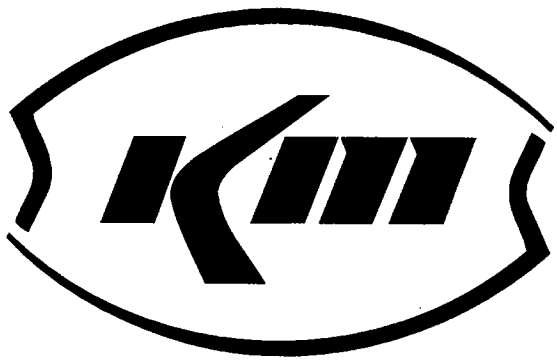
KERR-McGEE CHEMICAL CORPORATION



GROUNDWATER INTERCEPTION SYSTEM EVALUATION REPORT HENDERSON, NEVADA FACILITY

SEPTEMBER 15, 1993

KERR-McGEE CHEMICAL CORPORATION
POST OFFICE BOX 55 • HENDERSON, NEVADA 89009

September 13, 1993

Mr. Allen Biaggi
Environmental Management Specialist IV
Bureau of Chemical Hazards Management
State of Nevada
Division of Environmental Protection
333 West Nye Lane
Carson City, Nevada 89710

Dear Mr. Biaggi:

SUBJECT: Groundwater Interception System Report
KMCC Henderson, Nevada Facility

Attached please find two copies of a report entitled Groundwater Interception System Evaluation Report, Chromium Mitigation Program, Kerr-McGee Chemical Corporation, Henderson, Nevada. Kerr-McGee Chemical Corporation (KMCC) committed to the preparation of this report as a follow-up to the first half 1993 semi-annual performance report dated August 28, 1993.

This system evaluation report will be included as an attachment to the chromium recovery system evaluation requested under item number 43 of the Letter of Understanding draft dated August 17, 1993.

Please contact Susan Crowley at (702) 651-2234 if you have any questions concerning this report or the preparation of the Letter of Understanding response.

Sincerely,

Patrick S. Corbett
Plant Manager

PSC:j

Attachment

cc: Joe Livak - NDEP, Carson City, NV

GROUNDWATER INTERCEPTION SYSTEM EVALUATION REPORT CHROMIUM MITIGATION PROGRAM KERR-McGEE CHEMICAL CORPORATION HENDERSON, NEVADA

Prepared by:

Thomas W. Reed
Hydrology Department
Kerr-McGee Corporation

September 15, 1993

Susan Crowley, Environmental Engineer
Kerr-McGee Chemical Corporation
Henderson, Nevada

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(In Pockets)

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SUMMARY

Kerr-McGee has operated a groundwater chromium mitigation program at the Henderson facility for the past six years. Eleven interceptor wells have pumped over 200 millions gallons of water and the treatment system has removed an estimated 8500 pounds of chromium from the groundwater environment.

Monitor wells in the mitigation area have begun to show that the initial interception system may need to be modified. The decline in interception well recovery rates and the increases in chromium concentration in some monitor wells in the area are early warnings of the need for modifications in the program.

Possible causes for the decline in interception well recovery rates were investigated: the discontinued use of the nearby Beta ditch, the stablization and overlap of the drawdown cones, declines in well efficiencies, and the dewatering of the alluvium. The extensive dewatering of the alluvium is interpreted as the primary reason for the decline in interception well pumping rates.

The increases in chromium concentration in monitor wells in the interception area were also investigated. It was concluded that these increases were closely related to the alluvium dewatering. In the areas where the deepest alluvial channels are cut into the

Muddy Creek bedrock, small quantities of elevated chromium in groundwater appear to be getting past the interception wells.

To further improve the interception system, Kerr-McGee is installing four new recovery wells. These new wells are to be located in areas along the interception line where: 1) the Muddy Creek is most deeply eroded, 2) the chromium concentrations appear to be the highest, and 3) the existing interception wells are unable to fully capture the basal flow in the alluvium. Recovery rates of these new wells are not expected to be high because of the small amount of groundwater which remains in the alluvium.

Following the initial evaluation of these new wells, Kerr-McGee plans to evaluate both the treatment and recharge systems of the mitigation program for optimum performance. The next semi-annual report on the program, due to Nevada Department of Environmental Protection in January 1994, will include the evaluation of the new wells and any treatment or recharge program modifications.

GROUNDWATER INTERCEPTION SYSTEM

EVALUATION REPORT

CHROMIUM MITIGATION PROGRAM

KERR-McGEE CHEMICAL CORPORATION

HENDERSON, NEVADA

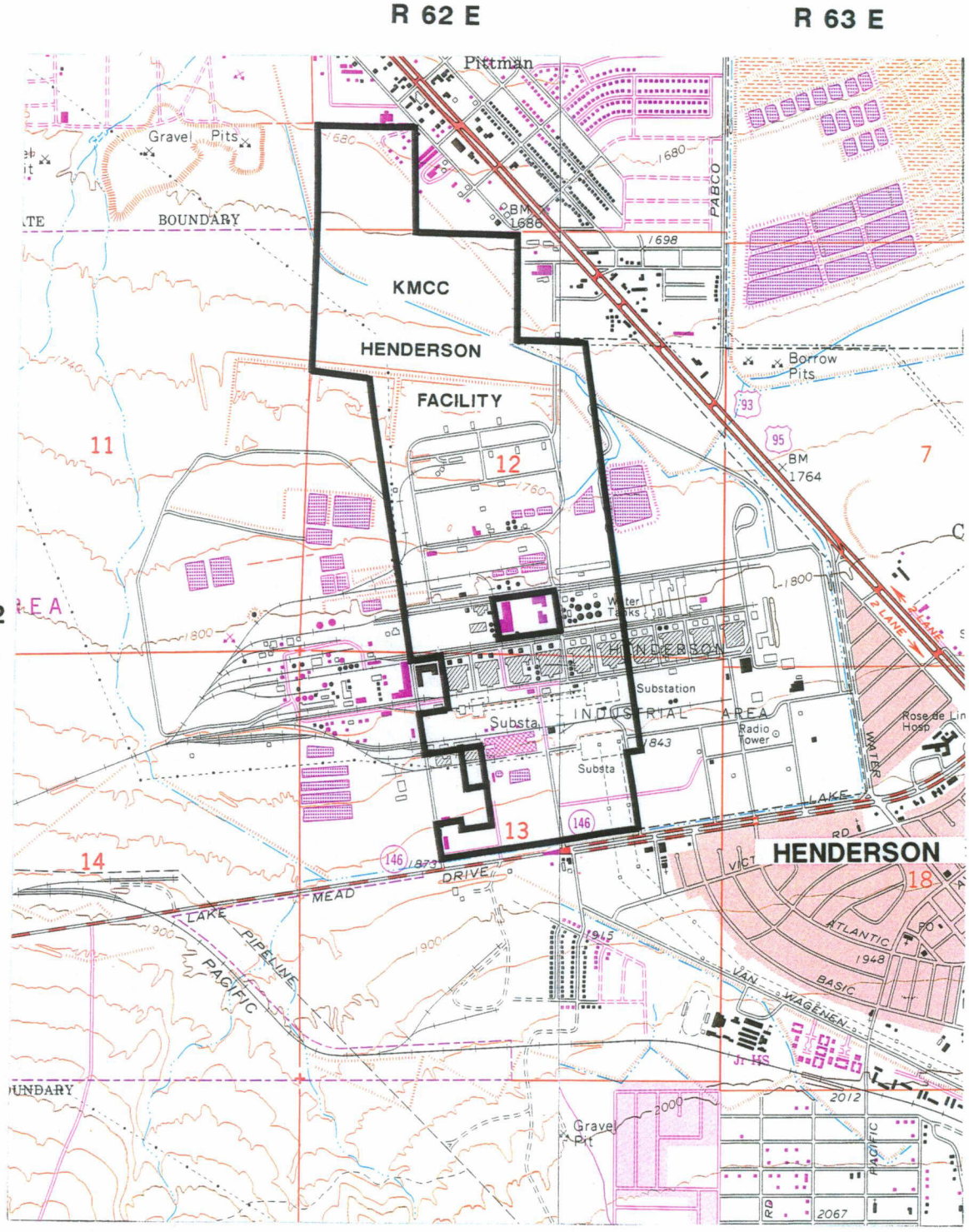
INTRODUCTION

Kerr-McGee Chemical Corporation (KMCC) operates a chemical plant in the Henderson Industrial Complex near Henderson, Nevada. The location of the facility is shown on Figure 1. The facility occupies a portion of the former Basic Magnesium Incorporated plant which was operated by the U.S. Government during the 1940's.

Over the years some of these operations have resulted in chromium impacts to the groundwater. Since 1981, KMCC has installed more than 100 wells to assess the extent of the groundwater impacts and to intercept those impacts in the facility area. Plate 1 shows the location of all groundwater monitoring and interception wells that have been constructed to date. Data from these wells have provided the basis for the groundwater evaluation presented in this report.

GENERAL HYDROGEOLOGIC SETTING

The Henderson facility is underlain by alluvial fan deposits



SOURCE: U.S.G.S. LAS VEGAS SE / HENDERSON, NEVADA 7.5 MINUTE QUADRANGLES: 1967, 1970

N

SCALE

0 2000 FEET

NEVADA

QUADRANGLE LOCATION

FIGURE 1: LOCATION OF THE KMCC HENDERSON, NEVADA FACILITY

consisting of poorly sorted silty sands and gravels. These deposits vary in thickness from less than 20 feet to over 60 feet where the deeper channeling has occurred in the underlying bedrock formation. It is within these channels that the coarser alluvial material is concentrated, along with the greatest groundwater flow potential. Groundwater flow within the alluvium moves in a northwesterly direction beneath the site and eventually discharges into Las Vegas Wash.

Caliche deposits, representing old soil horizons, are present within the alluvium. These low permeability layers influence the infiltration and percolation of water from the surface to the water table.

The Muddy Creek Formation, of Pleistocene age, underlies the alluvial fan deposits. The formation is predominately silty clay and clayey silt which greatly retards the flow of groundwater relative to that in the overlying alluvium. The erosional surface which developed on the Muddy Creek plays a major role in the path of groundwater flow beneath the facility.

GROUNDWATER INTERCEPTION SYSTEM

In December, 1983, the Nevada Division of Environmental Protection (NDEP) directed KMCC to investigate the extent of chromium contamination in the groundwater underlying the Henderson facility. KMCC subsequently installed numerous monitor wells downgradient

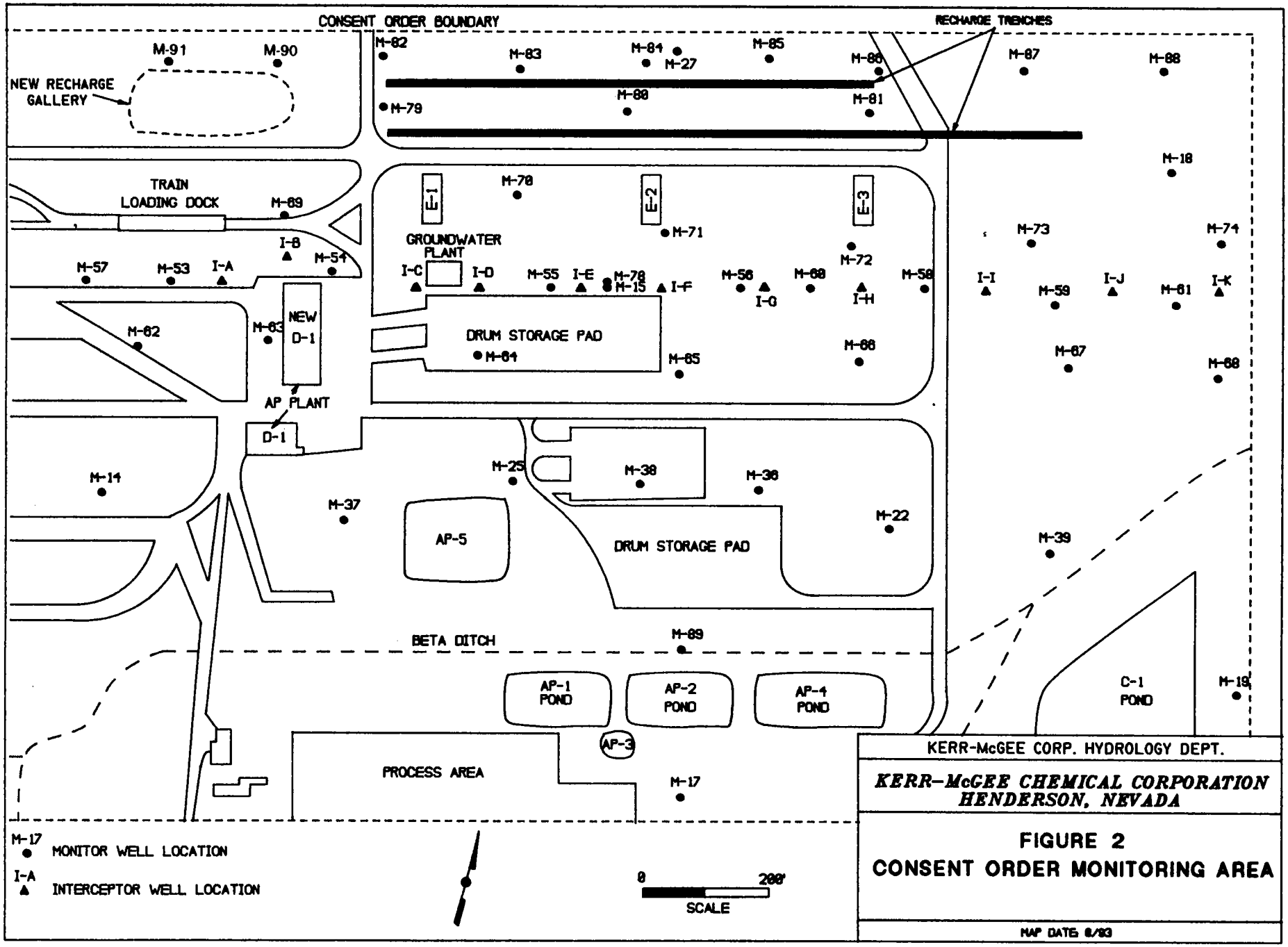
from the probable source(s) of the chromium impact. The collection and interpretation of data from these wells enabled KMCC to delineate the extent and degree of chromium impact to the groundwater beneath the facility.

On September 9, 1986, the NDEP and KMCC entered into a Consent Agreement providing for the interception and removal of the chromium in the groundwater system and the recharge of the treated water back into the aquifer. Under the provisions of this Order, eleven groundwater interception wells were installed, additional downgradient monitor wells were located, and two groundwater recharge trenches were constructed. Figure 2 illustrates the Consent Agreement Monitoring Area, and shows the locations of all groundwater interception and monitor wells installed in this area.

The water table configuration and pattern of chromium impacts which existed at the start of the program are illustrated in Plates 2 and 3.

Interception System Performance

The operation of the interception wells, the treatment plant, and the recharge system was initiated in September 1987. Through August 1993, approximately 200 million gallons of groundwater have been recovered, treated and recharged to the aquifer. At an average chromium recovery concentration of 5.0 mg/l and an average treated recharge concentration of 0.02 mg/l, this groundwater


CONSENT ORDER BOUNDARY
RECHARGE TRENCHES
NEW RECHARGE GALLERY
M-91
M-90
M-82
M-83
M-84
M-27
M-85
M-86
M-87
M-88
M-79
M-80
M-81
TRAIN LOADING DOCK
M-89
E-1
E-2
E-3
M-70
M-71
M-72
M-18
M-73
M-74
GROUNDWATER PLANT
I-B
I-A
M-57
M-53
M-54
I-C
I-D
M-55
I-E
M-78
M-15
I-F
M-56
I-G
M-60
I-H
M-58
I-I
M-59
I-J
M-61
I-K
NEW D-1
M-62
M-63
DRUM STORAGE PAD
M-64
M-65
M-66
M-67
M-68
AP PLANT
D-1
M-14
M-25
M-38
M-36
M-37
AP-5
M-22
DRUM STORAGE PAD
M-39
BETA DITCH
M-69
AP-1 POND
AP-2 POND
AP-4 POND
C-1 POND
M-19
AP-3
PROCESS AREA
M-17
M-17 MONITOR WELL LOCATION
I-A INTERCEPTOR WELL LOCATION
0
200'
SCALE
KERR-McGEE CORP. HYDROLOGY DEPT.
KERR-McGEE CHEMICAL CORPORATION
HENDERSON, NEVADA
FIGURE 2
CONSENT ORDER MONITORING AREA
MAP DATE 8/93

treatment represents approximately 8500 pounds of chromium removed from the groundwater environment in the 6 years of operation.

Two issues concerning interception system performance were the focus of the current evaluation. The first was the investigation of the decline in the groundwater recovery rates in the interception wells. The second issue was the investigation of the increased chromium concentrations in the 70 and 80 series monitor wells near the recharge area, as reported in the semi-annual reports to NDEP.

Groundwater Recovery Rates. Data presented in the semi-annual reports show a significant drop in groundwater recovery rates over the six years of operation (Figures 3 and 4). Initial recovery rate in 1987 was 111.5 gallons per minute compared to the 32.9 gallons per minute reported at the end of 1992. Several contributors to this decline in production have been identified and are discussed below.

1) Beta Ditch

The Beta ditch, which carried water across the Kerr-McGee site, is located about 500 feet upgradient of the interception well line (see Figure 2). Infiltration of water in that unlined ditch undoubtly contributed to the aquifer saturated thickness for many years. Flow in the ditch was discontinued two months after the interception pumping began, thereby

FIGURE: 3
INTERCEPTOR WELL DISCHARGE RATES
WELLS: I-A, I-B, I-C, I-D, I-E, I-F
KMCC HENDERSON, NEVADA FACILITY

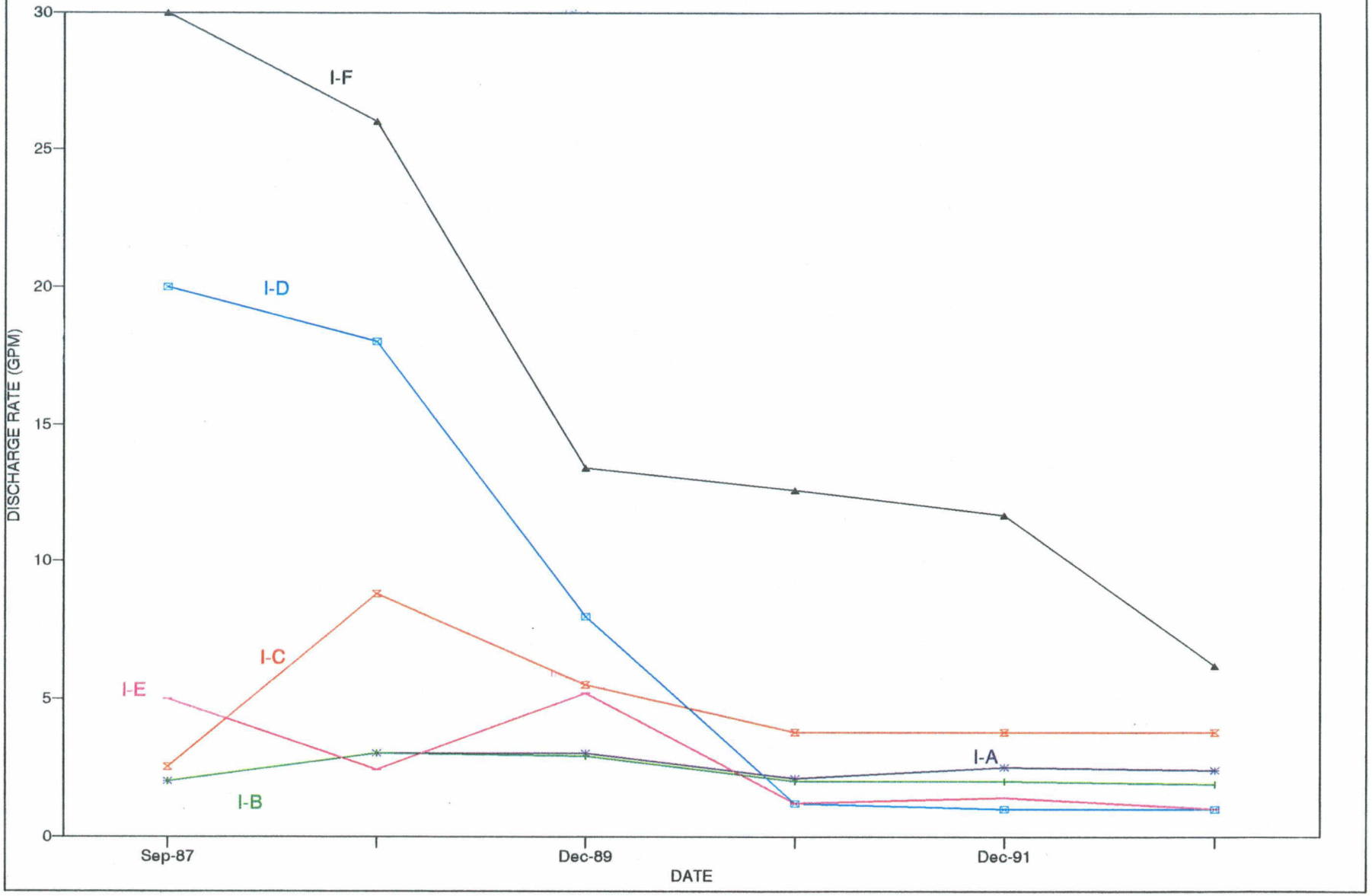
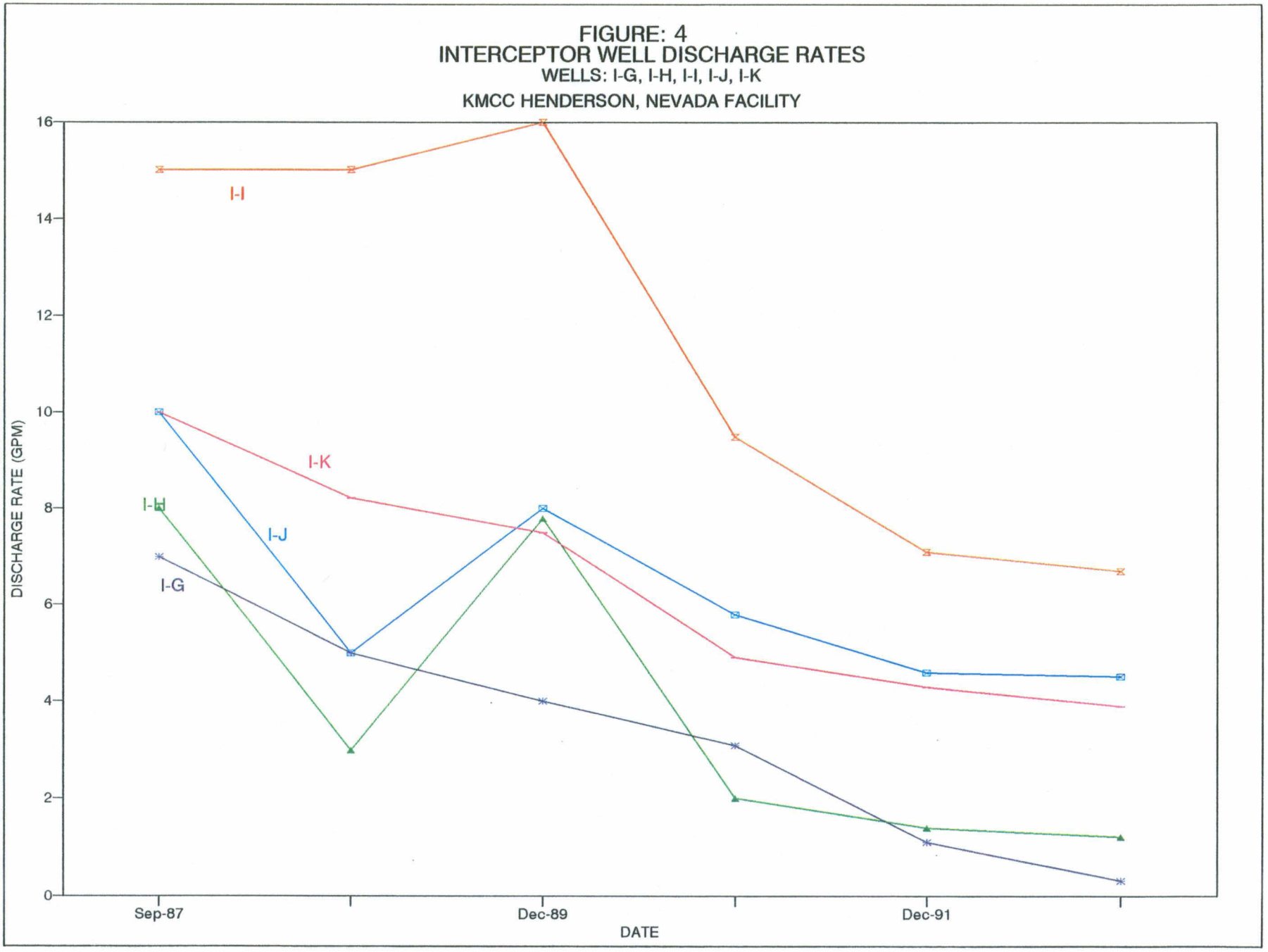


FIGURE: 4
INTERCEPTOR WELL DISCHARGE RATES
WELLS: I-G, I-H, I-I, I-J, I-K
KMCC HENDERSON, NEVADA FACILITY



eliminating one source of water to the wells. A gradual decline in the saturated thickness downgradient of the ditch would have occurred even without the interception pumping. The effect of discontinuing flow in the Beta ditch on the pumping rates of the wells cannot be quantified because of the lack of data on the historical infiltration rates.

2) Pumping Stabilization

The initial effect of pumping was expected to caused a decline in recovery rates as the cones of depression around the wells were becoming established and were overlapping with each other. This pumping stabilization effect, however, would have been more pronounced in the first year of pumping than in subsequent years.

3) Well Efficiency

The well efficiency, defined as the ability of water to enter a pumping well, is normally expected to decline as pumping is frequently cycled on and off over years of operation. Such losses in well efficiency are related to plugging of the screen or the sand pack by chemical deposits or suspended solids in the water.

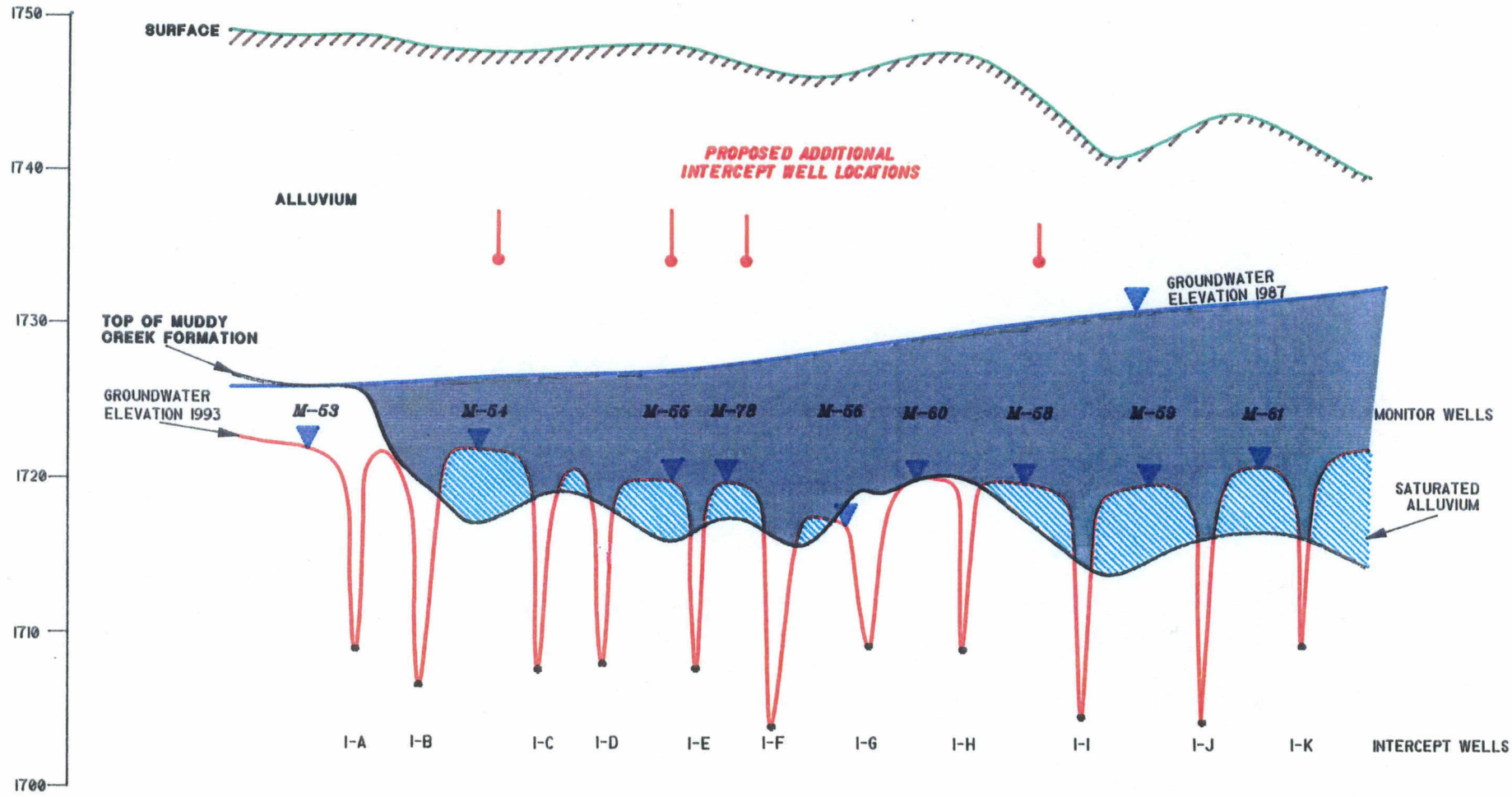
In an effort to evaluate well efficiency effects short-term recovery tests were conducted on eight of the interception wells in early 1993. The results of those tests are presented

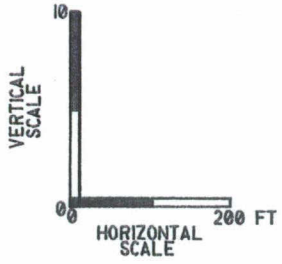
and discussed in Appendix A. A decline in well efficiencies was not evident from the data collected.

4) Alluvium Dewatering

As the saturated section of alluvium in each interception well was dewatered, individual well yields were expected to decrease. The degree of dewatering of the alluvium that has been accomplished in six years can be seen in the 1993 potentiometric surface map (Plate 4) and the updated structure map for the top of the Muddy Creek (Plate 5). These two maps were combined to prepare the saturated alluvium map (Plate 6). This map shows that the southern extent of alluvium saturation which was previously located much further to the south is now located in the immediate vicinity of the interception well line. The cross section along the interception line also shows the degree of dewatering accomplished (Figure 5).

After a thorough review of all of the above data, it is believed that early decline in production was primarily related to the discontinued use of the Beta ditch and the initial stablization of the drawdown cones. In more recent years, however, dewatering of the alluvium has been the primary cause for the decline noted in the pumping rates. No significant well losses have been noted in the existing wells.





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KERR-McGEE CHEMICAL CORP.
HENDERSON, NV.

FIGURE 5
WEST-EAST CROSS SECTION
ALONG THE INTERCEPTION WELL LINE

MAP DATE: 9/93

Chromium Concentrations in Monitor Wells. The increases in chromium concentrations in the 70 and 80 series monitor wells (Figures 6 and 7) appear to be inversely related to the decline in the recovery rates. Since the inception of the groundwater recovery system in 1987, some 10 to 15 feet of saturated alluvial aquifer has been effectively dewatered down to the Muddy Creek.

Figure 5 shows the water level data taken from both pumping wells and monitor wells. (Vertical exaggeration on this cross section makes the basal groundwater in the alluvium appear to be more pronounced than it really is.) Water levels in the alluvium have been lowered to the point where only the alluvium in the channels on the eroded Muddy Creek surface continue to contain groundwater.

This dewatered alluvial situation is also illustrated in Plate 6. It is apparent that the channels on the Muddy Creek surface (compared with Plate 5) contain the areas of saturated alluvium which "funnel" chromium-impacted groundwater through in the area of the interception wells.

Current Status of Chromium Impact

The configuration of the groundwater chromium plume was developed in 1985 to aid in the initial placement of the interception system (see Plate 3). The sources of the chromium impact at that time were traced to the areas beneath process buildings 4 and 5, and, to some extent, beneath the closed sodium chlorate ponds.

FIGURE 6

CHROMIUM CONCENTRATION IN MONITOR WELLS M-71, M-72, AND M-73

KMCC HENDERSON, NEVADA FACILITY

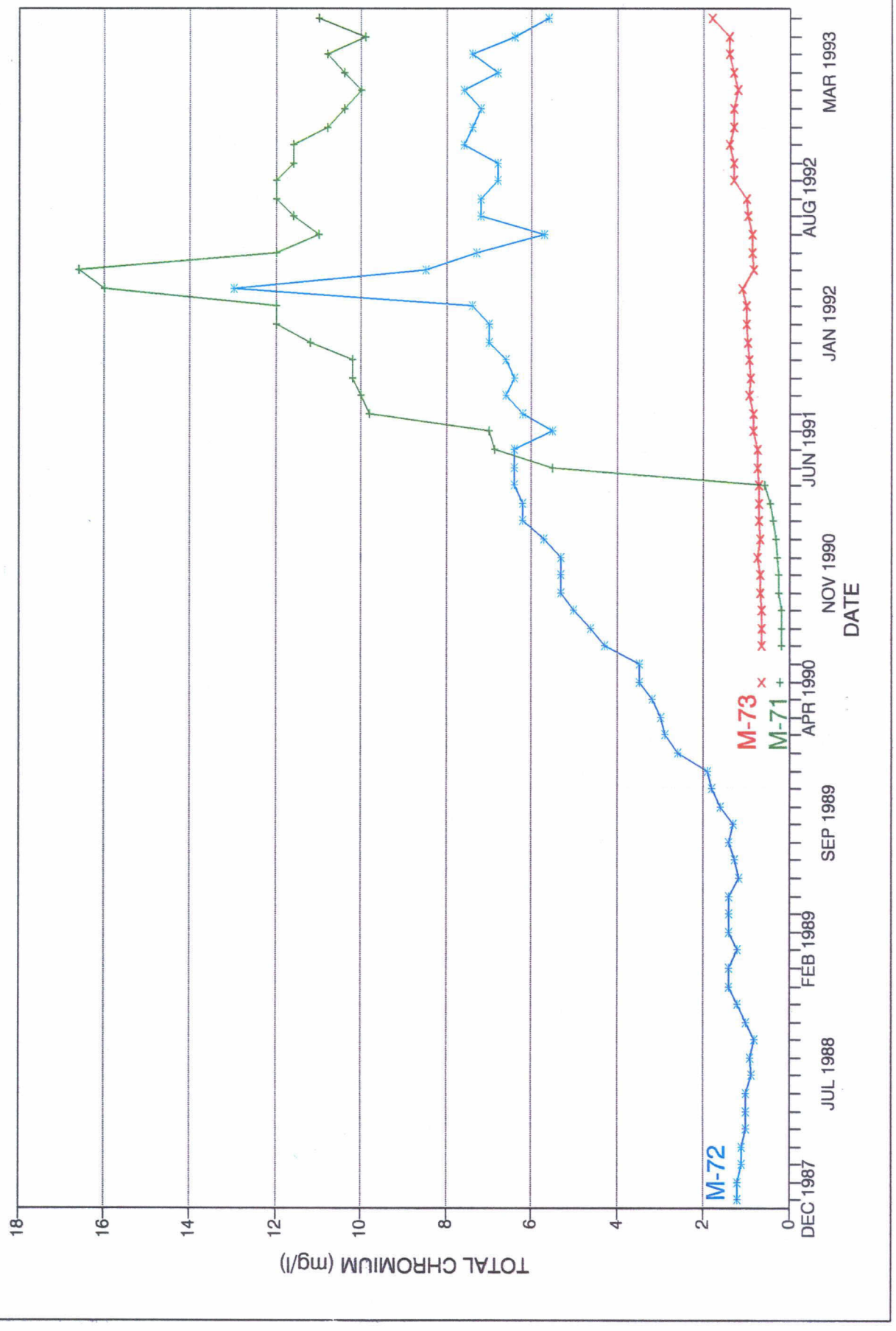
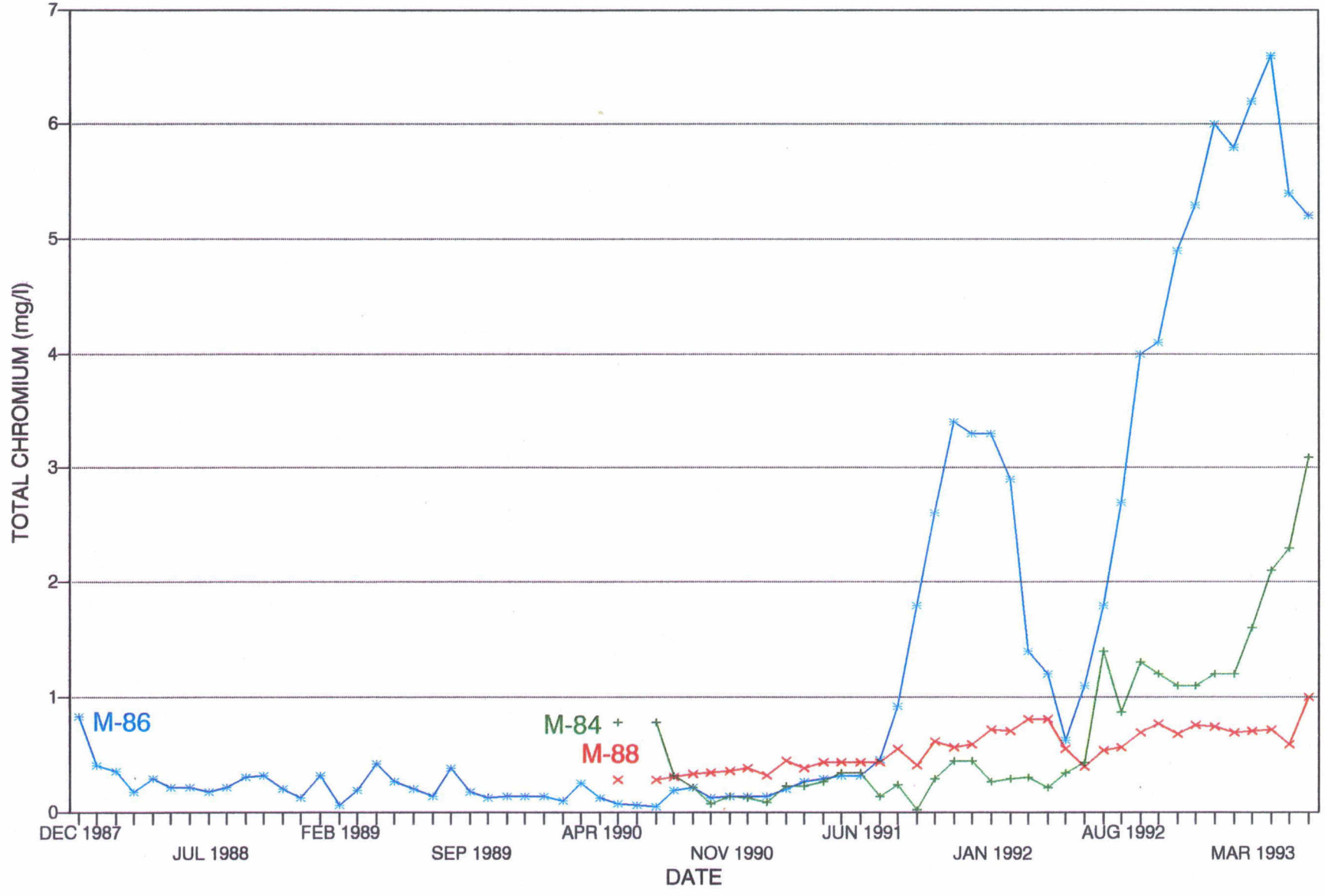


FIGURE 7

CHROMIUM CONCENTRATION IN MONITOR WELLS M-84, M-86, AND M-88

KMCC HENDERSON, NEVADA FACILITY



In June, 1993 another groundwater sampling event for all facility wells was conducted to determine the current status of the chromium plume beneath the entire site. Plate 7 is an isopleth map showing this chromium information. It is apparent from the chromium data in the area of the interception system that the channels of thicker alluvium are strongly influencing the trends of chromium concentrations immediately downgradient from the interception wells.

Additional Interception Well Installation

As a result of the dewatering and the subsequent localizing of chromium-impacted groundwater in erosional channels on the Muddy Creek surface, KMCC plans to install four additional interception wells at key locations along the interception system line. Figure 5 and Plates 6 and 7 show the locations of these wells. At each site, a new well will be installed to more effectively intercept the higher chromium concentrated water. Figure 8, taken from the semi-annual report, shows the location and magnitude of the higher chromium values recovered at the various interception wells in June of each year.

The new wells will be constructed and operated in a manner similar to that of the existing wells. Figure 9 is a well construction diagram for the proposed additional interception wells.

FIGURE 8
CHROMIUM VALUES FOR INTERCEPTION WELLS I-A THROUGH I-K
KMCC HENDERSON, NEVADA FACILITY

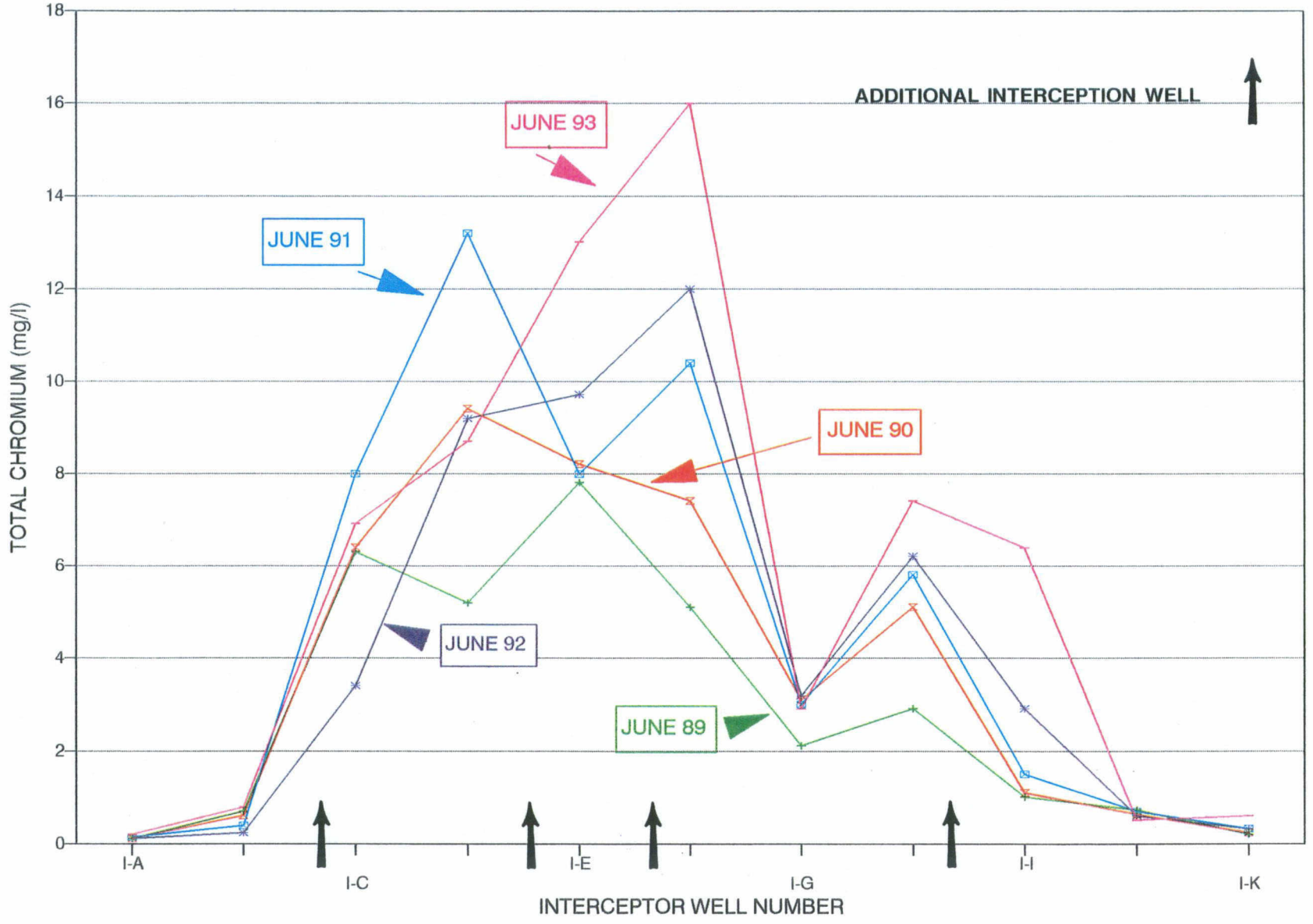
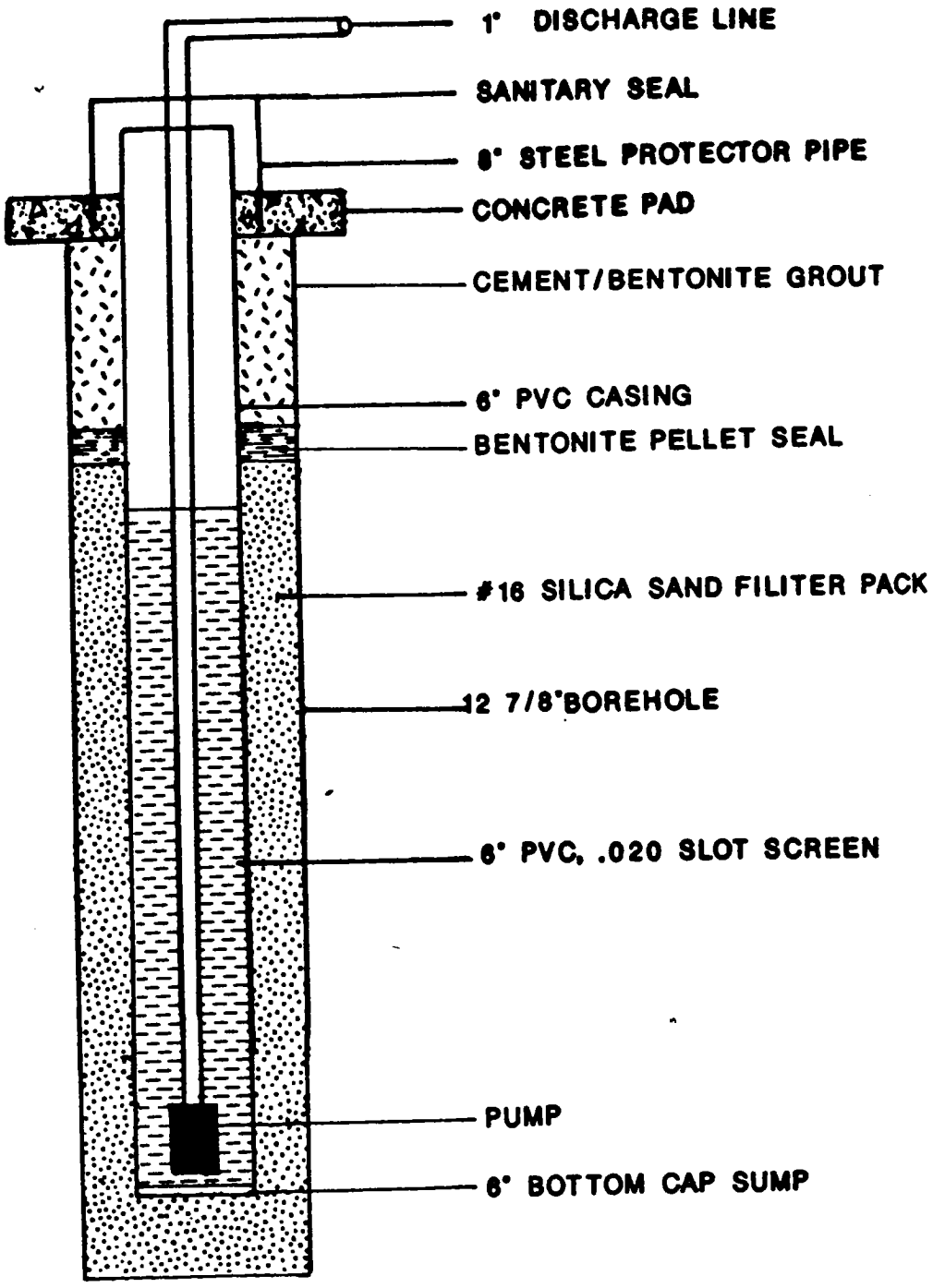


FIGURE 9

INTERCEPTION WELL CONSTRUCTION DIAGRAM



CONCLUSIONS

The groundwater interception, treatment and recharge systems have operated very successfully for much of the past six years. The interception wells have almost totally dewatered the alluvial aquifer in the target area. Groundwater recovery rates have declined significantly due to a number of factors.

The alluvial aquifer has been significantly altered in the interception area. The recent increases in chromium concentration seen in monitor wells are related to the complex pattern of channels which exist on top of the eroded Muddy Creek and the current position of interception wells. As these deeper channels are identified and their flow is captured, the mitigation program can be improved. It has become apparent that some replacement and fill-in wells are required to effectively intercept the remaining groundwater.

The treatment system has performed very well, consistently meeting the chromium standards set out in the consent order. Infrequent upsets, however, have allowed some iron precipitant to get into the discharge and adversely affect the recharge system. Modifications to the recharge system have been made on three occasions and have been reported in the semi-annual reports to NDEP.

REMEDIAL ACTIVITY AND FUTURE WORK

KMCC will install the four new interception wells as described above. These wells will be completed and operated similarly to the existing interception wells.

After these new wells are operational and the early data reviewed, KMCC proposes to evaluate the treatment system and identify any changes that may be necessary for that component of the mitigation system. Indications are that a filtration unit for the polishing of effluent may be necessary to protect the recharge system from plugging problems, however, further in-depth evaluation is warranted.

Following the treatment system evaluation, KMCC proposes to assess and modify the recharge system to see that it more closely conforms to the overall objectives of the mitigation program as laid out in the consent order.

KMCC proposes to complete all the above evaluations and field work by the end of 1993 and report the work, as completed, in the next semi-annual report to NDEP, due in late January, 1994.

APPENDIX A

INTERCEPTION WELL RECOVERY TEST DATA

Recovery Tests on Interception Wells

Pumping wells can develop operational problems associated with either the well or the pump. As pump problems have been encountered at Henderson, pumps have been pulled and repaired or replaced. This activity has been routinely summarized in the semi-annual reports. The overall integrity of the wells was a part of the current investigation.

Typically a well is inefficient because the sand pack or well screen gets plugged by sediment or chemical deposits, making it increasingly more difficult for water to enter the well. This added drawdown is referred to as well loss. Inefficient wells show a relatively large well loss at the start of pumping, setting up a steep gradient across the well face, before the aquifer permeability really influences the well production. Likewise, the well loss effect can be noted in the recovery characteristics for a well.

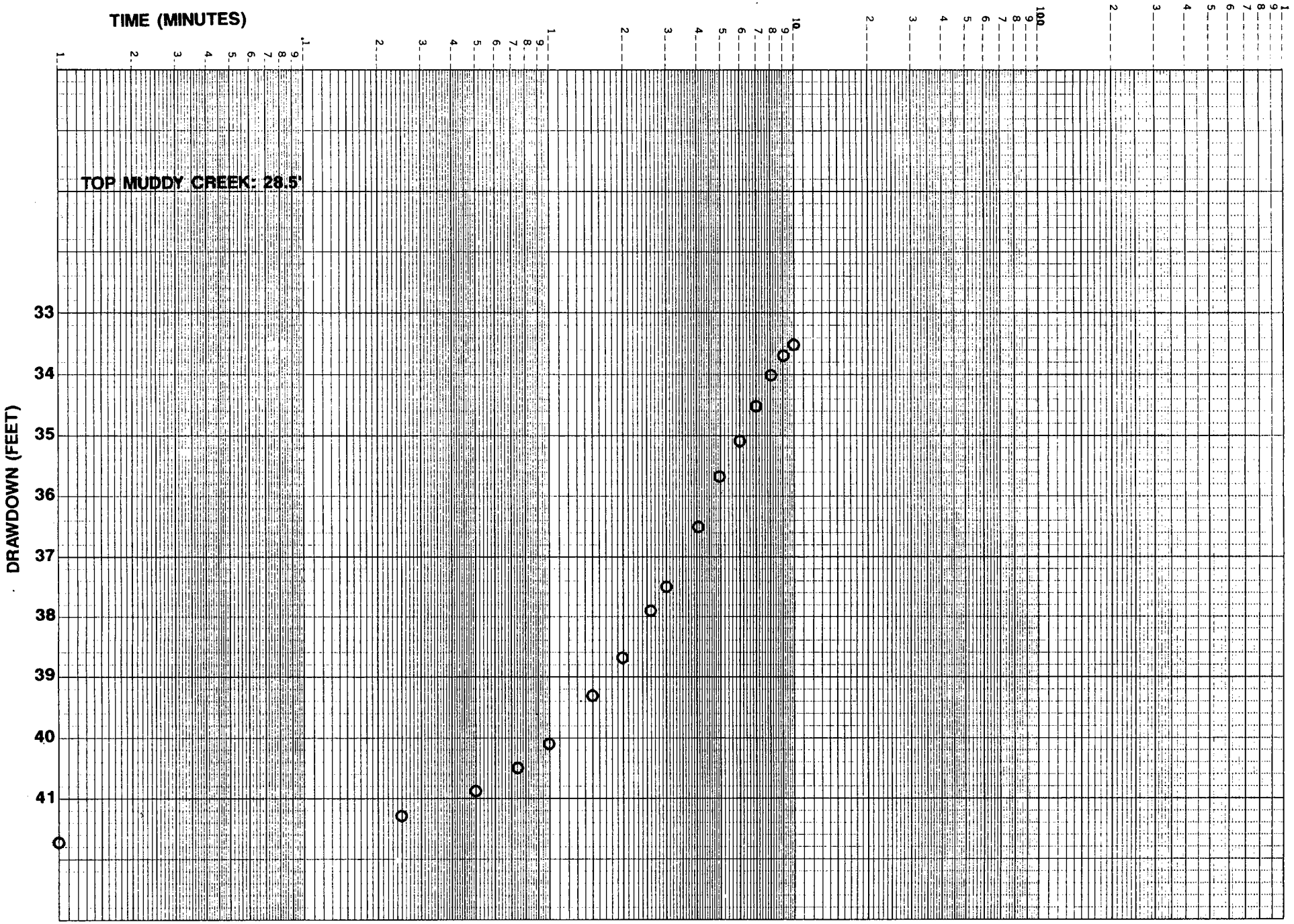
Recovery tests were conducted on eight of the eleven interceptor wells. While each pump was running a drawdown water level was recorded. The pump was shut off and the water level recovery was measured. Recovery was recorded for approximately 10 to 15 minutes for each well.

For the recovery tests several wells appeared to show high well losses, initially suggesting well plugging as part of the

explanation for the decreased production. Upon further inspection of the data, however, it was concluded that the increased drawdowns were more directly related to the dewatering of the alluvium and the greater influence of the low permeability of the Muddy Creek. Supporting this conclusion is the fact that the pumps have never shown any type of scale deposition and the pumped water has never had suspended solids that might be associated with screen or sand pack plugging. The graphs of the recovery data are presented on the following pages.

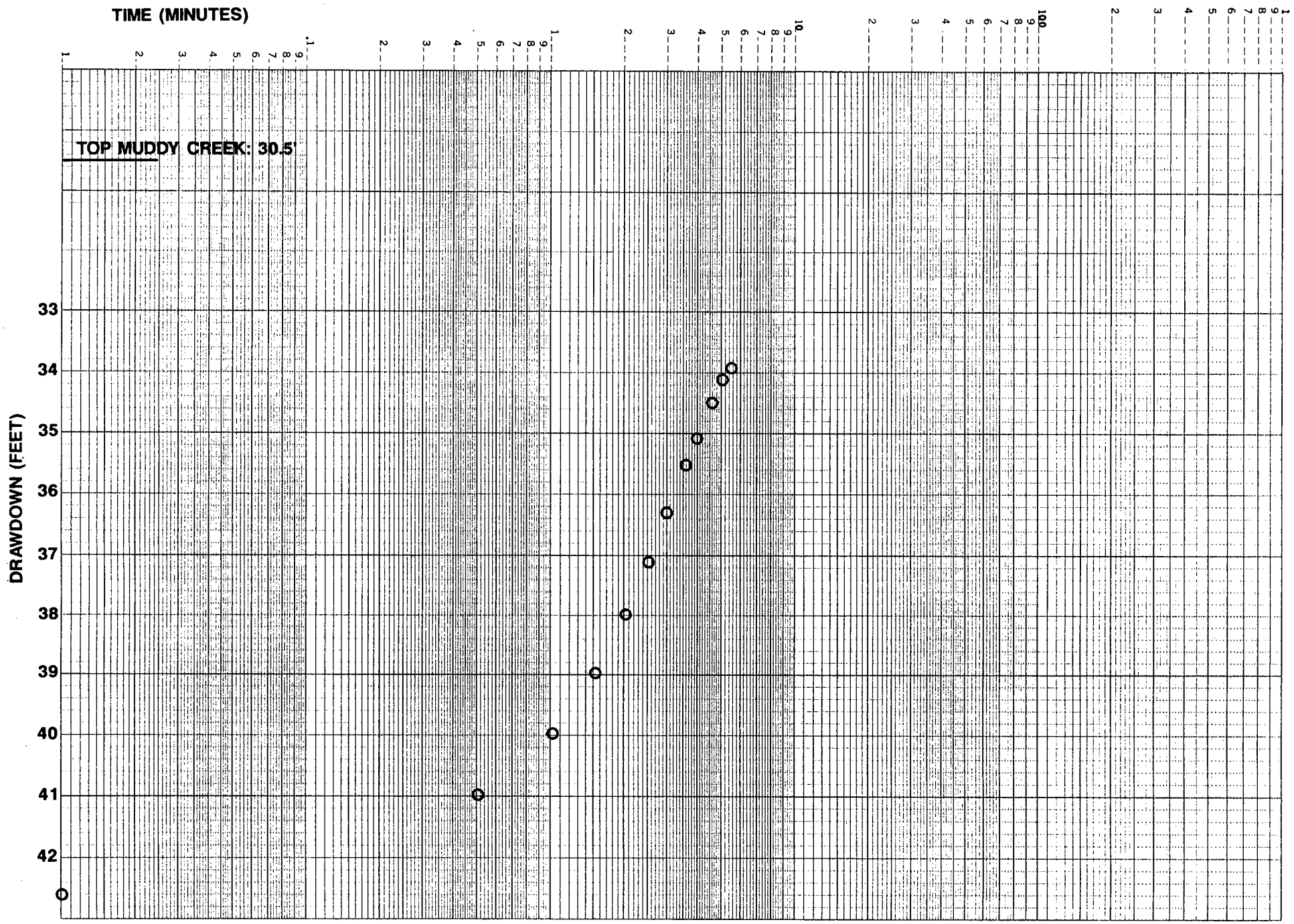
INTERCEPTION WELL A
RECOVERY VS TIME PLOT

HENDERSON KMCC FACILITY
2/17/93



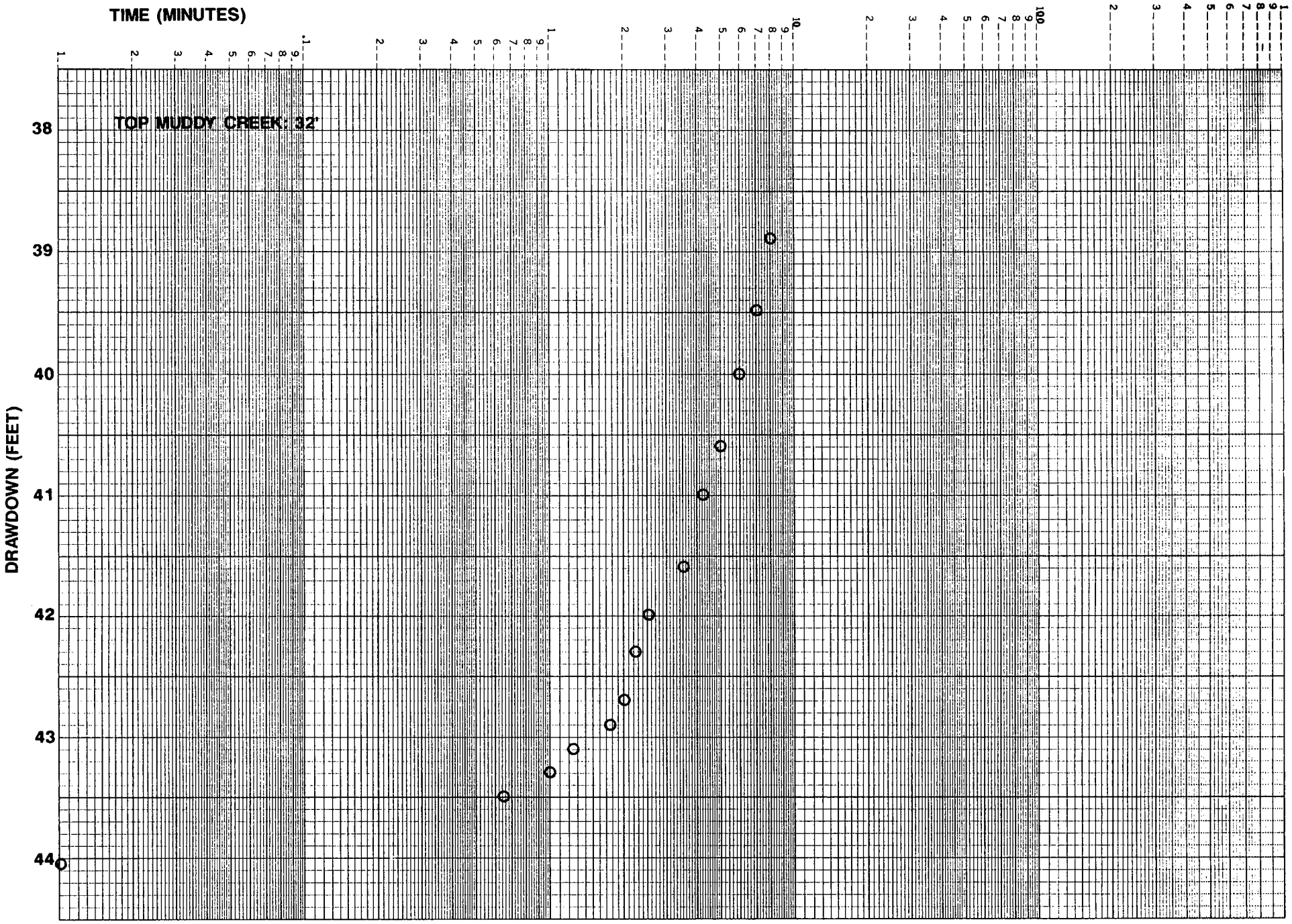
INTERCEPTION WELL C
RECOVERY VS TIME PLOT

HENDERSON KMCC FACILITY
2/17/93



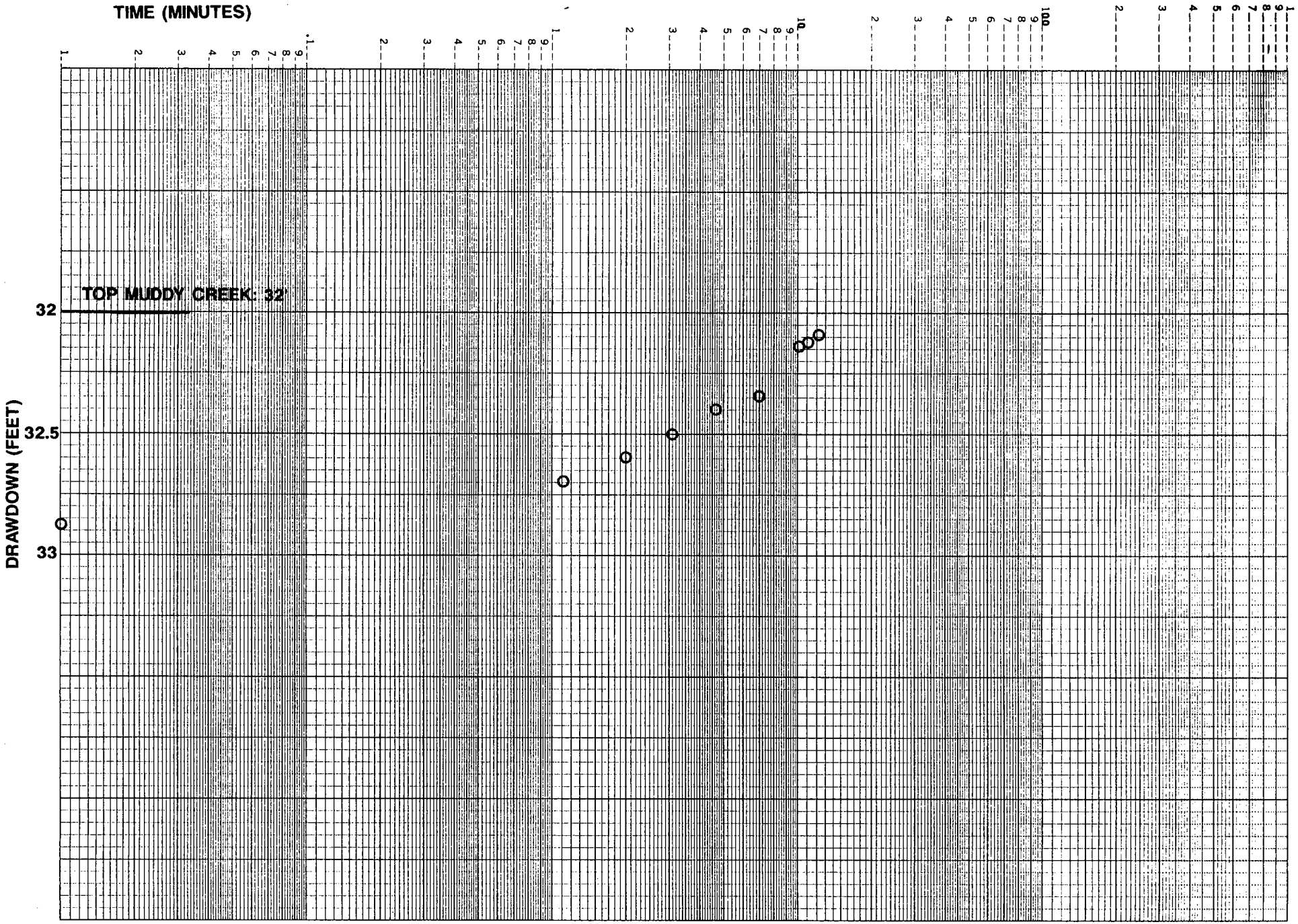
INTERCEPTION WELL D
RECOVERY VS TIME PLOT

HENDERSON KMCC FACILITY
2/17/93



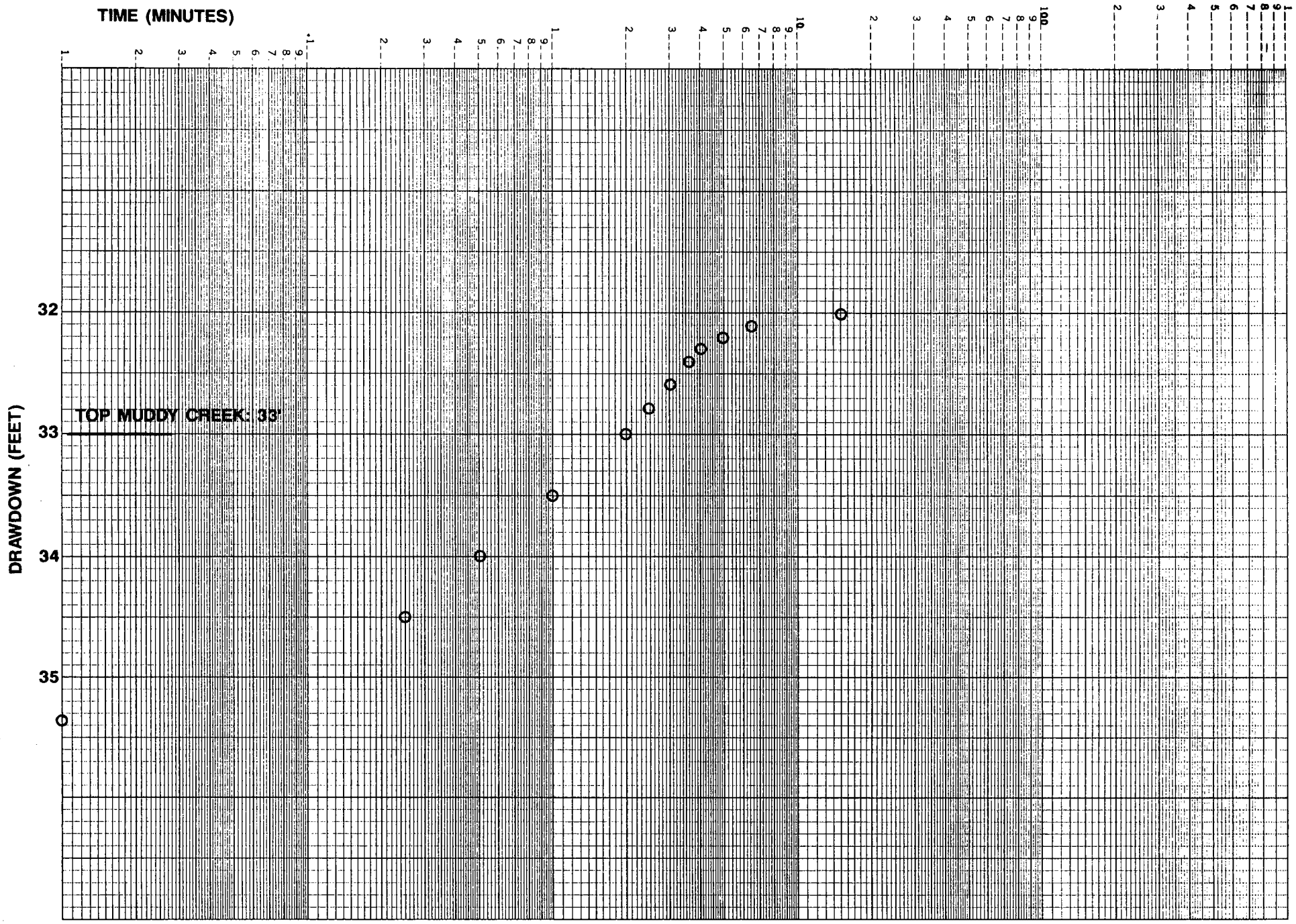
INTERCEPTION WELL E
RECOVERY VS TIME PLOT

HENDERSON KMCC FACILITY
2/17/93



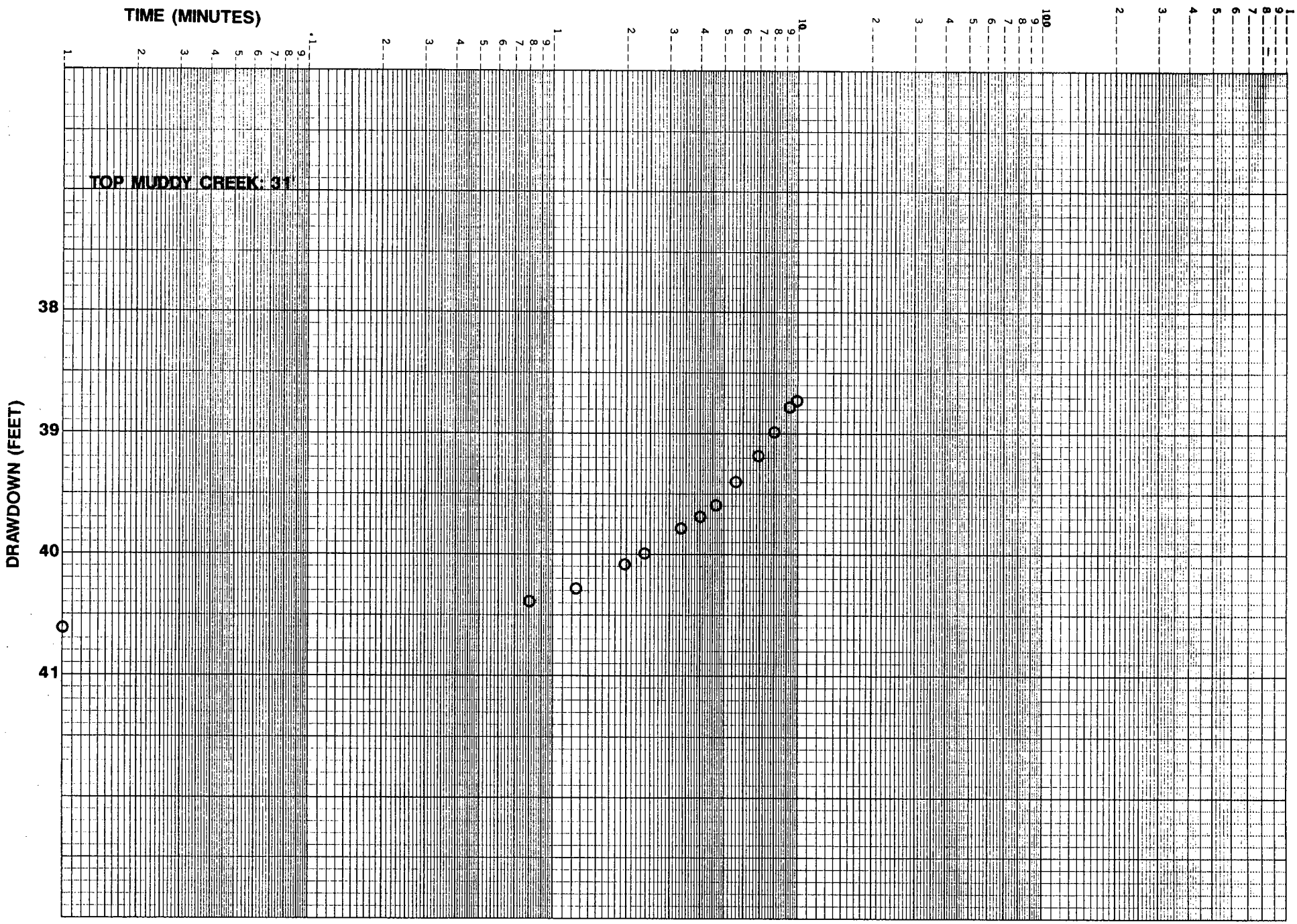
INTERCEPTION WELL F
RECOVERY VS TIME PLOT

HENDERSON KMCC FACILITY
2/17/93



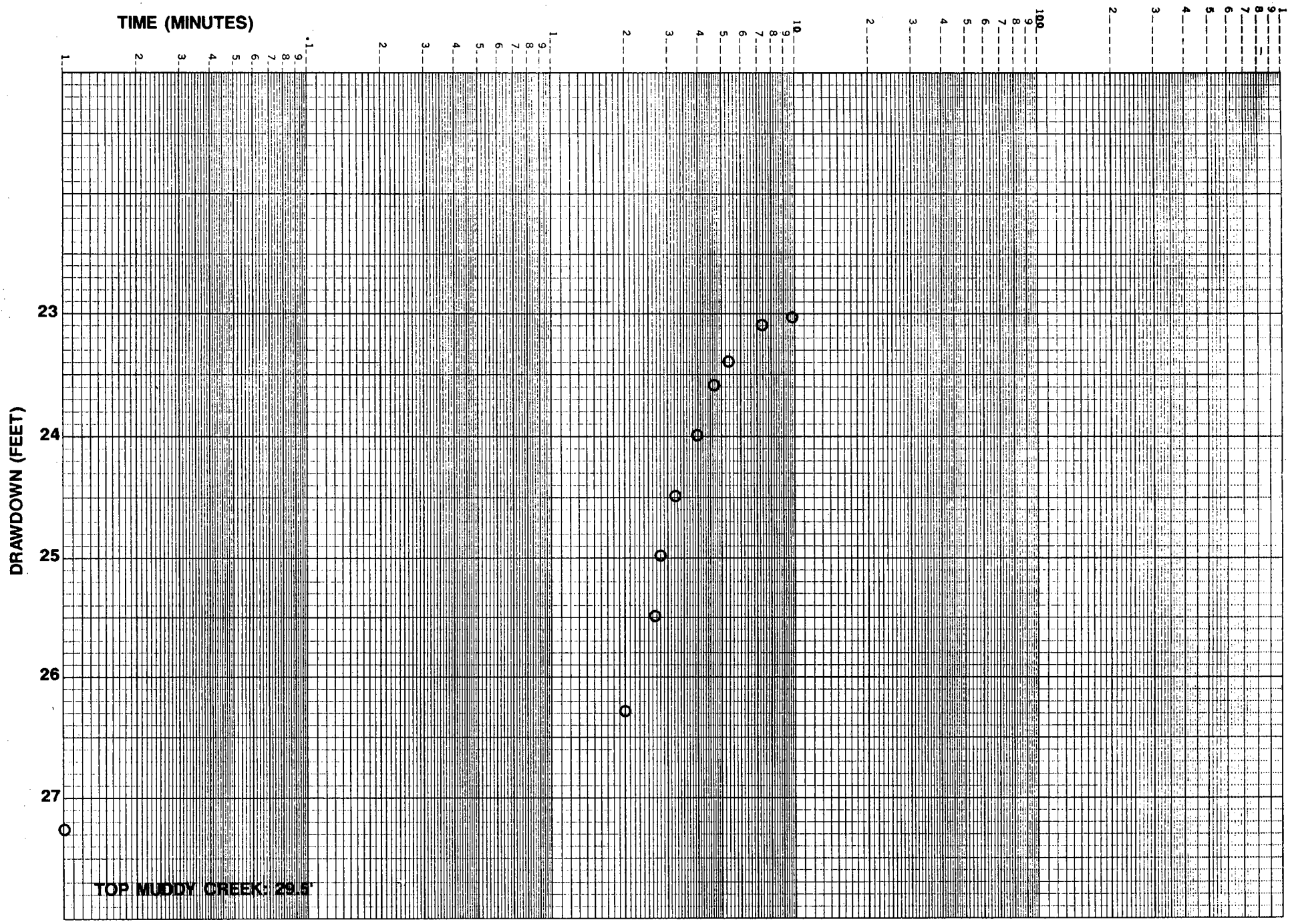
INTERCEPTION WELL G
RECOVERY VS TIME PLOT

HENDERSON KMCC FACILITY
2/17/93



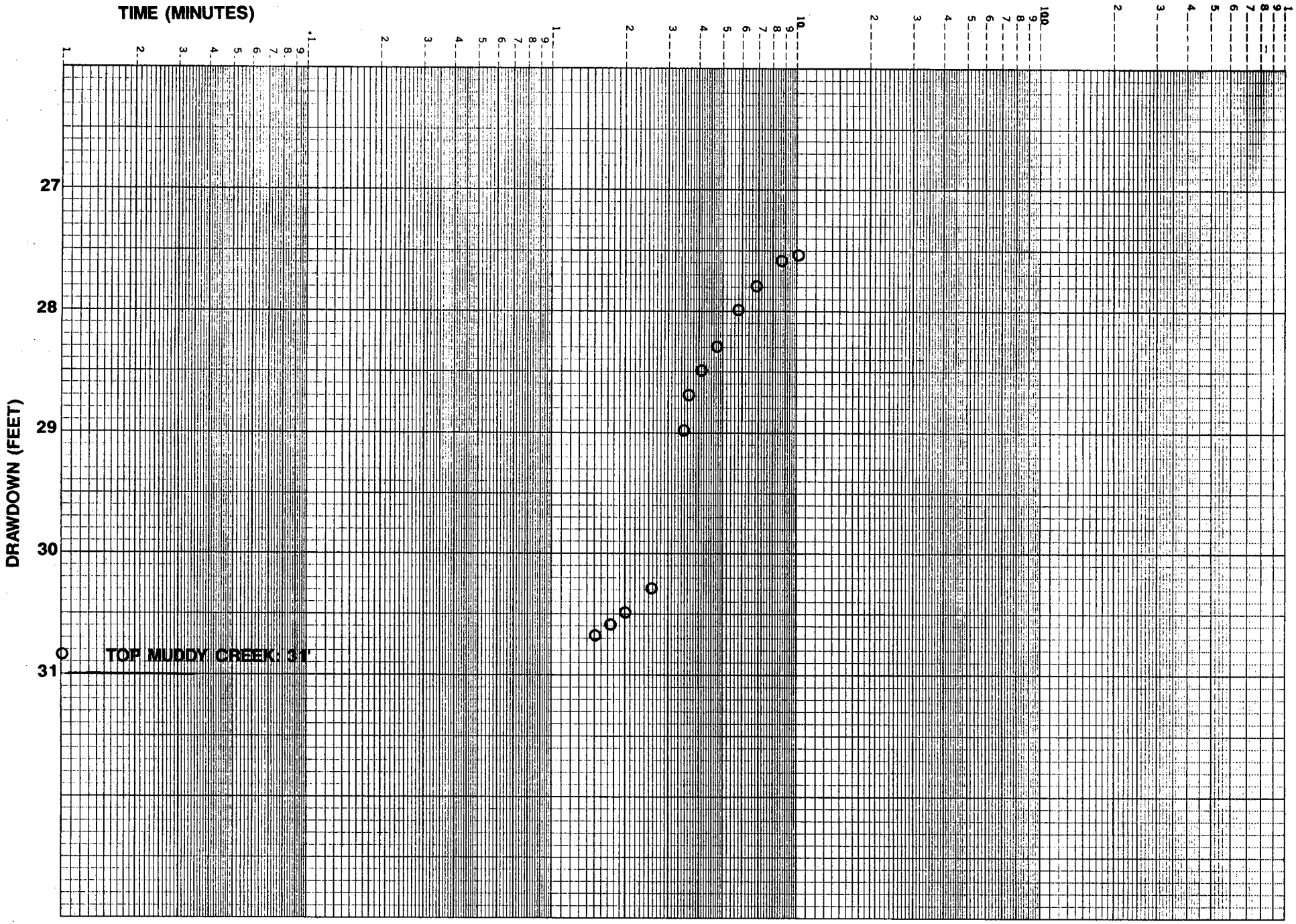
INTERCEPTION WELL I
RECOVERY VS TIME PLOT

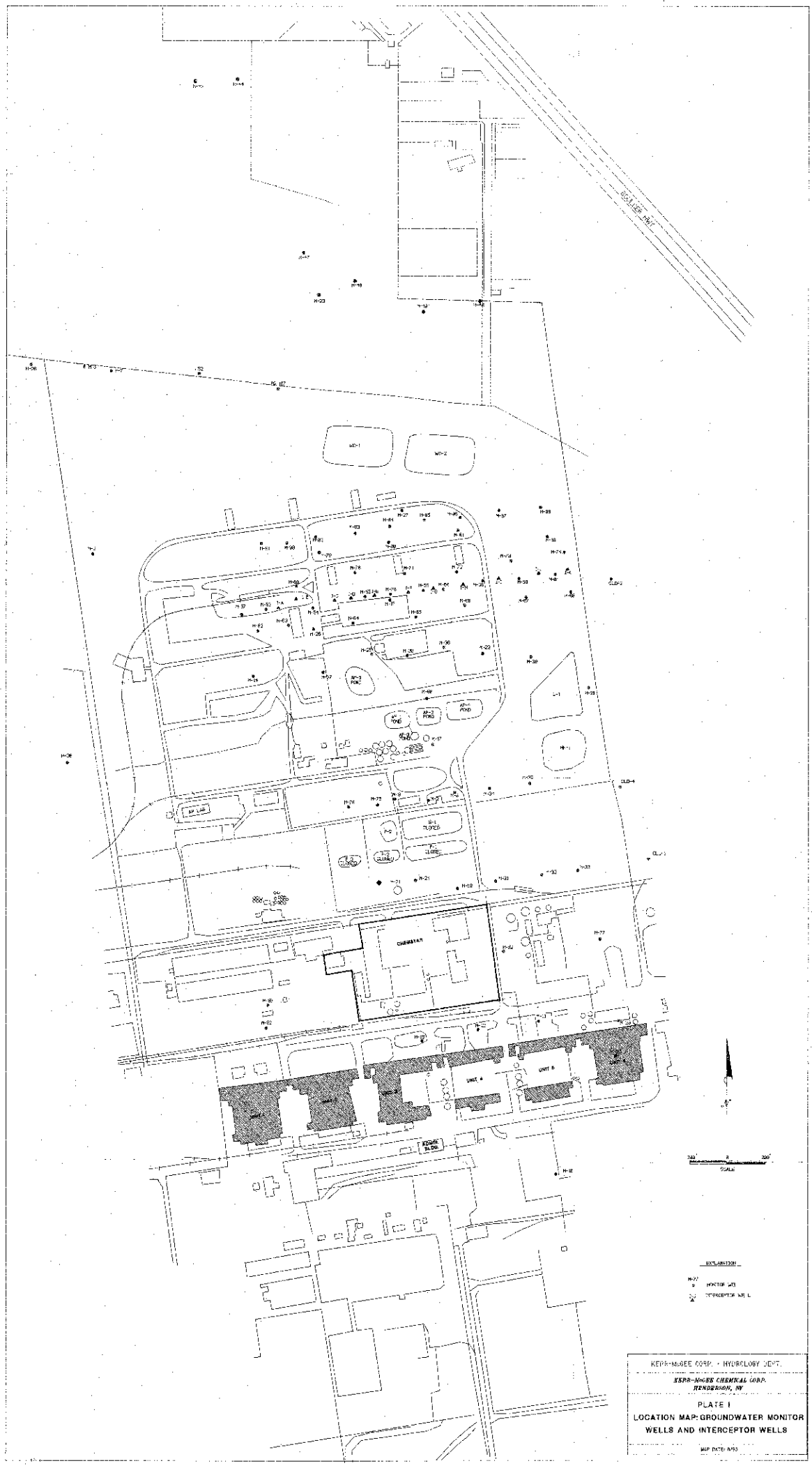
HENDERSON KMCC FACILITY
2/17/93



INTERCEPTION WELL J
RECOVERY VS TIME PLOT

HENDERSON KMCC FACILITY
2/17/93





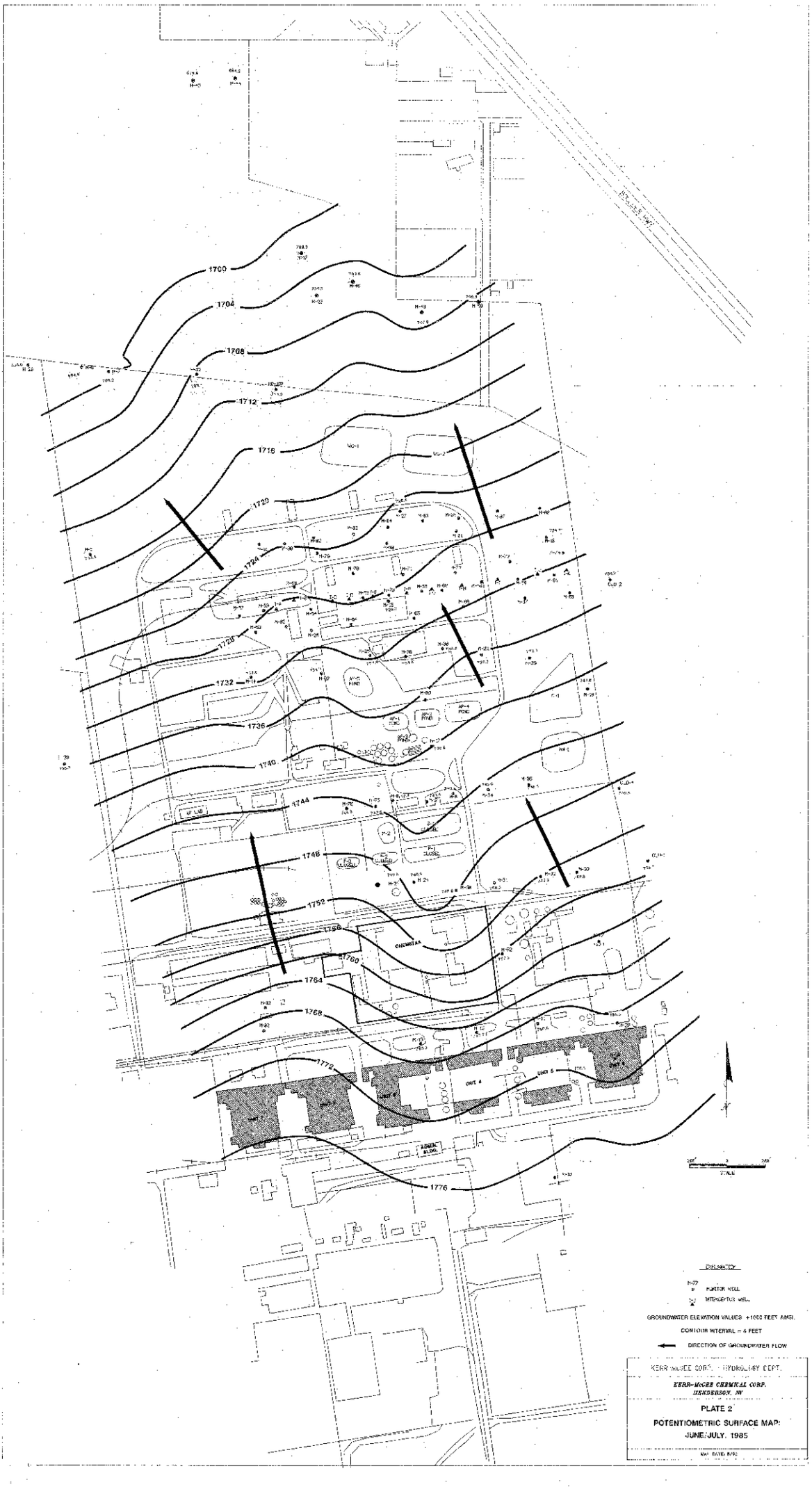
KERR-McGEE CORP. - HYDROLOGY DEPT.

KERR-McGEE CHEMICAL CORP.
HENDERSON, NV.

PLATE I

LOCATION MAP: GROUNDWATER MONITOR WELLS AND INTERCEPTOR WELLS

MAP DATED 8/93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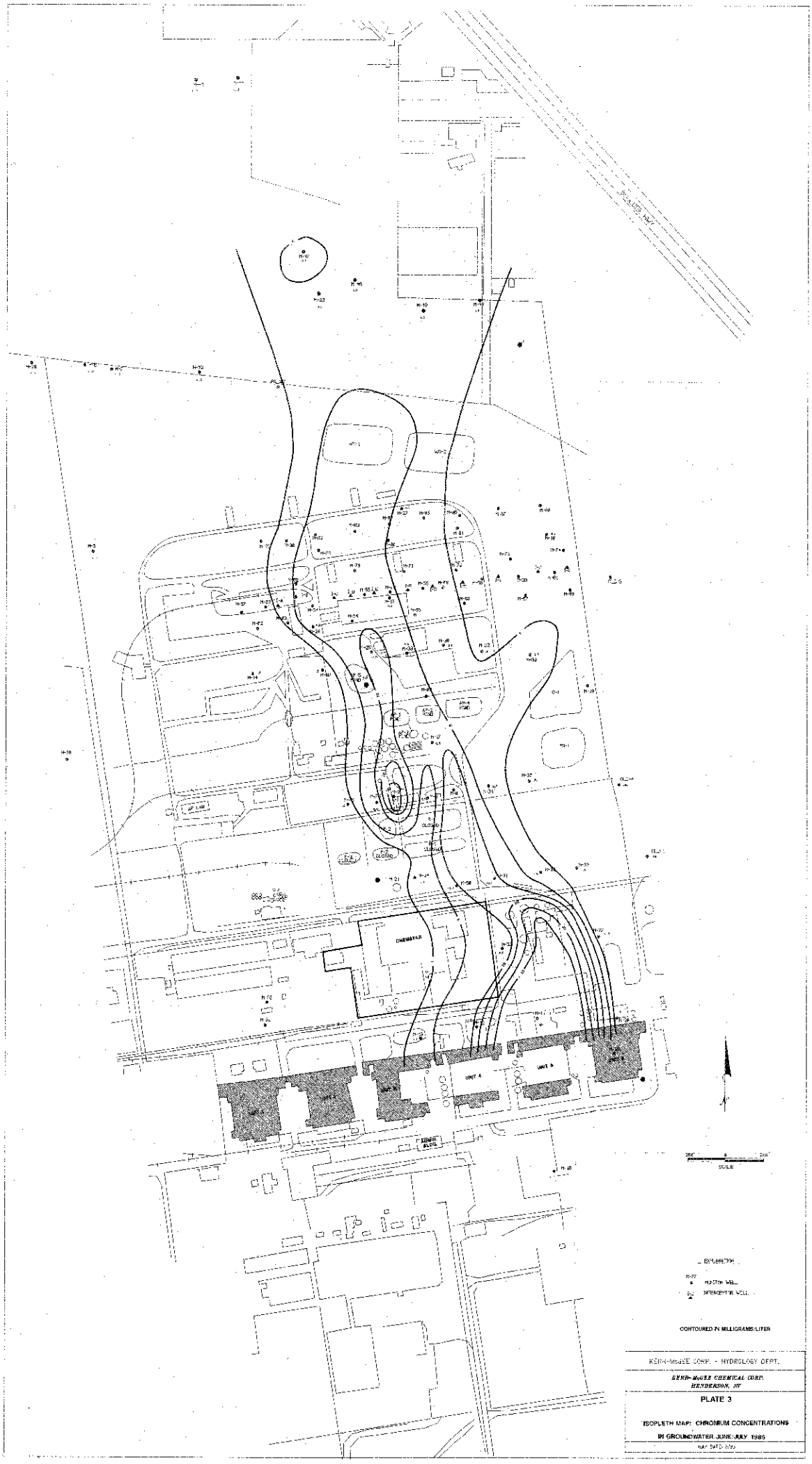
1776
UNIT 4
UNIT 5
UNIT 6
UNIT 7
UNIT 8
CHEMSTAR
EXPLANATION
PUMPING WELL
OBSERVATION WELL
GROUNDWATER ELEVATION VALUES +1000 FEET AMSL
CONTOUR INTERVAL = 4 FEET
DIRECTION OF GROUNDWATER FLOW
KERR-McGEE CORP. - HYDROLOGY DEPT.
KERR-McGEE CHEMICAL CORP.
HENDERSON, NV
PLATE 2
POTENTIOMETRIC SURFACE MAP:
JUNE/JULY, 1985



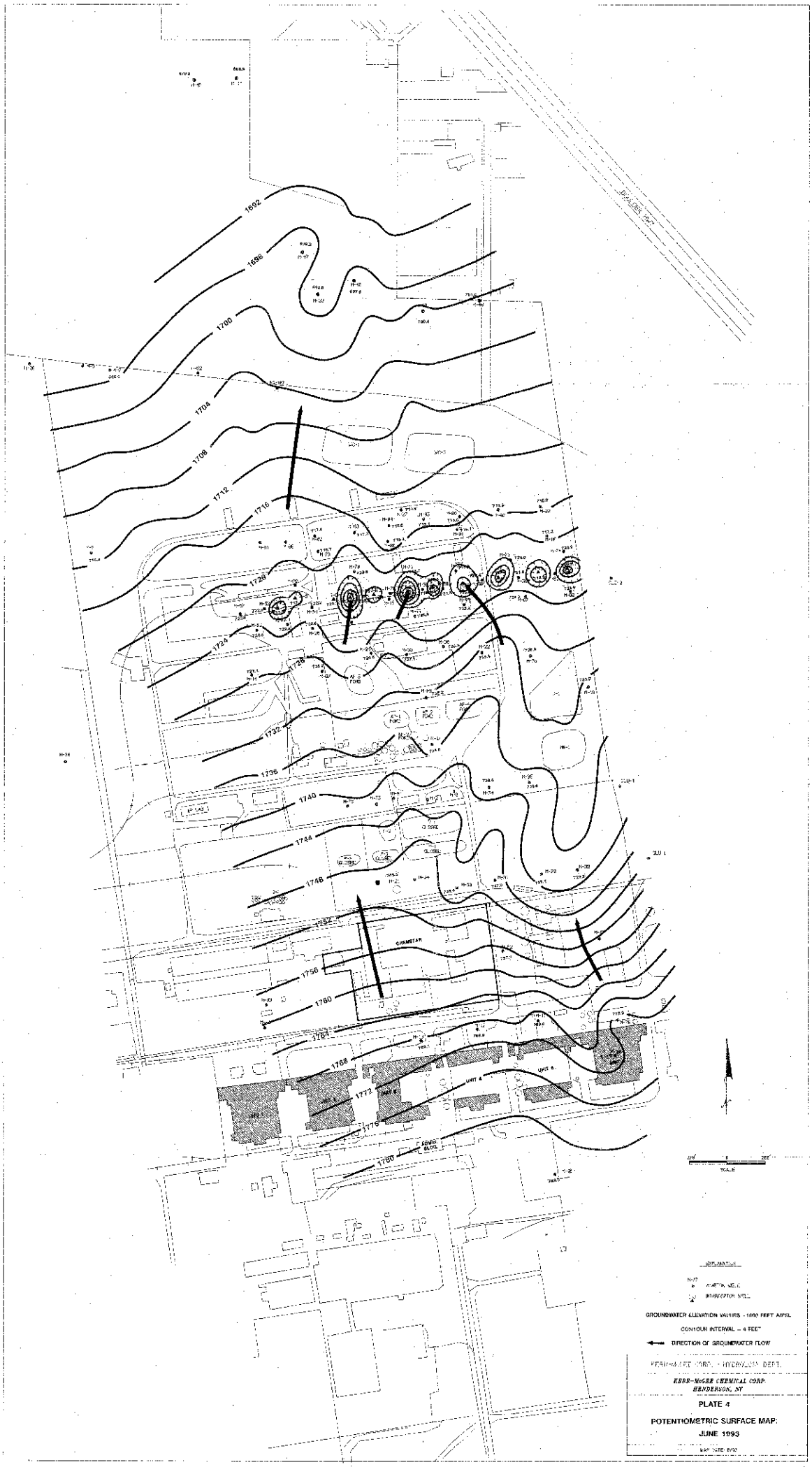
KERR-McGEE CORP. - HYDROLOGY DEPT.

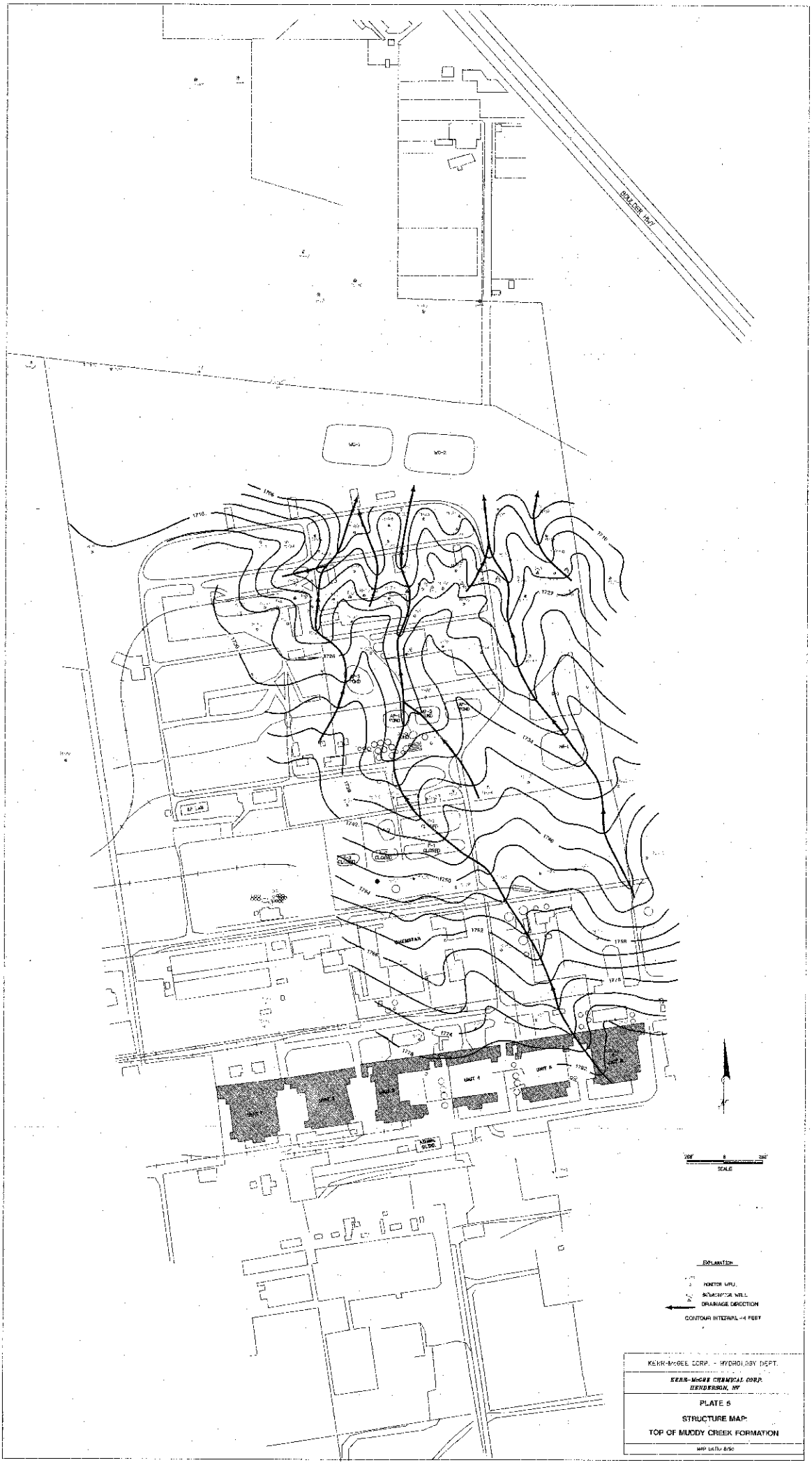
KERR-McGEE CHEMICAL CORP.
HENDERSON, NV

PLATE 3

ISOPLETH MAP: CHROMIUM CONCENTRATIONS
IN GROUNDWATER JUNE-JULY 1985

MAP DATED 8/85


1692
1696
1700
1704
1708
1712
1716
1720
1724
1728
1732
1736
1740
1744
1748
1752
1756
1760
1764
1768
1772
1776
1780
CHEMSTAR
UNIT 4
UNIT 5
UNIT 6
UNIT 7
FENCE BLDG
SCALE
GROUNDWATER ELEVATION VALUES - 1000 FEET AMSL
CONTOUR INTERVAL = 4 FEET
DIRECTION OF GROUNDWATER FLOW
KERR-McGEE CHEM. - HYDROLOGY DEPT.
KERR-McGEE CHEMICAL CORP.
HENDERSON, NV
PLATE 4
POTENTIOMETRIC SURFACE MAP:
JUNE 1993

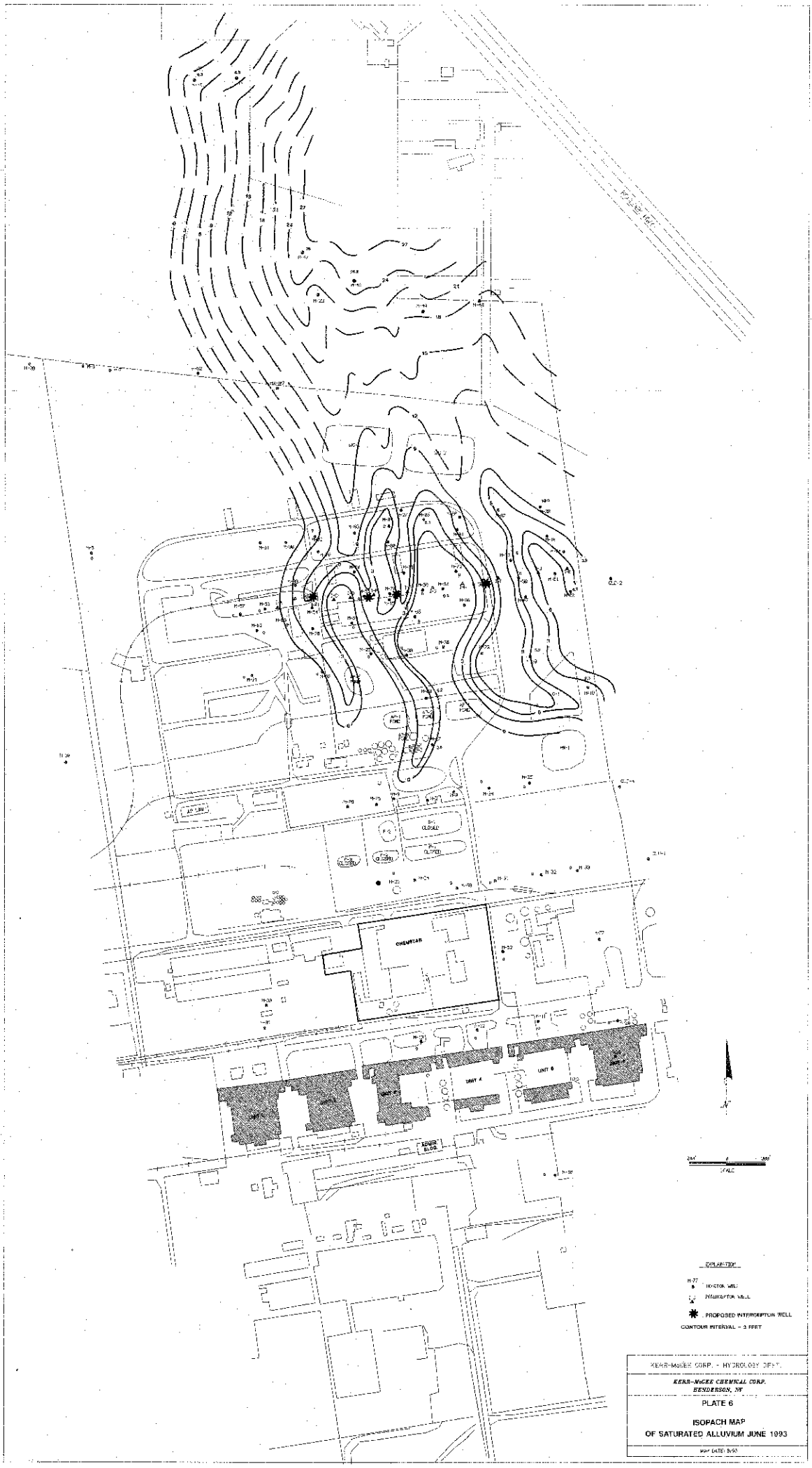


KERR-McGEE CORP. - HYDROLOGY DEPT.

KERR-McGEE CHEMICAL CORP.
HENDERSON, NV

PLATE 6

STRUCTURE MAP:
TOP OF MUDDY CREEK FORMATION



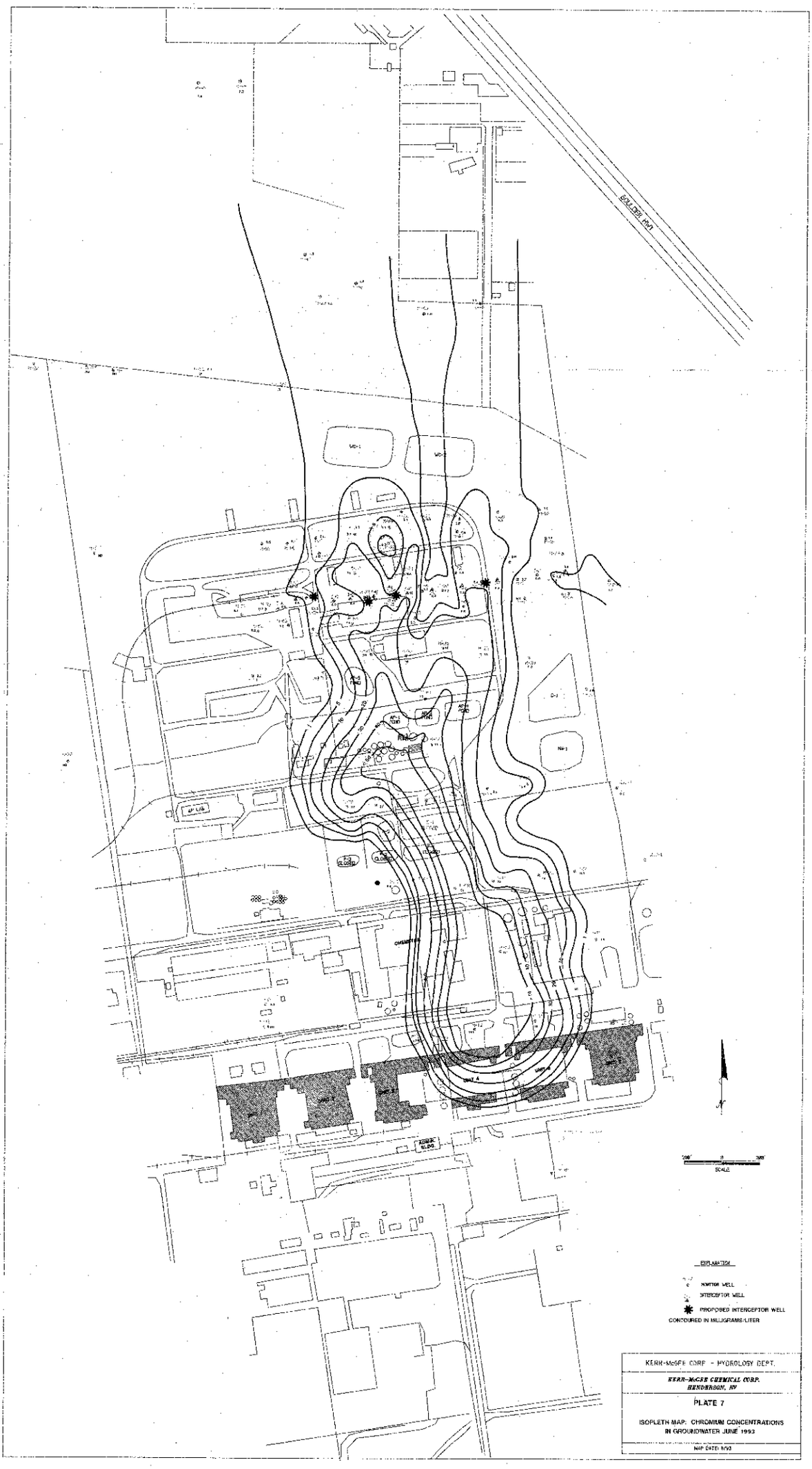
KERR-McGEE CORP. - HYDROLOGY DEPT.

KERR-McGEE CHEMICAL CORP.
HENDERSON, NV

PLATE 6

ISOPACH MAP
OF SATURATED ALLUVIUM JUNE 1993

MAY DATE: 5/93


EXPLANATION
MONITOR WELL
INTERCEPTOR WELL
PROPOSED INTERCEPTOR WELL
CONTOURED IN MILLIGRAMS/LITER
SCALE
KERR-McGEE CORP. - HYDROLOGY DEPT.
KERR-McGEE CHEMICAL CORP.
HENDERSON, NV
PLATE 7
ISOPLETH MAP: CHROMIUM CONCENTRATIONS
IN GROUNDWATER JUNE 1993
MAP DATED 8/93