CHARACTERIZATION OF INPUT PARAMETERS REQUIRED FOR SIMULATING AGRICULTURAL CHEMICALS FATE AND TRANSPORT IN UNSATURATED AND SATURATED ZONES

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E-048

Phase 1 Final Report (1987-1988)

Submitted to

University Center for Water Research
Oklahoma State University
Stillwater, Oklahoma

July 1, 1988

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CHARACTERIZATION OF INPUT PARAMETERS REQUIRED FOR SIMULATING AGRICULTURAL CHEMICALS FATE AND TRANSPORT IN UNSATURATED AND SATURATED ZONES

INTRODUCTION:

The extensive use of fertilizers and other agricultural chemicals, and the potential for ground-water contamination by water soluble chemicals has increased the need for knowledge about chemical transport by subsurface water movement. Leaching of agricultural chemicals along with the soil-water infiltration and deep percolation in many of the cropped watersheds in Oklahoma and other States in the Southern Plains of the U.S. is of great concern.

A field monitoring strategy is proposed to utilize various techniques to gather information regarding field processes affecting the fate of agricultural chemicals in unsaturated and saturated zones. The site selected for field-testing this strategy is the Agricultural Research Station (Okl. State Univ.) at Perkins (figure 1). The cropped watersheds are underlain by sandy soils and a shallow water table. The parameters which are required for computer simulation include unsaturated and saturated hydraulic properties, physical and chemical properties of unsaturated zone, chemical-soil interaction properties, dispersivity and persistivity in ground water and boundary conditions. Many of these parameters are not typically characterized for a

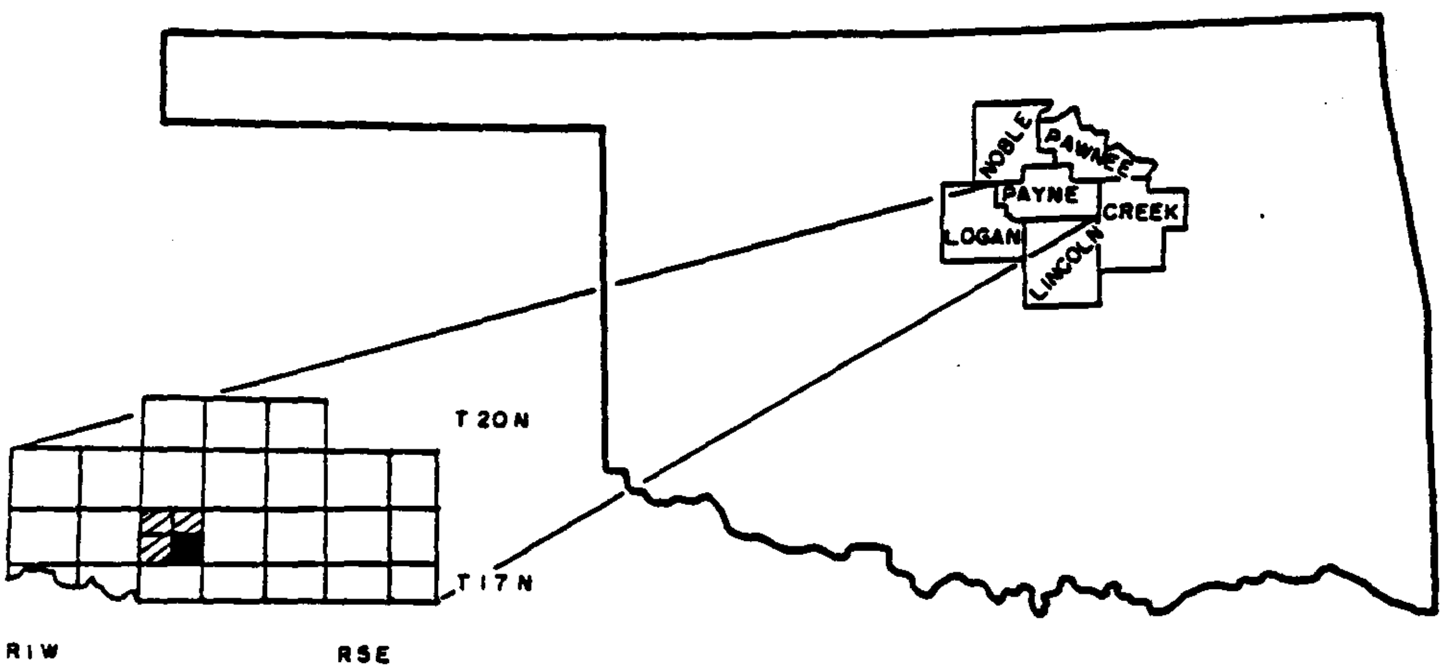


Fig. 1.-Location map of area of study

specific site. An expert system is being developed in order to identify the appropriate field methods and modeling strategies to establish a data base for computer model simulations for predicting chemical movement in both unsaturated and saturated zones.

PURPOSE:

Continued demand for water supplies in the Southwest, including Oklahoma, has intensified the need for information regarding ground-water quality associated with agricultural practices. The main purpose of this research is to evaluate the ground-water quality and to characterize the parameters required for simulating the fate and transport of nutrients and pesticides through the unsaturated and saturated zones.

OBJECTIVE:

The primary objective of this research is to evaluate the ground-water quality related to agricultural practices, and mainly identify and characterize input parameters required for simulating fate and transport of nitrate-N and a selected pesticide through the unsaturated and saturated zone. The initial results of the study have been published in Proceedings of American Water Resources Association (Naney et. al., 1987) and presented at the Oklahoma Water Resources Conference in September, 1987 (Kent, et. al., 1987).

METHODOLOGY:

The methods utilized to accomplish the objectives set in this study are conducted in various tasks.

TASK 1 Identify and select environmentally persistent and mobile pesticides for field monitoring at the Perkins site. The selection of target pesticides will be based on their half life and octanol water partioning coffecient values.

RESULTS:

The selection of the target pesticides has been accomplished, and the following pesticides and insecticides have been chosen for field monitoring: treflan, endosulfan, malathion, 2,4-D, lindane, aldrin, carbryl, and urea.

FUTURE PROPOSED RESEARCH:

None.

TASK 2 Utilize the data collection system which was established this year between the Agricultural Research Service (ARS), USDA and the Department of Geology (OSU) (Naney, Kent, et.al., 1987).

RESULTS:

The site geology has been characterized based on test drilling data, surface and borehole geophysical data. Based on the bore hole geophysical data (gamma ray) and core log data

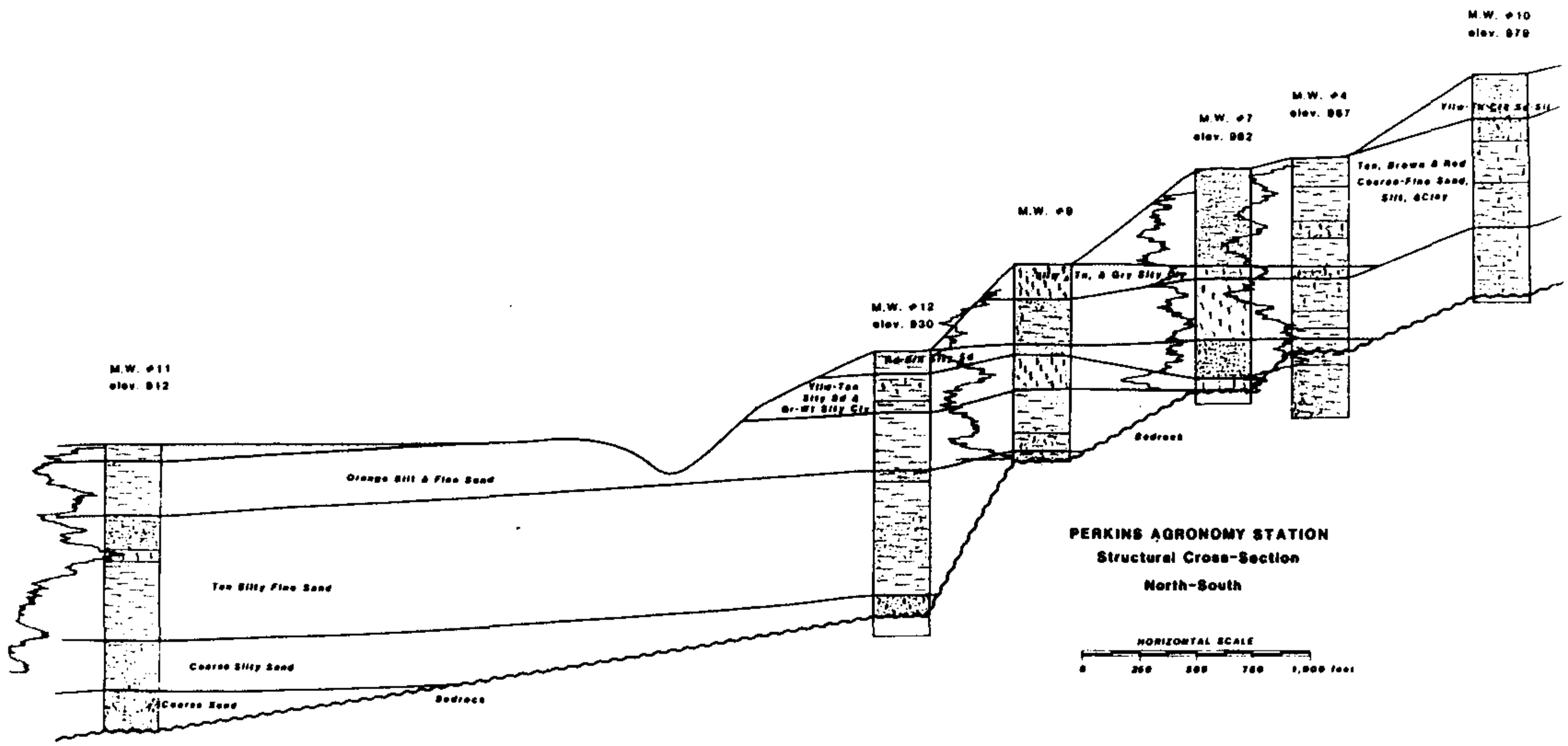

M.W. #11
elev. 912
M.W. #12
elev. 930
M.W. #9
M.W. #7
elev. 962
M.W. #4
elev. 967
M.W. #10
elev. 979
Orange Silt & Fine Sand
Tan Silty Fine Sand
Coarse Silty Sand
Coarse Sand
Bedrock
Ylw-Tan
Silty Sd &
Gr-Wt Silty Cly
Tan, Brown & Red
Coarse-Fine Sand,
Silt, &Clay
PERKINS AGRONOMY STATION
Structural Cross-Section
North-South
HORIZONTAL SCALE
0
250
500
750
1,000 feet

FIGURE 2

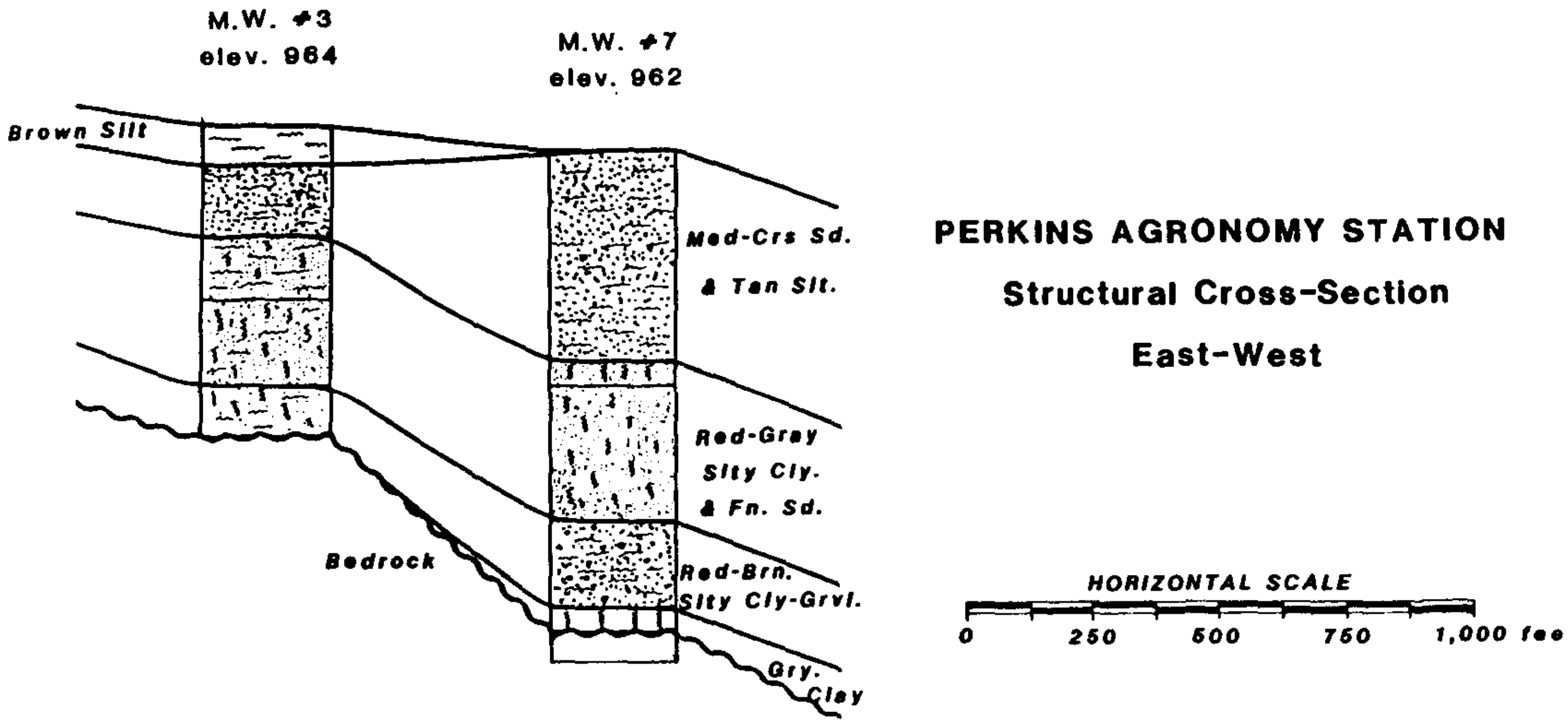

M.W. #3
elev. 964
M.W. #7
elev. 962
Brown Silt
Med-Crs Sd.
& Tan Slt.
Red-Gray
Slty Cly.
& Fn. Sd.
Red-Brn.
Slty Cly-Grvl.
Bedrock
Gry.
Clay
PERKINS AGRONOMY STATION
Structural Cross-Section
East-West
HORIZONTAL SCALE
0
250
500
750
1,000 feet

FIGURE 3

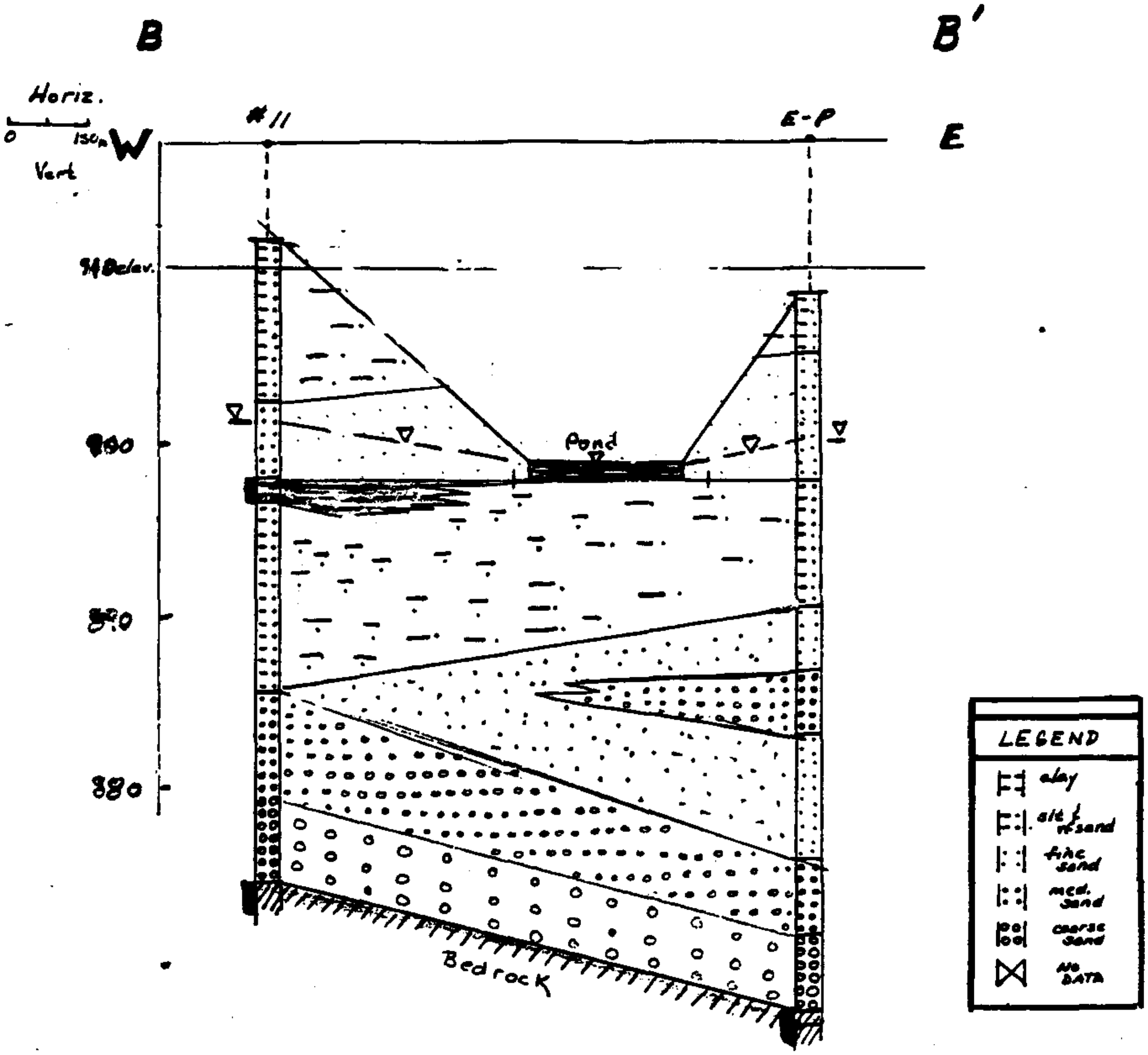
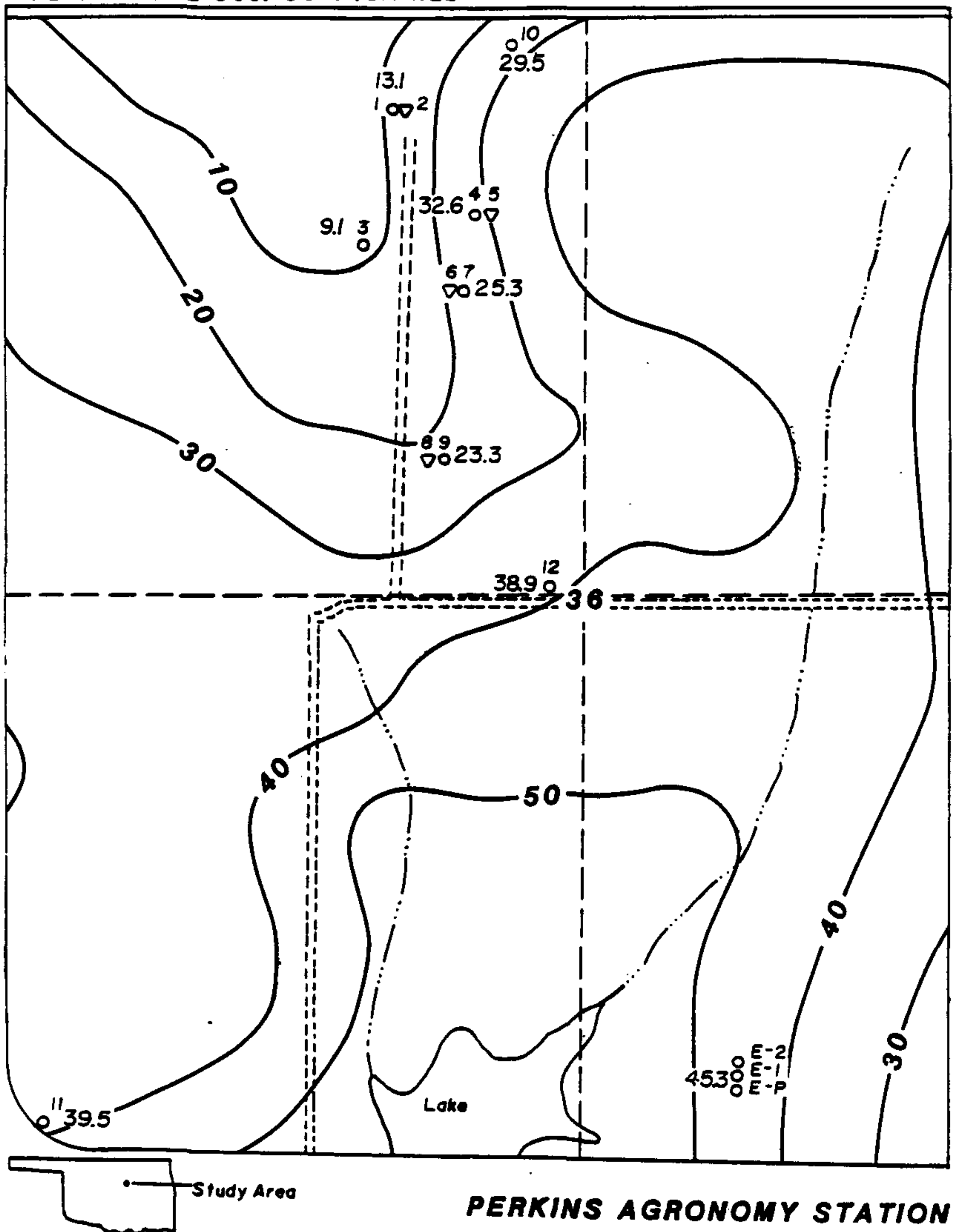

B
B'
Horiz.
0
150ft
Vert
W
E
#11
E-P
900
880
Pond
Bedrock
LEGEND
clay
fine sand
med. sand
coarse sand
NO DATA

FIGURE 4

W/2 &E/2 W/2 Sec. 36 T18N-R2E



PERKINS AGRONOMY STATION
Saturated Thickness Map

▽ Shallow Well

○ Deep Well

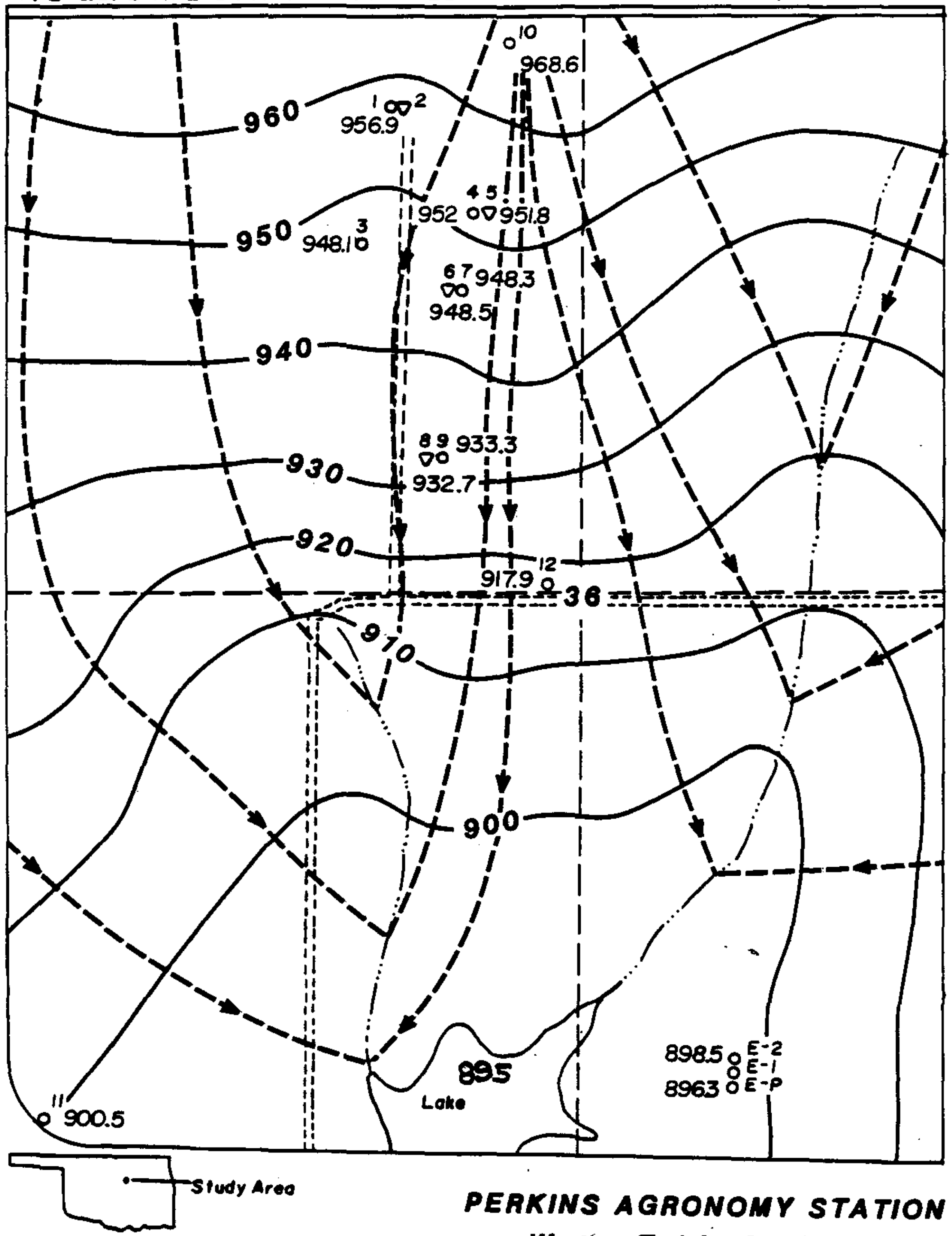
C.I. 10 feet

Scale

0 330 660 990 1,320 feet

FIGURE 5

W/2 &E/2 W/2 Sec. 36 T18N-R2E



PERKINS AGRONOMY STATION
Water Table Surface
Flow Net Map

▽ Shallow Well

○ Deep Well

C.I. 10 feet

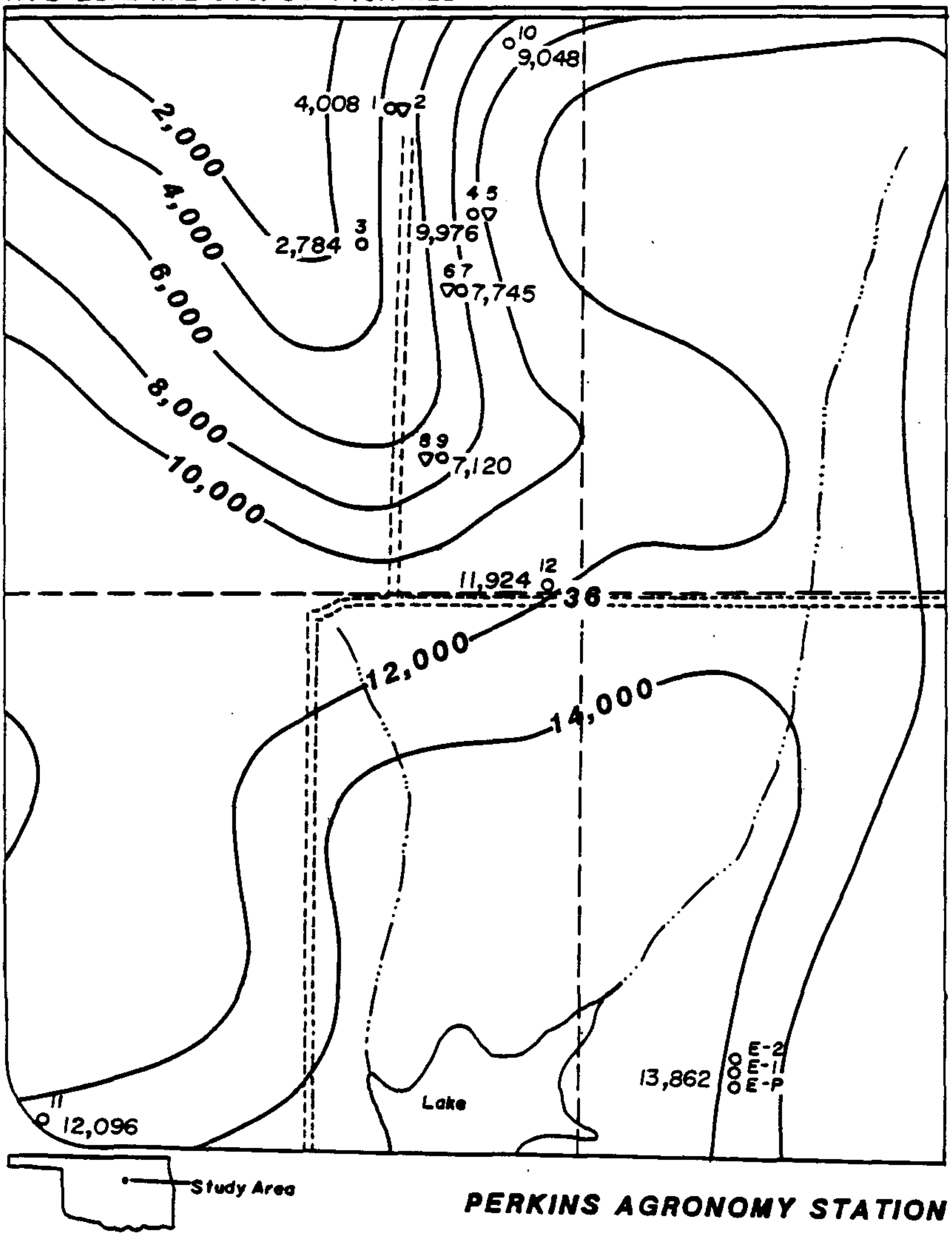
Scale

0 330 660 990 1,320 feet

FIGURE 6

a

W/2 &E/2 W/2 Sec. 36 T18N-R2E



PERKINS AGRONOMY STATION
Transmissivity Map

▽ Shallow Well

○ Deep Well

C.I. 2,000 gpd/ft

Scale

0 330 660 990 1,320 feet

Table 1. Summary of Water-Table Elevations, Bedrock Elevations, and Saturated Thicknesses.

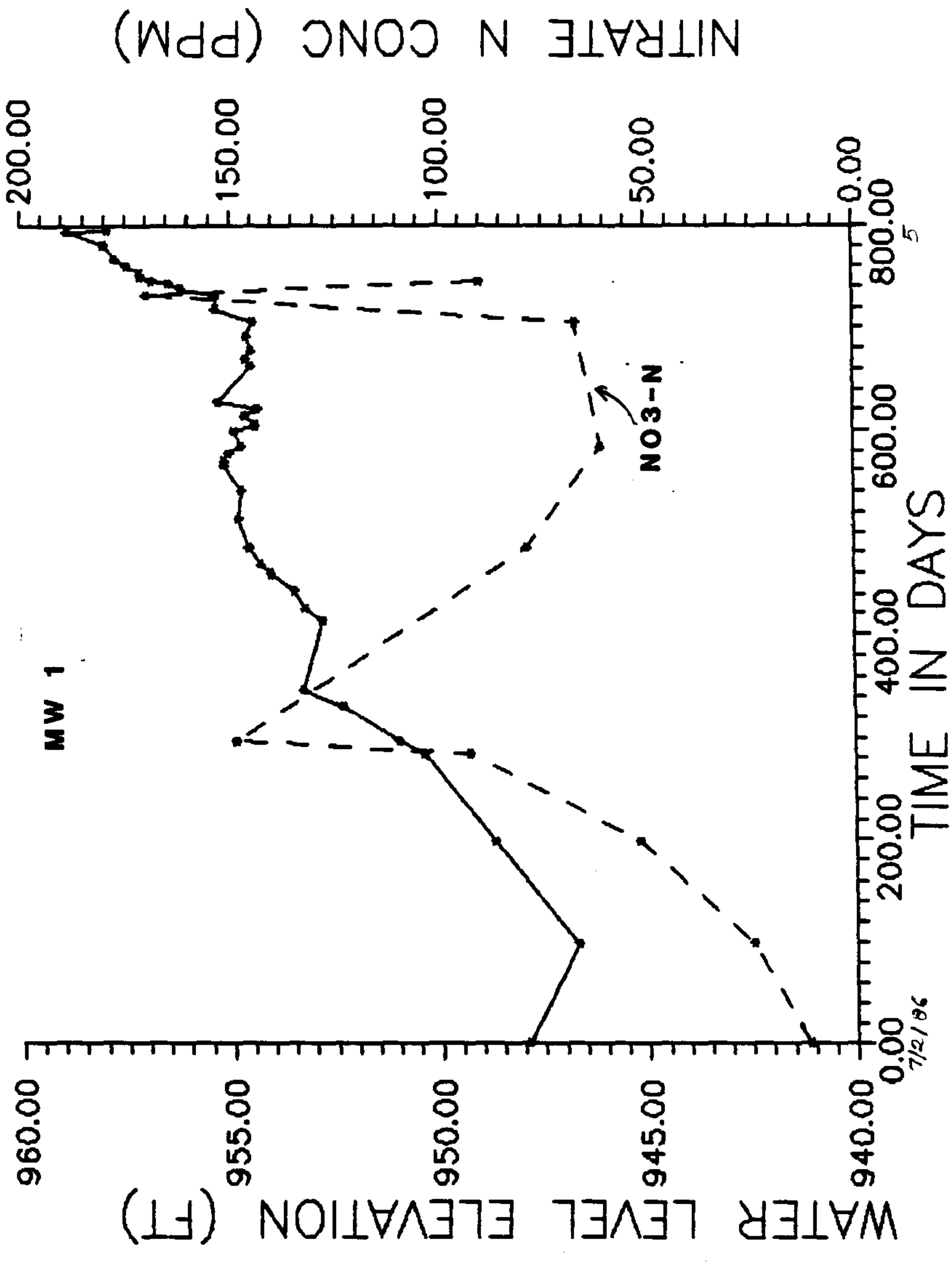
Well	Elev. of TOC (ft)	Stick Up (ft)	Land Surface Elev. (ft.)	Depth to Water (ft.)	Elev. of Water-Table (ft.)	Depth to Bedrock (ft.)	Elev. of Bedrock (ft.)	Sat. Thick. (ft.)
1	974	1.42	972.58	16.91	957.09	30	942.58	14.51
2	974	1.38	972.62	17.05	956.95	---	---	---
3	964	1.5	962.50	15.91	948.09	25	937.50	10.59
4	967	1.46	965.54	14.34	952.66	46.5	919.04	33.62
5	967	1.39	965.61	15.12	951.88	---	---	---
6	962	1.2	960.80	13.55	948.45	---	---	---
7	962	1.2	960.80	13.69	948.31	39	921.80	26.51
8	945	1.4	943.60	12.31	932.69	---	---	---
9	945	1.27	943.73	11.73	933.27	35	908.73	24.54
10	979	1.4	977.60	10.43	968.57	39	938.60	29.97
11	912	1.29	910.71	11.47	900.53	51	859.71	40.82
12	930	1.55	928.45	12.03	917.97	51	877.45	40.52
E-P	909	0.0	909.00	12.67	896.33	57	852.00	44.33

Note: --- = not applicable; the well borings did not penetrate bedrock.

cross-sections (figures 2, 3, 4) describe the subsurface geology at the site. The core log data for different monitoring wells is included in appendix A. Maps for saturated thickness (figure 5), water table elevation (figure 6), and transmissivity (figure 7) were ploted utilizing the data obtained from the testhole drilling and pump test analysis. Table 1 provides the summarized data for water-table elevations, bedrock elevation and saturated thickness.

Water Quality:

The network of nested monitoring well has been utilized for collecting the ground-water quality data since spring of 1986. Data for chemical analysis of different inorganic elements present in the different nested monitoring wells is shown in Appendix B. Unsually high values for nitrates and sulfates have been observed in the collected data. The chemical data is being further analyzrd for analysis of trends and its correlation with water level fluctuations, rainfall, cropping practices and land slope. Variation in the chemical quality with time has been plotted (appendix c). Preliminary analysis of data indicated generally higher concentrations of the leached chemicals in the shallow wells. A comparison of water level fluctuations and nitrates over a period of 800 days



WATER LEVEL ELEVATION (FT)
960.00
955.00
950.00
945.00
940.00
NITRATE N CONC (PPM)
200.00
150.00
100.00
50.00
0.00
TIME IN DAYS
0.00
200.00
400.00
600.00
800.00
MW 1
NO3-N
7/2/86

FIGURE 8

indicate a very good correlation (figure 8). Additional monitoring well drilling and installation with the assistance of the ARS, USDA has been completed. The new monitoring well network has been used for conducting a tracer test in the unsaturated and the saturated zones complete set of data has yet not been compiled for the tracer tests.

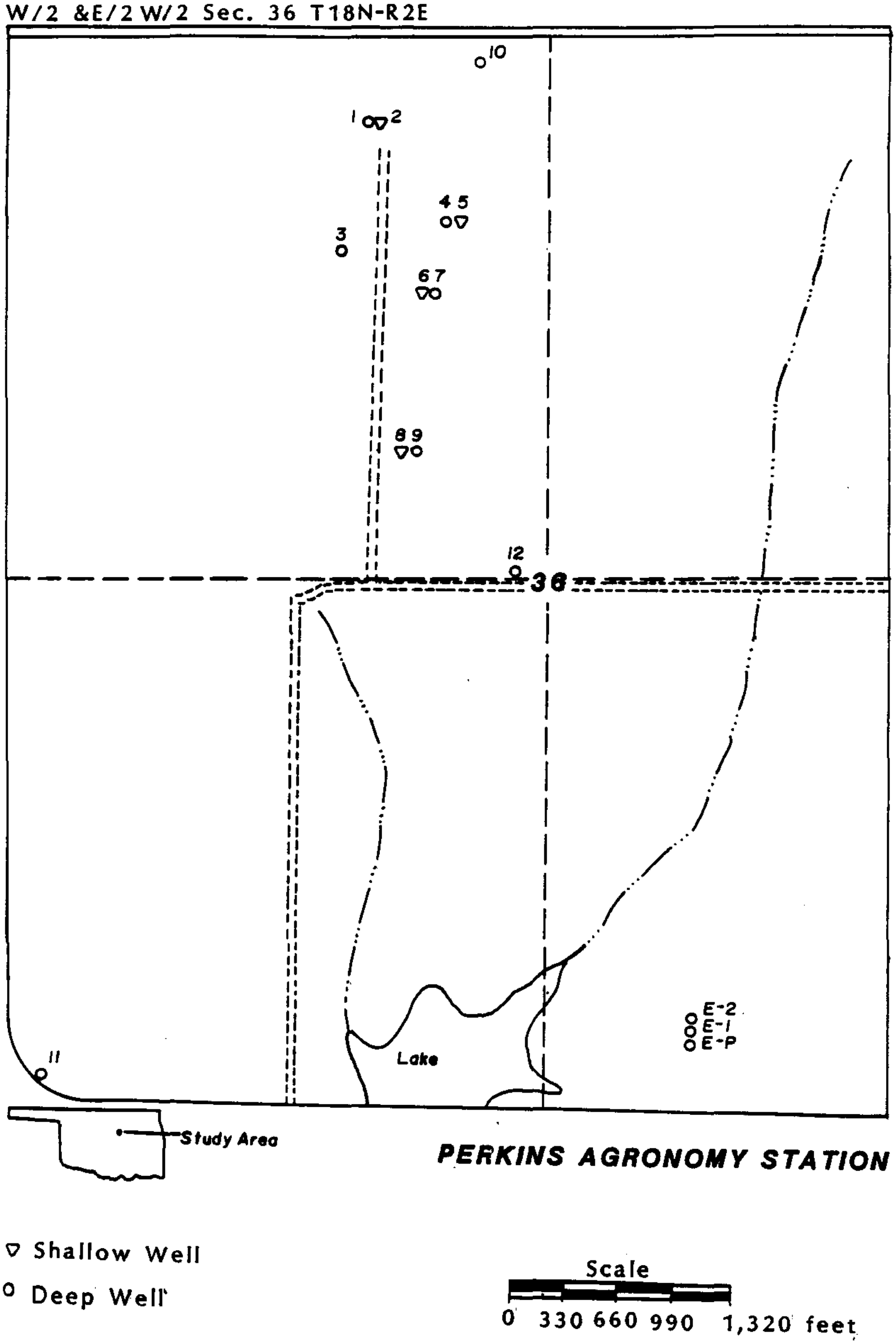
Future Proposed Research:

Continuous coring of soil samples is proposed for different monitored agricultural plots including the tracer nest. In addition, a deep test well will be drilled into bedrock in order to provide information on hydraulics and water quality in the underlying bedrock.

TASK 3 Characterize hydraulics of the unsaturated zone. Soil moisture levels will be obtained at different depths utilizing neutron soil-moisture logging.

Results:

Volumetric soil moisture measurements were made from March 3, to June 24 1988. Soil moisture determinations were made at 0.5 interval to a depth of 8.5 feet below the land surface. Soil moisture gradients have been established by installing tensiometers at different soil depths. Data is cureently being graphed and analyzed. Additional


W/2 &E/2 W/2 Sec. 36 T18N-R2E
10
1
2
4 5
3
6 7
8 9
12
36
Lake
11
E-2
E-1
E-P
Study Area
PERKINS AGRONOMY STATION
Shallow Well
Deep Well
Scale
0 330 660 990 1,320 feet

soil moisture data is already available for the Perkins site. The data obtained has been used to determine the values of unsaturated hydraulic conductivity for modeling in Task 6.

Future Proposed Research:

None

TASK 4 Define ground water hydraulics for the Perkins terrace aquifer. This would be accomplished by utilizing aquifer pumping test data, potentiometric data and information regarding the aquifer boundaries.

Results:

The monitoring well network (figure 9) has been effectively utilized to obtain data to characterize ground-water hydraulics at the site. Several methods were employed in order to determine hydraulic parameters for the Perkins aquifer including, transmissivity, stoitivity. The different techniques included Jacob'plot, Prickett plot, and theis fit method. The calculated aquifer parameters for the site are tabulated in table 2 and 3. An example of each method is shown in Appendix D.

Future Proposed Research:

None.

TASK 5 Develop expert system using the LOTUS system. The expert system will consist of a branched-decision tree which will identify methods and procedures for the development of a data base for the transport models.

Results:

The system is in the early stages of development.

Future Proposed Research:

An additional year will be required to finalize the expert system using the computer.

TASK 6 Computer modeling of nutrient and pesticide transport in the unsaturated and the saturated zones.

Results:

A preliminary evaluation of different computer models for chemical transport in the unsaturated and saturated zones has been conducted. Two models, PRZM for the unsaturated zone, and KONIKOW for the saturated zone have been selected for model calibration using existing data. Input data base for these models has been created and initially simulations has been conducted.

Future Proposed Research:

These models will be used with the data collected

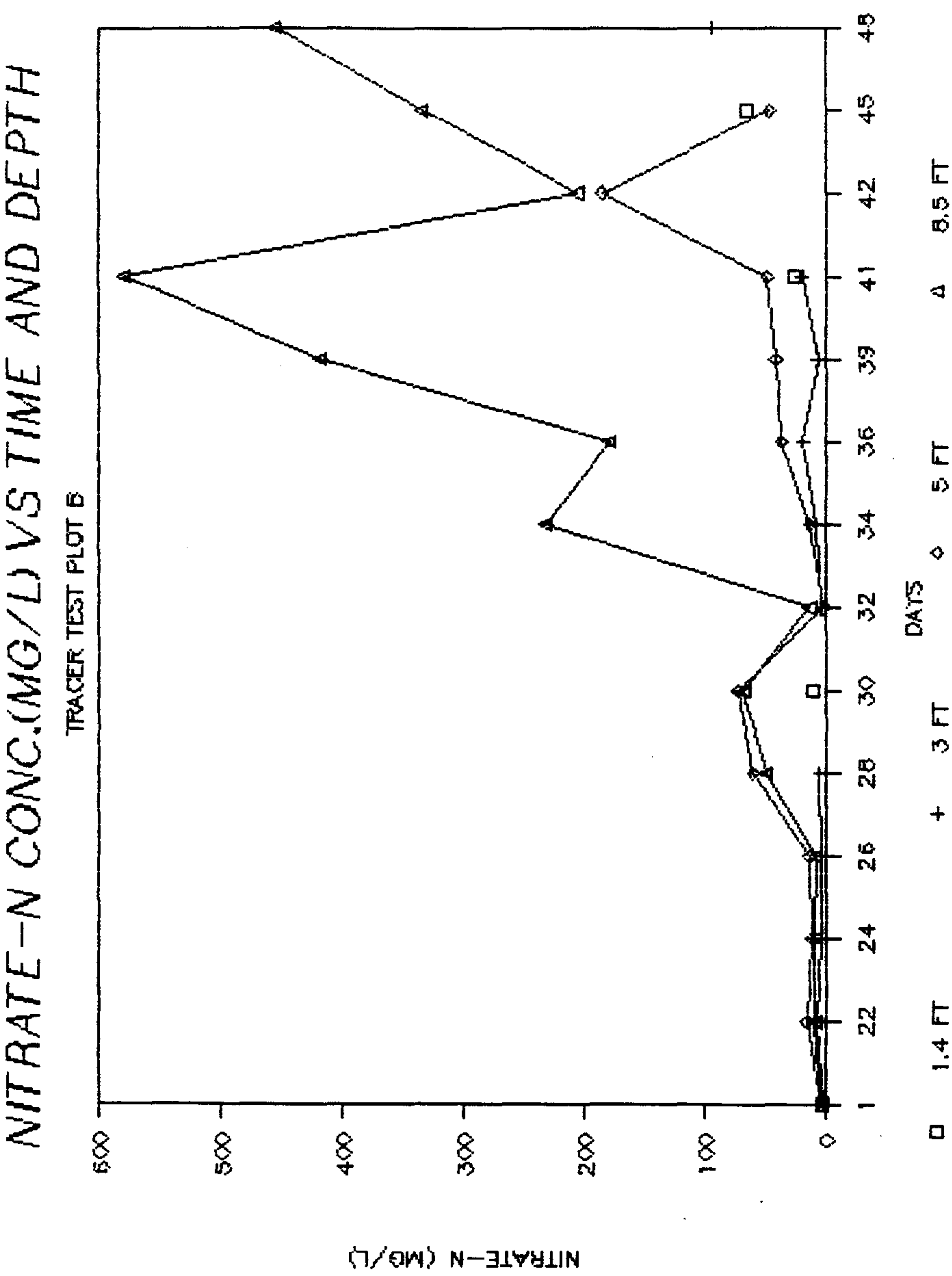

NITRATE-N CONC.(MG/L) VS TIME AND DEPTH
TRACER TEST PLOT 6
NITRATE-N (MG/L)
0
100
200
300
400
500
600
1
22
24
26
28
30
32
34
36
39
41
42
45
48
DAYS
□ 1.4 FT
+ 3 FT
◇ 5 FT
Δ 8.5 FT

FIGURE 10

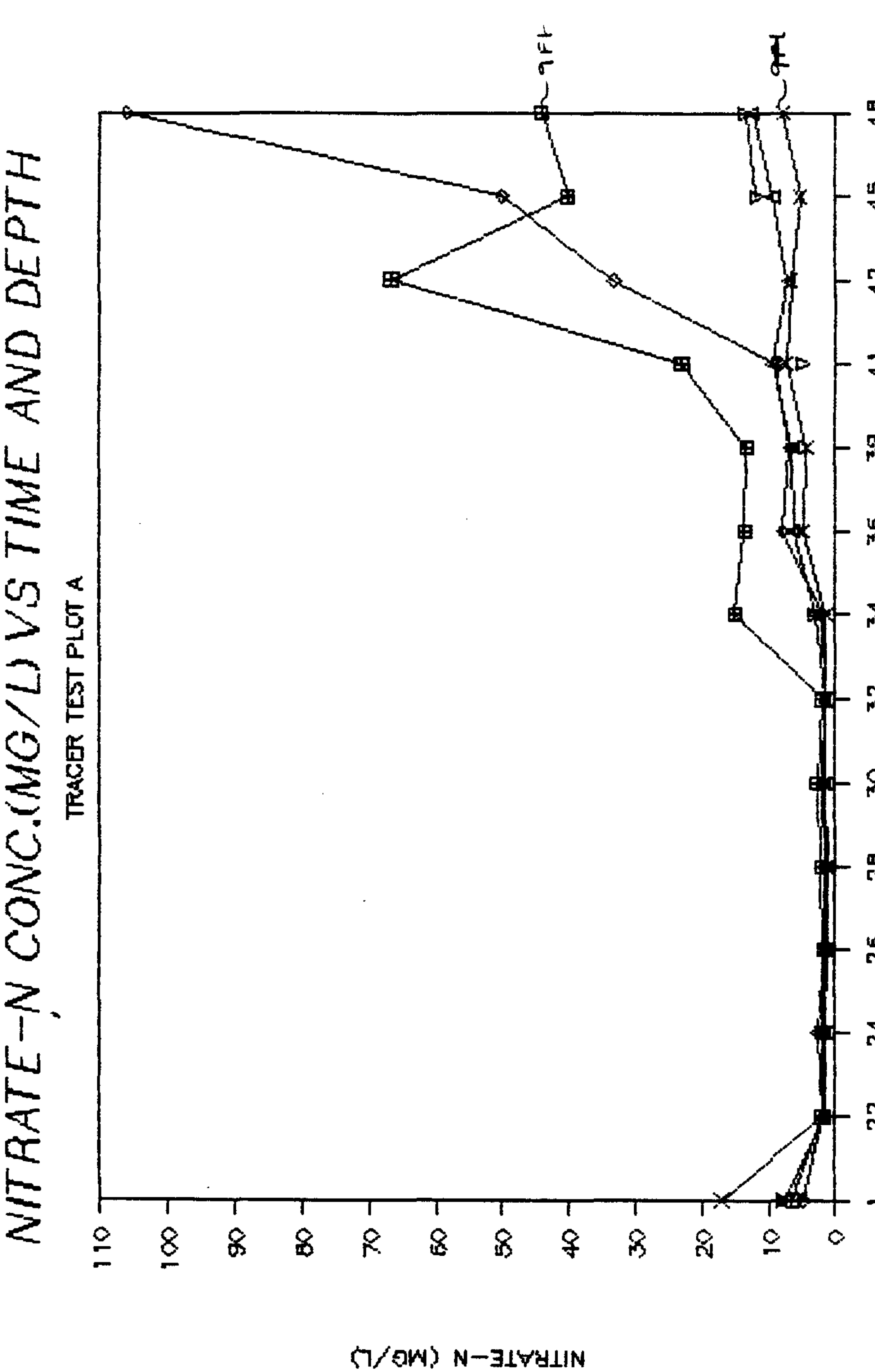

NITRATE-N CONC.(MG/L) VS TIME AND DEPTH
TRACER TEST PLOT A
NITRATE-N (MG/L)
110
100
90
80
70
60
50
40
30
20
10
0
1
22
24
26
28
30
32
34
36
39
41
42
45
48
DAYS
9 FT

FIGURE 11

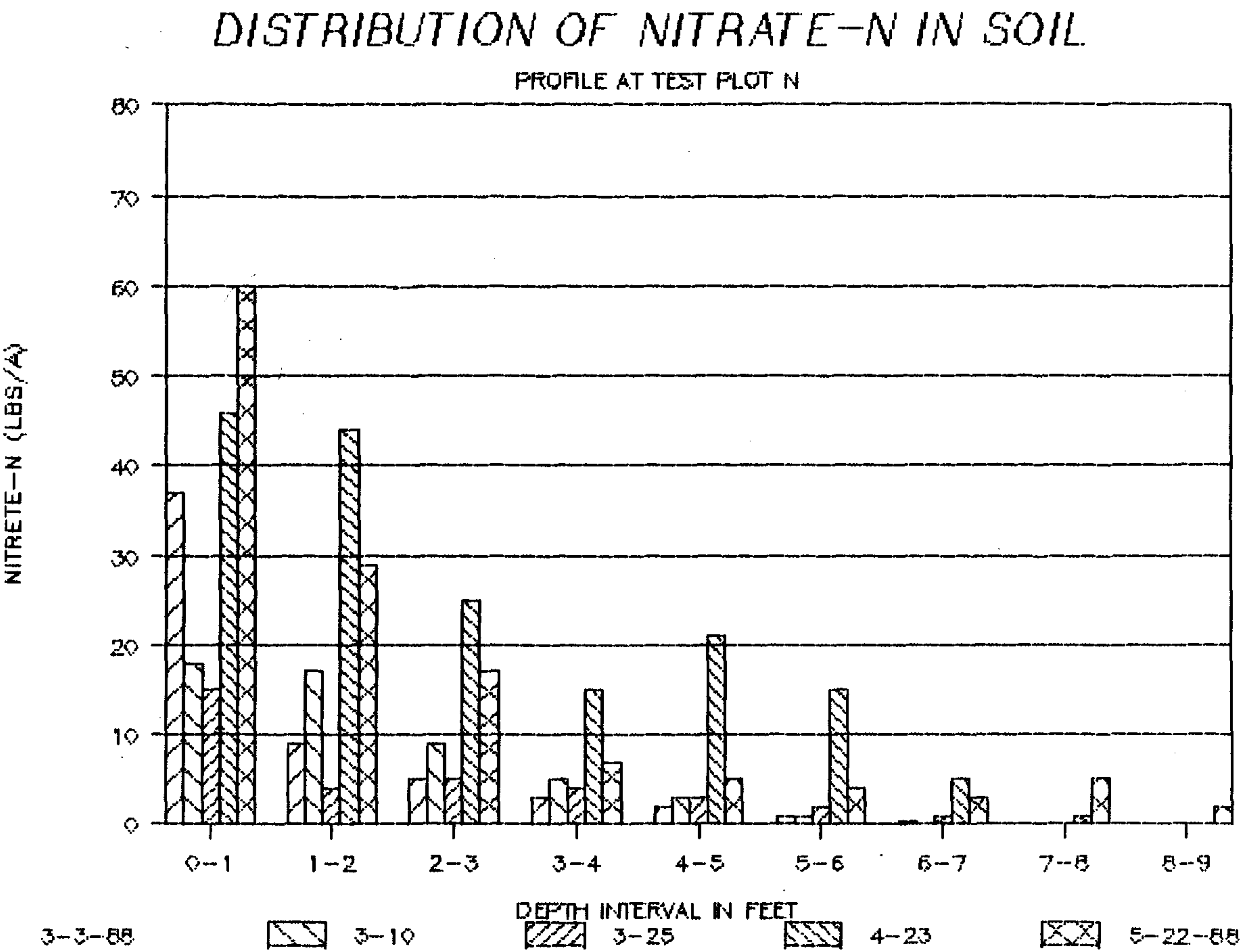

DISTRIBUTION OF NITRATE-N IN SOIL
PROFILE AT TEST PLOT N
NITRETE-N (LBS/A)
80
70
60
50
40
30
20
10
0
0-1
1-2
2-3
3-4
4-5
5-6
6-7
7-8
8-9
DEPTH INTERVAL IN FEET
3-3-88
3-10
3-25
4-23
5-22-88

FIGURE 12

in the 1988-1989 year for calibration and verification.

TASK 7 Field calibration and verification of the models by monitoring selected nutrients and pesticides which are persistent and mobile in ground water.

Results:

Monitoring in the unsaturated zone has involved the installation of vacuum-pressure lysimeters at different depths in the unsaturated soil. The lysimeter was designed, and constructed and installed to specifically monitor pesticides in the soil column. Saturated-zone monitoring of the pesticides has involved collecting ground water samples from previously installed monitoring wells. These wells are constructed of PVC casing and screens and are installed at both shallow (25 ft) and deep (48 ft) levels in the aquifer. Tracer tests in the unsaturated zone has been conducted and ammonium-nitrate fertlizer, pottasiun-sulfate, sodium-chloride, and zinc-chloride has been used as the tracer material. The variation of nitrate-n with time at different depths below the land surface is shown in figure 10 for test plot A and figure 11 for test plot B. Appendix E contains the plotted data illustrating the movement of nitrate-n and chloride in the subsurface at different times. Soil samples were taken at different times and analyzed for nitrate-n, chloride, zinc, pottasium and sulfates. Distribution of nitrate-n in soil verticl subsurface profile at different times is shown in figure 12. Data for distribution of nitrate-n, sulfates, phosphorous, pottasium, iron, mangnese, and zinc is shown in appendix F.

Ground water samples collected to date have been tested for nutrients (nitrates, chlorides etc.,) and pesticides (carbryl, urea, 2,4-d). Additional samples will be collected and will be tested for treflan, endosulfan, malathion, and 2,4-d. Water samples from the unsaturated zone have been obtained and are currently being analyzed for lindane, malathion, 2,4-D, treflan, and aldrin.

Future Proposed Research:

A similar protocal for ground water and soil moisture sampling is proposed for model calibration and verification during the 1988-1989 period.

SUMMARY

A hydrogeological site chracterization is conducted for Perkins Terrace aquifer at the OSU Agricultural Research Center, Perkins, Oklahoma. The Aquifer has an average saturated thickness of 30 feet with an average transmissivity of 10,000 gpd/ft and an average value of the hydraulic conductivity of 342 gpd/ft and a specific yield of 0.11.

Ground-water quality data regarding the inorganic elements and certain pesticides has been collected since spring of 1986. The data is being plotted and currently being analyzed.

Tracer test using inorganic conservative tracers has been conducted in the unsaturated and the saturated zones at Perkins test site. The database structured is being used as input parameters for simulating fate and transport of agricultural chemicals in the unsaturated and the saturated zone. Three numerical models, CMIS and PRZM for the unsaturated zone and KONIKOW for the saturated zone are being utilized for this purpose.

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Carsel, R.F., Mulkey, L.A., Lorber, M.N. and Baskin, L.B., 1985. The Pesticide Root Zone Model (PRZM): A procedure for evaluating pesticide leaching threats to groundwater. Ecol. Modelling, V. 30, p.49-69.

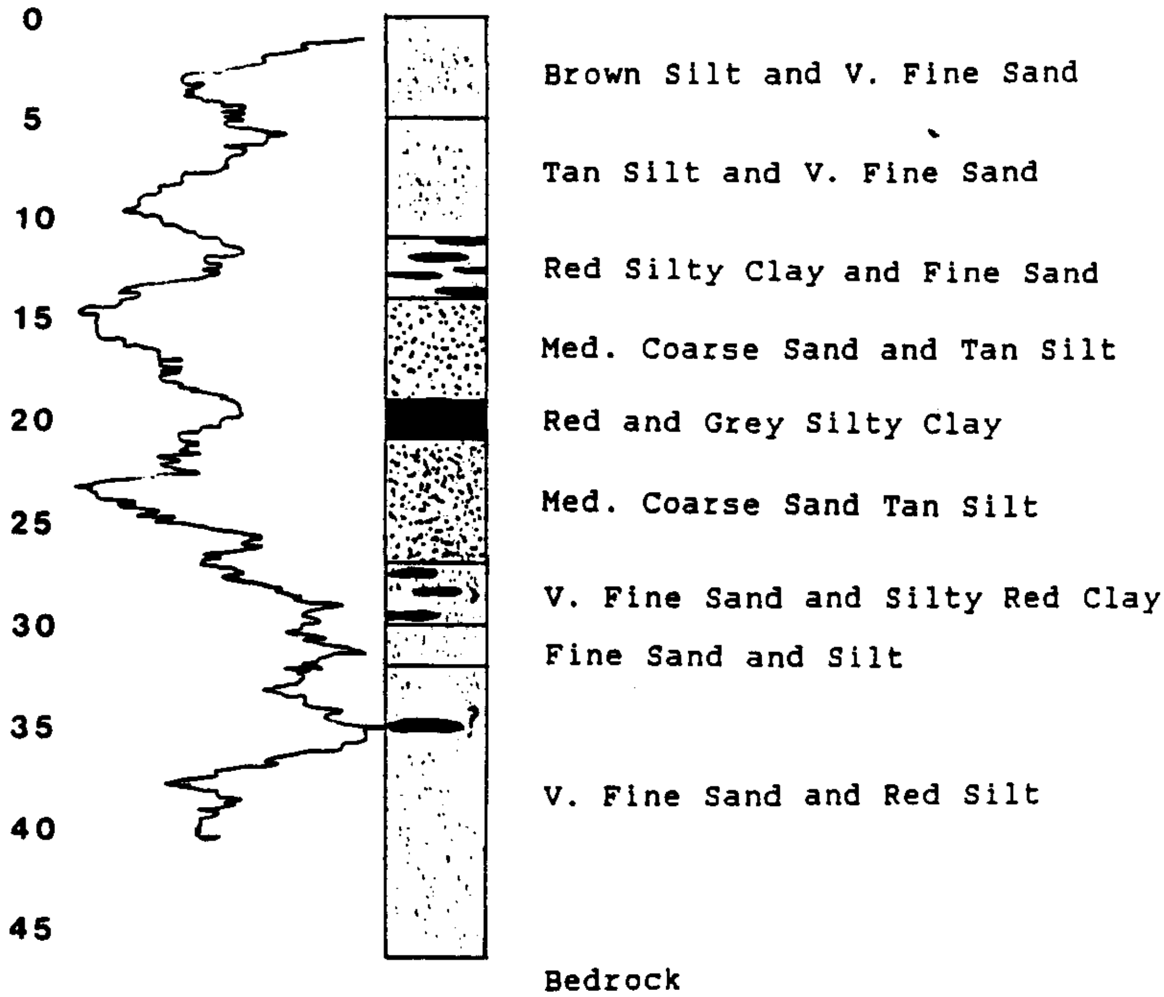
Naney, J.W., Kent, D.C. Smith, S.J., and Webb, B.B., 1987, Variability of ground water quality under sloping agricultural watersheds in Oklahoma. Symposium on monitoring, modeling, and mediating water quality, American Water Resources Association, P. 189-197

Kent, D.C., R.L. Dwivedi, and J. Naney, Hydrogeology and Ground Water Quality at Perkins Terrace Aquifer, in Abstract for Oklahoma Water Resources Conference, September 29-30, 1987, p.7.

Kent, D.C., LeMaster, L., and J. Wagner, 1986, Modified NRC version of USGS Solute Transport Model-v.1 Modifications, and v.2 Preprocessor, contract # CRB 11142-01-0, Final report to Robert S. Kerr Environmental Research Laboratory, U.S. Environmental Protection Agency Ada, Oklahoma.

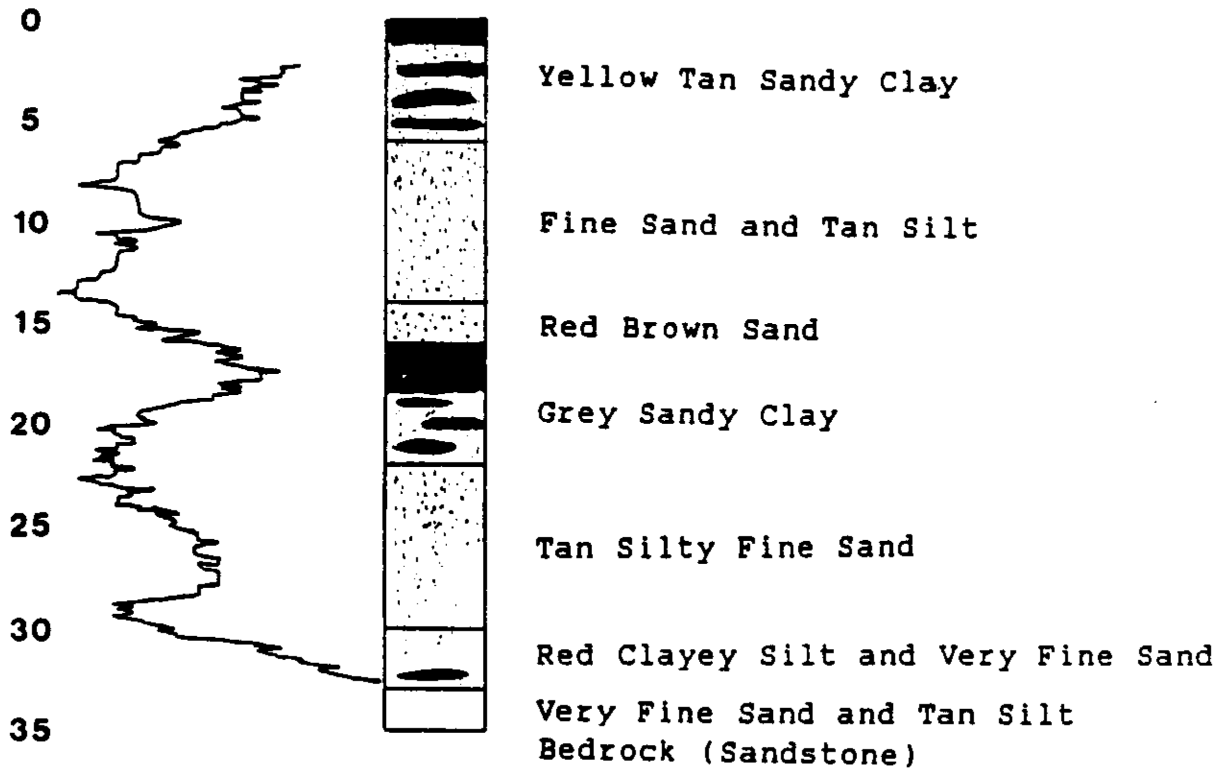
APPENDIX A

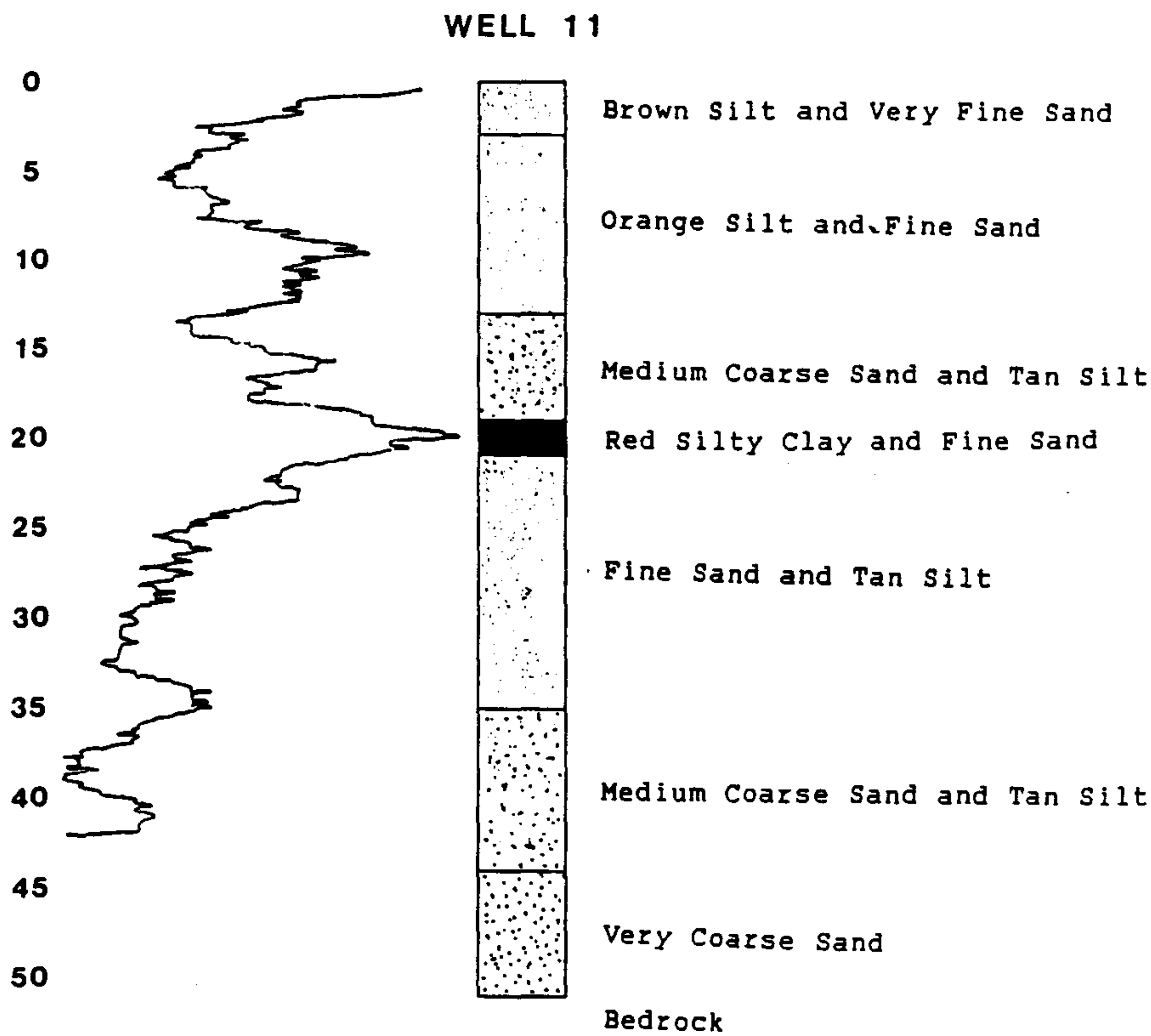
WELL 4



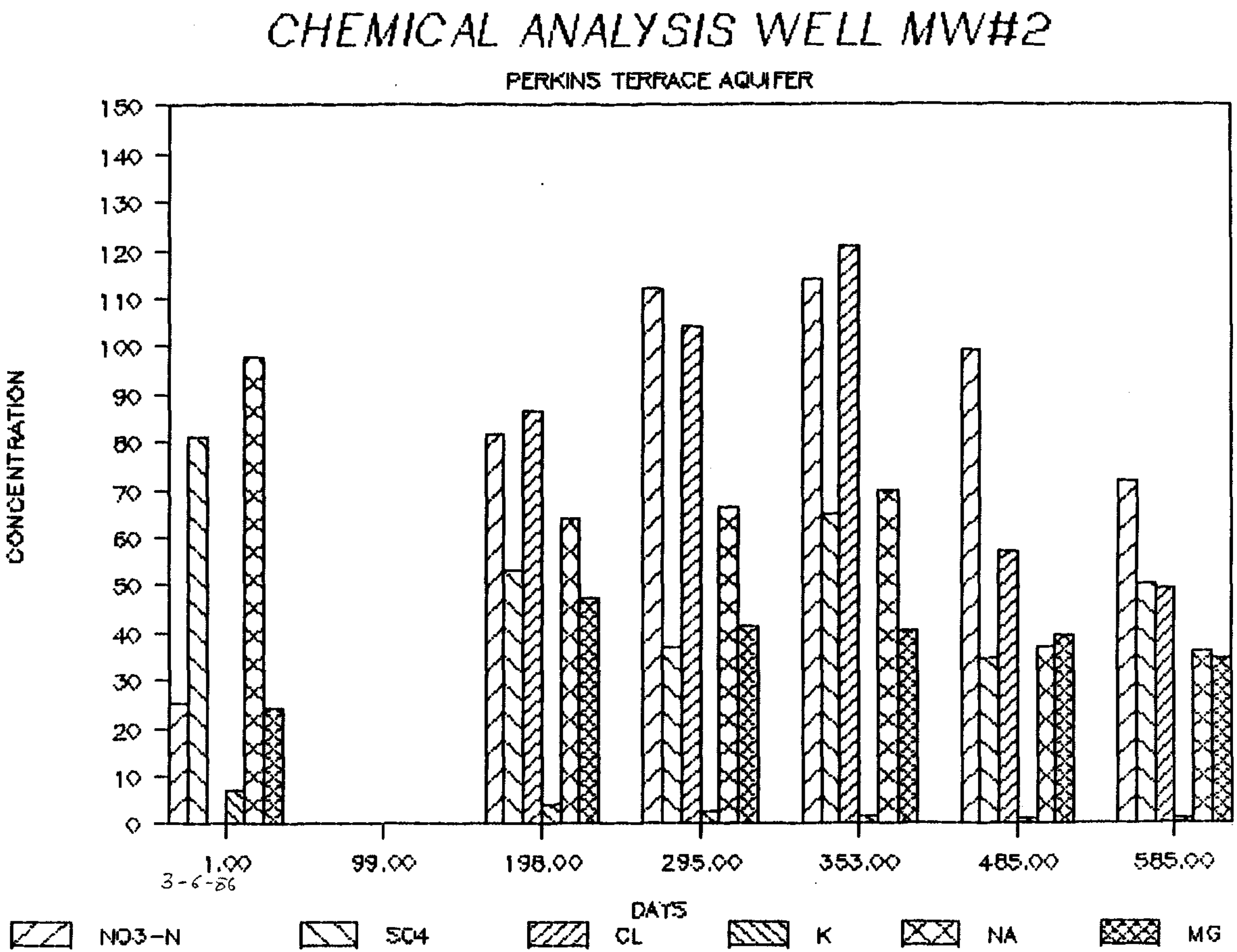
0
5
10
15
20
25
30
35
40
45
Brown Silt and V. Fine Sand
Tan Silt and V. Fine Sand
Red Silty Clay and Fine Sand
Med. Coarse Sand and Tan Silt
Red and Grey Silty Clay
Med. Coarse Sand Tan Silt
V. Fine Sand and Silty Red Clay
Fine Sand and Silt
V. Fine Sand and Red Silt
Bedrock

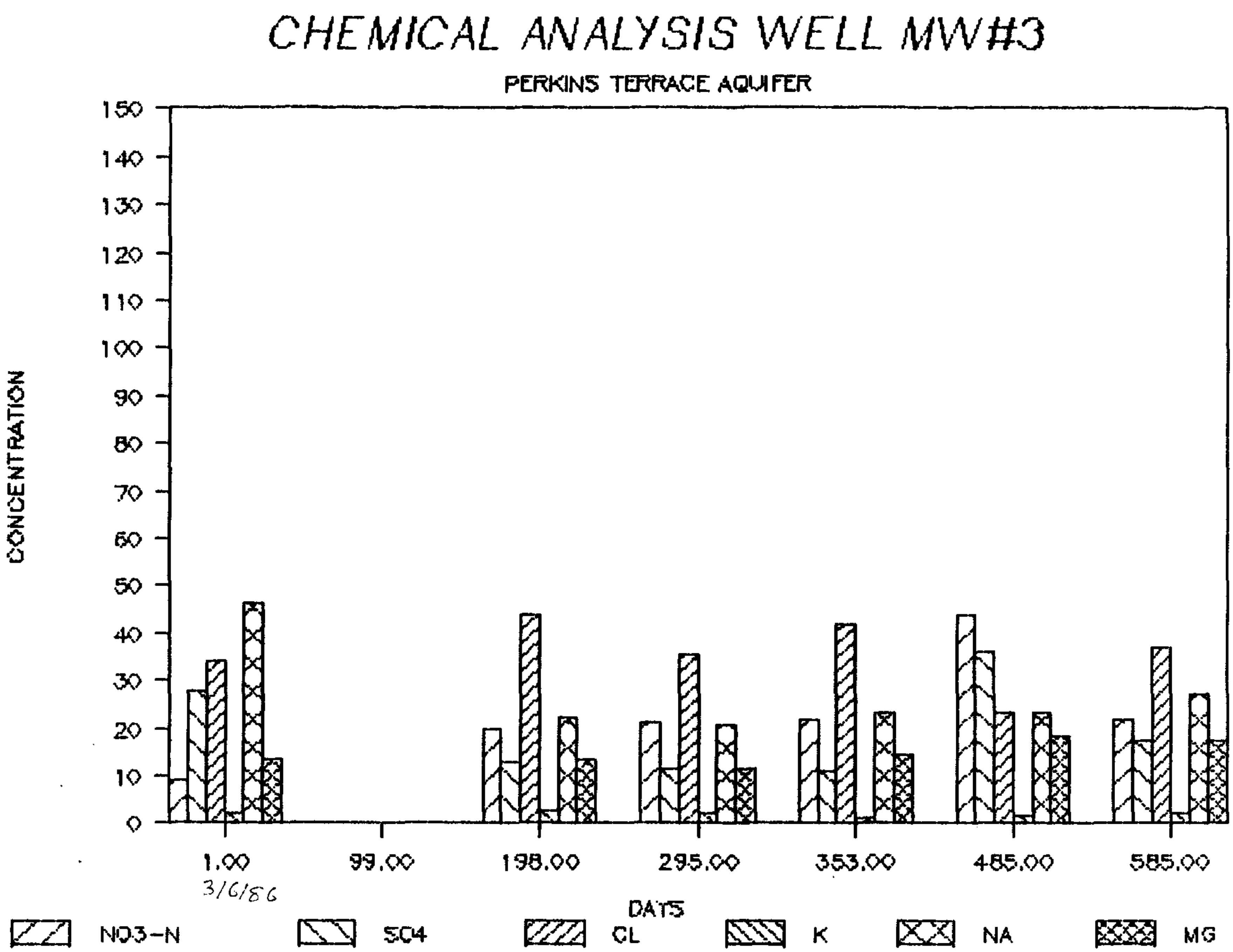
WELL 9


0
5
10
15
20
25
30
35
Yellow Tan Sandy Clay
Fine Sand and Tan Silt
Red Brown Sand
Grey Sandy Clay
Tan Silty Fine Sand
Red Clayey Silt and Very Fine Sand
Very Fine Sand and Tan Silt
Bedrock (Sandstone)


WELL 11
0
5
10
15
20
25
30
35
40
45
50
Brown Silt and Very Fine Sand
Orange Silt and Fine Sand
Medium Coarse Sand and Tan Silt
Red Silty Clay and Fine Sand
Fine Sand and Tan Silt
Medium Coarse Sand and Tan Silt
Very Coarse Sand
Bedrock

APPENDIX B

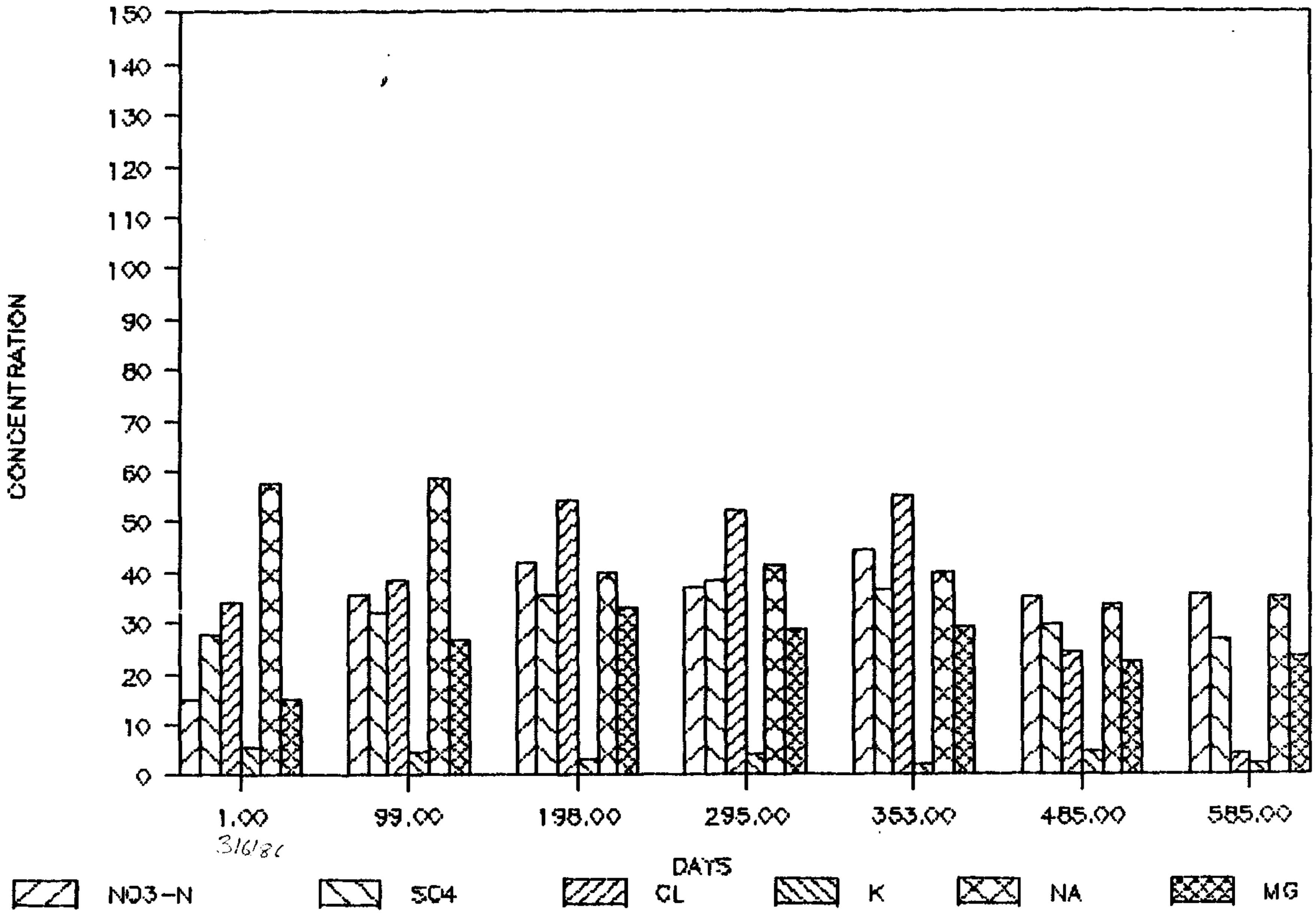

CHEMICAL ANALYSIS WELL MW#2
PERKINS TERRACE AQUIFER
CONCENTRATION
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1.00
3-6-86
99.00
198.00
295.00
353.00
485.00
585.00
DAYS
NO3-N
SO4
CL
K
NA
MG

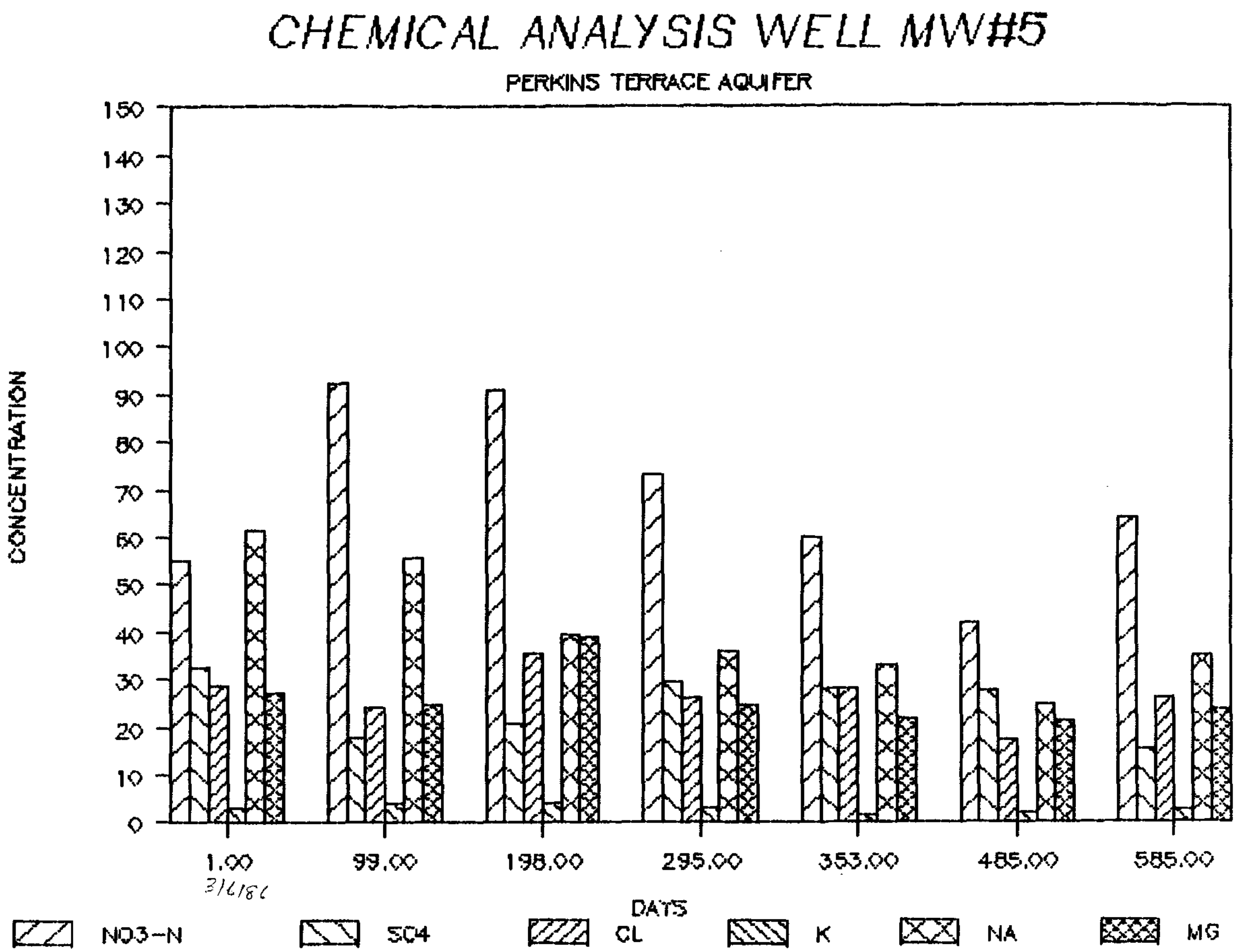


CHEMICAL ANALYSIS WELL MW#3
PERKINS TERRACE AQUIFER
CONCENTRATION
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1.00
3/6/86
99.00
198.00
295.00
353.00
485.00
585.00
DAYS
NO3-N
SO4
CL
K
NA
MG

CHEMICAL ANALYSIS WELL MW#4

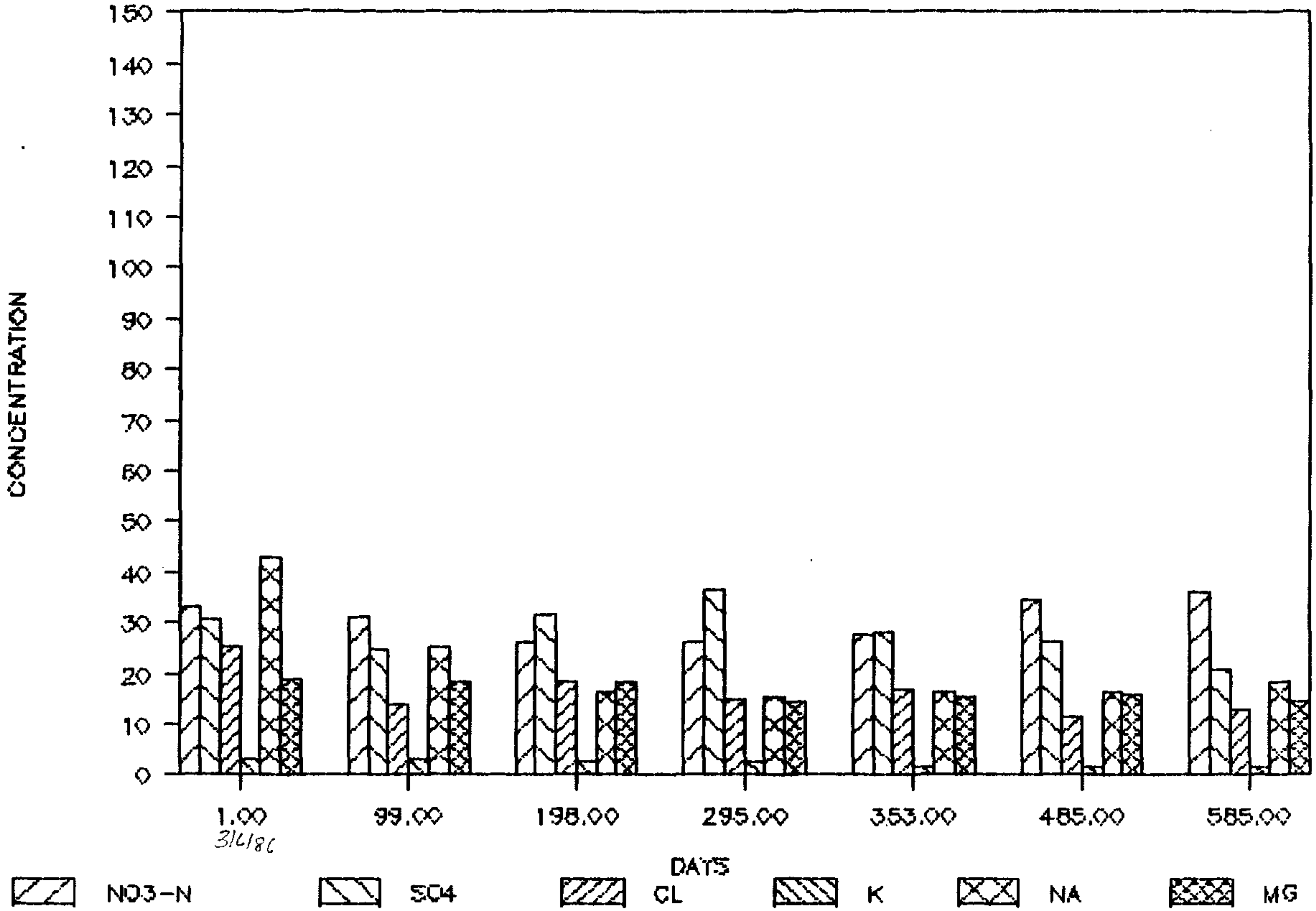
PERKINS TERRACE AQUIFER




CHEMICAL ANALYSIS WELL MW#5
PERKINS TERRACE AQUIFER
CONCENTRATION
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1.00
3/6/86
99.00
198.00
295.00
353.00
485.00
585.00
DAYS
NO3-N
SO4
CL
K
NA
MG

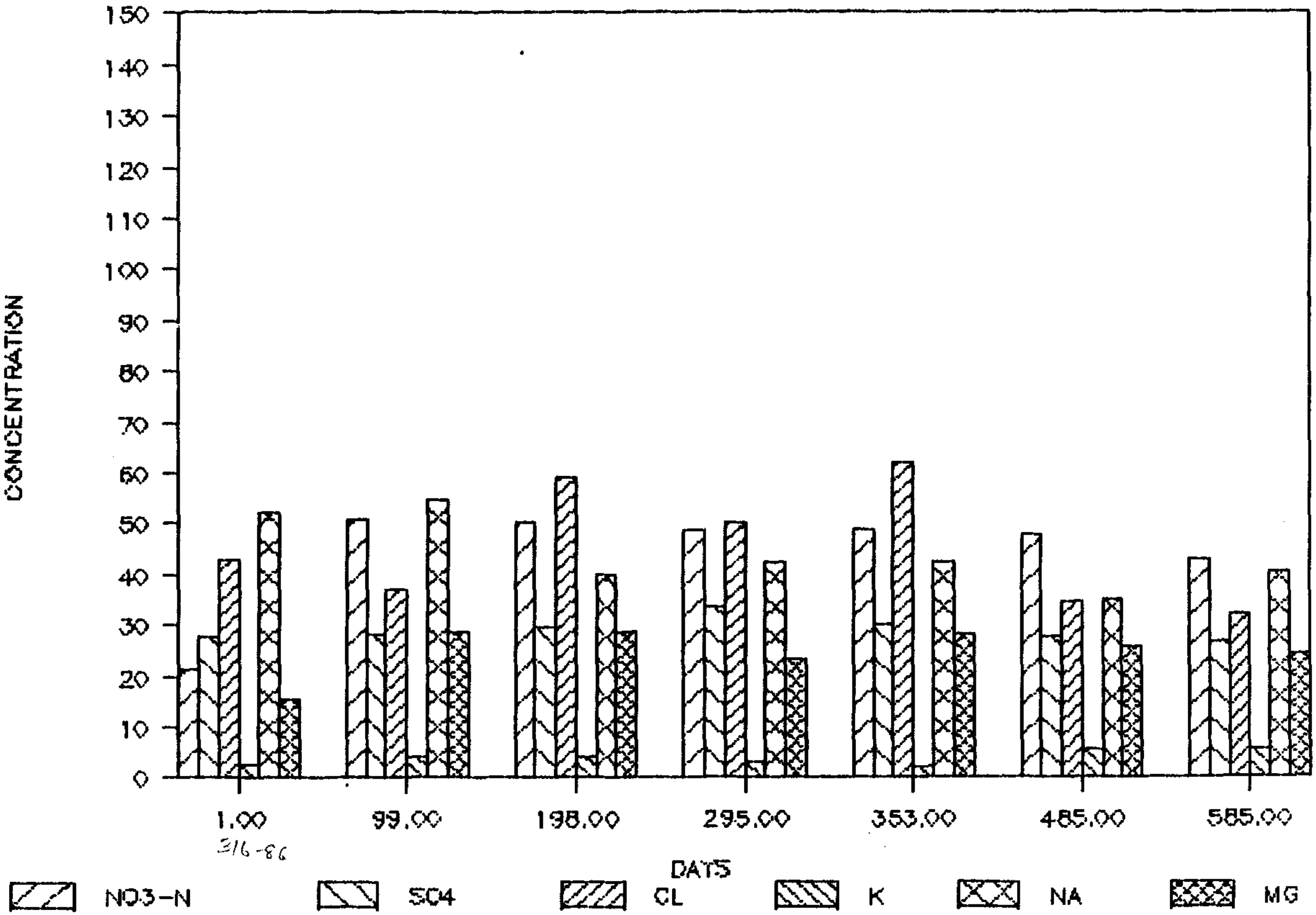
CHEMICAL ANALYSIS WELL MW#6

PERKINS TERRACE AQUIFER



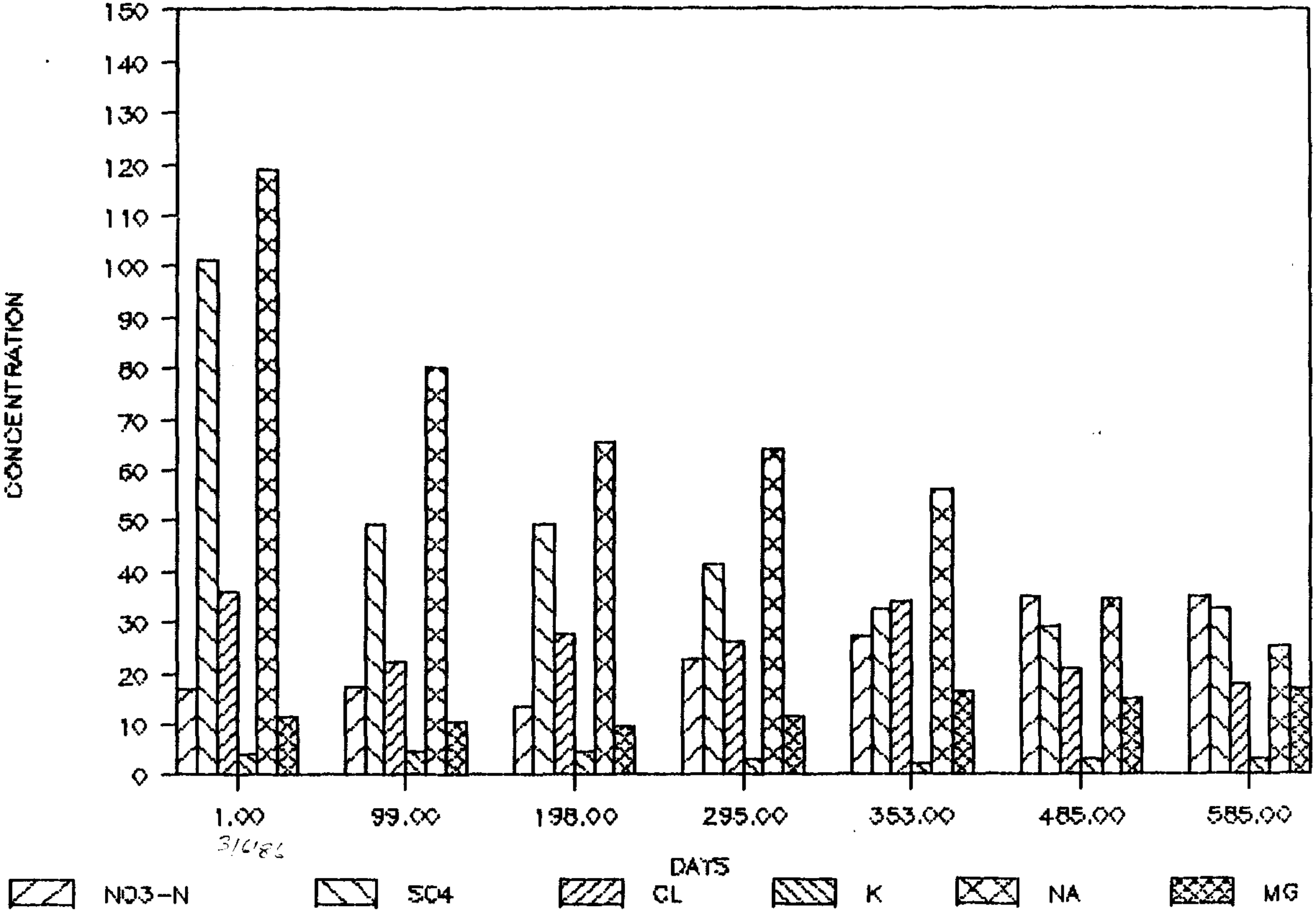
CHEMICAL ANALYSIS WELL MW#7

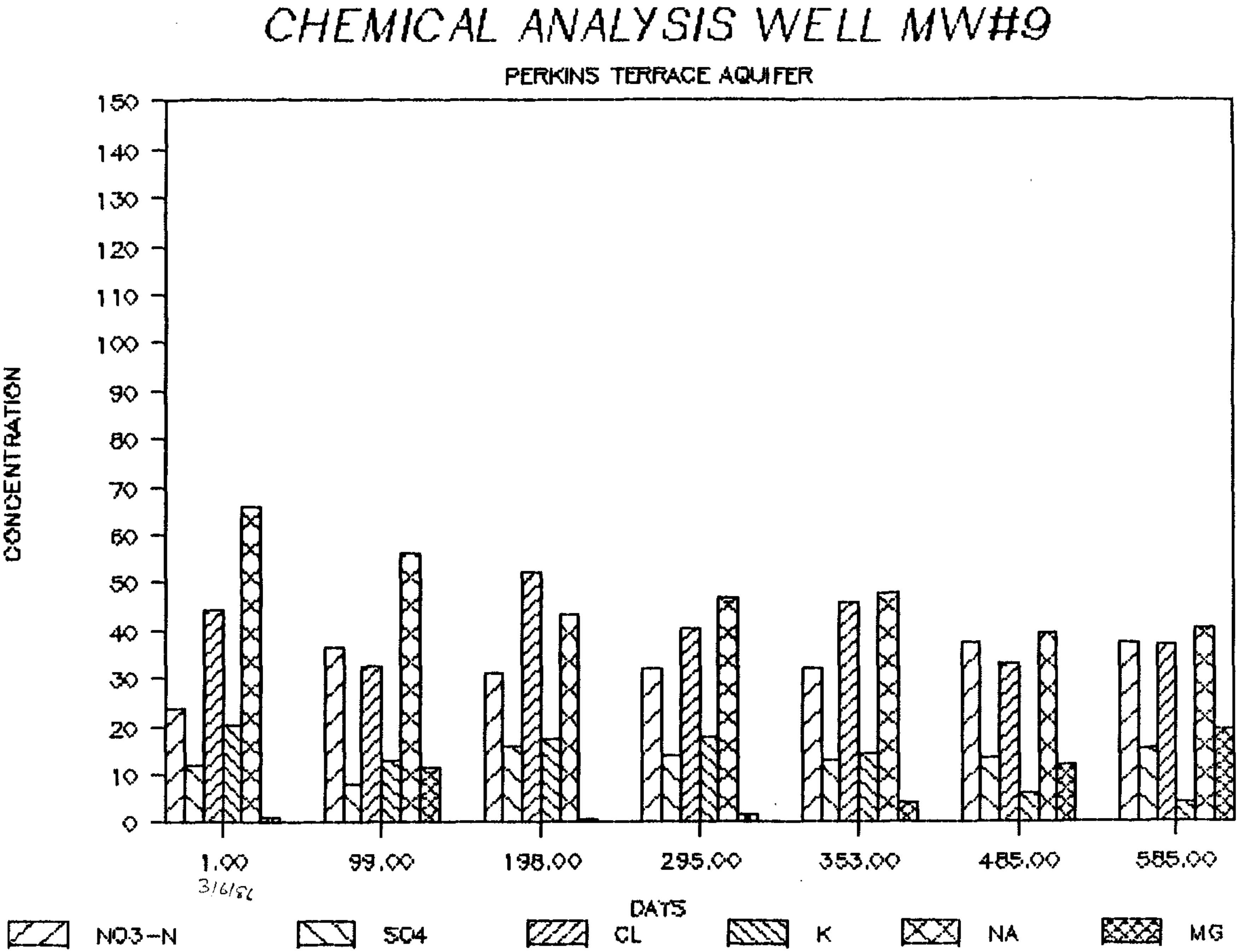
PERKINS TERRACE AQUIFER



CHEMICAL ANALYSIS WELL MW#8

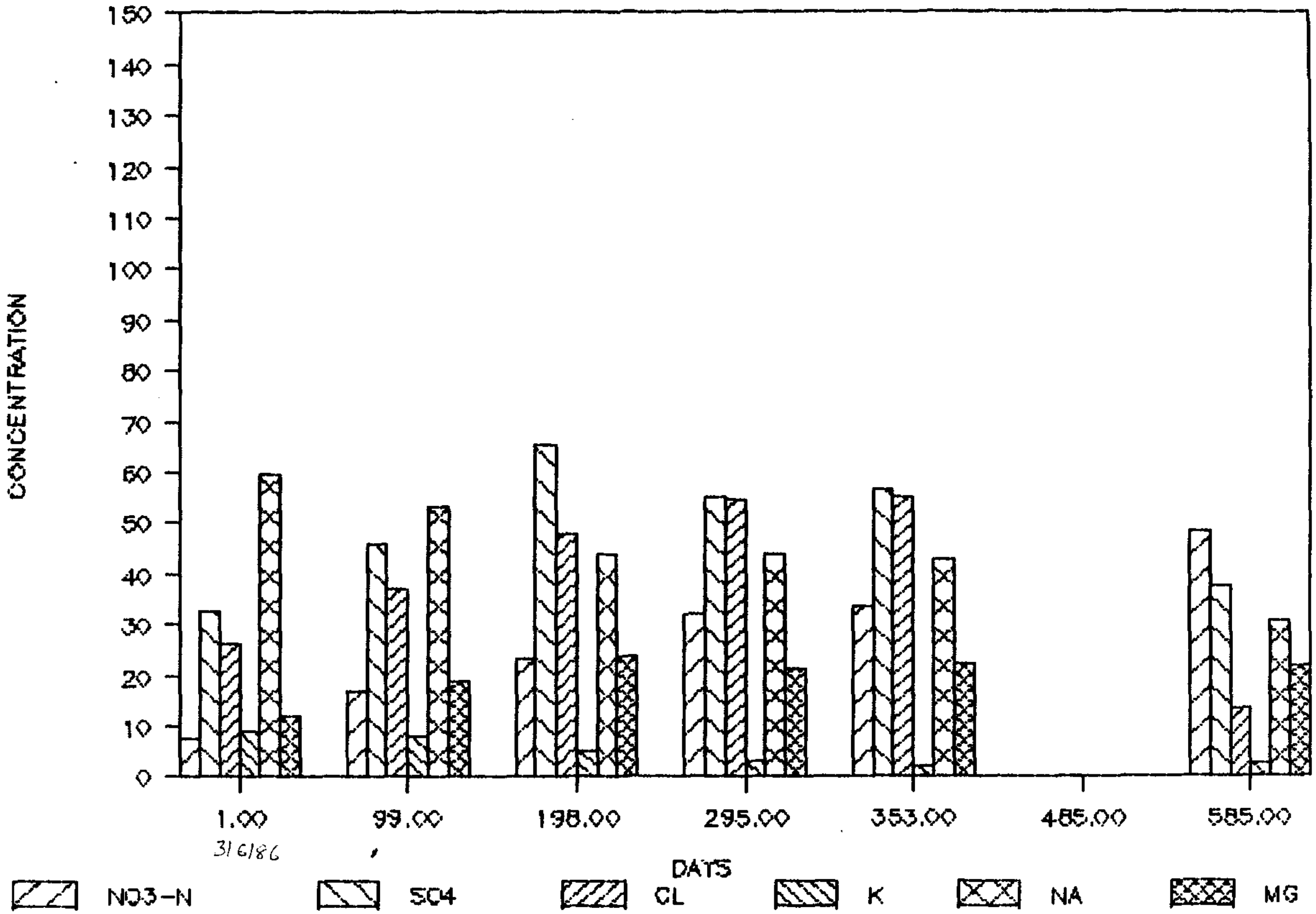
PERKINS TERRACE AQUIFER

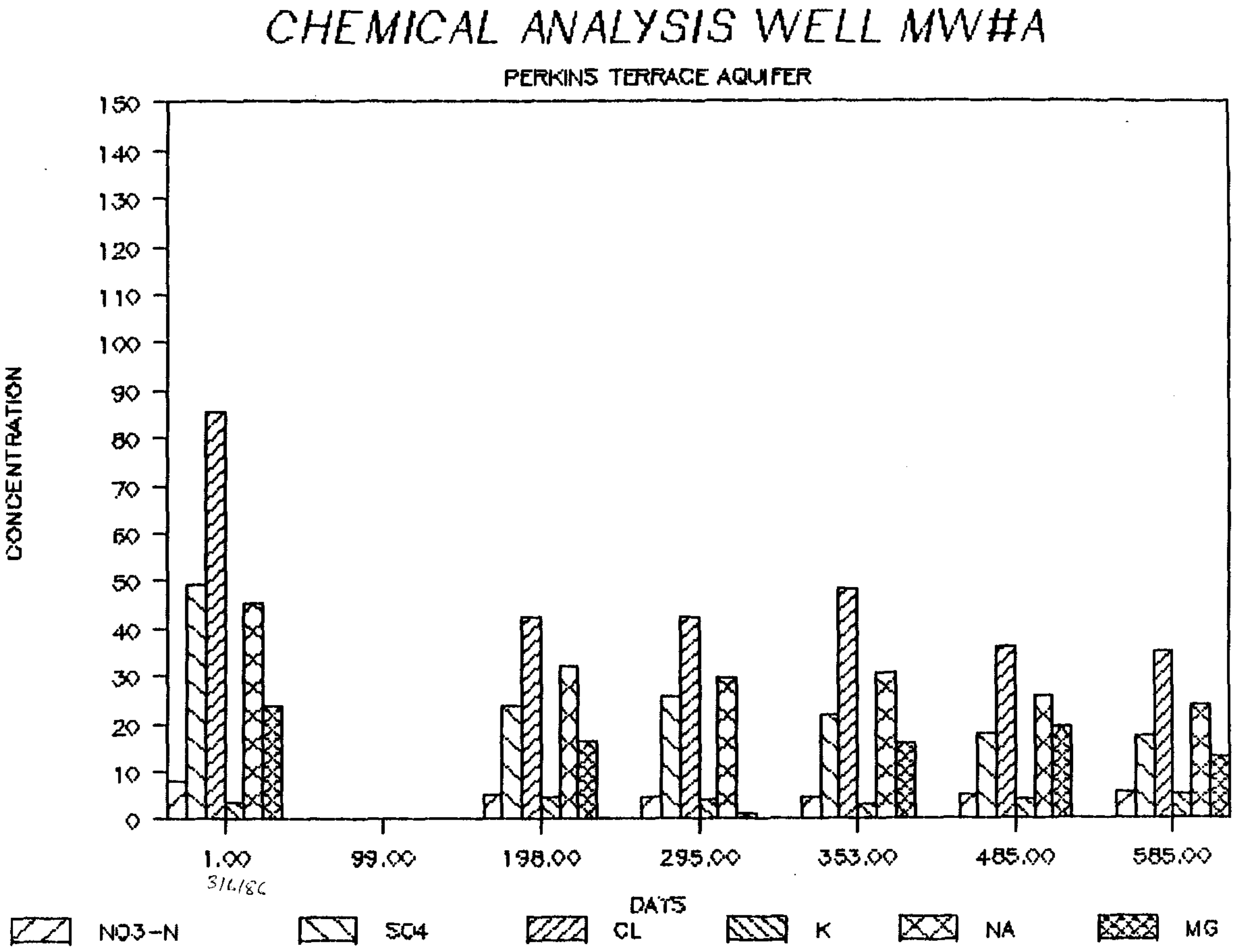


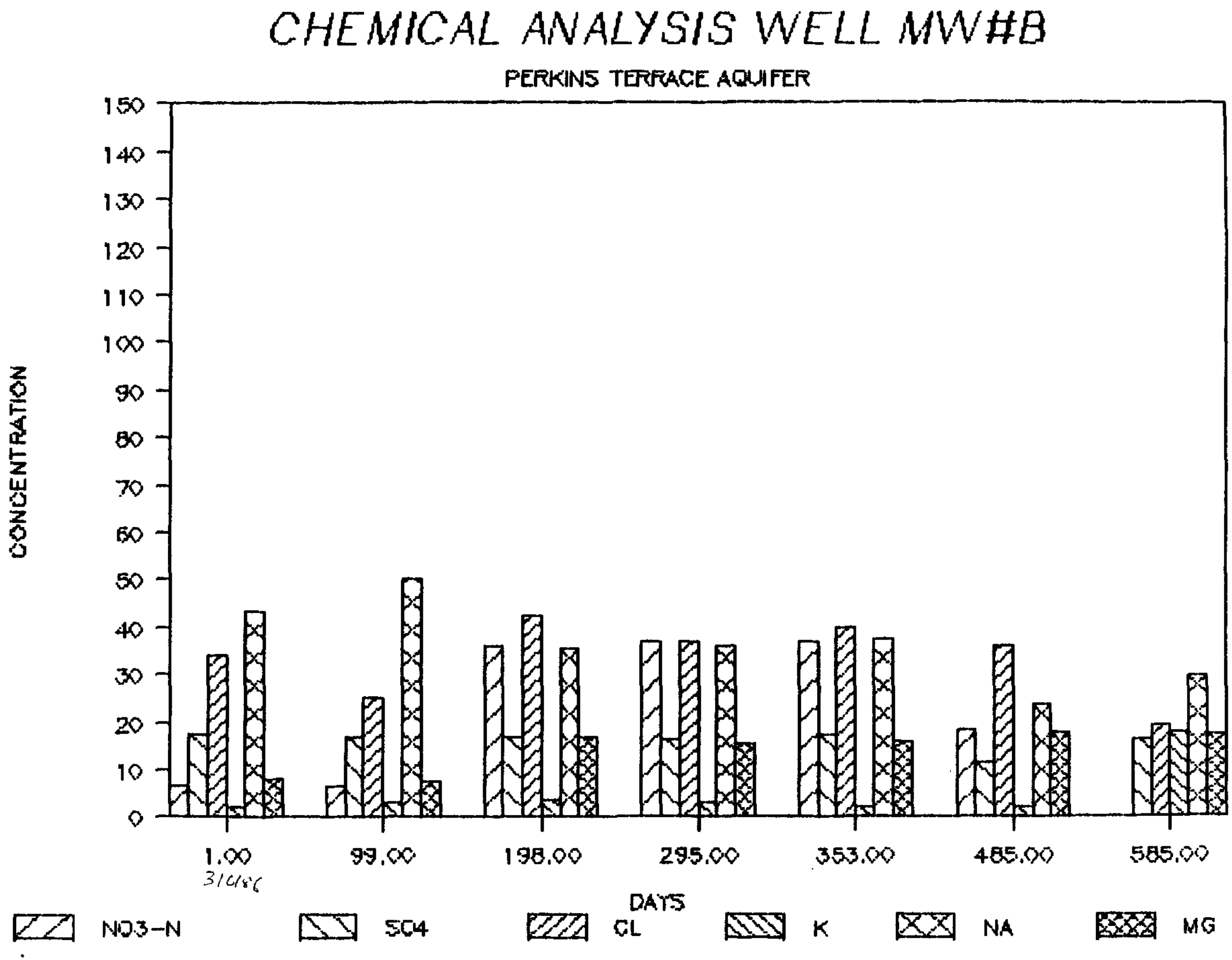

CHEMICAL ANALYSIS WELL MW#9
PERKINS TERRACE AQUIFER
CONCENTRATION
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
1.00
3/6/86
99.00
198.00
295.00
353.00
485.00
585.00
DAYS
NO3-N
SO4
CL
K
NA
MG

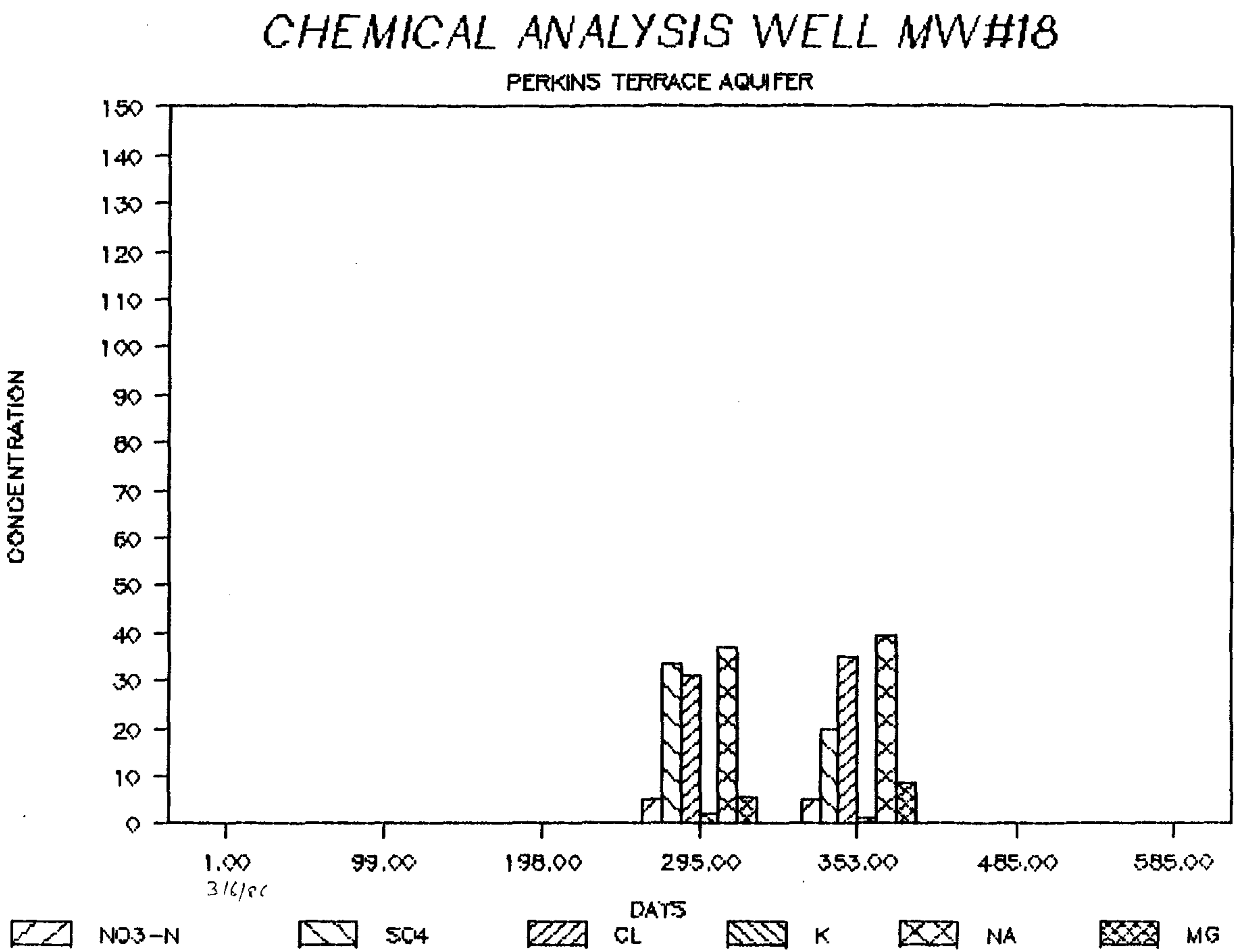
CHEMICAL ANALYSIS WELL MW#0

PERKINS TERRACE AQUIFER




CHEMICAL ANALYSIS WELL MW#A
PERKINS TERRACE AQUIFER
CONCENTRATION
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1.00
99.00
198.00
295.00
353.00
485.00
585.00
3/6/86
DAYS
NO3-N
SO4
CL
K
NA
MG

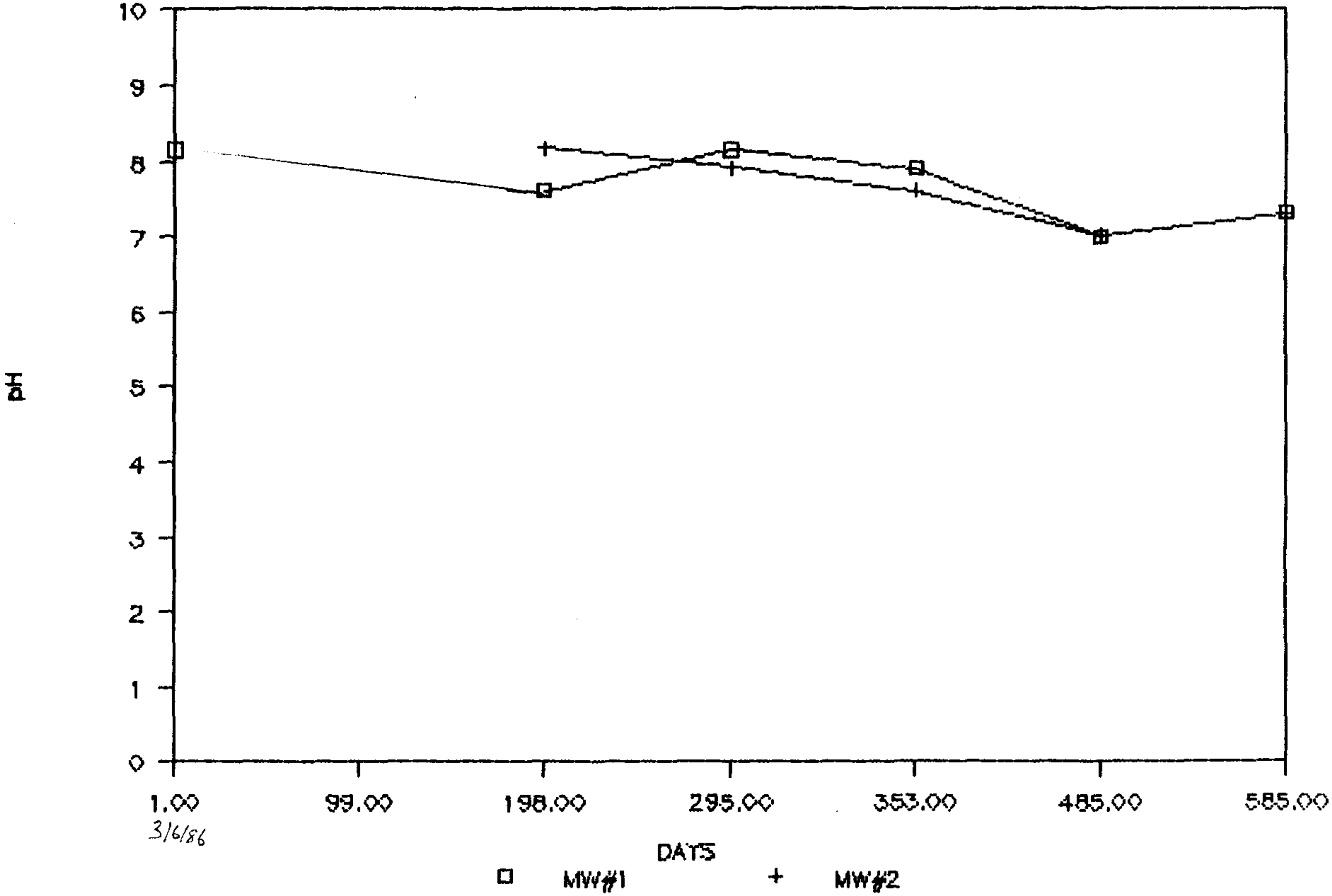

CHEMICAL ANALYSIS WELL MW#B
PERKINS TERRACE AQUIFER
CONCENTRATION
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1.00
31486
99.00
198.00
295.00
353.00
485.00
585.00
DAYS
NO3-N
SO4
CL
K
NA
MG


CHEMICAL ANALYSIS WELL MW#18
PERKINS TERRACE AQUIFER
CONCENTRATION
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1.00
99.00
198.00
295.00
353.00
485.00
585.00
DAYS
NO3-N
SO4
CL
K
NA
MG

APPENDIX - C

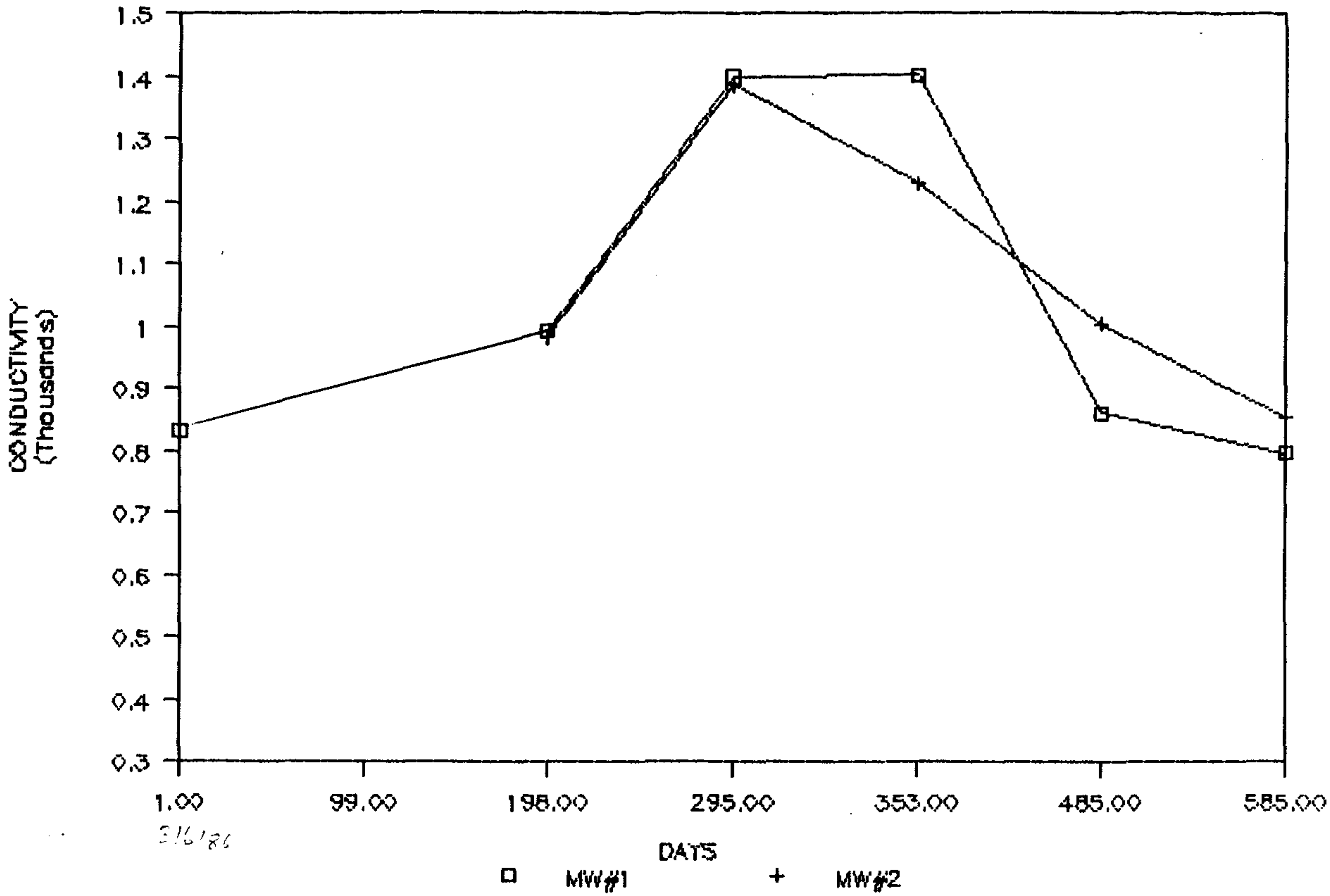
pH ANALYSIS WELL MW#1 VS. WELL MW#2

PERKINS TERRACE AQUIFER



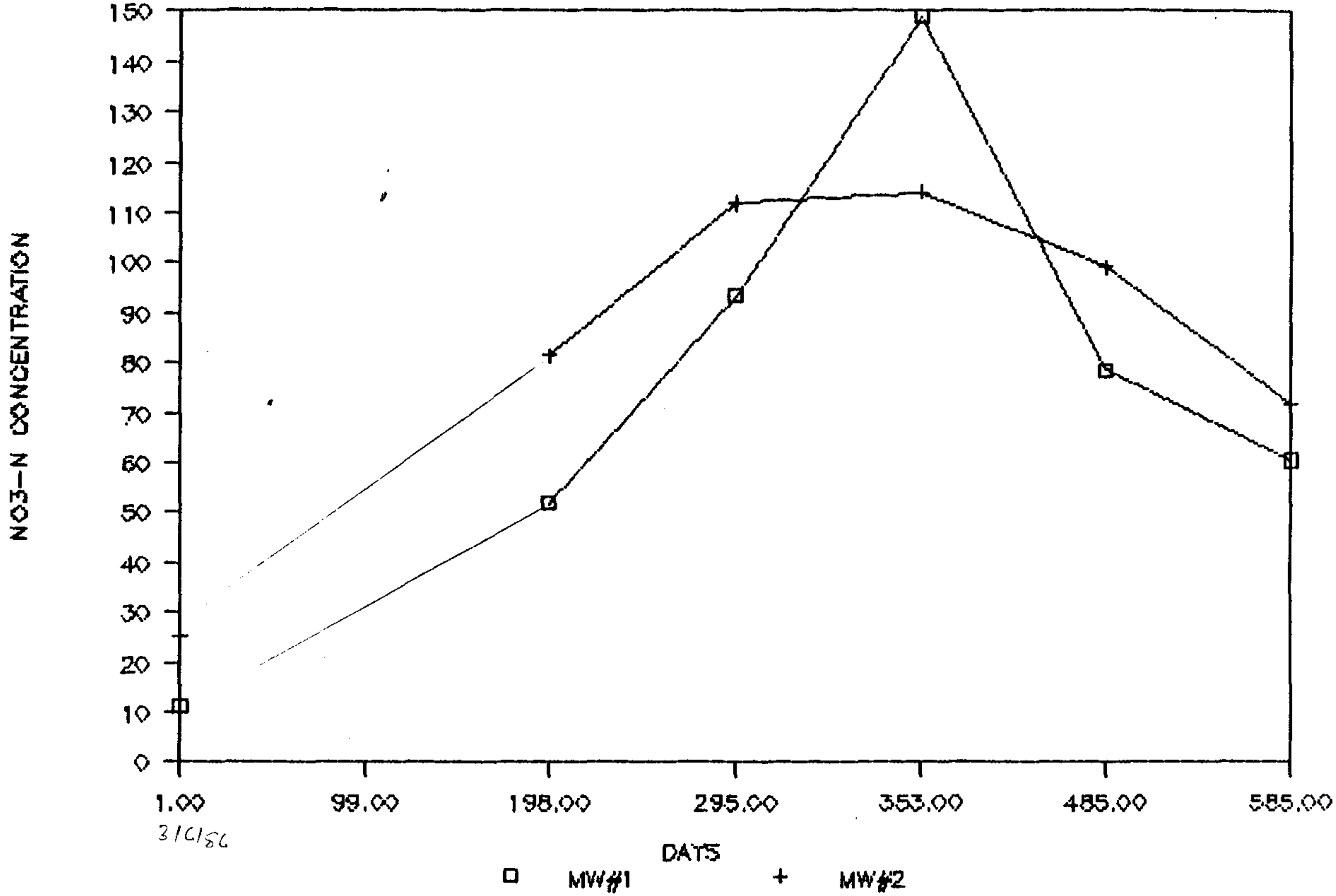
CONDUCTIVITY WELL MW#1 VS. WELL MW#2

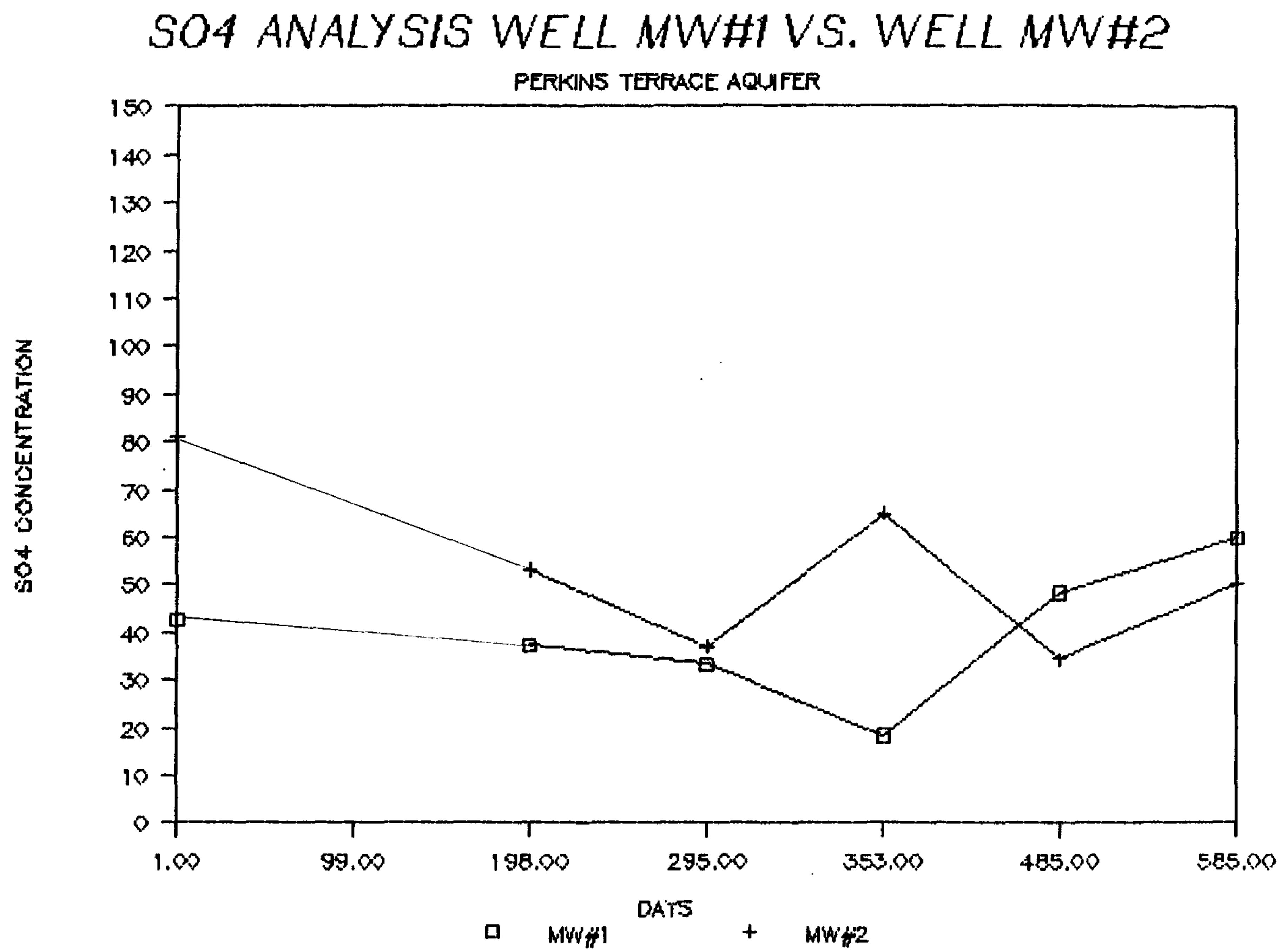
PERKINS TERRACE AQUIFER

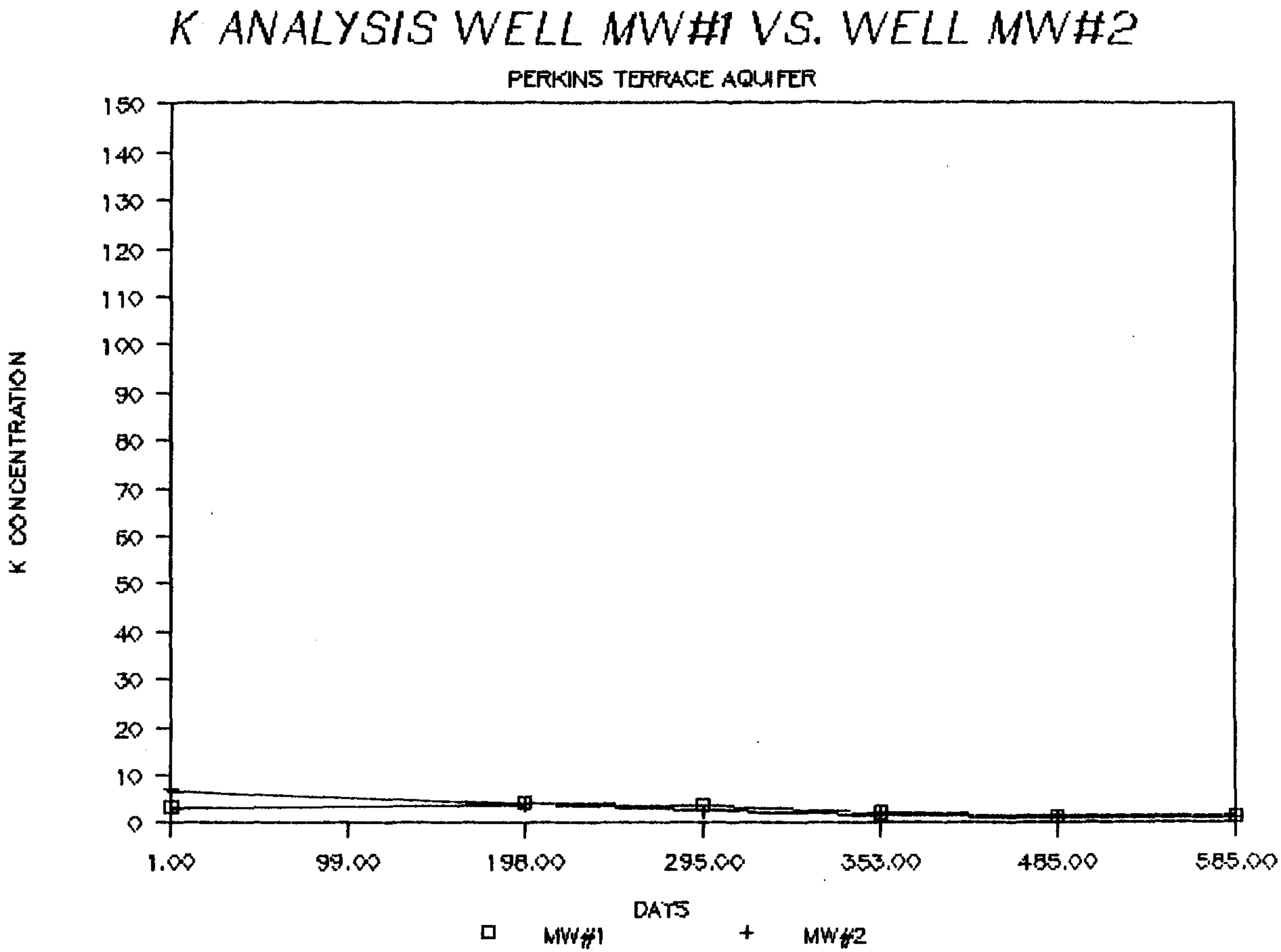


NO3-N ANALYSIS WELL MW#1 VS. WELL MW#2

PERKINS TERRACE AQUIFER

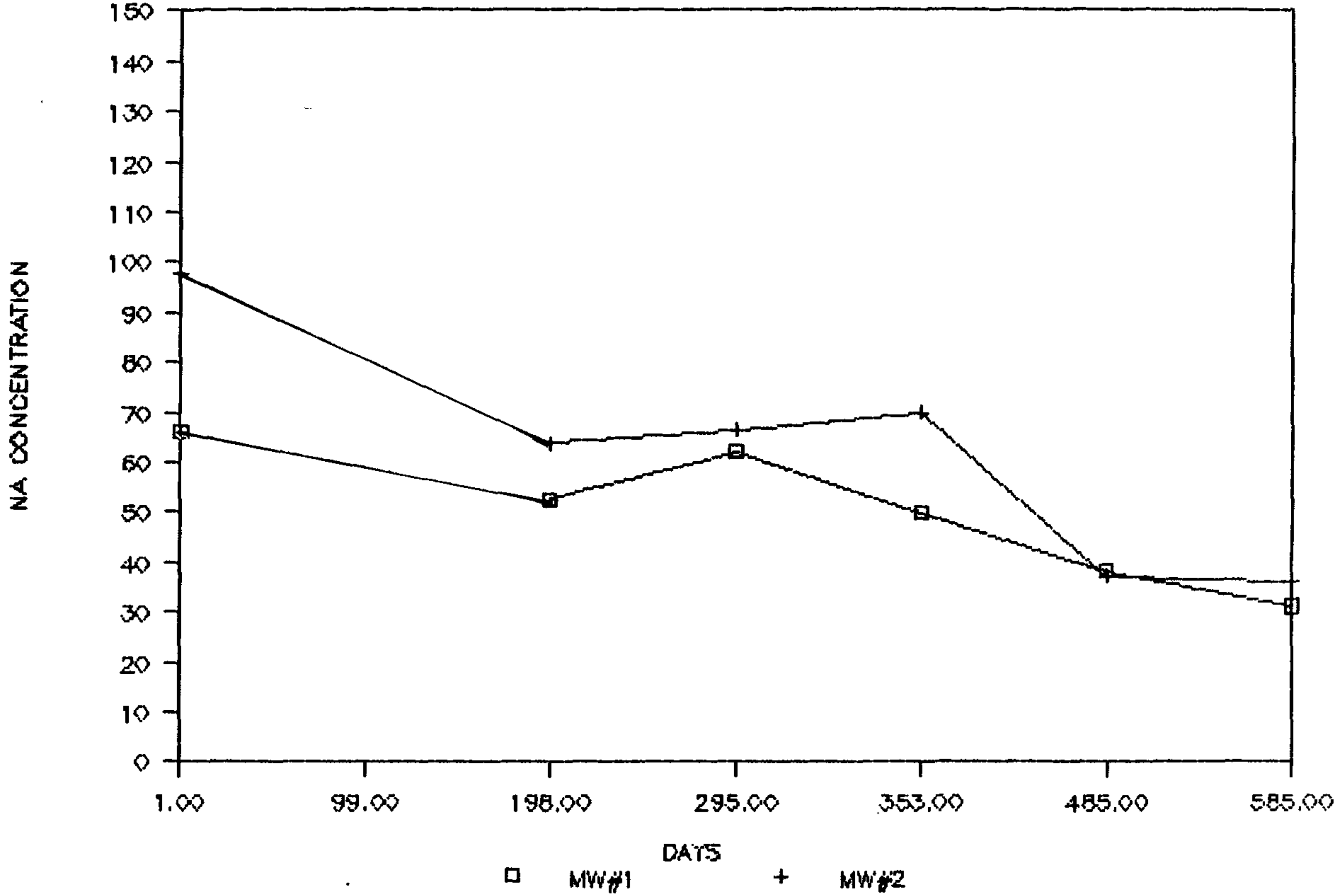


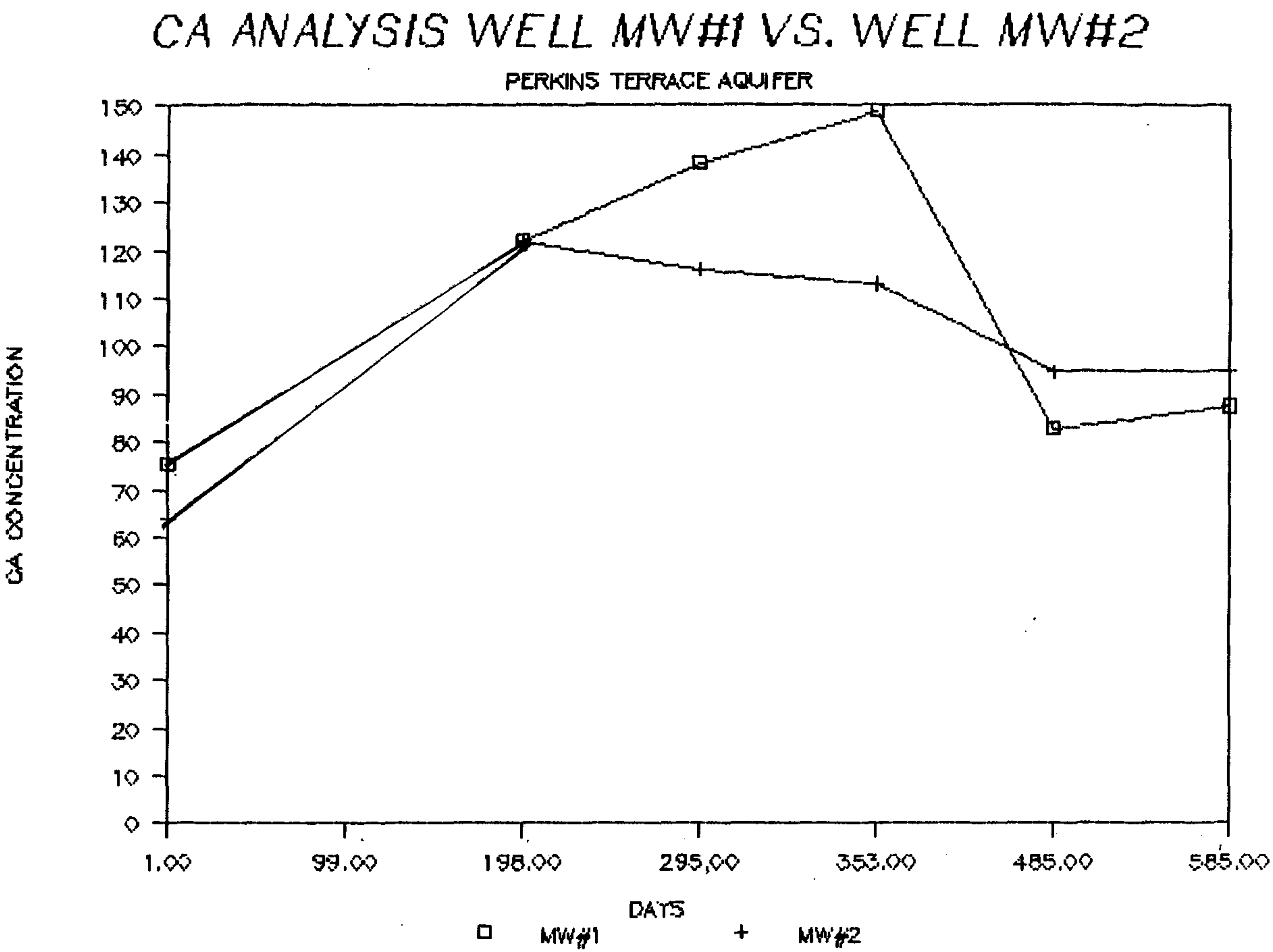

SO4 ANALYSIS WELL MW#1 VS. WELL MW#2
PERKINS TERRACE AQUIFER
SO4 CONCENTRATION
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1.00
99.00
198.00
295.00
353.00
485.00
585.00
DAYS
MW#1
MW#2

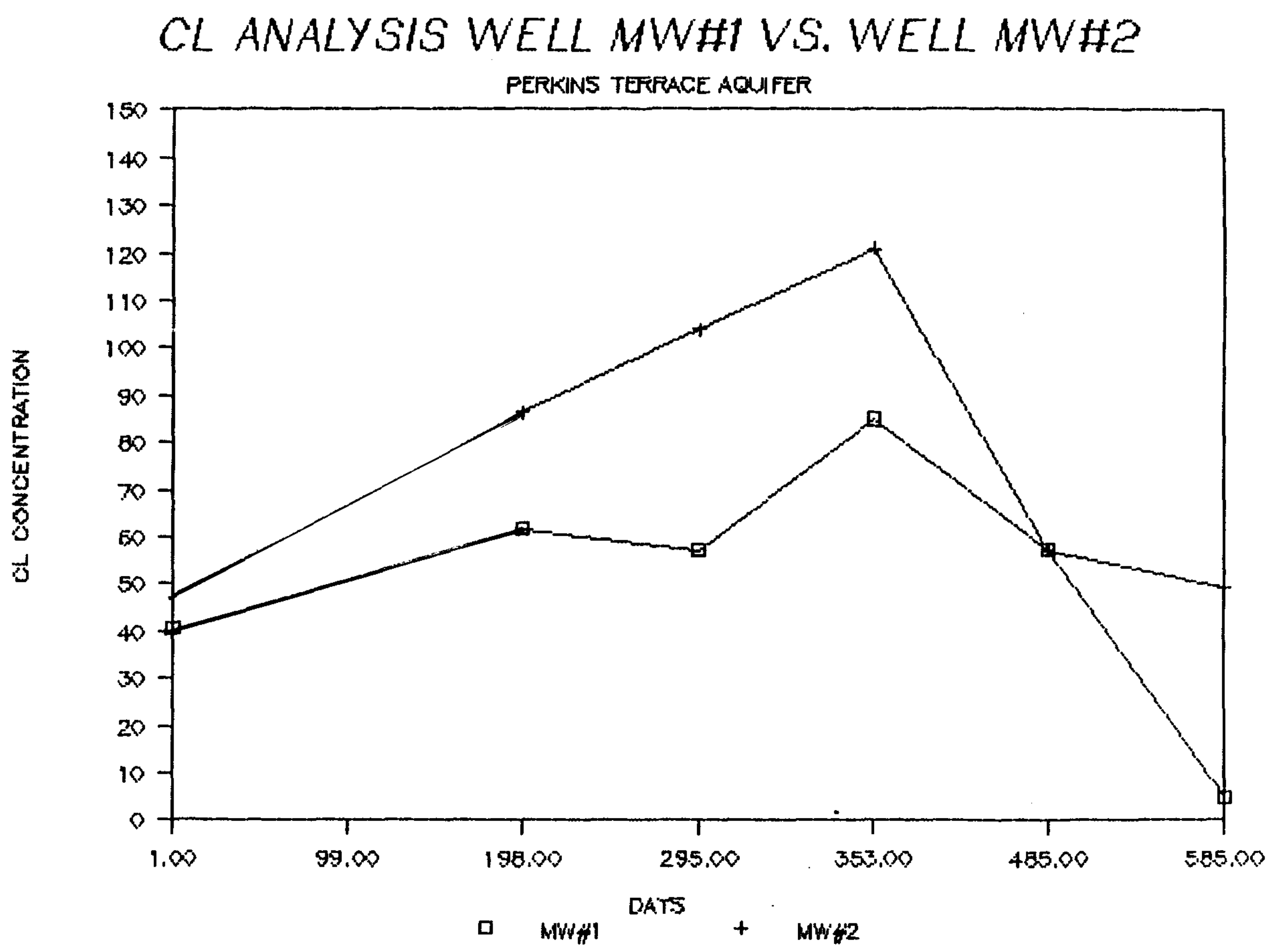

K ANALYSIS WELL MW#1 VS. WELL MW#2
PERKINS TERRACE AQUIFER
K CONCENTRATION
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1.00
99.00
198.00
295.00
353.00
485.00
585.00
DAYS
MW#1
MW#2

NA ANALYSIS WELL MW#1 VS. WELL MW#2

PERKINS TERRACE AQUIFER

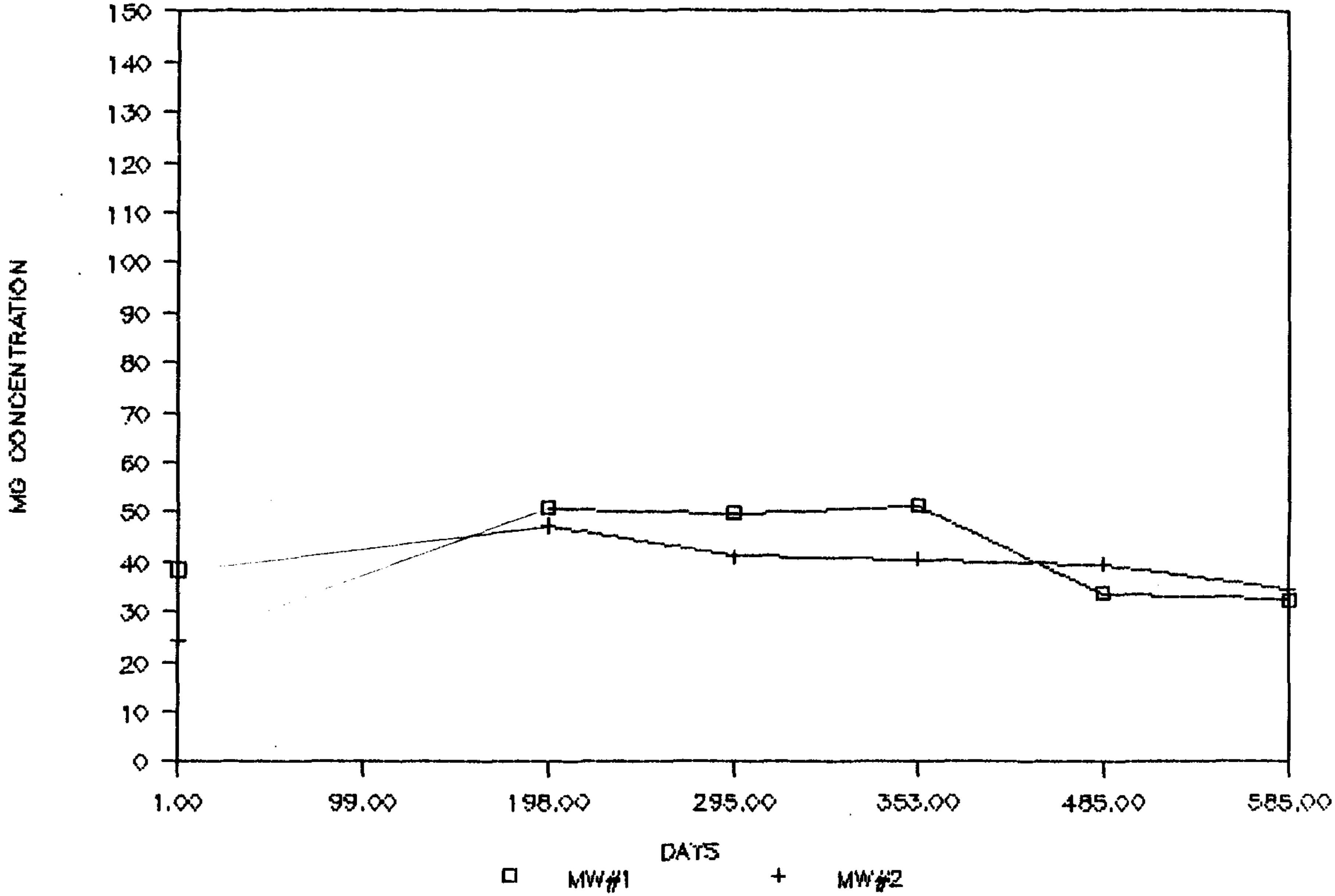



CA ANALYSIS WELL MW#1 VS. WELL MW#2
PERKINS TERRACE AQUIFER
CA CONCENTRATION
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1.00
99.00
198.00
295.00
353.00
485.00
585.00
DAYS
MW#1
MW#2


CL ANALYSIS WELL MW#1 VS. WELL MW#2
PERKINS TERRACE AQUIFER
CL CONCENTRATION
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1.00
99.00
198.00
295.00
353.00
485.00
585.00
DATS
MW#1
MW#2

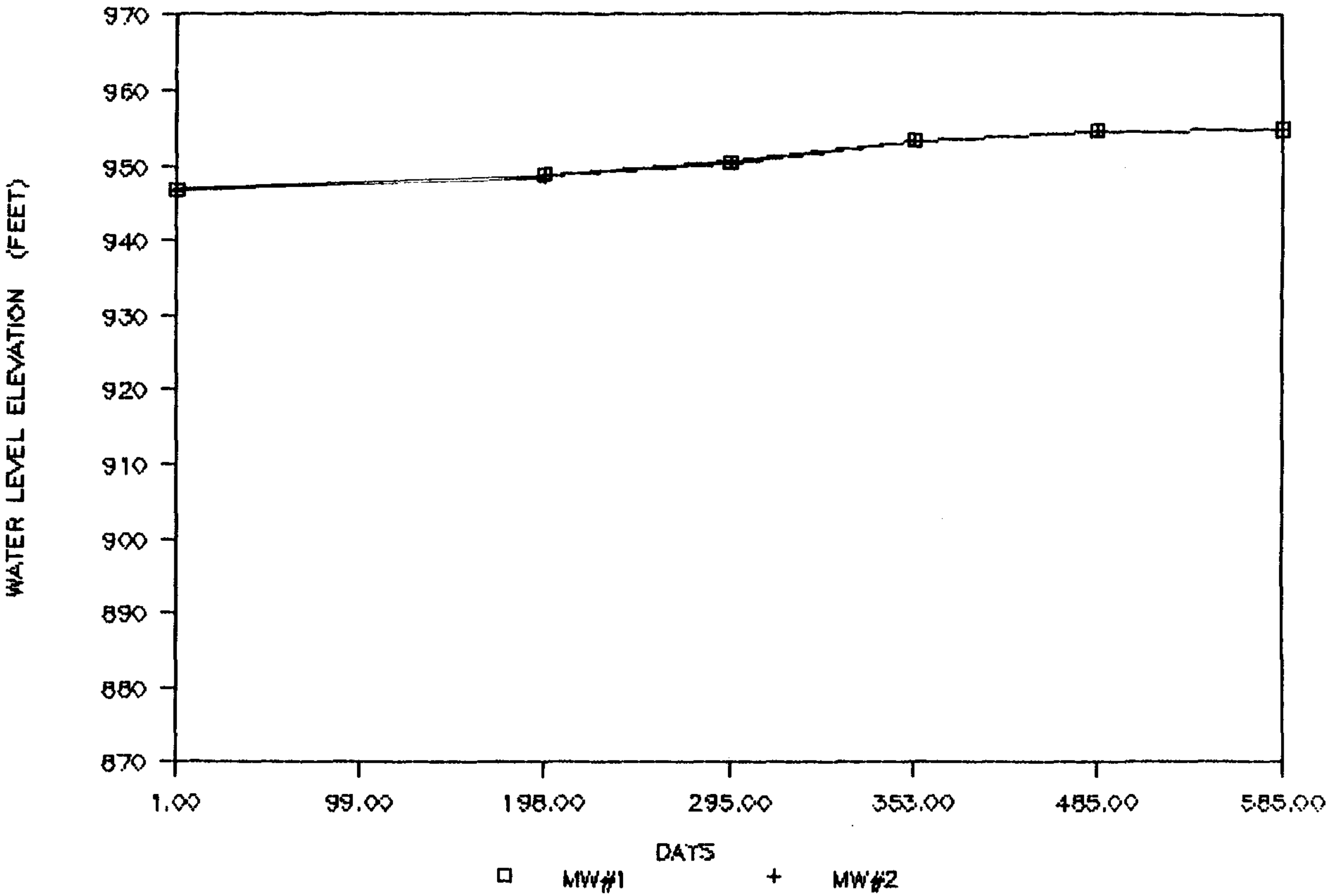
MG ANALYSIS WELL MW#1 VS. WELL MW#2

PERKINS TERRACE AQUIFER

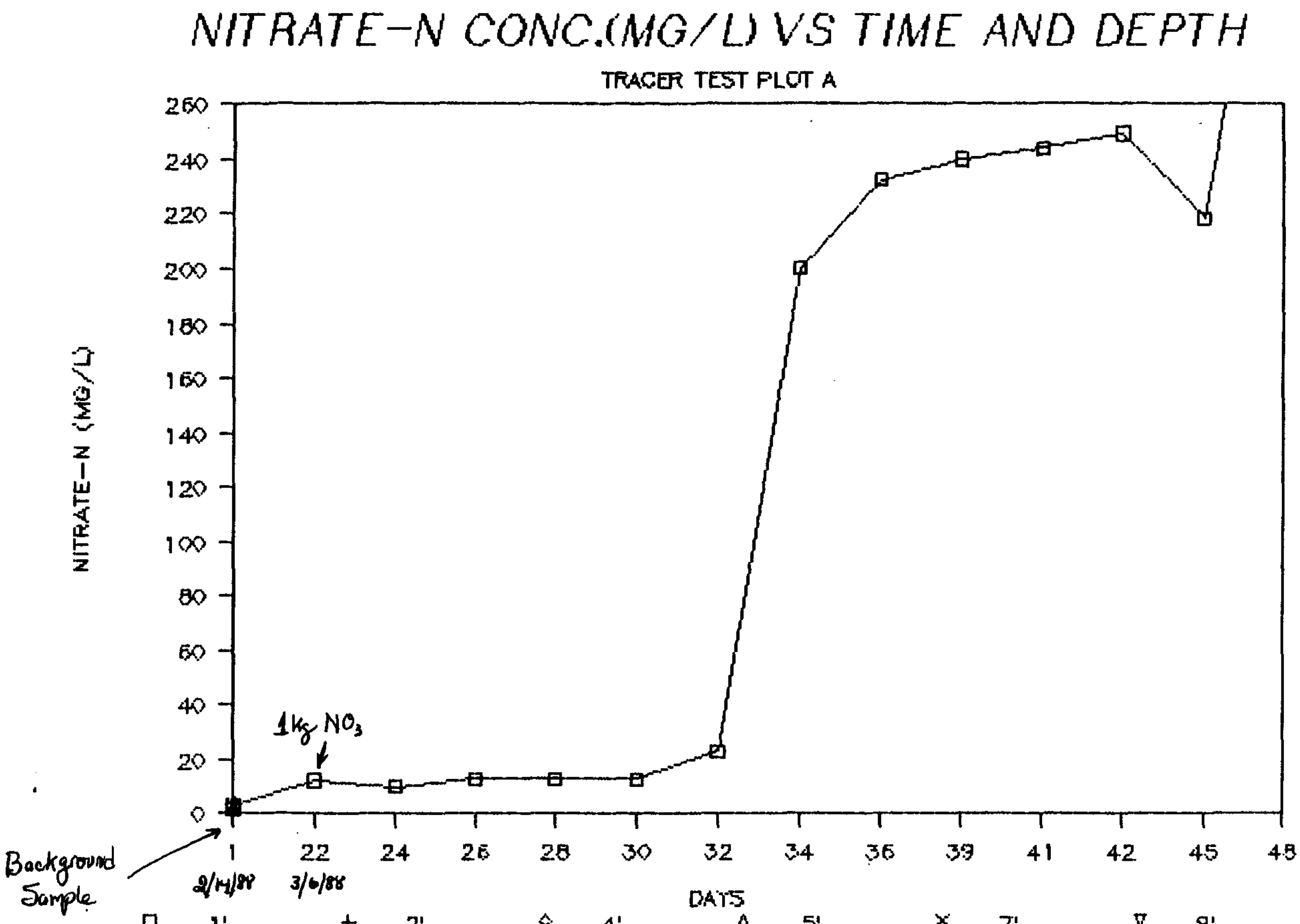


WATER LEVEL WELL MW#1 VS. WELL MW#2

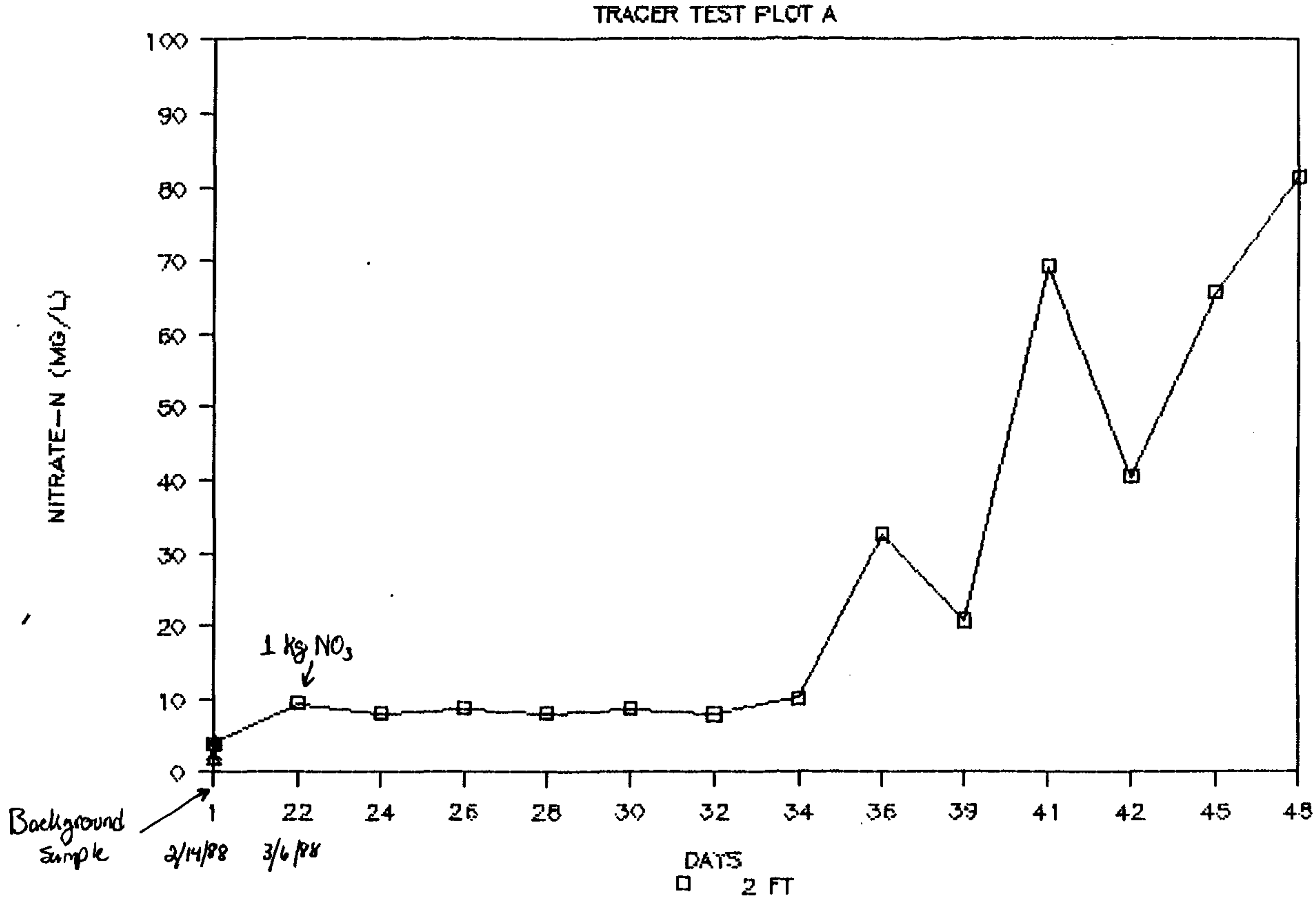
PERKINS TERRACE AQUIFER

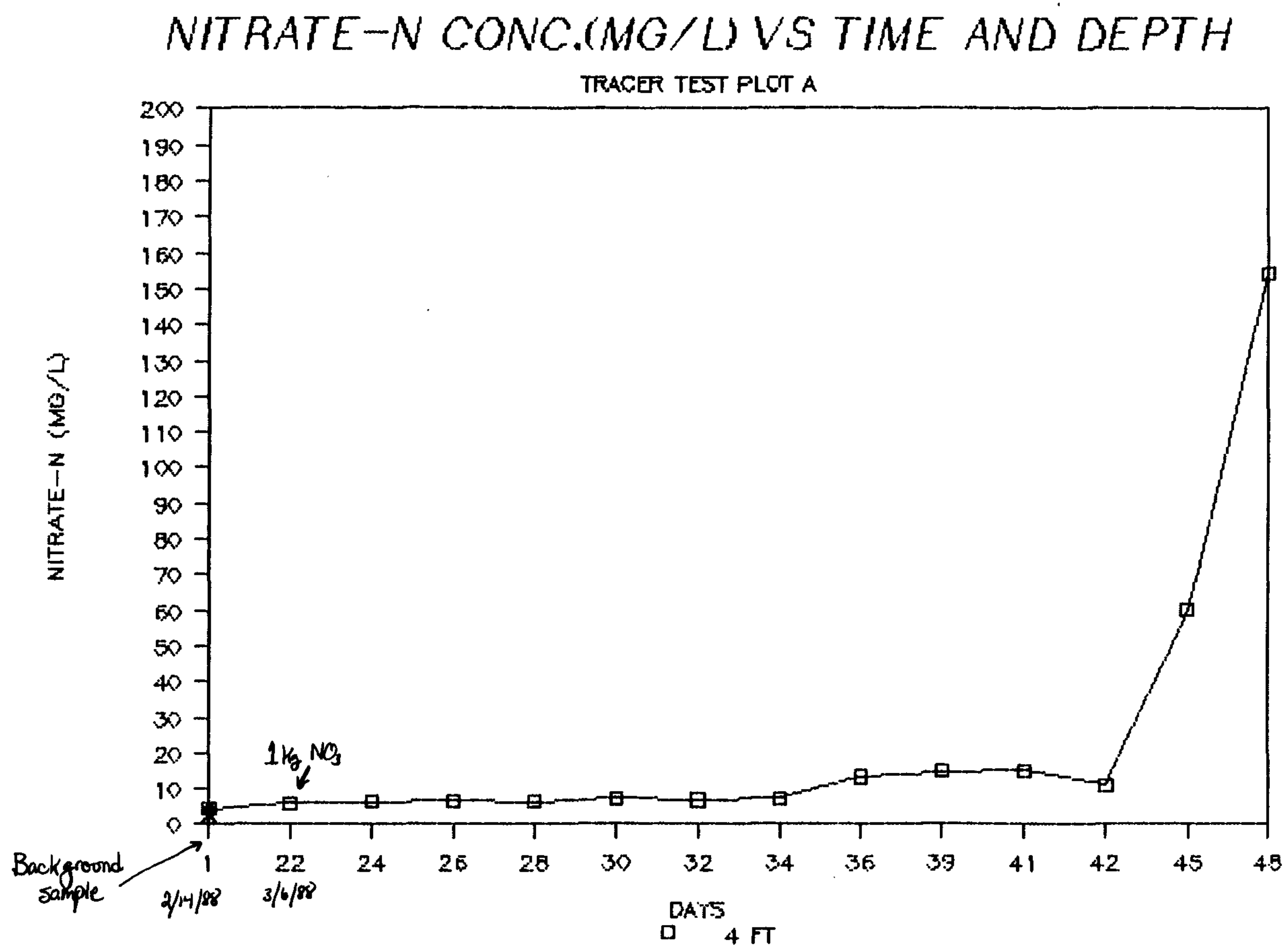


APPENDIX - D


NITRATE-N CONC.(MG/L) VS TIME AND DEPTH
TRACER TEST PLOT A
NITRATE-N (MG/L)
260
240
220
200
180
160
140
120
100
80
60
40
20
0
1kg NO3
1
22
24
26
28
30
32
34
36
39
41
42
45
48
Background Sample
2/14/88
3/6/88
DAYS
□ 1'
+ 2'
◇ 4'
Δ 5'
× 7'
∇ 9'

NITRATE-N CONC.(MG/L) VS TIME AND DEPTH

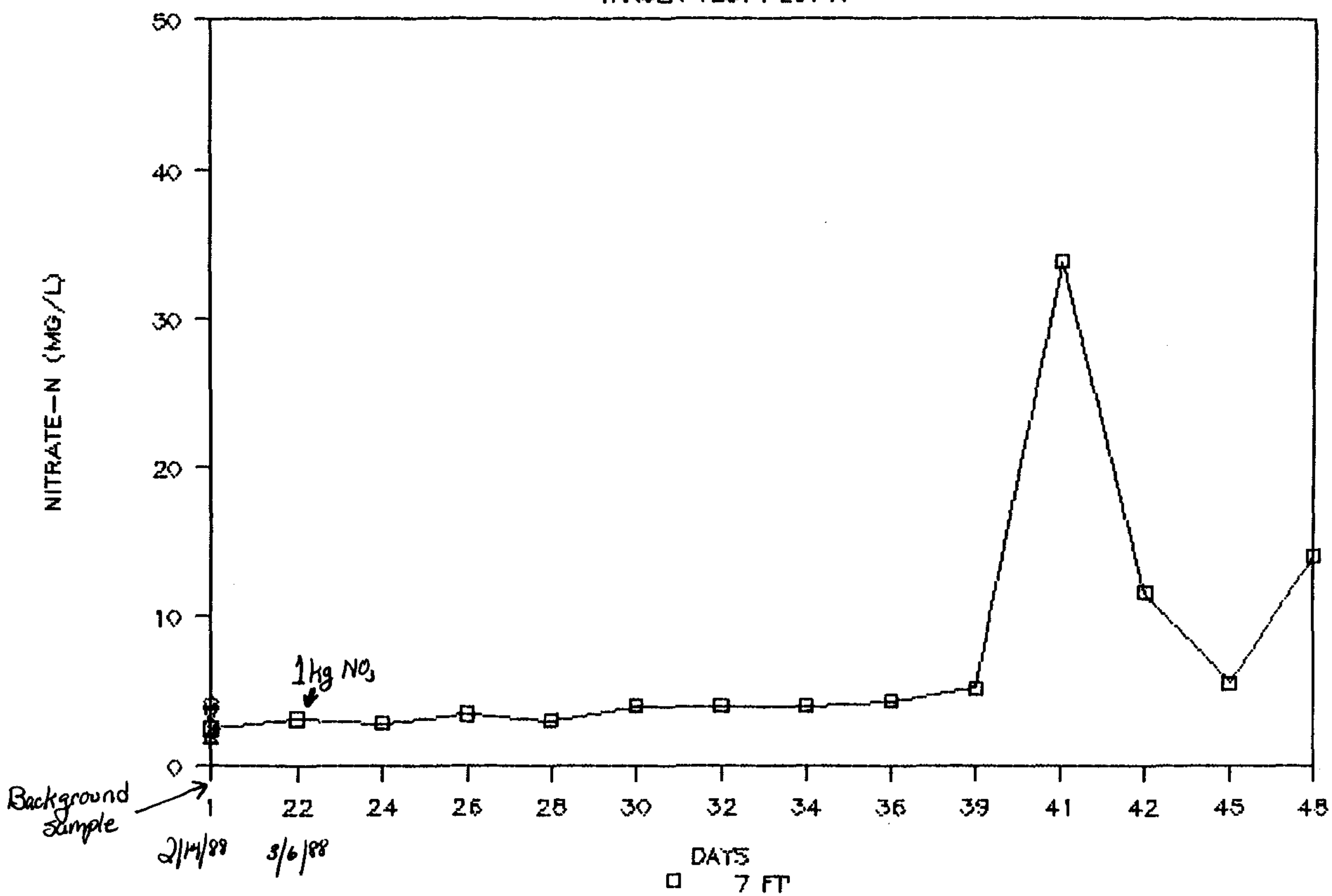


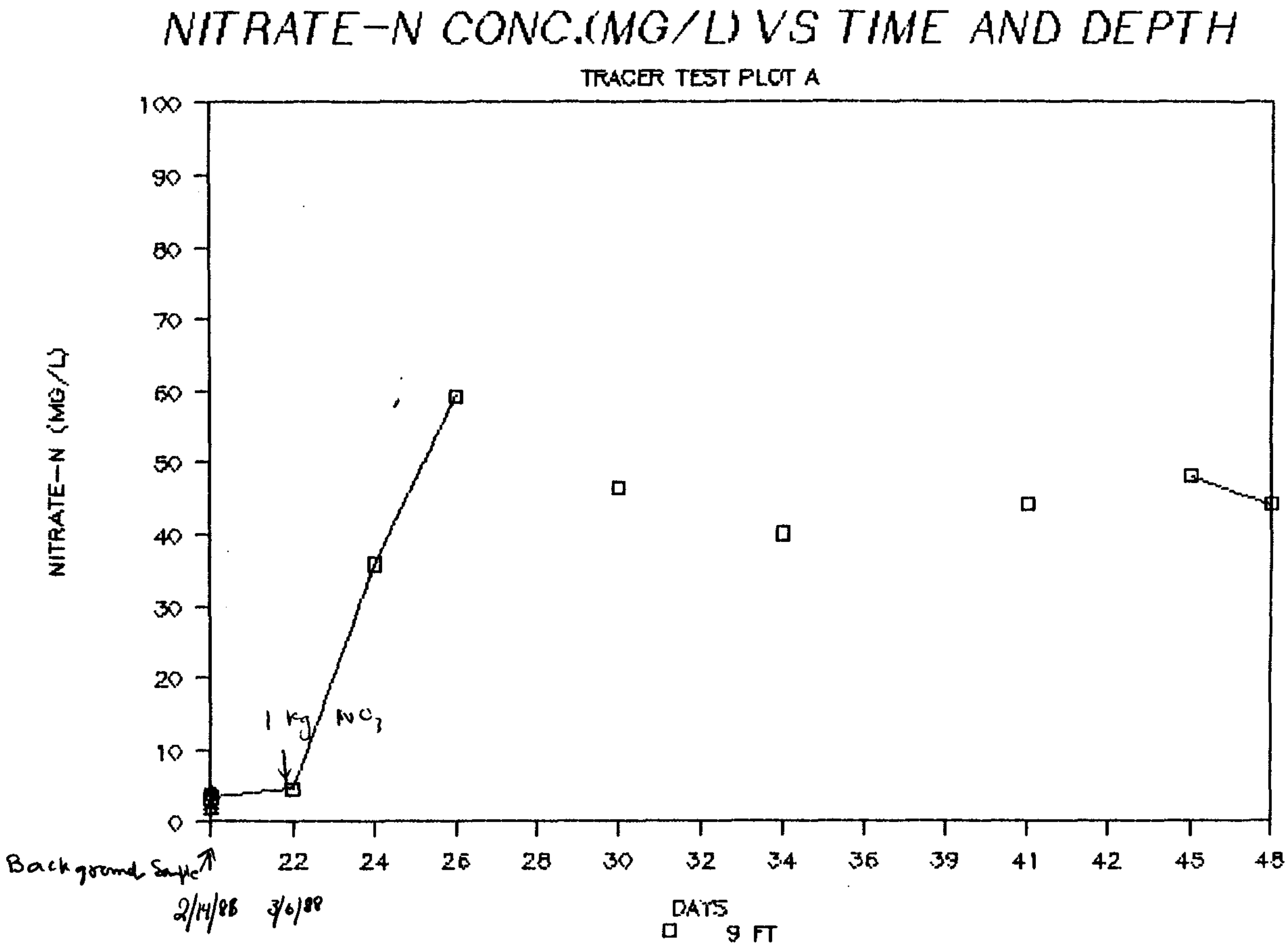


NITRATE-N CONC.(MG/L) VS TIME AND DEPTH
TRACER TEST PLOT A
NITRATE-N (MG/L)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1 Kg NO3
Background sample
1
22
24
26
28
30
32
34
36
39
41
42
45
48
2/14/88
3/6/88
DAYS
4 FT

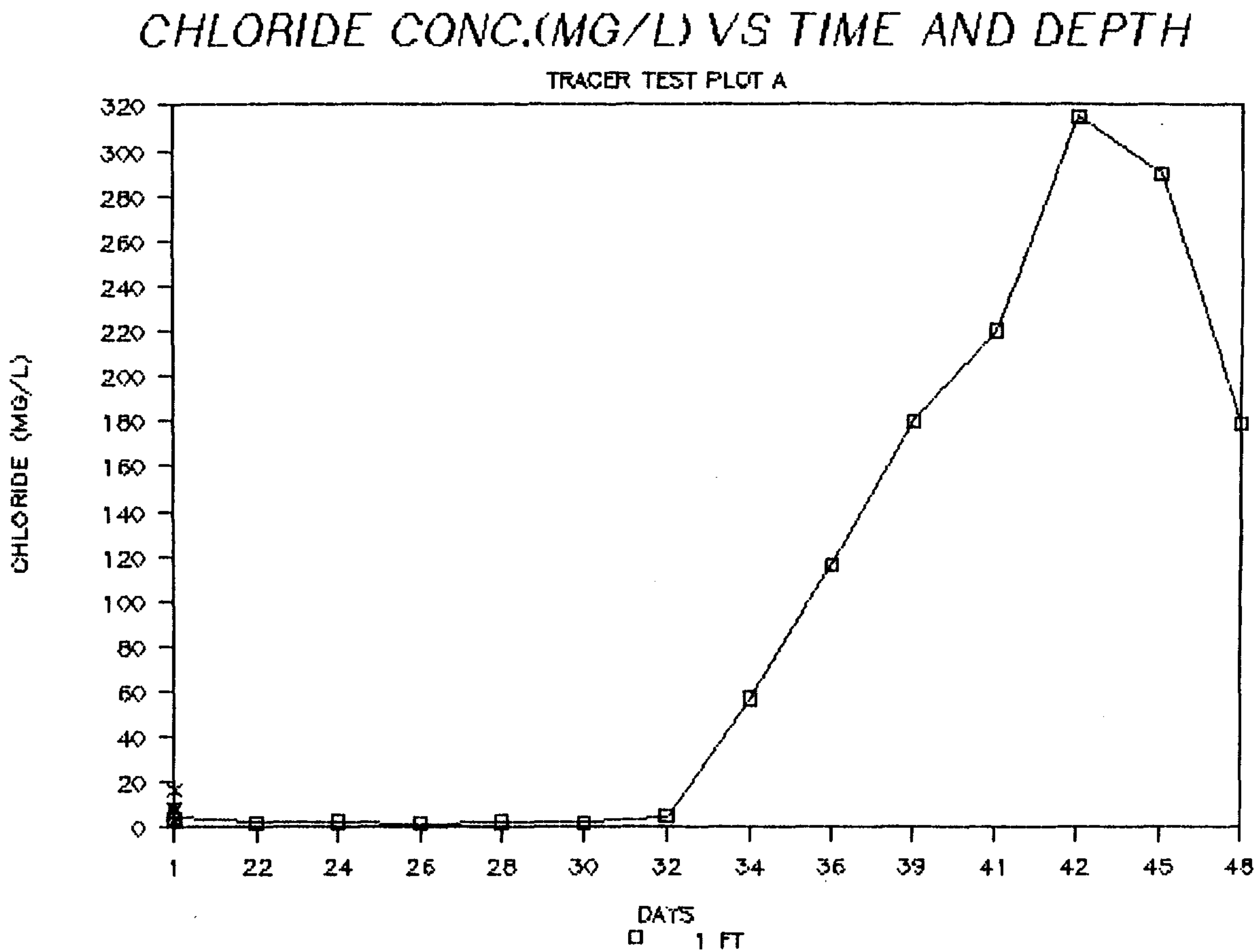
NITRATE-N CONC.(MG/L) VS TIME AND DEPTH

TRACER TEST PLOT A

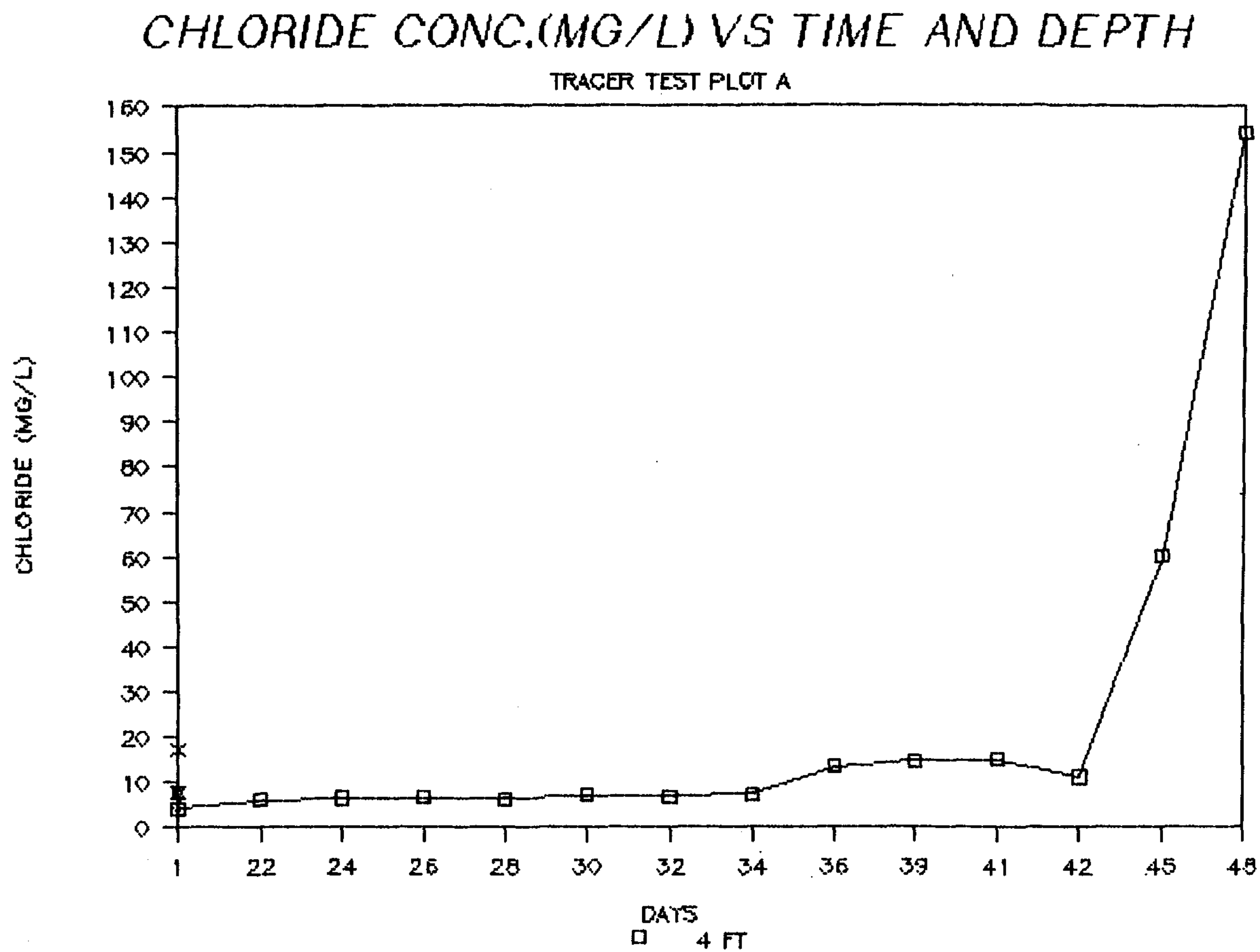




NITRATE-N CONC.(MG/L) VS TIME AND DEPTH
TRACER TEST PLOT A
NITRATE-N (MG/L)
100
90
80
70
60
50
40
30
20
10
0
1 kg NO3
Background Sample
22
24
26
28
30
32
34
36
39
41
42
45
48
2/14/88
3/6/88
DAYS
9 FT

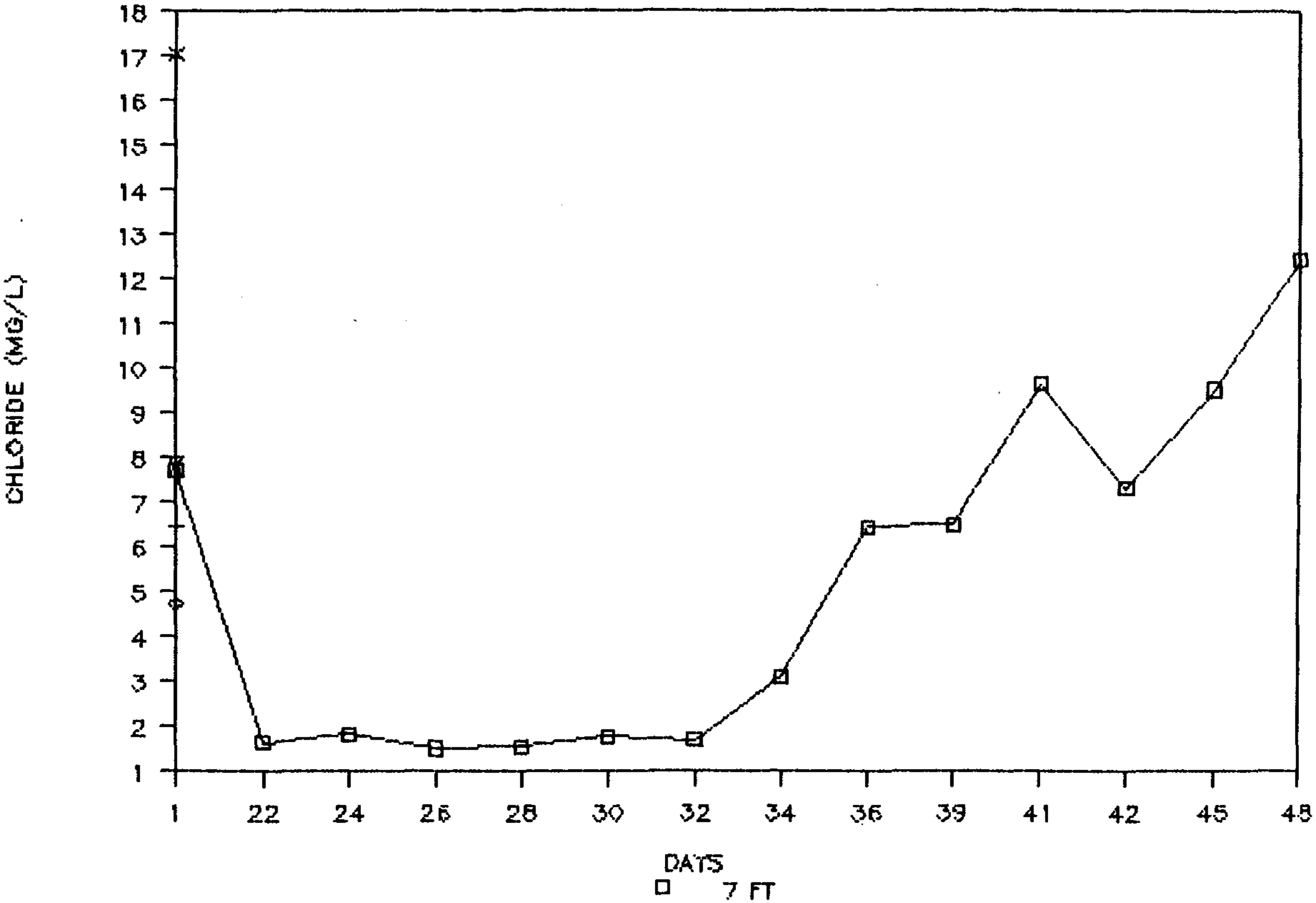


CHLORIDE CONC.(MG/L) VS TIME AND DEPTH
TRACER TEST PLOT A
CHLORIDE (MG/L)
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
1
22
24
26
28
30
32
34
36
39
41
42
45
48
DAYS
1 FT


CHLORIDE CONC.(MG/L) VS TIME AND DEPTH
TRACER TEST PLOT A
CHLORIDE (MG/L)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
1
22
24
26
28
30
32
34
36
39
41
42
45
48
DAYS
4 FT

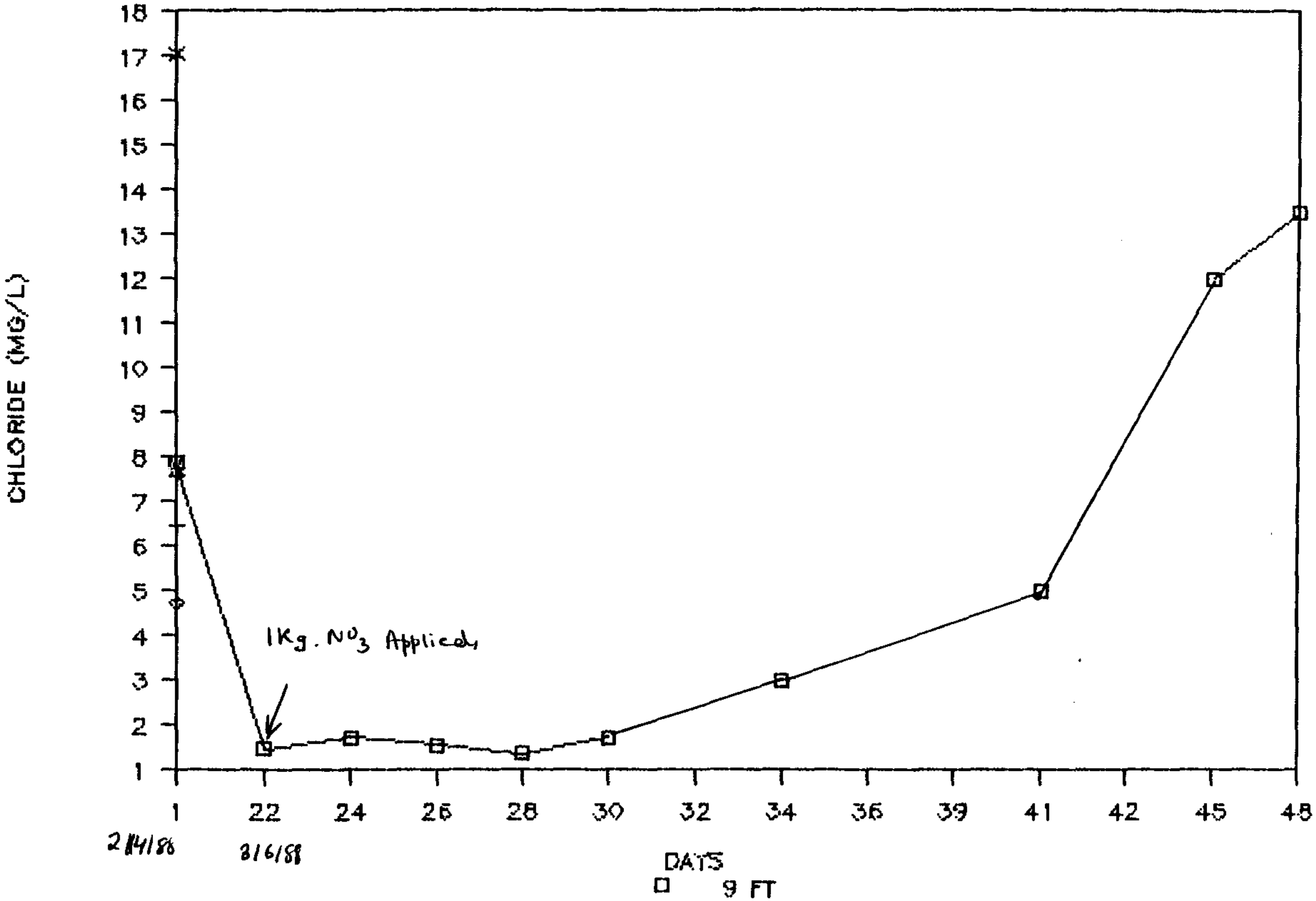
CHLORIDE CONC.(MG/L) VS TIME AND DEPTH

TRACER TEST PLOT A

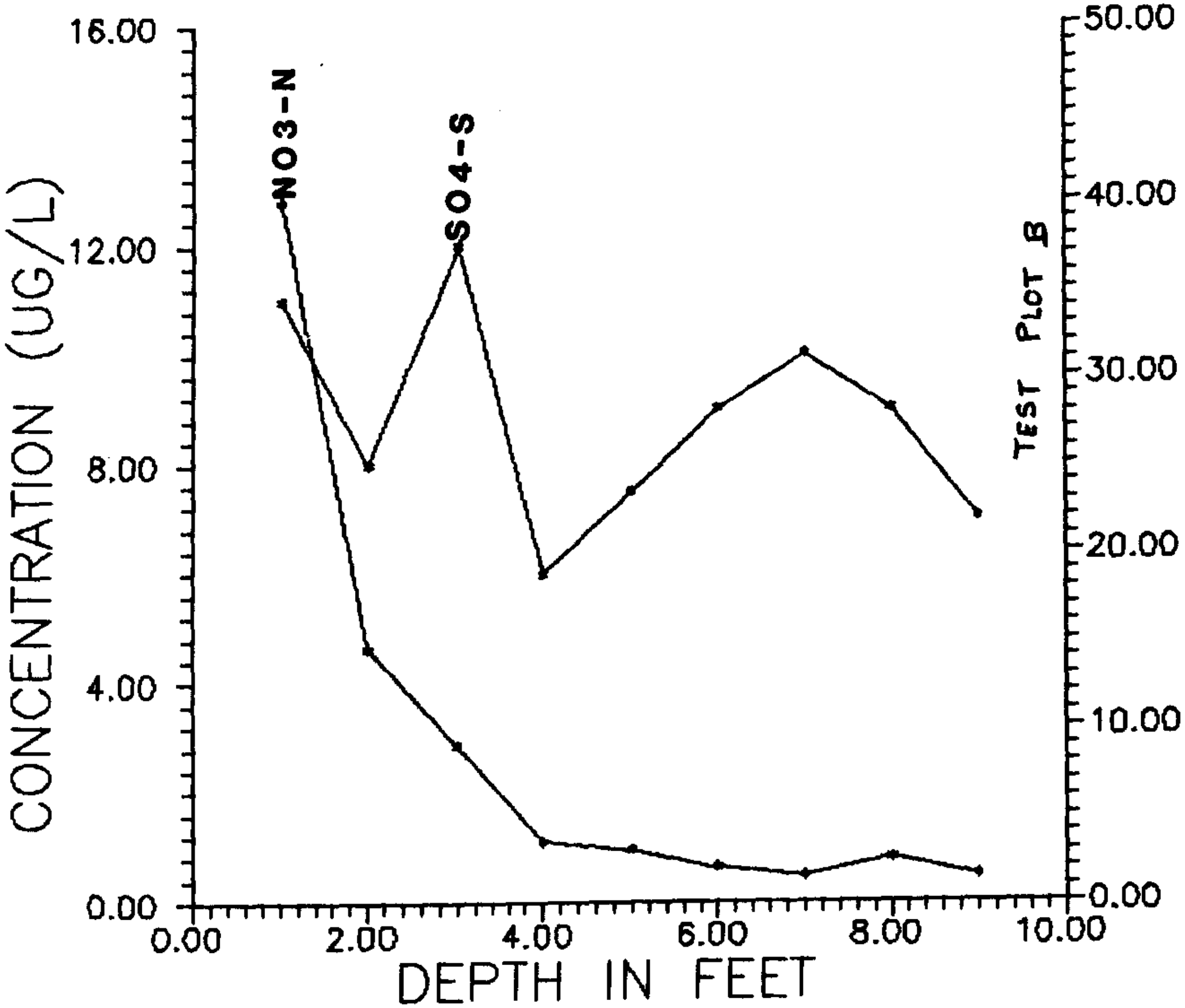


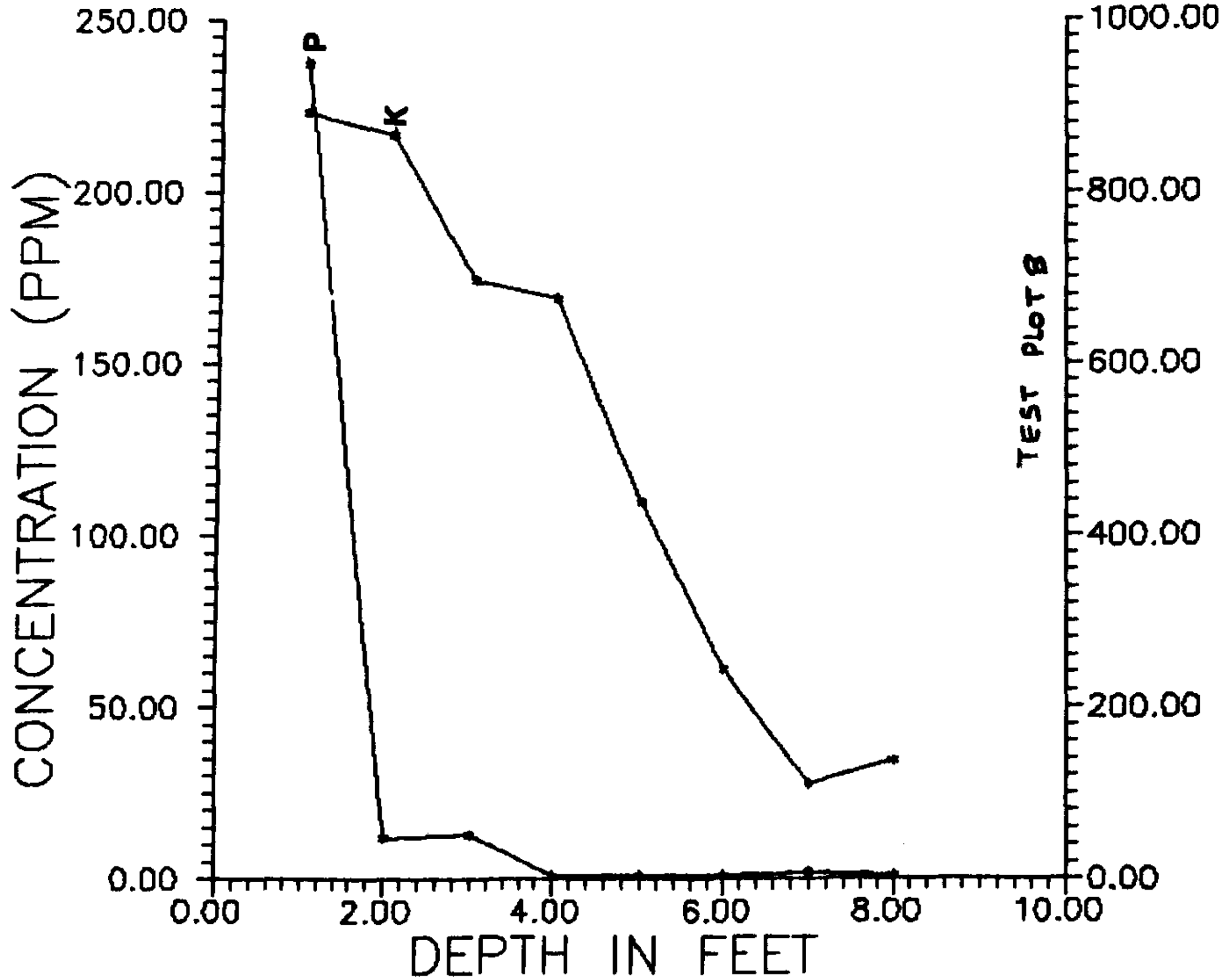
CHLORIDE CONC.(MG/L) VS TIME AND DEPTH

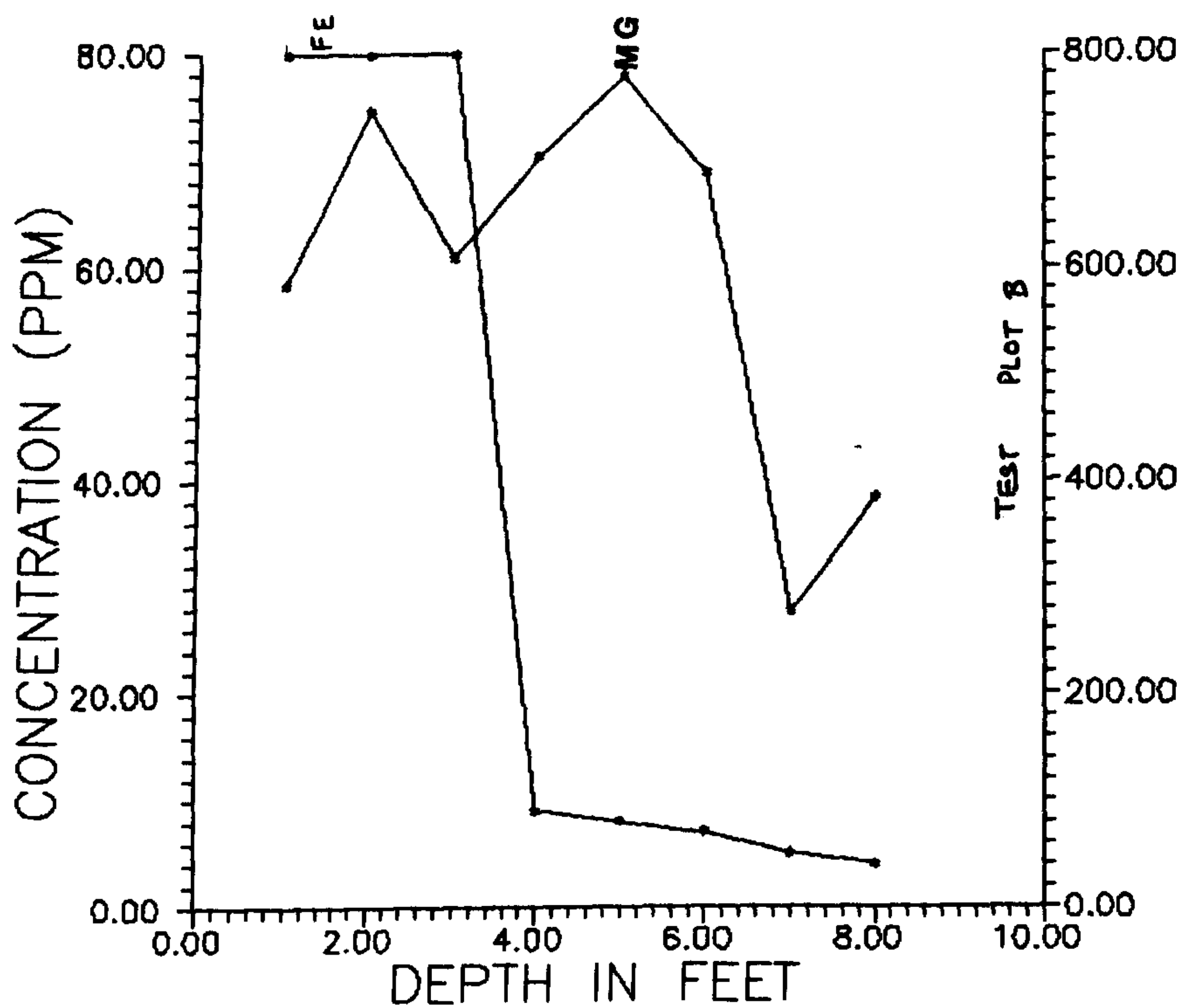
TRACER TEST PLOT A

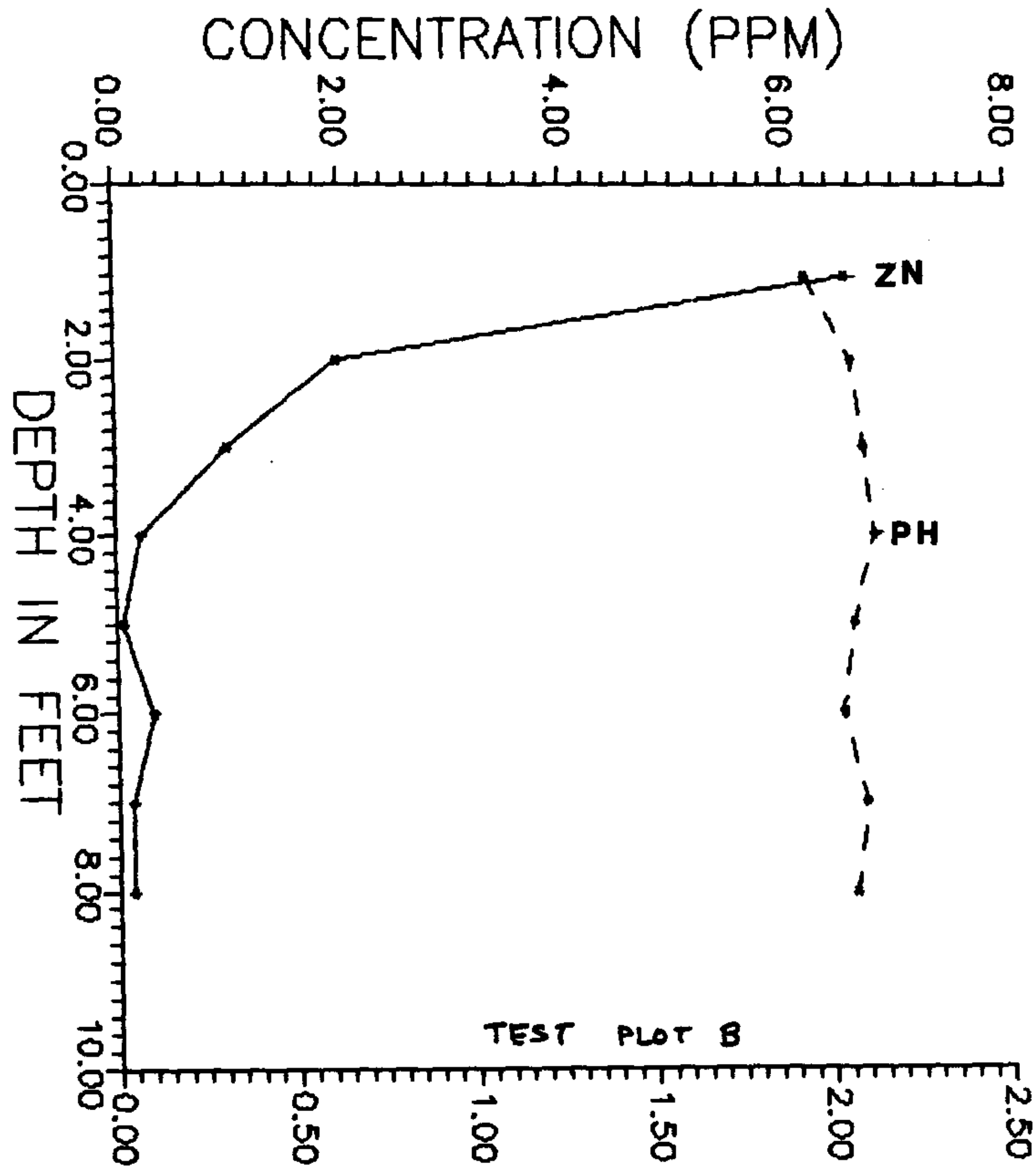


APPENDIX = E


NO3-N
SO4-S
TEST PLOT B
CONCENTRATION (UG/L)
DEPTH IN FEET
16.00
12.00
8.00
4.00
0.00
0.00
2.00
4.00
6.00
8.00
10.00
50.00
40.00
30.00
20.00
10.00
0.00


250.00
200.00
150.00
100.00
50.00
0.00
CONCENTRATION (PPM)
0.00
2.00
4.00
6.00
8.00
10.00
DEPTH IN FEET
1000.00
800.00
600.00
400.00
200.00
0.00
TEST PLOT B
P
K


FE
MG
80.00
60.00
40.00
20.00
0.00
CONCENTRATION (PPM)
800.00
600.00
400.00
200.00
0.00
TEST PLOT B
0.00
2.00
4.00
6.00
8.00
10.00
DEPTH IN FEET


CONCENTRATION (PPM)
0.00
2.00
4.00
6.00
8.00
DEPTH IN FEET
0.00
2.00
4.00
6.00
8.00
10.00
ZN
PH
TEST PLOT B
0.00
0.50
1.00
1.50
2.00
2.50