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Final Report
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Database for the First Macrodispersion Experiment (MADE-1)

Prepared by
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Norris, Tennessee

REPORT SUMMARY

Database for the First Macrodispersion Experiment (MADE-1)

Results from an investigation of the transport of nonreactive tracers in a saturated, heterogeneous aquifer were assembled to create the macrodispersion experiment (MADE-1) database. Detailed measurements of site hydraulic characteristics as well as spatial distributions of tracer concentrations throughout the duration of the experiment are contained in this database, which will assist utilities in establishing dispersivity for use with hydrogeochemical models.

INTEREST CATEGORIES

Land and water quality—hydrogeochemical modeling
Waste and water management
Waste disposal and use
Risk analysis, management, and assessment

KEYWORDS

Groundwater
Dispersion
Transport
Hydrodynamics
Leachate migration
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BACKGROUND Dispersive transport is a physical process influencing the migration and distribution of chemicals entering the subsurface environment. Advective and dispersive transport mechanisms are solely responsible for movement of chemical plumes in the subsurface and therefore influence where and when chemical and biological interactions with ambient minerals and aqueous components will occur. As an integral part of the solid-waste environmental studies (SWES) project, the field-scale macrodispersion experiment (MADE) was conducted to perform a complete hydraulic characterization of a heterogeneous aquifer and to execute a tracer injection and plume tracking program.

OBJECTIVE To create a comprehensive database for developing predictive methods for quantifying macrodispersion in the saturated subsurface.

APPROACH Researchers performed field studies at the MADE site to establish the heterogeneous hydraulic character of the aquifer in which the tracer experiment was conducted. They injected a solution containing four tracers into the aquifer's saturated zone, using five wells screened over a depth of 0.6 m. Over a 48-hour period, they introduced 10 m^3 of solution, producing a finite-duration, rectangular source that resulted in formation of a three-dimensional plume. A sampling network that grew to contain 258 multilevel samplers captured the three-dimensional distribution of the tracer in the saturated zone. Synoptic samplings of the plume established the spread of chemicals over time.

RESULTS A total of 2483 hydraulic conductivity measurements were obtained to characterize the aquifer in the tracer plume's vicinity. In addition, large-scale aquifer tests established an average hydraulic conductivity in two aquifer regions. Tracer concentration distributions were measured on eight occasions during the 20-month experiment. For the purpose of interpreting groundwater flow behavior, hydraulic head measurements were made before and during the field experiment. All data were assembled into the MADE-1 database.

EPRI PERSPECTIVE Efforts to understand the process of dispersive transport and to develop prediction methodologies require data from fundamental and detailed field experiments. Measurements of all parameters deemed relevant to understanding the dispersion process were gathered, and a database was formulated for distribution through the Electric Power Software Center. EPRI is analyzing and interpreting these results and has used the information to validate an existing method for predicting dispersion (report EN-6405). The Institute expects that making this database available to the scientific and engineering community will stimulate new ideas and elicit new theories for predicting dispersive transport.

PROJECT

RP2485-5
Project Manager: Dave McIntosh
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ABSTRACT

The data developed from the Macrodispersion Experiment (MADE-1) conducted at Columbus Air Force Base in northeastern Mississippi are presented. The study was designed to obtain a comprehensive data base of field-scale transport of a nonreactive solute in a heterogeneous aquifer. These data were intended to provide the basis for development and validation of the advection-dispersion component of geohydrochemical models. Data developed from the study are presented in digital form, and include tracer concentration measurements associated with a large-scale natural-gradient tracer experiment conducted over a period of 20 months, hydraulic head data recorded at the test site before and during the natural-gradient experiment, and aquifer hydraulic conductivity estimates obtained from over 2400 borehole flowmeter measurements. Brief descriptions of the test site and methods of data acquisition are provided.

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SUMMARY

The MADE-1 project was designed to acquire detailed data on physical transport processes in heterogeneous aquifers. A large-scale natural-gradient tracer experiment and detailed hydrogeologic characterization of the test site comprised the two primary components of the project. Data derived from the study were intended to support development and validation of the advective-dispersion components of geohydrochemical models. Studies associated with MADE-1 were conducted at Columbus Air Force Base in northeastern Mississippi between 1984 and 1988.

The natural-gradient tracer experiment was performed in a shallow alluvial aquifer consisting of heterogeneous, lenticular deposits of sand and gravel. The experiment was initiated with the pulse injection of approximately 10 m^3 of groundwater containing bromide and three fluorinated benzoic acid tracers. Eight comprehensive samplings (or snapshots) of the tracer plumes were subsequently conducted over a period of approximately 20 months. The time interval between the plume snapshots ranged from approximately 5 to 19 weeks. A network of 258 multilevel sampling wells, each equipped with up to 30 discrete sampling points in the vertical dimension, were used to monitor the tracer plumes in three dimensions. Tracer samples were analyzed using high pressure liquid chromatography coupled with ultraviolet adsorption detection. Data from the natural-gradient experiment are given in digital form on Diskette No. 1.

Hydrogeological investigations emphasized estimation of the three-dimensional structure of hydraulic conductivity of the alluvial aquifer. The principal method of measuring the spatial distribution of conductivity was borehole flowmeter testing in fully-penetrating wells. Flowmeter measurements were carried out at 15-cm vertical intervals in 58 wells located in the vicinity of the tracer experiment. Files containing the hydraulic conductivity estimates derived from flowmeter measurements for each test well are given on Diskette No. 2.

The hydraulic head field was monitored during the natural-gradient experiment with a network of 48 piezometers. Ten of these piezometers were equipped with continuous groundwater level recorders. The remaining piezometers were

monitored at approximately two- to four-week intervals during the experiment. The hydraulic head data recorded prior to and during the experiment are presented on Diskette No. 3.

Section 1.0

INTRODUCTION

The MADE-1 natural-gradient tracer experiment was conducted during the period October 1986 through June 1988. The field study was performed for EPRI by the Tennessee Valley Authority with Massachusetts Institute of Technology and GeoTrans, Inc., as subcontractors. In conjunction with the field tracer experiment, the hydrogeology of the test site was characterized in detail with emphasis on measurement of the spatial variability of the hydraulic conductivity field. The goal of these studies was to develop a data base of nonreactive solute transport in a saturated heterogeneous aquifer that could be used for validating the advection-dispersion components of groundwater transport models.

The data obtained from the field tracer experiment and site characterization investigations are presented in digital form with this report. Specifically, the report contains the tracer concentration measurements for the natural-gradient experiment, the hydraulic head data recorded before and during the field experiment, and the hydraulic conductivity data base for the aquifer at the test site derived from borehole flowmeter tests. A brief description of the test site and the methods used to acquire these data are presented in the following sections of the report. References are given to other EPRI publications which present more detailed discussions of the data acquisition procedures and data analysis.

Section 2.0

SITE DESCRIPTION

The experimental site is located at Columbus Air Force Base in northeastern Mississippi (Figure 2.1). The area is approximately 6 km east of the Tombigbee River and 2.5 km south of the Buttahatchee River, and lies above the 100-year floodplain of both streams. Land surface slopes gently northward across the site from elevation 66.5 m above MSL in the southeastern corner to elevation 64.6 m at the northern extreme. The site is situated on the youngest of a series of Pleistocene Age terrace deposits associated with the Buttahatchee River. The shallow alluvial terrace deposit forms an unconfined aquifer averaging approximately 11 m in thickness. The aquifer is composed of poorly-sorted to well-sorted sandy gravel and gravelly sand with minor amounts of silt and clay. Sediments are generally unconsolidated and cohesionless below the water table. Soil facies occur as irregular lenses and layers which vary in thickness and areal extent. Marine sediments belonging to the Eutaw Formation (Cretaceous) and consisting of clays, silts, and fine-grained sands form an aquitard beneath the alluvial aquifer. A more comprehensive hydrogeological description of the test site can be found in Boggs et al. [1990].

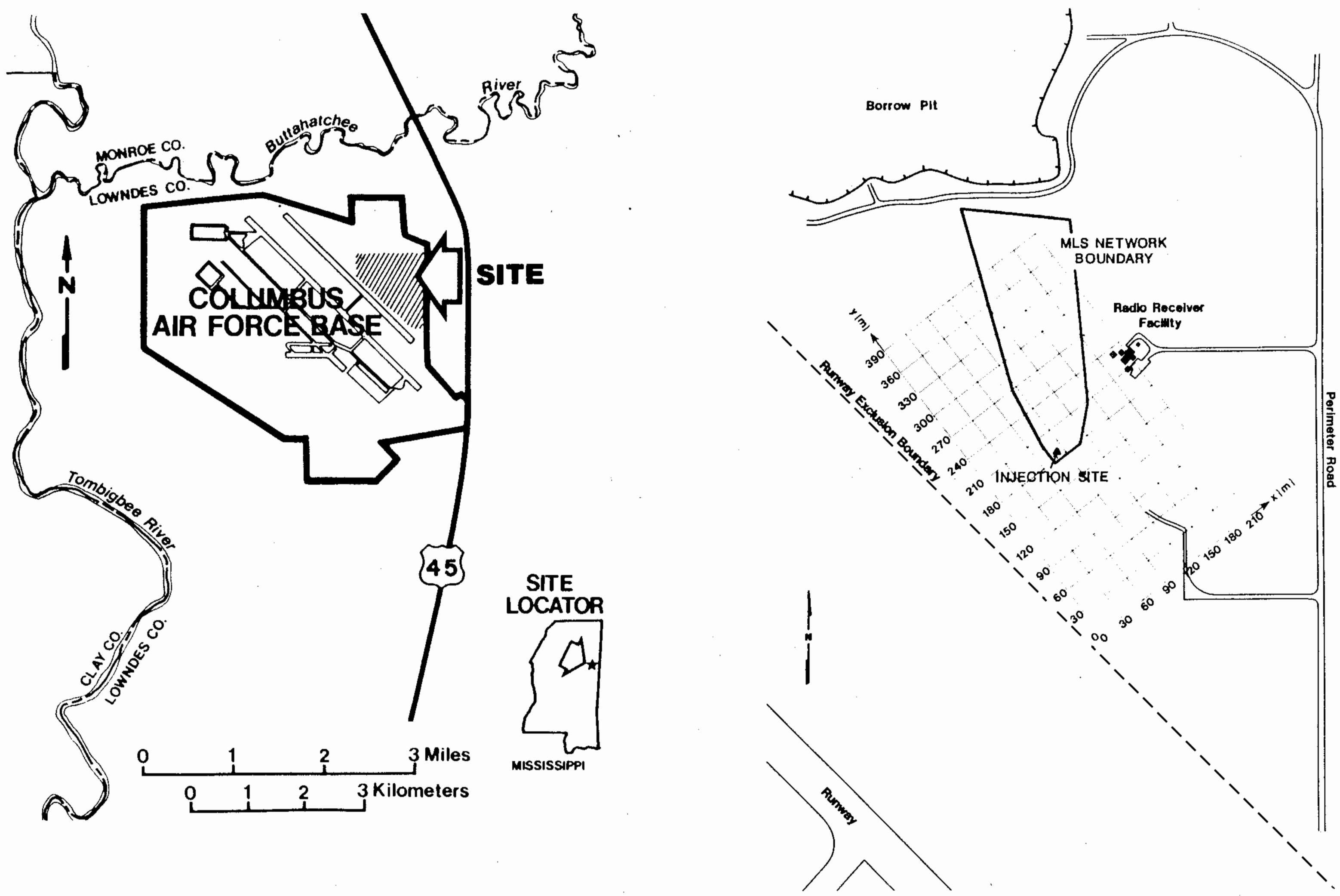

Figure 2.1 Site Location Map

Section 3.0

TRACER INJECTION

3.1 TRACERS

Because the intent of the natural-gradient tracer experiment was to investigate physical transport processes, a group of inorganic and organic anions which were shown to be conservative in previous laboratory and field groundwater studies were selected as tracers. These tracers included bromide in the form of calcium bromide, pentafluorobenoic acid (PFBA), trifluoromethylbenzoic acid (TFBA), and orthodifluorobenzoic acid (DFBA). Bromide was the primary tracer because it performed conservatively in numerous previous field and laboratory experiments [e.g., Jester and Uhler, 1974; Bassett et al., 1981], and because it consistently showed the best analytical accuracy and precision of the four tracers. The three fluorinated benzoic acids (FBA) were shown by Malcolm et al. [1980] and Bentley and Walter [1983] to perform conservatively in field studies, and were included in the tracer solution as backups and checks on bromide.

3.2 INJECTION PROCEDURE

The method of injecting the tracer solution into the aquifer was designed, to the extent possible, to produce a uniform pulse release of tracers into approximately the middle of the saturated zone of the alluvial aquifer with a minimal amount of disturbance to the natural flow field. The tracer solution was introduced into the aquifer through five 5.2-cm diameter PVC wells (Figure 3.1). The injection wells were spaced one meter apart in a linear array. Each well was screened between elevation 57.5 and 58.1 m (or between depths of 7.4 to 8.0 m below ground surface). Beginning on October 28, 1986, 10.07 m^3 of a groundwater mixture containing 2500 mg/L of bromide and 400 mg/L of each of the FBA tracers were introduced into the metered injection wells at a uniform rate over a period of 48.5 hours. The maximum pressure head increase recorded in the injection wells during the period was 0.64 m.

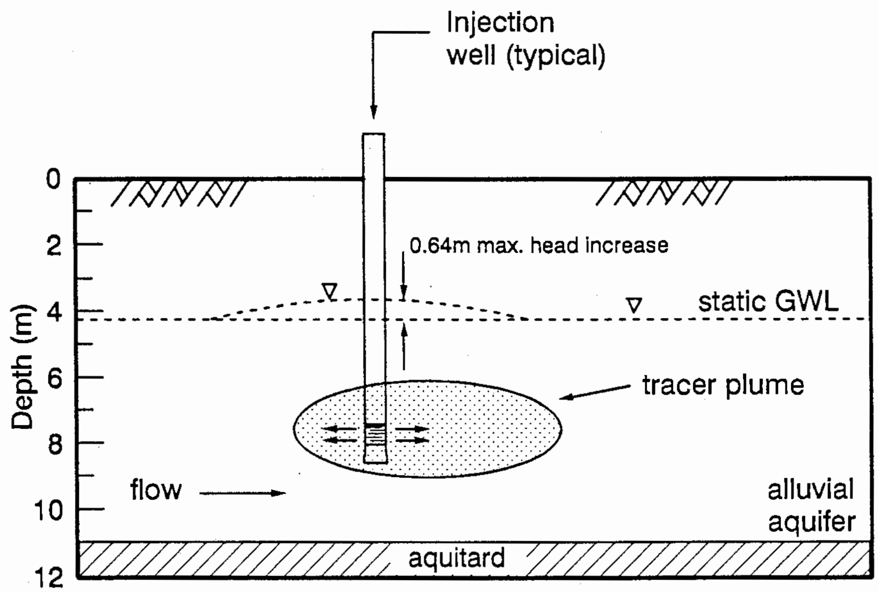

Figure 3.1 Schematic of Injection Well

Section 4.0

TRACER SAMPLING AND ANALYSIS METHODS

The primary goal in designing the tracer sampling network was to obtain detailed measurements defining the three-dimensional distribution of the plume at various times during the experiment. This required the use of multilevel samplers (MLS) to provide representative groundwater samples from discrete zones in the aquifer. Because the natural vertical hydraulic gradients were large in comparison to the horizontal gradients in some areas of the test site, special MLS designs were required to prevent or minimize artificial vertical groundwater movement in the disturbed annulus created by sampler installation.

4.1 SAMPLING NETWORK

Two basic MLS designs, referred to as the augered MLS and the driven MLS, were developed and tested for use in the field study. Both samplers generally consisted of a rigid pipe through which 20 to 30 teflon sampling tubes were inserted to different sampling depths. A uniform spacing between sampling ports of 38 cm was used on the majority of MLS, although several of the initial driven MLS prototypes installed in the injection site vicinity had port spacings ranging from 25 to 46 cm. The augered MLS was installed by augering to the base of the alluvial aquifer, installing the sampler through an 8.6-cm ID by 18-cm OD hollow-stem auger, removing the auger, and allowing the aquifer to collapse around the sampler. The external bentonite packers between sampling ports on the augered samplers were intended to prevent artificial groundwater movement in the well annulus. The driven MLS was constructed from 4.4-cm diameter flush-joint steel casing. These devices were installed by augering to the water table, lowering the sampler into the auger hole, then driving the sampler to final depth using a 63.6-kg standard penetration hammer. Unlike the augered MLS which tended to reduce the density of the aquifer material at the point of installation, the driven sampler tended to compact the aquifer locally [Boggs et al., 1988].

A plan view of the array of the 258 multilevel samplers constructed for the field tracer experiment is shown in Figure 4.1, with expanded views of the network shown in Figures 4.2 and 4.3. The network consisted of approximately

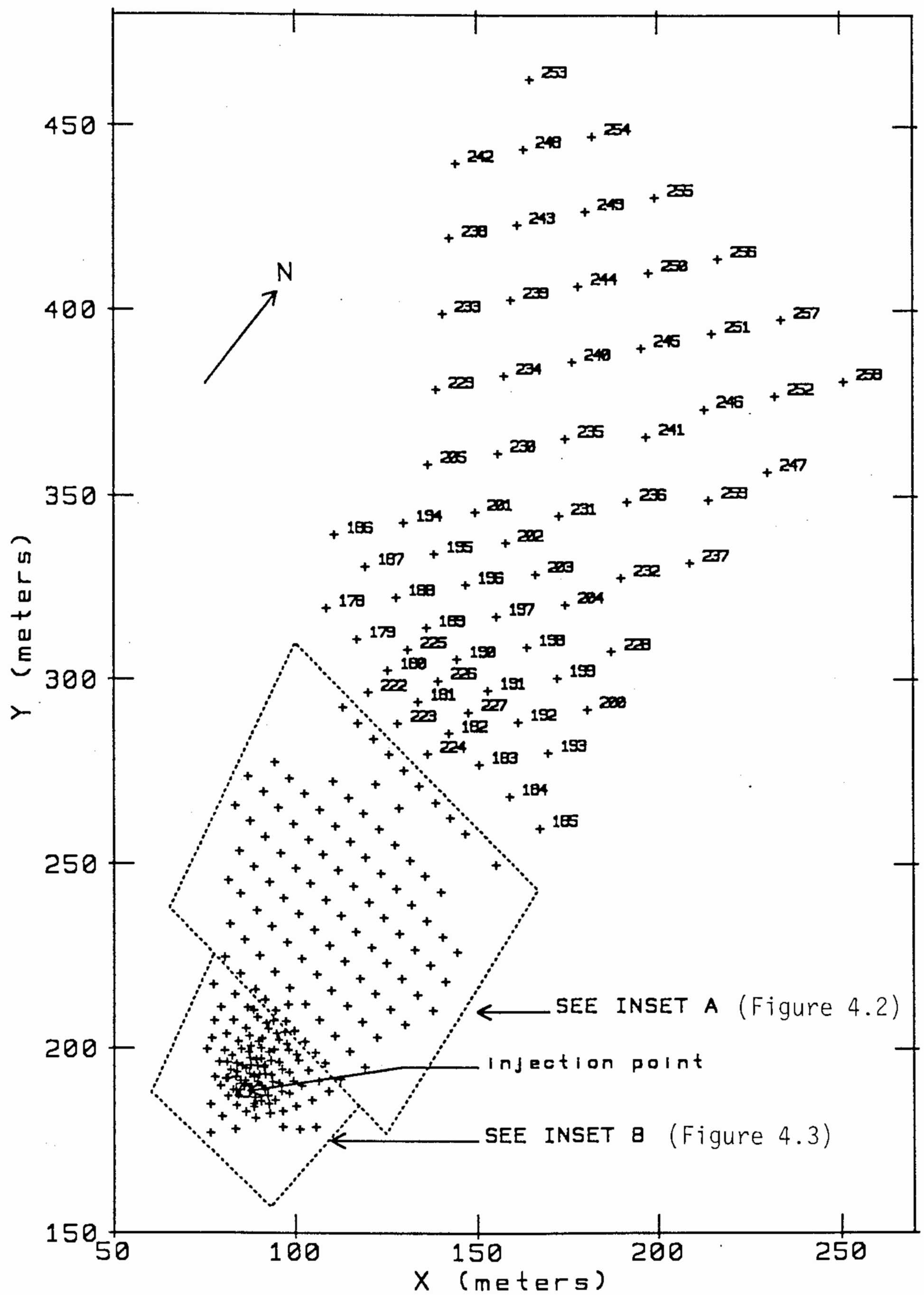

Figure 4.1 Multilevel Sampling Well Network

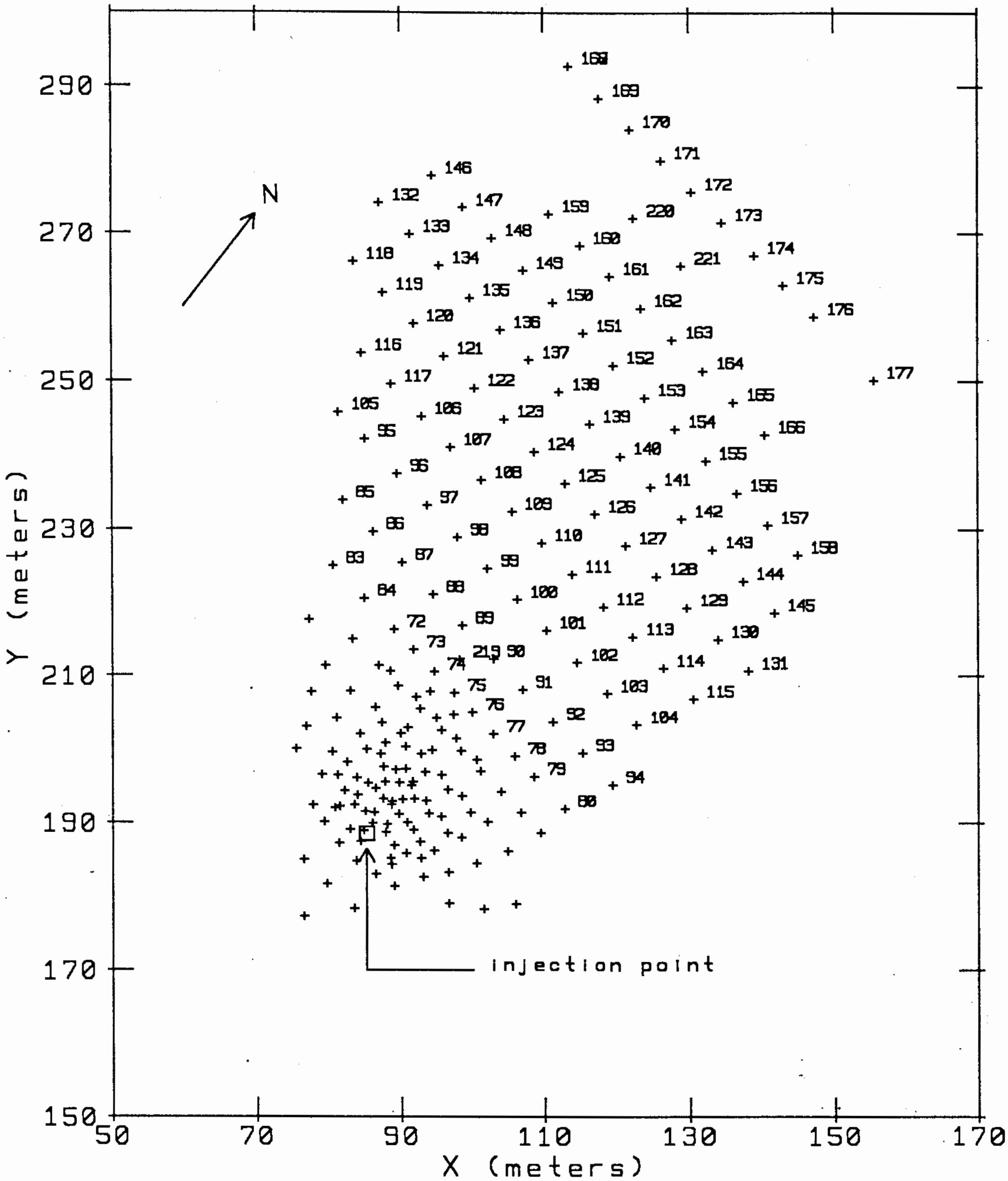

Figure 4.2 Multilevel Sampling Well Network, Inset A

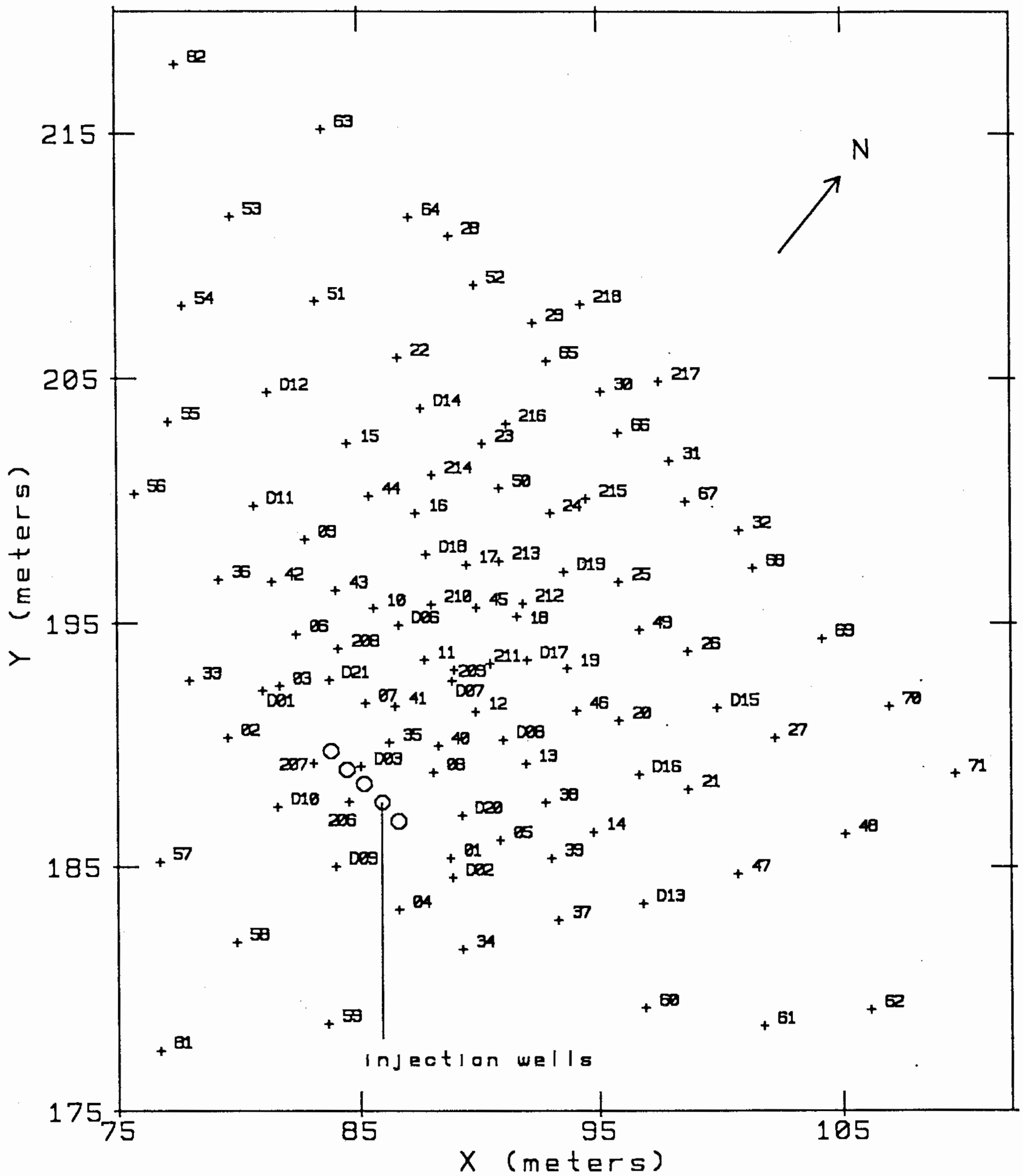

Figure 4.3 Multilevel Sampling Well Network, Inset B

6000 sampling points for monitoring the tracer plume in three dimensions. The initial sampling network installed prior to the tracer injection included 70 samplers located within approximately 20 m of the injection wells. Additional samplers were installed periodically during the experiment as the overall direction and transverse dimensions of the plume became evident.

4.2 SAMPLE COLLECTION AND ANALYSIS

Groundwater samples were collected from the multilevel samplers using a mobile sampling cart equipped with three, 10-channel peristaltic pumps. This device permitted simultaneous collection of groundwater samples from all sampling tubes for a single MLS. Sampling protocols implemented for the study were relatively simple because of the chemical stability of the bromide and FBA tracers. Approximately 120 mL was purged from each sampling tube prior to collecting duplicate 11-mL samples in separate glass vials. Samples were then refrigerated at approximately 4°C until analyzed. Groundwater samples were filtered in the laboratory through 0.45-micron filters prior to analysis. Samples were analyzed for all four tracers simultaneously using high pressure liquid chromatography (HPLC) coupled with ultraviolet adsorption detection.

The emphasis of the monitoring program was on "snapshots" of the three-dimensional concentration distribution of each tracer. A total of eight snapshot sampling events were conducted during the experiment at intervals ranging from 5 to 19 weeks. A summary of general information regarding the plume snapshots is given in Table 4.1.

TABLE 4.1

Plume Snapshot Sampling Summary

Snapshot	Elapsed Time (days)	MLS Sampled	Samples Analyzed
1	9	45	809
2	49	61	1034
3	126	102	1795
4	202	124	1812
5	279	128	1681
6	370	139	1557
7	503	162	2239
8	594	182	519

Note that for the eighth snapshot, only samples collected from MLS located along the approximate centerline of the network and those located beyond a distance of 160 m from the injection site were analyzed. Tracer data for each of the snapshot sampling events are given on Diskette No. 1. An illustration of this information is provided in Table 4.2. Note that the analytical detection limit for snapshots 1 through 4 was 0.1 mg/L for all tracers. For snapshots 5 through 8, measurements were reported down to 0.01 mg/L.

Each group of 100 samples analyzed using the HPLC method included twelve instrument calibration standards, four quality control standards, and four blind split samples. From the quality control standards measurements, estimates of the analytical accuracy (expressed in terms of the mean percent bias) and precision (expressed as the mean relative standard deviation) for each tracer were made. These results are summarized by snapshot and presented in file QC.DAT on Diskette No. 1.

TABLE 4.2

Example of Tracer Data

Sample ID	Bromide (mg/L)	PFBA (mg/L)	TFBA (mg/L)	DFDA (mg/L)	X (m)	Y (m)	Z (m)	Sampling Date Yr	Sampling Date Julian Day	Days Since Injection
S01D00101A1	.60	.30	.20	< .10	81.1	192.3	60.35	86	309	6
S01D00101A2	< .10	.10	.10	.60	81.1	192.3	60.35	86	309	6
S01D00201A1	< .10	< .10	.20	.20	89.0	184.6	59.56	86	309	6
S01D00203A1	.40	.20	< .10	.30	89.0	184.6	60.07	86	309	6
S01D00204A1	.30	< .10	< .10	2.20	89.0	184.6	60.33	86	309	6
S01D00205A1	.30	.10	.20	1.80	89.0	184.6	60.58	86	309	6
S01D00206A1	.20	.20	.10	.20	89.0	184.6	60.83	86	309	6
S01D00207A1	.30	< .10	.20	.70	89.0	184.6	61.09	86	309	6
S01D00209A1	.20	< .10	< .10	.10	89.0	184.6	61.59	86	309	6
S01D00301A1	750.00	130.00	120.00	130.00	85.2	189.2	58.95	86	309	6
S01D00304A1	63.00	13.00	13.00	37.00	85.2	189.2	59.72	86	309	6
S01D00305A1	46.00	11.00	11.00	29.00	85.2	189.2	59.97	86	309	6
S01D00306A1	35.00	8.80	8.30	37.00	85.2	189.2	60.22	86	309	6
S01D00308A1	2.50	.80	.80	2.90	85.2	189.2	60.73	86	309	6
S01D00309A1	5.40	1.70	1.70	26.00	85.2	189.2	60.98	86	309	6

Note that the 11-digit sample identification numbers listed in these files are coded as follows:

Digits	Description
1 - 3	snapshot number
4 - 7	multilevel sampler number
8 - 9	multilevel sampler port number
10	port orientation, e.g., A = port facing injection site, B= port facing downgradient
11	sample replicate number (either 1 or 2)

For example, sample S01D00305A1 represents the first replicate sample collected during snapshot 1 from port 5-A of sampler D003.

Section 5.0

HYDRAULIC CONDUCTIVITY MEASUREMENT METHODS

5.1 BOREHOLE FLOWMETER METHOD

The borehole flowmeter method is similar to the conventional aquifer test except that measurements of flow entering the well at different elevations are made as the well is pumped at a constant rate. The hydraulic conductivity of each interval or layer of the aquifer is proportional to the measured flow for that interval. The layer hydraulic conductivities are computed using a linearized form of the Cooper-Jacob well equation. The key assumptions of the method are (1) the aquifer is layered and each layer is homogeneous and of uniform thickness, (2) the storage coefficient of each layer is linearly related to the layer transmissivity, and (3) the well losses attributable to each layer can be estimated. Rehfeldt et al. [1989a] provide a comprehensive discussion of the theoretical basis for the method and field procedures for its implementation.

Flow measurements were made with an impeller-type meter. The device consists of a lightweight plastic impeller suspended between two needle bearings. Rotation of the impeller produced by flow through the meter is detected by optical sensors. The optical signal is converted to a voltage that is proportional to the rate of rotation. Laboratory calibration of the instrument is required before and after field testing to convert recorded voltage measurements to flowrates. The lower threshold of flow measurement for the impeller meter is approximately 0.005 L/s. This corresponds to a detection limit for hydraulic conductivity measurement of about 10^{-6} m/s.

A map showing the locations of 58 wells tested using the flowmeter method is presented in Figure 5.1. All wells were constructed of 5.1-cm diameter flush-joint PVC slotted pipe, and were screened over the full saturated thickness of the aquifer. In designing the flowmeter test well network, Rehfeldt et al. [1989b] report that the following requirements were considered. First, sufficient closely-spaced wells were needed for variogram analysis to adequately define the horizontal correlation scale. For this purpose three well clusters (K22-K28, K29-K35, and K51-K55) were installed. Second, proper estimation of the variance of lnK required that part of the wells be spaced

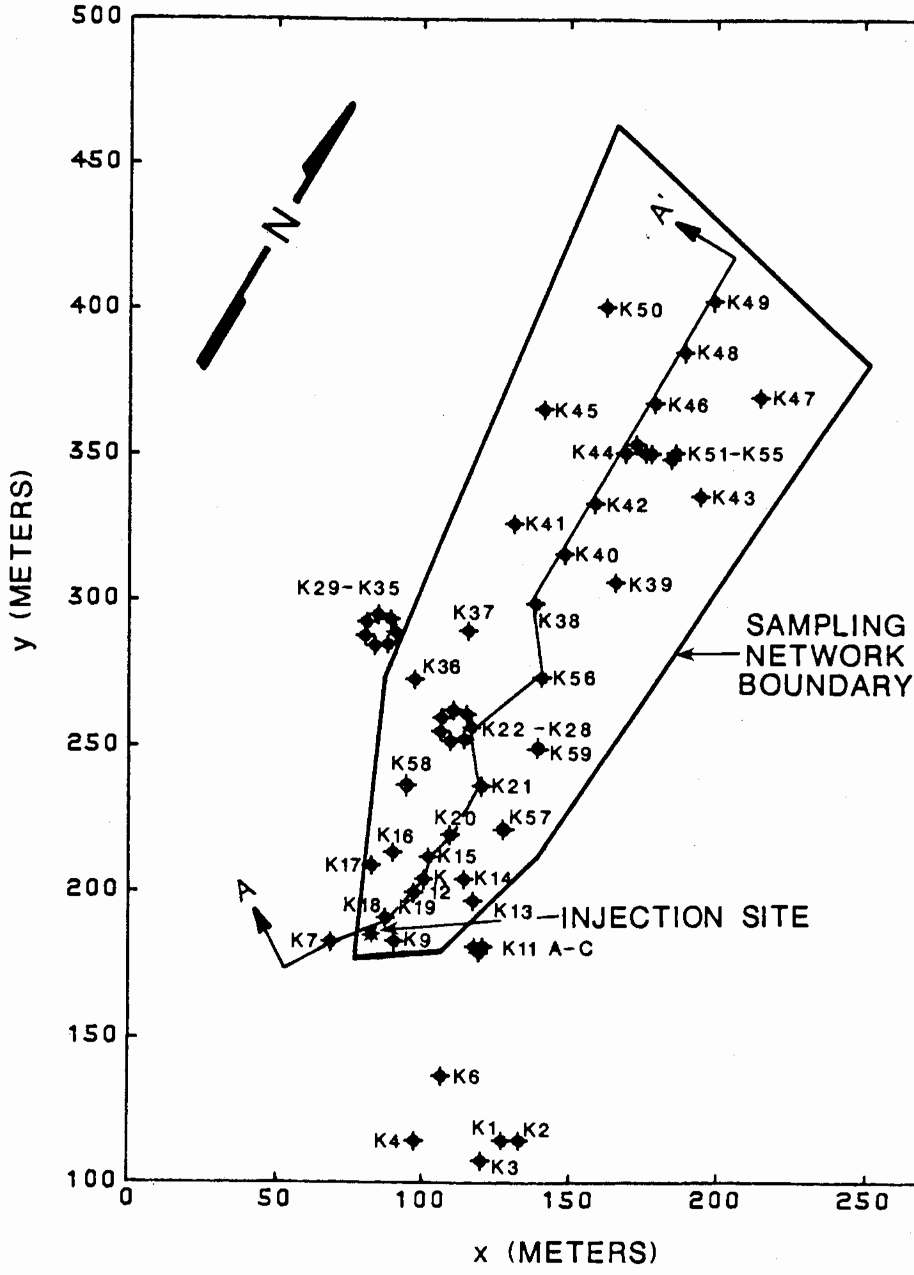

Figure 5.1 Borehole Flowmeter Test Well Network

sufficiently far apart so as to be uncorrelated. Likewise, delineation of trends in the conductivity field required coverage of essentially the entire experimental site using widely-spaced wells. Third, to estimate horizontal anisotropy in the hydraulic conductivity field required linear arrays of test wells along at least three directions. Wells located along three lines in the near-field region of the tracer test site were designed to satisfy this requirement. Flowmeter measurements within each well were made at 15-cm vertical intervals. Figure 5.2 shows a vertical profile of the hydraulic conductivity along the longitudinal axis of the tracer plume, and provides an indication of the extreme heterogeneity of the alluvial aquifer.

To date, a total of 2483 estimates of hydraulic conductivity have been obtained at the tracer test site from flowmeter measurements. These data are given on Diskette No. 2 and illustrated in Table 5.1.

TABLE 5.1

Example of Borehole Flowmeter Derived Hydraulic Conductivity Data

FLOWMETER WELL K-12
WELL COORDINATES: X = 100.61 Y = 204.29
[A] DEPTH BELOW GRADE (M)
[B] DEPTH BELOW GRADE (FT)
[C] ELEVATION ABOVE MEAN SEA LEVEL (M)
[D] ELEVATION ABOVE MEAN SEA LEVEL (FT)
[E] HYDRAULIC CONDUCTIVITY (CM/S)
[F] HEAD IN THE AQUIFER (FT ABOVE SEA LEVEL)

[A]	[B]	[C]	[D]	[E]	[F]
3.770	12.370	61.634	202.210	0.1027E-01	205.2
3.923	12.870	61.481	201.710	0.1027E-01	205.2
3.923	12.870	61.481	201.710	0.6609E-02	205.2
4.075	13.370	61.329	201.210	0.6609E-02	205.2
4.075	13.370	61.329	201.210	0.1362E-01	205.2
4.228	13.870	61.176	200.710	0.1362E-01	205.2
4.228	13.870	61.176	200.710	0.4866E-02	205.2
4.380	14.370	61.024	200.210	0.4866E-02	205.2
4.380	14.370	61.024	200.210	0.1758E-01	205.2
4.532	14.870	60.872	199.710	0.1758E-01	205.2
4.532	14.870	60.872	199.710	0.7555E-02	205.2
4.685	15.370	60.719	199.210	0.7555E-02	205.2
4.685	15.370	60.719	199.210	0.1129E-01	205.2
4.837	15.870	60.567	198.710	0.1129E-01	205.2
4.837	15.870	60.567	198.710	0.2295E-01	205.2
4.990	16.370	60.414	198.210	0.2295E-01	205.2
4.990	16.370	60.414	198.210	0.7019E-02	205.2
5.142	16.870	60.262	197.710	0.7019E-02	205.2
5.142	16.870	60.262	197.710	0.1480E-02	205.2

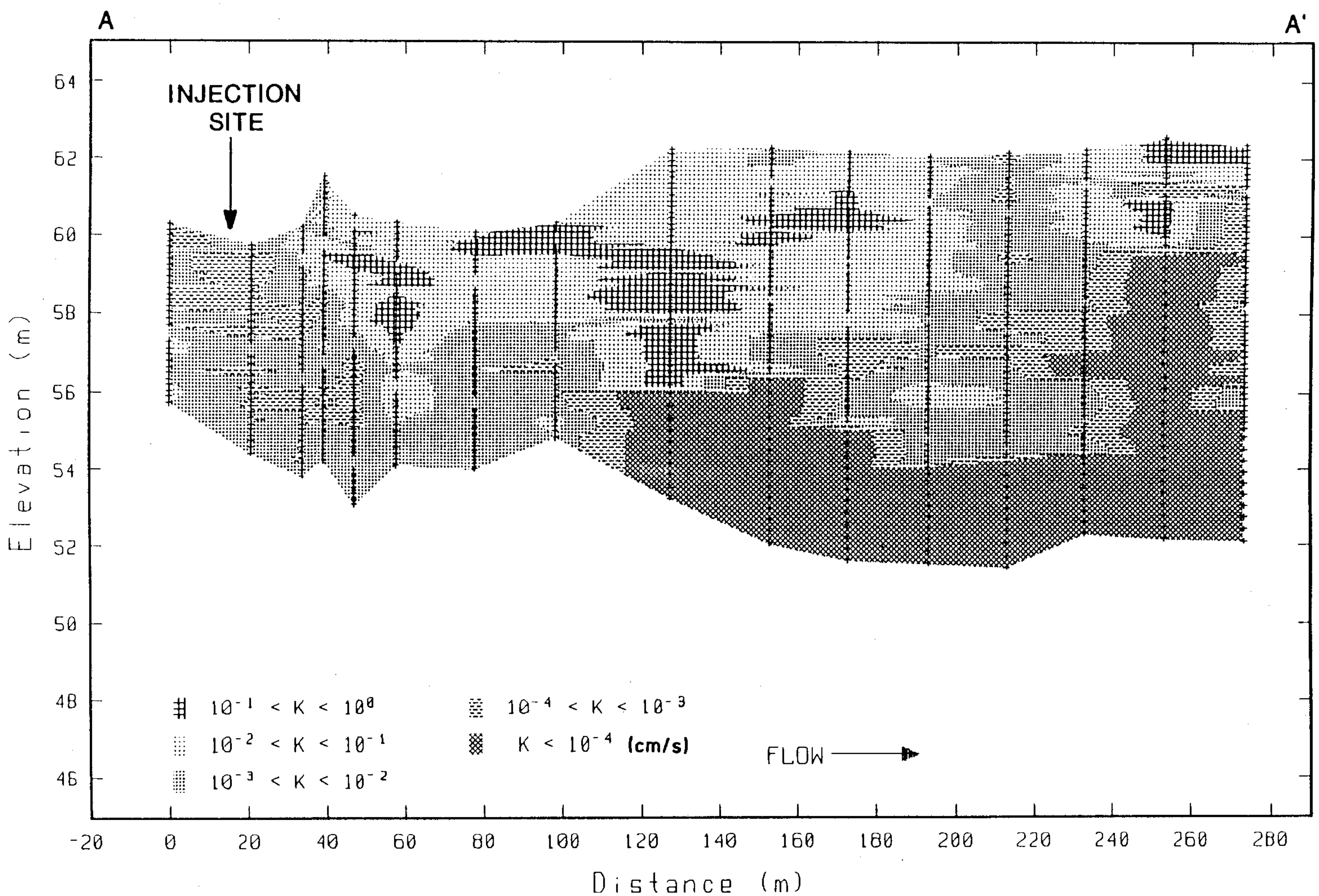

Figure 5.2 Hydraulic Conductivity Profile Along Tracer Plume Pathway

5.2 AQUIFER TESTS

Two constant-rate aquifer tests were conducted at the site to determine the global hydraulic properties of the alluvial aquifer. The methods, results, and data for these tests are described in detail in Boggs et al. [1990]. A summary of the aquifer test results is given in Table 5.2. The production well for aquifer test AT1 was located approximately midway between Wells K1 and K4 (Figure 5.1). Consequently, the results of AT1 are representative of the area south of the tracer injection site. The hydraulic properties estimated from AT2 better reflect the overall aquifer characteristics in the region of the tracer experiment, since the production well for this test was sited in the vicinity of Wells K22 through K28 (Figure 5.1).

TABLE 5.2

Global Hydraulic Properties of Alluvial Aquifer

Test	Transmissivity (cm^2/s)	Hor. K ($cm/s \times 10^{-3}$)	Vert. K ($cm/s \times 10^{-3}$)	Specific Yield
AT1	1.8	2.2	0.13	0.04
AT2	20.1	20.0	2.8	0.10

Section 6.0

PIEZOMETRIC MEASUREMENTS

Monitoring of the hydraulic head field in the alluvial aquifer at the test site was conducted prior to and during the field tracer experiment using the piezometer network shown on Figure 6.1. Piezometers were constructed of either 5.1-cm or 10.2-cm diameter PVC pipe with either 0.6-m or 1.2-m slotted well screens at the lower end. Piezometers with a suffix letter of A or B represent multistaged piezometers. The type-"A" piezometers were screened at an average elevation of 61.1 m, while the type-"B" piezometers were screened at an average elevation of 56.3 m. The as-constructed specifications for all piezometers are given in file WELLSPEC.DAT on Diskette No. 3.

Water levels in the piezometers were manually measured with an electric probe on two- to four-week intervals. In addition, 10 piezometers (P8B, P42B, P44B, P52, P53AB, P54AB, and P55AB) were equipped with float-driven analog or digital recorders. Hydrographs of the data acquired at Wells P8B, P22B, and P52 are presented in Figure 6.2 to indicate the variability of the groundwater table elevation during the course of the experiment. Groundwater level measurements for all piezometers monitored during the period December 1984 through March 1990 are presented on Diskette No. 3 and illustrated in Table 6.1.

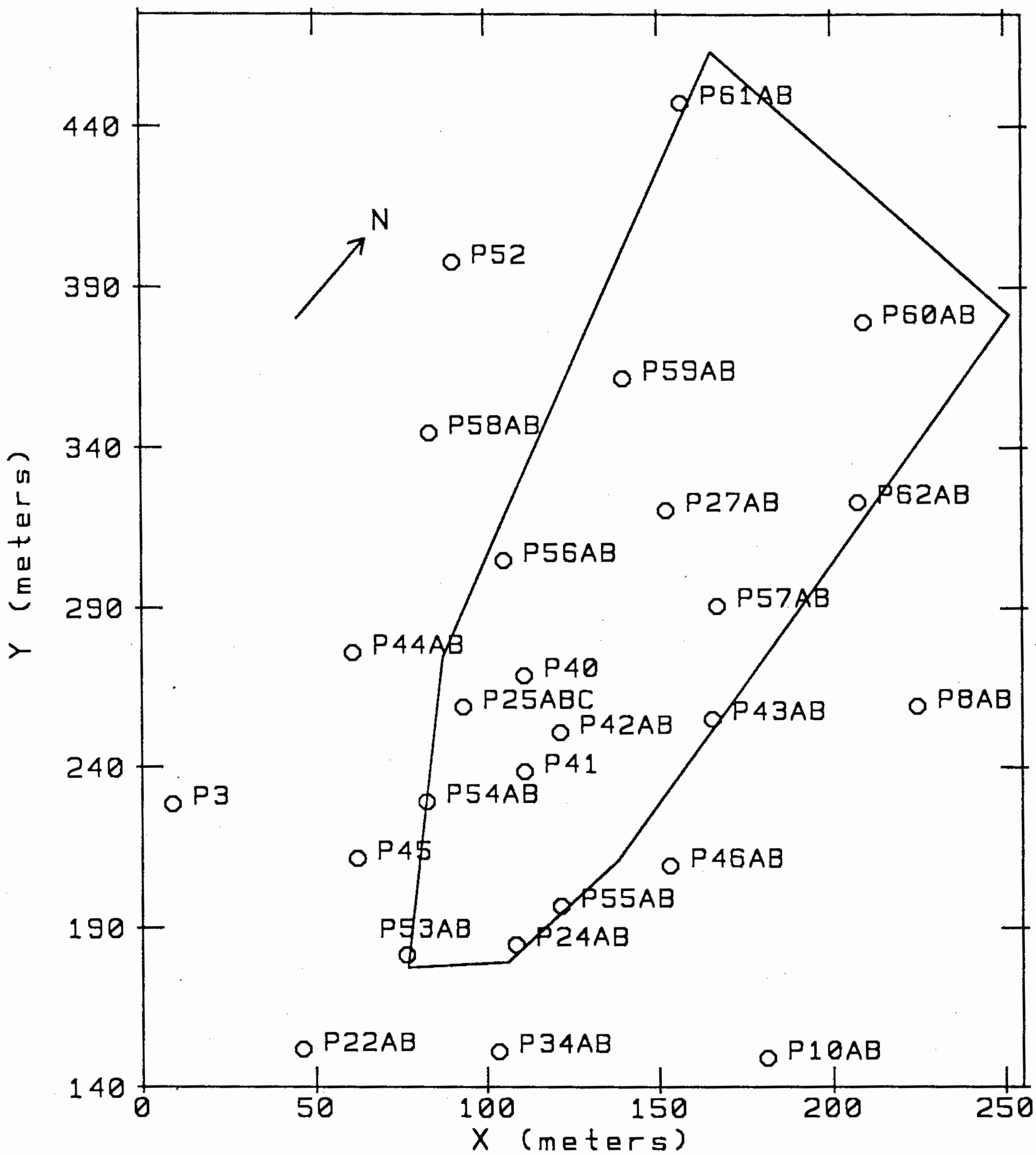

Figure 6.1 Piezometer Network

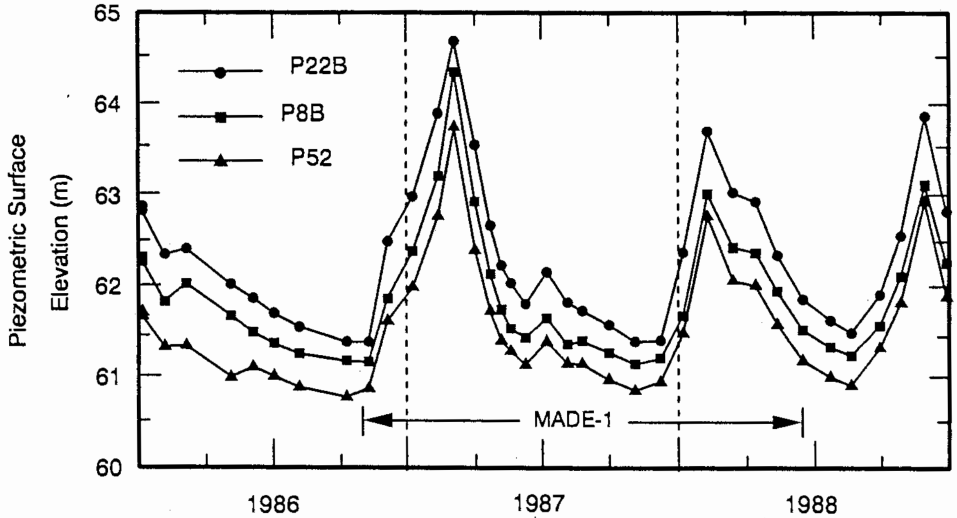

Figure 6.2 Hydrographs for Piezometers P8B, P22B, and P52

TABLE 6.1

Example of Piezometric Head Data

Piez. No.	Coordinates X(m)	Y(m)	Date	Water Level Elevation (MASL)
P-3	8.7	228.0	12/29/83	64.61
P-3	8.7	228.0	01/24/84	64.44
P-3	8.7	228.0	02/22/84	63.83
P-3	8.7	228.0	03/26/84	63.66
P-3	8.7	228.0	04/26/84	63.53
P-3	8.7	228.0	05/24/84	63.26
P-3	8.7	228.0	11/17/84	61.93
P-3	8.7	228.0	11/19/84	61.96
P-3	8.7	228.0	11/20/84	61.93
P-3	8.7	228.0	11/21/84	61.93
P-3	8.7	228.0	11/26/84	61.96
P-3	8.7	228.0	11/27/84	61.97
P-3	8.7	228.0	11/28/84	62.65
P-3	8.7	228.0	11/29/84	62.90
P-3	8.7	228.0	11/30/84	62.99
P-3	8.7	228.0	12/03/84	63.58
P-3	8.7	228.0	12/04/84	63.69
P-3	8.7	228.0	12/05/84	63.78
P-3	8.7	228.0	12/06/84	63.83
P-3	8.7	228.0	12/10/84	63.80

Section 7.0

SECOND NATURAL-GRADIENT TRACER EXPERIMENT (MADE-2)

A second natural-gradient field tracer test, cosponsored by the USAF, was initiated in July 1990 using a different set of tracers. The principal objective of the second field study was essentially the same as that of the first experiment, i.e., to acquire field-scale data on physical transport processes for transport model validation. Tritiated water was used as the conservative reference tracer to preclude the possibility of tracer adsorption that may have occurred with bromide during the MADE-1 experiment. In addition, four hydrocarbons were included in the tracer solution. They consisted of benzene, naphthalene, ^{14}C-tagged paraxylene, and orthodichlorobenzene. These organics are components of a variety of hydrocarbon fuels (e.g., jet fuel, gasoline), and represent a range of mobilities in groundwater. Their purpose was to provide field-scale observations of transport of organic compounds for comparison with model predictions based on laboratory-measured retardation properties. Injection of the tracer solution was carried out at the same site and in the same manner as the previous experiment. Monitoring is expected to last approximately 14 months. During this period, five snapshot samplings of the tritium and organic plumes will be performed using the network of multilevel samplers. In addition, tracer samples will be collected approximately monthly from 56 positive displacement gas-lift samplers installed in two parallel rows or "fencelines" normal to the direction of plume movement. Tracer measurements from the fencelines are intended to provide tracer breakthrough curves from which retardation factors can be estimated for each organic tracer. The MADE-2 field study is expected to conclude in September 1991 and its results will be made available soon thereafter.

Section 8.0

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