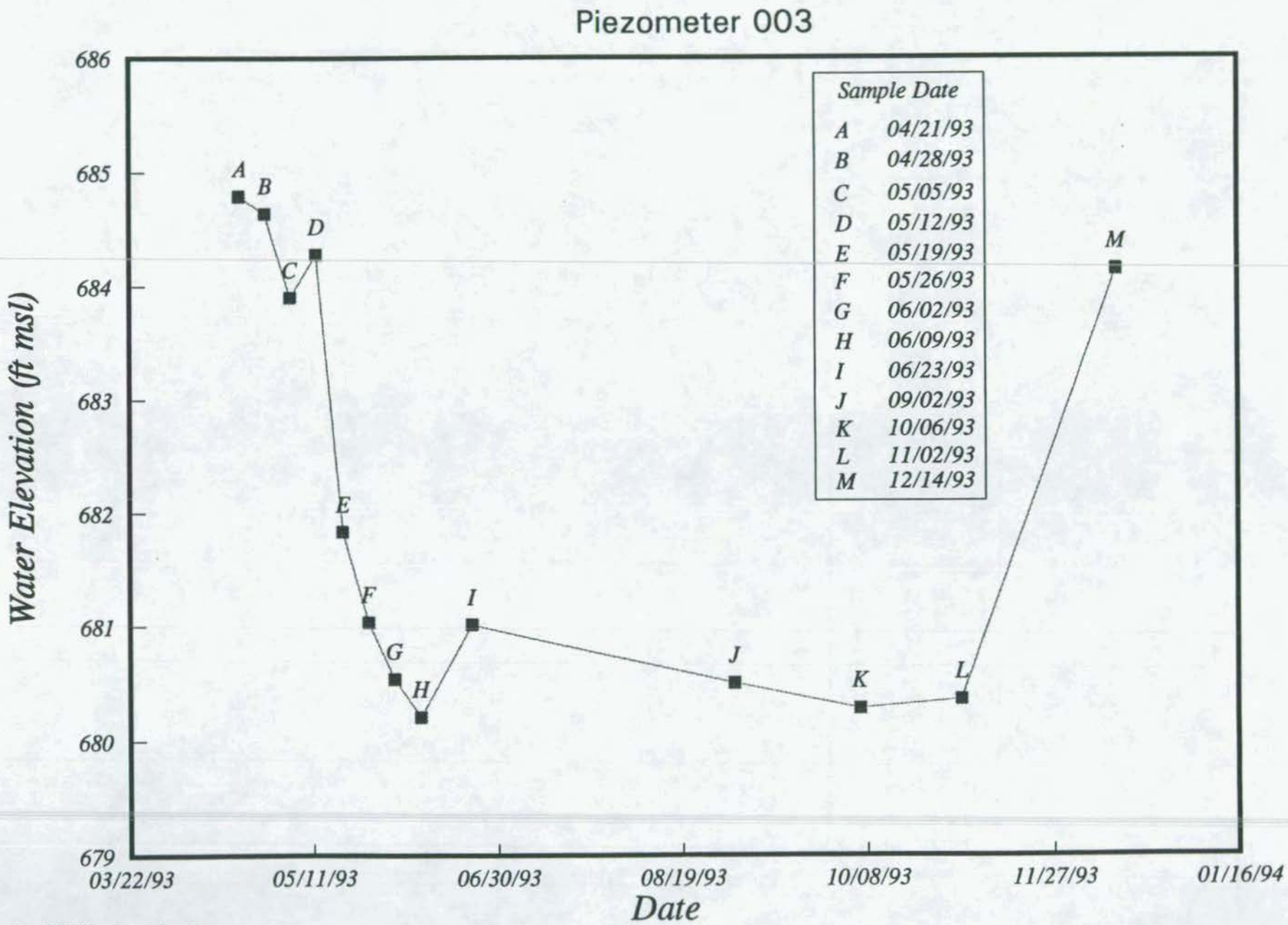

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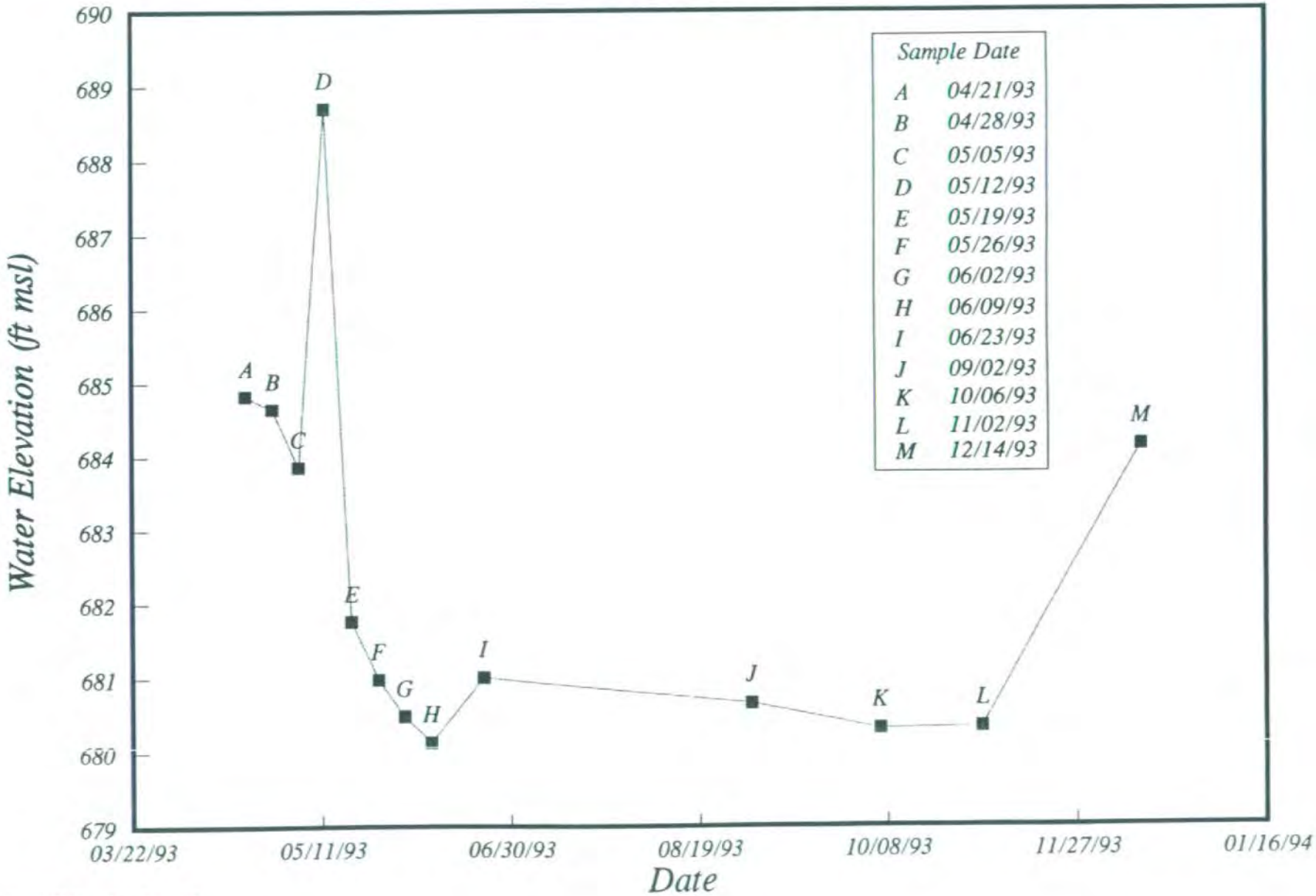

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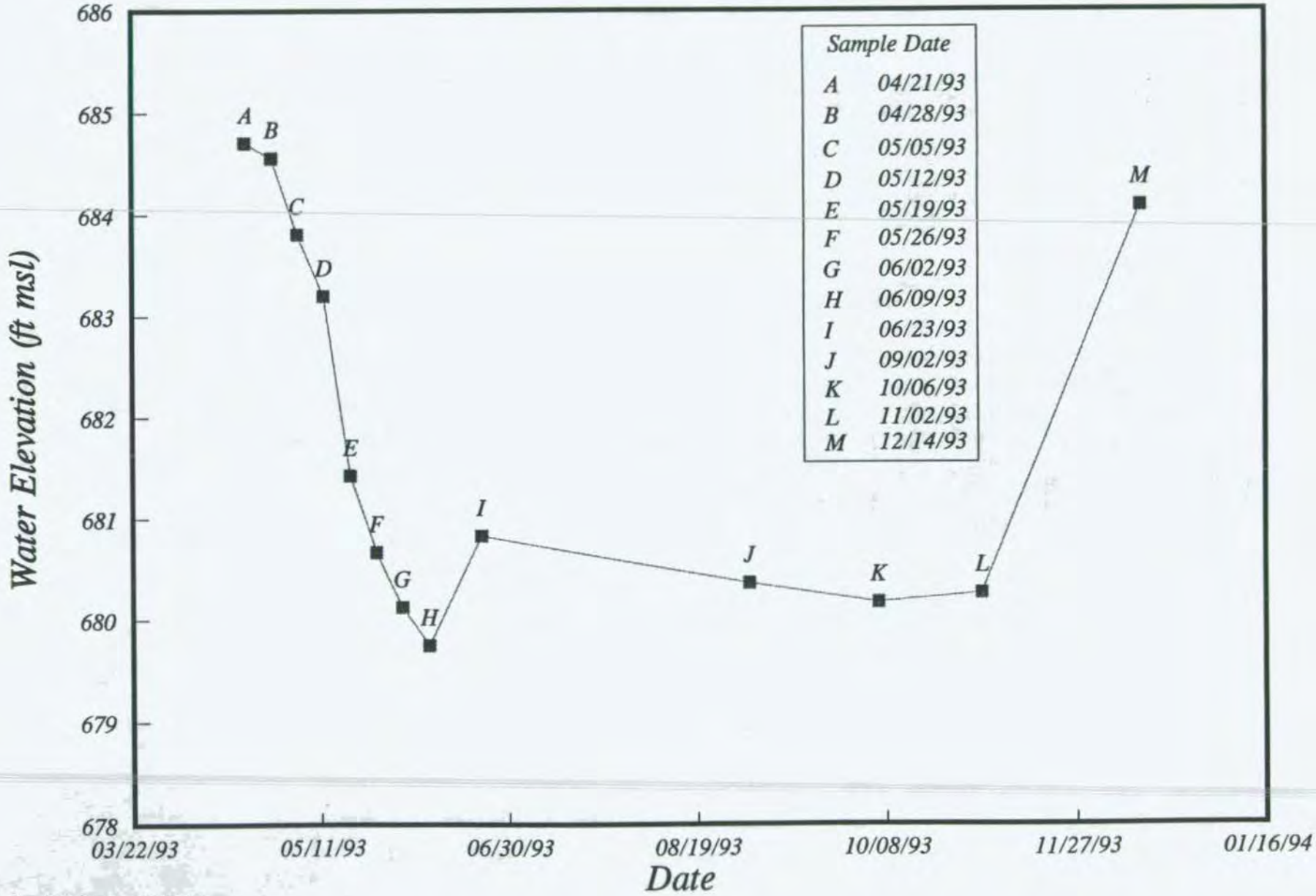

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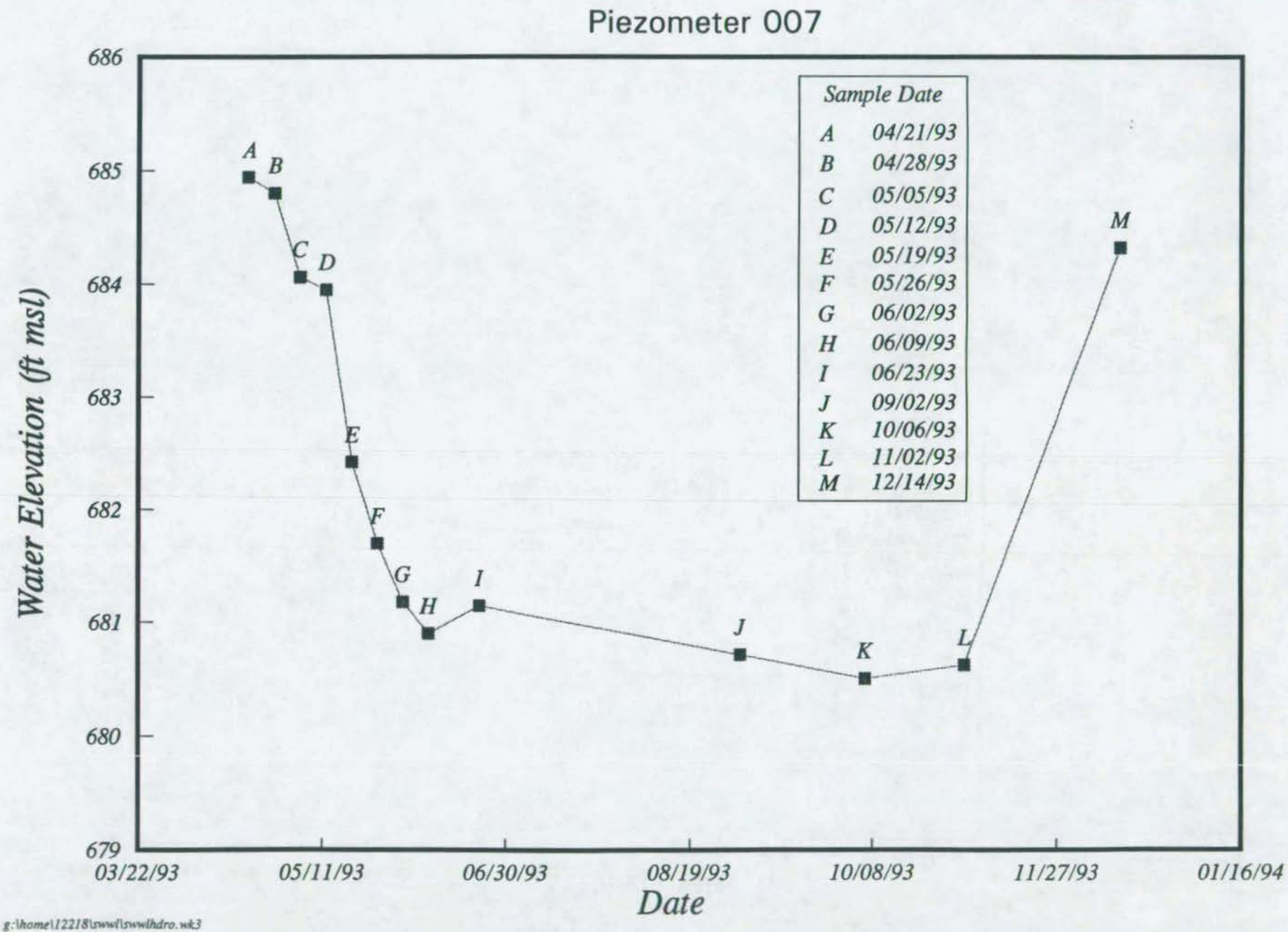

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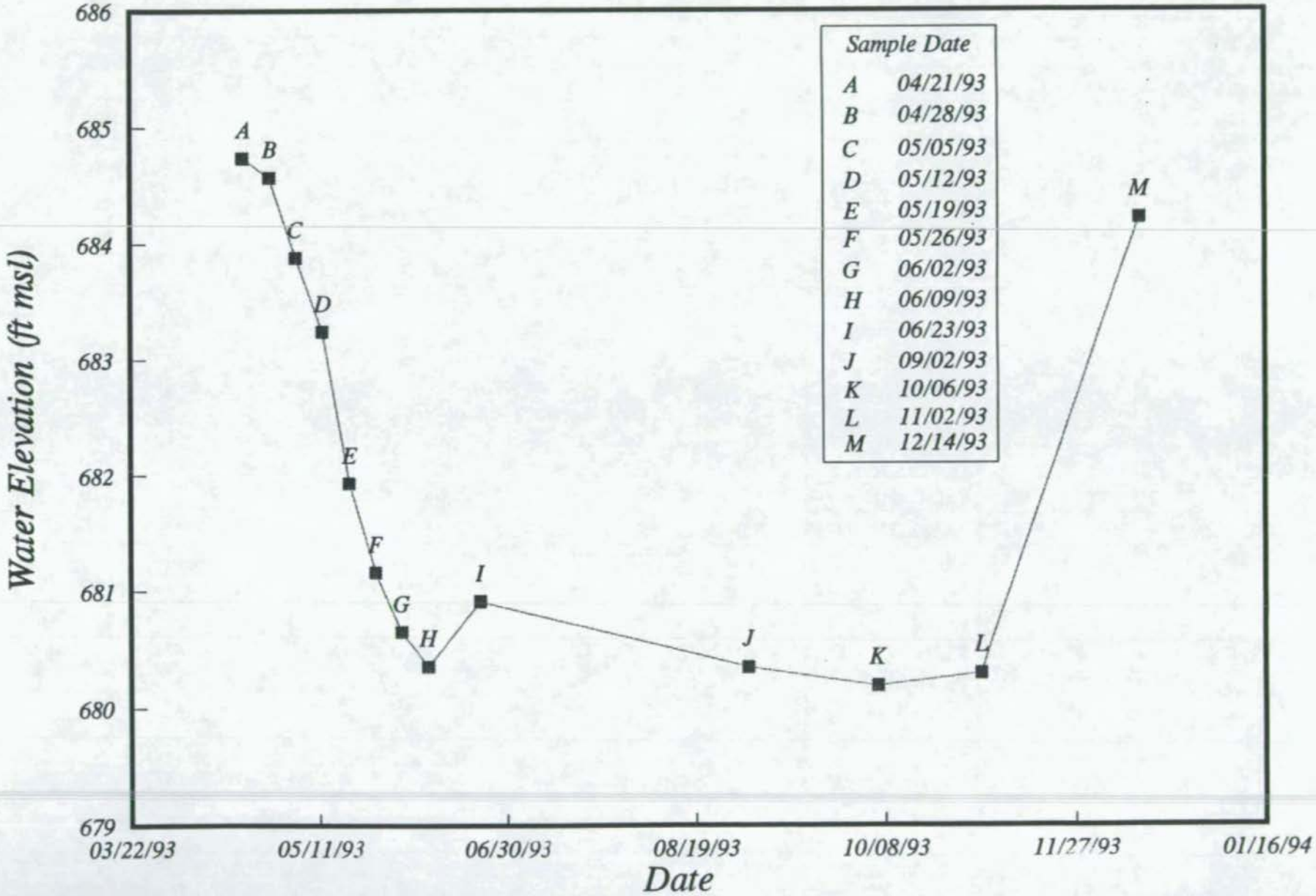

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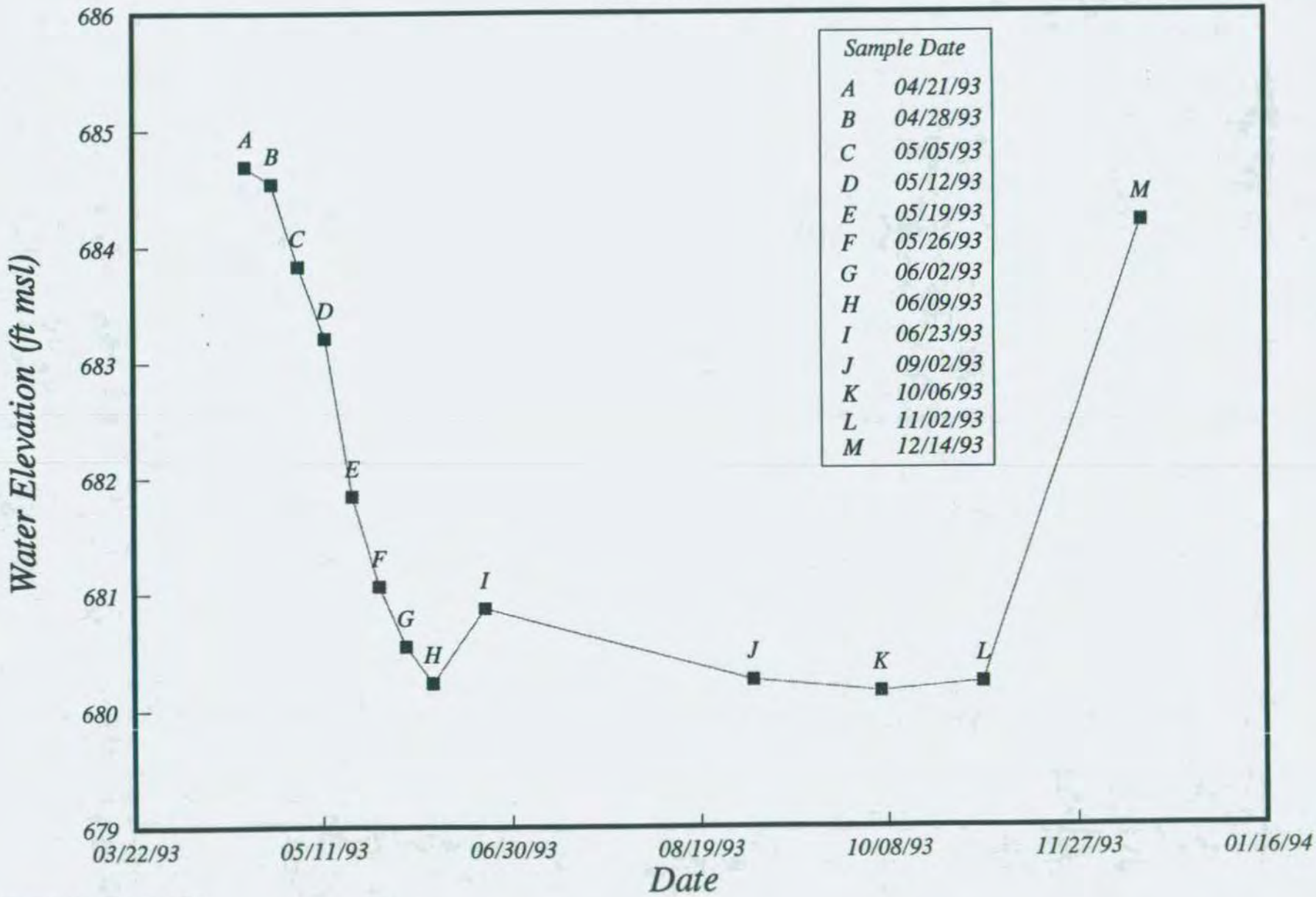

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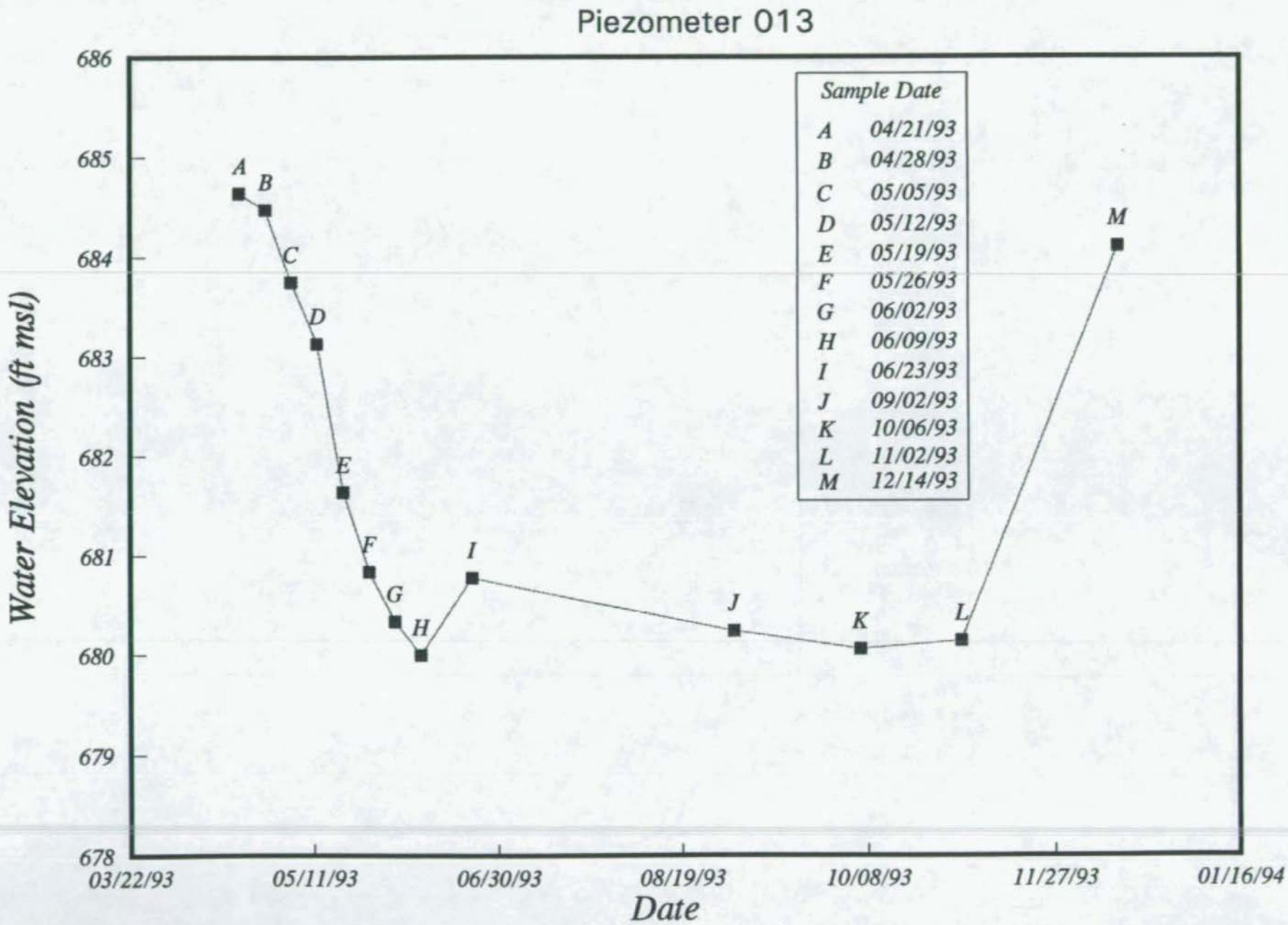

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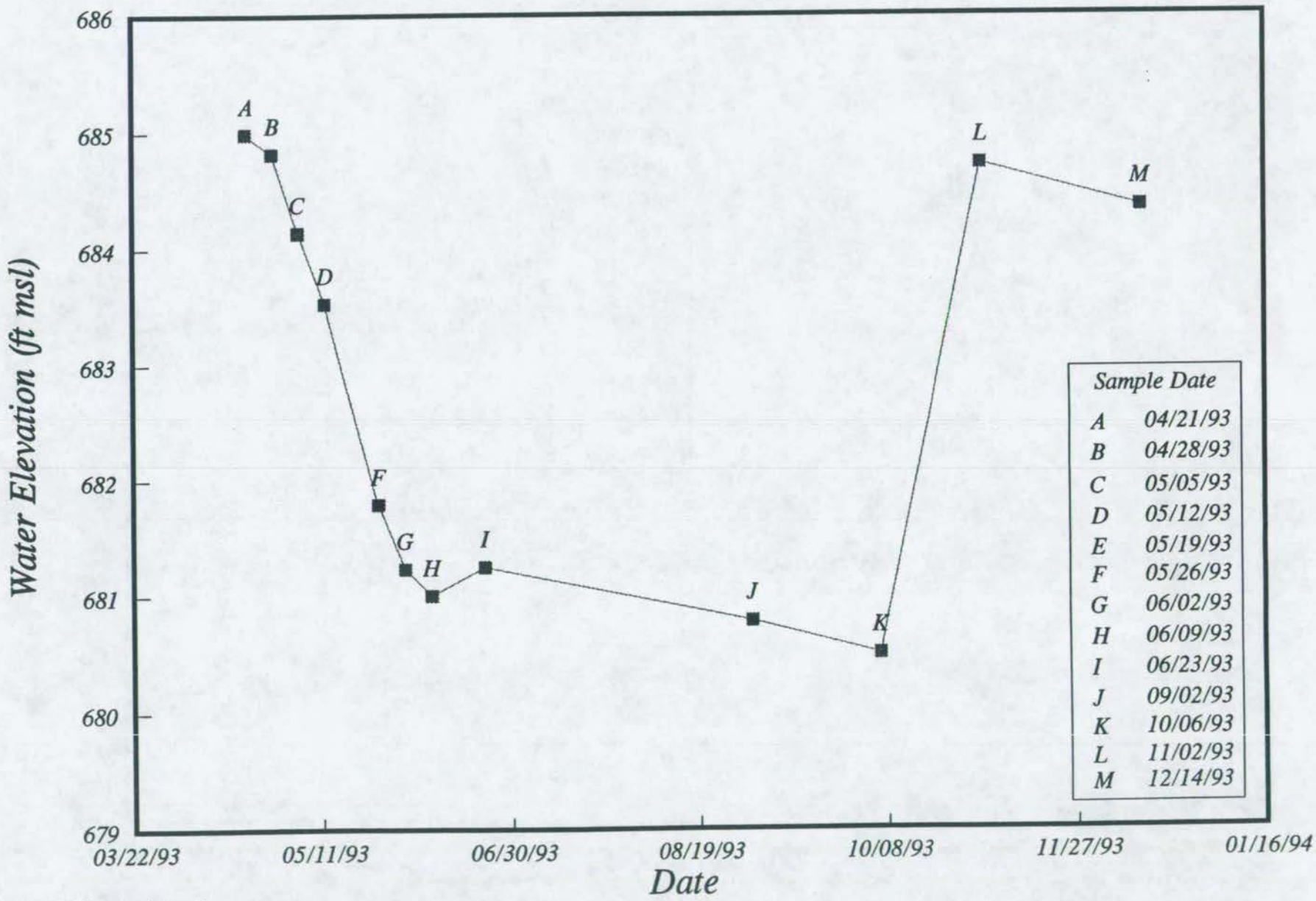

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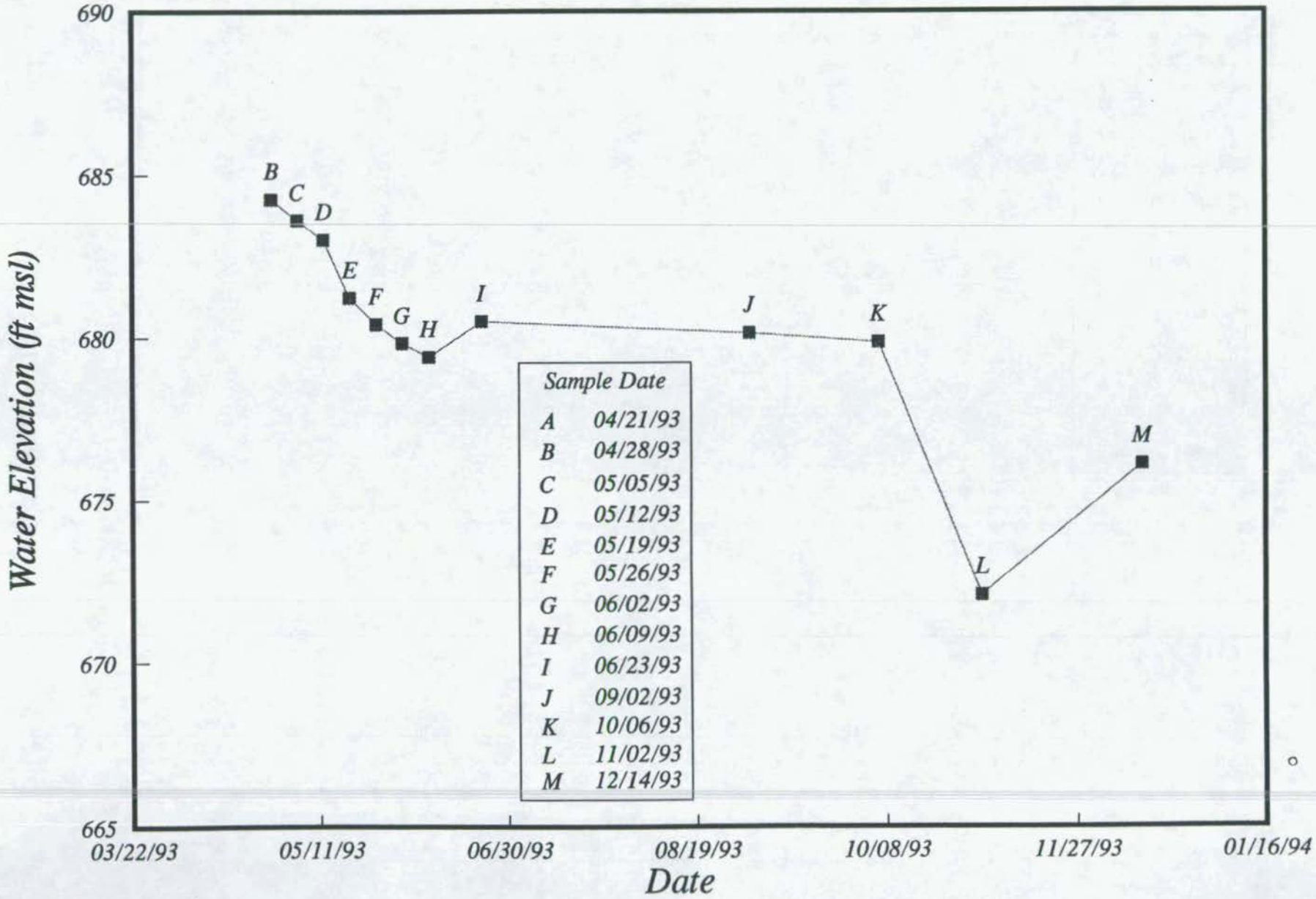

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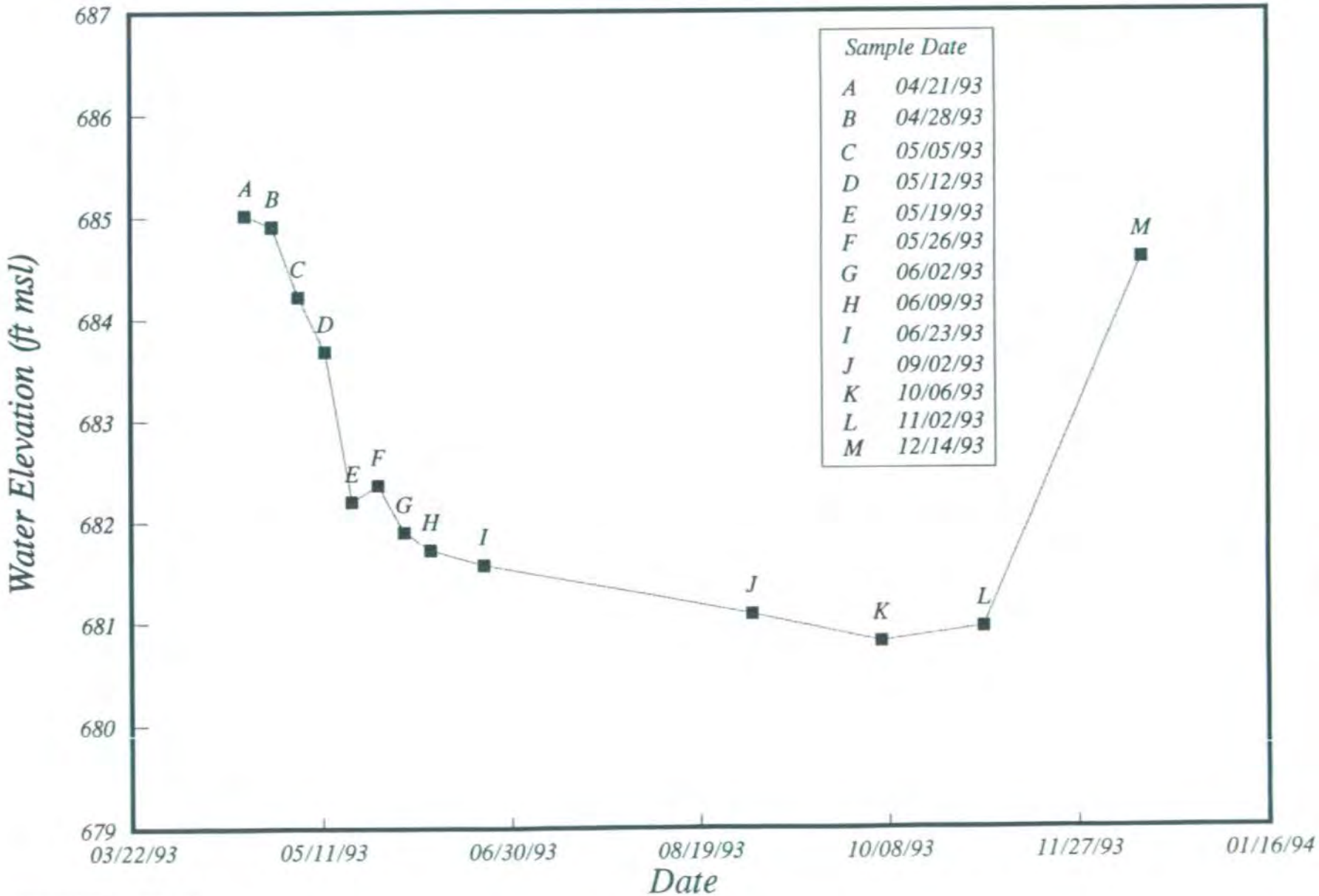

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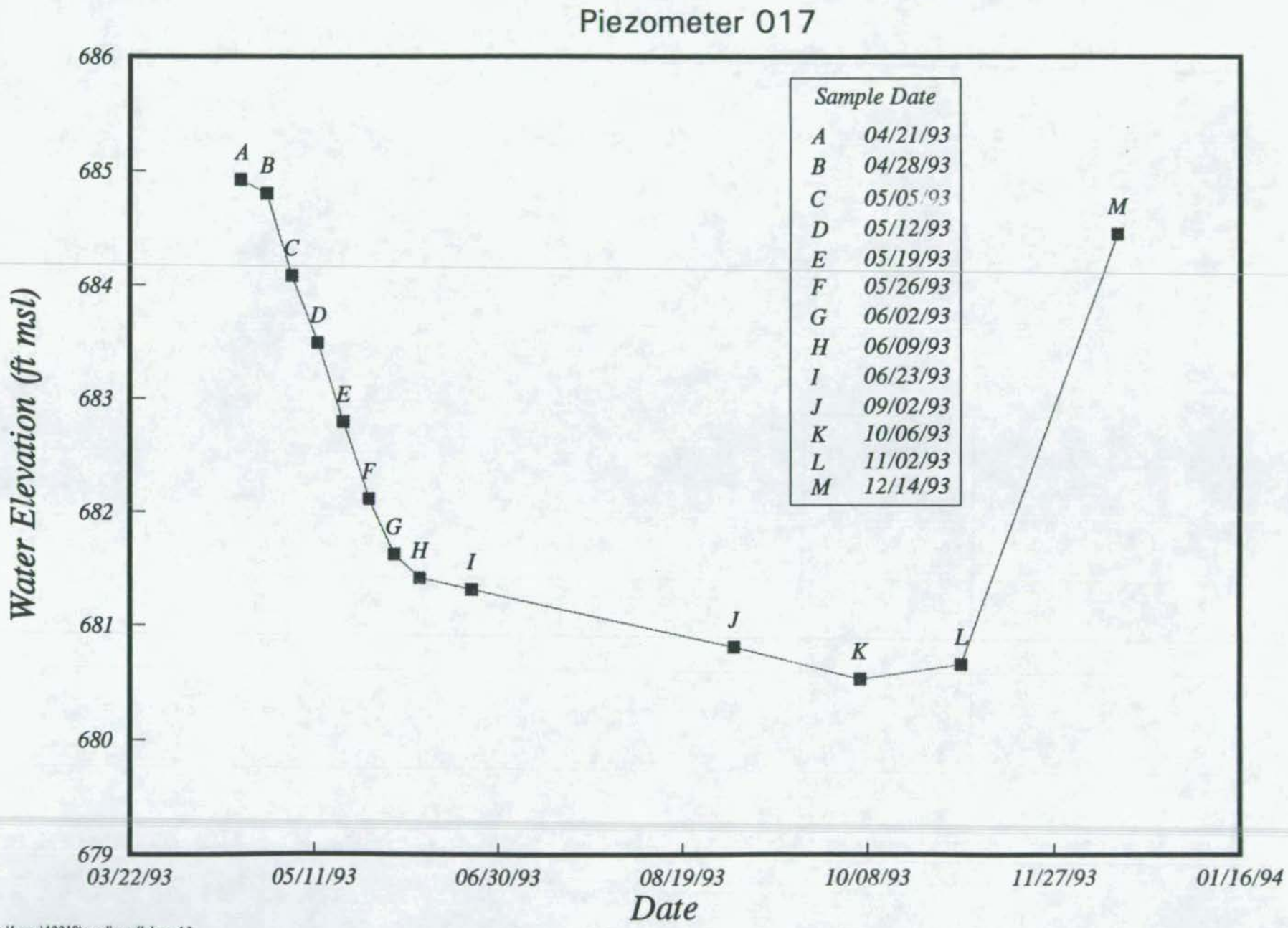

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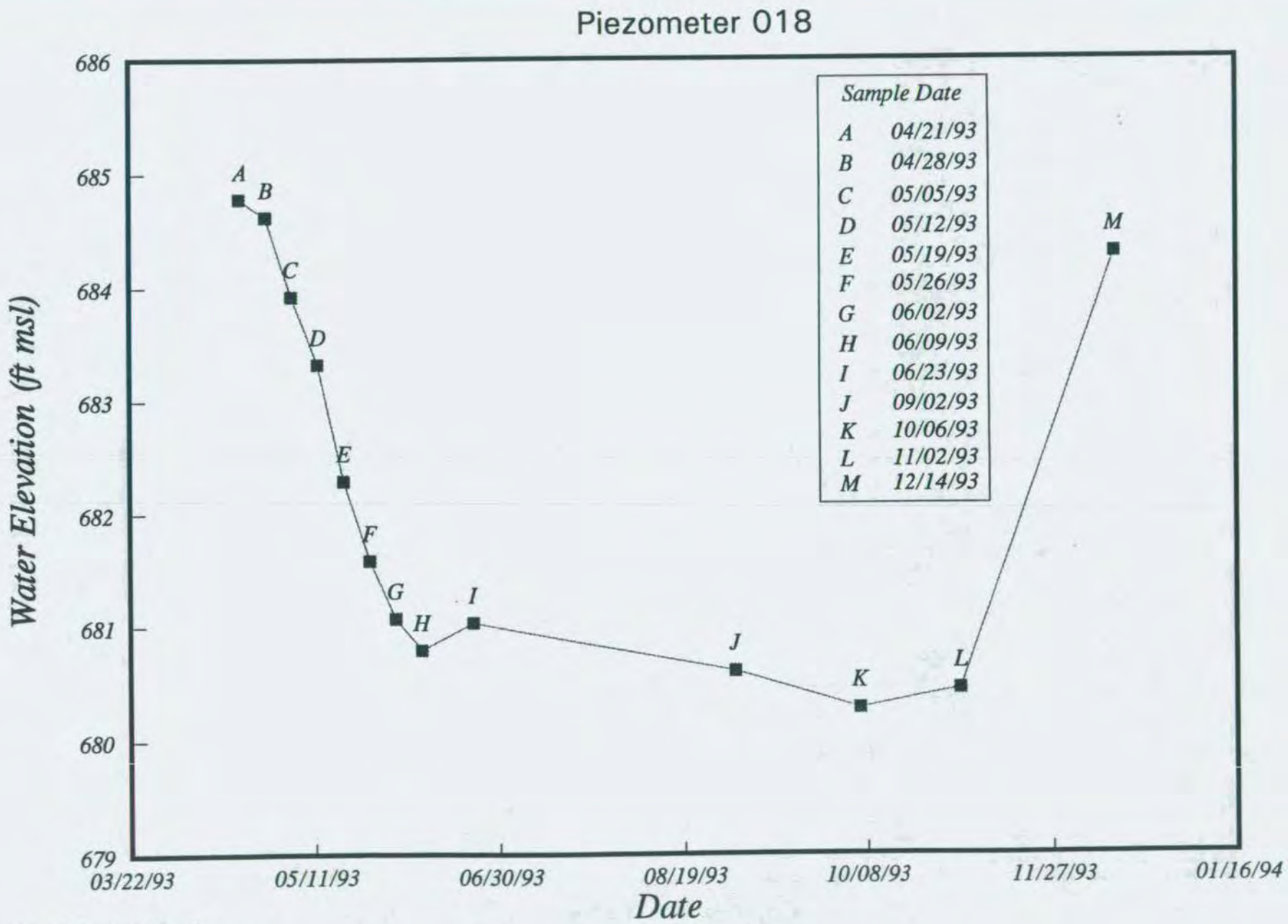

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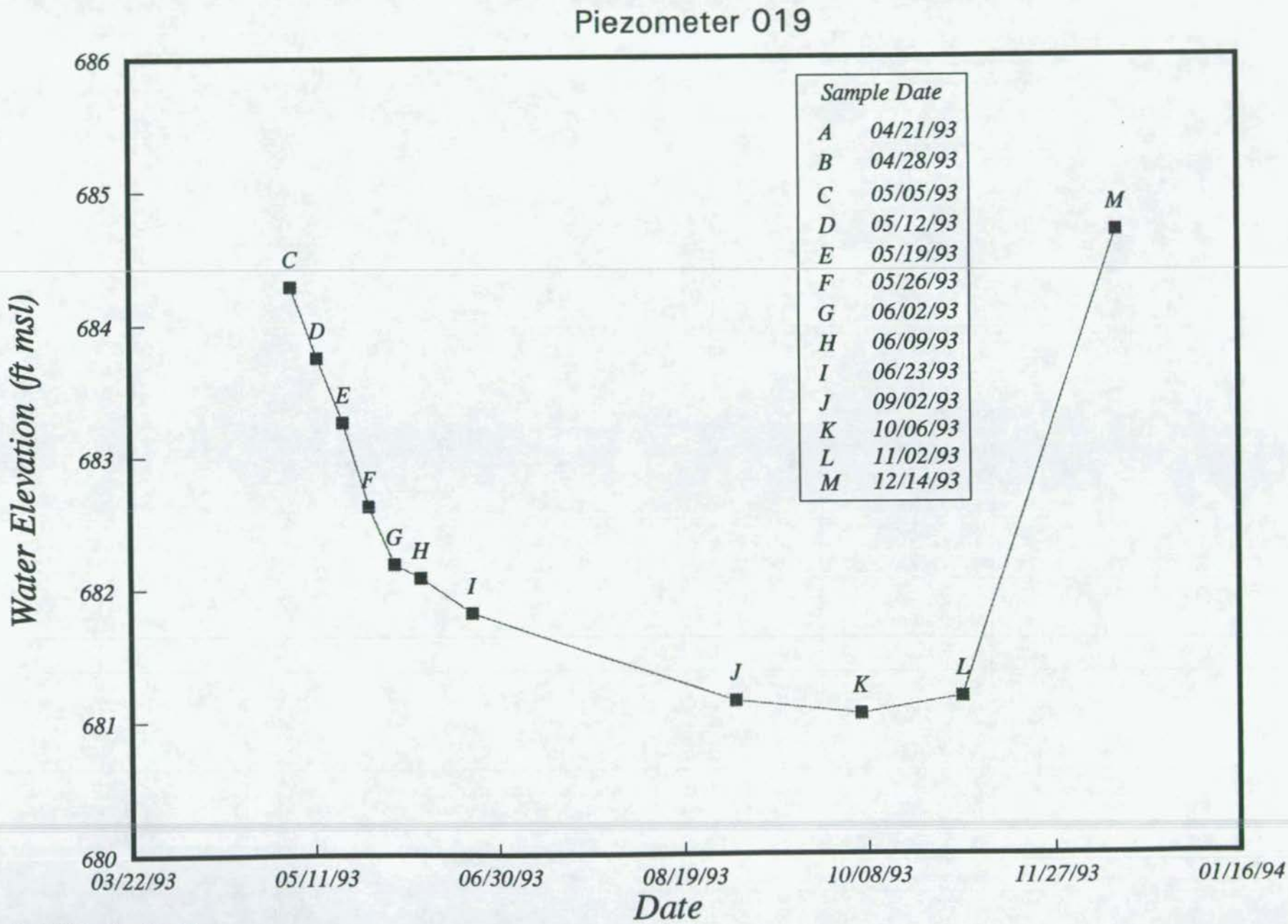

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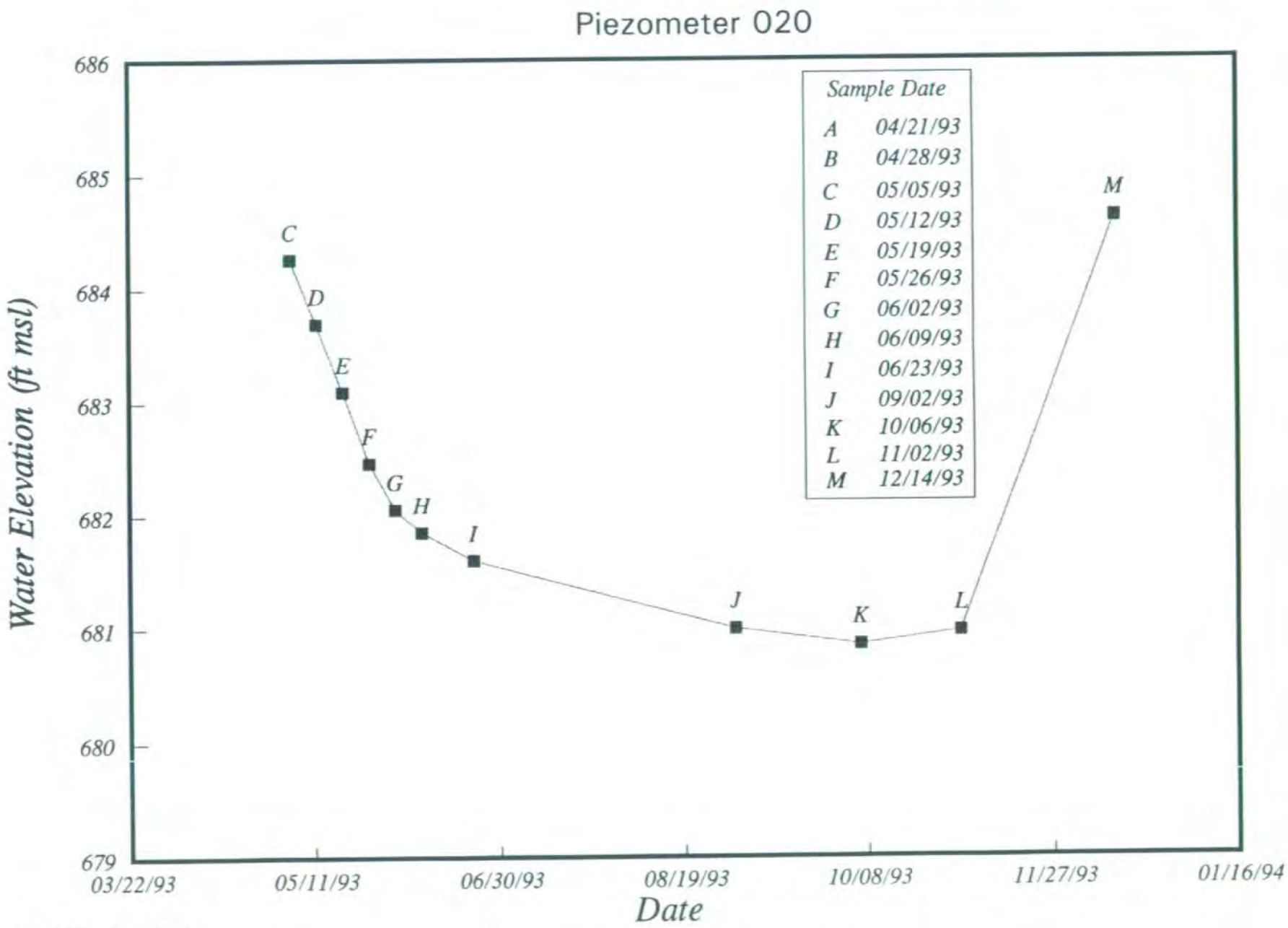

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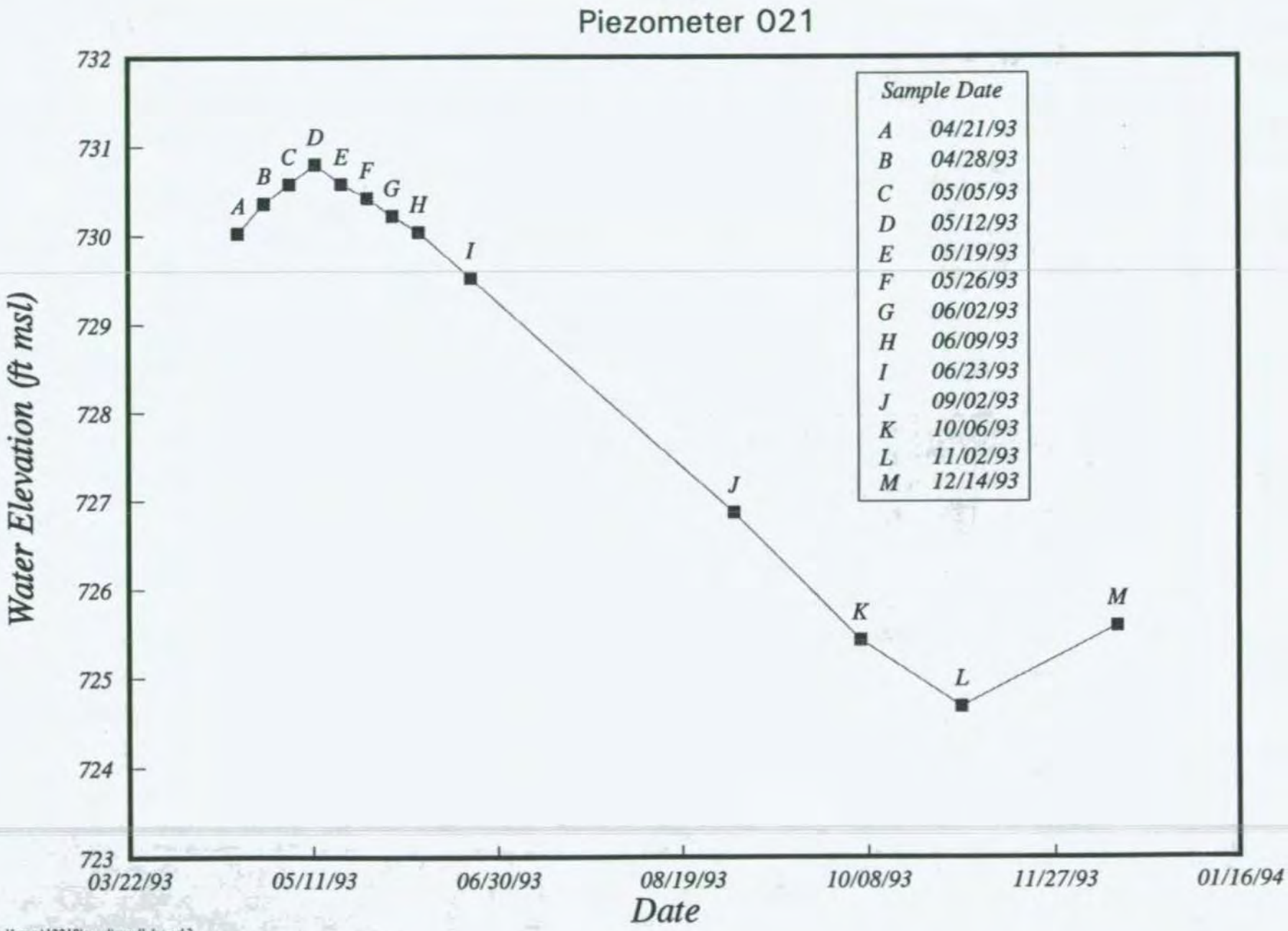

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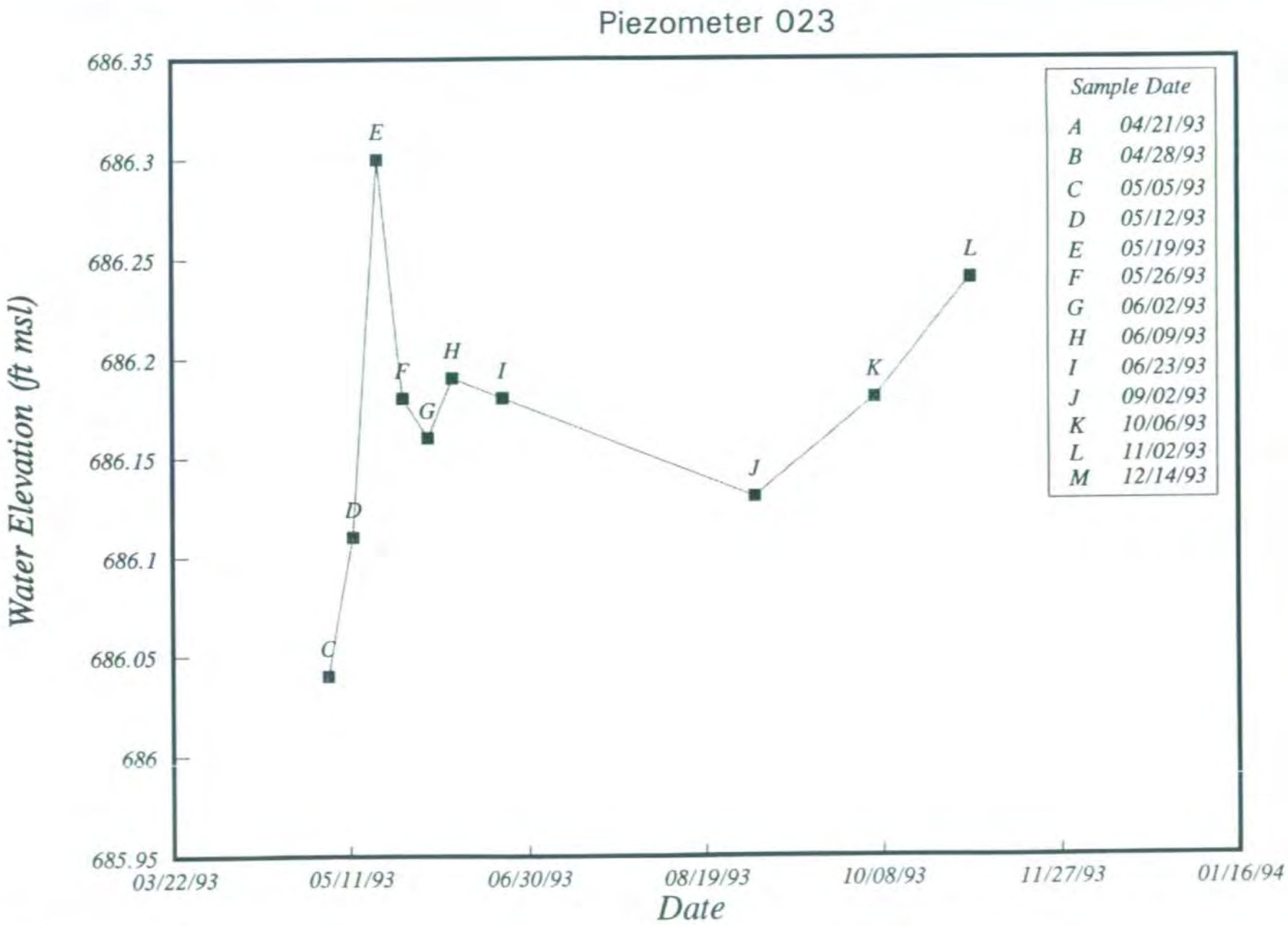

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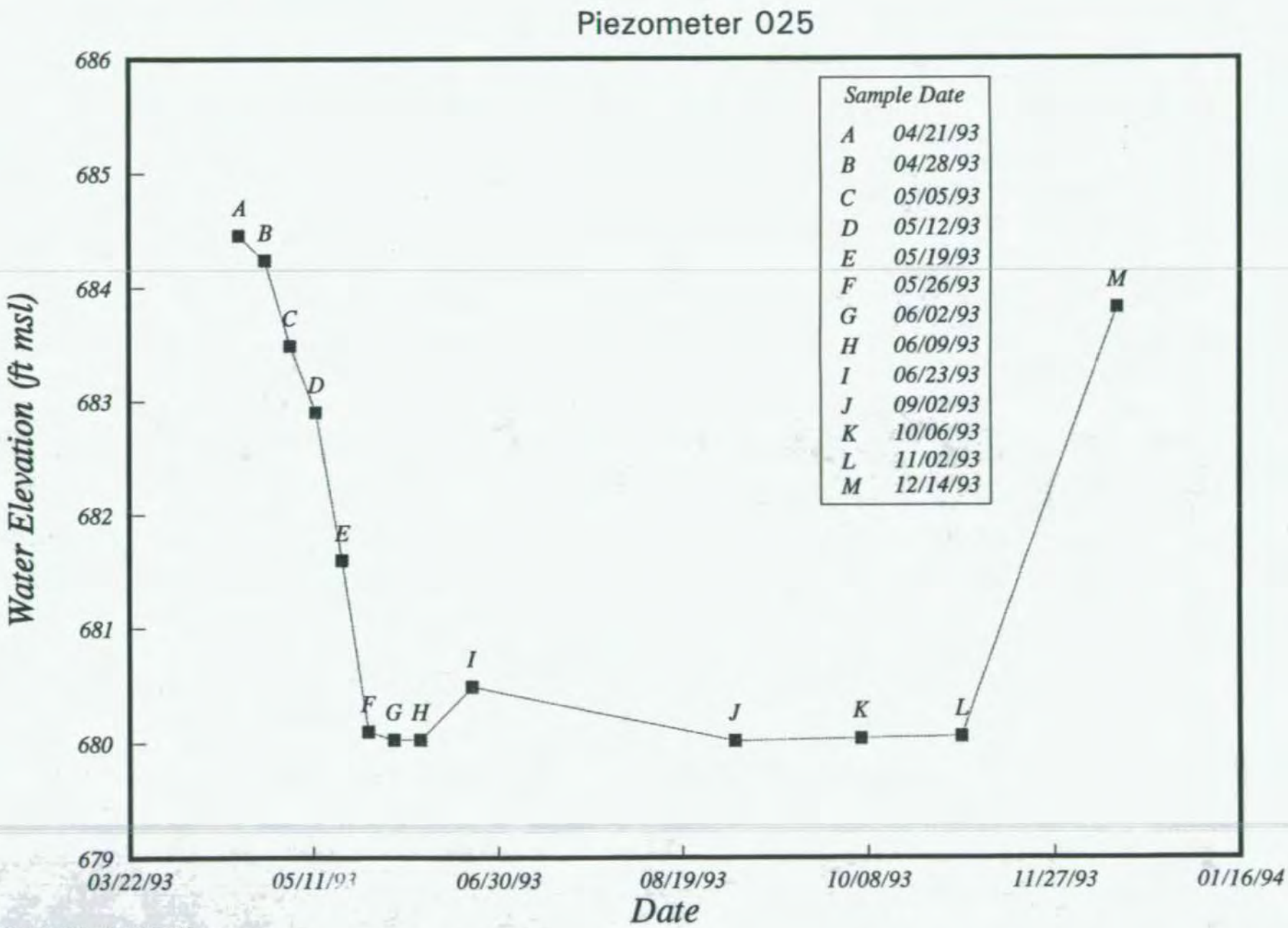

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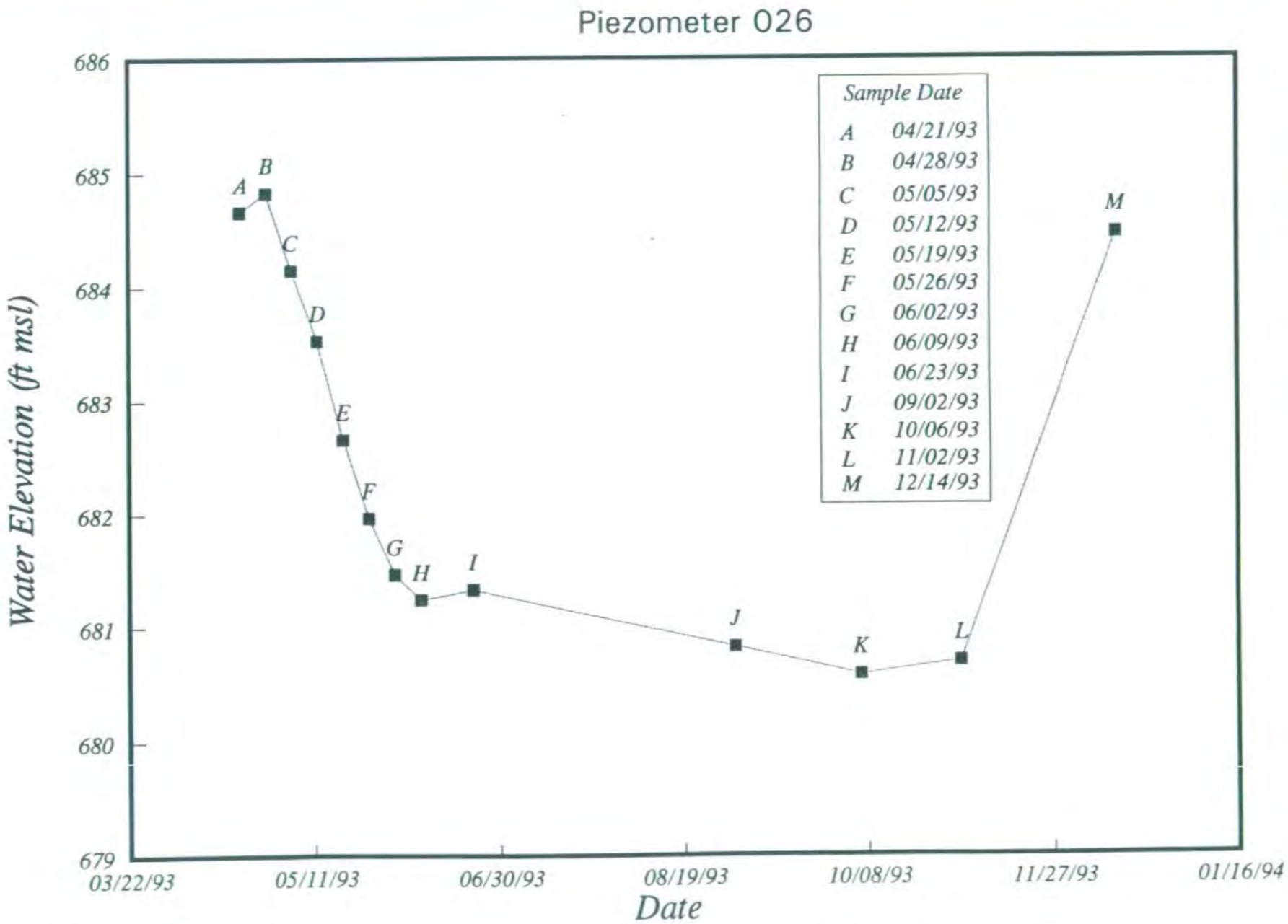

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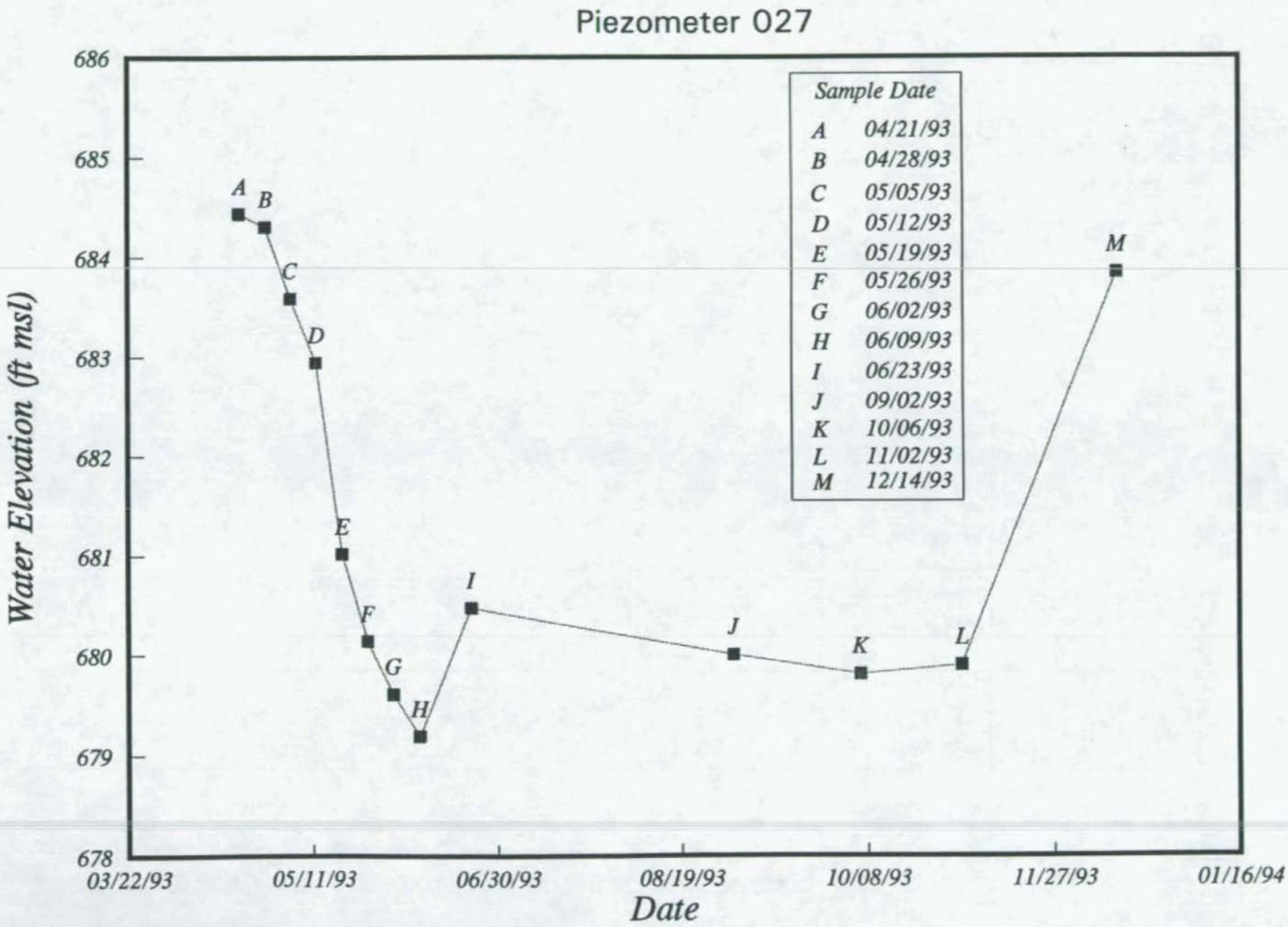

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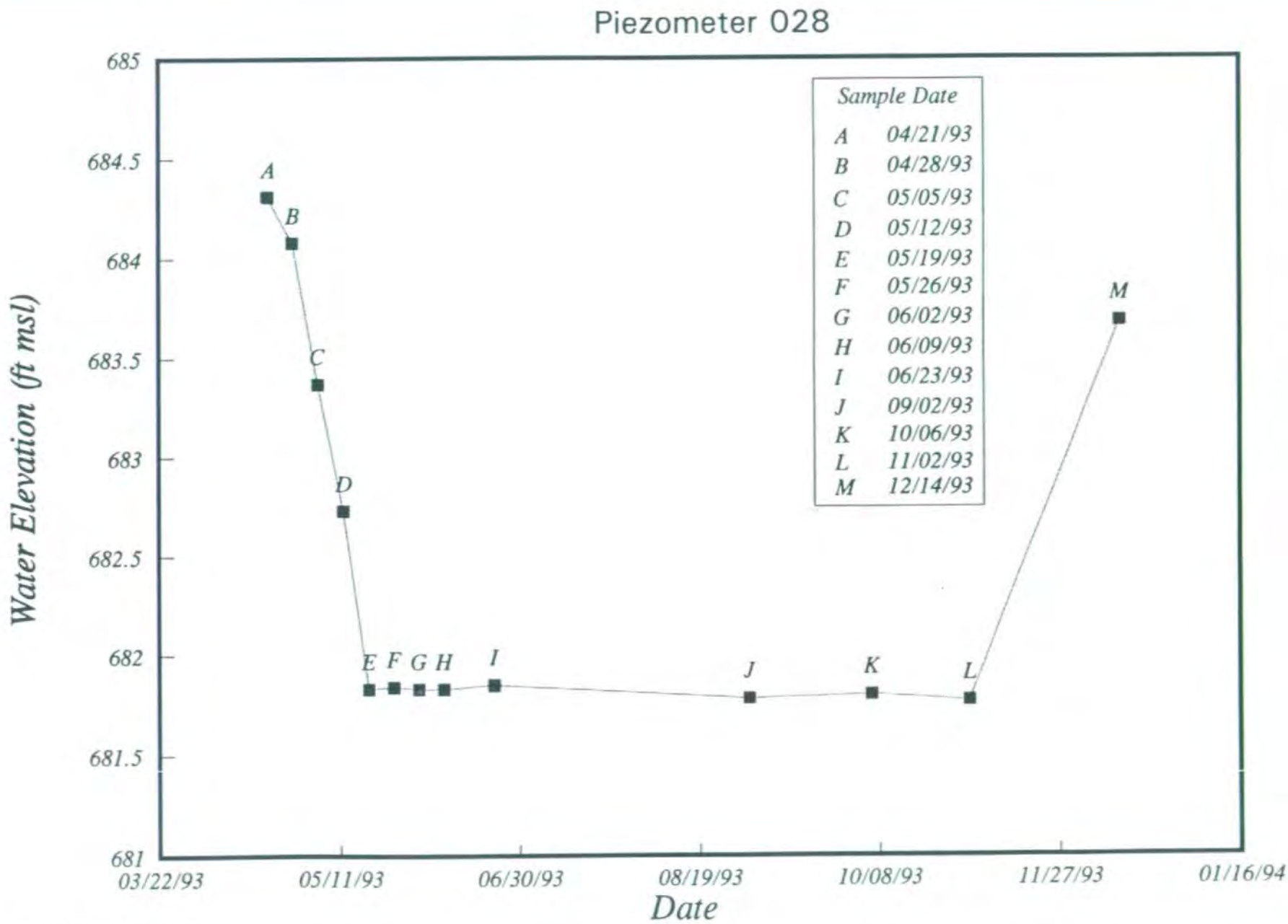

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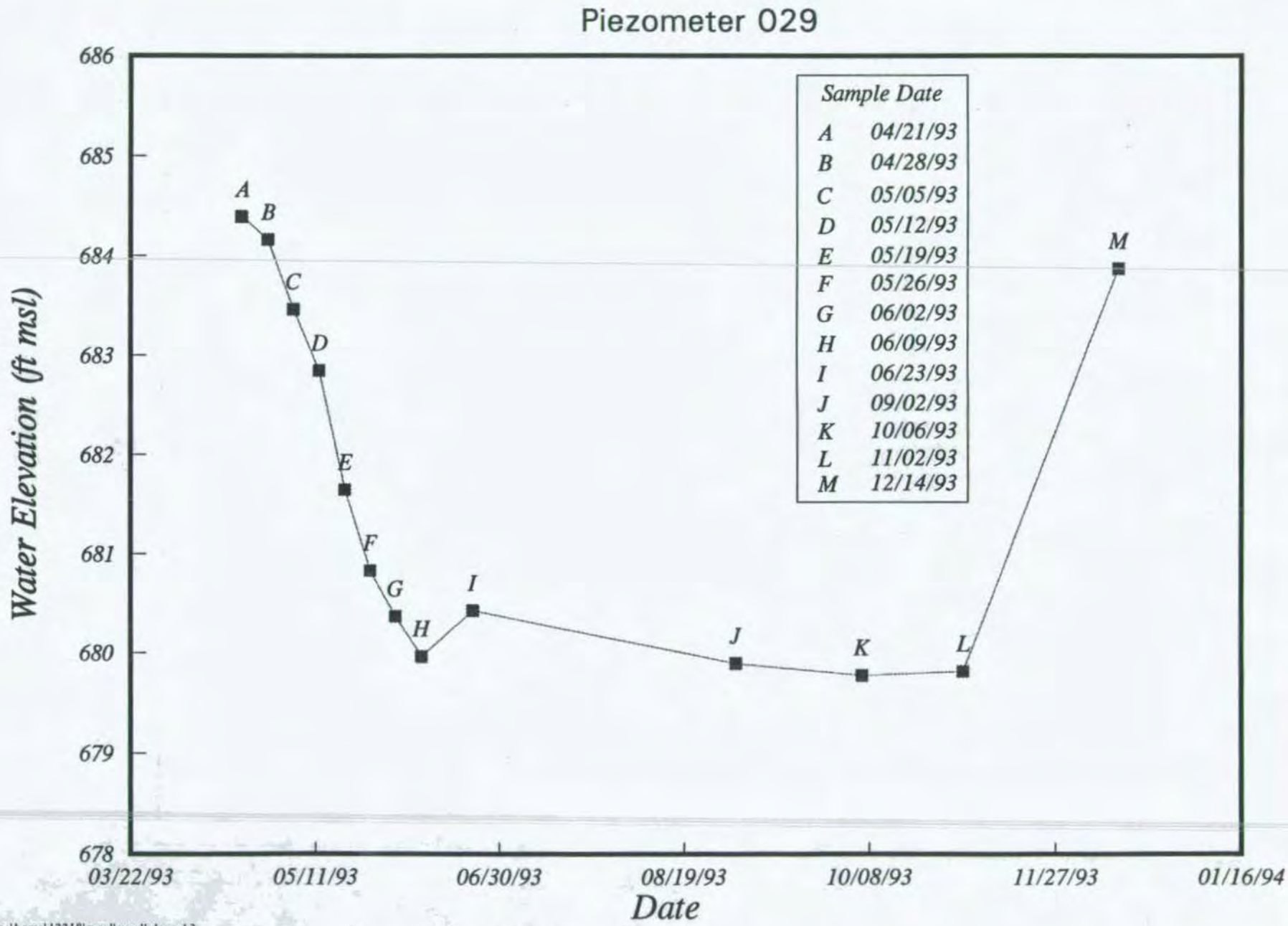

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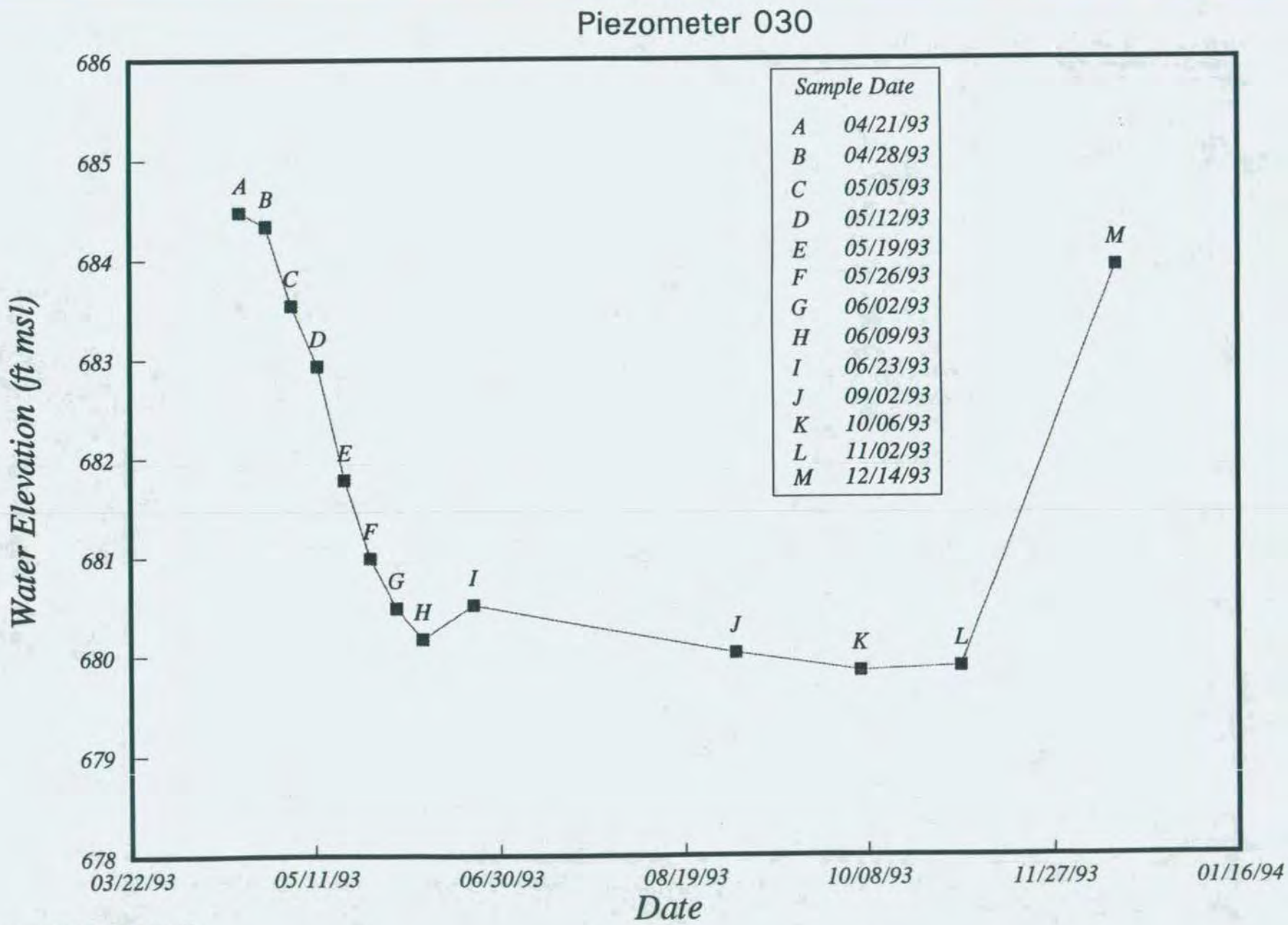

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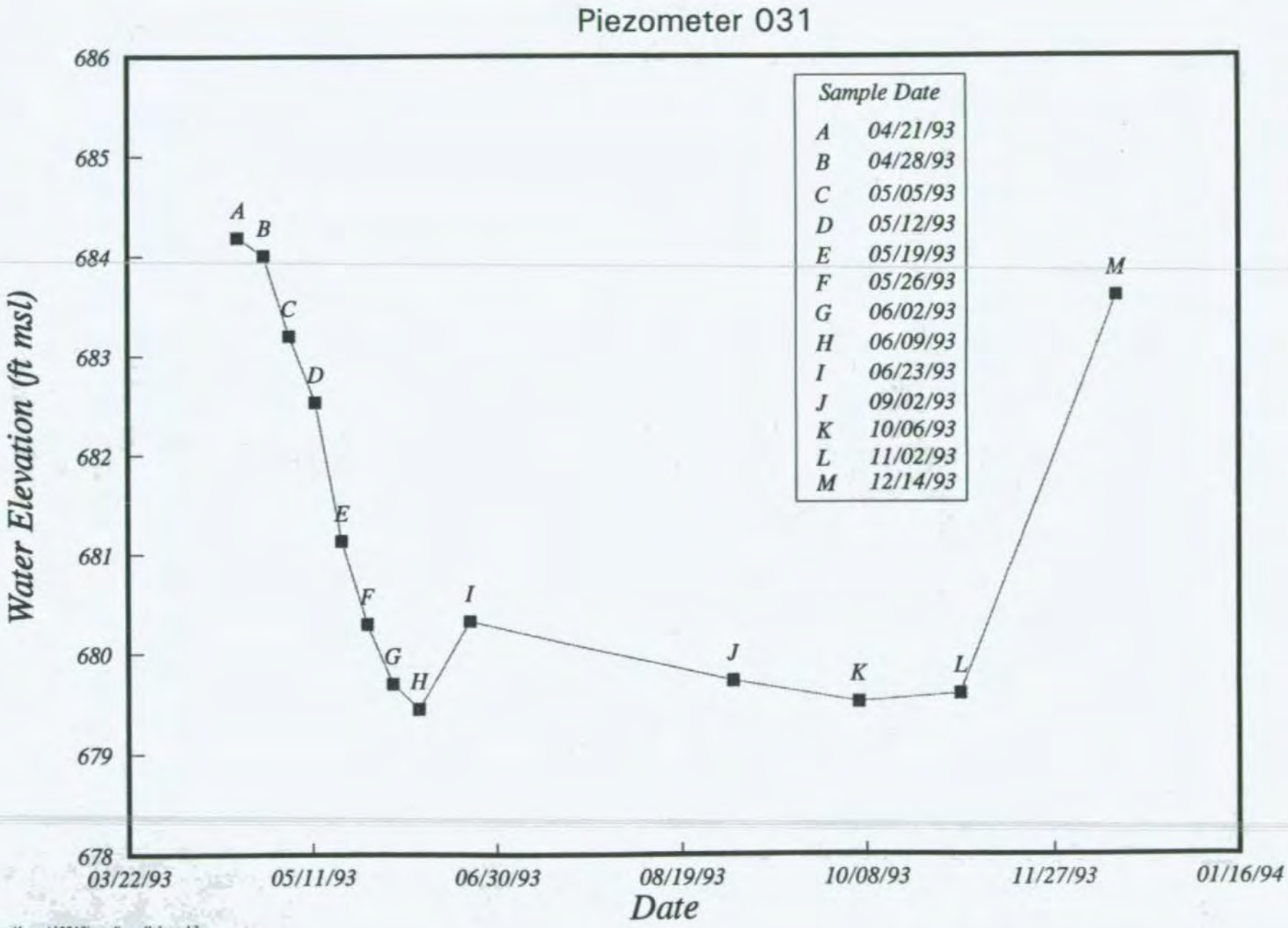

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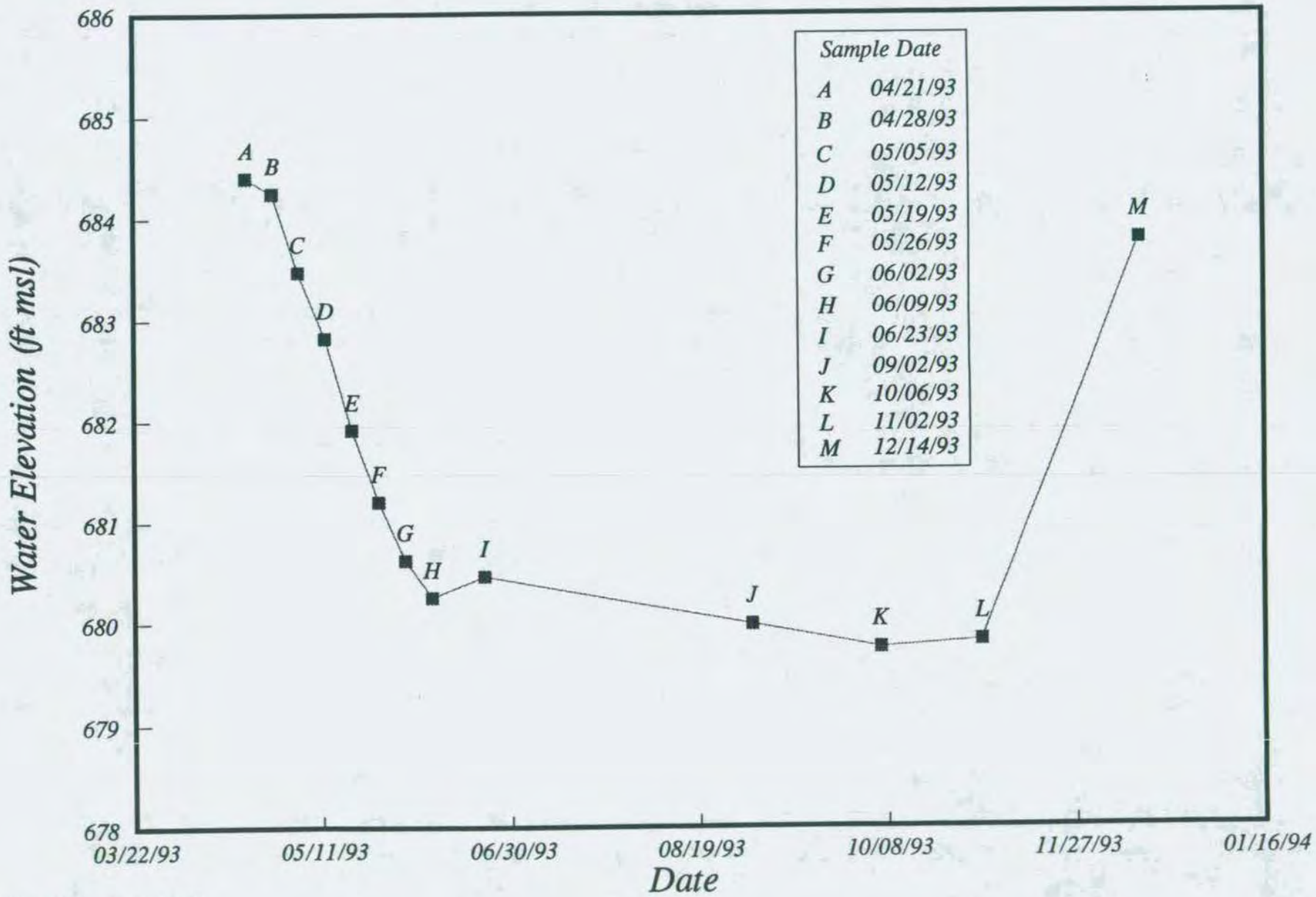
Piezometer 032



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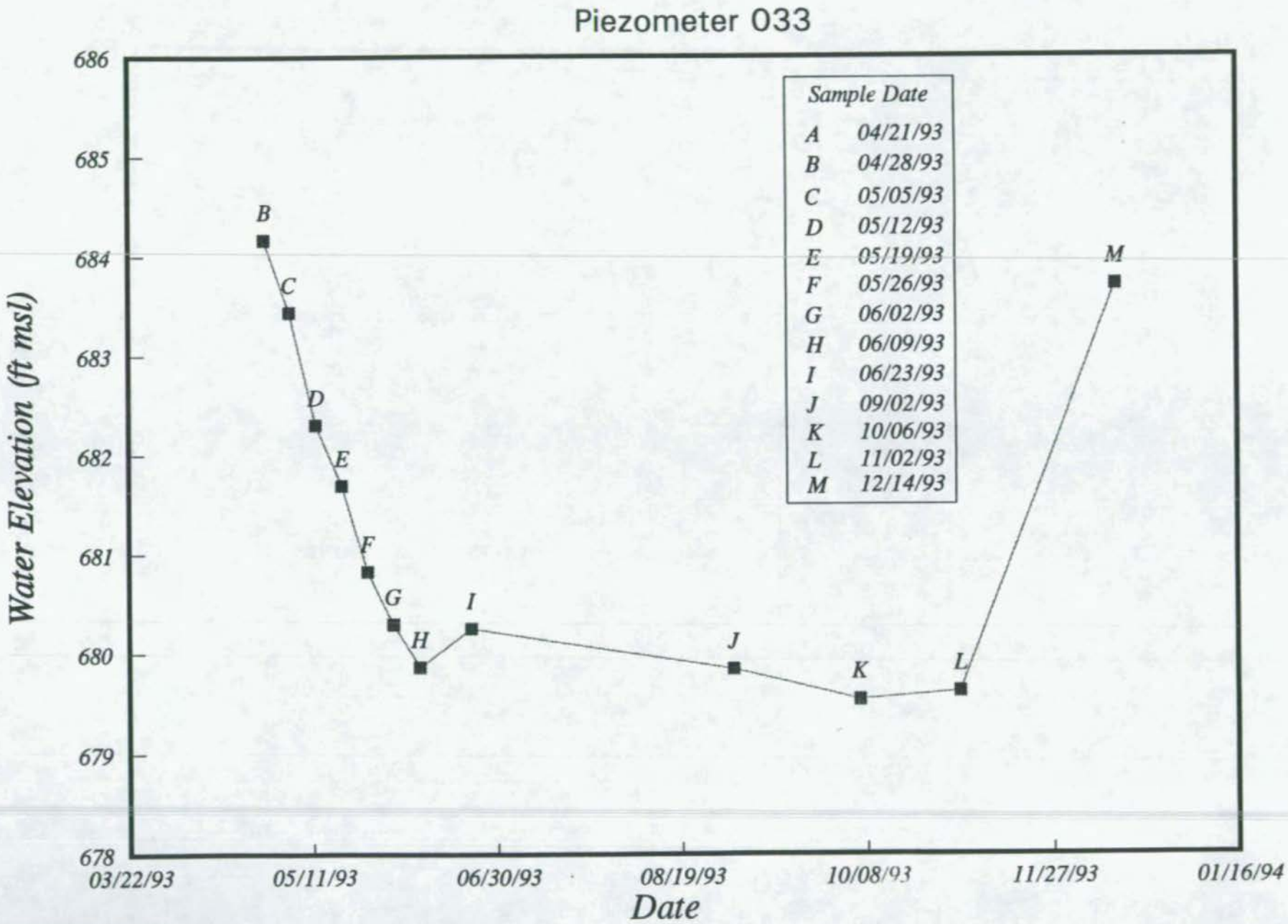

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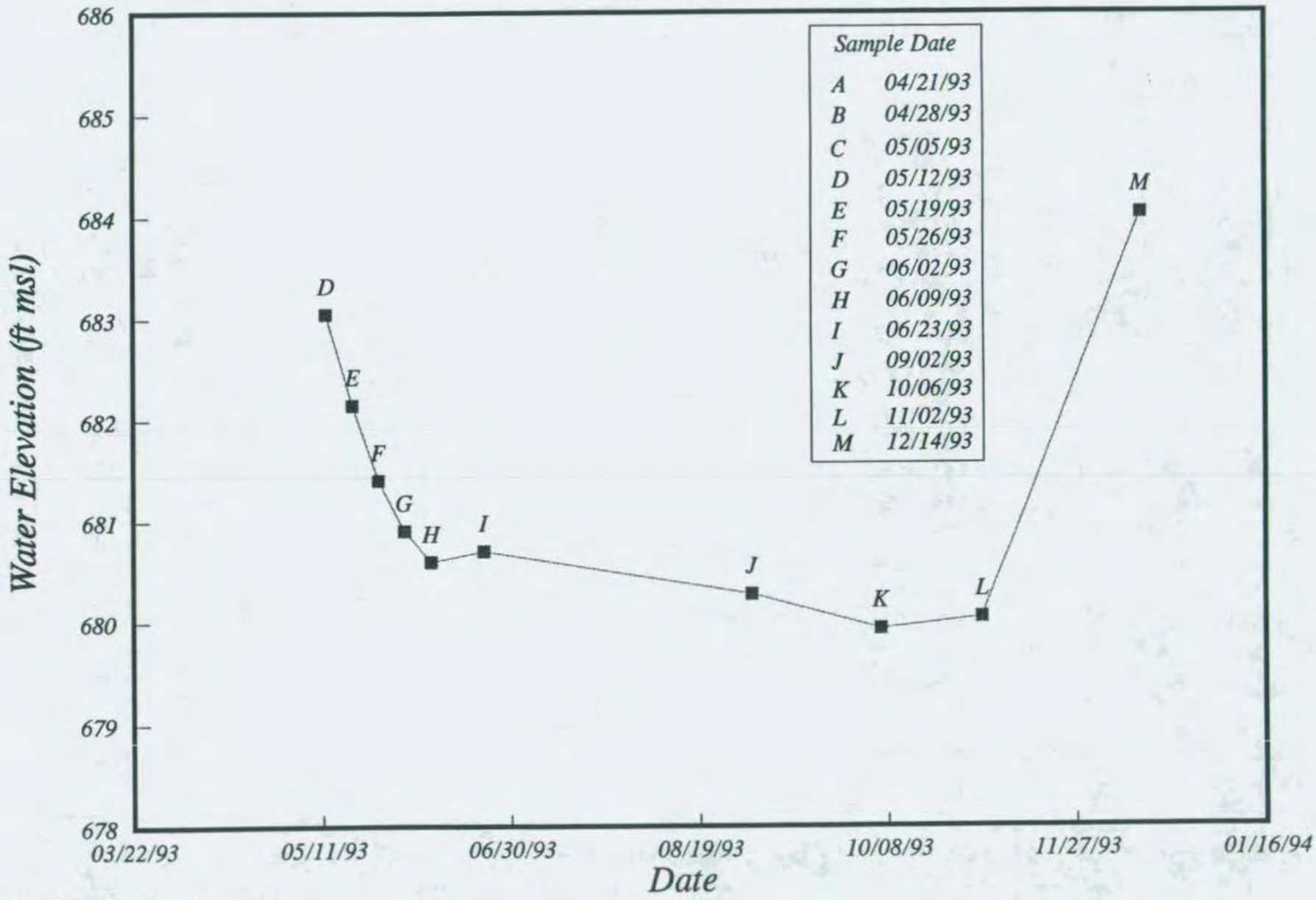
Piezometer 034



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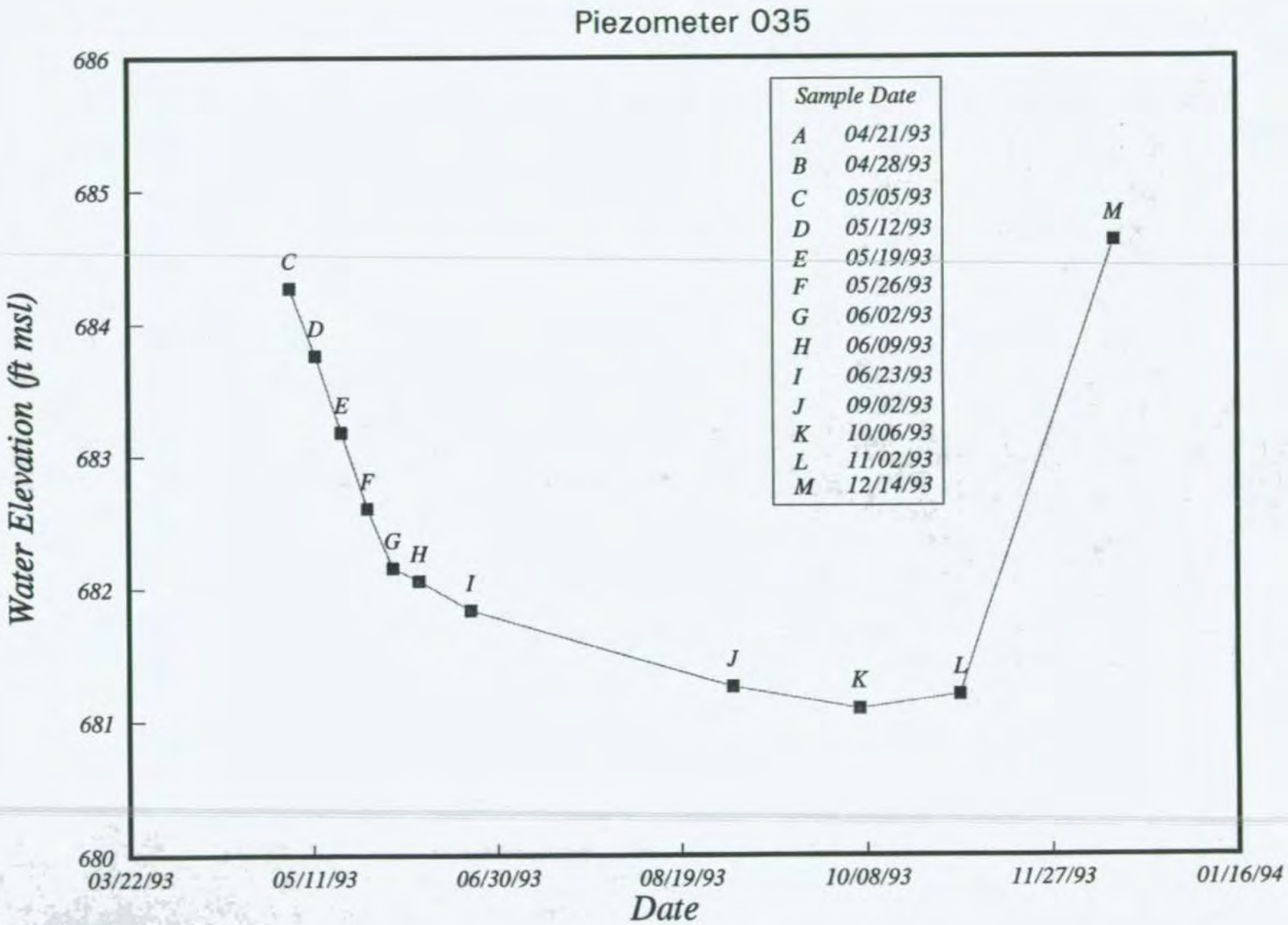

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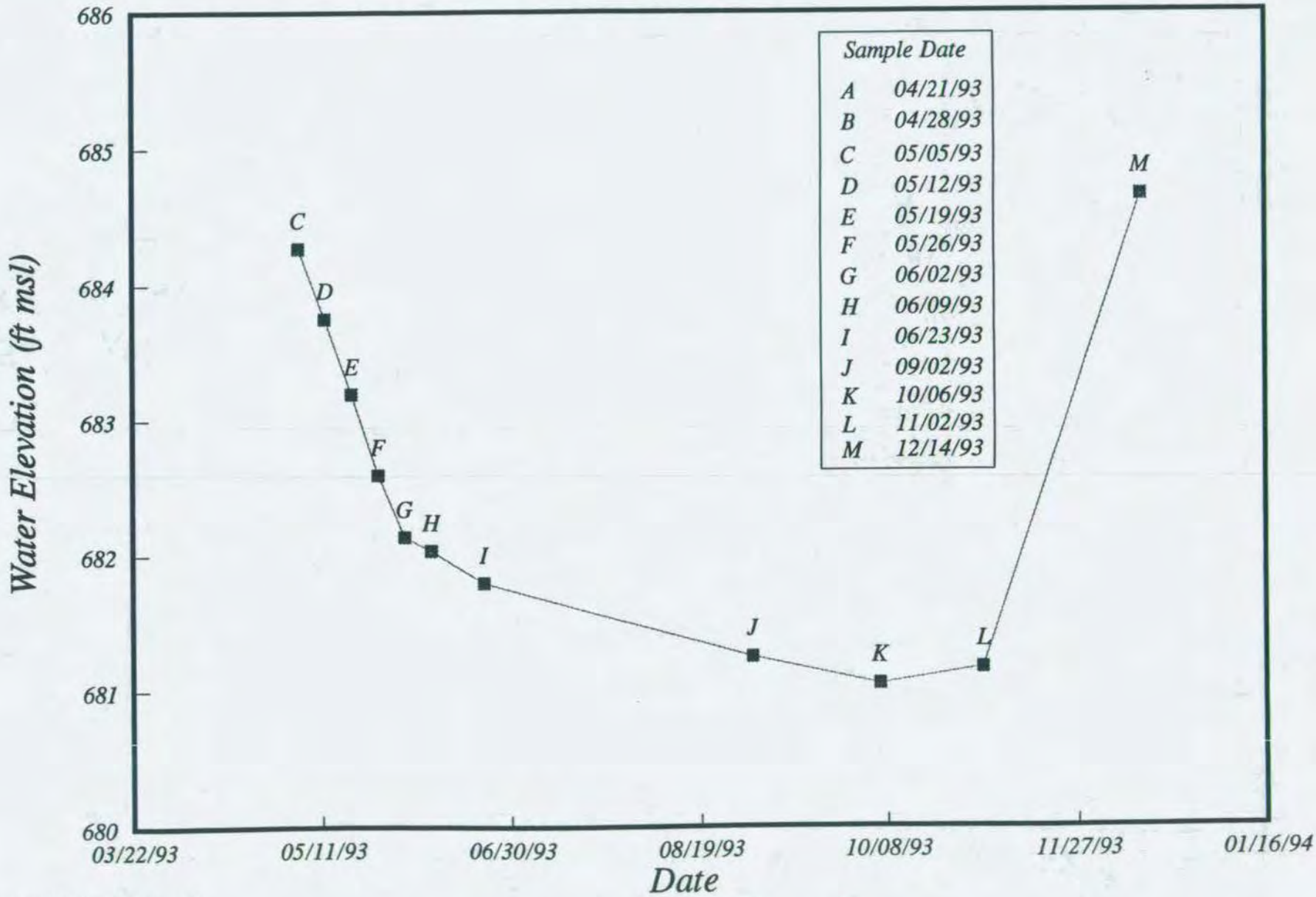
Piezometer 036



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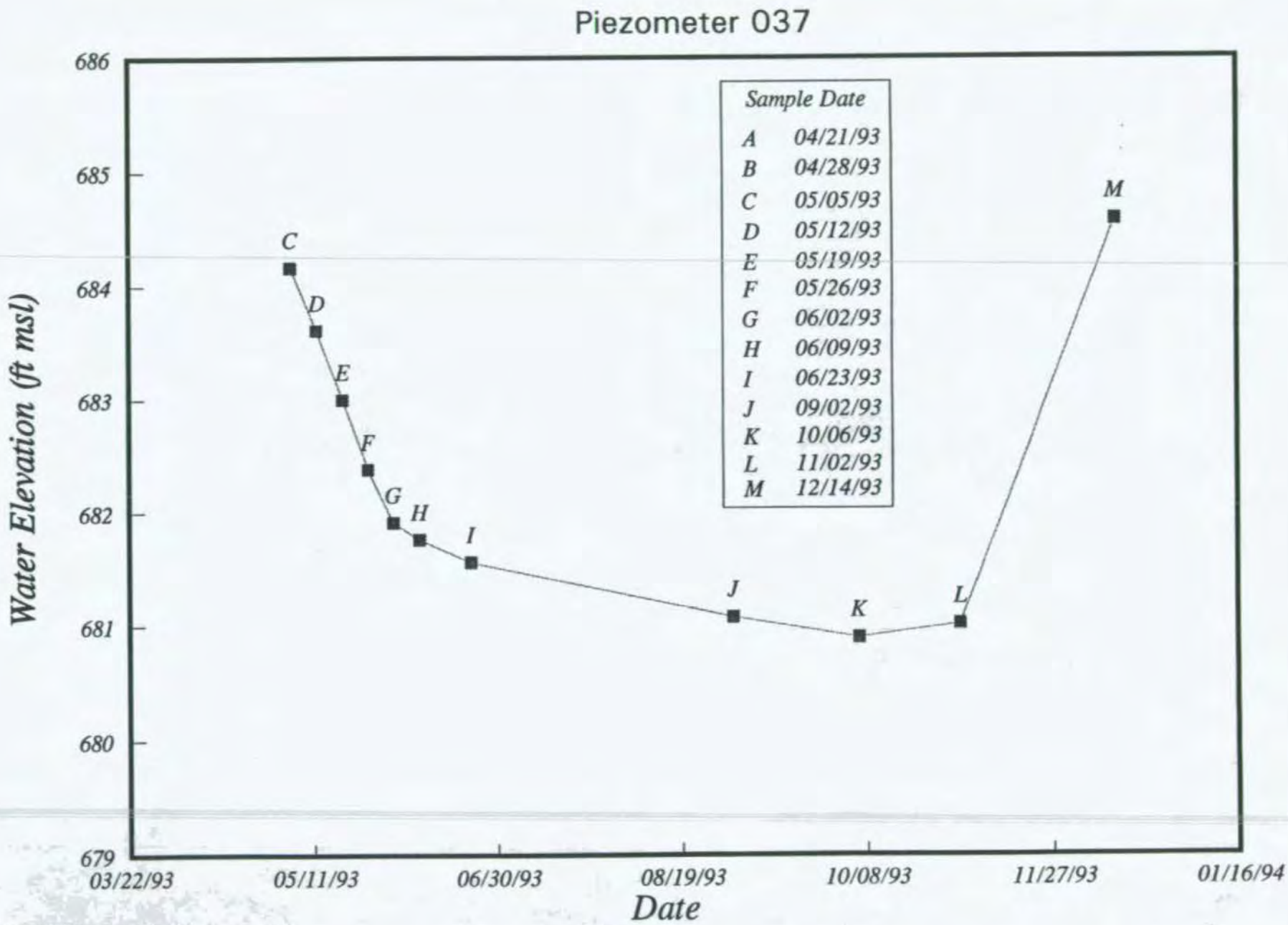

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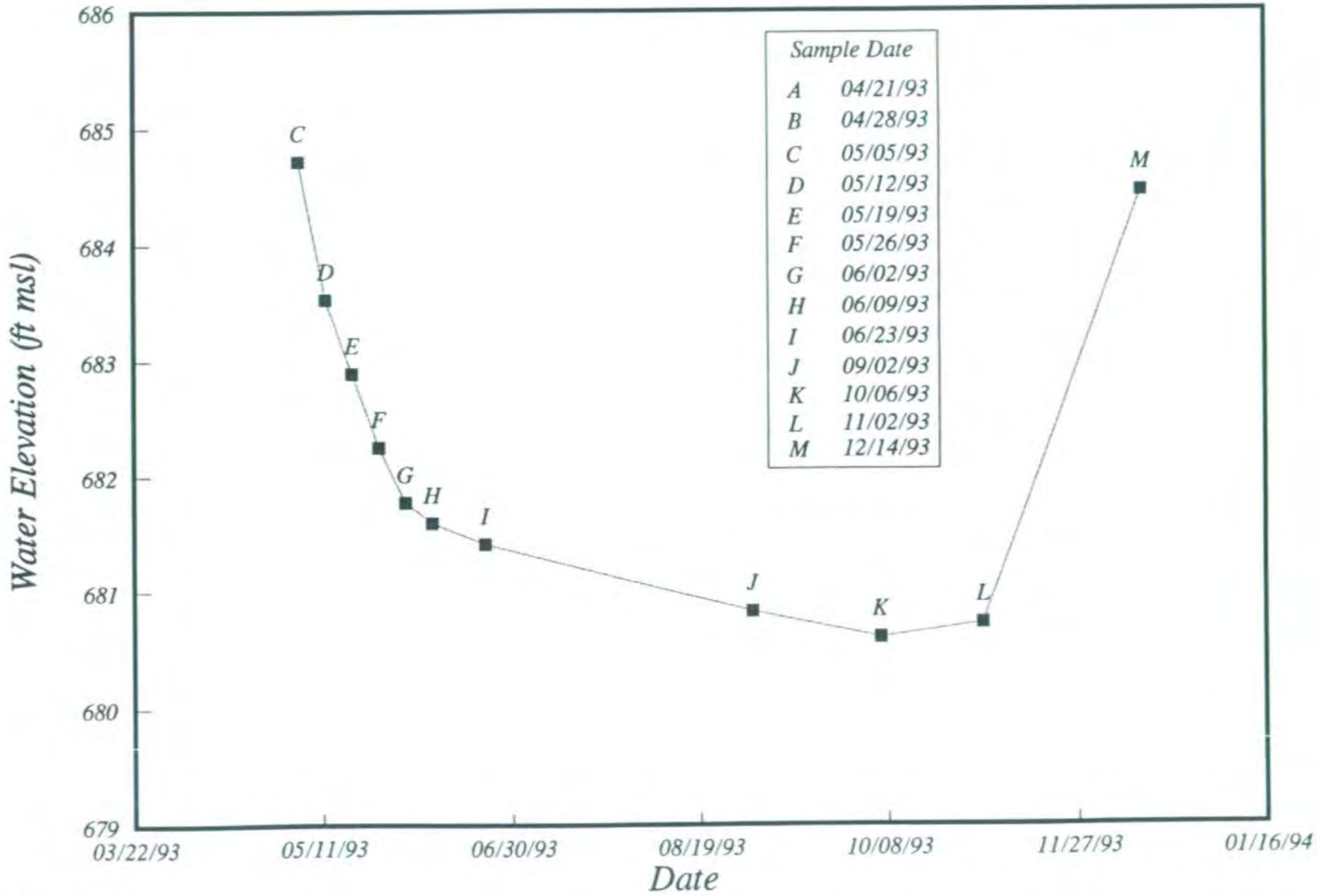
Piezometer 038



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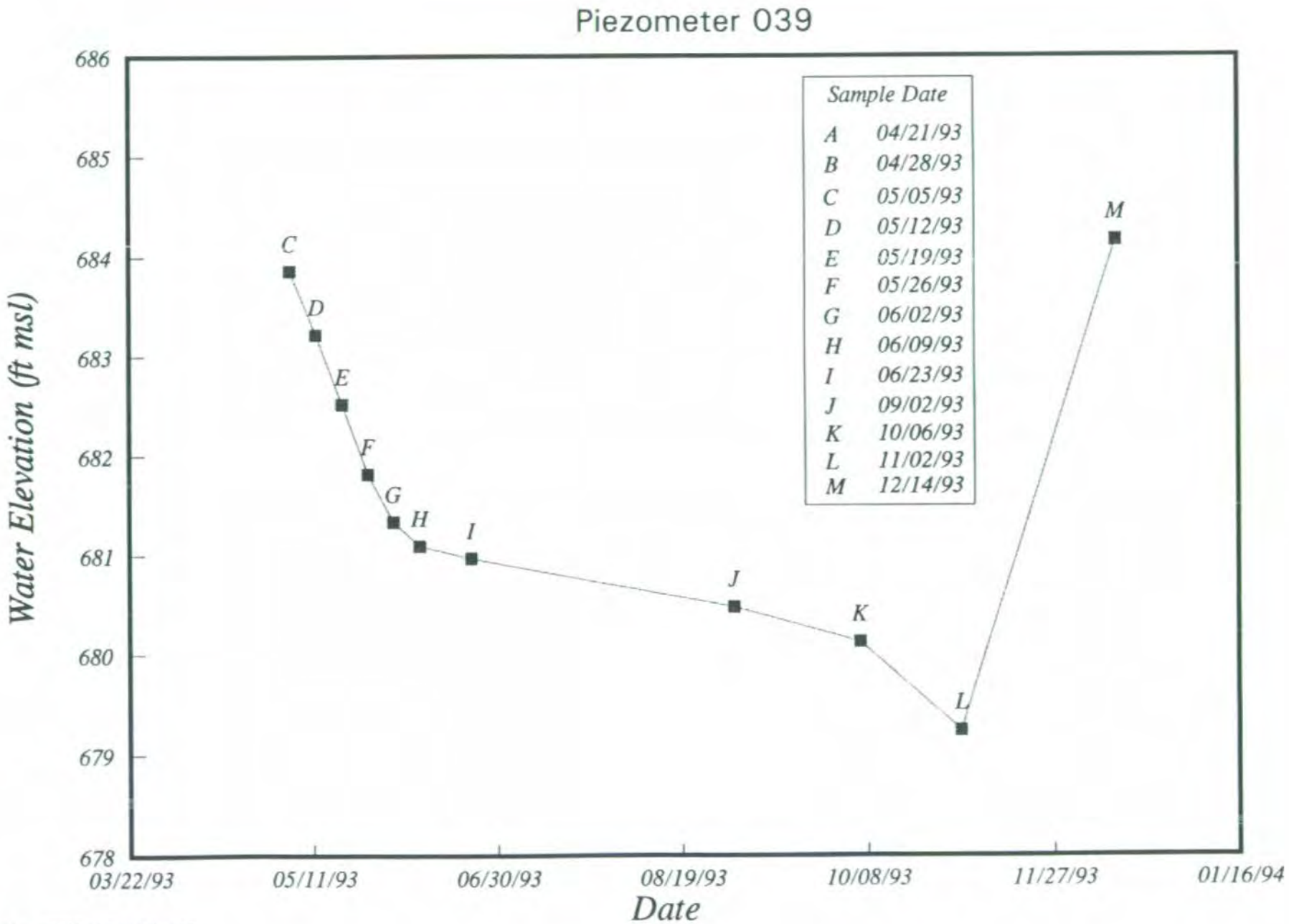

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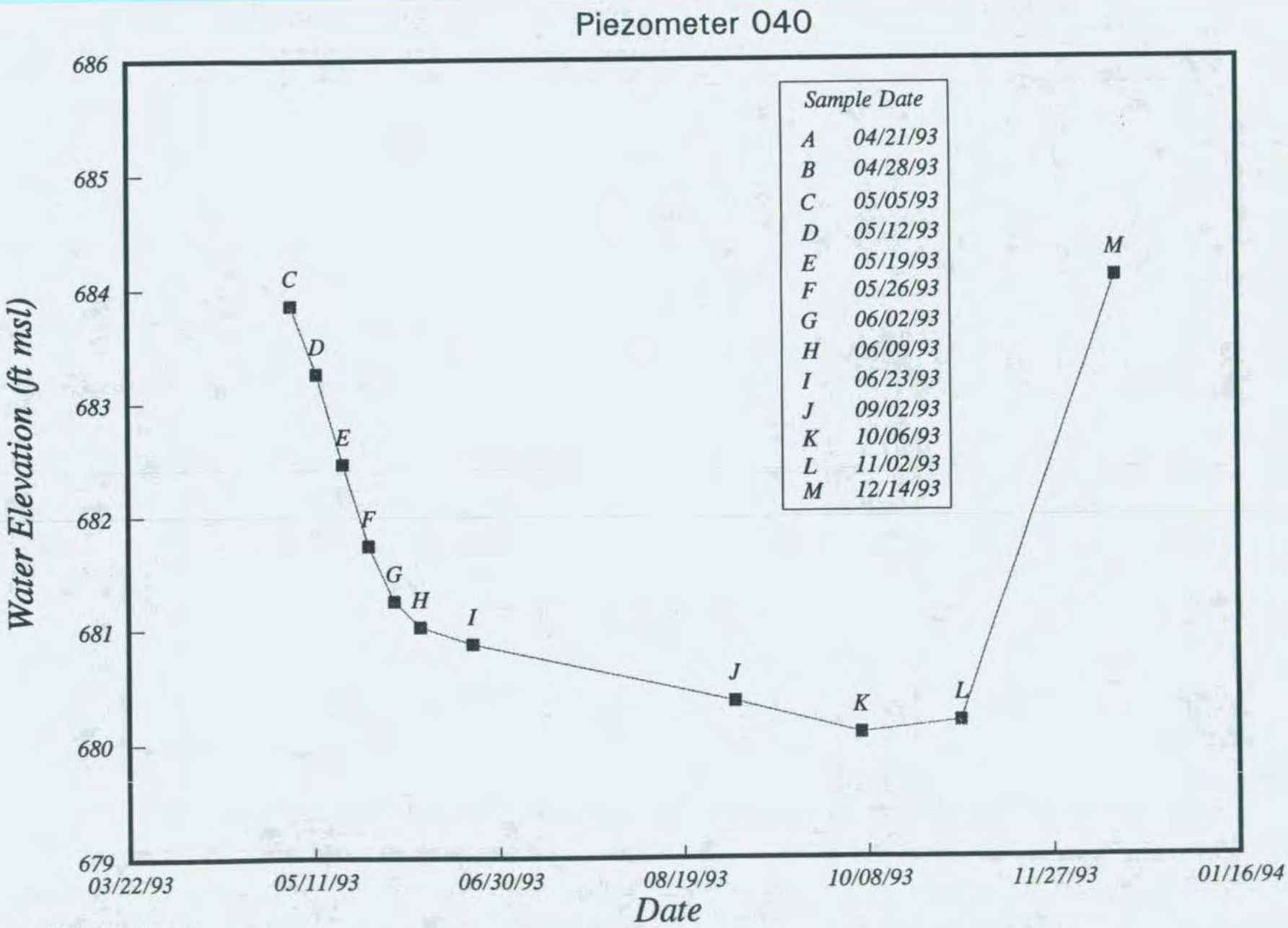

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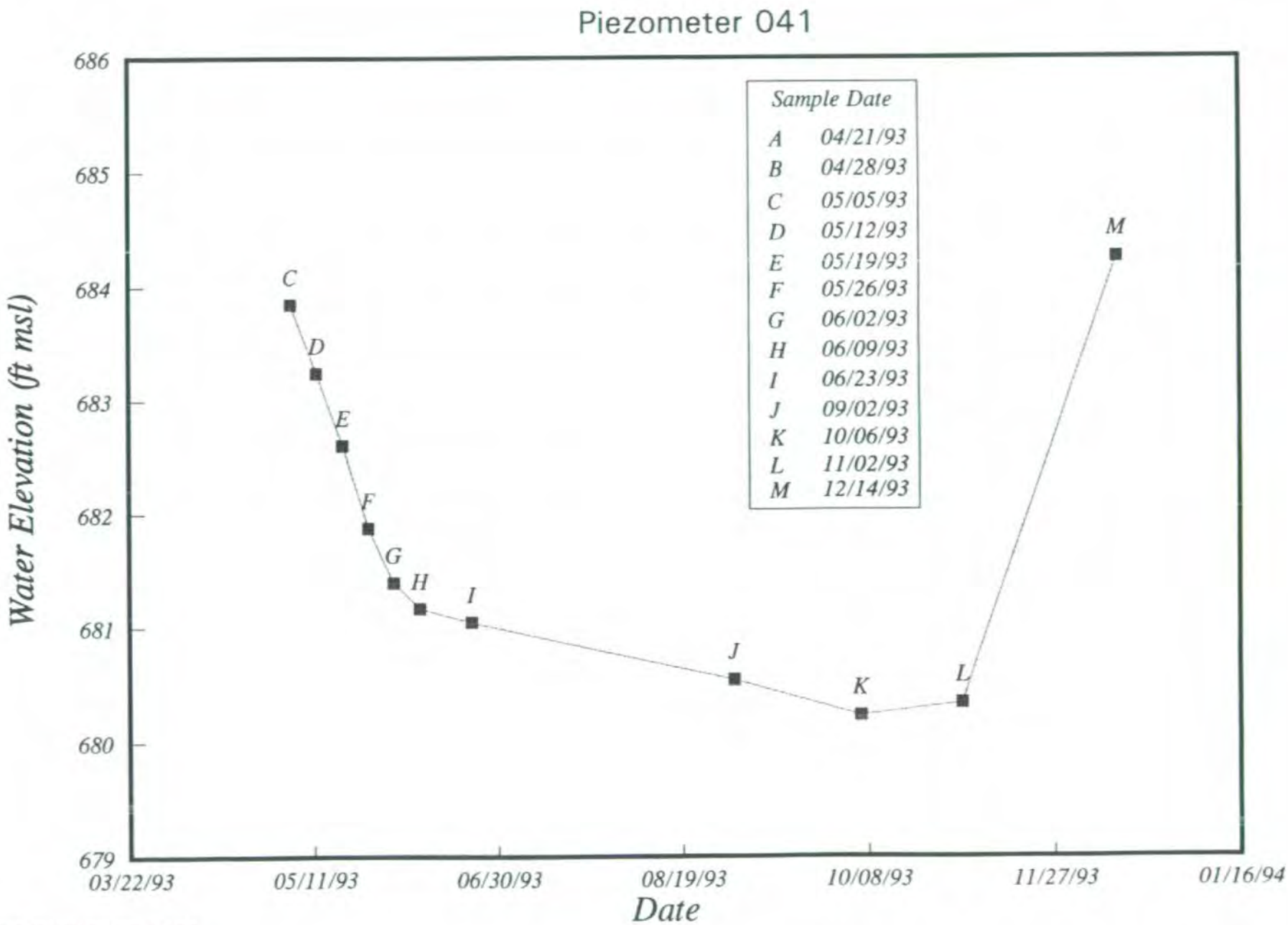

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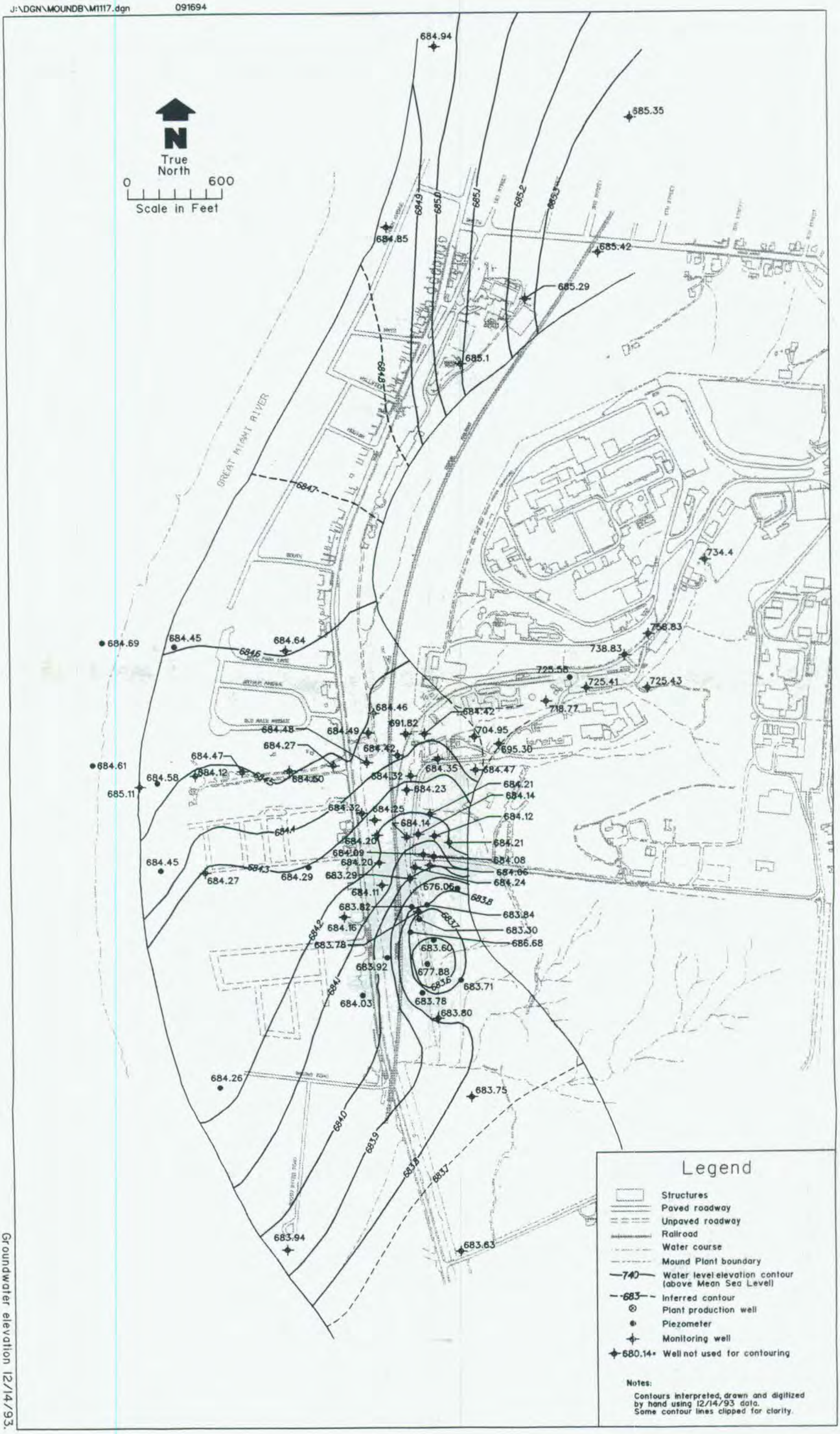
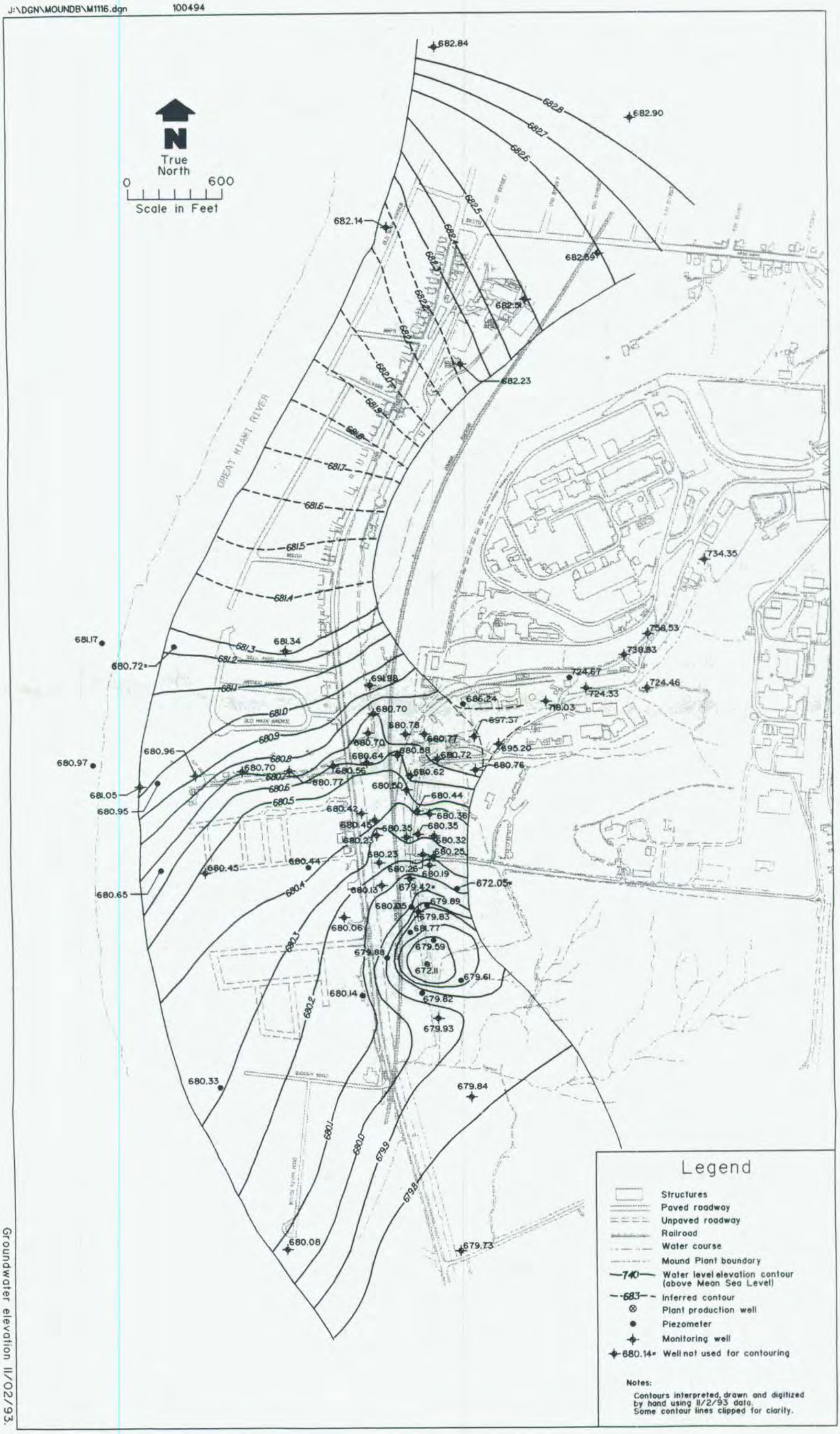
J:\DGN\MOUNDB\M1117.dgn 091694



Groundwater elevation 12/14/93.

J:\DGN\MOUNDB\M1116.dgn 100494



Groundwater elevation 11/02/93.

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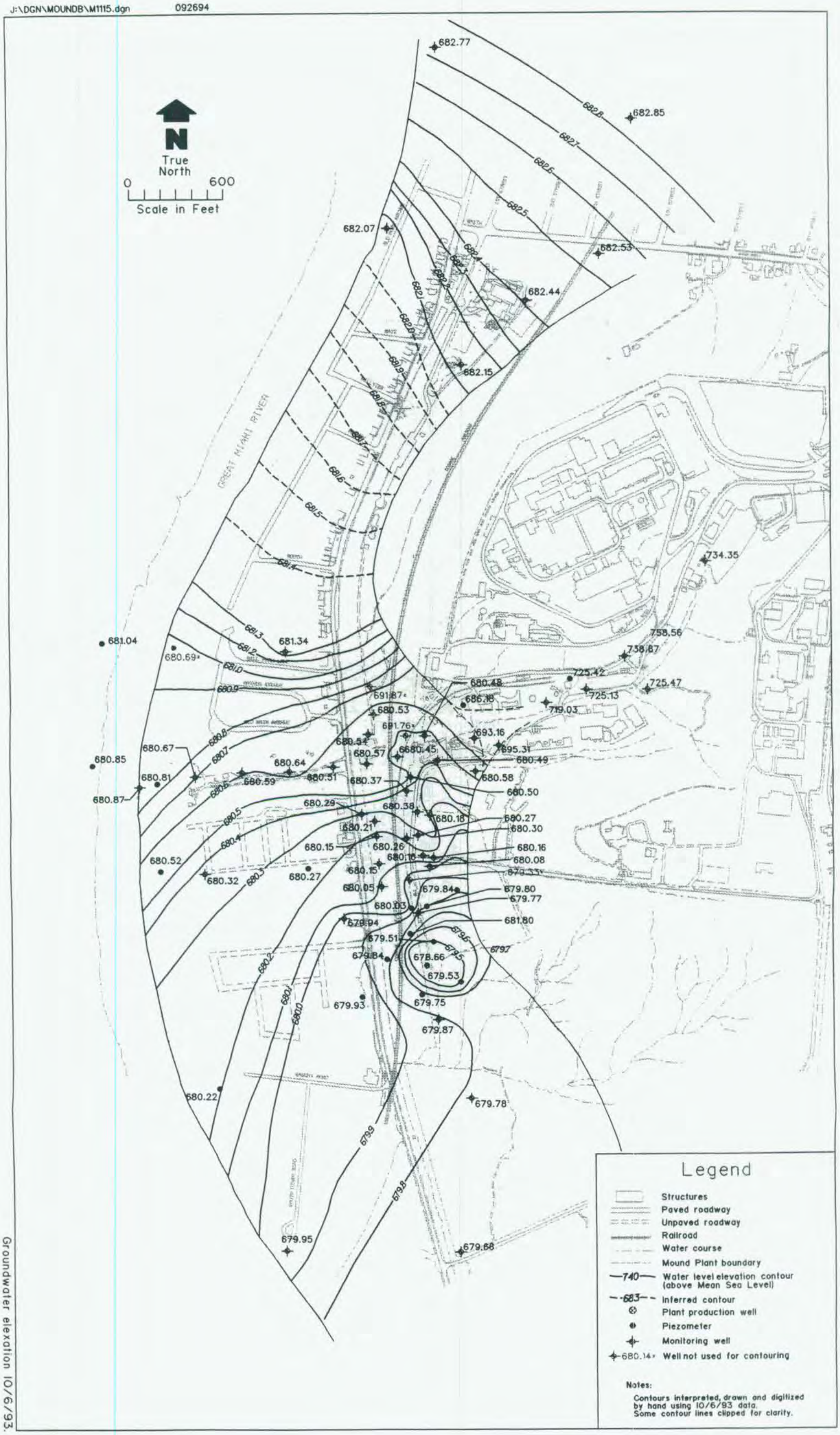

Groundwater elexation 10/6/93.

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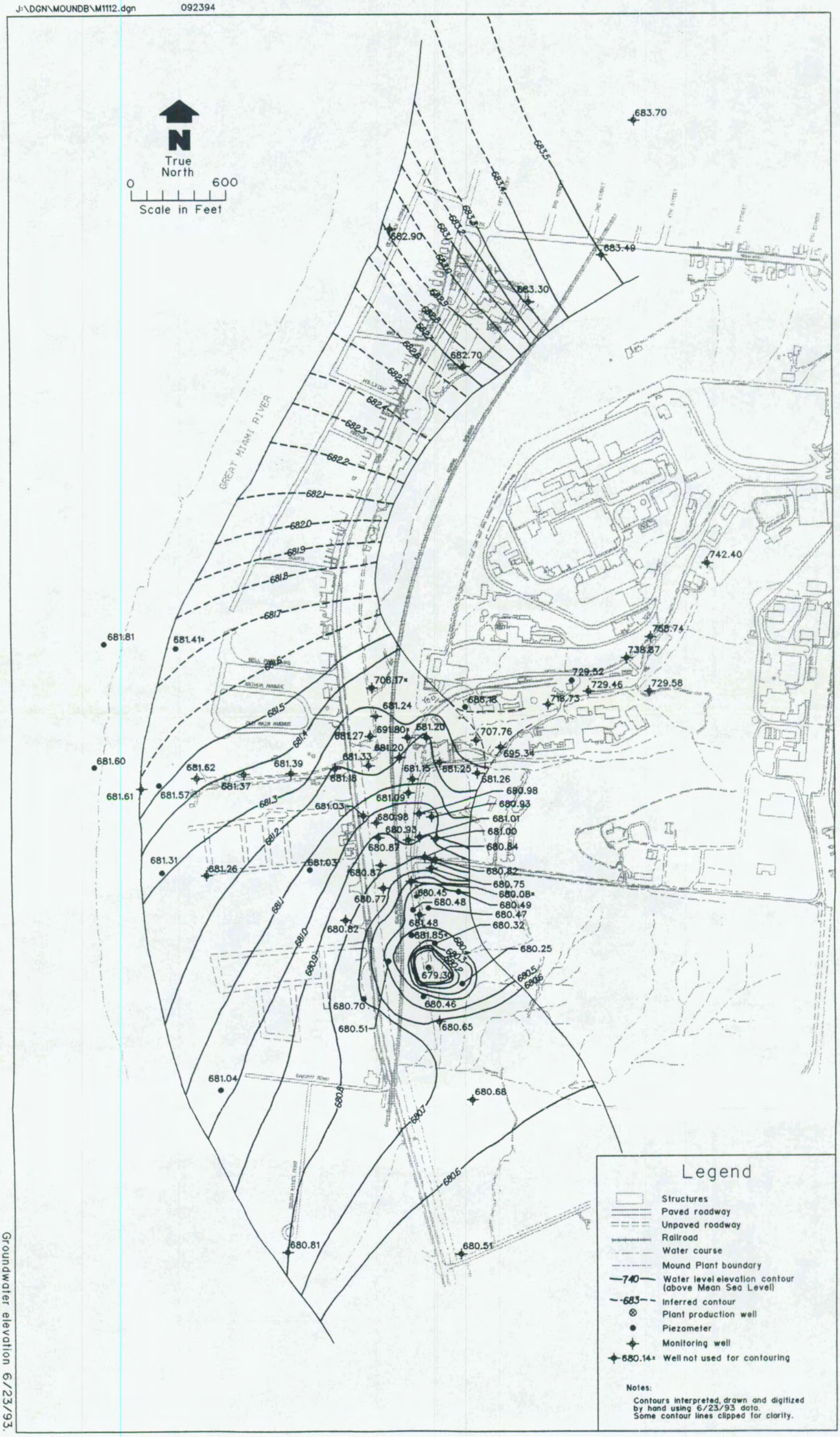
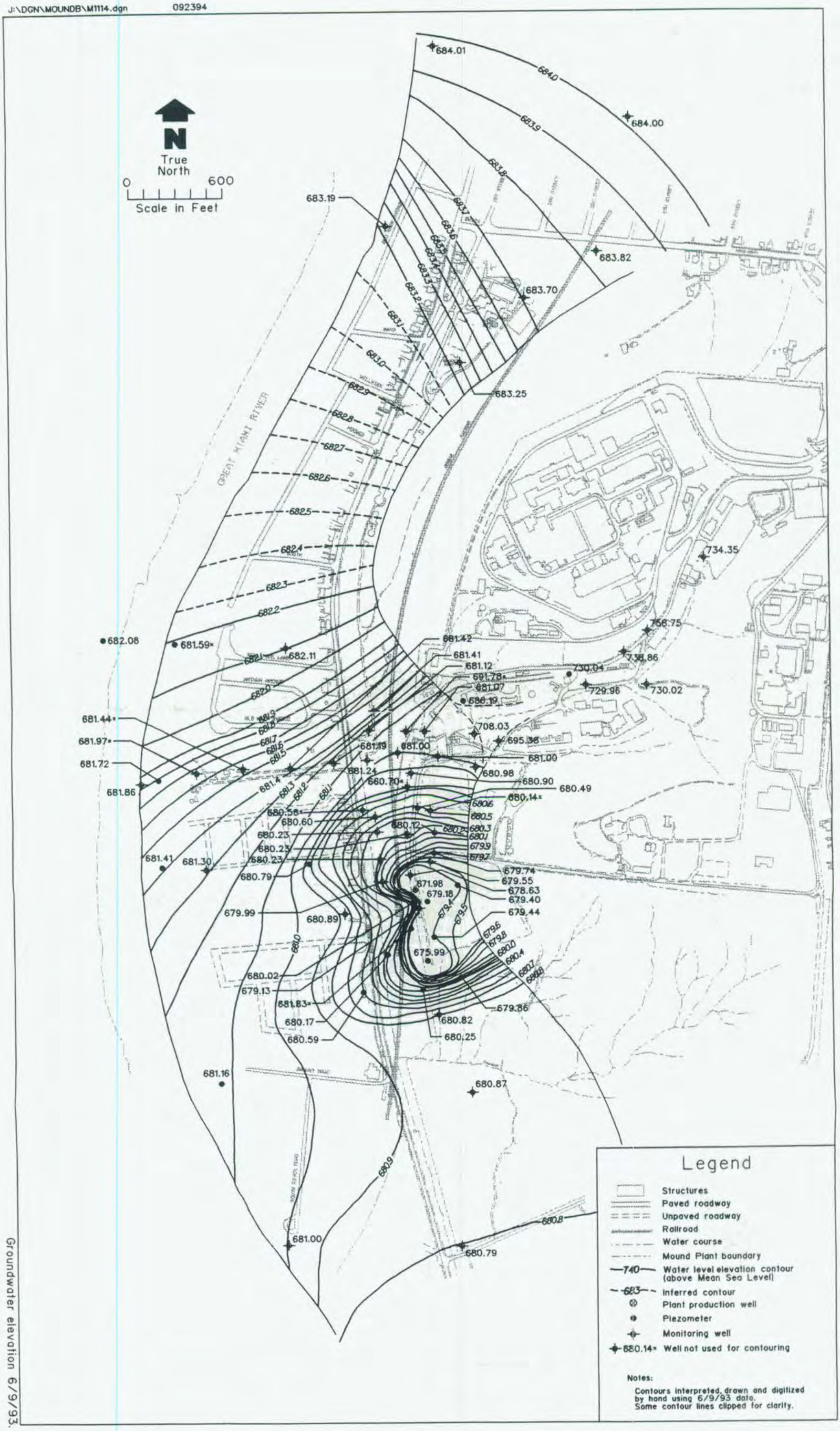


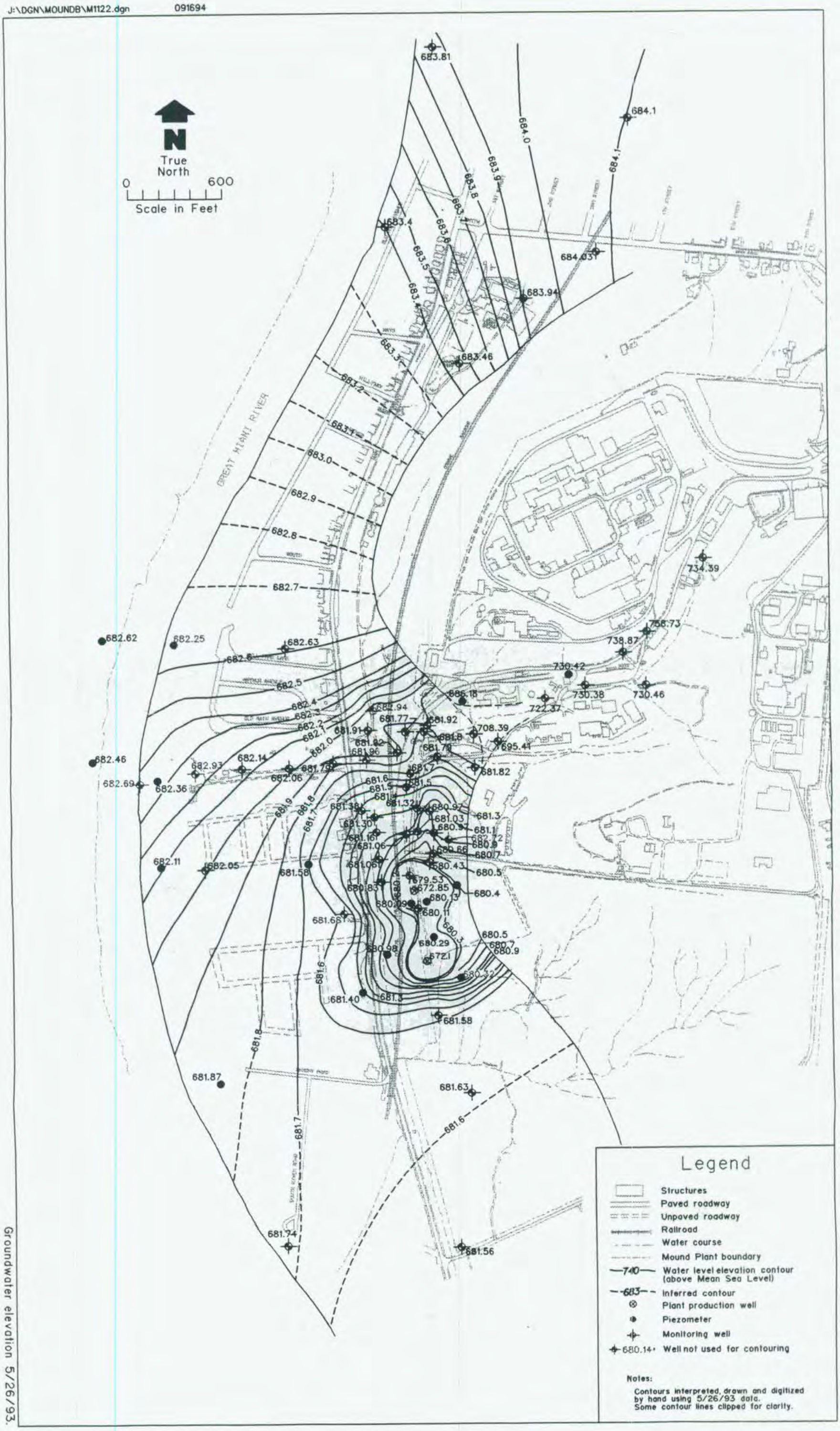
Groundwater elevation 6/23/93.

J:\DGN\MOUNDB\M1114.dgn 092394



Groundwater elevation 6/9/93.

J:\DGN\MOUNDB\M1122.dgn 091694

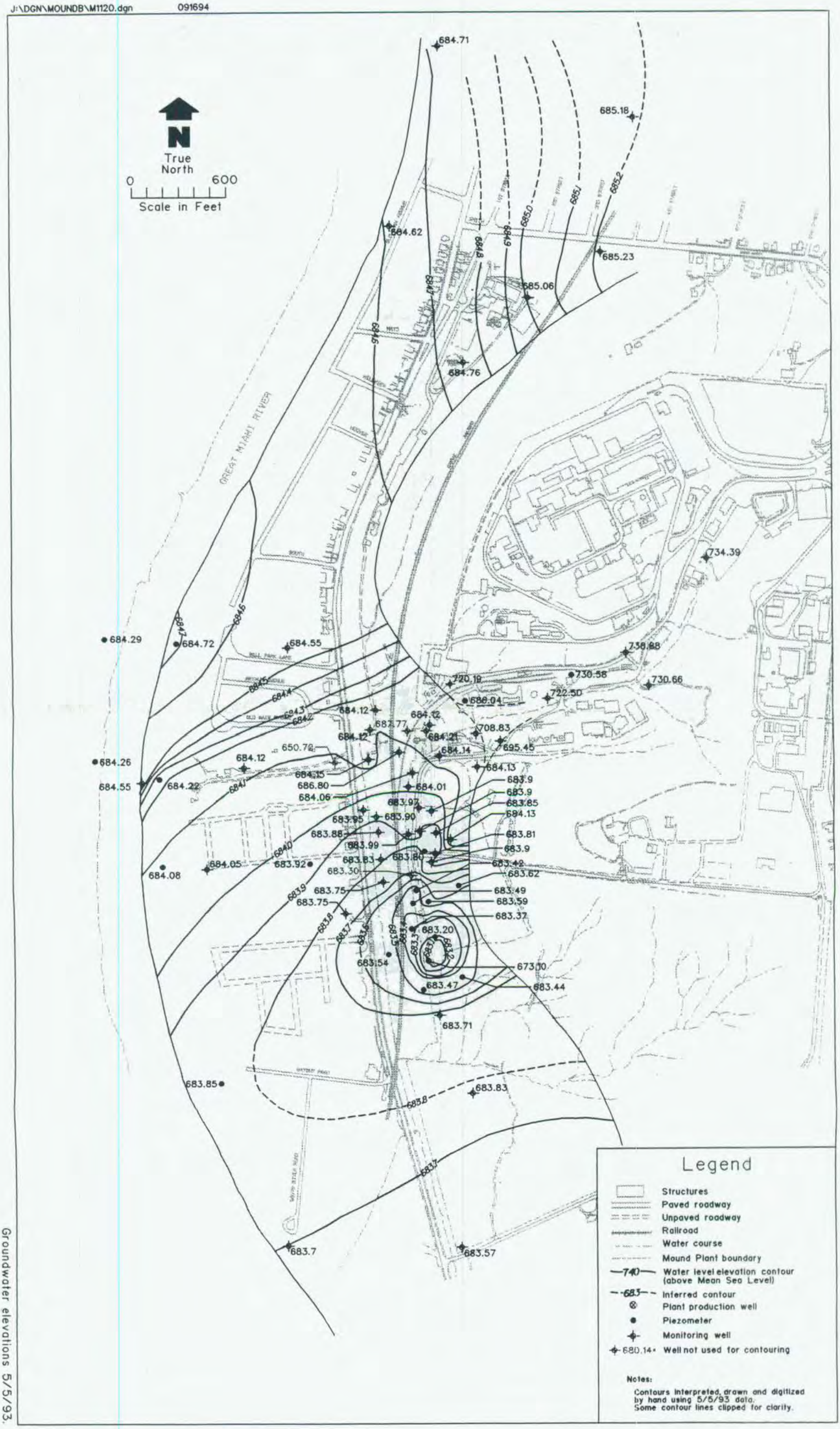


Groundwater elevation 5/26/93.

J:\DGN\MOUNDB\M1121.dgn 100694

Groundwater elevation 5/19/93.

J:\DGN\MOUNDB\M1120.dgn 091694



Groundwater elevations 5/5/93.

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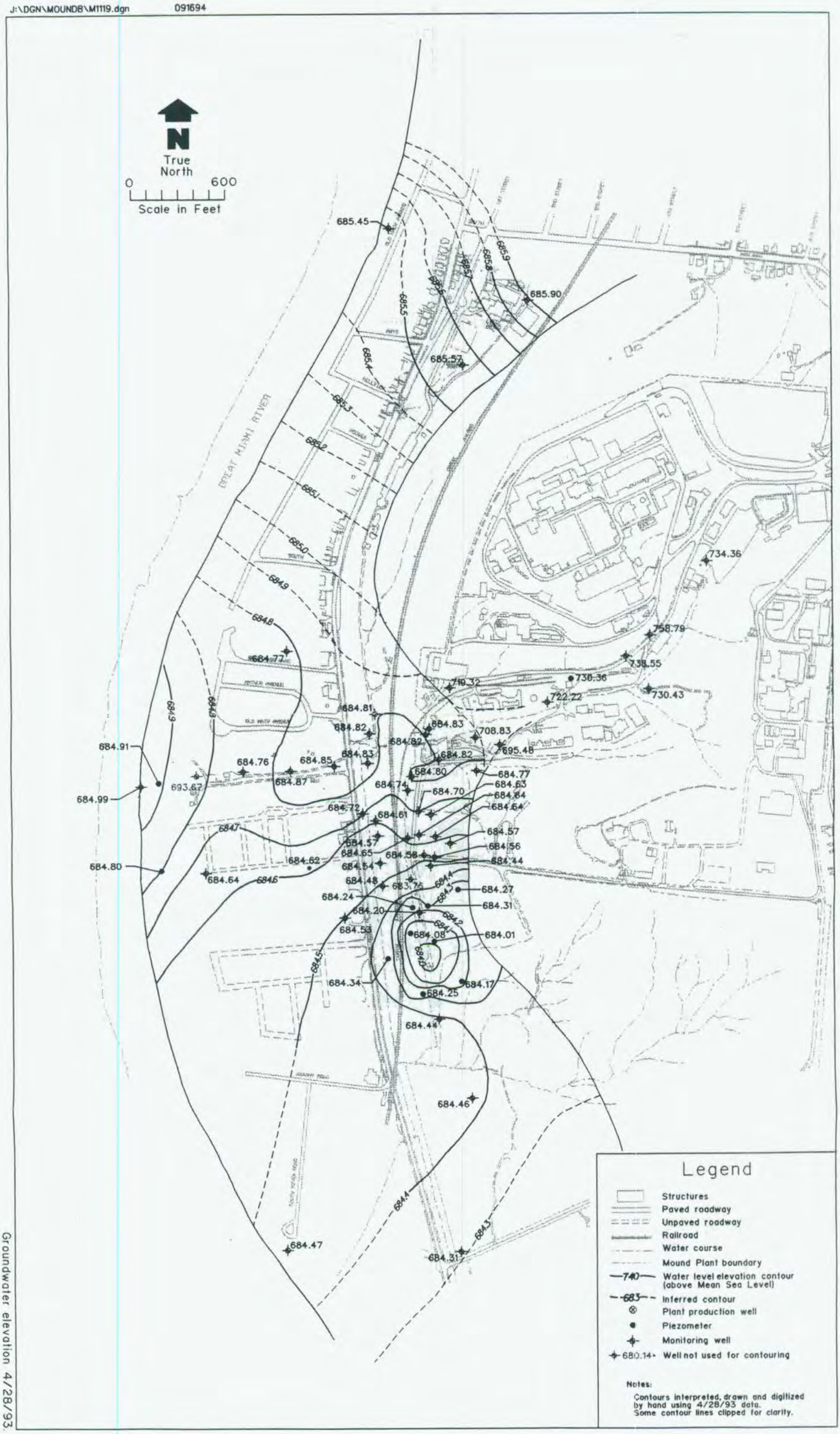
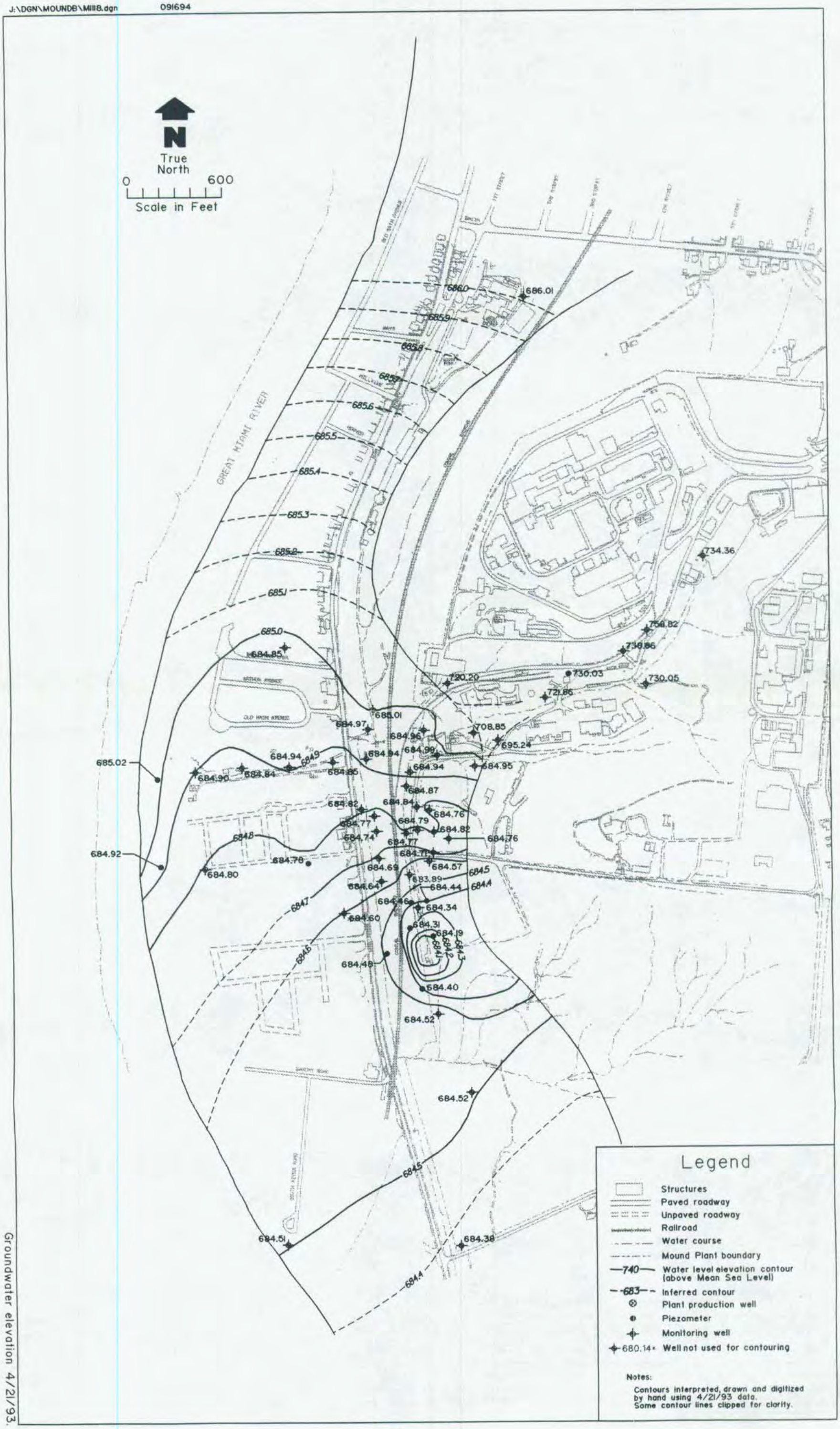


Groundwater elevation 4/28/93.

J:\DGN\MOUNDB\MIII8.dgn 091694



Groundwater elevation 4/21/93.

D.2.2. CALIBRATIONS AND HYDROGRAPHS OF CONTINUOUSLY MONITORED WELLS AND PIEZOMETERS, 1 JULY TO 31 DECEMBER 1993

MONITORING WELL HAND MEASUREMENTS VS. TRANSDUCER MEASUREMENTS

P001

Date	Hand Measurement Feet below TOC	Telog Measurement Feet above Transducer
7/1	37.7	9.98
7/15	34.5	13.206
9/1	39	8.78
10/5	60.19	8.43
11/1	39.12	8.617
12/15	33.34	12.4057

ALL DATA

Regression Output:

Constant	15.56093
Std Err of Y Est	1.819398
R Squared	0.386905
No. of Observations	6
Degrees of Freedom	4
X Coefficient(s)	−0.13101
Std Err of Coef.	0.082458

MINUS DATA

7/1	37.7	9.98
7/15	34.5	13.206
9/1	39	8.78
11/1	39.12	8.617

Regression Output:

Constant	47.32069
Std Err of Y Est	0.044380
R Squared	0.999710
No. of Observations	4
Degrees of Freedom	2
X Coefficient(s)	−0.98922
Std Err of Coef.	0.011908

P008

Date	Hand Measurement Feet below TOC	Telog Measurement Feet above Transducer
7/15	17.39	8.2427
9/2	21.95	3.683169
10/6	22.11	3.481163
11/2	22	3.582166
12/14	18.07	

ALL DATA

Regression Output:

Constant	25.75084
Std Err of Y Est	0.025888
R Squared	0.999911
No. of Observations	4
Degrees of Freedom	2
X Coefficient(s)	−1.00676
Std Err of Coef.	0.006703

MINUS DATA

P014

Date	Hand Measurement Feet below TOC	Telog Measurement Feet above Transducer
7/1	37.2	4.5742
7/1	37.07	5.2216
7/15	33.87	7.9408
8/2	38.49	5.3871
8/16	37.58	4.2361
9/1	38.32	3.5096
9/16	38.72	3.0636
10/5	38.61	3.1787
10/19	38.67	3.1355
11/1	34.38	3.3585
11/11	38.53	3.2866
12/15	34.75	7.0632
1/4	36.67	5.1928

ALL DATA

Regression Output:

Constant	27.56610
Std Err of Y Est	1.191504
R Squared	0.473601
No. of Observations	13
Degrees of Freedom	11
X Coefficient(s)	−0.61966
Std Err of Coef.	0.196974

MINUS DATA

7/15	33.87	7.9408
8/2	38.49	5.3871
8/16	37.58	4.2361
9/1	38.32	3.5096
9/16	38.72	3.0636
10/5	38.61	3.1787
10/19	38.67	3.1355
11/11	38.53	3.2866
12/15	34.75	7.0632
1/4	36.67	5.1928

Regression Output:

Constant	39.20555
Std Err of Y Est	0.677793
R Squared	0.867659
No. of Observations	10
Degrees of Freedom	8
X Coefficient(s)	−0.92477
Std Err of Coef.	0.127692

P017

Date	Hand Measurement Feet below TOC	Telog Measurement Feet above Transducer
7/15	5.35	10.671
9/2	9.68	6.265105
10/5	9.98	5.992436
11/2	9.83	6.100069
12/14	8.03	9.85285

ALL DATA

Regression Output:

Constant	15.97240
Std Err of Y Est	0.058656
R Squared	0.999507
No. of Observations	5
Degrees of Freedom	3
X Coefficient(s)	−1.00270
Std Err of Coef.	0.012847

MINUS DATA

MONITORING WELL HAND MEASUREMENTS VS. TRANSDUCER MEASUREMENTS

P020

Date	Hand Measurement Feet below TOC	Telog Measurement Feet above Transducer
7/15	5.63	6.2362
9/2	9.37	1.978184
10/5	10.01	1.762304
11/2	9.89	1.884636
12/14	6.25	5.525812

ALL DATA

Regression Output:

Constant	12.04610
Std Err of Y Est	0.214521
R Squared	0.992936
No. of Observations	5
Degrees of Freedom	3
X Coefficient(s)	-1.04110
Std Err of Coef.	0.050698

MINUS DATA

P021

Date	Hand Measurement Feet below TOC	Telog Measurement Feet above Transducer
7/15	18.63	9.6496
9/2	20.85	7.600444
10/5	22.09	6.085064
11/2	22.54	5.29654
12/14	21.93	6.222188

ALL DATA

Regression Output:

Constant	29.97275
Std Err of Y Est	0.208179
R Squared	0.988900
No. of Observations	5
Degrees of Freedom	3
X Coefficient(s)	-1.08457
Std Err of Coef.	0.066339

MINUS DATA

P035

Date	Hand Measurement Feet below TOC	Telog Measurement Feet above Transducer
7/15	2.75	21.03
8/2/93	5.16	18.96
9/2	6.8	17.478
9/17	7.14	17.102
10/5	6.96	17.478
11/2	6.86	17.76
11/11	6.86	17.713
12/14	3.43	21.234
1/4	5.3	19.403

ALL DATA

Regression Output:

Constant	24.01993
Std Err of Y Est	0.302803
R Squared	0.967615
No. of Observations	9
Degrees of Freedom	7
X Coefficient(s)	-0.93642
Std Err of Coef.	0.064750

MINUS DATA

7/15	2.75	21.03
8/2/93	5.16	18.96
9/2	6.8	17.478
9/17	7.14	17.102
10/5	6.96	17.478

Regression Output:

Constant	23.45769
Std Err of Y Est	0.094122
R Squared	0.997501
No. of Observations	5
Degrees of Freedom	3
X Coefficient(s)	-0.87540
Std Err of Coef.	0.025294

P036

Date	Hand Measurement Feet below TOC	Telog Measurement Feet above Transducer
7/15	3	23.973
9/2	7.11	19.91402
10/5	7.31	19.63724
11/2	7.19	19.95015
12/14	3.7	23.41199

ALL DATA

Regression Output:

Constant	27.03207
Std Err of Y Est	0.101006
R Squared	0.998304
No. of Observations	5
Degrees of Freedom	3
X Coefficient(s)	-0.99837
Std Err of Coef.	0.023753

MINUS DATA

MONITORING WELL HAND MEASUREMENTS VS. TRANSDUCER MEASUREMENTS

P037

Date	Hand Measurement Feet below TOC	Telog Measurement Feet above Transducer
7/15	3	18.64
8/2	5.49	16.821
9/2	7.21	14.915
9/17	7.55	14.404
10/5	7.39	15.054
11/2	7.27	15.287
11/11	7.29	15.24
12/14	3.7	18.913
1/4	5.58	17.053

ALL DATA

Regression Output:

Constant		22.01042
Std Err of Y Est		0.353424
R Squared		0.960864
No. of Observations		9
Degrees of Freedom		7
X Coefficient(s)	−0.95019	
Std Err of Coef.	0.072480	

MINUS DATA

7/15	3	18.64
8/2	5.49	16.821
9/2	7.21	14.915
9/17	7.55	14.404
10/5	7.39	15.054

Regression Output:

Constant		21.45739
Std Err of Y Est		0.279418
R Squared		0.980891
No. of Observations		5
Degrees of Freedom		3
X Coefficient(s)	−0.89598	
Std Err of Coef.	0.072201	

P038

Date	Hand Measurement Feet below TOC	Telog Measurement Feet above Transducer
7/15	2.76	24.024
9/2	7.05	19.72122
10/5	7.27	19.30398
11/2	7.15	19.44306

ALL DATA

Regression Output:

Constant		26.87906
Std Err of Y Est		0.105660
R Squared		0.998560
No. of Observations		4
Degrees of Freedom		2
X Coefficient(s)	−1.03277	
Std Err of Coef.	0.027731	

MINUS DATA

P039

Date	Hand Measurement Feet below TOC	Telog Measurement Feet above Transducer
7/15	4.32	12.5
8/2	6.87	10.232
9/2	8.75	8.2463
9/17	9.15	7.8769
10/5	9.1	7.8769
10/11	9.01	7.7846
10/19	9.17	7.6306
11/2	9.99	7.9693
11/11	9	8.0154
12/14	5.06	11.986
1/4	7.14	9.8622

ALL DATA

Regression Output:

Constant		16.57073
Std Err of Y Est		0.302632
R Squared		0.973637
No. of Observations		11
Degrees of Freedom		9
X Coefficient(s)	−0.93761	
Std Err of Coef.	0.051427	

MINUS DATA

P040

Date	Hand Measurement Feet below TOC	Telog Measurement Feet above Transducer
7/15	4.18	21.865
9/2	6.65	17.34562
10/5	8.93	16.97666
11/2	6.83	17.11502
12/14	4.92	21.03522

ALL DATA

Regression Output:

Constant		26.11645
Std Err of Y Est		1.224043
R Squared		0.801522
No. of Observations		5
Degrees of Freedom		3
X Coefficient(s)	−1.15026	
Std Err of Coef.	0.330471	

MINUS DATA

MONITORING WELL HAND MEASUREMENTS VS. TRANSDUCER MEASUREMENTS

P041

Date	Hand Measurement Feet below TOC	Telog Measurement Feet above Transducer
7/15	4.04	22.494
9/2	8.55	17.99267
10/5	8.88	17.67116
11/2	8.75	17.94674
12/14	4.82	21.85079

ALL DATA

Regression Output:

Constant		26.58983
Std Err of Y Est		0.090100
R Squared		0.998916
No. of Observations		5
Degrees of Freedom		3
X Coefficient(s)	−0.99868	
Std Err of Coef.	0.018989	

MINUS DATA

P042

Date	Hand Measurement Feet below TOC	Telog Measurement Feet above Transducer
7/15	5.44	30.641
9/2	18.54	18.15426
10/5	17.4	19.11478
11/2	16.56	20.03164
12/14	20.47	16.71348

ALL DATA

Regression Output:

Constant		35.68983
Std Err of Y Est		0.216776
R Squared		0.998862
No. of Observations		5
Degrees of Freedom		3
X Coefficient(s)	−0.94113	
Std Err of Coef.	0.018339	

MINUS DATA

Well 0116

Date	Hand Measurement Feet below TOC	Telog Measurement Feet above Transducer
7/15	60.11	10.324
9/2	60.48	9.94201
10/5	60.19	10.172698
12/14	59.49	10.799881

ALL DATA

Regression Output:

Constant		62.35064
Std Err of Y Est		0.043449
R Squared		0.990427
No. of Observations		4
Degrees of Freedom		2
X Coefficient(s)	−0.86637	
Std Err of Coef.	0.060225	

MINUS DATA

Well 0302

Date	Hand Measurement Feet below TOC	Telog Measurement Feet above Transducer
7/1	10.21	8.4681
7/15	7.59	11.075
8/2	10.04	8.4969
8/16	11.21	7.5174
9/2	11.68	6.74
9/16	12.21	6.429
10/1	12.14	6.5523
10/5	12.14	6.55
10/19	12.18	6.54
11/2	12.03	6.71
11/11	12.01	6.7036
12/14	8.26	10.477
1/4	10.27	8.4969

ALL DATA

Regression Output:

Constant		18.70370
Std Err of Y Est		0.099252
R Squared		0.996321
No. of Observations		13
Degrees of Freedom		11
X Coefficient(s)	−1.00297	
Std Err of Coef.	0.018375	

MINUS DATA

MONITORING WELL HAND MEASUREMENTS VS. TRANSDUCER MEASUREMENTS

Well 0343

Date	Hand Measurement Feet below TOC	Telog Measurement Feet above Transducer
7/1	14.17	11.521
7/15	11.56	14.227
8/2	14.05	11.698
8/16	15.22	10.628
9/2	15.95	9.8148
9/16	16.24	9.5124
10/1	17.54	9.5526
10/5	16.2	10.009
10/11	16.15	10.096
10/19	16.29	9.9731
11/2	16.09	10.153
11/11	16.11	10.132
12/14	12.23	13.954
1/4	14.29	11.974

ALL DATA

Regression Output:

Constant		24.48138
Std Err of Y Est		0.339647
R Squared		0.955318
No. of Observations		14
Degrees of Freedom		12
X Coefficient(s)	−0.89346	
Std Err of Coef.	0.055779	

MINUS DATA

7/1	14.17	11.521
7/15	11.56	14.227
8/2	14.05	11.698
8/16	15.22	10.628
9/2	15.95	9.8148
9/16	16.24	9.5124

Regression Output:

Constant		25.76032
Std Err of Y Est		0.057651
R Squared		0.999089
No. of Observations		6
Degrees of Freedom		4
X Coefficient(s)	−0.99956	
Std Err of Coef.	0.015089	

Well 0387

Date	Hand Measurement Feet below TOC	Telog Measurement Feet above Transducer
7/1	40.83	9.1821
7/15	37.51	12.464
8/2	40.03	9.9179
8/16	41.23	8.7854
9/2	41.84	8.0929
9/16	42.39	7.6801
10/1	41.1	7.7178
10/6	42.24	7.7539
10/19	42.25	7.725
11/2	42.09	7.9
11/11	42.13	7.9
12/14	38.27	11.79
1/4	40.7	9.7664

ALL DATA

Regression Output:

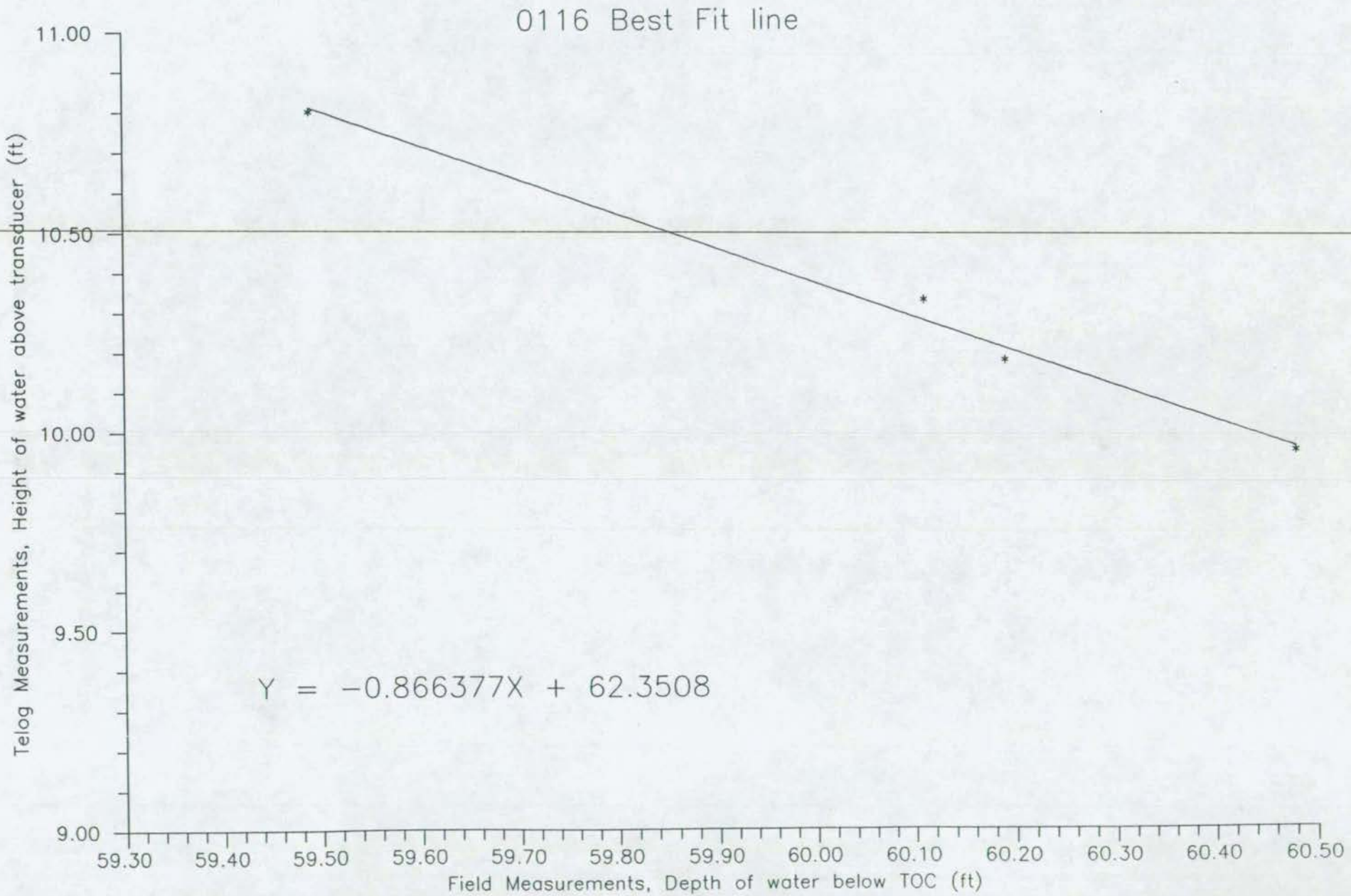
Constant		50.33475
Std Err of Y Est		0.380393
R Squared		0.948806
No. of Observations		13
Degrees of Freedom		11
X Coefficient(s)	−1.00951	
Std Err of Coef.	0.070702	

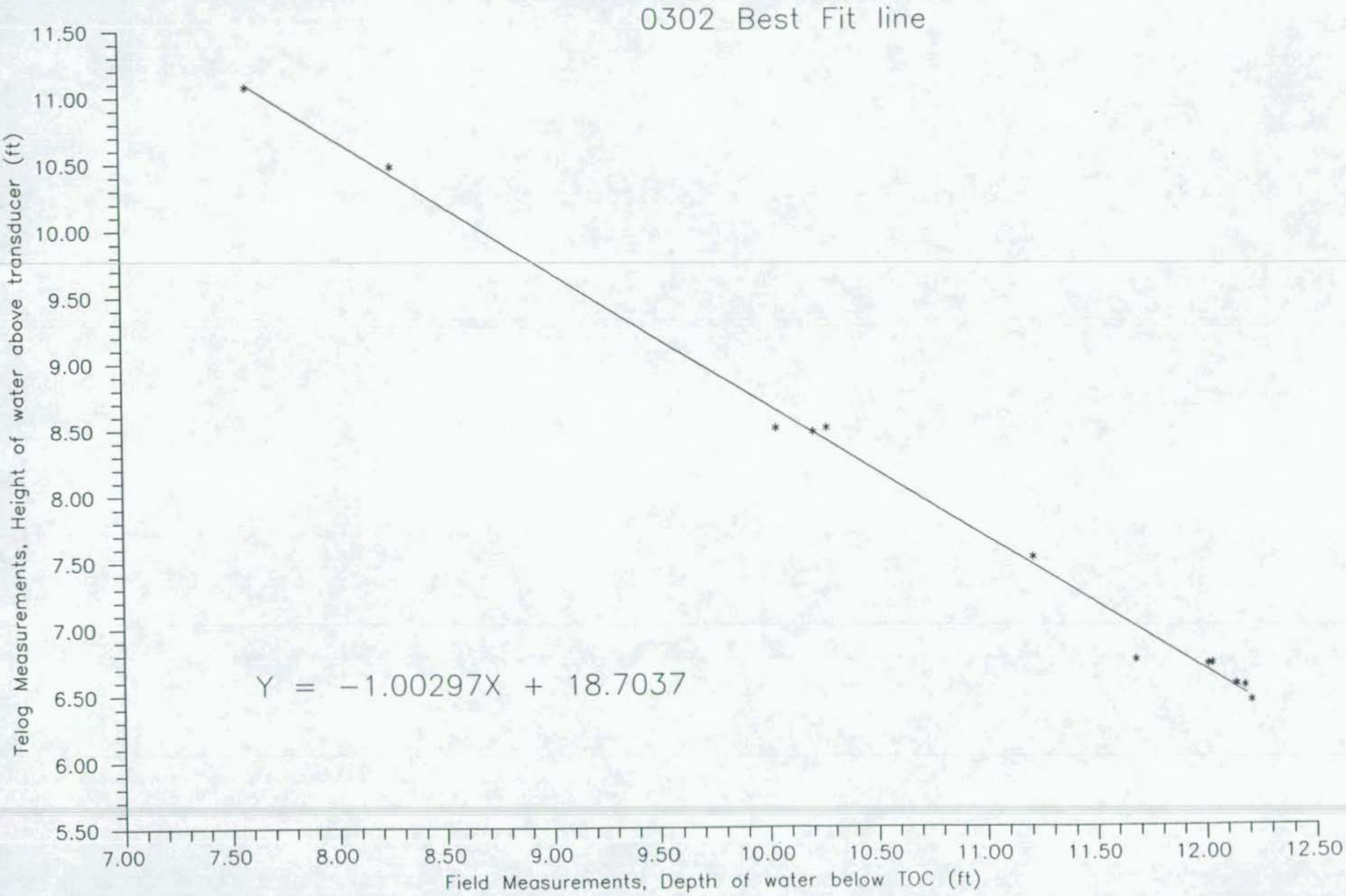
MINUS DATA

7/1	40.83	9.1821
7/15	37.51	12.464
8/2	40.03	9.9179
8/16	41.23	8.7854
9/2	41.84	8.0929
9/16	42.39	7.6801
10/6	42.24	7.7539
10/19	42.25	7.725
11/2	42.09	7.9
11/11	42.13	7.9
12/14	38.27	11.79

Regression Output:

Constant		49.99408
Std Err of Y Est		0.045279
R Squared		0.999360
No. of Observations		11
Degrees of Freedom		9
X Coefficient(s)	−0.99985	
Std Err of Coef.	0.006429	


0116 Best Fit line
11.00
10.50
10.00
9.50
9.00
Telog Measurements, Height of water above transducer (ft)
Y = -0.866377X + 62.3508
59.30
59.40
59.50
59.60
59.70
59.80
59.90
60.00
60.10
60.20
60.30
60.40
60.50
Field Measurements, Depth of water below TOC (ft)


0302 Best Fit line
Y = −1.00297X + 18.7037
Telog Measurements, Height of water above transducer (ft)
Field Measurements, Depth of water below TOC (ft)
11.50
11.00
10.50
10.00
9.50
9.00
8.50
8.00
7.50
7.00
6.50
6.00
5.50
7.00
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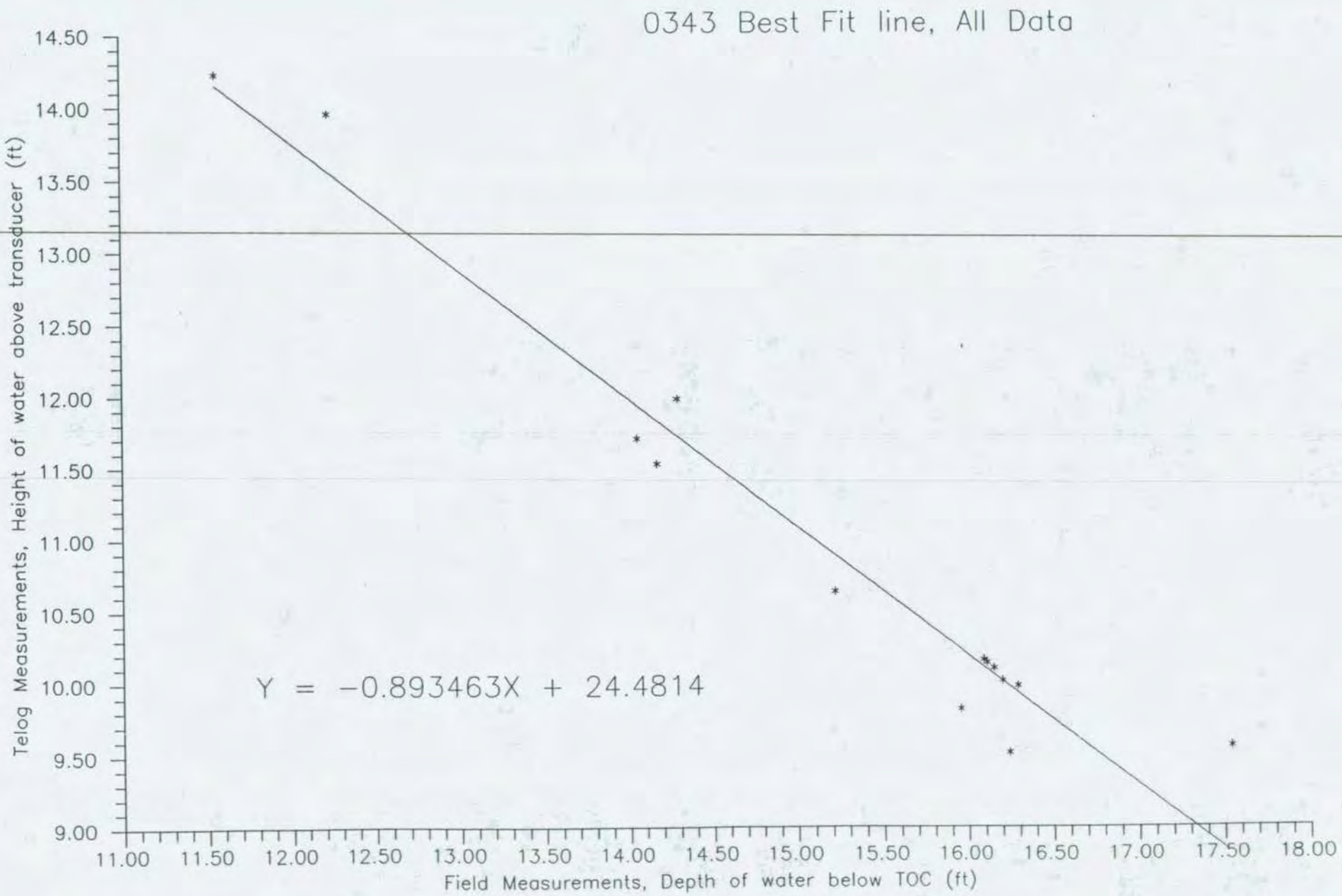
8.50
9.00
9.50
10.00
10.50
11.00
11.50
12.00
12.50


0343 Best Fit line, All Data
Y = -0.893463X + 24.4814
Telog Measurements, Height of water above transducer (ft)
Field Measurements, Depth of water below TOC (ft)
14.50
14.00
13.50
13.00
12.50
12.00
11.50
11.00
10.50
10.00
9.50
9.00
11.00
11.50
12.00
12.50
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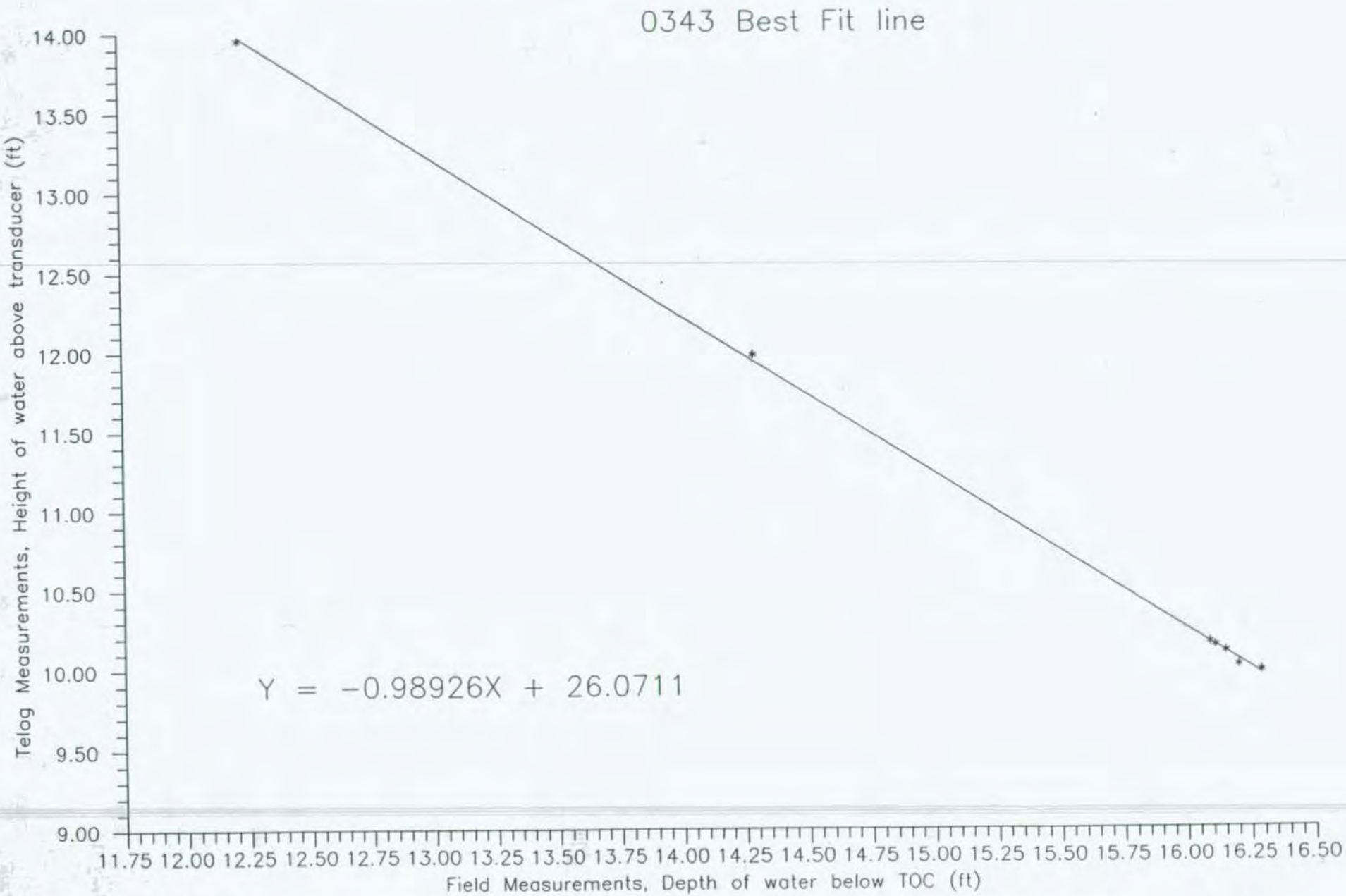
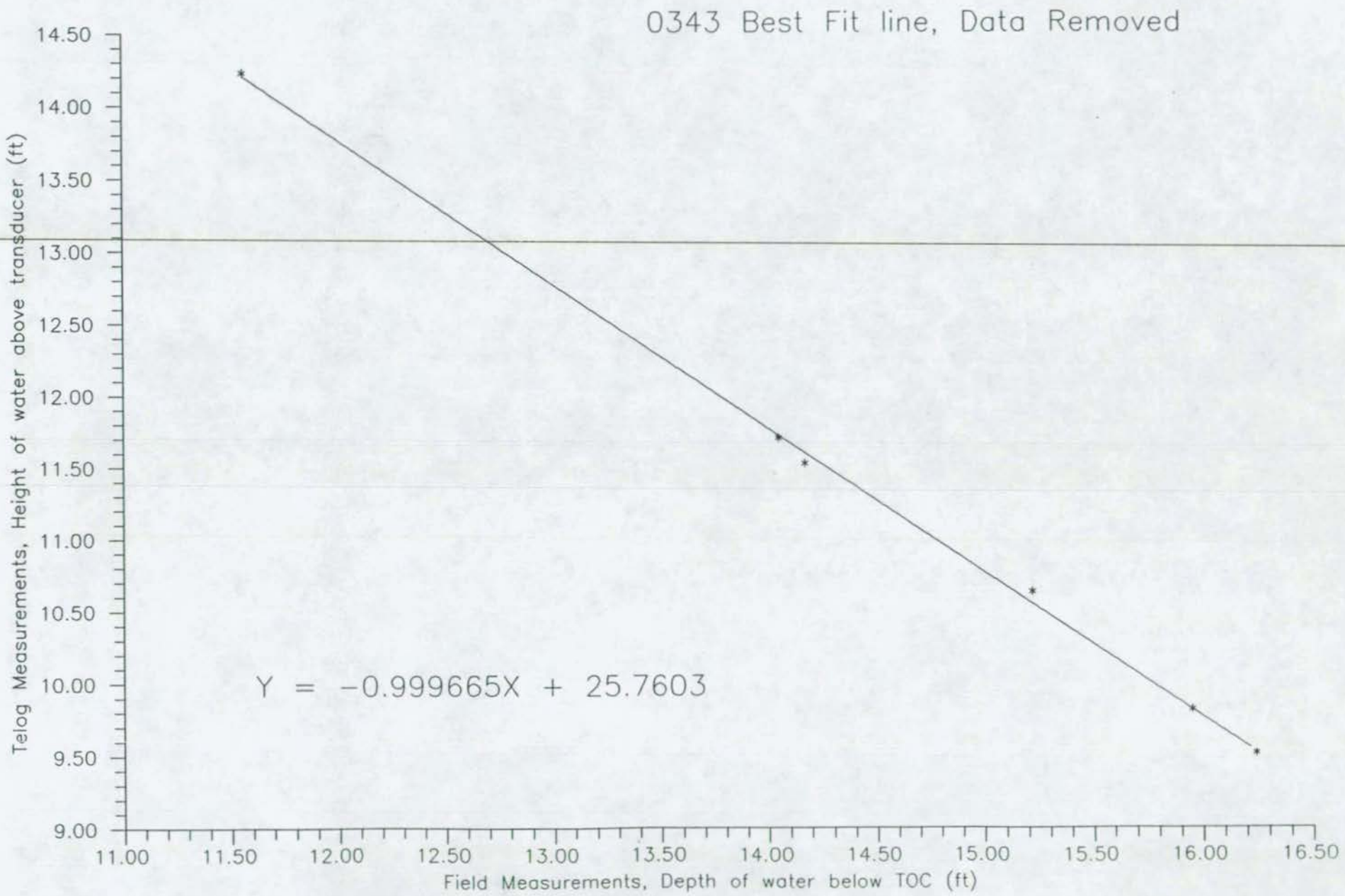
16.00
16.50
17.00
17.50
18.00


0343 Best Fit line
Y = -0.98926X + 26.0711
Telog Measurements, Height of water above transducer (ft)
14.00
13.50
13.00
12.50
12.00
11.50
11.00
10.50
10.00
9.50
9.00
11.75 12.00 12.25 12.50 12.75 13.00 13.25 13.50 13.75 14.00 14.25 14.50 14.75 15.00 15.25 15.50 15.75 16.00 16.25 16.50
Field Measurements, Depth of water below TOC (ft)


0343 Best Fit line, Data Removed
Y = -0.999665X + 25.7603
Telog Measurements, Height of water above transducer (ft)
Field Measurements, Depth of water below TOC (ft)
14.50
14.00
13.50
13.00
12.50
12.00
11.50
11.00
10.50
10.00
9.50
9.00
11.00
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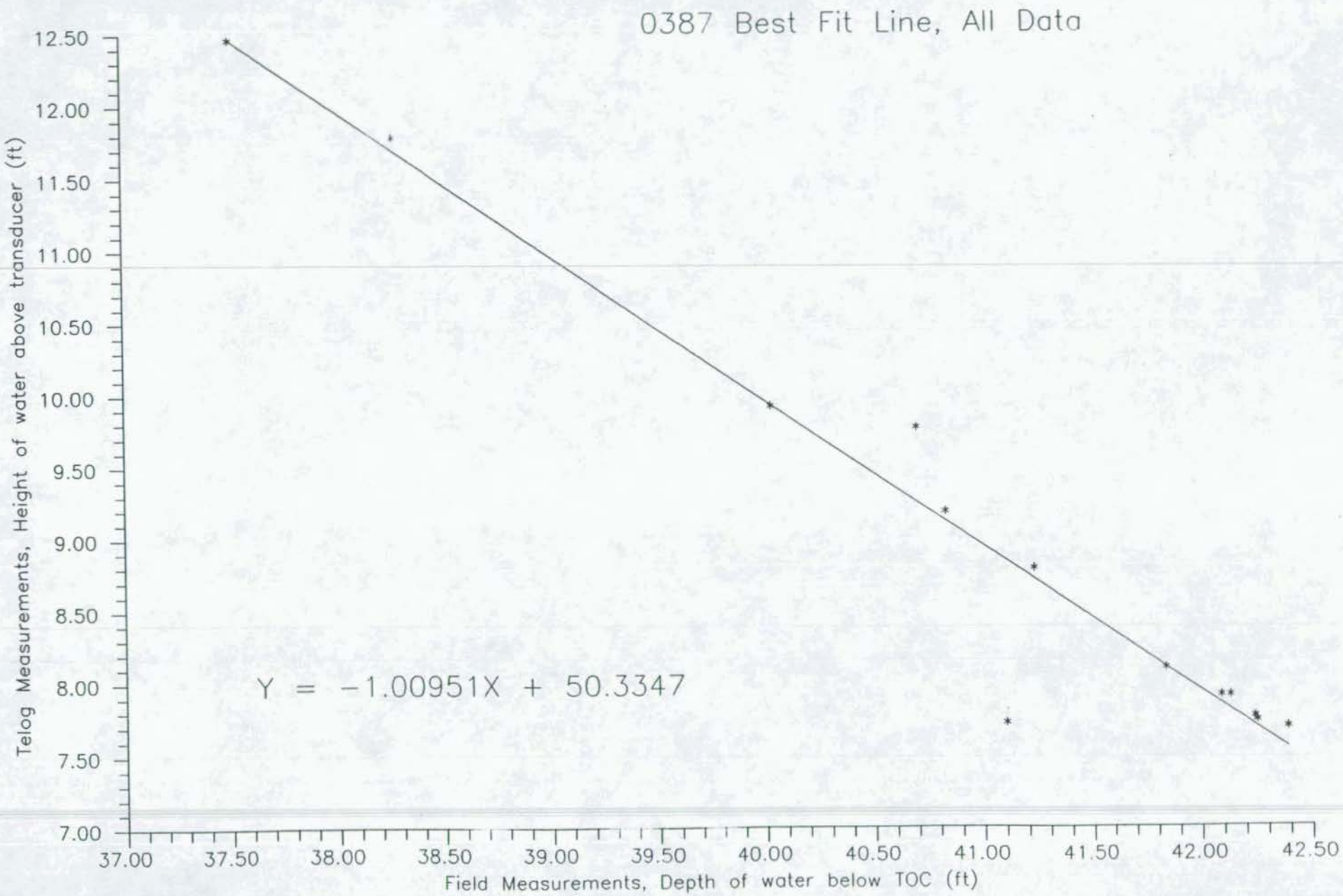
14.50
15.00
15.50
16.00
16.50


0387 Best Fit Line, All Data
Y = -1.00951X + 50.3347
Telog Measurements, Height of water above transducer (ft)
Field Measurements, Depth of water below TOC (ft)
12.50
12.00
11.50
11.00
10.50
10.00
9.50
9.00
8.50
8.00
7.50
7.00
37.00
37.50
38.00
38.50
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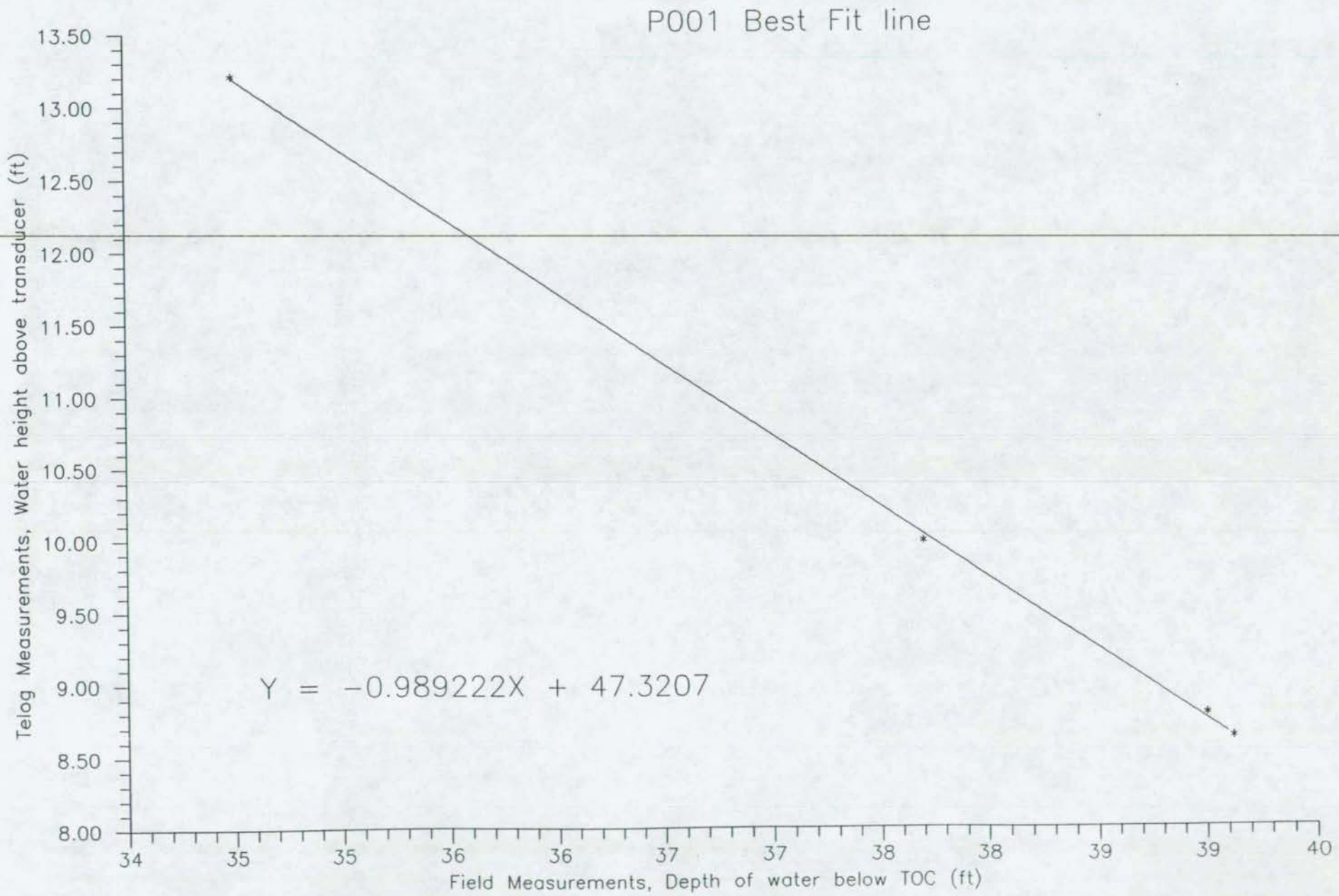
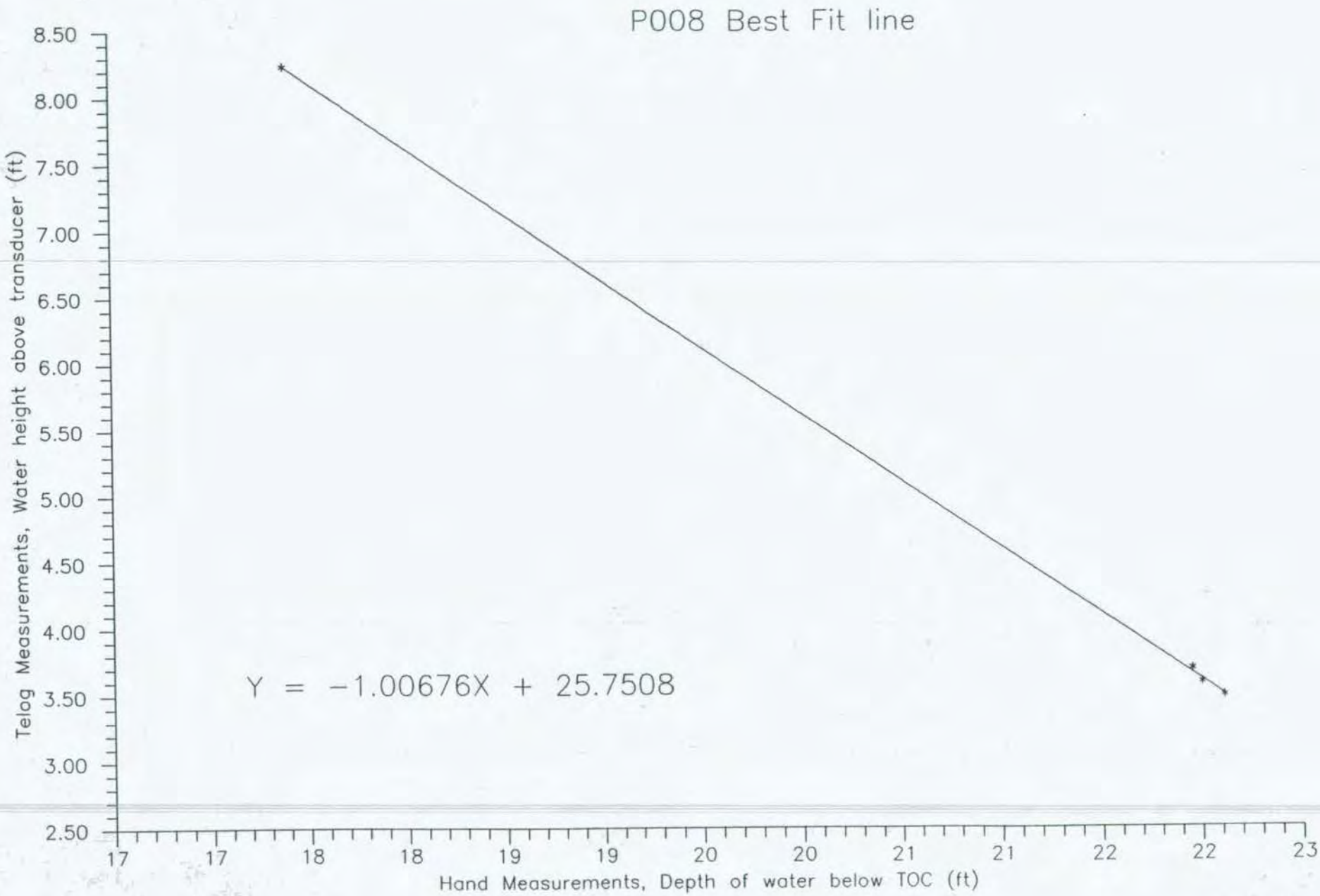
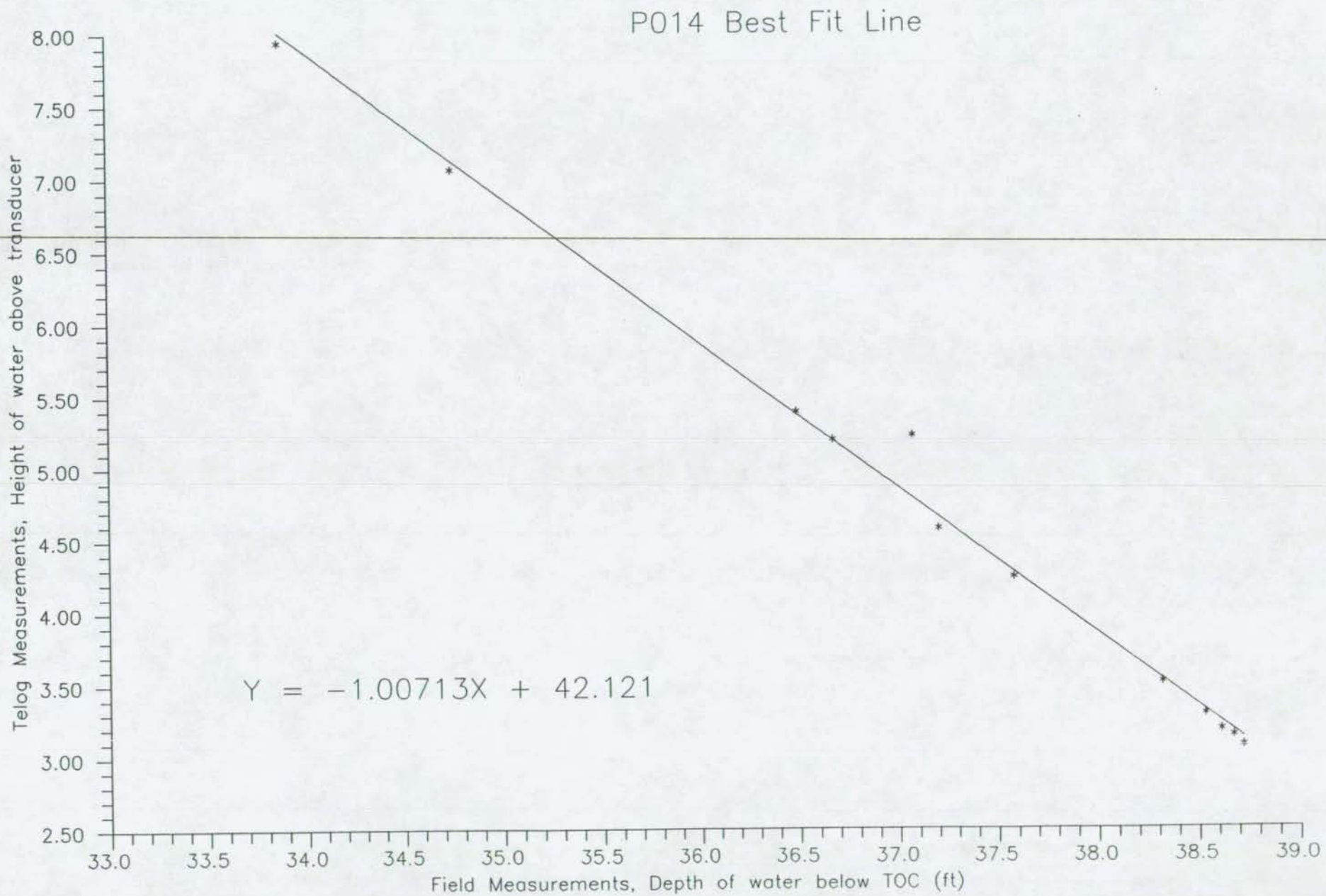
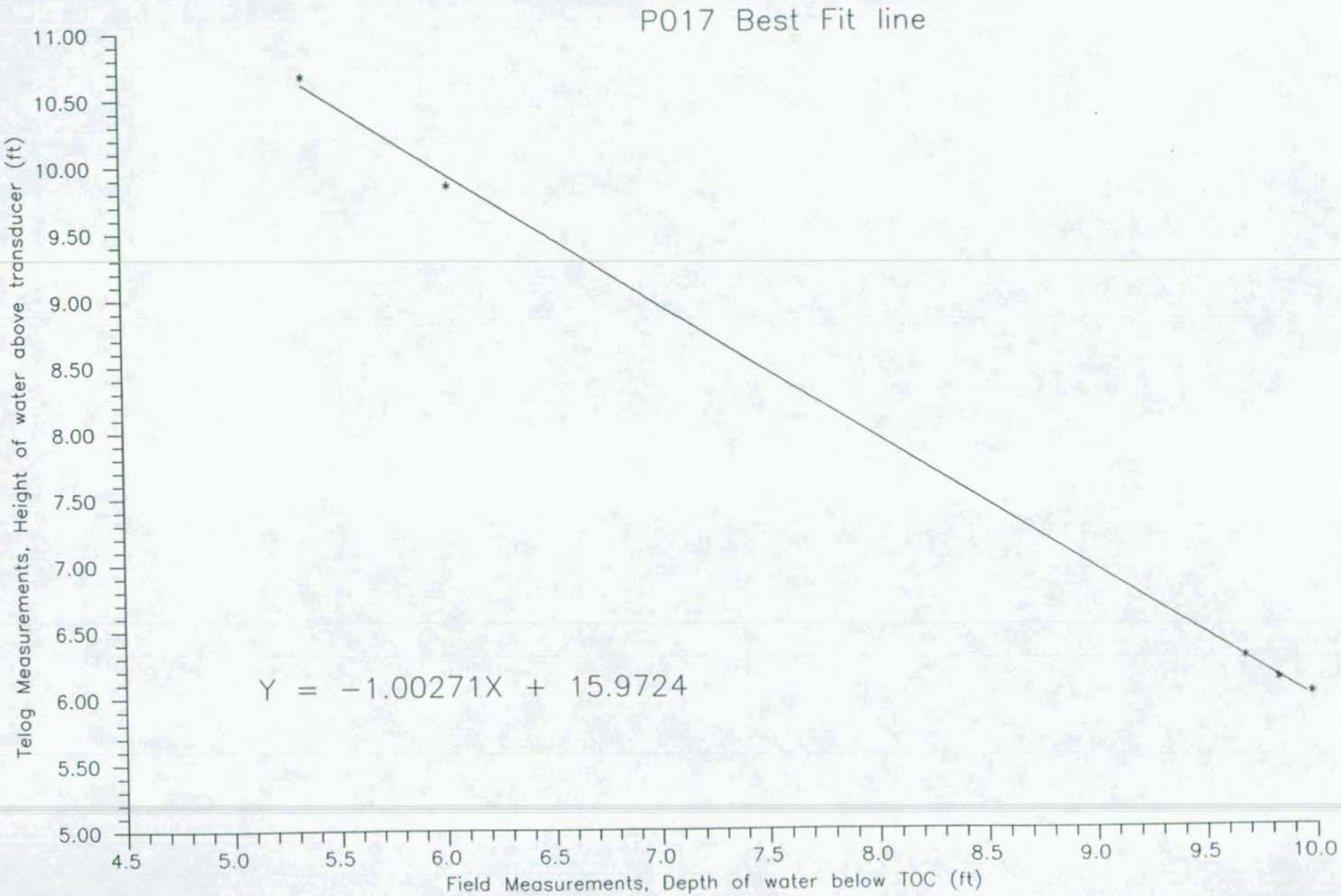
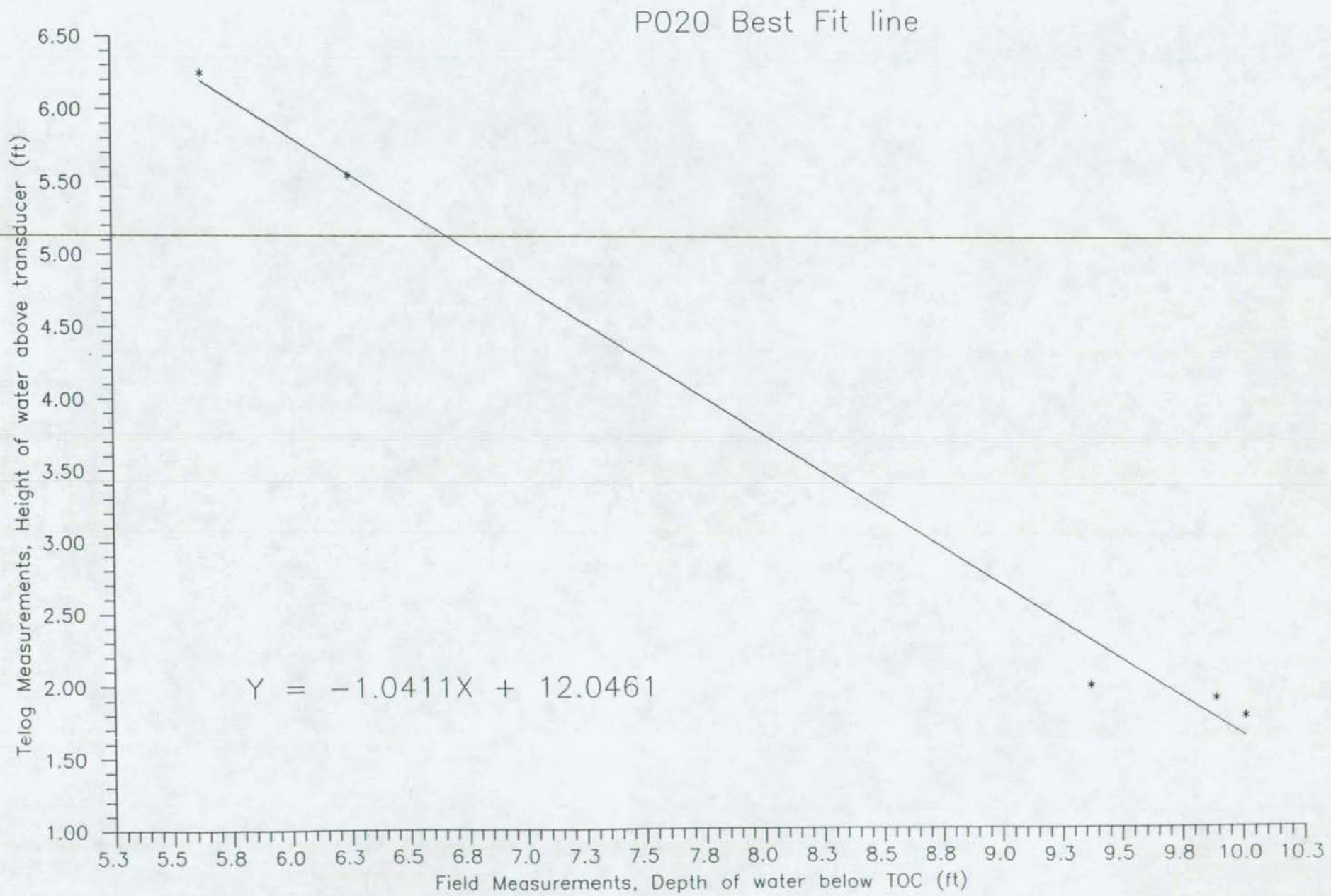
40.00
40.50
41.00
41.50
42.00
42.50

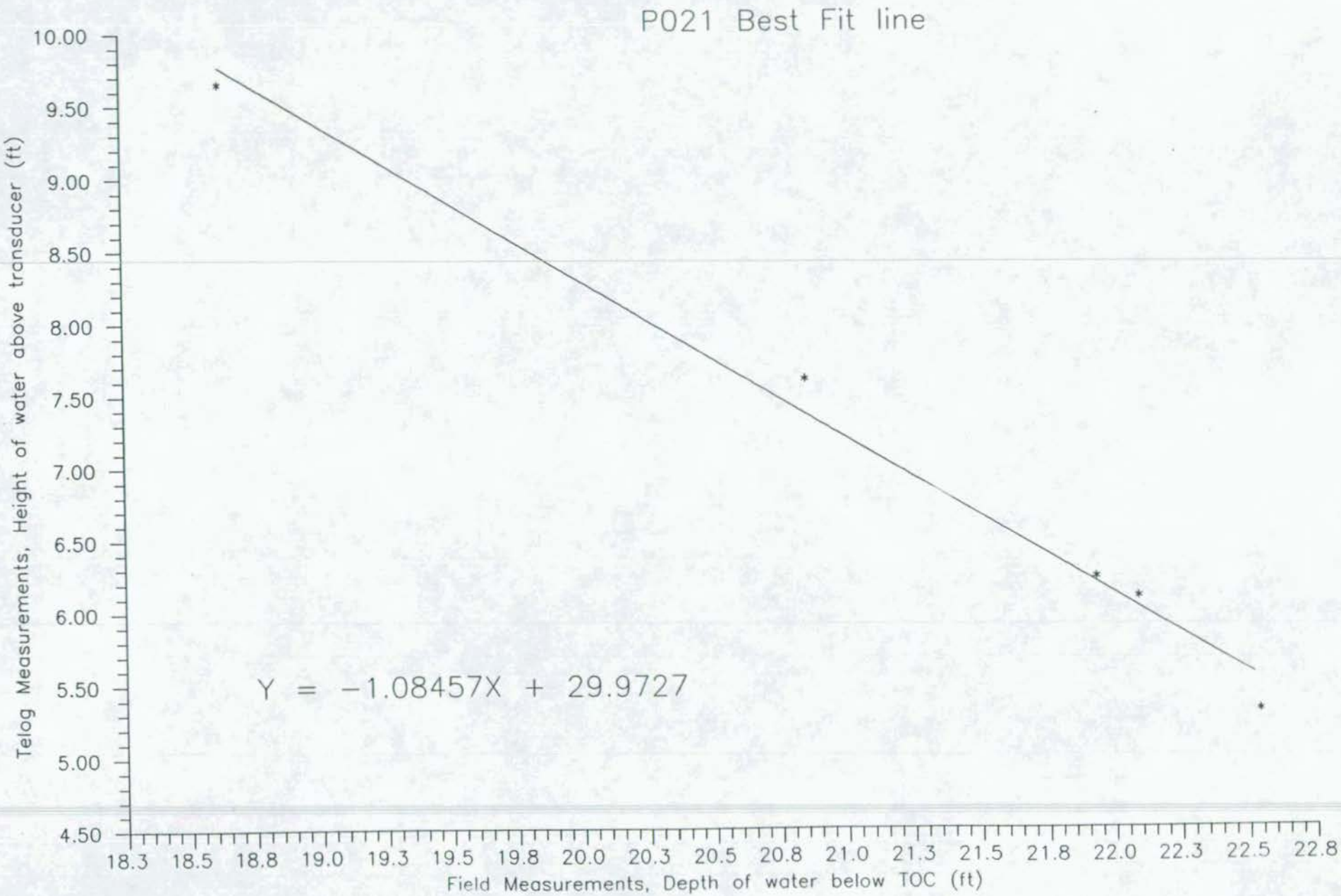

P001 Best Fit line
Telog Measurements, Water height above transducer (ft)
13.50
13.00
12.50
12.00
11.50
11.00
10.50
10.00
9.50
9.00
8.50
8.00
Y = -0.989222X + 47.3207
34
35
35
36
36
37
37
38
38
39
39
40
Field Measurements, Depth of water below TOC (ft)

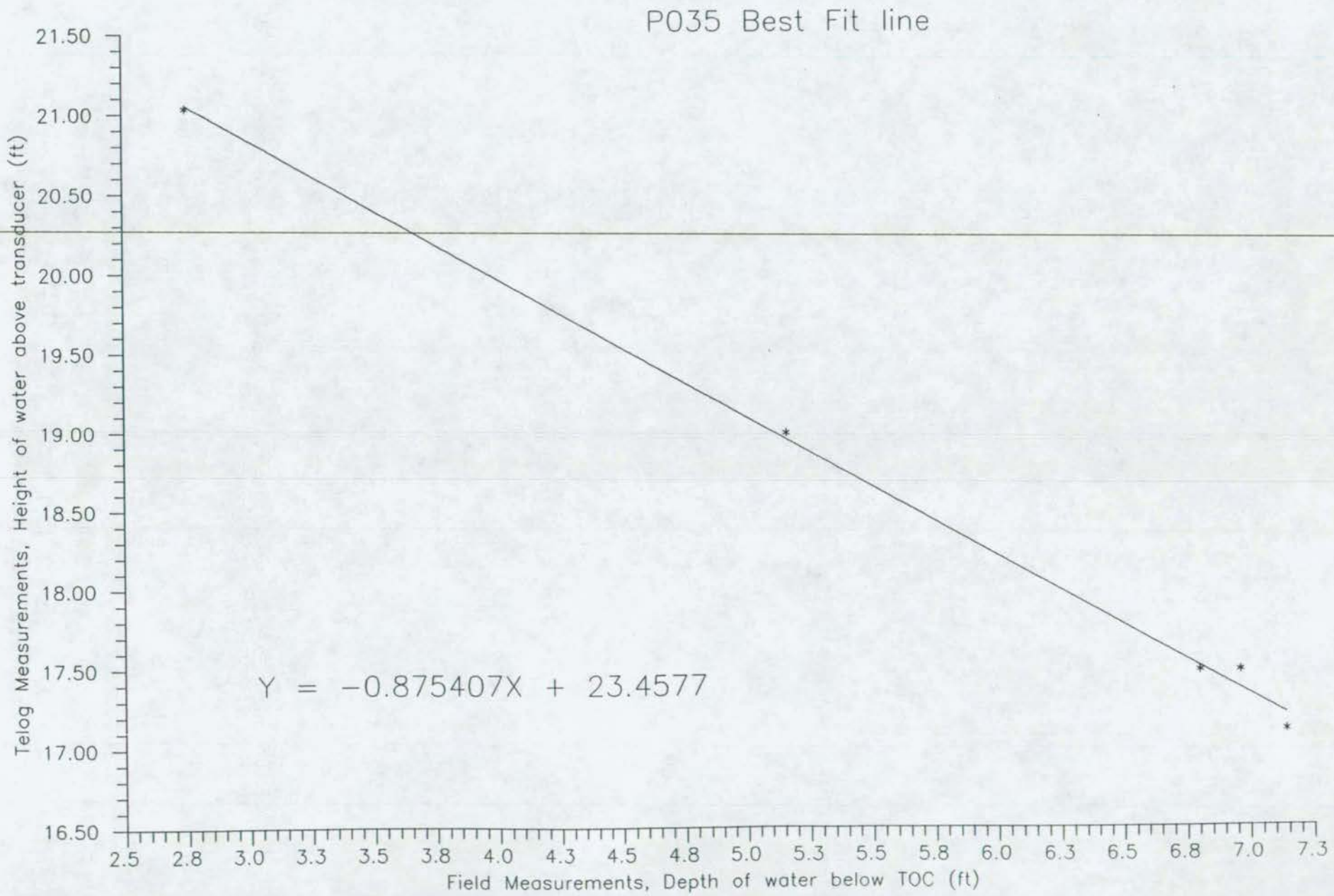

P008 Best Fit line
Y = −1.00676X + 25.7508
Telog Measurements, Water height above transducer (ft)
8.50
8.00
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
3.50
3.00
2.50
17
17
18
18
19
19
20
20
21
21
22
22
23
Hand Measurements, Depth of water below TOC (ft)

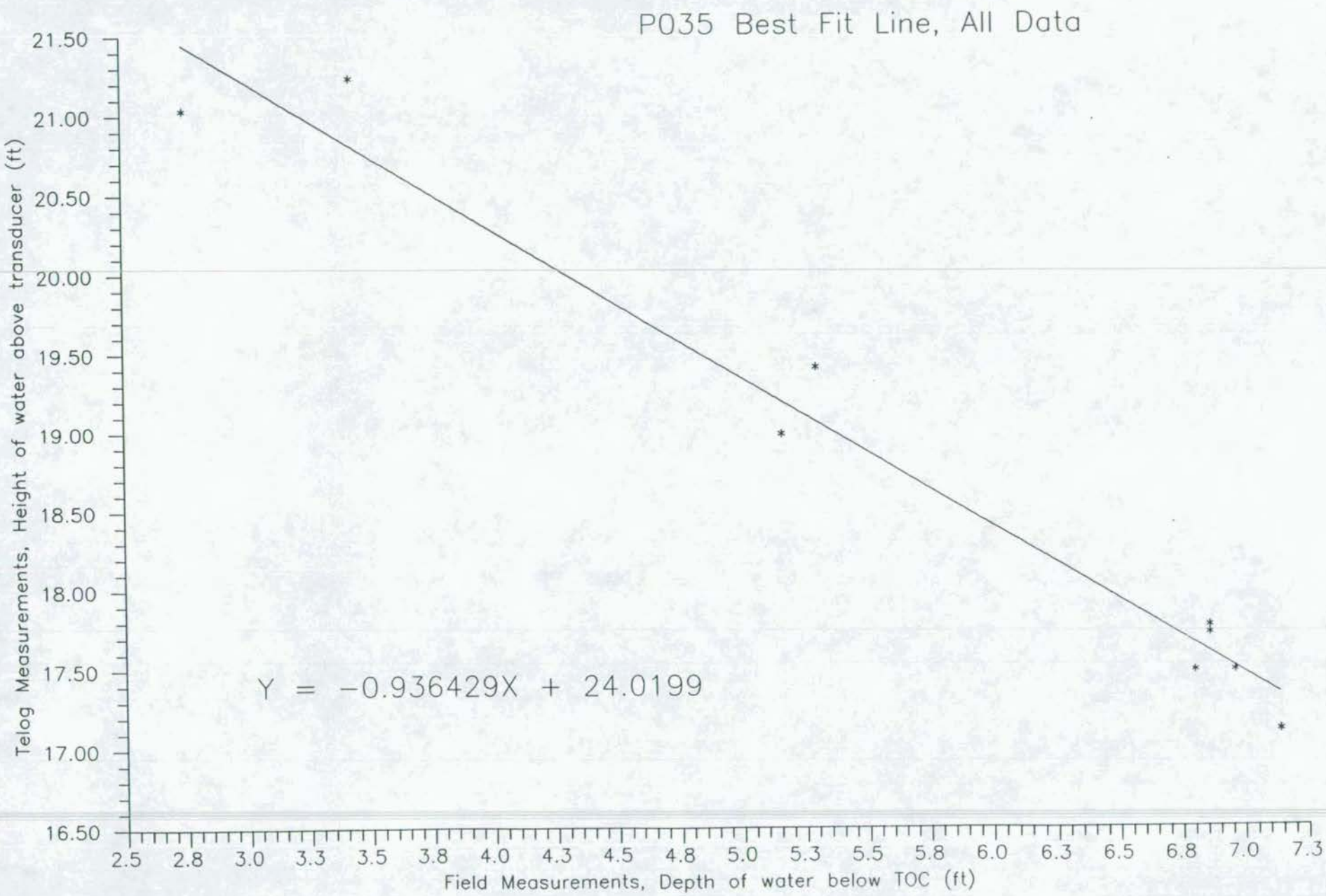

P014 Best Fit Line
Y = -1.00713X + 42.121
Telog Measurements, Height of water above transducer
Field Measurements, Depth of water below TOC (ft)
8.00
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
3.50
3.00
2.50
33.0
33.5
34.0
34.5
35.0
35.5
36.0
36.5
37.0
37.5
38.0
38.5
39.0

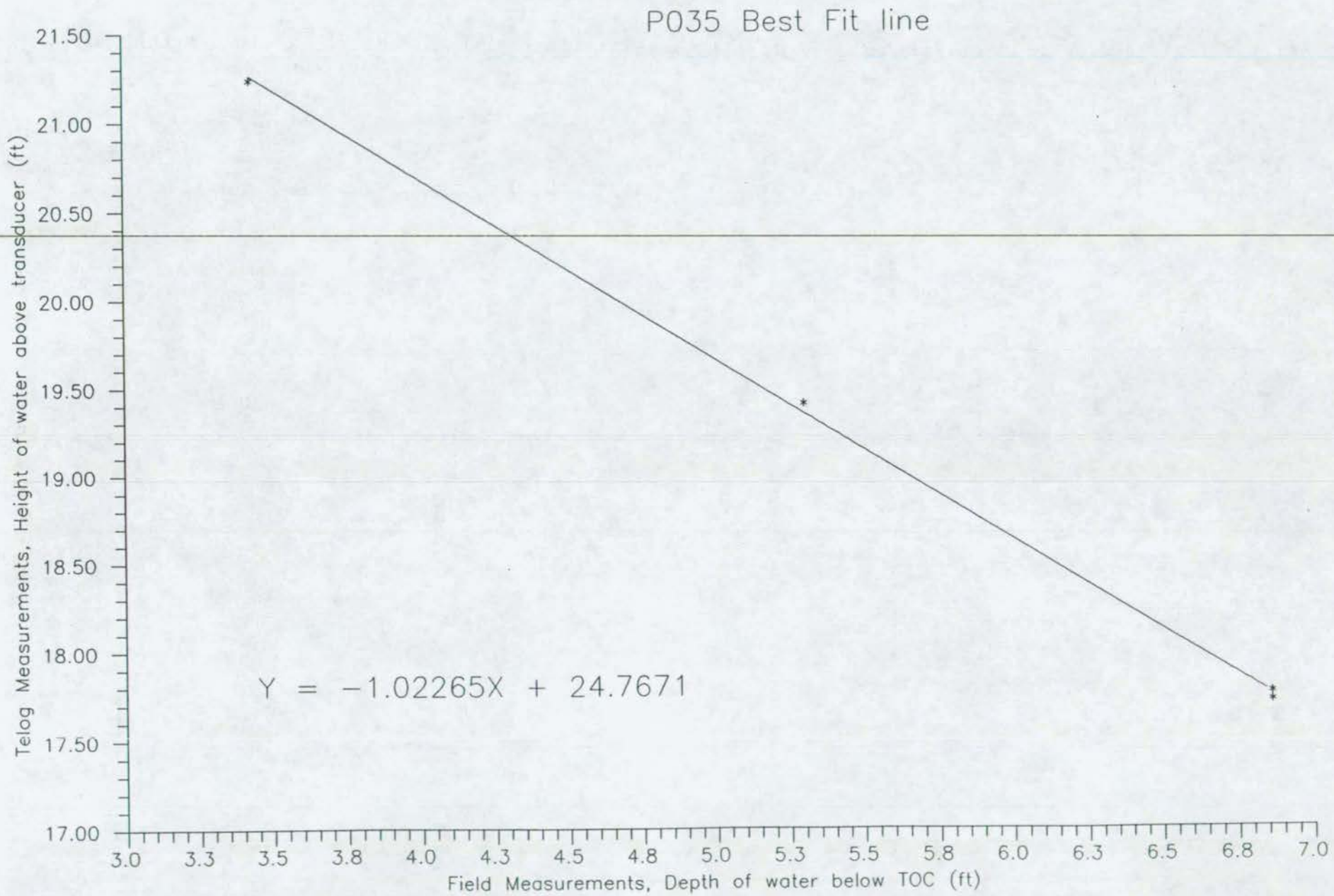

P017 Best Fit line
Y = −1.00271X + 15.9724
Telog Measurements, Height of water above transducer (ft)
Field Measurements, Depth of water below TOC (ft)
11.00
10.50
10.00
9.50
9.00
8.50
8.00
7.50
7.00
6.50
6.00
5.50
5.00
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0

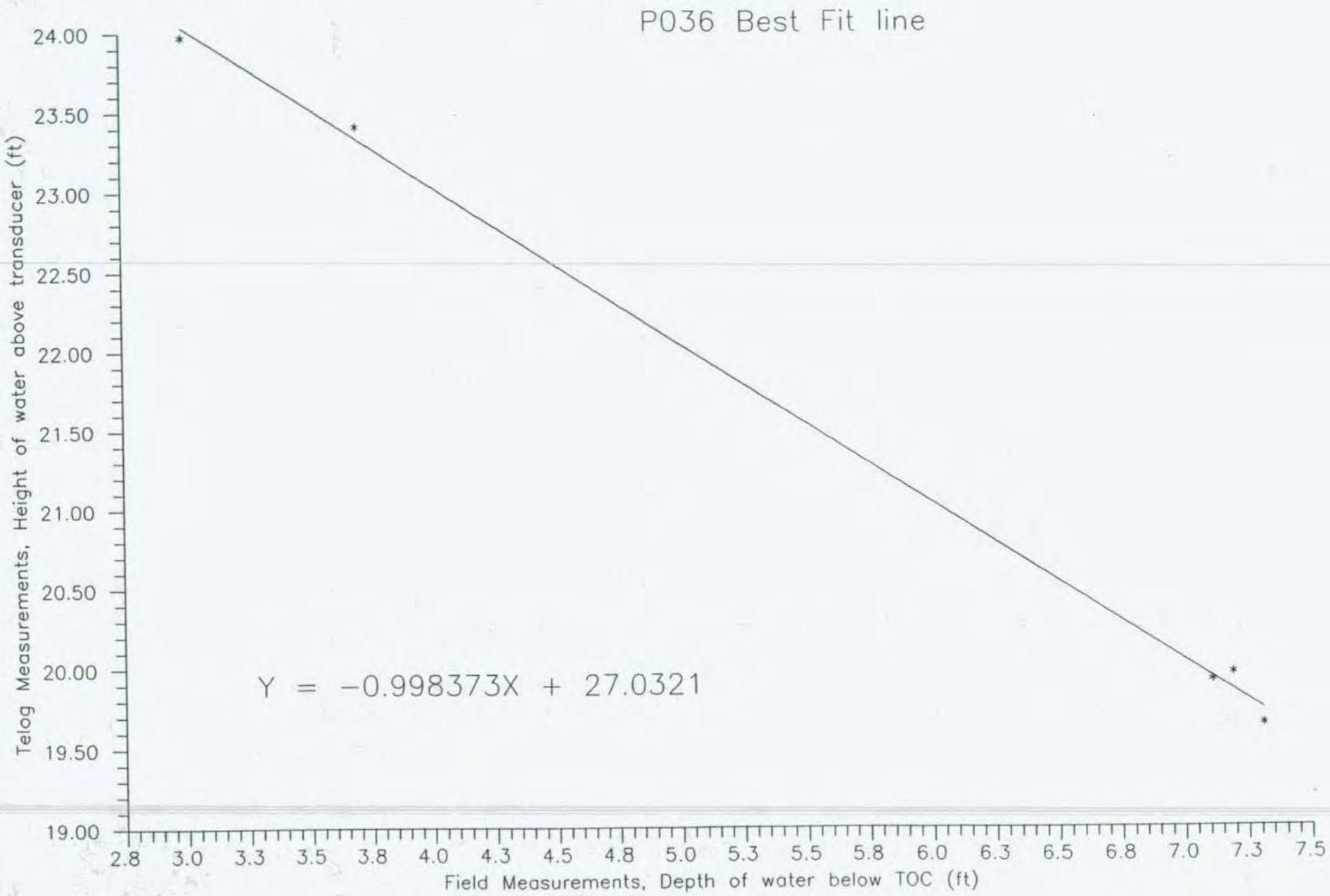

P020 Best Fit line
Y = -1.0411X + 12.0461
Telog Measurements, Height of water above transducer (ft)
6.50
6.00
5.50
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
5.3 5.5 5.8 6.0 6.3 6.5 6.8 7.0 7.3 7.5 7.8 8.0 8.3 8.5 8.8 9.0 9.3 9.5 9.8 10.0 10.3
Field Measurements, Depth of water below TOC (ft)

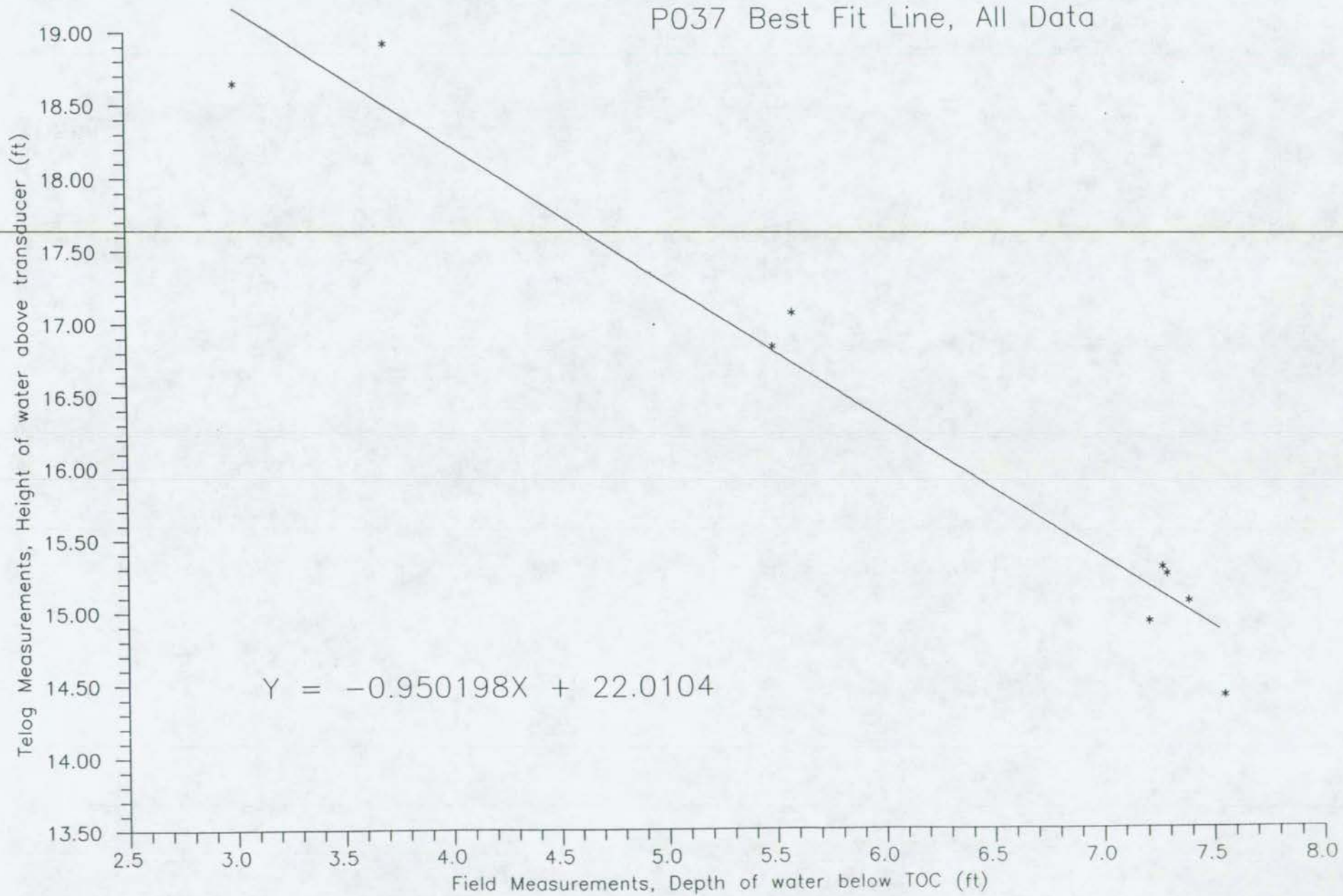

P021 Best Fit line
Y = −1.08457X + 29.9727
Telog Measurements, Height of water above transducer (ft)
10.00
9.50
9.00
8.50
8.00
7.50
7.00
6.50
6.00
5.50
5.00
4.50
18.3 18.5 18.8 19.0 19.3 19.5 19.8 20.0 20.3 20.5 20.8 21.0 21.3 21.5 21.8 22.0 22.3 22.5 22.8
Field Measurements, Depth of water below TOC (ft)

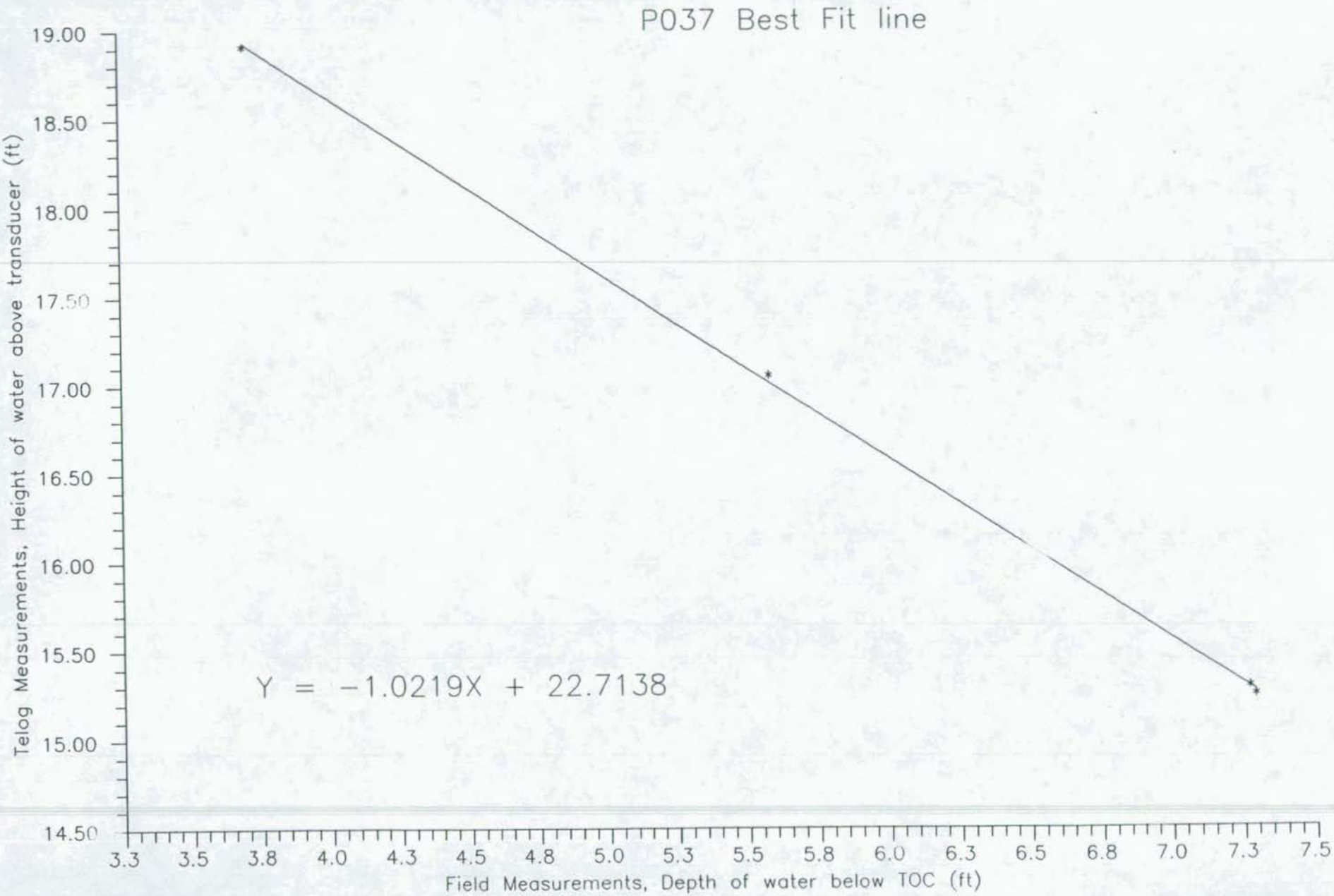

P035 Best Fit line
Y = -0.875407X + 23.4577
Telog Measurements, Height of water above transducer (ft)
21.50
21.00
20.50
20.00
19.50
19.00
18.50
18.00
17.50
17.00
16.50
2.5
2.8
3.0
3.3
3.5
3.8
4.0
4.3
4.5
4.8
5.0
5.3
5.5
5.8
6.0
6.3
6.5
6.8
7.0
7.3
Field Measurements, Depth of water below TOC (ft)

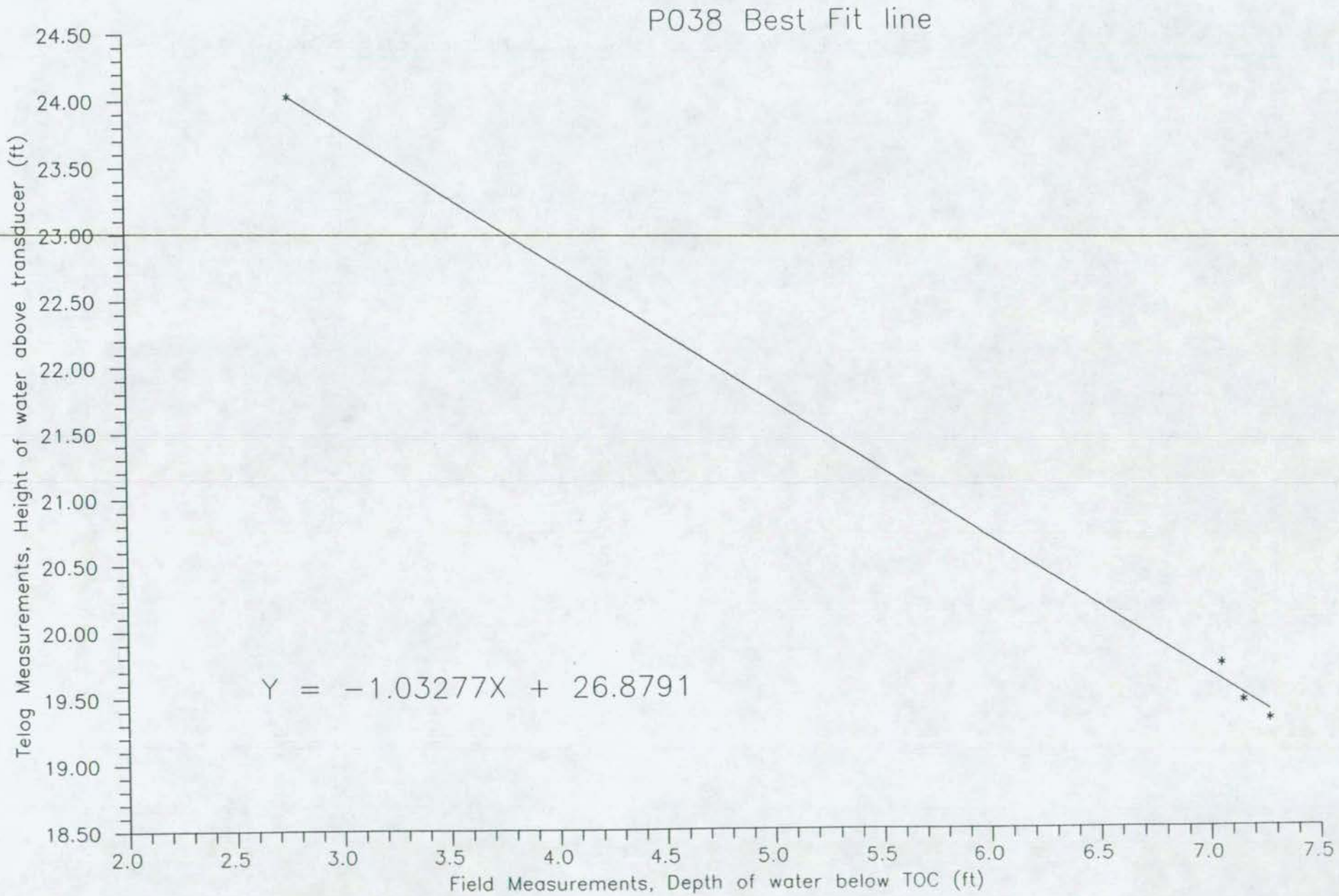

P035 Best Fit Line, All Data
Y = -0.936429X + 24.0199
Telog Measurements, Height of water above transducer (ft)
21.50
21.00
20.50
20.00
19.50
19.00
18.50
18.00
17.50
17.00
16.50
2.5
2.8
3.0
3.3
3.5
3.8
4.0
4.3
4.5
4.8
5.0
5.3
5.5
5.8
6.0
6.3
6.5
6.8
7.0
7.3
Field Measurements, Depth of water below TOC (ft)

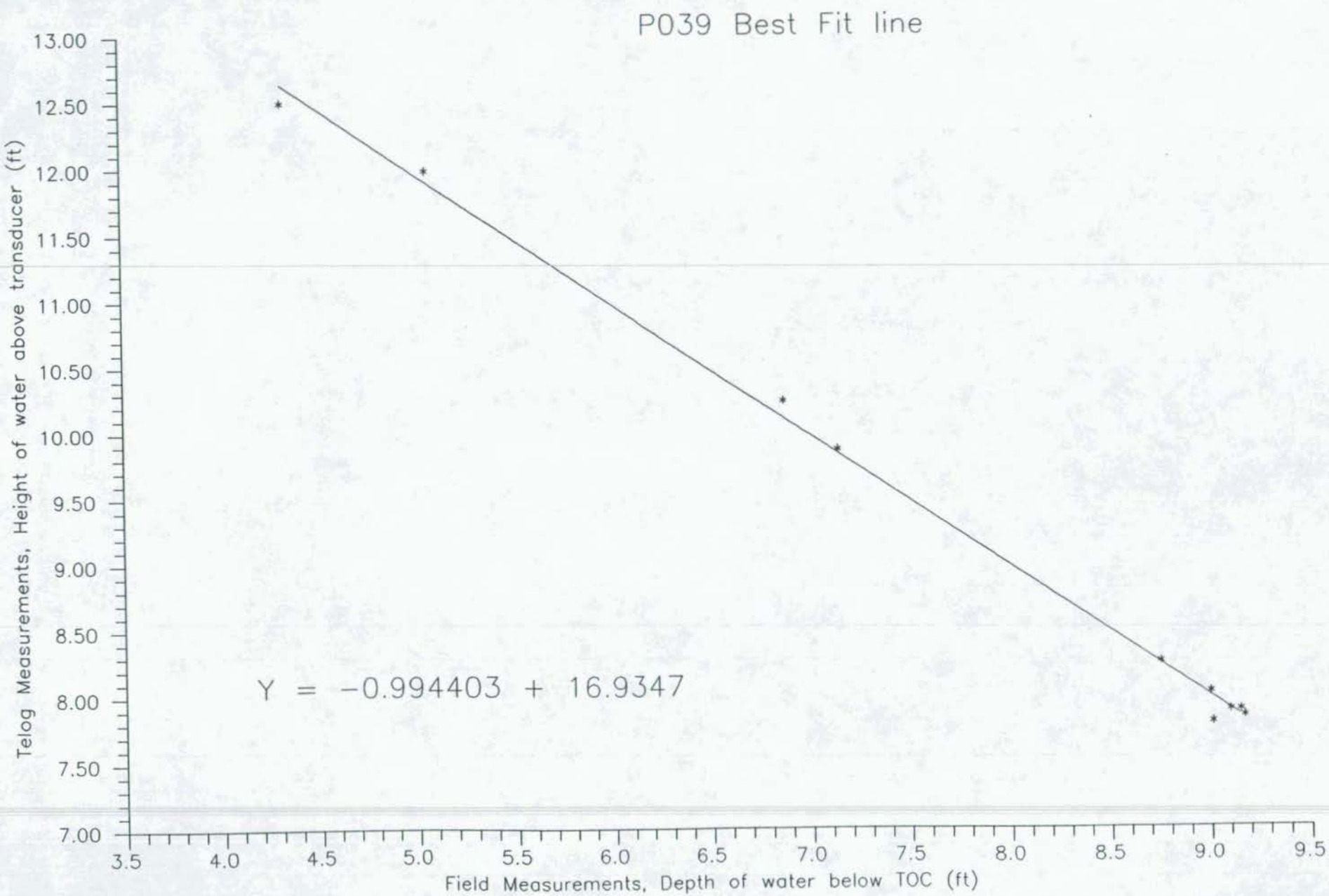

P035 Best Fit line
Telog Measurements, Height of water above transducer (ft)
21.50
21.00
20.50
20.00
19.50
19.00
18.50
18.00
17.50
17.00
Y = −1.02265X + 24.7671
3.0
3.3
3.5
3.8
4.0
4.3
4.5
4.8
5.0
5.3
5.5
5.8
6.0
6.3
6.5
6.8
7.0
Field Measurements, Depth of water below TOC (ft)

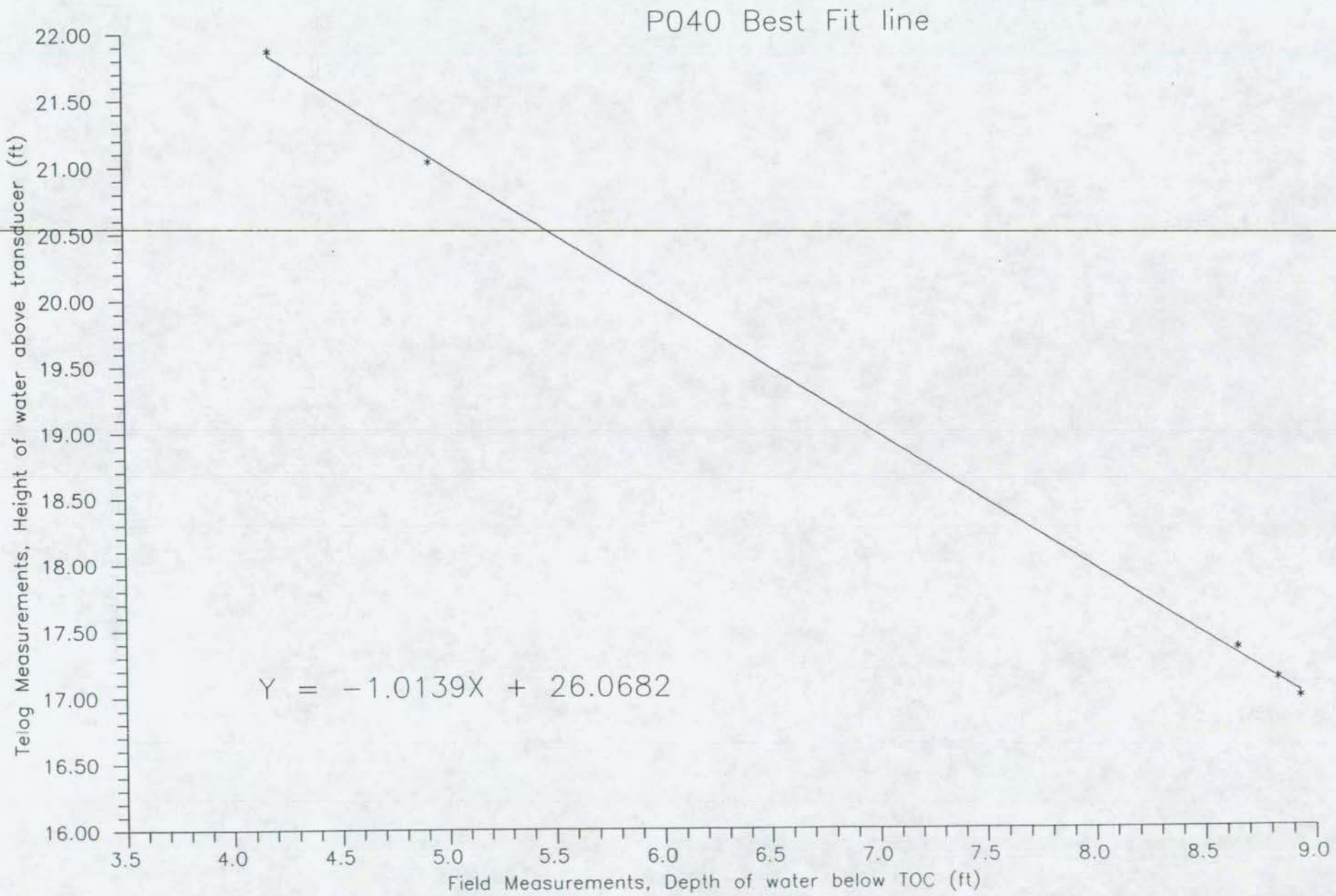

P036 Best Fit line
Y = −0.998373X + 27.0321
Telog Measurements, Height of water above transducer (ft)
24.00
23.50
23.00
22.50
22.00
21.50
21.00
20.50
20.00
19.50
19.00
2.8
3.0
3.3
3.5
3.8
4.0
4.3
4.5
4.8
5.0
5.3
5.5
5.8
6.0
6.3
6.5
6.8
7.0
7.3
7.5
Field Measurements, Depth of water below TOC (ft)

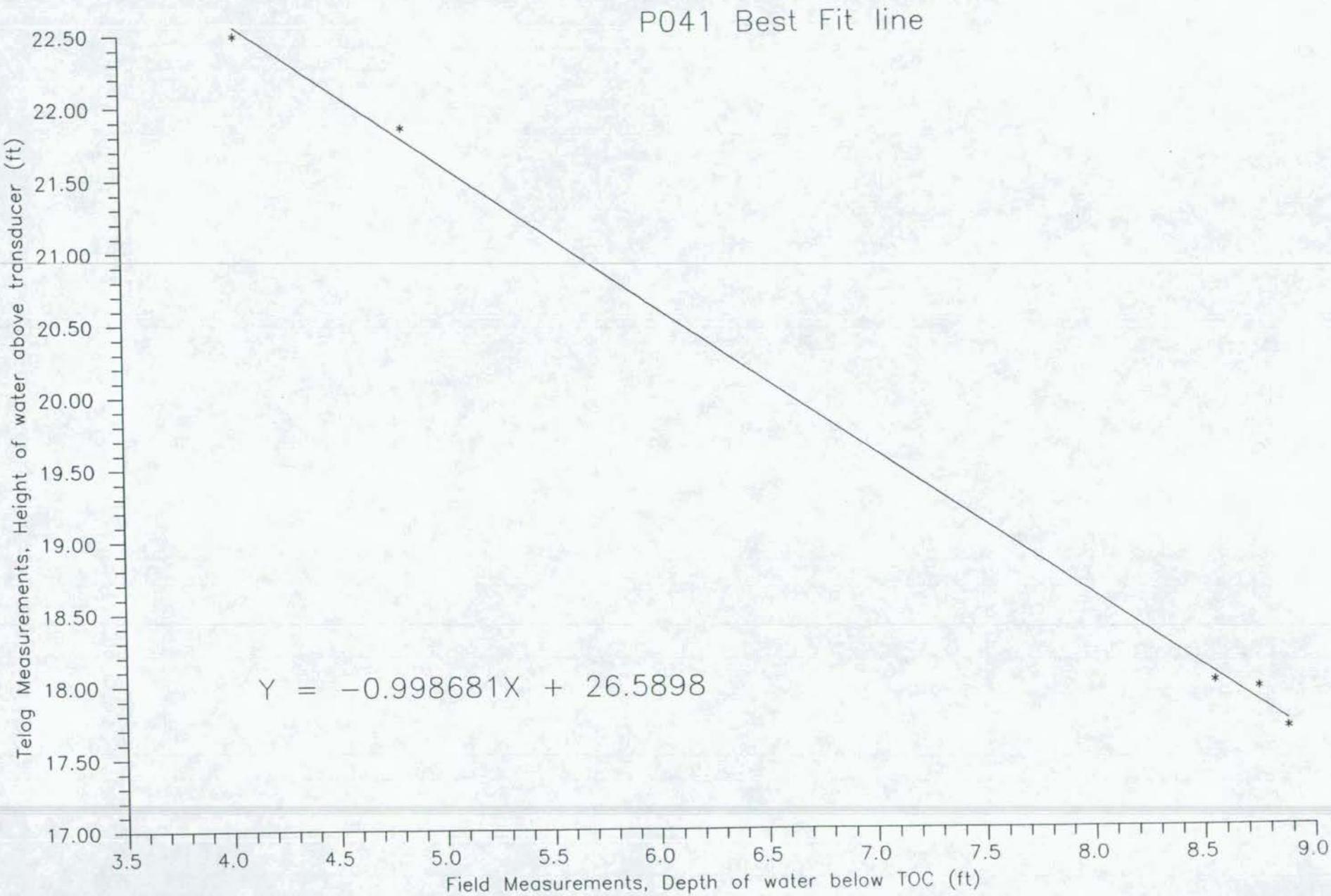

P037 Best Fit Line, All Data
Y = -0.950198X + 22.0104
Telog Measurements, Height of water above transducer (ft)
19.00
18.50
18.00
17.50
17.00
16.50
16.00
15.50
15.00
14.50
14.00
13.50
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
Field Measurements, Depth of water below TOC (ft)

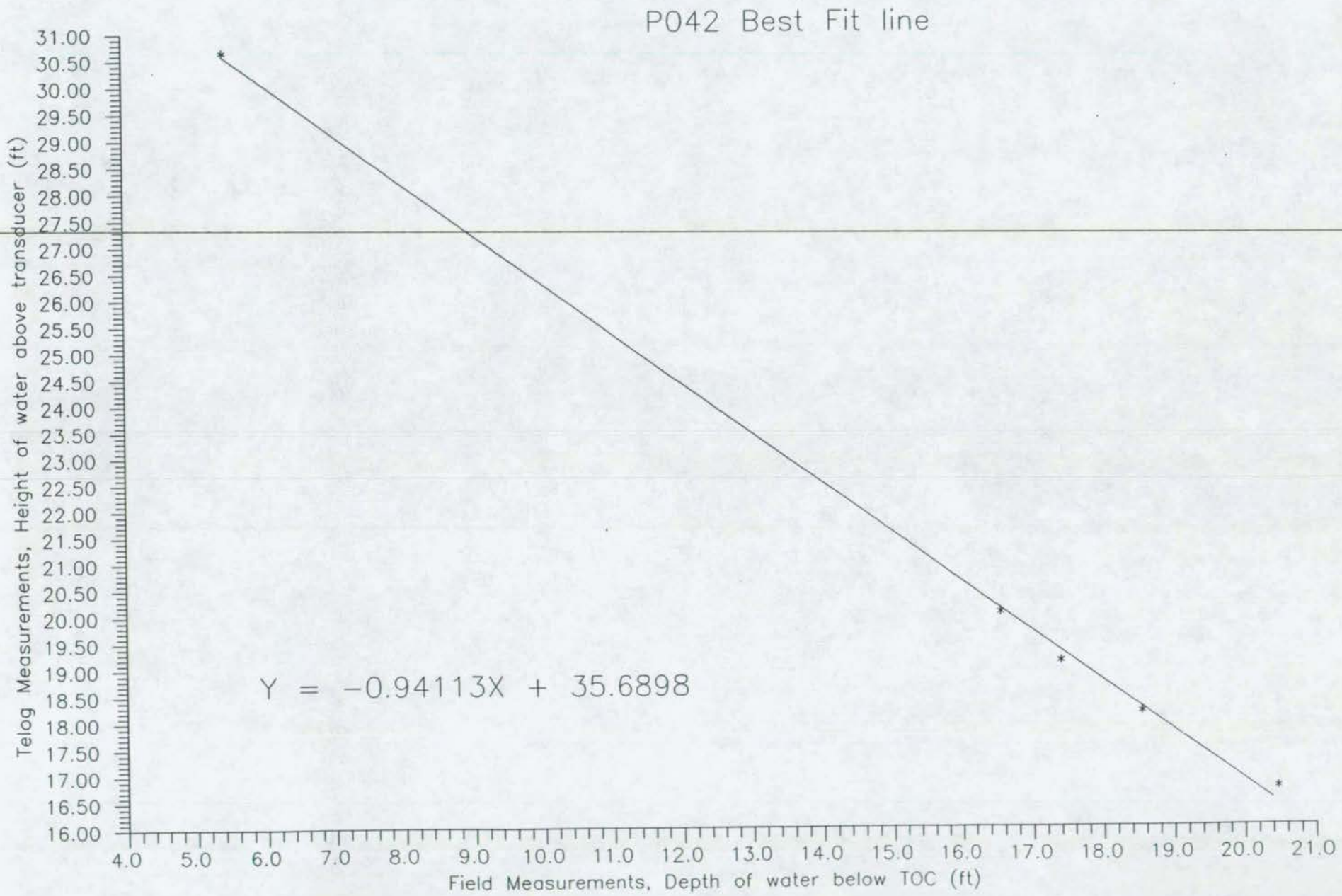

P037 Best Fit line
Y = -1.0219X + 22.7138
Telog Measurements, Height of water above transducer (ft)
19.00
18.50
18.00
17.50
17.00
16.50
16.00
15.50
15.00
14.50
3.3
3.5
3.8
4.0
4.3
4.5
4.8
5.0
5.3
5.5
5.8
6.0
6.3
6.5
6.8
7.0
7.3
7.5
Field Measurements, Depth of water below TOC (ft)


P038 Best Fit line
Y = −1.03277X + 26.8791
Telog Measurements, Height of water above transducer (ft)
Field Measurements, Depth of water below TOC (ft)
24.50
24.00
23.50
23.00
22.50
22.00
21.50
21.00
20.50
20.00
19.50
19.00
18.50
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5

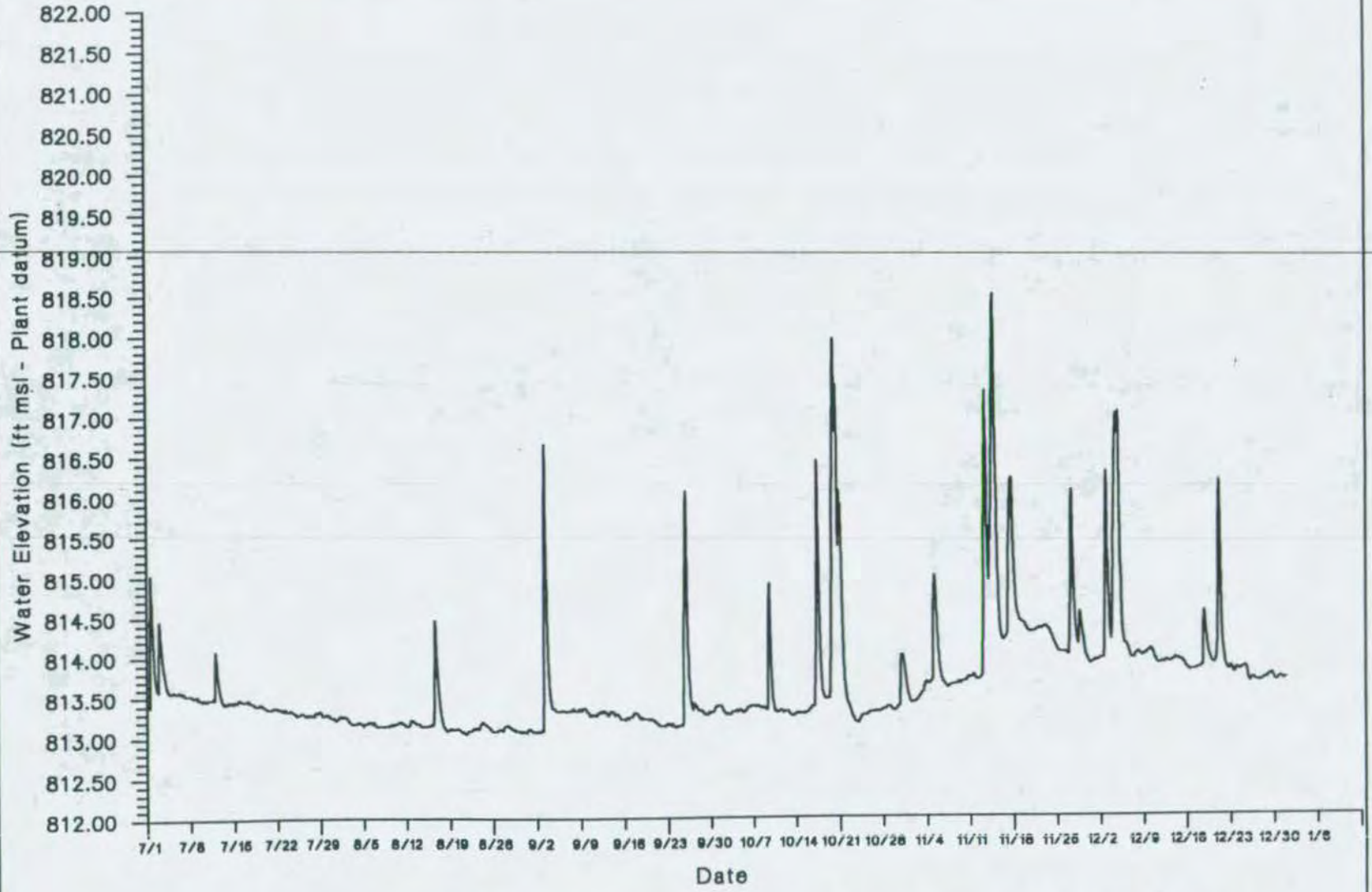

P039 Best Fit line
Y = -0.994403 + 16.9347
Telog Measurements, Height of water above transducer (ft)
13.00
12.50
12.00
11.50
11.00
10.50
10.00
9.50
9.00
8.50
8.00
7.50
7.00
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
Field Measurements, Depth of water below TOC (ft)


P040 Best Fit line
Y = -1.0139X + 26.0682
Telog Measurements, Height of water above transducer (ft)
22.00
21.50
21.00
20.50
20.00
19.50
19.00
18.50
18.00
17.50
17.00
16.50
16.00
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
Field Measurements, Depth of water below TOC (ft)


P041 Best Fit line
Y = −0.998681X + 26.5898
Telog Measurements, Height of water above transducer (ft)
22.50
22.00
21.50
21.00
20.50
20.00
19.50
19.00
18.50
18.00
17.50
17.00
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
Field Measurements, Depth of water below TOC (ft)

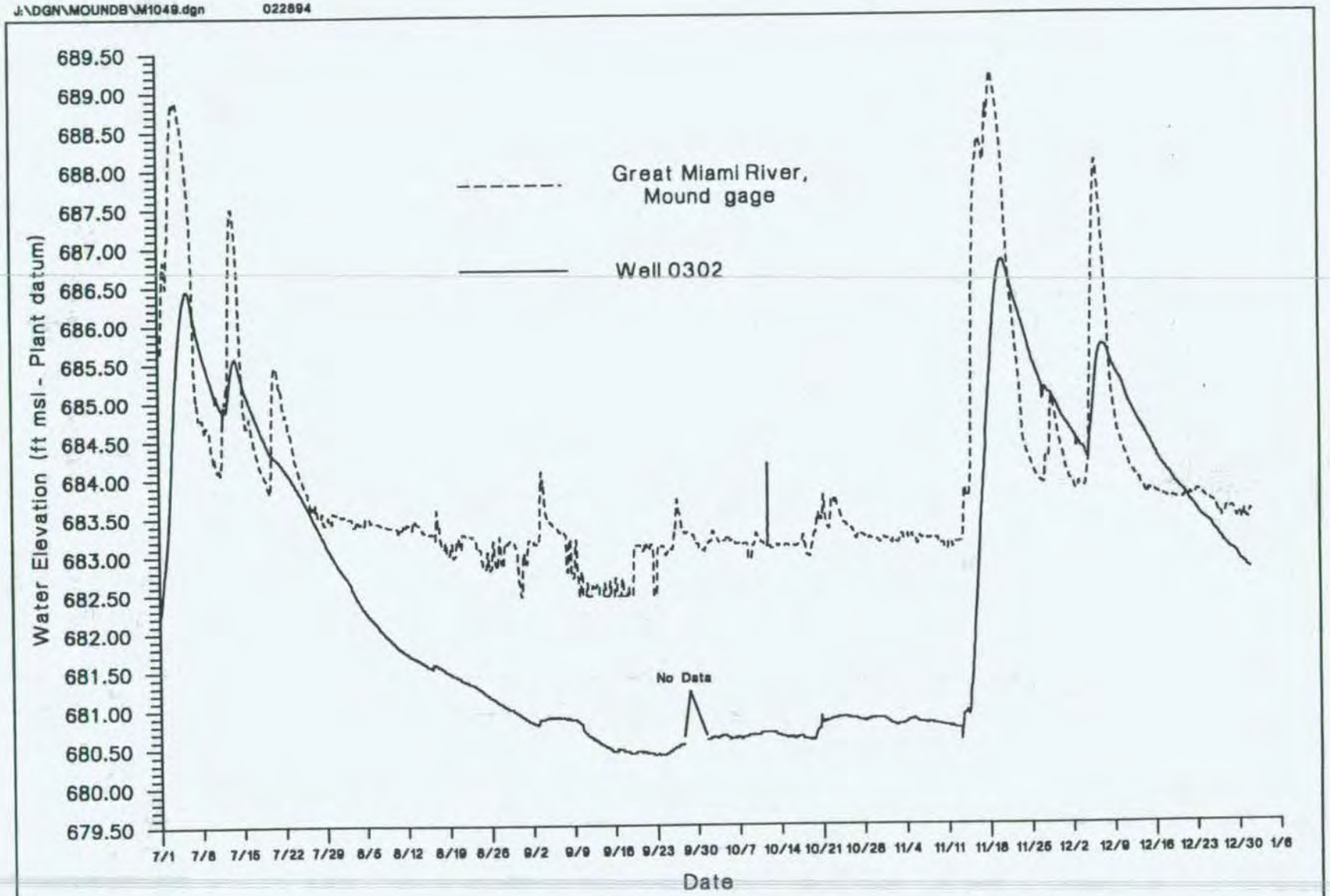

P042 Best Fit line
Y = -0.94113X + 35.6898
Telog Measurements, Height of water above transducer (ft)
31.00
30.50
30.00
29.50
29.00
28.50
28.00
27.50
27.00
26.50
26.00
25.50
25.00
24.50
24.00
23.50
23.00
22.50
22.00
21.50
21.00
20.50
20.00
19.50
19.00
18.50
18.00
17.50
17.00
16.50
16.00
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
20.0
21.0
Field Measurements, Depth of water below TOC (ft)

J:\DGN\MOUNDB\M1048.dgn 022894



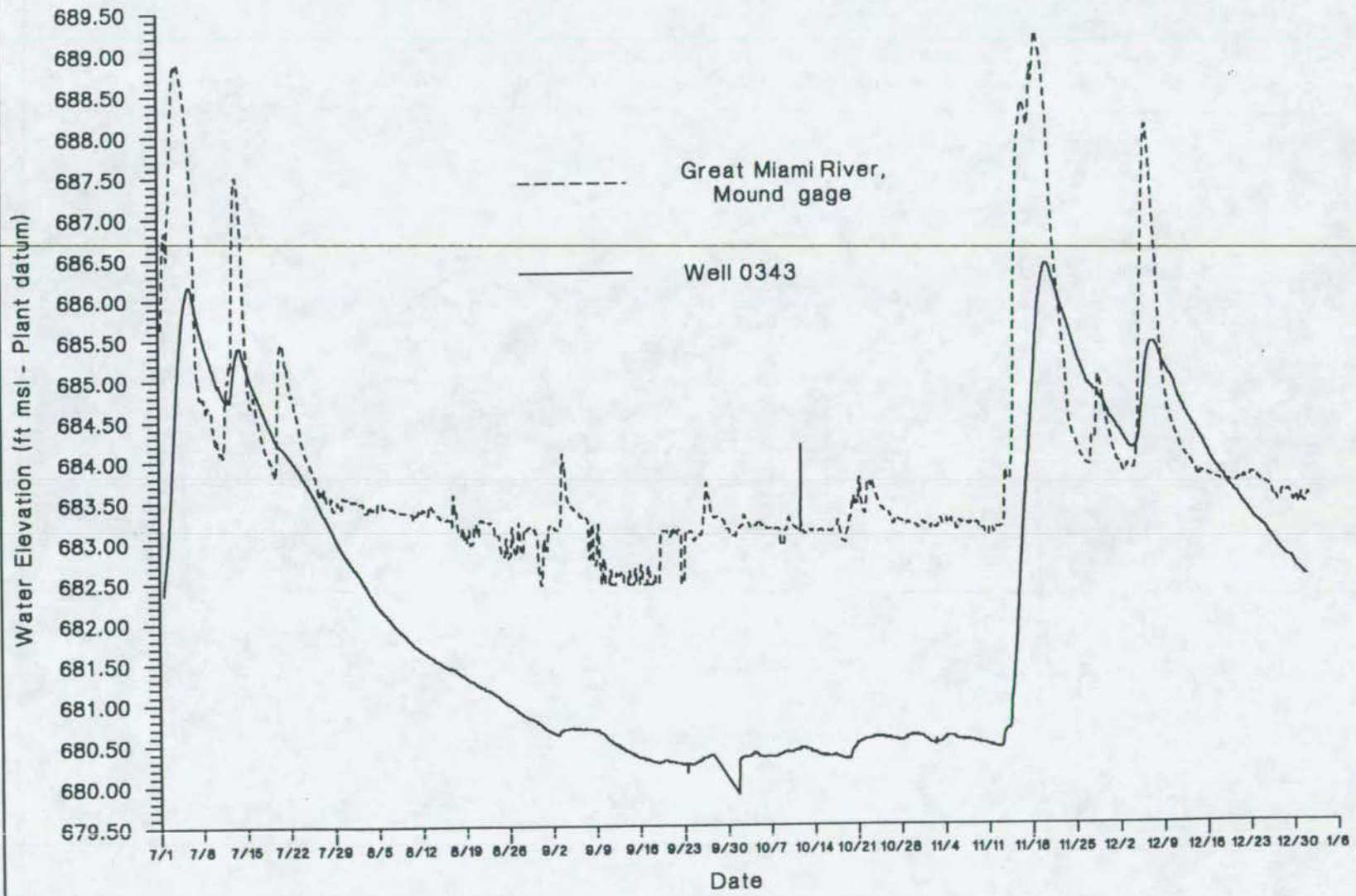
Hydrograph for well 0116 from 1 July 1993 through 31 December 1993.

J:\DGN\MOUNDB\M1049.dgn 022894



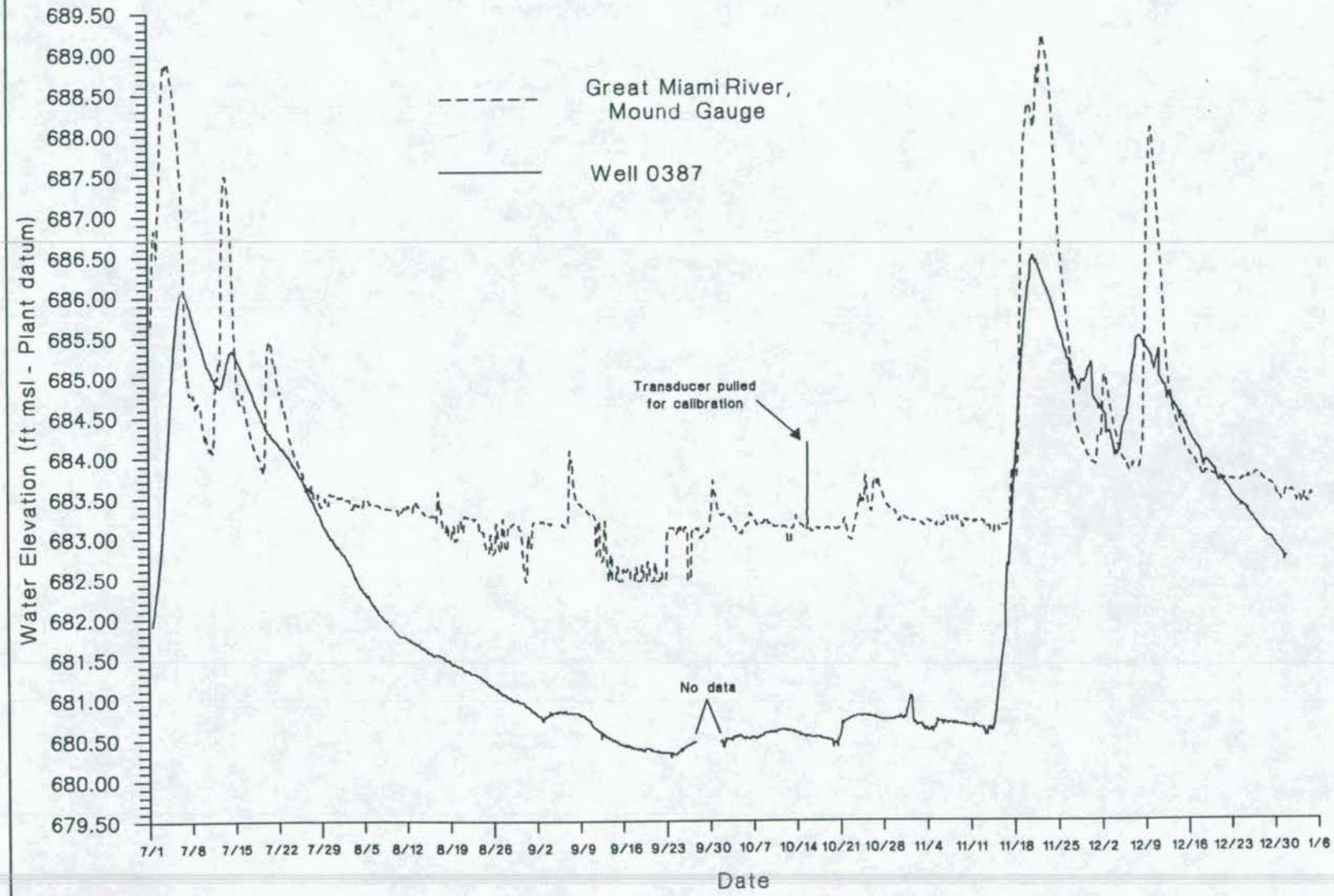
Comparison of groundwater elevations at well 0302 with stage in the Great Miami River (Mound gage) from 1 July 1993 through 31 December 1993.

J:\DGN\MOUNDB\M1041.dgn 022894



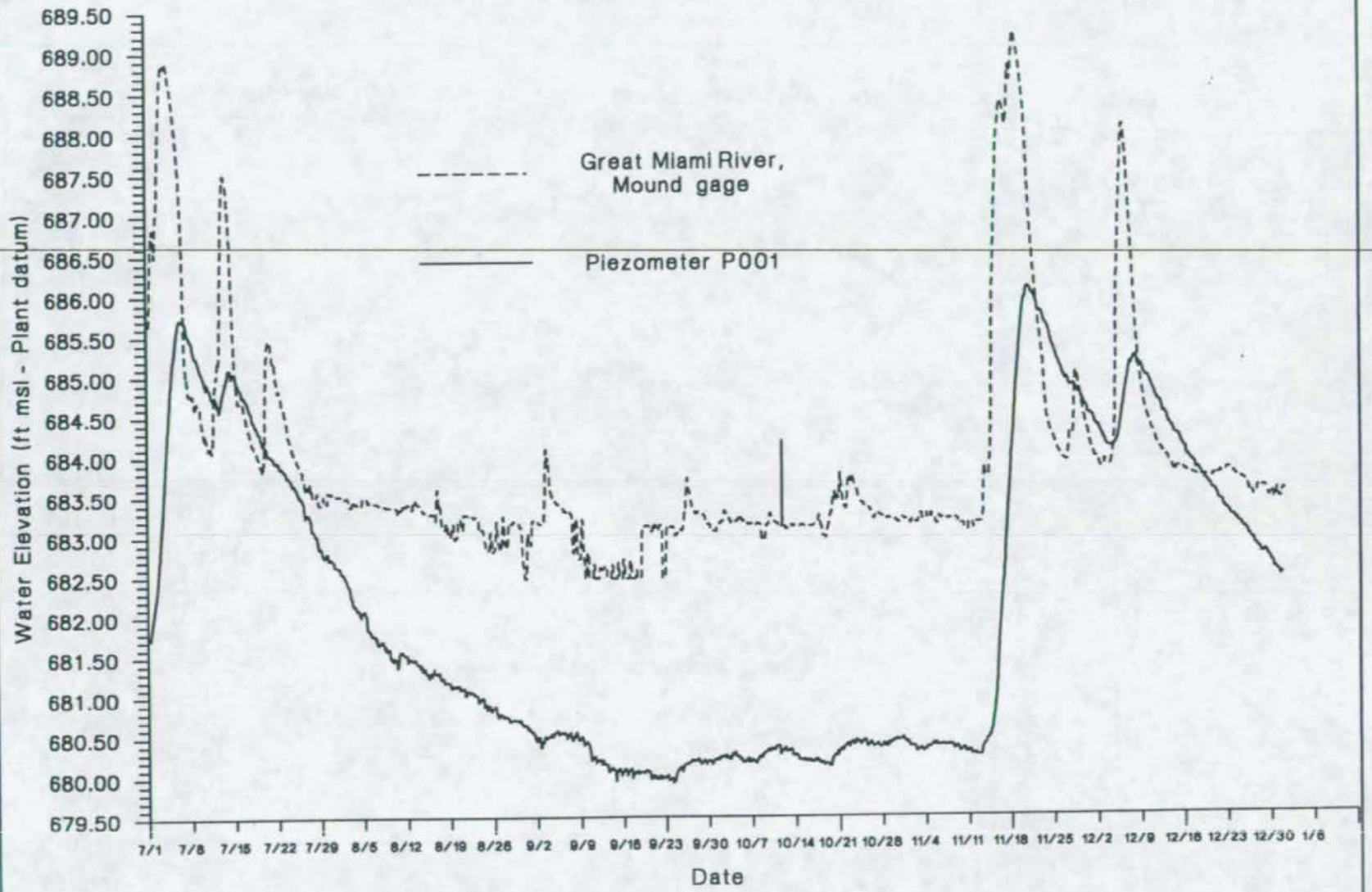
Comparison of groundwater elevations at well 0343 with stage in the Great Miami River (Mound gage) from 1 July 1993 through 31 December 1993.

J:\DGN\MOUNDB\M1029.dgn 031594



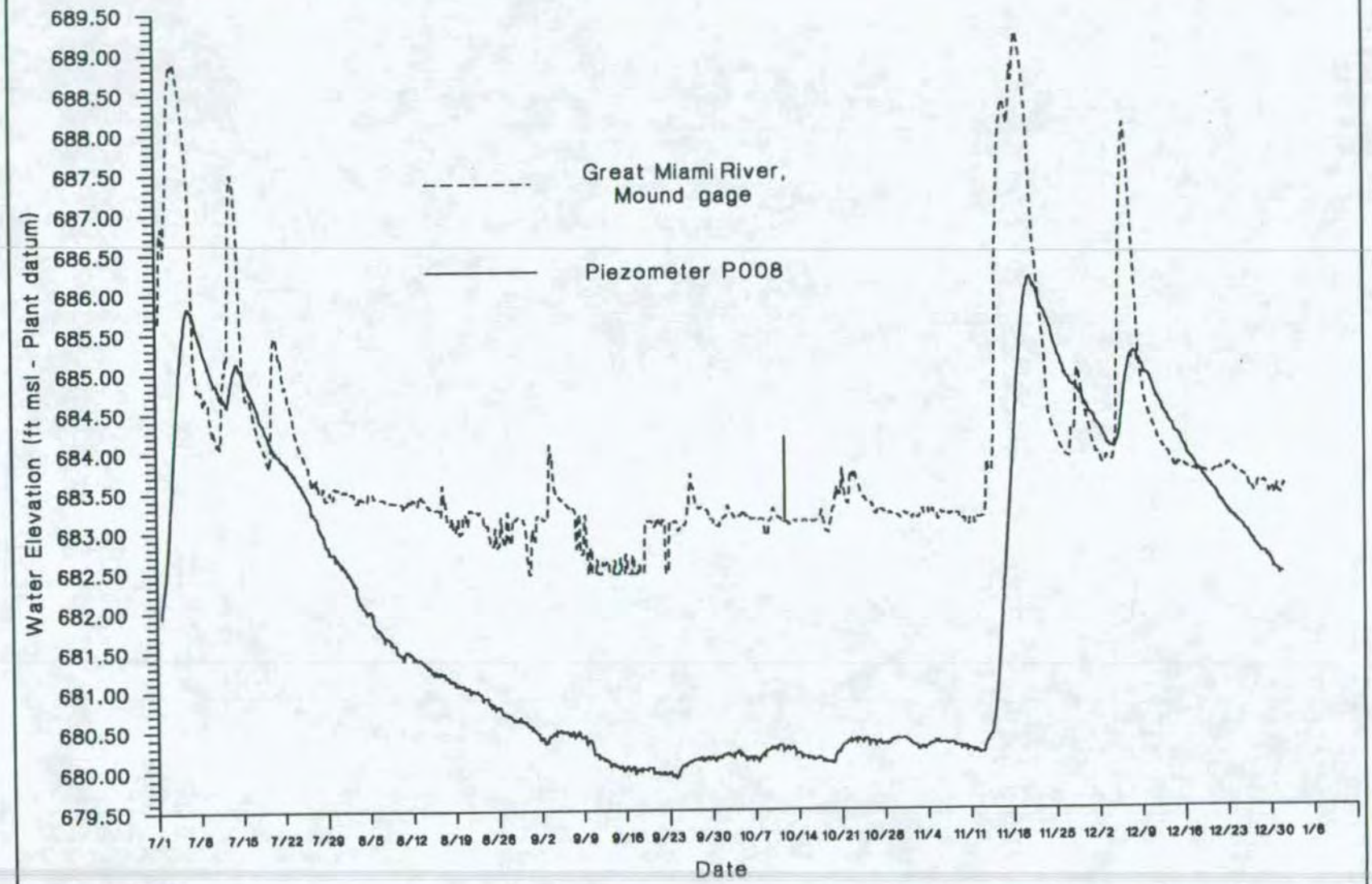
Comparison of groundwater elevations at well 0387 with stage in the Great Miami River from 1 July 1993 through 31 December 1993.

J:\DGN\MOUNDB\M1050.dgn 022894



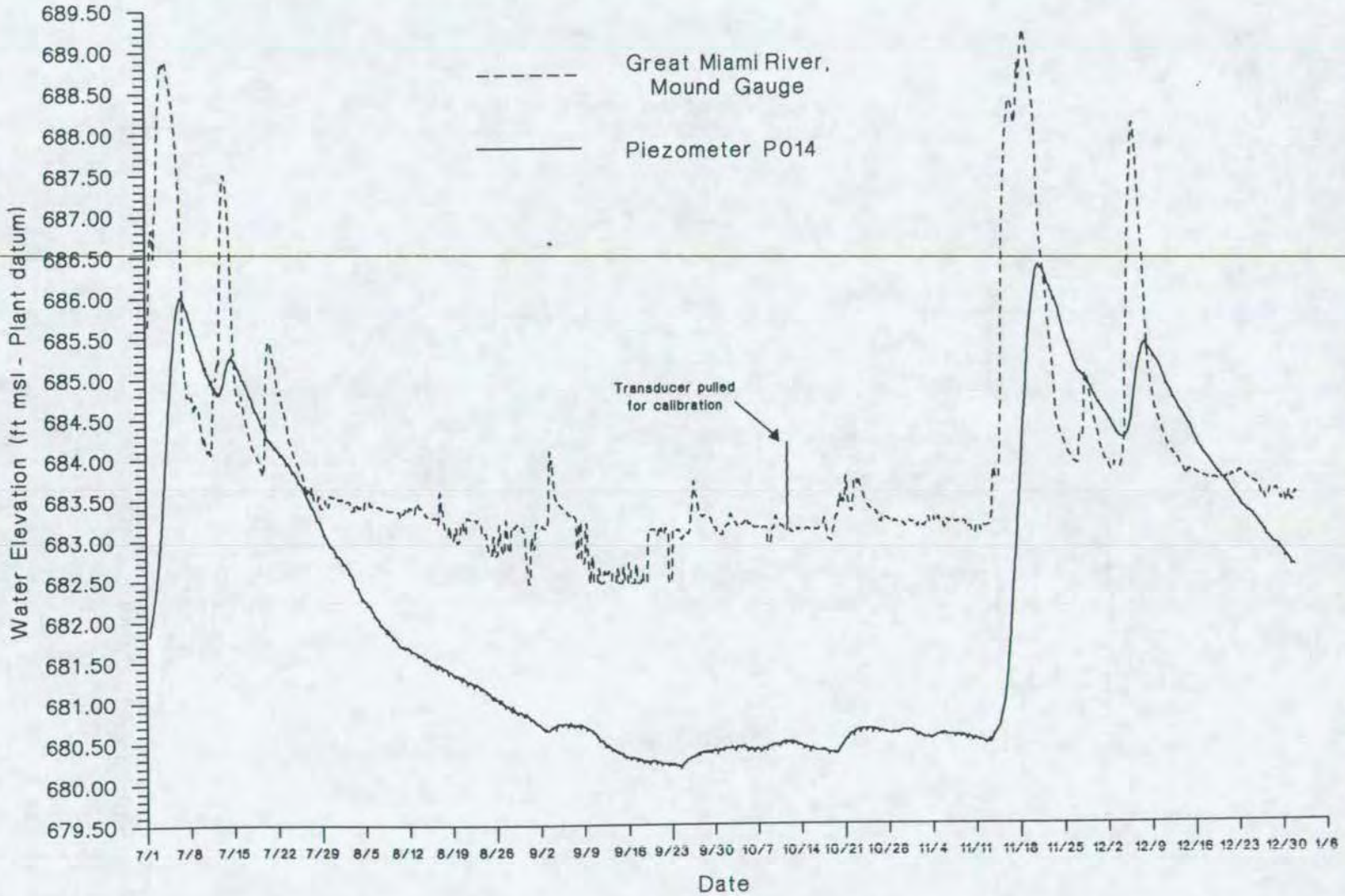
Comparison of groundwater elevations in piezometer P001 with stage in the Great Miami River (Mound gage) from 1 July 1993 through 31 December 1993.

J:\DGN\MOUNDB\M1047.dgn 022894



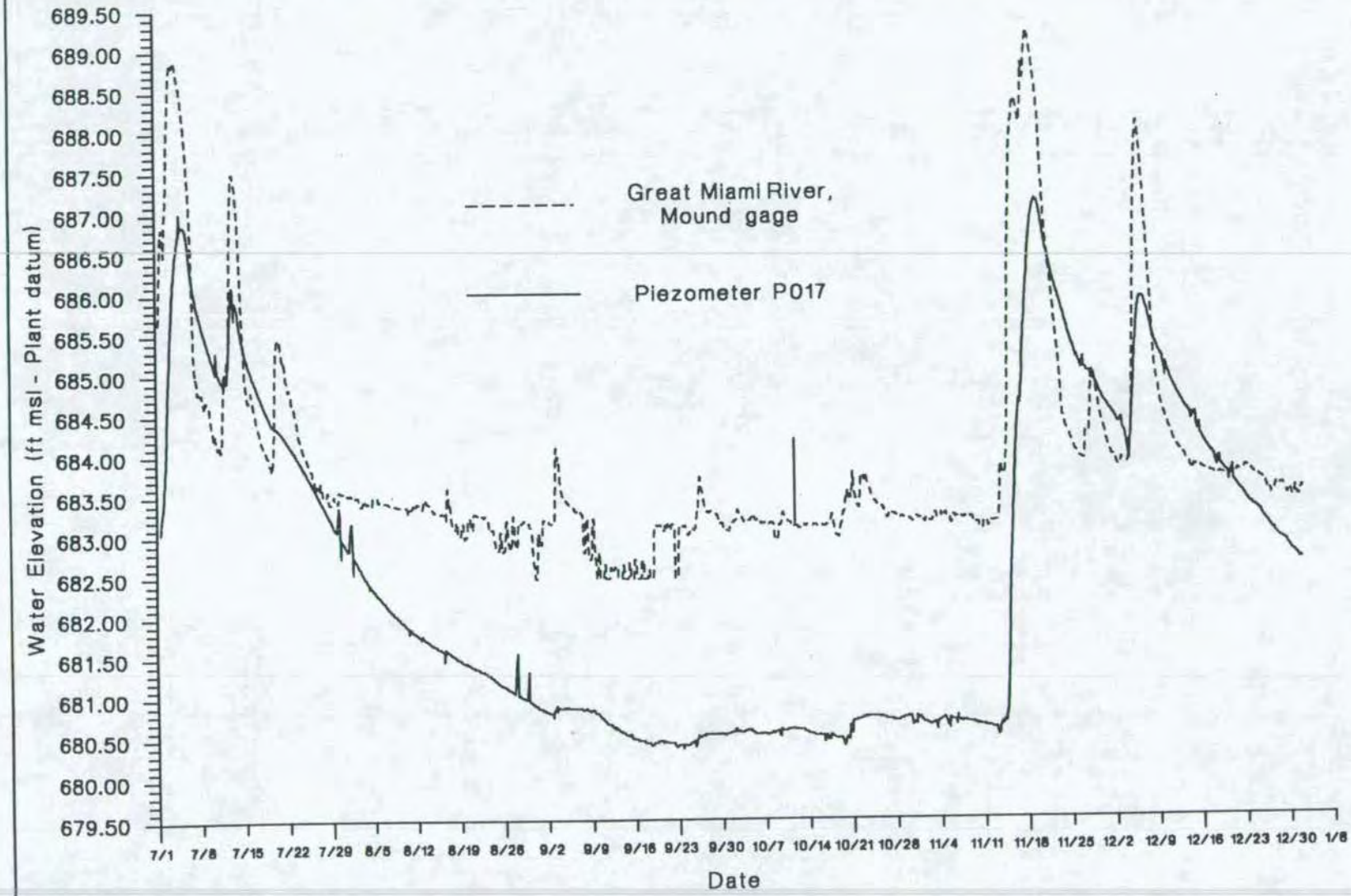
Comparison of groundwater elevations in piezometer P008 with stage in the Great Miami River (Mound gage) from 1 July 1993 through 31 December 1993.

J:\DGN\MOUNDB\M1025.dgn 031594



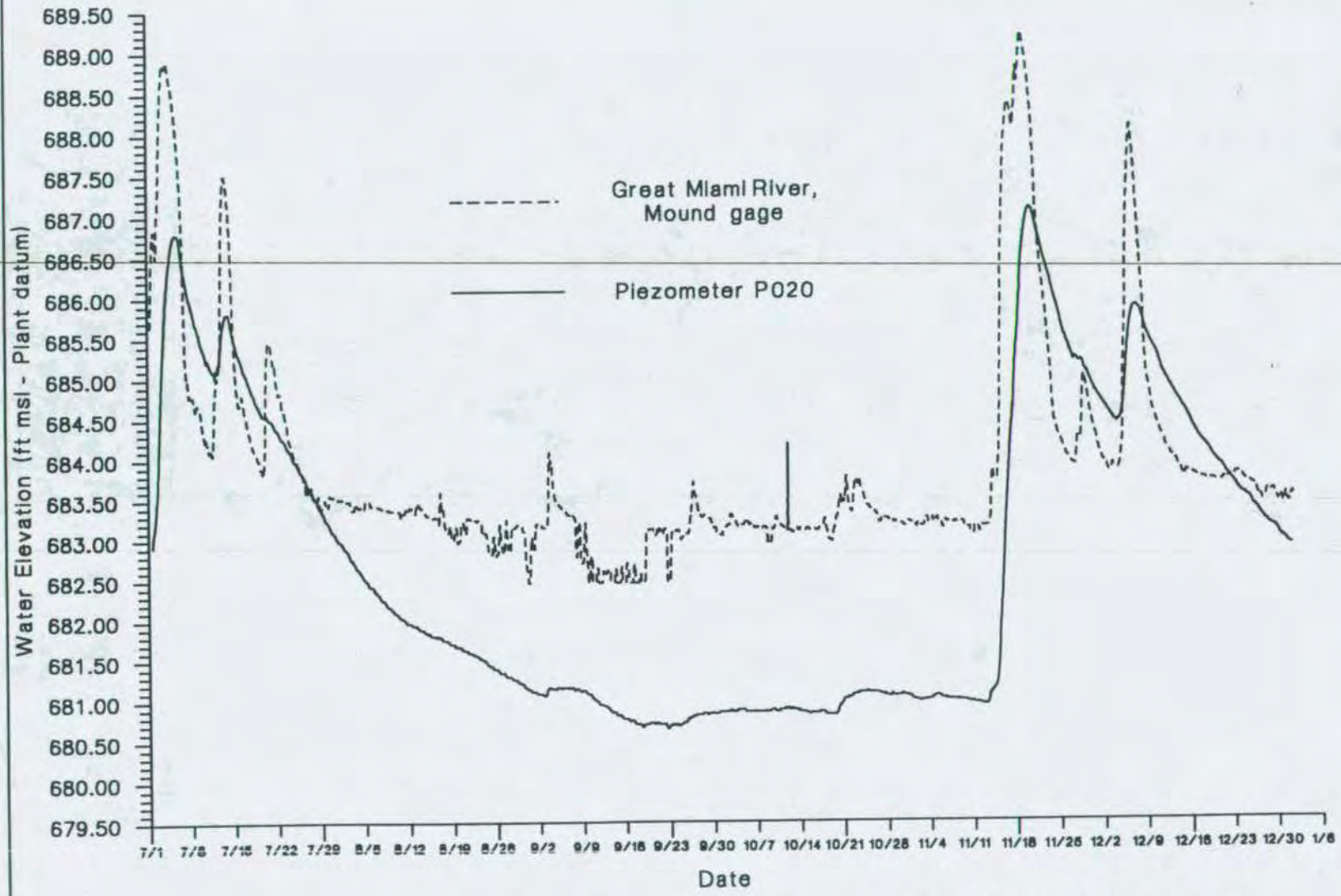
Comparison of groundwater elevations in piezometer P014 with stage in the Great Miami River from 1 July 1993 through 31 December 1993.

J:\DGN\MOUNDB\M1058.dgn 030294



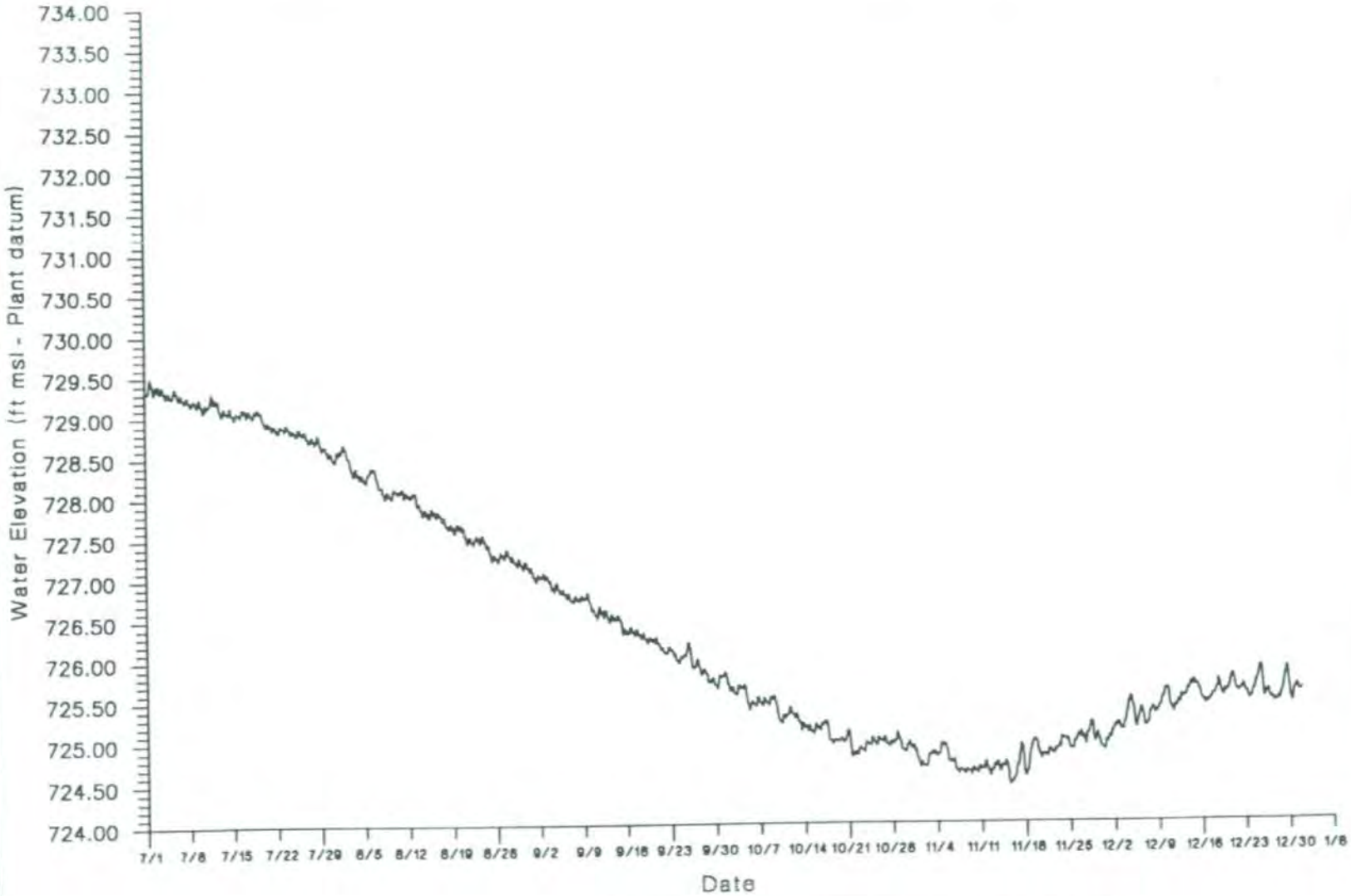
Comparison of groundwater elevations in piezometer P017 with stage in the Great Miami River (Mound gage) from 1 July 1993 through 31 December 1993.

J:\DGN\MOUNDB\M1062.dgn 030194



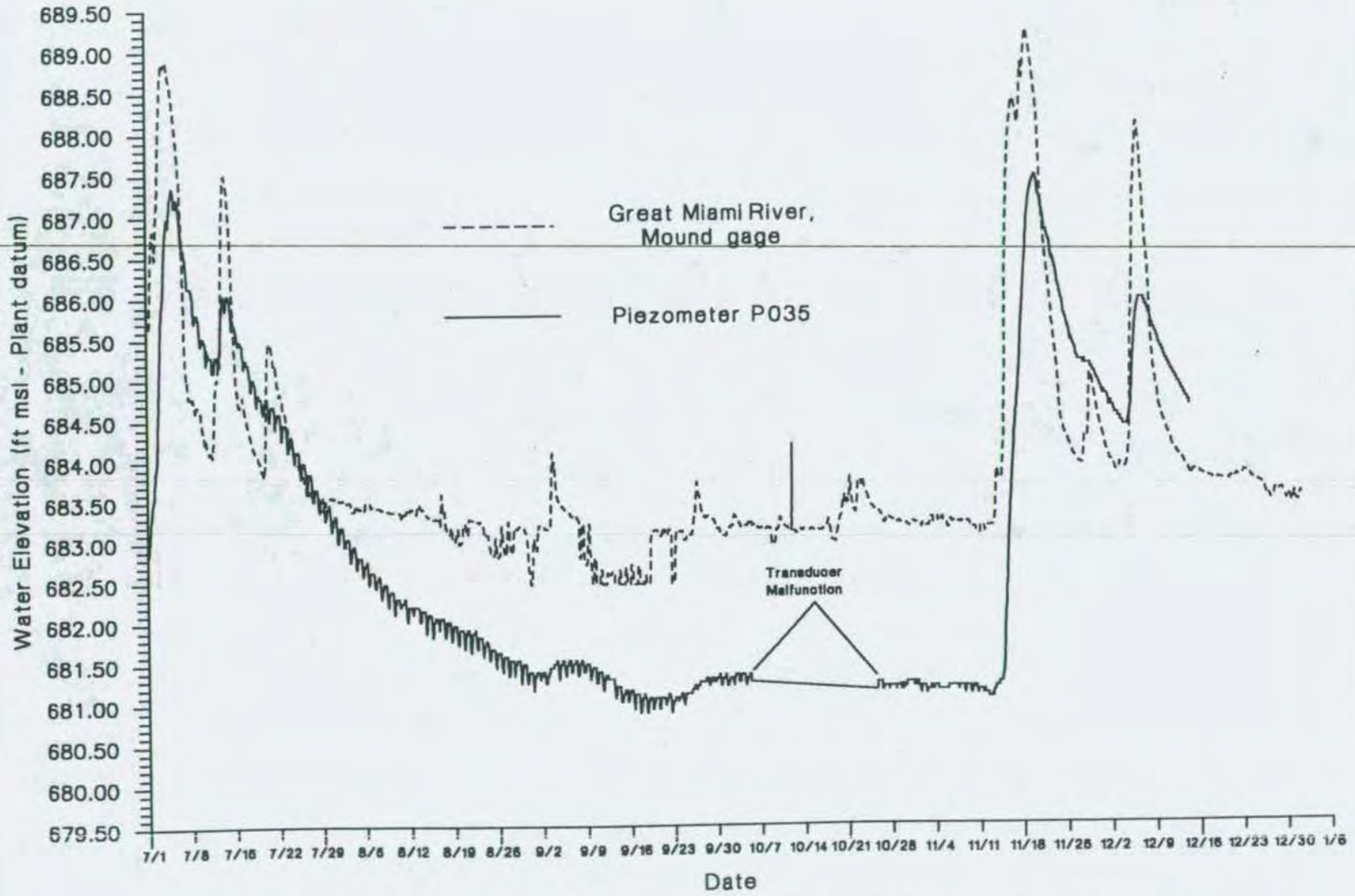
Comparison of groundwater elevations in piezometer P020 with stage in the Great Miami River (Mound gage) from 1 July 1993 through 31 December 1993.

J:\DGN\MOUNDB\M1081.dgn 030294



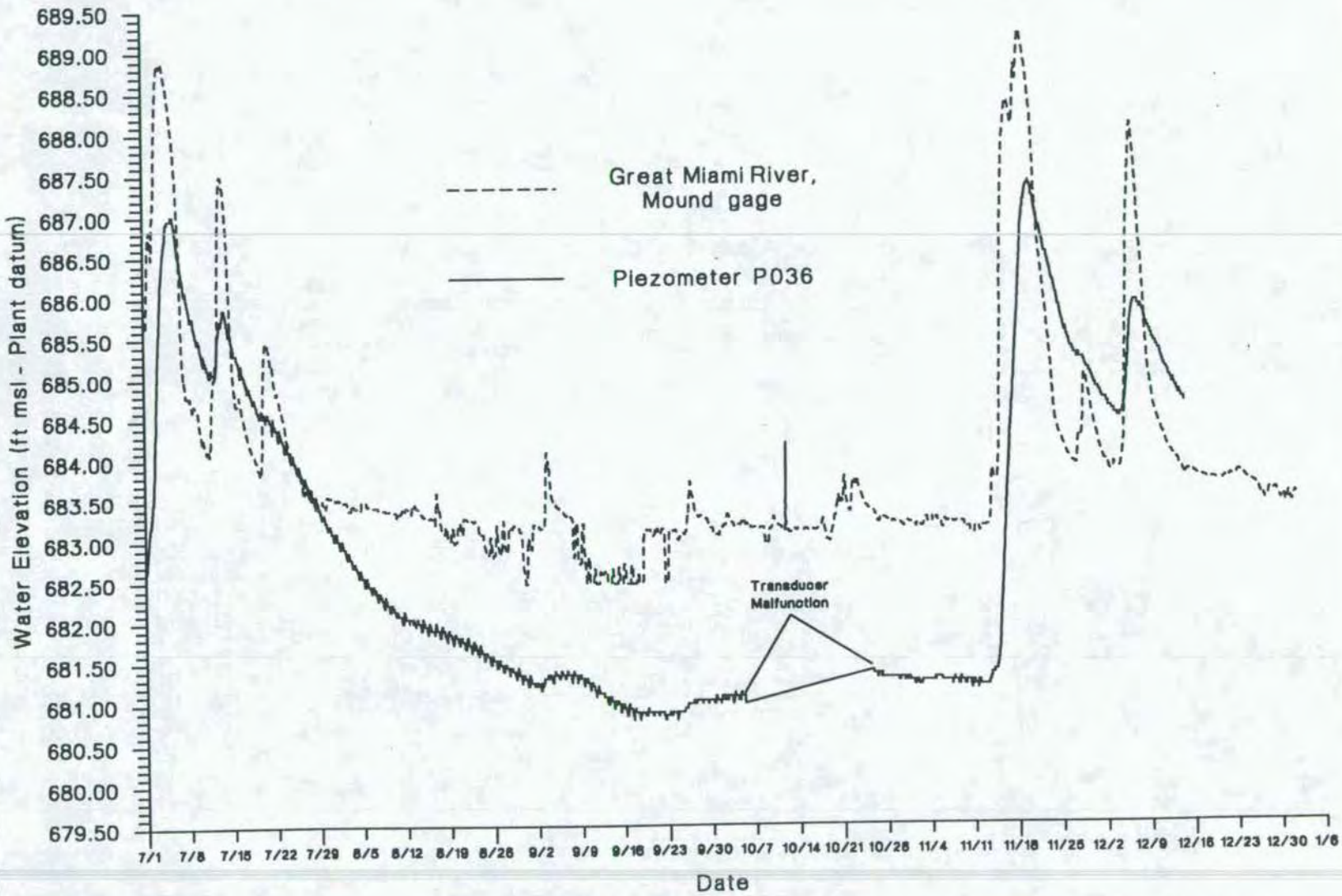
Groundwater elevations in piezometer P021
from 1 July 1993 through 31 December 1993.

J:\DGN\MOUNDB\M1043.dgn 022894



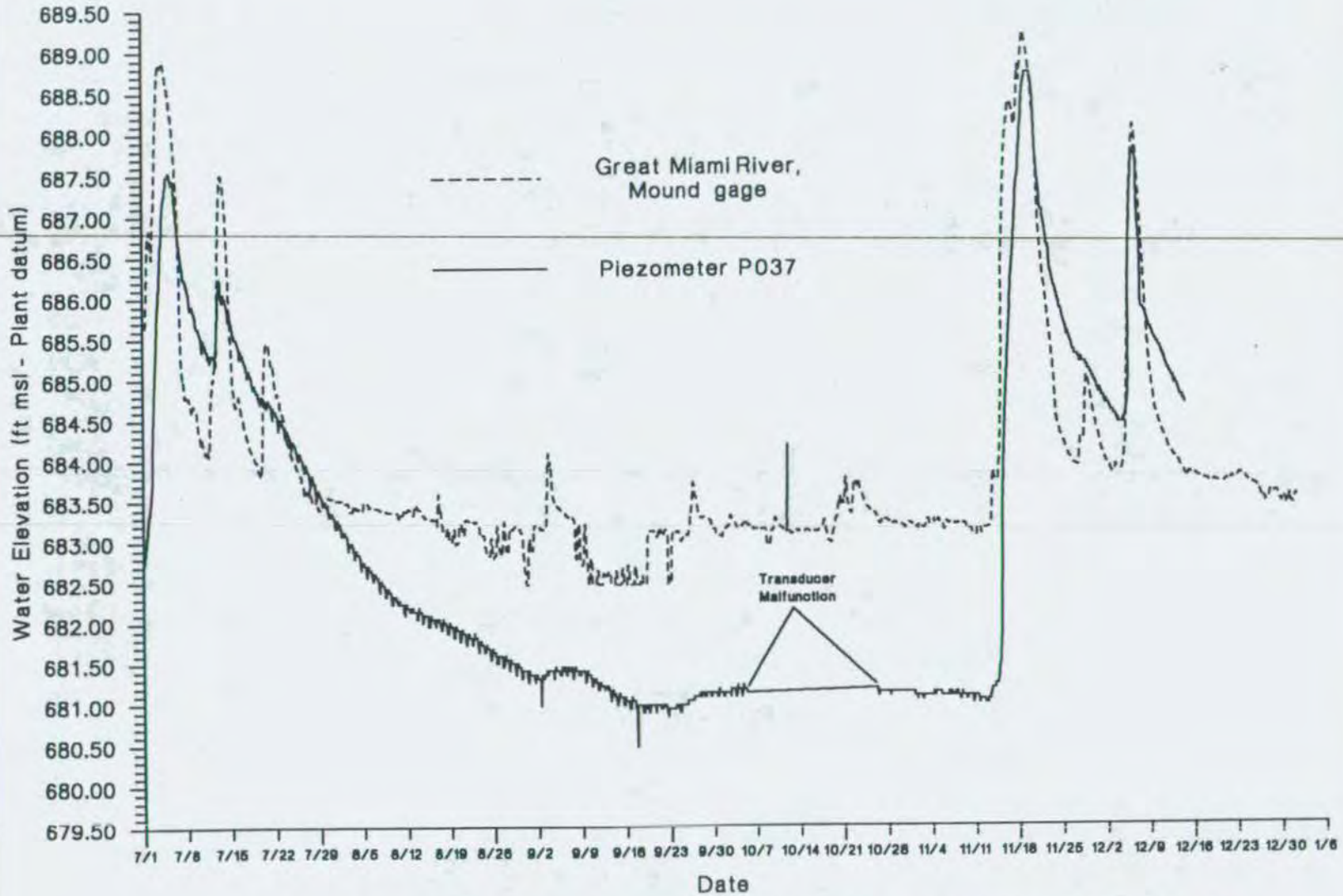
Comparison of groundwater elevations in piezometer P035 with stage in the Great Miami River (Mound gage) from 1 July 1993 through 31 December 1993.

J:\DGN\MOUNDB\M1044.dgn 022894



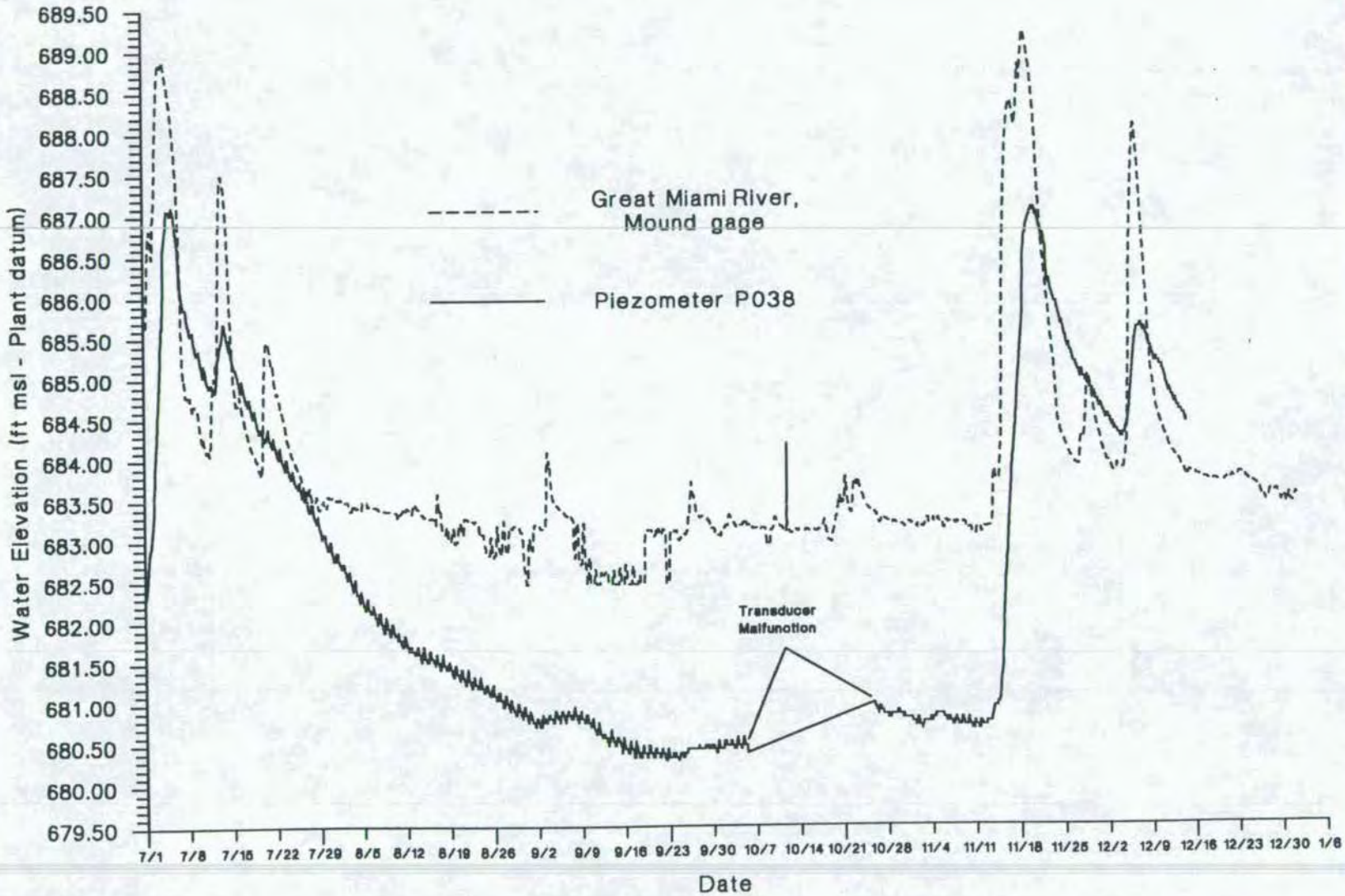
Comparison of groundwater elevations in piezometer P036 with stage in the Great Miami River (Mound gage) from 1 July 1993 through 31 December 1993.

J:\DGN\MOUNDB\M1048.dgn 022894



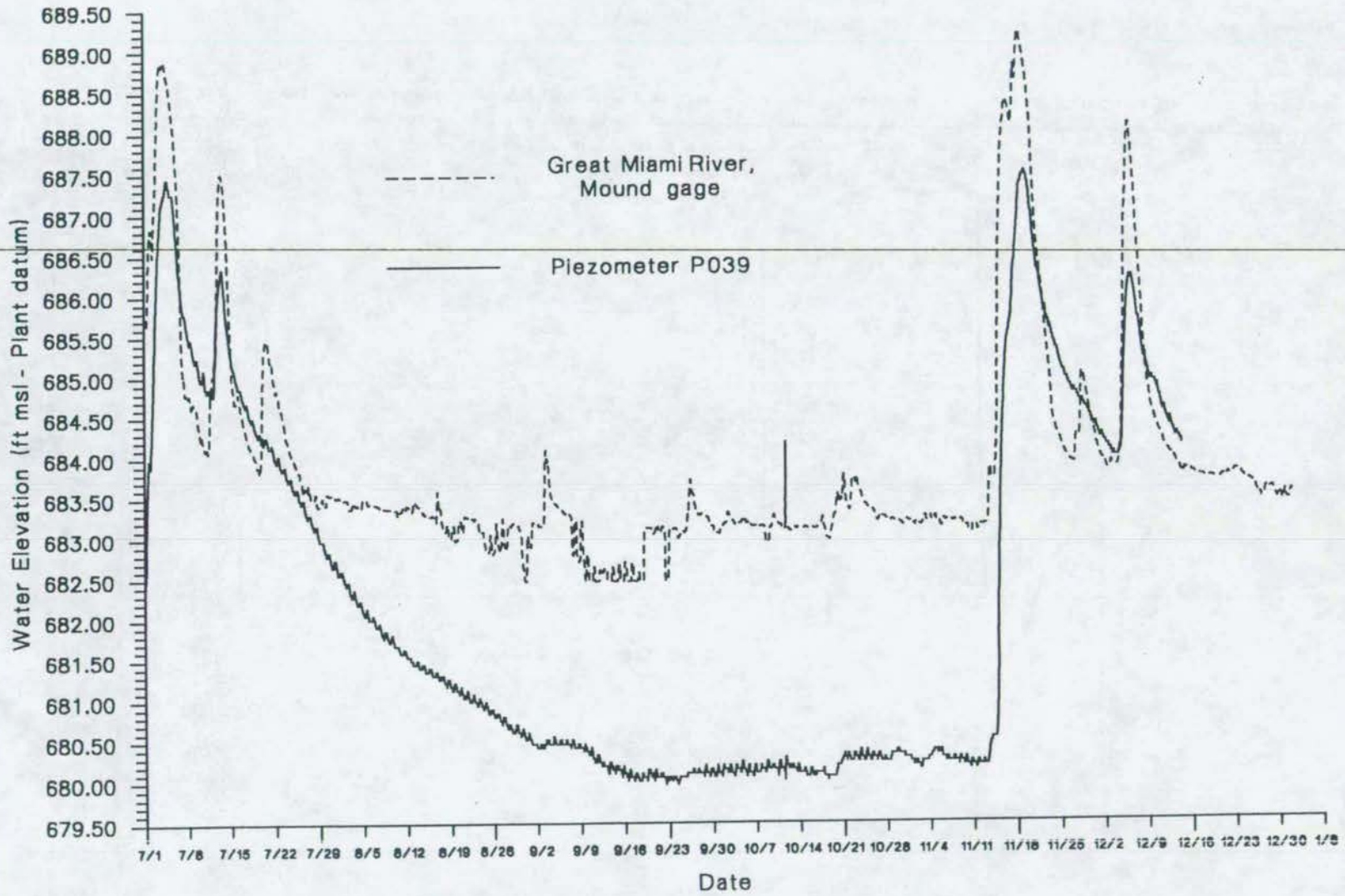
Comparison of groundwater elevations in piezometer P037 with stage in the Great Miami River (Mound gage) from 1 July 1993 through 31 December 1993.

J:\DGN\MOUNDB\M1045.dgn 022894



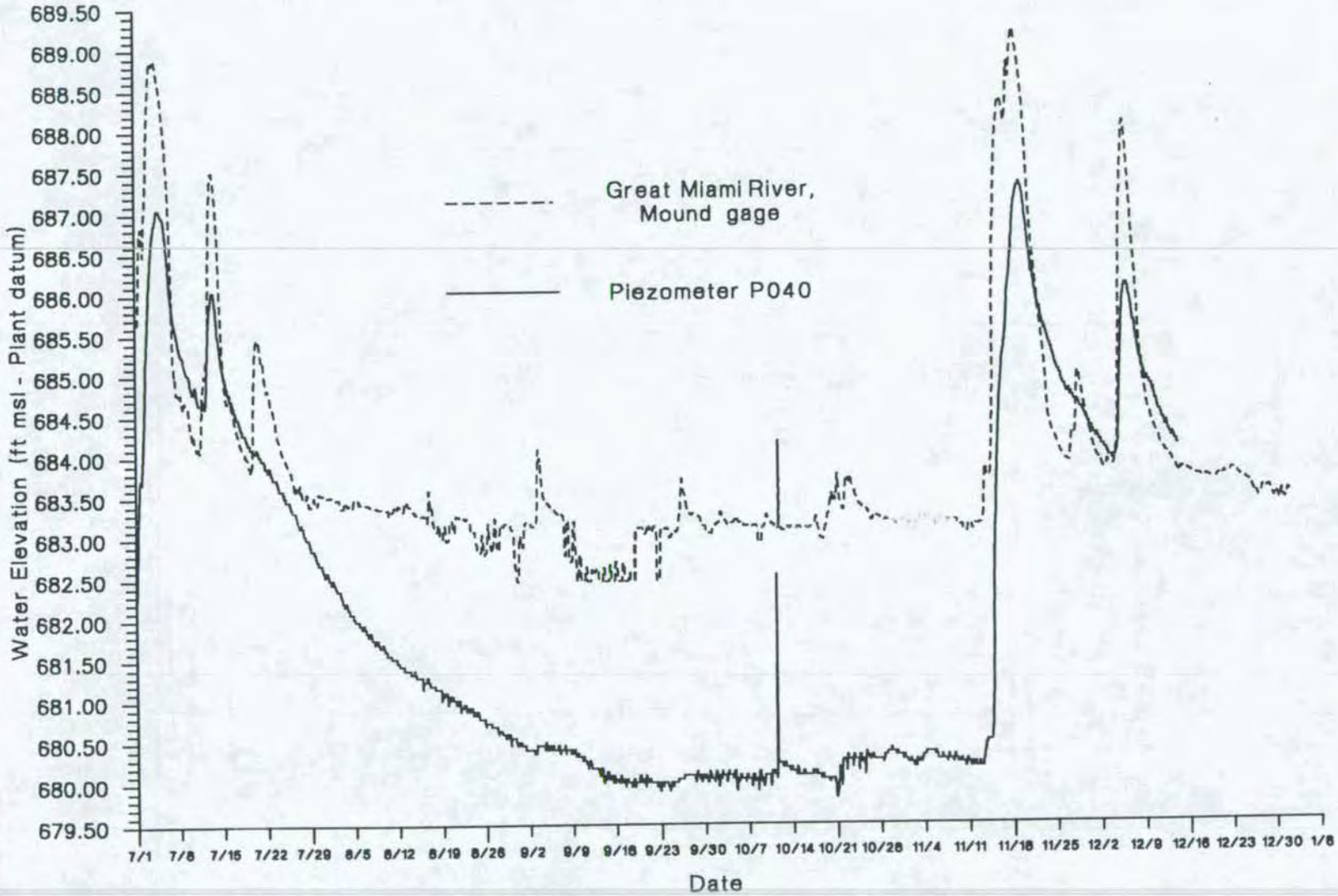
Comparison of groundwater elevations in piezometer P038 with stage in the Great Miami River (Mound gage) from 1 July 1993 through 31 December 1993.

J:\DGN\MOUNDB\M1060.dgn 030294



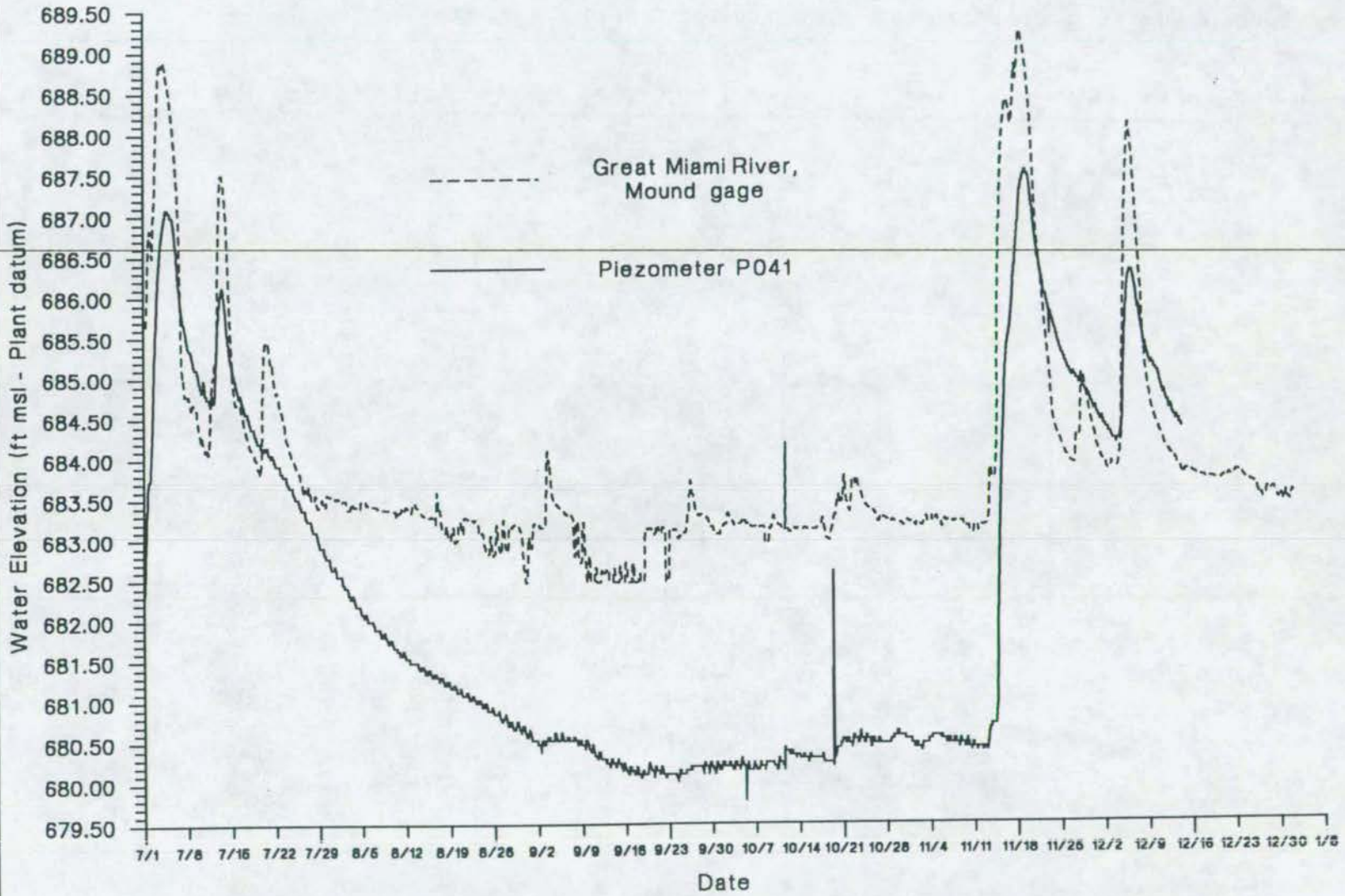
Comparison of groundwater elevations in piezometer P039 with stage in the Great Miami River (Mound gage) from 1 July 1993 through 31 December 1993.

J:\DGN\MOUNDB\M1058.dgn 030294



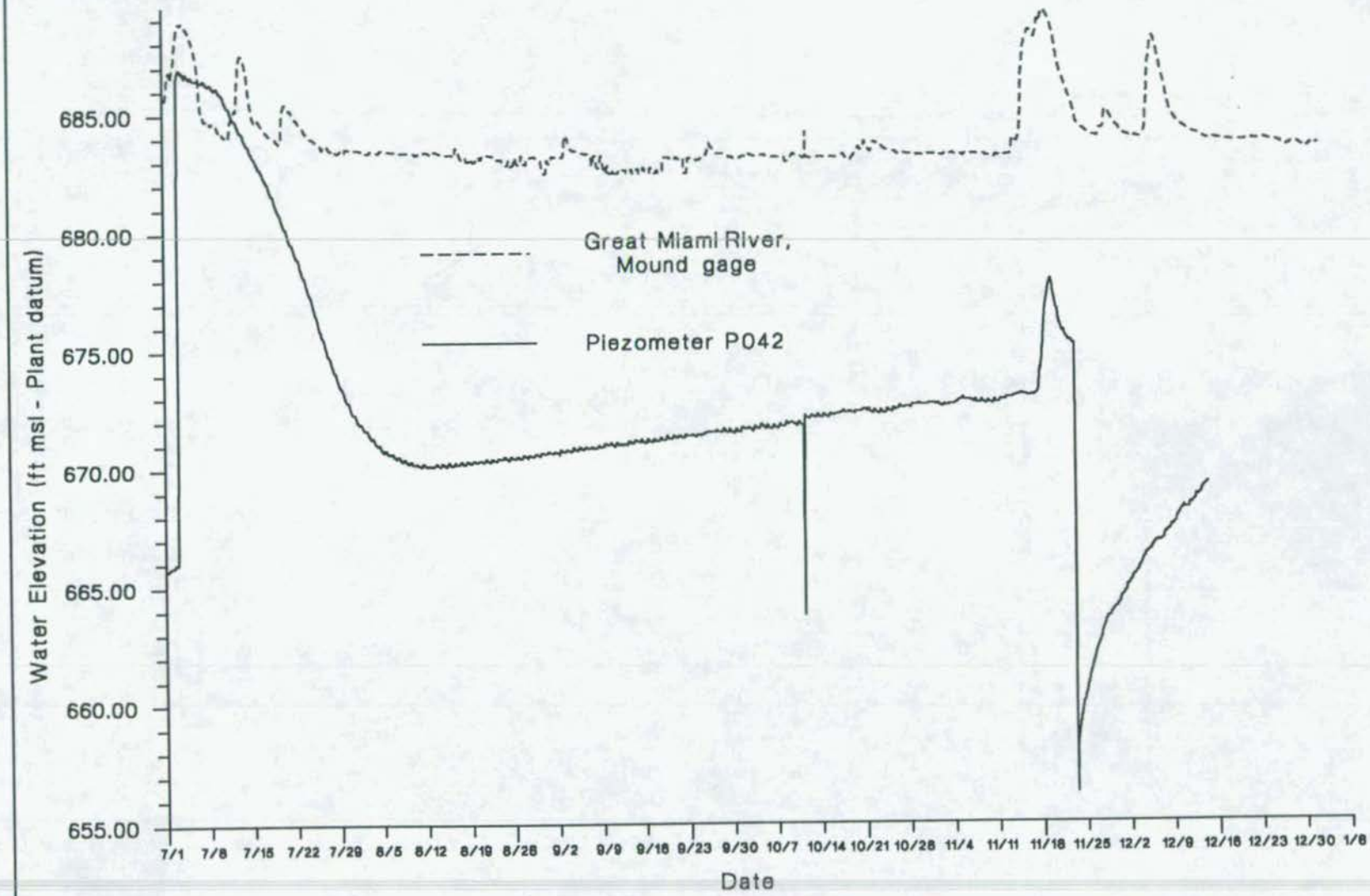
Comparison of groundwater elevations in piezometer P040 with stage in the Great Miami River (Mound gage) from 1 July 1993 through 31 December 1993.

J:\DGN\MOUNDB\M1057.dgn 030294



Comparison of groundwater elevations in piezometer P041 with stage in the Great Miami River (Mound gage) from 1 July 1993 through 31 December 1993.

J:\DGN\MOUNDB\M1042.dgn 022894



Comparison of groundwater elevations in piezometer P042 with stage in the Great Miami River (Mound gage) from 1 July 1993 through 31 December 1993.

D.2.3. CALCULATIONS OF VERTICAL GRADIENTS

Calculation of Vertical Gradients

Figure D.2.3 is an example of the vertical gradient calculation for well 0305 (completed in the lower Buried Valley Aquifer) and well 0309 (completed in bedrock). The calculation uses the following equation:

$$Grad_{vert} = \frac{H_{sh} - H_d}{D_d - D_{sh}}$$

Where:

$Grad_{vert}$ = vertical gradient

H_{sh} = Groundwater elevation in the shallow well (ft)

H_d = Groundwater elevation in the deeper well (ft)

D_d = Depth below level surface of the mid-point of the filter pack for the deeper well (ft)

D_{sh} = Depth below level surface of the mid-point of the filter pack for the shallow well (ft)

(-) indicates movement upward

(+) indicates movement downward

For this example:

H_{sh} = 679.50

H_d = 680.15

D_d = 48.3

D_{sh} = 33.35

and the vertical gradient equals:

$$Grad_{vert} = \frac{679.50 - 680.15}{48.3 - 33.35}$$

$$Grad_{vert} = \frac{-0.65}{14.95}$$

$$Grad_{vert} = -.0.043$$

Groundwater movement in the area of these two wells in upward, from the bedrock to the Buried Valley Aquifer.

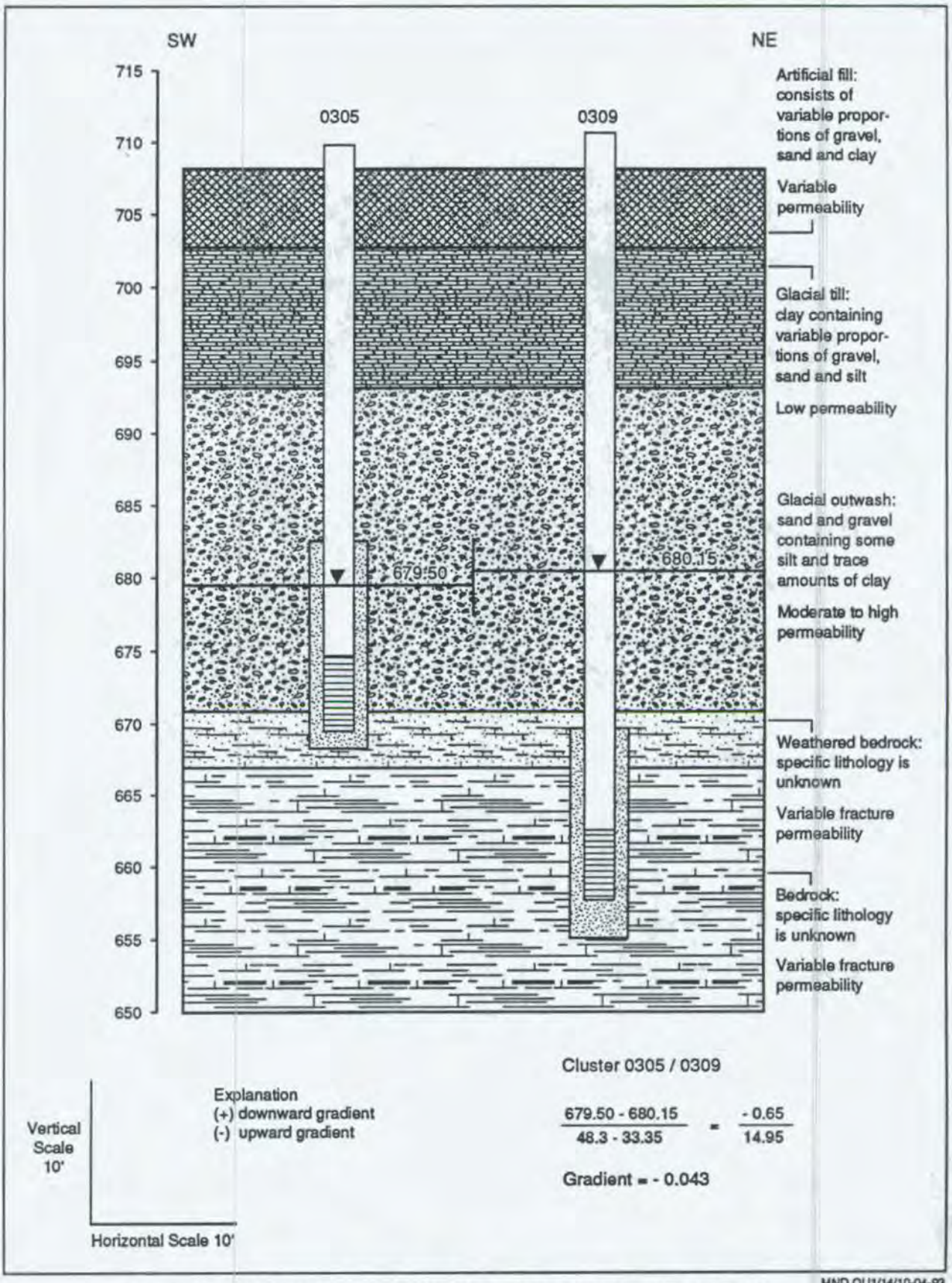


Figure D.2.3. Vertical gradient calculation at well cluster 0305 and 0309.

Table D.2.3. Vertical Gradients

Gradient Between	Date	Water Elevation (ft MSL)	Screen Mid-Point Depth (ft)	Δ Head (ft)	Δ Depth (ft)	Vertical Gradient (ft/ft)	Direction	Comments
Calculated for OU9								
0328	5/5	684.71	106	0.01	86	0.0001		No gradient
0327		684.72	26					
0333	5/5	684.55	69	0.07	46.5	0.0015	Downward	
0334		684.62	22.5					
0336	5/5	685.22	109	0.01	77	-0.00012		No gradient
0337		685.23	32					
P038	7/1	684.6	94	0.62	72.5	0.009	Downward	
P035		683.22	21.5					
P042	7/1	685.76	66	-2.4	17	-0.14	Upward	Maybe result of confining pressure
P041		683.36	49					
P042	7/29	376.40	66	9.5	17	0.56	Downward	
P041		682.90	49					
P042	10/11	669.38	66	8.43	17	0.50	Downward	
P041		677.81	49					
0393	5/10	683.38	46	-0.04	18	-0.002	Upward	Pre - 1993 aquifer test
P003		683.34	28.3					
0393	5/13	682.72	46	-0.21	18	-0.012	Upward	During 1993 aquifer test
P003		682.51	28.3					

Table D.2. (page 2 of 4)

Gradient Between	Date	Water Elevation (ft MSL)	Screen Mid-Point Depth (ft)	Δ Head (ft)	Δ Depth (ft)	Vertical Gradient (ft/ft)	Direction	Comments
Calculated for OU1								
0302		681.04	112.8	0.08	64	0.00125	Downward	
0128		681.12	48.8					
0343		680.06	85	0.97	63.5	0.0153	Downward	
0383		679.89	21.5					
0394		680.4	95.7	-0.2	65.95	-0.0030	Upward	
0156		680.2	29.75					
0304		680.4	95.7	-0.19	40.55	-0.0047	Upward	
0157		680.12	55.15					
0342		680.64	152.5	-0.43	97.35	-0.004	Upward	
0157		680.21	55.15					
P026		680.89	80.5	-0.14	31.75	-0.004	Upward	
0126		680.75	48.75					
P030		680.01	84.5	-0.14	60.8	-0.002	Upward	
P029		679.87	23.7					
P036		681.42	50.5	-0.01	29	-0.0003		No gradient
P035		681.41	21.5					
P037		681.23	81.5	0.19	31	0.006	Downward	
P036		681.42	50.5					
P038		681.12	94	0.11	12.5	0.009	Downward	

Table D.2. (page 3 of 4)

Gradient Between	Date	Water Elevation (ft MSL)	Screen Mid-Point Depth (ft)	Δ Head (ft)	Δ Depth (ft)	Vertical Gradient (ft/ft)	Direction	Comments
P037		681.23	81.5					
P009		680.07	55.15	-0.04	33.85	-0.0012		No gradient
0377		680.03	21.3					
0387		680.74	77.15	-0.03	34.5	-0.0009		No gradient
0392		680.71	42.65					
P002		680.30	59.2	-0.30	18.7	-0.016	Upward	
P001		680.20	40.5					
P002		680.30	59.2	-0.04	21.4	-0.002	Upward	
0370		680.26	37.8					
0310		680.13	49.2	-0.05	13.4	-0.0037	Upward	
0306		680.08	35.8					
0310		680.13	49.2	-0.01	17.54	-0.0006		No gradient
0153		680.12	35.8					
P003		680.06	32	-0.03	4.5	-0.007	Upward	
0397		680.03	27.5					
0393		680.25	46	-0.22	18.51	-0.012	Upward	
0397		680.03	27.5					
0307		680.3	47.5	0.01	9.89	0.001		No gradient
0313		680.31	37.6					
0309		680.15	48.3	-0.65	14.94	-0.04	Upward	

Table D.2. (page 4 of 4)

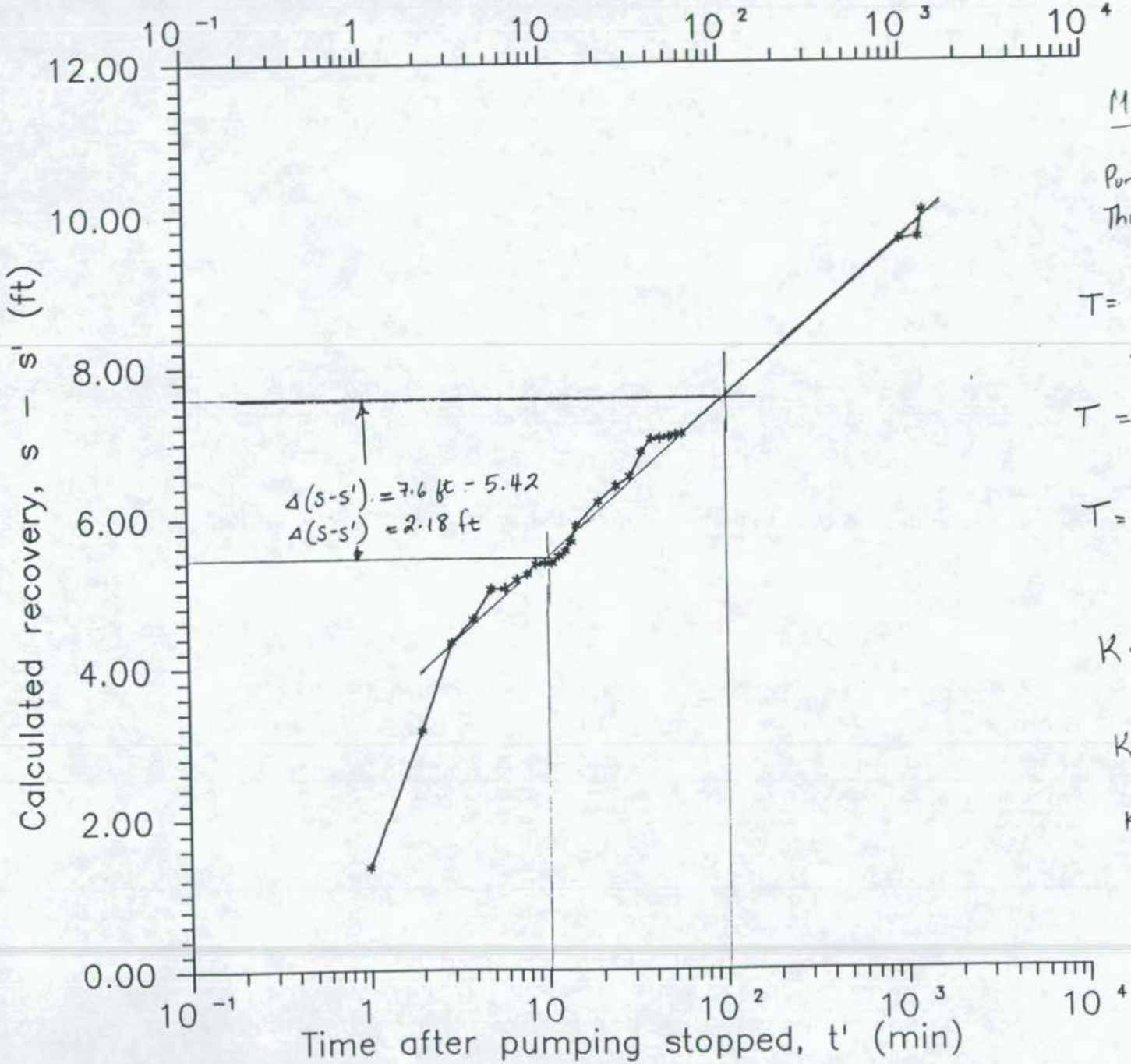
Gradient Between	Date	Water Elevation (ft MSL)	Screen Mid-Point Depth (ft)	Δ Head (ft)	Δ Depth (ft)	Vertical Gradient (ft/ft)	Direction	Comments
0305		679.50	33.4					

D.2.4. PUMPING TEST DATA FROM BOREHOLE 0352

Well 0352
Recovery Data , Mini–Aquifer Test

Initial Level: 1.6 ft (below TOC)
Total Discharge = 325 gal (140 min) 2.32 gpm

Date	Time	Elapsed Time (min)	WL Depth (ft)	Comments
9 Feb 93	13:25		1.6	Depth below TOC
	13:45			Pumping began
	16:04	0	13.47	
	16:05	1	12.11	
	16:06	2	10.31	
	16:07	3	9.13	
	16:08	4	8.83	
	16:09	5	8.43	
	16:10	6	8.42	
	16:11	7	8.31	
	16:12	8	8.24	
	16:13	9	8.1	
	16:14	10	8.09	
	16:15	11	8.09	
	16:16	12	8	
	16:17	13	7.93	
	16:18	14	7.81	
	16:19	15	7.6	
	16:24	20	7.28	
	16:29	25	7.07	
	16:34	30	6.95	
	16:39	35	6.62	
	16:44	40	6.45	
	16:49	45	6.44	
	16:54	50	6.42	
	16:59	55	6.4	
	17:04	60	6.38	
10 Feb 93	9:30	986	3.83	
	1345	1241	3.8	
	1455	1311	3.45	
16 Feb 93	8:30		3.58	
	13:21		3.62	
	17:51		3.65	



Monitoring Well 0352

Pumping rate = 2.3 gpm
Thickness = 40 ft

$$T = \frac{264Q}{\Delta(s-s')}$$

$$T = \frac{(264)(2.3\,gpm)}{2.18\,ft}$$

$$T = 279\ gpd/ft = 37.3\ ft^2/day$$

$$K = \frac{T}{b}$$

$$K = \frac{37.3\ ft^2/day}{40\,ft}$$

$$K = 0.93\ ft/day$$

Calculation of transmissivity from pumping on 9 February 1993.

D.3. ESTIMATES OF GROUNDWATER BUDGET

APPENDIX D.3.

ESTIMATION OF WATER BUDGET FOR THE BURIED VALLEY AQUIFER ADJACENT TO THE MOUND PLANT

Figure D.3.1 depicts the areas used for estimation of inflows and outflows in the preliminary water budget. For purposes of estimation, the Buried Valley Aquifer on and adjacent to the Mound Plant is subdivided into four blocks. The groundwater system in each block is assumed to be in a steady state. The steady-state condition is not entirely correct as seasonal changes in water levels are observed. For the purposes of the preliminary water budget, the flow directions and hydraulic gradients are estimated from the 12 May 1993 data set. The spring conditions are assumed to represent equilibrium between water stored in the aquifer and flows into and out of the Buried Valley Aquifer in the blocks. It is emphasized that the estimation errors may locally be large. The preliminary water budget is the first attempt to estimate these parameters for the Mound Plant Site.

The water budget for the Buried Valley Aquifer consists of inflow and outflow. Inflows include infiltration of precipitation, recharge from the river when the river stage is at a higher elevation than the groundwater elevation, and flow from upgradient areas. Outflows include pumping, evapotranspiration, and flow out of the area.

Inflows from precipitation are estimated by considering the area and the amount of rainfall that infiltrates into the groundwater. In the Miamisburg area, 6 inches per year, i.e., 0.5 ft/yr is reasonable (Schairbaum and Frost 1988). Recharge from the river is estimated by considering approximately half of the wetted perimeter, in the case of the Great Miami River, this is approximately 150 feet. Hydraulic gradients are estimated from the water elevation maps (Figures 6.3 and 6.4 in the text). Hydraulic conductivities are estimated from the OU 1 aquifer test (DOE 1994d). In general, hydraulic conductivities were observed to be highest near the Mound Plant well field and decreased northward. This is attributed to the increasing amounts of low permeability glacial tills in the sediments. Due to the fine-grained nature of the river sediments, the hydraulic conductivity of the river bed, although completely unknown, is assumed to be less than the average measured values in the Buried Valley Aquifer and is arbitrarily chosen to be 70 ft/day (an order of magnitude lower than the conductivity in the Buried Valley Aquifer). Flow rates are then estimated by considering Darcy's Law:

$$Q = KiA$$

where

Q = flow rate (ft^3/day)
A = area (ft^2)
i = hydraulic gradient (ft/ft)
K = hydraulic conductivity (ft/day)

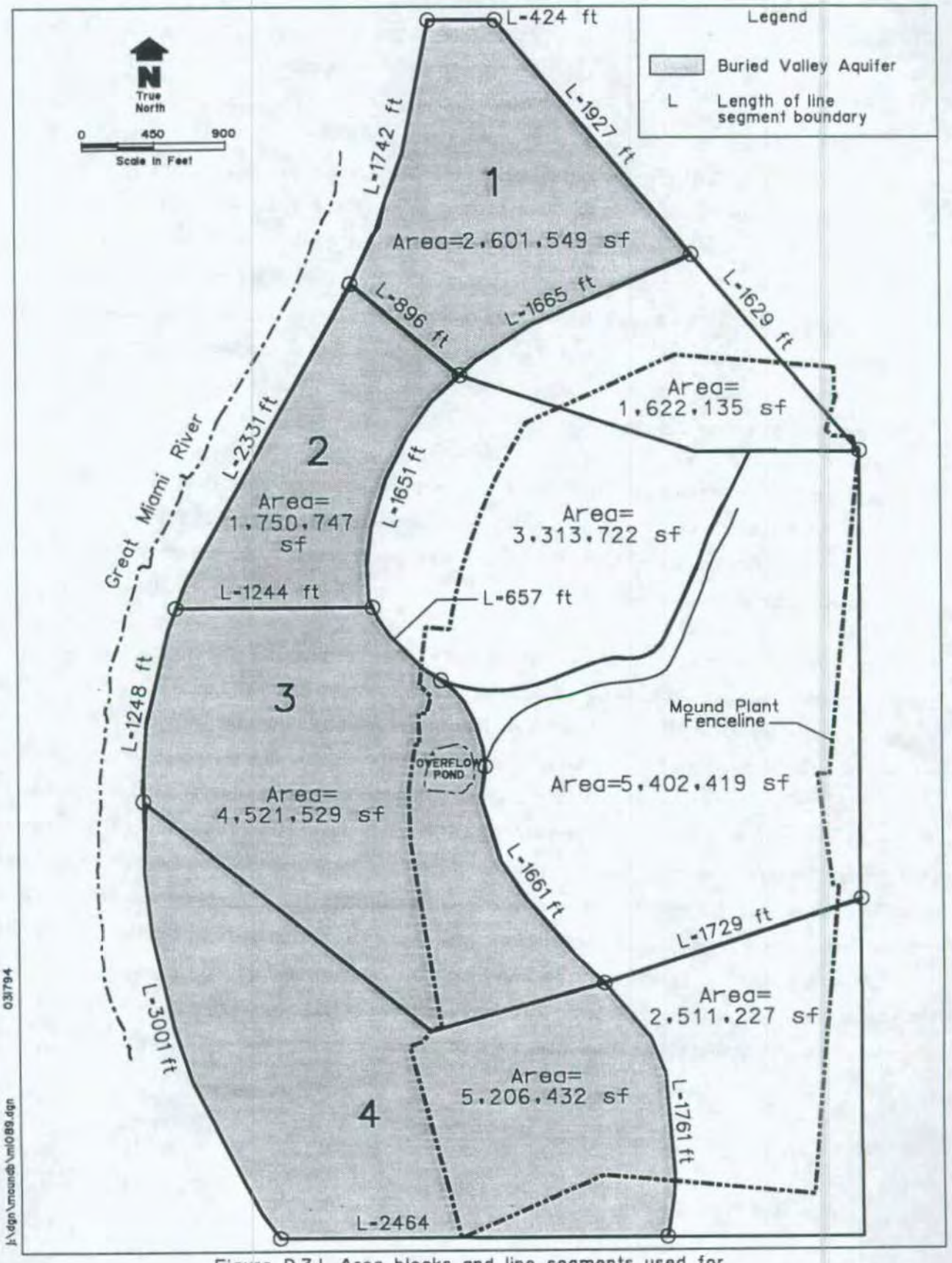


Figure D.3.I. Area blocks and line segments used for water budget estimates.

Table D.3.1 depicts the results of the estimations of the water budget in each block (Figure D.3.1). The following paragraphs discuss the inflows and outflows in each block.

Block 1

Block 1 is the northernmost block in the map area. The eastern boundary is determined by the lack of data points beyond the northeastern line depicted (Figure D.3.1). The southern boundary is assumed to be the point where the valley begins to narrow. Inflows include subflow from the Buried Valley Aquifer, precipitation and leakage from bedrock. Outflows include subflow across the south boundary and inflow to the Great Miami River. Inflow to the Great Miami River is not calculated, but is assumed to balance the estimated inflows. The deep axis of the buried valley is assumed to trend from southwest to northeast through Block 1, so the saturated thickness is relatively large. Due to the common occurrence of glacial tills in the area, the hydraulic conductivity is assumed to be less than half that measured in Block 3.

Block 2

Block 2 is downgradient from Block 1. The northern boundary is assumed to be the point where the valley begins to narrow, it is shared with Block 1. The southern boundary is selected as the point where the valley begins to widen. Inflows include subflow from the Buried Valley Aquifer along the common line with Block 1, precipitation and leakage from the bedrock. Outflows include subflow across the southern boundary and inflow to the Great Miami River. Inflow to the Great Miami River is not calculated, but is assumed to balance the estimated inflows. The deep axis of the buried valley is assumed to occur west of Block 2, so the saturated thickness is taken as the average across the block. Due to the common occurrence of glacial tills in the area, the hydraulic conductivity is assumed to be half that measured in Block 3.

Block 3

Block 3 is downgradient from Block 2. The northern boundary is assumed to be the point where the valley begins to widen. Block 3 is interpreted to be the single most important reach of the Buried Valley Aquifer as it contains the plant drainage and pumpage facilities. It also contains the historic landfill known as Area B (see DOE 1994d). Inflows include subflow from the Buried Valley Aquifer along the common line with Block 2, subflow from the tributary valley, infiltration from the Miami-Erie canal, precipitation and leakage from the bedrock. Outflows include only pumpage from the Mound Plant production wells. The southern boundary is assumed to be a no-flow boundary because all flows within the block are assumed to be captured by the plant production wells. The deep axis of the buried valley is assumed to trend from northwest to southeast through Block 3, so the saturated thickness

Table D.3.1. Water Budget For The Buried Valley Aquifer Adjacent to Mound Plant

Component	Length (ft)	Saturated Thickness (ft)	Hydraulic Gradient (ft/ft)	Hydraulic Conductivity (ft/day)	ft^3/day	gpd	MGY	Comment
Block 1								
Inflow								
Precipitation							9.7	$(2.6E6 ft^2)(0.5 ft/yr)^a$ = $1.3E6 ft^3/yr$
Bedrock	1665	50	0.1	1	8,300	62,000	22.7	
Buried Valley Aquifer	1927	110	0.00019	300	12,100	90,400	33	
Inflow subtotal							65.4	
Outflow								
S. boundary	896	110	0.00047	300	13,900	104,000	37.9	
Great Miami River	1742						27.5	assumed to balance inflow
Outflow subtotal							65.4	
Block 2								
Inflow								
Precipitation							6.5	$(1.75E6 ft^2)(0.5 ft/yr)^a$ = $8.75E5 ft^3/yr$
Bedrock	1651	50	0.1	1	8,250	61,700	22.5	
Buried Valley Aquifer	896	110	0.00047	300	13,900	104,000	37.9	
Inflow subtotal							60.4	
Outflow								
S. boundary	1244	75	0.00038	400	14,000	105,000	38.4	
Great Miami River	2331						22	assumed to balance inflow
Outflow subtotal							60.4	
Block 3								
Inflow								
Buried Valley Aquifer	1244	75	0.00038	400	14,000	105,000	38.4	
Precipitation							16.8	$(4.5E6 ft^2)$ $(0.5 ft/yr)^a$ = $2.25E6 ft^3/yr$
M-E Canal						275,000	100	from published data[b]

Table D.3.1. (page 2 of 2)

Component	Length (ft)	Saturated Thickness (ft)	Hydraulic Gradient (ft/ft)	Hydraulic Conductivity (ft/day)	ft^3/day	gpd	MGY	Comment
Great Miami River	1,248	150	0.0003	70	3,900	29,400	10.7	Gradients from 5/12/93 water level map
Bedrock	2,318	40	0.09	1	8,300	62,400	22.8	
Trib. valley	135	30	0.05	55	11,100	83,300	30.4	
Inflow Subtotal							219.10	
Outflow								
Pumpage							196	Appendix D.5.1
Block 4								
Inflow								
Precipitation							19.4	(5.2E6 ft^2)(0.5 ft/yr)[a] = 2.6E6 ft^3/yr
Great Miami River	3001	150	0.00022	70	6,900	519,000	18.9	gradient averaged along river segment
Bedrock	1761	30	0.08	1	4,200	31,600	11.5	
Inflow subtotal							49.8	
Outflow								
S. boundary	1642	100	0.00018	700	20,700	154,800	56	

[a]Schairbaum and Frost 1988
[b]Styron and Meyer 1981
gpd - gallons per day
MGY - million gallons per year

is larger than in the upgradient blocks. Hydraulic conductivity is assumed to be the average measured in the OU 1 aquifer test, approximately 700 ft/day.

Block 4

Block 4 is south of Block 3. The northern boundary is assumed to be the no-flow boundary common with Block 3. The southern boundary is arbitrarily chosen as the map area boundary. Inflows include infiltration from the Great Miami River, precipitation and leakage from bedrock. Outflow includes only subflow across the southern boundary. The deep axis of the buried valley is assumed to trend from north to south through the eastern part of Block 4, so the saturated thickness is assumed to be large. Due to the absence of glacial tills in the area, the hydraulic conductivity is assumed to be the average measured in Block 3.

FLOW RATES ACROSS THE BEDROCK CONTACT

Two different methods are used to estimate the amount of inflow from the bedrock, both based on data reported in the Hydrogeologic Investigations: Bedrock Report (DOE 1994b). These two methods calculate the flow rate per unit length of contact between bedrock and the Buried Valley Aquifer (Figure D.3.1). Descriptions of the fracture flow system indicate that the fractured carapace is approximately 100 ft thick and that numerous seeps and springs outcrop along exposed bedrock faces on the Main and SM/PP Hills.

The first method assumed Darcy's Law is valid and that groundwater gradients in the bedrock, saturated thickness and permeability can be used to calculate flow per day. As reported in the Hydrogeologic Investigations: Bedrock Report (DOE 1994b), the saturated thickness of the fracture carapace for the Main Hill is about 50 ft and only about 30 ft on the SM/PP Hill. The saturated thickness is assumed to be in complete communication with the Buried Valley Aquifer. The permeabilities are assumed to be about 1 ft/day. The gradients are calculated from the elevation change on the hills to the groundwater surface in the Buried Valley Aquifer. For the SM/PP Hill, the gradient is assumed to be the difference between locations 0350 and 0353 (Plate 8). The saturated thicknesses are recognized to be lower on the SM/PP Hill than the Main Hill (DOE 1994b). The results are recalculated to gallons per day (Table D.3.2).

In the second model, the actual flow rates measured in the falling head tests and in the trench (DOE 1994b) are recalculated to determine rate of flow per square foot. This is used to estimate flow per segment length of contact between bedrock and the Buried Valley Aquifer. The saturated thicknesses of the fracture carapace are again assigned from the data presented in the Bedrock Report (DOE 1994b). Results are also depicted in Table D.3.1.

Table D.3.2. Estimates of Outflow from Bedrock

Segment	Length (ft)	Saturated Thickness (ft)	Hydraulic Gradient (ft/ft)	Hydraulic Conductivity (ft^2 /day)	Flow			gpm/ft
					ft^3/day*	gpd*	MGY*	
Method 1								
1	1665	30	0.1	1	5,000	37,300	13.6	0.015
2	1651	50	0.1	1	8,200	61,700	22.5	0.025
3n	657	50	0.1	1	3,300	24,500	8.9	0.025
3s	1661	30	0.08	1	4,000	29,800	10.8	0.012
4	1761	30	0.08	1	4,200	31,600	11.5	0.012
Method 2			flow rate	area				
			gpm	ft^2	g/ft^2	gpm*	gpd*	gpm/ft
1	1665	30	8.75E-3	12	7.3E-4	60.8	87,500	0.036
2	1651	50	8.75E-3	12	7.3E-4	60.3	86,700	0.036
3n	657	50	8.75E-3	12	7.3E-4	23.9	34,500	0.036
3s	1661	30	5.53E-3	10	5.5E-4	27.4	39,400	0.016
4	1761	30	5.53E-3	10	5.5E-4	29	41,800	0.016

*Flow given for entire length of segment.
gpd - gallons per day

D.4. PRECIPITATION DATA

D.4.1. PRECIPITATION DATA FROM MOUND PLANT

1993 Rainfall — ARAC Data*

	— 1993 —											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1			0.30	0.32	0.1	0.3	0.35					
2	0.23				0.02		0.21		0.60	0.28		0.20
3			0.15		0.10	0.18			0.53		0.05	0.11
4			0.80					0.23			0.01	0.58
5	1.27			0.04							0.13	
6			0.02								0.04	
7			0.15			0.91	0.11					
8			1.10			0.03						
9						0.03				0.34		
10						0.44	0.63	0.21				0.03
11	0.35		0.02				0.63					
12	0.30			1.00	0.31			0.18	0.09			
13	0.30				0.98						1.30	
14				0.13		0.04	0.16				1.10	
15		0.71		0.66		0.06			0.12		0.06	0.02
16		0.30								0.19		
17		0.11	0.20		0.04			0.91		0.33	1.12	
18												0.12
19				0.73	0.31					1.60		
20				0.14				0.07	0.01	1.12		0.06
21	0.42			0.17		0.44				0.08		0.17
22	1.30	0.51	0.20			0.02			0.06			
23			0.47									
24			0.41		0.09							
25									0.45		0.04	
26				1.60							0.39	
27									0.05		0.35	
28												
29												
30										0.17		
31												
MIN AV	0.23	0.11	0.02	0.04	0.02	0.02	0.11	0.07	0.01	0.08	0.01	0.02
MAX AV	1.30	0.71	1.10	1.60	0.98	0.91	0.63	0.91	0.60	1.60	1.30	0.58
MTH AV	0.60	0.41	0.35	0.53	0.26	0.24	0.38	0.32	0.24	0.51	0.42	0.16
TOTAL	**4.17**	**1.63**	**3.82**	**4.79**	**1.85**	**2.15**	**1.53**	**1.60**	**1.91**	**4.11**	**4.59**	**1.29**

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
108 — wet days 257 — dry days												
	4.2	5.8	9.6	14.4	16.3	18.4	19.9	21.5	23.5	27.6	32.2	33.4
1993 totals — cumulative												

*Data for APR/MAY/JUN from static collection device @ SD Plant Area.

D.4.2. PRECIPITATION FROM USGS GAUGE

United States Department of Interior - Geological Survey - Water Resources Division
State 39 Dist 39
Primary Computations of Rainfall (inches)

03271500 DATE PROCESSED: 01-26-1994 @ 12:27 BY RJVELEY
G MIAMI R AT MIAMISBURG OH IN DD: FROM DCP THR (IN): 0.00
(00045) RAINFALL NO STATISTICS STORED
PROVISIONAL DATA FOR WATER YEAR ENDING SEPT. 30, 1994 TEST DIFF:****** PUNCH INTERVAL: 60 MIN

		Rainfall Amounts at Indicated Times in Inches																							
Date	Total Rainfall	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
10/01/93	.06	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.06
10/02/93	.31	.10	.09	.06	.04	.01	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/03/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/04/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/05/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/06/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/07/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/08/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/09/93	.40	.00	.00	.00	.01	.00	.04	.14	.04	.08	.04	.01	.03	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/10/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/11/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/12/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/13/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/14/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/15/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/16/93	.13	.00	.00	.00	.00	.00	.00	.01	.00	.02	.00	.01	.04	.05	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/17/93	.25	.04	.05	.00	.00	.00	.01	.09	.05	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

United States Department of Interior - Geological Survey - Water Resources Division
State 39 Dist 39
Primary Computations of Rainfall (inches)

03271500 DATE PROCESSED: 01-26-1994 @ 12:27 BY RJVELEY
G MIAMI R AT MIAMISBURG OH IN DD: FROM DCP THR (IN): 0.00
(00045) RAINFALL NO STATISTICS STORED
PROVISIONAL DATA FOR WATER YEAR ENDING SEPT. 30, 1994 TEST DIFF:****** PUNCH INTERVAL: 60 MIN

		Rainfall Amounts at Indicated Times in Inches																							
Date	Total Rainfall	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
10/18/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/19/93	.82	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.04	.04	.05	.00	.04	.00	.24	.06	.07	.18	.10	.00	.00	.00
10/20/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/21/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/22/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/23/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/24/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/25/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/26/93	.23	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.23	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/27/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/28/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/29/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10/30/93	.19	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.04	.07	.03	.03	.01	.00	.01	.00	.00	.00	.00
10/31/93	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.01	.00	.00	.00	.00	.00	.00
11/01/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
11/02/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
11/03/93	.10	.00	.00	.00	.00	.01	.03	.03	.03	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

United States Department of Interior - Geological Survey - Water Resources Division
State 39 Dist 39
Primary Computations of Rainfall (inches)

03271500 DATE PROCESSED: 01-26-1994 @ 12:27 BY RJVELEY
G MIAMI R AT MIAMISBURG OH IN DD: FROM DCP THR (IN): 0.00
(00045) RAINFALL NO STATISTICS STORED
PROVISIONAL DATA FOR WATER YEAR ENDING SEPT. 30, 1994 TEST DIFF:****** PUNCH INTERVAL: 60 MIN

		Rainfall Amounts at Indicated Times in Inches																							
Date	Total Rainfall	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
11/04/93	.02	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.01	.01	.00	.00
11/05/93	.12	.11	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
11/06/93	.05	.00	.00	.00	.00	.00	.00	.00	.00	.00	.02	.02	.00	.00	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00
11/07/93	.01	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
11/08/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
11/09/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
11/10/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
11/11/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
11/12/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
11/13/93	1.28	.04	.00	.05	.16	.35	.14	.24	.12	.03	.05	.05	.05	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
11/14/93	1.10	.00	.02	.05	.01	.00	.00	.00	.00	.00	.16	.04	.04	.11	.09	.10	.15	.17	.08	.02	.04	.02	.00	.00	.00
11/15/93	.10	.00	.00	.00	.09	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
11/16/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
11/17/93	1.10	.02	.09	.11	.14	.10	.16	.01	.01	.19	.07	.05	.01	.00	.00	.03	.09	.01	.01	.00	.00	.00	.00	.00	.00
11/18/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
11/19/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
11/20/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

United States Department of Interior - Geological Survey - Water Resources Division
State 39 Dist 39
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11/21/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
11/22/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
11/23/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
11/24/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
11/25/93	.05	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.01	.04	.00
11/26/93	.37	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.14	.11	.11
11/27/93	.30	.07	.12	.09	.02	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
11/28/93	.02	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.02	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
11/29/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
11/30/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/01/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/02/93	.28	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.02	.06	.08	.06	.06	.00	.00	.00	.00	.00	.00
12/03/93	.14	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.04	.03	.03	.00	.02	.02
12/04/93	.66	.04	.02	.07	.07	.01	.01	.02	.01	.02	.00	.09	.01	.00	.02	.09	.01	.07	.06	.02	.02	.00	.00	.00	.00
12/05/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/06/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/07/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

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12/08/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/09/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/10/93	.03	.00	.00	.00	.00	.03	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/11/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/12/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/13/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/14/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/15/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/16/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/17/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/18/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/19/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/20/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/21/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/22/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/23/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/24/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

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12/25/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/26/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/27/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/28/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/29/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/30/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12/31/93	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

D.5. INDUSTRIAL AND MUNICIPAL PUMPING RATES

D.5.1. 1992 PUMPING RATES FOR MOUND PLANT PRODUCTION WELLS FROM OU 1 REMEDIAL INVESTIGATION REPORT

Table G8. Mound Plant Production Well Pumping Rates

Month/Year	Groundwater Pumped (millions of gallons)		
	Well No. 1 (0071)	Well No. 2 (0271)	Well No. 3 (0076)
01-92			16.58
02-92			17.33
03-92			19.34
04-92			17.63
05-92			15.70
06-92		17.18	
07-92			19.50
08-92			13.27
09-92			14.18
10-92			14.60
11-92			14.73
12-92			16.08
Totals	**0.0**	**17.18**	**178.94**
	Total Gallons Pumped 196,120,000		
Month/Year	**Water Treated (millions of gallons)***		
01-93	15.83		
02-93	12.36		
03-93	16.29		
04-93	13.87		
05-93	17.50		
06-93	17.91		
Totals	**93.76**		
	Total Gallons Treated 93,760,000		

*Mound Plant production well pumping totals are not officially recorded until the end of the year. Mound Plant monthly water softening totals were used to estimate production well pumping rates for the period of January — June 1993.

D.5.2. 1992 PUMPING RATES FOR MIAMISBURG AND DAYTON POWER AND LIGHT COMPANY PRODUCTION WELLS

Table G7a. Pumping Rates for the Miamisbury Water Treatment Plant, January 1991 through June 1993

Month/Year	Water Treated (millions of gallons)
01-91	65.86
02-91	52.41
03-91	27.07
04-91	65.78
05-91	64.48
06-91	87.40
07-91	99.84
08-91	68.54
09-91	39.88
10-91	35.01
11-91	34.61
12-91	51.91
Total	692.79
01-92	29.96
02-92	55.60
03-92	48.47
04-92	56.88
05-92	71.06
06-92	74.54
07-92	66.36
08-92	67.49
09-92	59.73
10-92	53.42
11-92	54.54
12-92	53.52
Total	691.57
01-93	45.00
02-93	41.15
03-93	51.56
04-93	48.91
05-93	61.01
06-93	77.85
Total	325.48
Total Water Treated	1,709,840,000

Table G7b. Dayton Power and Light Hutching Power Station Production Well Pumping Rates, January 1991 through June 1993

Time Period	Groundwater Pumped (millions of gallons)
January - December 1991	283.8
January - December 1992	208.0
January - June 1993	127.9
Total Gallons Pumped 619,700,000	