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Migration and degradation of dissolved gasoline in a highly transmissive unconfined gravel and cobble aquifer : a study of the Champion Missoula Sawmill spill Missoula Montana

William M. Peery
The University of Montana

MIGRATION AND DEGRADATION OF DISSOLVED GASOLINE IN A HIGHLY TRANSMISSIVE, UNCONFINED, GRAVEL AND COBBLE AQUIFER: A STUDY OF THE CHAMPION MISSOULA SAWMILL SPILL MISSOULA, MONTANA

by
William M. Peery

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Approved by:

William W. Woessner
Chairman, Board of Examiners

[signature]
Dean of Graduate School

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Migration and Degradation of Dissolved Gasoline in a Highly Transmissive, Unconfined, Gravel and Cobble Aquifer: A Study of the Champion Missoula Sawmill Spill, Missoula, Montana

Director: Dr. William W. Woessner WWW 1-25-89

In May of 1985, a pressure test on a buried tank at the Champion Missoula Sawmill resulted in the loss of approximately 600 gallons (2,271 l) of leaded gasoline to the Missoula Aquifer, a highly transmissive, glacio-alluvial aquifer. Within ten weeks, domestic wells located in the California Street area, 1200 feet (366 m) west and downgradient of the spill site, had become contaminated with benzene, toluene, and xylene (BTX). The spill occurred at a time when the water table was at its highest because of spring recharge from the Clark Fork River.

The goal of this study was to document the migration and fate of the dissolved phase of a gasoline spill. I took monthly water level measurements at 57 wells and obtained seasonal water quality data for organic, inorganic, and bacterial contamination. I used a two-dimensional ground water flow model to determine the distribution of transmissivity throughout the study area. I used a solute transport model to compare the migration of a simulated plume in the modeled flow field with the actual migration of the BTX plume and to predict contaminant migration beyond the time span of the study.

The ground water flow and modeling study revealed that BTX migration from the spill site followed a northwest path that appears to be controlled by zones of high transmissivity. Though a downward gradient exists within the study area, water quality analyses during my study showed no mixing of the contaminant below the upper 25 saturated feet (7.6 m) of the aquifer.

Over a two year period, BTX concentrations at the spill well decreased by approximately 65%. Water quality analyses reveal that seasonal plumes of BTX are created as the water table rises and contacts contaminated soil, but that concentrations of the plumes are quickly reduced to near or below detection levels by the time the plumes have migrated 1200 feet (366 m) to the residential California-Montana Streets area. This attenuation is a result of dispersion and biodegradation. High levels of dissolved manganese and iron in Champion monitoring wells and domestic wells immediately off-site are associated with the BTX plume and are result of oxidation of the hydrocarbons by bacteria.

ACKNOWLEDGEMENTS

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To the people of California-Montana Streets area, thank you for letting me have the roam of your wells for a year. May this report shed light on a problem that has affected some of you far too long.

To those in Missoula who have shared my life and allowed me to share theirs..

....and to Guinness, you were always happy to see me.

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It is the greatest fun to be bewildered, but only when there lies ahead the sure certainty of having things straightened out, and soon.

— Lewis Thomas

INTRODUCTION

In May of 1985, the Champion International sawmill in Missoula, Montana lost approximately 600 gallons (2,271 l) of leaded gasoline to the Missoula Aquifer as a result of a pressure test on a buried gasoline tank. The dissolved phase of this spill contaminated domestic wells 1200 feet (366 m) downgradient of the spill site with benzene, toluene, and the o-, m-, p- xylenes (BTX). These lighter, non-polar, aromatic hydrocarbons are the more water-soluble components of gasoline.

This study was unfunded. Though it does not contain the same degree of sampling density as other published studies, my conclusions are supported by data collected on the physical and bio-chemical aspects of the ground water system and from the literature. This study is important because it documents the migration and fate of dissolved gasoline in a highly transmissive, gravel and cobble, water table aquifer. Such an aquifer is typical of the valley fill aquifers found in the west.

PREVIOUS STUDIES

Previous studies document the interaction between organic contaminants and ground water, focusing on attenuation by dispersion, sorption, and bio-chemical processes. Dispersion cannot be predicted accurately because of scale problems between lab and field experiments. But adsorption of an organic solute can be estimated with order of magnitude accuracy, if the octanol-water partition coefficient of the solute and the organic carbon content of the 0.124mm size fraction of the aquifer are known (Newsom, 1985; Roberts et al., 1985; and Schwarzenbach and Geiger, 1985). For those aquifers in which the organic content is less than 0.1% (<0.001 gram of organic carbon for one gram of aquifer material), the sorption of an organic solute by a mineral will depend on the surface area and nature of the mineral surface (Schwarzenbach and Geiger, 1985).

Barker et al. (1987) conducted a study of the natural attenuation of BTX in a sandy, unconfined aquifer and found that the dissolved plume moved slightly slower than the ground water flow because of sorption. The authors concluded that attenuation was primarily by biodegradation, which was controlled by the availability of dissolved oxygen, and that the plume moved further and persisted longer in zones with lower levels of dissolved oxygen. Bouwer (1984) and Wilson et al. (1986) also emphasize that the availability of oxygen is the controlling factor in the rate of aerobic biodegradation of BTX.

Similar to Barker et al. (1987), The results of my study indicate that attenuation of the BTX plume(s) is by processes of biodegradation and dispersion.

GOALS AND OBJECTIVES

This study began in July, 1986, one year after the initial spill. My goals were to document the migration and fate of the dissolved phase of a gasoline spill through a highly transmissive, gravel and cobble, water table aquifer. I planned to evaluate the migration of and mechanisms acting to attenuate the plume. Water quality data had been collected prior to this study. I used those data along with water quality data collected during my study year to interpret the bio-chemical aspects of attenuation. There was minimal data on the physical system throughout the study site, and therefore, my study emphasized the following objectives:

(1) To determine the flow of ground water and characterize the stratigraphy of the Champion-California Street area, and to evaluate their effects on lateral and vertical contaminant migration;

(2) To determine the effects of recharge from the Clark Fork River and irrigation ditches on contaminant migration;

(3) To monitor water quality in selected shallow and deep wells for BTX, bacteria, and changes in water chemistry. I used these data to trace the lateral and vertical migration of the gasoline.

(4) To develop a model of two-dimensional ground water flow and solute transport that reproduces field data and aids in evaluating migration pathways. I used the results of my modeling efforts to predict future contaminant migration beyond the time span of the study.

STUDY AREA AND HISTORY OF SPILL

Missoula, Montana is located in west-central Montana at the confluence of the Clark Fork and Bitterroot Rivers (Figure 1). The city lies within a fault-bounded, intermontane basin that receives an average annual precipitation of 13 inches (33 cm). The city's water supply comes entirely from the Missoula Aquifer, which is unconfined and composed of 100 to 150 feet (30-46 m) of interlayered silts, coarse sands, gravels, cobbles, and boulders.

The study area encompasses the Champion Missoula Sawmill and California-Montana Streets neighborhood in Missoula. This area is located along the southern bank of the Clark Fork River between Orange and Russell Streets (Figure 2). The Clark Fork River forms the northern boundary of the study area, and the Missoula irrigation ditch forms the southern boundary.

During April and May of 1985, residents of the California-Montana Streets area reported petroleum like tastes and odors contaminating drinking water supplied by their domestic wells. A buried fuel tank, east of the area at the Champion Missoula Sawmill, was a possible source of the contamination. On May 17, 1985, a pressure test on the buried tank at the Champion site resulted in a blowout and loss of approximately 600 gallons (2,271 l) of leaded gasoline. Within one month, petroleum odors were detected in

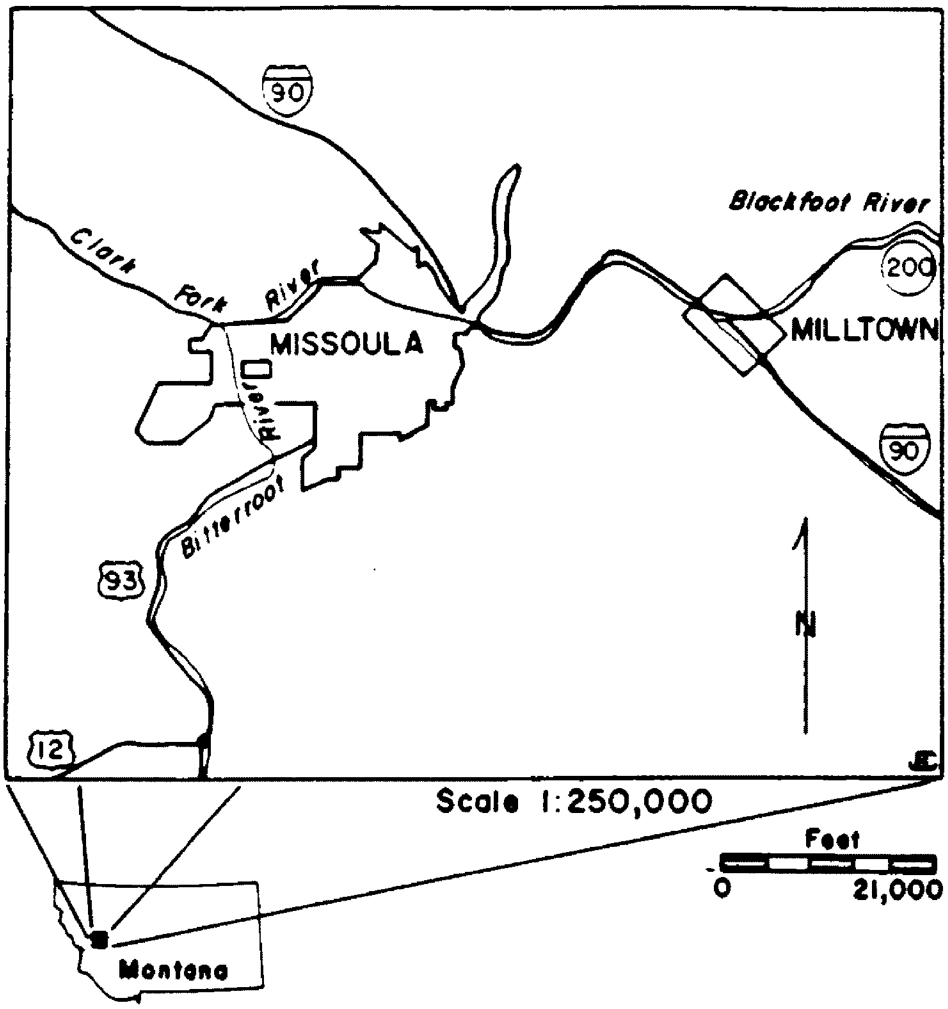

Figure 1: Location of Missoula, Montana (Clark, 1986).

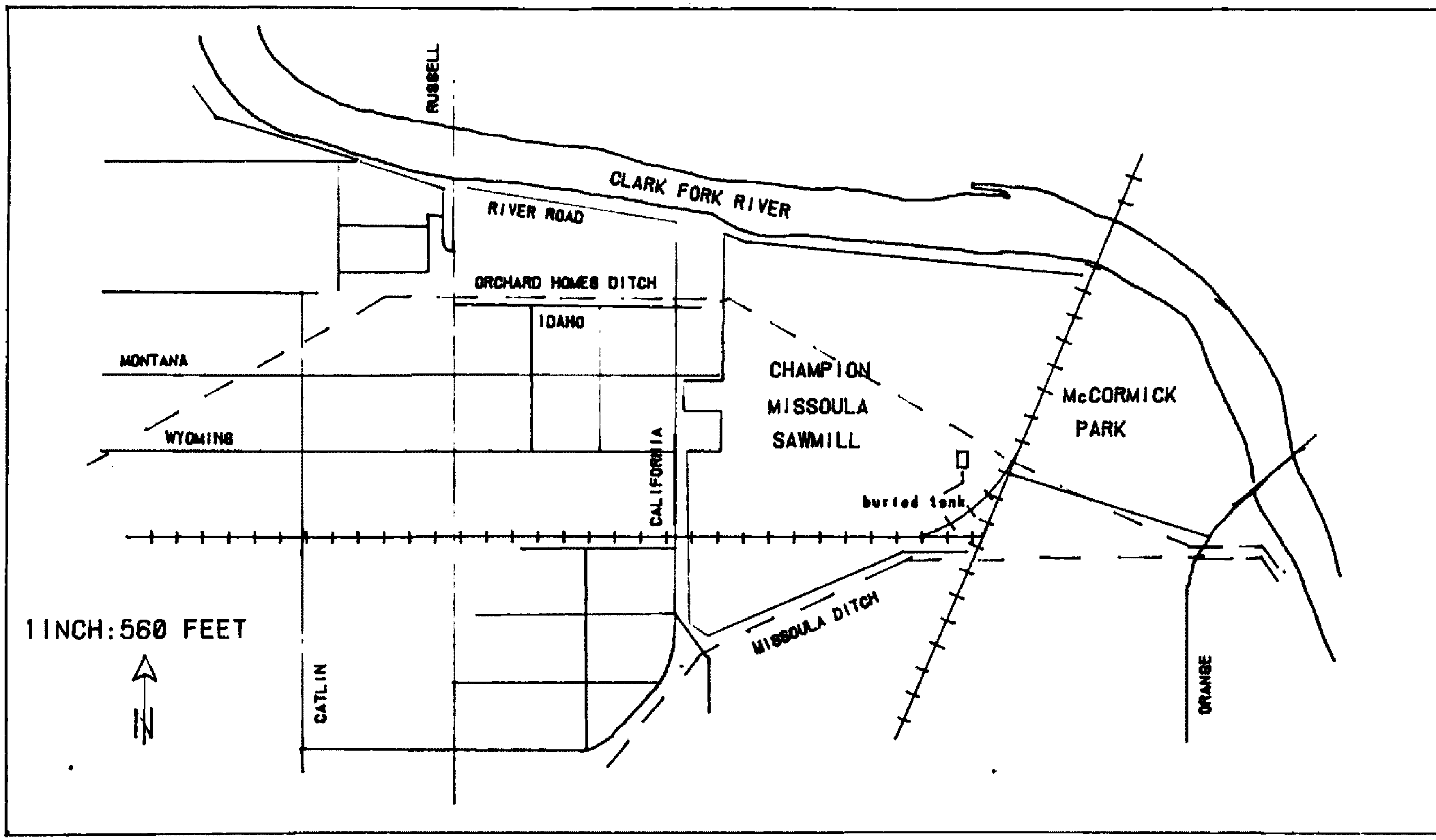

Figure 2: Location of study area.

wells 1200 feet (366 m) to the west in the residential area (J.R. Carr/Associates, 1985), and by July 26, 1985, samples from nine domestic wells had measurable amounts of BTX.

A preliminary potentiometric surface map indicated that all the contaminated wells were downgradient and in the flow path of the spill site (Woessner, personal communication, 1986). Because of the nature of the site and amount of the spill, active remediation efforts such as bioreclamation, complete soil removal, and free product recovery were judged to be inappropriate by state officials. Champion replaced the nine wells that were contaminated with BTX, in addition to seven others that the Montana Water Quality Bureau judged to be at risk of future contamination (Figure 3). Replacement wells were completed at a depth of 100 feet (30 m).

After the discovery of the spill, Champion pumped the remaining gasoline from the tank and removed the tank from the ground. Examination of the excavated tank revealed at least six pencil sized holes caused by corrosion and the slightly larger hole created by the pressure test (Price, personal communication, and Arrigo, 1986). The presence of corrosion holes and complaints by residents of poor water quality in the springs prior to 1985 suggest that the tank had been leaking prior to the investigation.

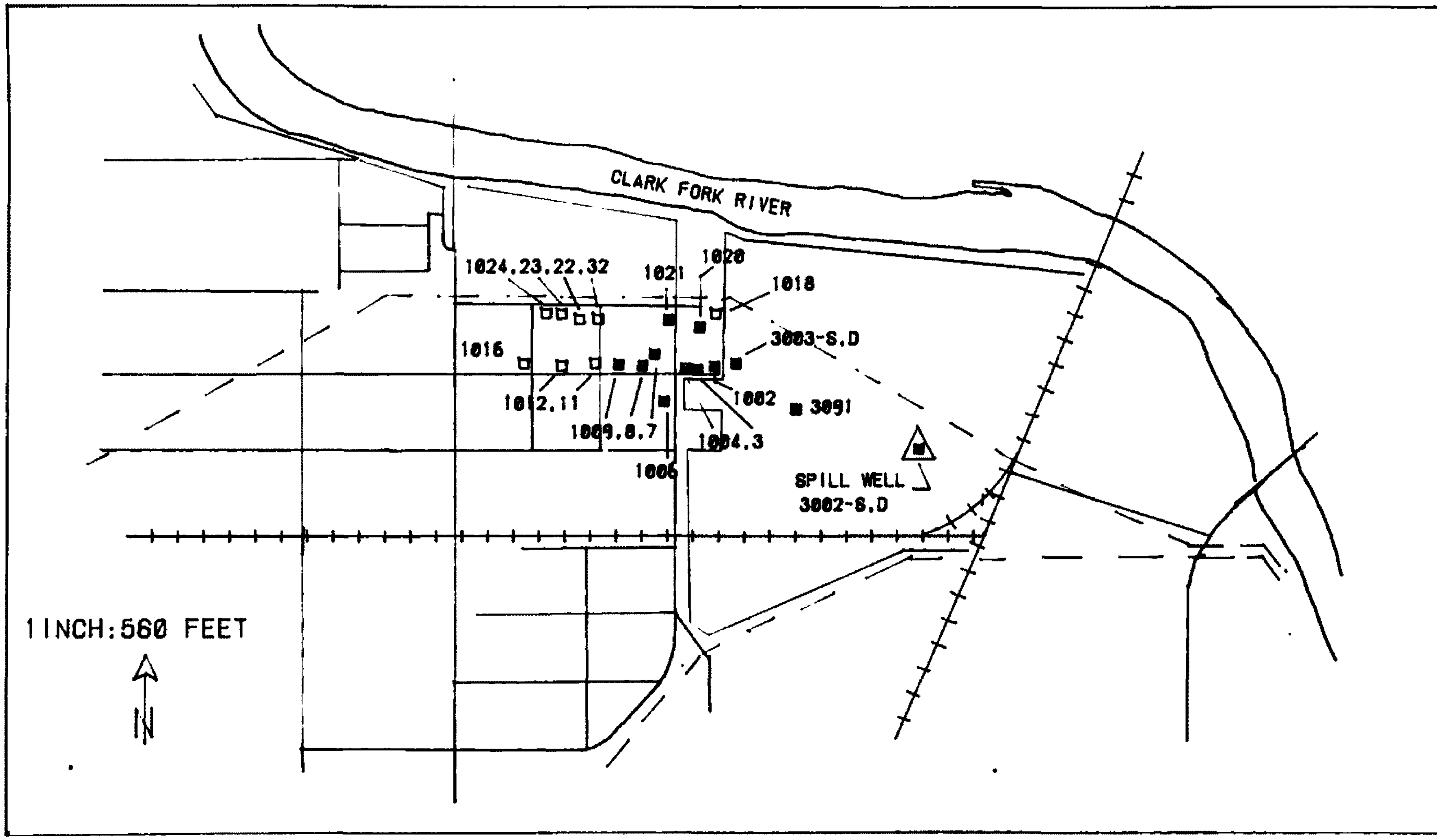

Figure 3: ■ – represents the location of a well contaminated with BTX; □ – represents the location of a residential well judged to be at risk of future contamination and replaced.

HYDROGEOLOGY

The Missoula Aquifer is principally Pleistocene in age and glacio-alluvial in origin. It is unconfined and composed of sand, gravel, cobbles, and boulders with discontinuous and interlayered silts and clays. Grain size analyses by Clark (1986) on four samples of aquifer material collected to a depth of 20 feet (6 m) indicate that the sediment is poorly sorted, and that 90% of the sediment is coarse-sand size or larger. Mean diameters of grains are in the coarse to very coarse pebble range. The thickness of the sands and gravels varies throughout the valley, but a well log within the study area indicates that the base of the aquifer is at least 140 feet (43 m) below land surface. The vadose zone is typically 30 feet (9 m) thick. The general ground water flow direction across the valley is to the southwest with a water table gradient of 0.0009 (Clark, 1986), but an initial study by the University of Montana in June, 1985 indicated that flow in the study area is to the west-northwest (Woessner, personal communication, 1986).

Clark (1986) documented the Clark Fork River as the principal source of recharge for the Missoula Aquifer. He estimated that the river recharged an average of 36 million gallons of water a day (1577 l/sec) to the aquifer along an eight mile (13 km) reach. The water table fluctuates between 26-36 feet (8-11 m) below land surface in the vicinity of the spill site, with the lowest periods of the water table coinciding with low river stages in January, February, and March and high periods coinciding with higher river stages and maximum recharge in May and June (Clark, 1986). Clark used aquifer tests, well log data, and permeameter tests to estimate values for hydraulic conductivity, specific yield, porosity, and transmissivity. These values are within the ranges proposed by Fetter (1980) and Freeze and Cherry (1979) for aquifer material similar to the Missoula Aquifer and are as follows:

Hydraulic Conductivity (K)	= 10,000 gpd/ft^2 (408 m/day)
Specific Yield (Sy)	= 10.6%
Porosity (n)	= 19.7%
Transmissivity (T)	= 1,000,000 gpd/ft (12,420 m^2/day)

An approximation of the true velocity of ground water flow across the Missoula Valley can be obtained from the above data using a water table gradient (i) of 0.0009 and the equation:

$$
\begin{aligned}
vel &= K(i)/n \\
&= 10{,}000 \text{ gpd/ft}^2 \; (.0009) \; /.197 \\
&= 45.68 \text{ gpd/ft}^2 \; (1 \text{ ft}^3 \; / \; 7.48 \text{ gal}) \\
&= 6.11 \text{ ft/d} \; (1.86 \text{ m/d})
\end{aligned}
$$

I believe this value of the true velocity to be a minimum for the spill site area for reasons that I will explain further in the discussion section of this study.

METHODS

I examined 40 well logs from the study area to correlate the stratigraphy beneath the spill site with that of the residential area. In July 1986, I gauged the irrigation ditches with a Price AA current meter to determine if the aquifer was recharged with water by leakage through the ditch beds.

I took monthly water level measurements from July, 1986 to June, 1987 (except for August and December). Using a steel tape measure graduated to hundredths of a foot, I measured water table levels in a network of 57 wells. I also measured the stage of the Clark Fork River from the Champion Railroad and Russell Street bridges (Figure 4). Champion monitoring sites 3001 to 3004 each contain a nest of two, two inch stainless steel wells screened at different depths. Domestic well sites 1020, 1008, 1016, and 1022 also contain two wells; the original shallow wells, which were not filled with cement to allow future sampling of water quality, and the 100 foot replacement wells. I used the water table measurements to construct potentiometric surface maps for each month. However, to construct these maps from my field measurements, it was necessary to adjust head data for wells deeper than 60 feet (18 m) by +0.2-0.3 feet (+0.06 m). This was to compensate for the water level differences between shallow and deep wells. I determined the actual amount of adjustment each month through consideration of the water level differences between the shallow and deep wells for that month (see Appendix A for amount of adjustments). In

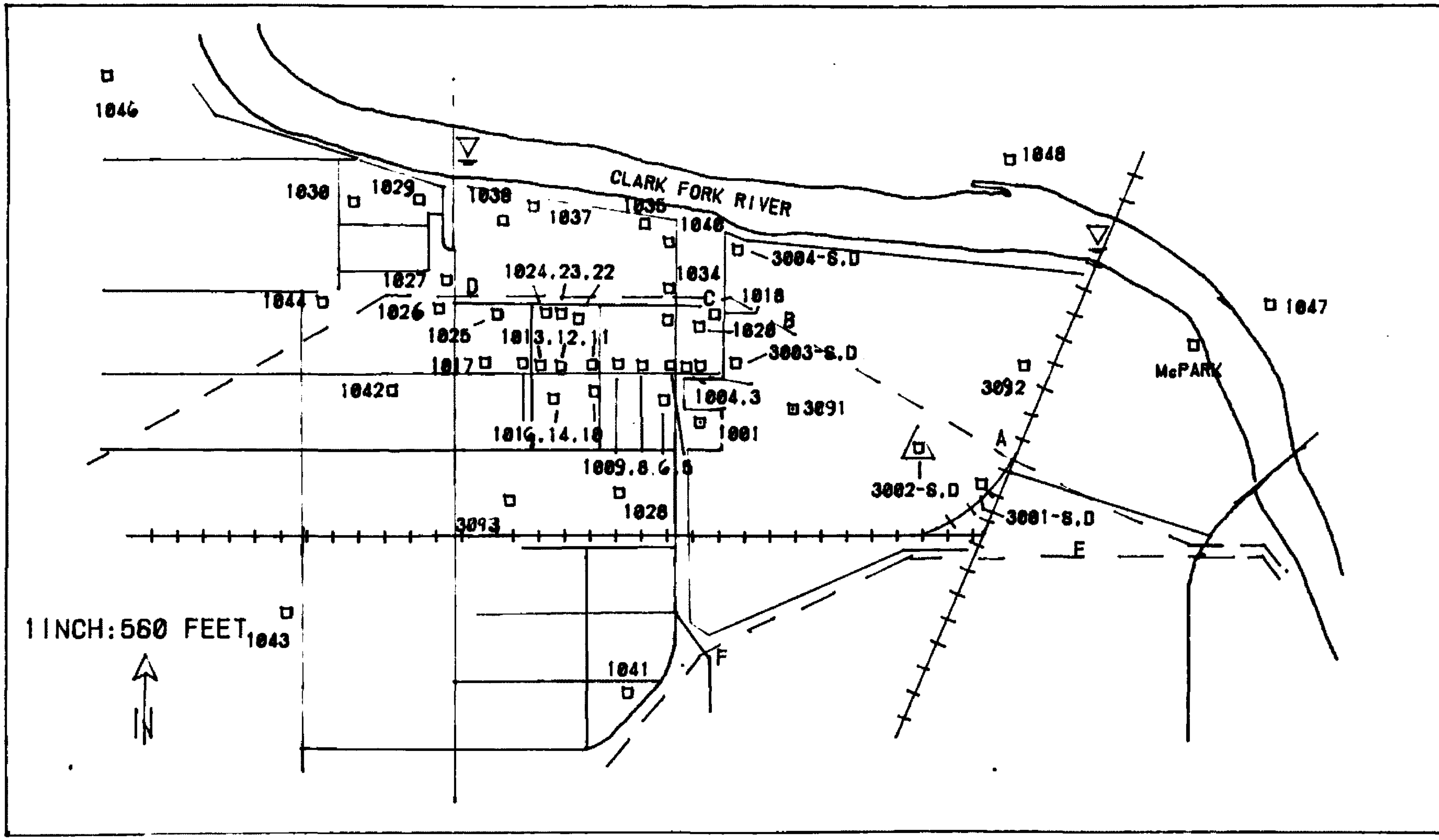

Figure 4: Monitoring well network; A-F are ditch gauging points; ∇- are stage measuring points for the Clark Fork River.

doing so, I contoured the potentiometric surface within the 50-60 foot (15-18 m) level of the aquifer. This process smoothed the contours of each month's map.

I used water quality data collected by Champion and the Montana Water Quality Bureau prior to June, 1986 to supplement data collected during my study year. All sampling and analyses procedures followed strict quality assurance/quality control plans developed by the Water Quality Bureau.

I directly participated in water quality sampling with personnel from the Montana Water Quality Bureau and Champion in November, 1986 and May, 1987 as part of those agencies' quarterly sampling schedule. The November samples were analyzed for levels of BTX, bacteria, total organic carbon, and dissolved lead, and the May samples were analyzed for BTX, bacteria, phenols, and dissolved iron and manganese. On both occasions, I followed standard E.P.A. quality assurance procedures, as dictated by the Water Quality Bureau personnel, for volatile organic and metal sample preparation and preservation, sampling, and field instrument decontamination. I obtained bacteria samples from stainless steel bailers that were decontaminated in the field and sterilized using a blow torch. Bacteria samples were collected in autoclaved bottles to prevent field contamination.

Water quality samples for organics and metals came from shallow and deep monitoring wells on Champion property and from shallow (< 68 ft., (< 21 m)) domestic wells within the California Street area. I based my selection of the domestic wells on availability of the well and its past risk of contamination by BTX. Bacteria samples came from Champion monitoring wells, and on one occasion, from a well located upgradient in McCormick Park. I evacuated at least three well volumes by bailer or by pump prior to sampling any well. Dissolved oxygen levels were measured in evacuated well bores with a YSI Model 54A oxygen meter. After sampling, I calibrated the meter in the laboratory by titration and made any necessary adjustments to the field data.

The Montana Water Quality Bureau Lab in Helena analyzed water quality samples for organics and metals using standard procedures, and Amatec Laboratories in Billings, Montana analyzed bacteria samples. A complete list of sampled wells and well depths is located in Appendix B.

I combined water table measurements with river stage measurements to calibrate a two-dimensional ground water flow model (PLASM, Prickett and Lonnquist, 1971). I adjusted hydraulic conductivity and river leakance values (Clark, 1986) within zones of the model until the distribution of simulated head values matched actual field head data. I applied this same method of forward modeling to a two-dimensional solute transport model (Randomwalk, Prickett et al., 1981). Default values of aquifer properties for these models came from Clark (1986) and data from water quality sampling.

RESULTS

Stratigraphy

In order to characterize the stratigraphy beneath the study area, I examined well logs from the new, 100 foot (30 m) domestic wells. Figure 5 is a cross section from Champion monitoring well 3001 to domestic well 1016-D. It is based on a composite cross section of the Champion wells logged by J.R. Carr/Associates (1985) and the logs from the new domestic wells. The stratigraphy beneath the study area, to a depth of 50 feet (15 m) or greater, is described by the drillers as predominantly "loose" sand, gravel, and boulders. Below this upper zone, there is a 10-20 foot (3-6 m) thick layer of "tight" sand and gravel. I interpret "tight" to imply a higher content of clay and silt, because this layer corresponds with a clay, sand, and gravel layer that occurs at about 75 feet (23 m) below land surface on Champion property. At well 1003, this layer is about 57 feet (17 m) below land surface. It becomes deeper further west. Zones of silt, fine grained sand, and gravel are interlayered in the upper interval of coarse sand and gravels, especially north of this line in the vicinity of wells 1022-1024 and 1020-1021, but they appear to be

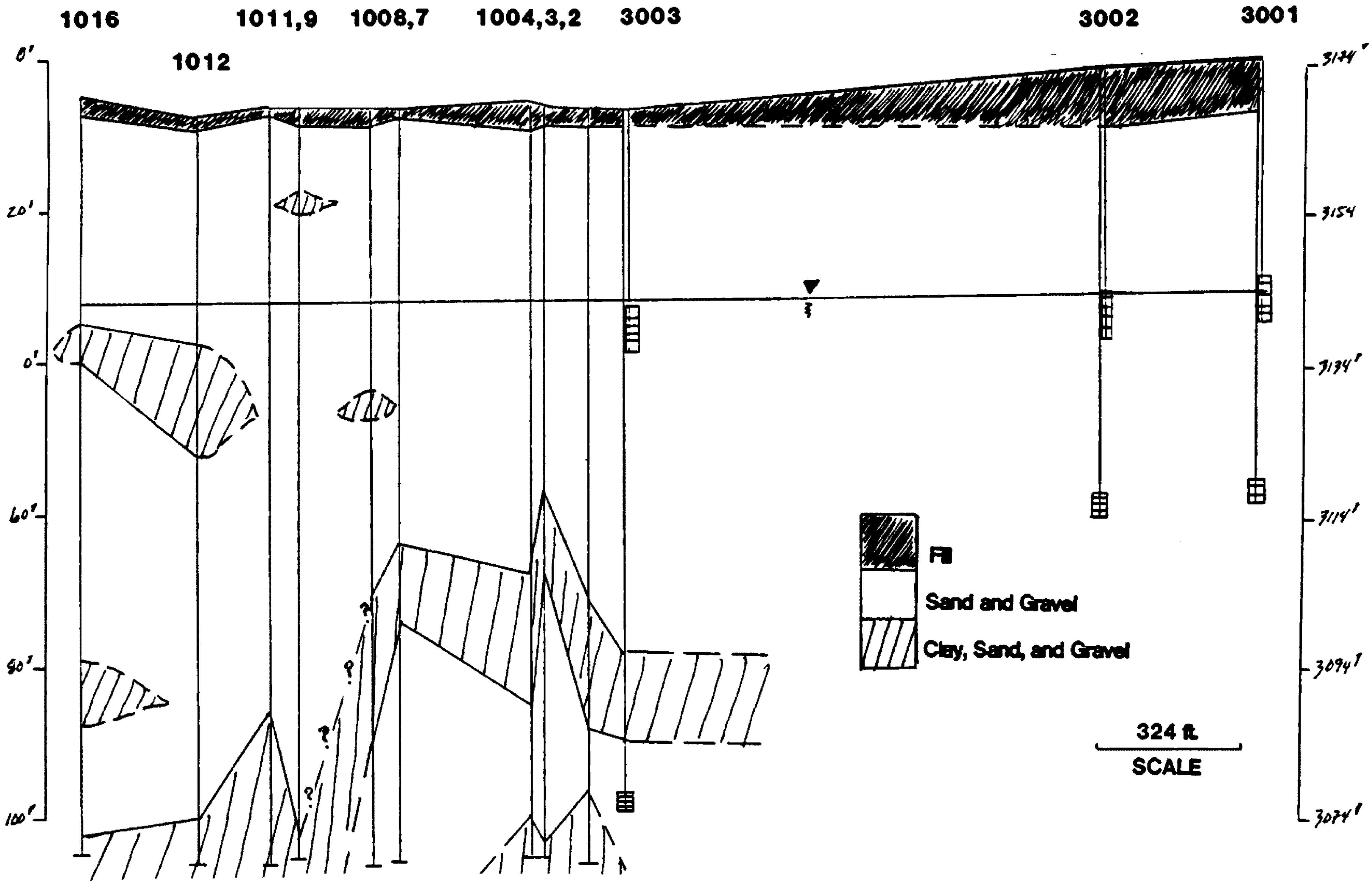

Figure 5: East-west cross section of study area from well 3001-S,D to well 1016-D.

laterally discontinuous. Both the "tight" and "loose" gravel intervals are water bearing.

The gasoline spill seeped into the "loose" gravel interval beneath Champion property (well 3002). Because of the lack of shallower intervals of clay, sand, and gravel, the dissolved plume migrated with the ground water flow into the residential area.

Seepage Study

In an attempt to assess how irrigation ditches affected the ground water system, I conducted seepage studies of the two ditches in the study area. The Missoula ditch flows southwestward along the southern boundary of the Champion yard at about 63 cubic feet per second (cfs) (1.78 cms), or three times the rate of the Orchard Homes ditch (Figure 2). The latter flows westward through the spill site and residential area at 16 to 21 cfs (0.45-0.60 cms). The headgates of both ditches lie on the Clark Fork River to the east of the study area, and they remain open from early spring to fall. The beds of the ditches consist of fine to coarse sand, gravel and cobbles and are perched above the water table by approximately 25 to 30 feet (8-9 m).

I gauged the Orchard Homes and Missoula ditches in July, 1986 to determine whether a significant amount of leakage (>5% of flow) was occurring through their beds. I was able to determine significant leakage for only the section of the Orchard Homes ditch which runs through Champion property (Table 1).

Table 1: Results of streamgaging Orchard Homes (OHD) and Missoula (MD) ditches, July, 1986. See Figure 4 for site locations.

LOCATION	DATE	INFLOW/OUTFLOW cfs	%CHANGE
OHD-sites A/B	7/17/86	21.05/17.34	17.6
OHD-sites C/D	7/22/86	16.52/16.32	1.2
MD-sites E/F	7/19/86	62.90/59.80	4.9
MD-sites E/F	7/22/86	64.59/68.14	5.5

Ground Water Flow

The monthly water level measurements from the two groups of nested wells (Champion wells 3001-3004 and domestic wells 1020,1008,1016, and 1022) provide evidence for a downward flow gradient throughout the study area (Appendix A). Well 3001 exhibits an upward gradient and is the exception. The yearly averages of the water level differences between the shallow and deep wells of each nested well (Appendix A) indicate that water levels are approximately 0.23-0.34 feet (0.07-0.10 m) higher in the shallower wells. These differences translate into a vertical component to the flow gradient that ranges from 0.004 to 0.01, depending on a well's location in the aquifer. This range of values is one to two orders of magnitude greater than the horizontal component (approximately 0.0007). High monthly differences coincide with those months when there is an increased rate of recharge from the Clark Fork River to the ground water system (May and June).

The monthly water table maps show that ground water flow is to the northwest from the spill site through the residential area (Figure 6 and Appendix A), and that beyond Russell Street, the flow direction turns to the southwest. The northwest flow path remains consistent throughout the seasons as the water table fluctuates between 27-37 feet (8-11 m) beneath land surface at the spill well, 3002. The horizontal component of the flow gradient is small, approximately 0.0007 between well 3002 and well 1013 (Table 2), and seasonal variations are interpreted to be a result of varying recharge rates from the Clark Fork River (Clark, 1986).

Table 2: Horizontal gradients between wells 3002-D and 1013 from July, 1986 to June, 1987.

July	- .0006	February	- .0007
September	- .0007	March	- .0007
October	- .0008	April	- .0006
November	- .0007	May	- .0006
January	- .0008	June	- .0007

The northwest direction of ground water flow through the study site differs from the southwest direction across the valley determined by Clark (1986). I believe that the northwest direction is a result of higher transmissivities along the river. To test this hypothesis, I developed a two-dimensional model of ground water flow.

I used PLASM (Prickett and Lonnquist, 1971) to

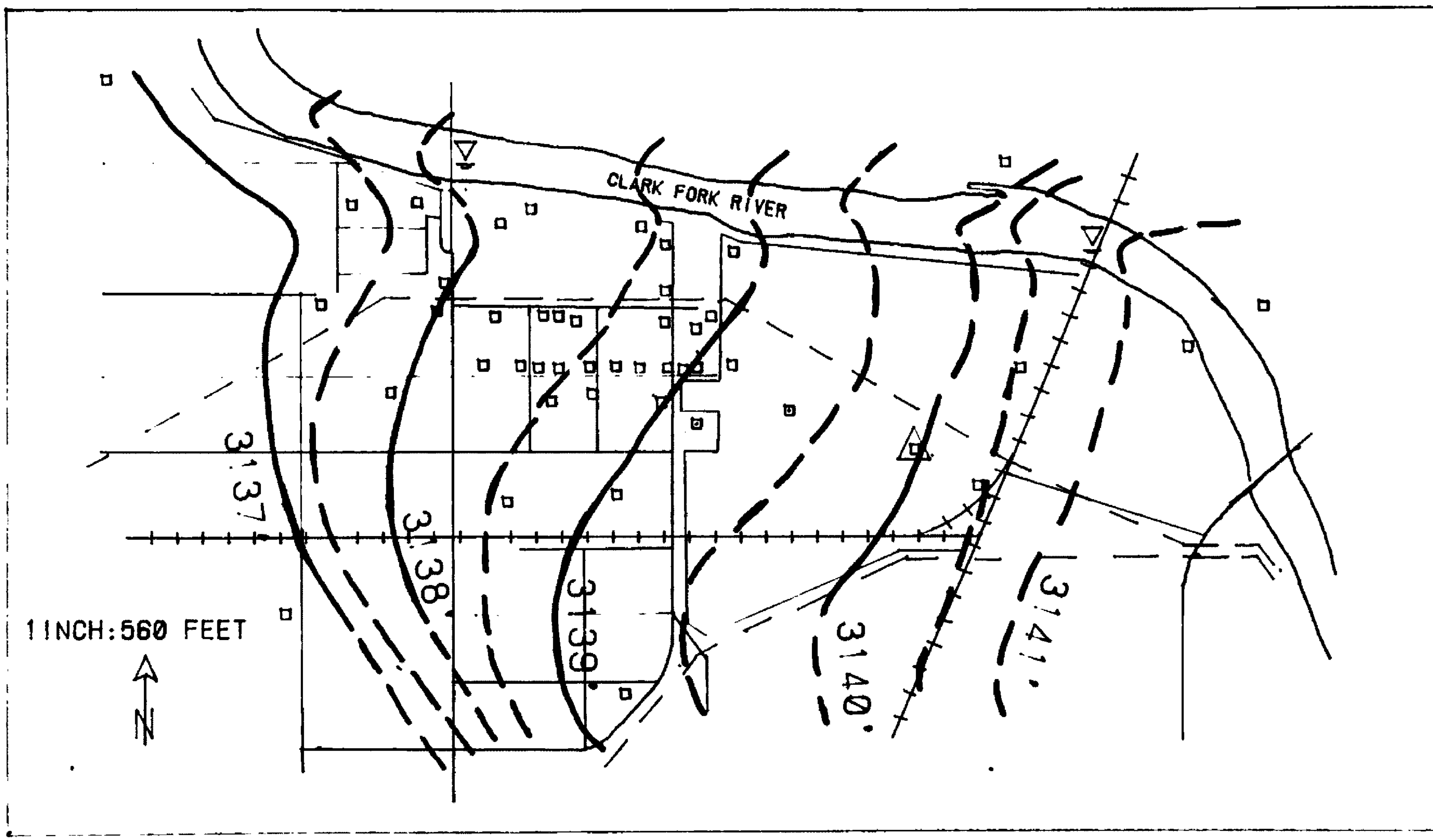

Figure 6: Potentiometric surface for October, 1986; contour interval is .5 feet.

reproduce the monthly potentiometric surface maps that I constructed from monthly water level measurements. I calibrated a steady-state and a transient flow model. The steady-state model reproduced water levels for July, 1986, and the transient model reproduced monthly water levels from July, 1986 to June, 1987.

My PLASM model is developed around a 22x17 grid with variable spacing, which encompasses a field area of approximately 6640x4260 feet (2024x1298 m) (Figure 7). The northern and eastern boundaries represent the Clark Fork River, and the southern boundary is a no-flow boundary parallel to ground water flow. The western boundary is a constant head boundary determined by equipotential lines from the monthly potentiometric surface maps.

Calibration of each transient run involved eleven monthly time steps of 30.33 days, and began with the steady-state head array generated for the month of July, 1986. Monthly stage and water level values for the Clark Fork River and constant head boundary nodes were input prior to each time step. I based these values on field data. Model parameters that remained constant during steady-state and transient runs were specific yield, porosity (Clark, 1986), and aquifer thickness. The latter value came from a well log for 1020-D.

specific yield (Sy) = .106
porosity (n) = .197
aquifer thickness (b) = 140 ft. (43 m)

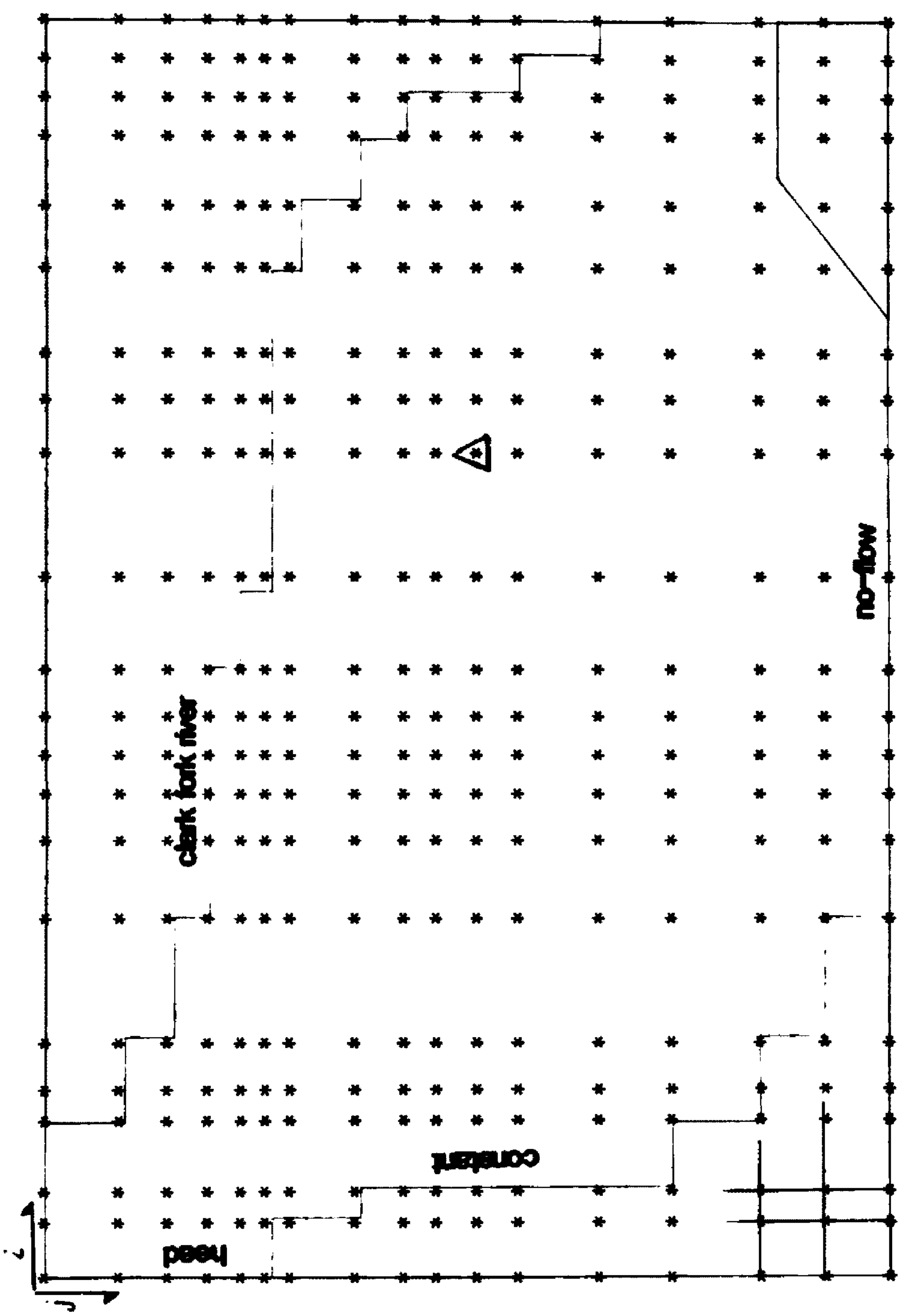

Figure 7: PLASM node array; Δ – represents node for spill well 3002-S,D.

Hydraulic conductivity (K) and leakance were the only model parameters that I was able to adjust in order to calibrate the model. I chose a conductivity value of 10,000 gpd/ft^2 (408 m/d) as a default value for my model (Clark, 1986). Leakance through the bed of the Clark Fork River is the sole source of recharge in the model. I chose leakance values within the range determined by Brick (1987), and adjusted these values for river nodes prior to each monthly time step during transient simulations. A leakance value of 1.00 gpd/ft^3 (0.0015 lps/m^3) produces a flow of 8.43 x 10^6 gpd (370 l/s) through the model riverbed area. This is 41% higher than the average daily flow determined using Clark's (1986) estimated recharge value of 36 million gpd (1577 l/s) (see Appendix C for computation). Monthly leakance values (gpd/ft^3) for the Clark Fork River that best reproduced the field data are as follows:

July	- 1.10	January	- 1.00
August	- 0.95	February	- 0.95
September	- 0.95	March	- 0.95
October	- 0.90	April	- 1.05
November	- 1.00	May	- 1.25
December	- 1.00	June	- 1.15

I was able to reproduce the monthly flow fields for the period of my study most accurately with the K distribution in Figure 8. The modeled conductivity across the study area ranges from a high of 70,000 gpd/ft^2 (2856 m/d) adjacent to the river to lows of 1,000 and 2,200 gpd/ft^2 (40.8 and 90 m/d) to the west and southwest of the study area. K values

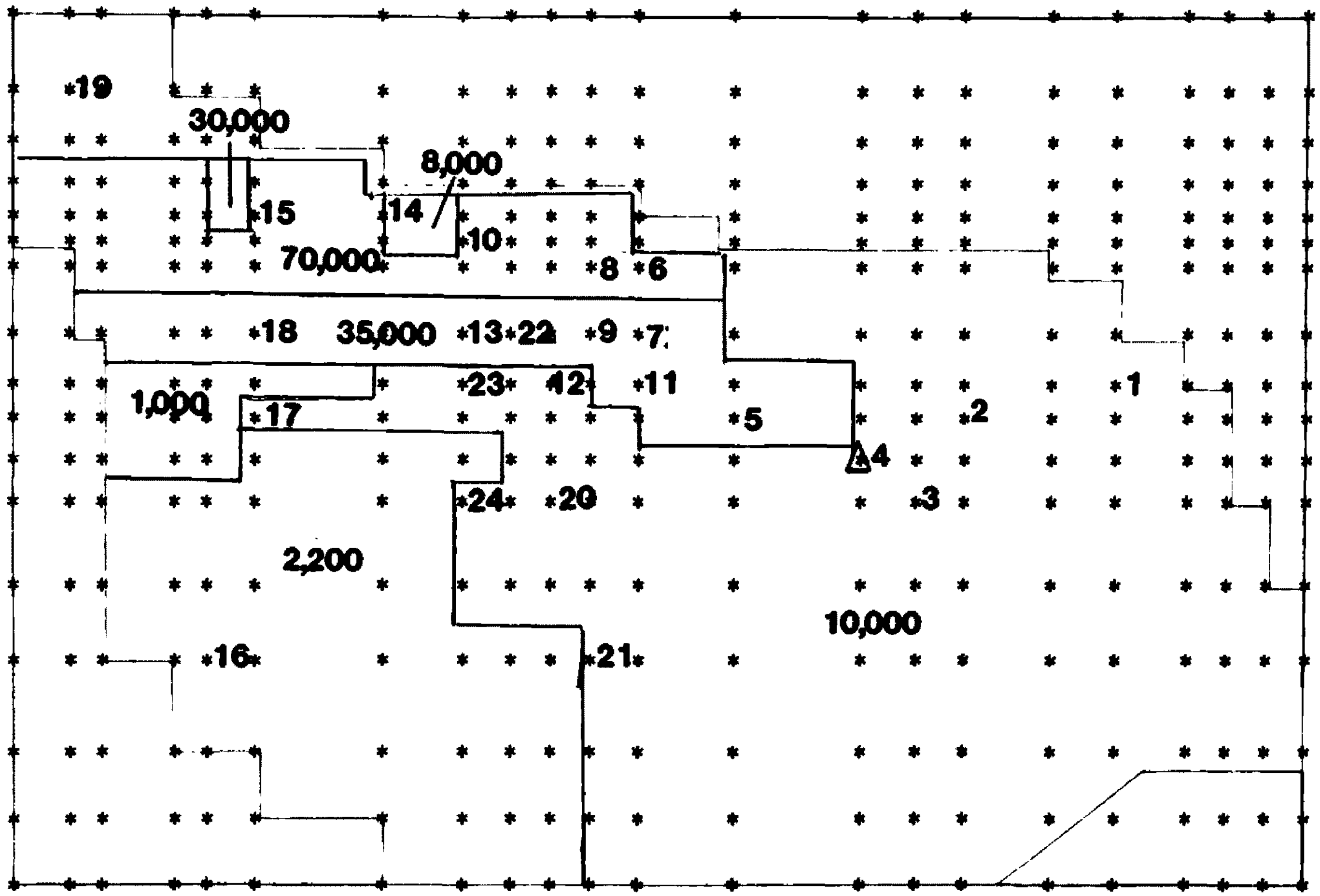

Figure 8: Distribution of hydraulic conductivity zones (gpd/ft²) for PLASM calibration; 1–24 are locations of calibration wells (see Table 5); △–represents node for spill well 3002-S,D.

within the spill site are as high as 35,000 gpd/ft^2 (1428 m/d). Figure 9 is the modeled flow field for October, 1986. It is very similar to the actual flow field (Figure 6), and it is typical of the other seasonal maps. The modeled flow maps, monthly head arrays generated by PLASM, and a summary of my methods of calibration are located in Appendix C.

I believe that my ground water model reproduces the flow regime that existed within the study site during my study. I do not suggest that the distribution of K zones in Figure 8 is factual, but that there are zones of higher transmissivities near the river, and that transmissivities decrease to the southwest. This model documents three other aspects of the flow regime:

(1) Ground water flow through the spill site is to the northwest. South of the spill well, flow is to the west-southwest.

(2) Highest recharge values occur during periods of highest river stage.

(3) Mounding of the water table beneath the Clark Fork River is less than 0.3 feet (0.09 m) higher than the water table beneath its banks.

In order to determine how well my model of ground water flow reproduced the actual flow field, I used Randomwalk (Prickett et al., 1981) to model contaminant migration from the spill well through the California Street area. This two-dimensional solute transport model uses a statistical randomwalk approach to model solute dispersion. The

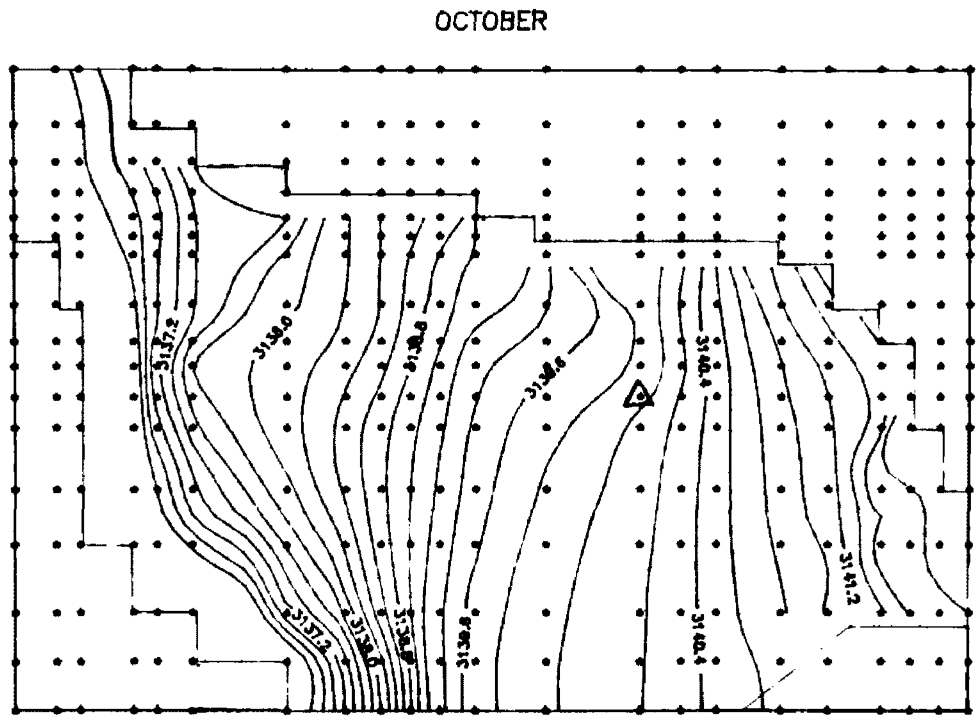

Figure 9: Modeled potentiometric surface for October, 1986; contour interval is .2 feet (from 3136.6 ft to 3141.8 ft); △ – represents node for spill well 3002-S,D.

"discreet" version of this model uses the monthly head array files created by PLASM as input for aquifer properties and to also determine velocity vectors between nodes. The velocity vectors are then used to determine the migration direction of the solute plume.

I could not calibrate this model because concentrations of BTX throughout the study area, prior to the beginning of this study, were not known. Therefore, I used this model only as a means of tracing the migration of contaminant particles as determined by the velocity vectors of my modeled flow field. I based my estimates of dispersivity and retardation (Appendix C) on time constraints for the migration of the plume and on work by Northern Engineering and Testing (1986, 1987). Figure 10 illustrates the areal extent of a contaminant plume under the simulated flow field conditions from May to August, 1986. The plume is very similar to the actual plume configuration for the summer of 1985 (Figure 11). Within four months of the spill, the plume has migrated along a northwest path and into the residential area. There, it is affected by the zones of high transmissivities along the river. The arm of the plume that extends due west (across Russell Street) is located in the field between Idaho and River Roads (Figure 2).

This version of Randomwalk does not account for the degradation of the contaminant particle, only retardation. This results in simulated contaminant levels persisting over

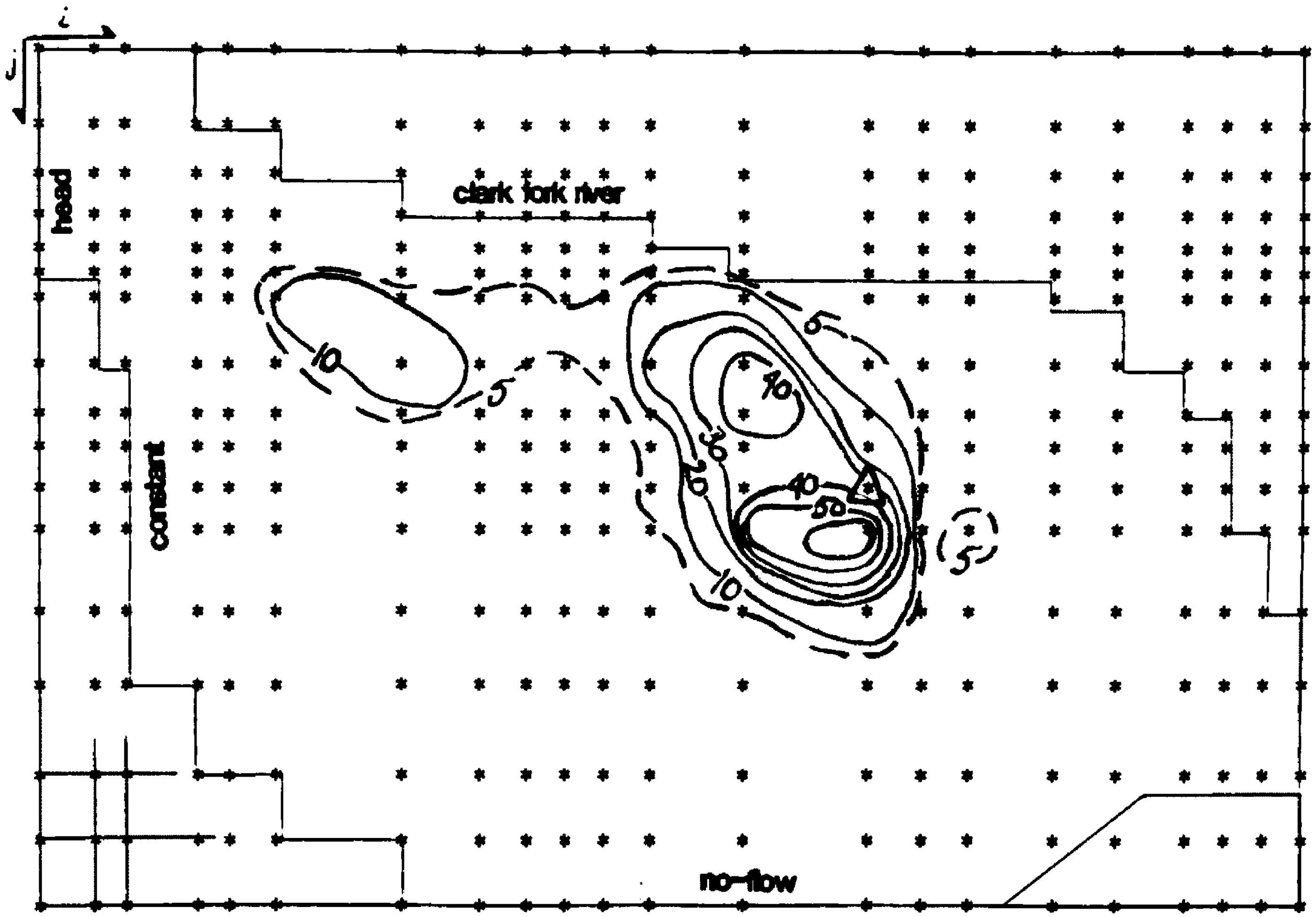

Figure 10: Modeled (Randomwalk) contaminant migration from May, 1985 to August, 1985; contour interval is 10 particles; contours do not represent the actual concentrations of BTX, only the relative concentrations; △— represents node for spill well 3002-S,D.

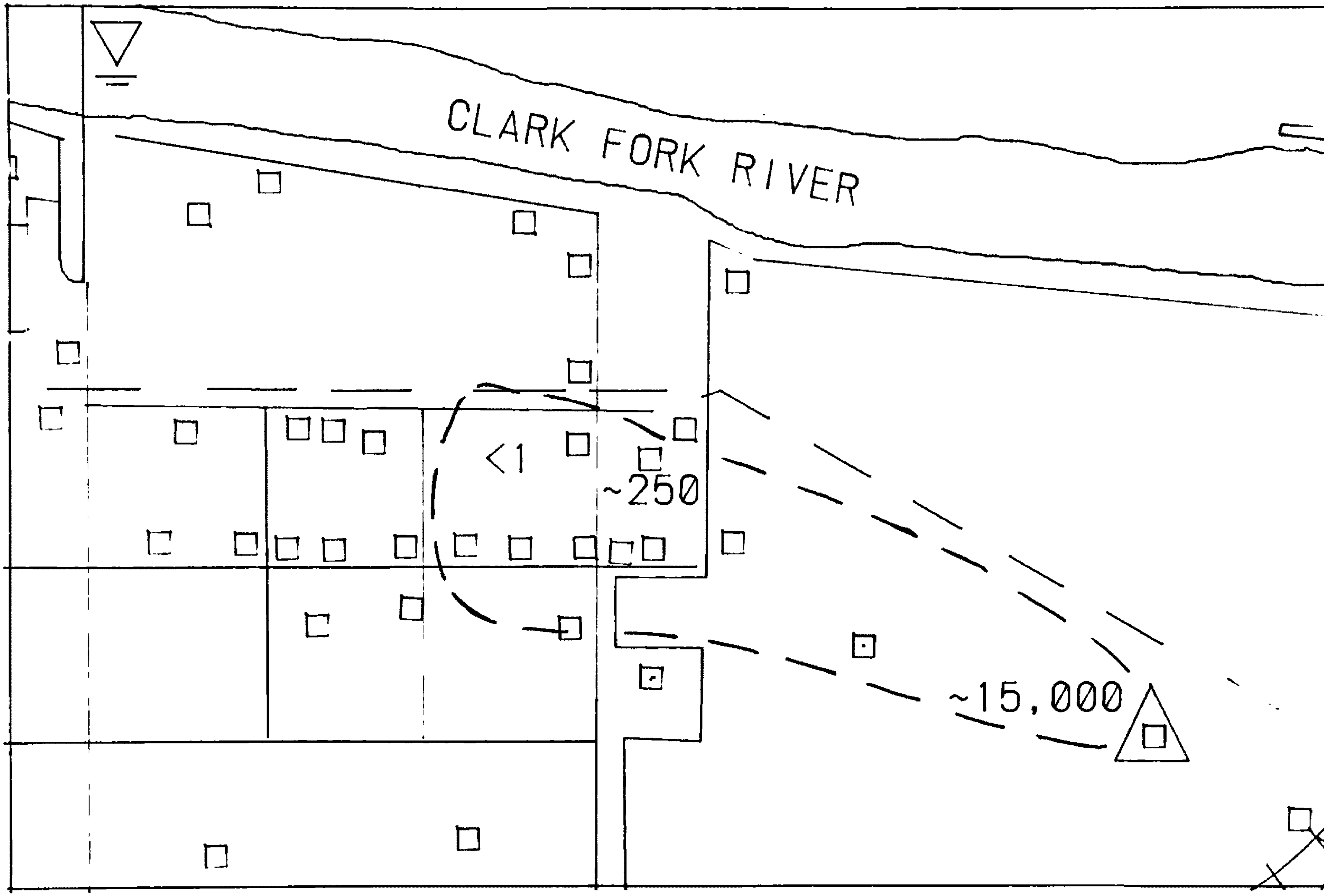

Figure 11: Areal extent of BTX plume on July 26, 1985; concentrations in ug/l (ppb).

a broader area of the study site and at much higher levels than field data. Also, longitudinal and transverse dispersion are modeled as constant parameters. It would be more realistic if these properties increased asymptotically (Prickett, personal communication, 1988). This would result in a narrower plume configuration on Champion property, which is observed in field data. However, the simulated northwest migration of the contaminant indicates that the modeled flow field approximates actual field conditions, and that there is a wide range of transmissivities across the study area.

Water Quality

In order to characterize the water quality of the study area, it was necessary to document the background levels of inorganic and organic parameters. These data would be used to delineate the areal extent of the BTX plume(s) (Figure 11) and to investigate other bio-chemical parameters associated with the fate of the plume(s). Numerous analyses were conducted to accomplish this goal. What follows is a summary of those analyses (Appendix B).

Inorganic analyses conducted by the Water Quality Bureau in April, 1986 show that the ground water within the study area is rich in calcium-magnesium-bicarbonate with a hardness (as $CaCO_3$) that is typically less than 185 mg/l. Chloride levels are below 6 mg/l and sulfates and nitrates are less than 30 mg/l and 0.8 mg/l, respectively. These values are well within drinking water standards. Background levels of inorganics and metals throughout the study area are within background levels for the Missoula Valley, as determined by Clark (1986).

The inorganic analyses also indicate that the water quality of wells along River Road (1035-1037) is different from the water quality of wells throughout the California Street area. The elevated levels of chlorides (>9 mg/l), sodium (>8 mg/l), and potassium (>2 mg/l) in wells 1035-1037 may indicate that private septic fields are influencing water quality.

Table 3 is a summary of total BTX levels in wells in the study area from May, 1985 to May, 1987. Wells are arranged in downgradient order, beginning with the spill well 3002-S,D. A significant point from Table 3 is that BTX was present in the aquifer before the spill on May 17, 1985. Well 1006 had detectable concentrations of BTX on May 21, 1985, four days after the spill. This well is more than 1200 feet (366 m) downgradient from the spill site. If ground water velocity is estimated at 6 ft/day (1.8 m/d) (p. 10), the center of the plume would have migrated about 24 feet (7.3 m) in four days. Thus, the dissolved plume released May 17 was not the source of the BTX discovered in well 1006. However, because of its corroded state, the gasoline tank at the spill site remains the most likely source of the BTX

Table 3: Summary of total BTX levels (ug/l) from May, 1985 to May, 1987

Well	Date>	5/21/85	7/18/85	7/26/85*	8/18/85*	9/18/85	10/1/85	4/3/85	8/7/86	11/86	5/87
3002-S					14200	14820	9030		1250	467	4751
3002-D					34	<1			<1	<1	<1
3091					<1	24		<1		<1	
3003-S					247	62		<1	5	<1	74
3003-D					<1	<1		<1	<1	<1	
1002				220		142	205				
1003			3	<1		145					
1004				251		79		<1			
1005						<1		<1		<1	<1
1006		266				<1		<1			
1007			88	28		<1	<1	<1			
1008-S			3	<1		<1		<1		<1	
1009			63	<1		<1		<1			
1018						<1		<1		<1	<1
1020-S				261		94		<1		3	4
1021				276		42	98				
1022-S						<1		<1		<1	<1
1037								<1		<1	

* - Quality control in lab is suspect for these analyses

BTX data prior to 11/86 is compiled from summary in Appendix B

Organic analyses for wells 1018 and 1037 on 4/87 are located in Appendix B discovered in study site wells.

Table 3 also reveals several trends in water quality. One is that the water quality in the deeper monitoring wells on Champion property (3002-D, 3003-D, 3004-D, 3091) is markedly better than that of their shallower counterparts. The deepest well in which BTX was detected was 3091. This well is 650 feet (198 m) downgradient of the spill site and 67 feet (20 m) below land surface. BTX levels were recorded only once during the 9/18/85 sampling, indicating the downward component of the flow gradient is capable of mixing the BTX plume within the upper 37 saturated feet (11 m) of the aquifer. During my study year, water quality analyses showed mixing only within the upper 25 saturated feet (8 m) at well 1020-S.

The second trend is that BTX levels decrease downgradient from the spill site. This is to be expected. The third trend is that BTX levels vary seasonally. This seasonal variance in BTX concentrations is a result of seasonal water table fluctuations, and it indicates that residual saturation persists in the vadose zone. This seasonal variance is illustrated in Figure 12, which compares hydrographs of wells 3002-S,D (from July, 1986 to June, 1987) to BTX levels at 3002-S (from August, 1985 to May, 1987).

Champion conducted an EPA priority pollutant scan on wells 3001-S,D, 3003-S,D, 3004-S,D, and domestic well 1005

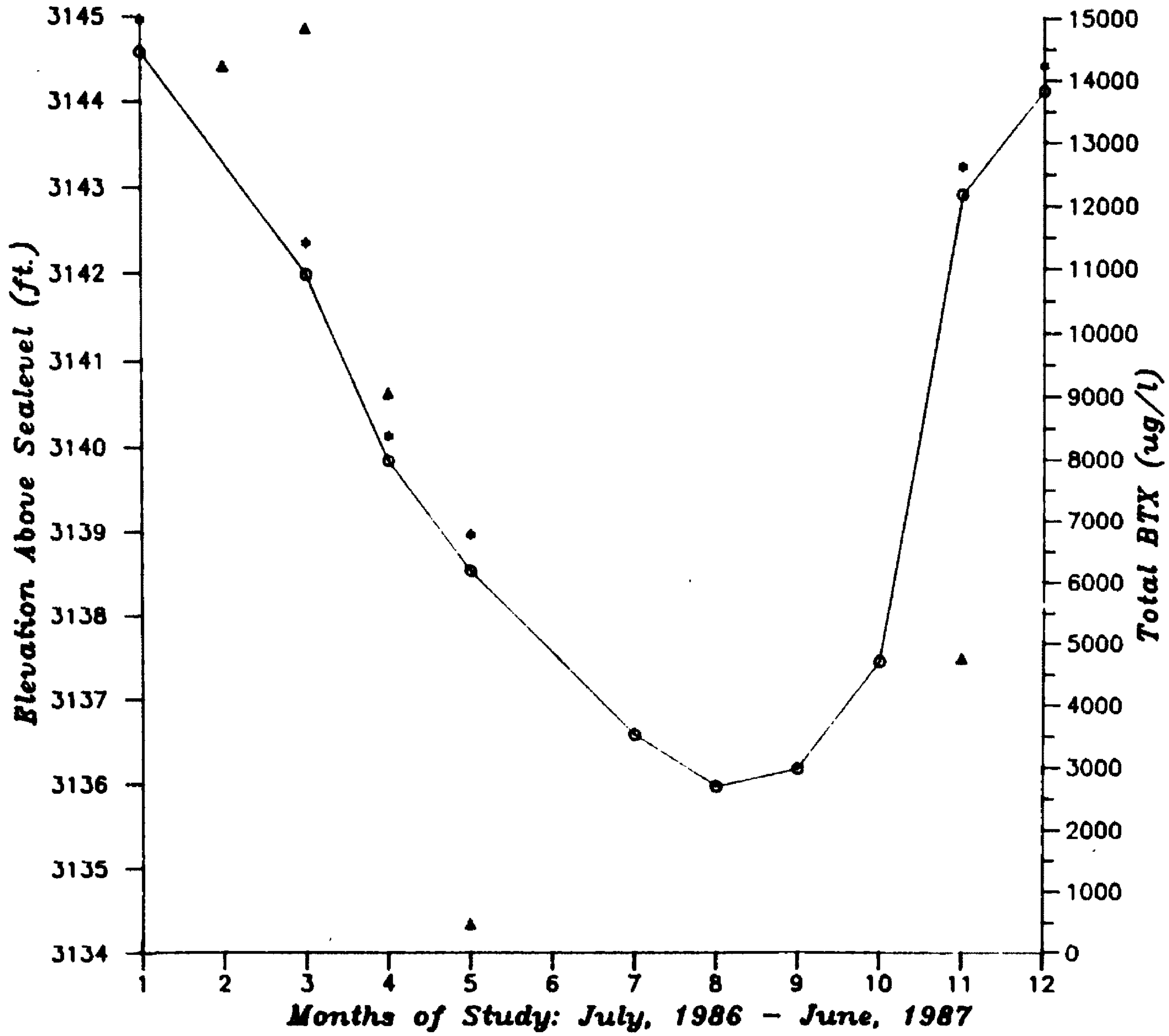

Figure 12: Hydrograph vs. total BTX for spill site well 3002-S,D; ▲ - represents BTX concentration at well 3002-S; ✳ – represents head measurement at well 3002-S; ○ -represents head measurement at well 3002-D.

in April, 1986 (spill site well 3002-S,D was excluded) to document whether other contaminants were present on the Champion site. The scan analyzed for 36 volatile compounds, 46 semivolatile organic compounds, 11 phenols, pesticides, polychlorinated biphenyls (PCBs), and 22 total metals (see Appendix B). All organics in these five wells were below analytical detection limits, but total metal levels in wells 3001, 3003, and 3004 for iron and manganese exceeded drinking water standards of >0.3 mg/l and >0.05 mg/l respectively (Table 4).

During my study year (July, 1986 to June, 1987), residents at wells 1005, 1018, and 1037 continued to complain of poor water quality even though contamination by BTX had not been documented during the first year of monitoring water quality. Though wells 1005 and 1018 are located within the contaminated area of the study site (Figure 11), available information indicated that they were deeper than the contaminated wells. From replacement well chemistry, I believed that the depth of these two wells prevented their contamination. The November, 1986 sampling failed to show BTX migration beyond well 1020-S (Table 3). Therefore, my later sampling of 1005, 1018, and 1037 in April and May, 1987 encompassed other parameters that I felt could be causes of the poor water quality in these wells (Table 4). I was particularly interested in documenting levels of total phenols and dissolved iron and manganese

Table 4: Phenols, metals, and bacteria levels from April, 1986 to May, 1987

Sample Date	Well#	(ug/l) Total Phenol	(mg/l) Fe	Mn	Bacteria #/100 ml	(mg/l) dissolved oxygen
4/86+	3001-S		3.44	1.10		
	3001-D		.68	.02		
	3003-S		17.10	9.02		
	3003-D		5.24	.25		
	3004-S		7.42	.22		
	3004-D		1.67	.83		
	1005		.12	.01		
11/86	McPark				<30	
	3002-S				220<#<7000	
	3003-S				220<#<2100	
4/87*	1018	<.004	.51	6.13	see Appendix B for complete list of organics	
	1037	<.004	1.07	<.02		
5/87	McPark	11	.18	<.005		
	3001-S	1	.04	.03		2.5
	3002-S	23	1.14	10.1	70000	2.0
	3002-D	4	<.01	.01	74000	6.0
	3091		.06	.01		
	3003-S	7	<.01	3.22	5600	3.8
	3003-D					5.8
	3004-S	5	.04	.27	4600	2.0
	3004-D				61000	7.3
	1018	1	.21	.92		
	1020-S		.15	.98		
	1005	3	<.01	<.005		
	1022-S	74	.04	<.005		2.2
	1037		<.01	<.005		

+- Metal analyses for 4/86 are for total iron and manganese

*- Metal analyses for 4/87 are for total iron and manganese, by Energy Laboratories, Billings, Mt.; Organics and phenols by Lancaster Laboratories, Lancaster, Pa.

upgradient, on-site, and downgradient of the spill site. Phenols could be responsible for complaints of skin and eye irritation from residents of wells 1005 and 1037 (Fessenden, personal communication, 1987), and high levels of the metals could be responsible for poor taste and odors in wells 1018 and 1037. In addition to these organic and inorganic parameters, I continued to sample bacteria populations at select wells on Champion property to supplement November analyses. I would use the bacterial analyses to document oxidation of the hydrocarbons.

Bacteria was the only parameter in Table 4 sampled on a seasonal basis. Analyses indicate that an indigenous population of bacteria (Appendix B) exists within the upper 10 saturated feet (3 m) of the aquifer beneath Champion, and that bacteria levels fluctuate seasonally and decrease downgradient by an order of magnitude from well 3002-S to 3003-S (Figure 13). These trends are similar to the BTX trends in Figure 12.

The levels of dissolved iron and manganese across the Missoula Valley are below drinking water standards and usually below analytical detection limits. But levels of these metals are close to or above drinking water standards Champion's site and immediately off-site at wells 1018 and 1020-S (Figure 14). Levels upgradient at well McPark and downgradient at well 1022-S are within background levels for the Missoula Valley. As in the water quality analyses for

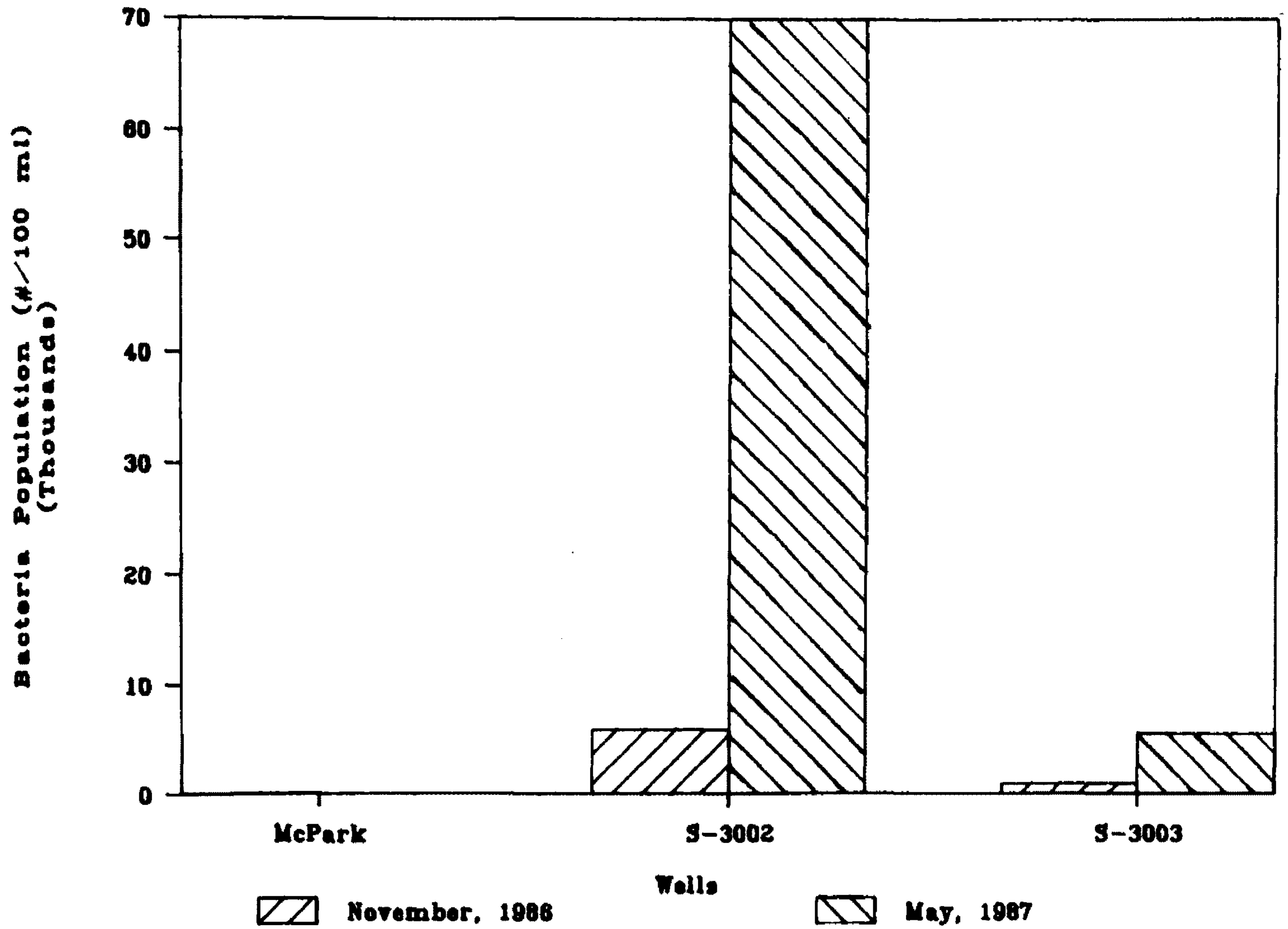

Figure 13: Bacteria population across Champion site in November, 1986 and May, 1987; McPark is upgradient well located in McCormick Park.

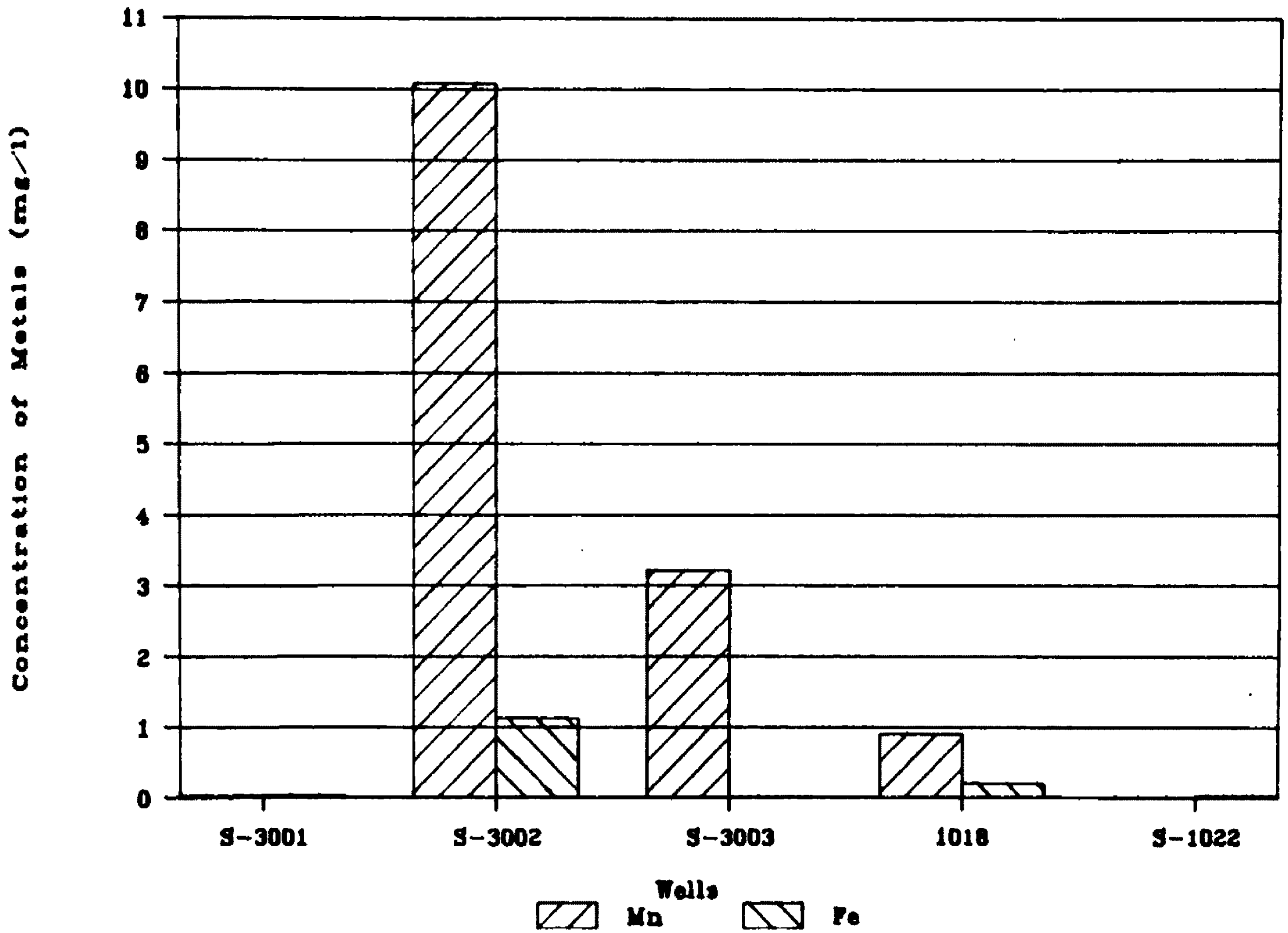

Figure 14: Concentrations of dissolved manganese and iron across the study area, May, 1987; concentrations in mg/l (ppm).

BTX (Table 3), metal analyses indicate that the water quality of the deeper wells on the Champion site is better than the water quality of the shallower wells.

Phenol analyses for the 5/87 sampling indicate that detectable levels of phenol exist across the entire study area (1 to 74 ug/l) and are not restricted to Champion property. These analyses are inconclusive because background levels are not established.

Of the three wells (1005, 1018, 1037) with poor water quality for which I had hoped to find elevated levels of either dissolved metals or total phenols, only well 1018 had elevated metal concentrations. Concentrations of metals and phenols in wells 1005 and 1037 are near or below analytical detection.

DISCUSSION

Ground Water Flow

Potentiometric maps of monthly water level measurements show that ground water flow is to the northwest from the spill site, and that the flow turns to the southwest towards the western and southern margins of the study area. The northwest flow pattern is a result of higher transmissivities along the river. The closeness of potentiometric lines to the west and south of the study area (Figure 6) indicate steeper ground water flow gradients and thus lower transmissivities.

There is insufficient well log data along the river and to the south of the study area to support my belief that transmissivity varies between these areas. Specific capacity analyses from well logs are inconclusive, and therefore it is impossible to determine hydraulic conductivity values from the logs. However, there is no other way to reproduce the head distribution with ground water modeling unless transmissivities decrease southward from the river. The conductivity values that I used to calibrate my flow model all fall within the range for silty sand and gravel (Freeze and Cherry, 1979). I believe that an increase in the silt and fine sand content of the aquifer is responsible for lowering the transmissivity of the aquifer to the southwest of the study area.

It is hard to contour the potentiometric surface from the study area to beneath the river and north of the river because of a lack of wells. Simulated monthly head levels (Appendix C) indicate that a water table mound beneath the river is rarely 0.3 feet (0.09 m) higher than the water table in wells located adjacent to the river. Though the gradient from the mound to the bank is one order of magnitude greater than the horizontal component of the flow gradient, I do not know whether the mound is significant enough to act as a hydrologic divide and thus prevent ground water flow in the study site from flowing northwest beneath the river (or southwest beneath the river from the north).

The height of the mound has strong implications on the quality of water available to the residents of River Road in the study area. A higher mound would dictate that river recharge strongly influences their water quality. A lower mound would make it possible for ground water flow from the Champion site to affect the water quality of their wells. Because the height of the water table mound beneath the river appears to be small, I believe that the height of the mound created by recharge through the Orchard Homes ditch is insignificant. I do not believe that recharge through the ditch bed affects the migration of the BTX plume outside of Champion property. The similarity in monthly water level fluctuations in shallow and deep wells indicates that the tight layer of sand and gravel does not act as a continuous confining layer, and that the aquifer behaves as an unconfined system.

Fate of the Dissolved Gasoline Plumes

It is difficult to determine the rate of contaminant migration and the degree of dispersion of the dissolved plume(s) since the initial spill in May, 1985. BTX levels in well 1006 on May 21, 1985 and petroleum odors in domestic wells as early as the fall of 1984 (personal communication with residents) are clear indications that gasoline was in the aquifer prior to the spill in May. Domestic wells in the California Street area were not consistently sampled during the summer of 1985, so a background level of organics was not established. A lack of monitoring wells north of the Orchard Homes ditch on Champion property and in the field between Idaho and River Roads (Figure 11) prevents determining the northern extent of any BTX plume.

Some residents who complained of poor water quality in the spring of 1985 noticed that petroleum odors and tastes became worse after the May 17, 1985 spill. If the BTX concentrations measured in domestic wells on 7/26/85 (Table 3) are a result of the May spill, then BTX migration from the spill site must be 15-20 ft/day (4-6 m). I assume that the dissolved plume migrates at ground water velocity, because total organic carbon levels appear to be extremely low (Appendix B) and the bulk of the aquifer material is well above 0.125mm in size (Clark, 1986). These are important factors in adsorption of organics (Newsom, 1985; Roberts et al., 1985; and Schwarzenbach and Geiger, 1985). This rate of flow is possible if the transmissivity of the aquifer is on the order of 5,000,000 gpd/ft (62,090 m^2/d) in the vicinity of the spill well. In order to calibrate the flow model, it was necessary to assign a transmissivity of 4,900,000 gpd/ft (60,850 m^2/d) to this area (K=35,000 gpd/ft^2 (1428 m/d) - Figure 8). If the average conductivity of the aquifer is 10,000 gpd/ft^2 (408 m/d), then ground water flow velocity from the spill well to the residential area can be bracketed between an average of 6 to a maximum of 20 ft/day (1.8-6.0 m/d). I believe that the actual velocity is closer to the upper end of this range.

BTX sampling in 1986 and 1987 (Table 3) indicate that gasoline contamination persists in the vadose zone beneath the spill site and that dissolved plumes of higher concentrations continue to flush through the system in the spring. These seasonal plumes occur when the water table rises and contacts a larger volume of contaminated soil (Figure 12). However, BTX concentrations at the spill well decreased by approximately 65% between July, 1985 and May, 1987. Though part of this decrease is due to the water table never fully recovering each spring, much of the attenuation is due to such natural processes as biodegradation and dispersion.

BTX concentrations at the spill well, 3002-S, decreased throughout the summer of 1985 but remained an order of magnitude greater than concentrations in domestic wells located 1200 feet (366 m) downgradient (Table 3 and Figure 11). This trend in the order of magnitude decrease of BTX concentrations remained consistent during my study year. This indicates that the bulk of the plume(s) was attenuated before reaching the residential area. If this degree of attenuation was produced by dispersion, then the high transmissivity of the aquifer should maximize longitudinal dispersion as opposed to transverse dispersion, and in fact, this is what occurs as illustrated in Figure 11. Large longitudinal dispersion should result in higher levels of BTX contamination in the residential area within months of the spill as the core of the dissolved plume moved through the area (Figure 10). Yet decreasing BTX levels throughout the summer of 1985 do not document the passing of a core. Therefore, I believe biodegradation played a significant role in attenuating the BTX plume.

Analyses on 11/86 and 5/87 (Table 4) show that an indigenous population of bacteria exists on Champion's property. The order of magnitude increase in the bacterial population at the spill well 3002-S (Figure 13 and Appendix B) suggests that the bacteria are able to utilize gasoline as a food source. I believe that a population of bacteria within the upper 10 saturated feet (3 m) of the aquifer, possibly one to two orders of magnitude greater than what was detected by my study methods, was acclimated to the presence of BTX prior to the May spill. I believe that the bacteria were able to significantly degrade the contaminant plume so that with dispersion, the concentration of the plume was reduced by an order of magnitude by the time it had migrated 1200 feet (366 m) to the residential area. Shelton (personal communication, 1988b) concurs that such a rate of degradation is possible within the study area.

I believe that the high levels of dissolved iron and manganese beneath Champion and immediately off-site at wells 1018 and 1020 (Table 4 and Figure 14) are a result of reducing conditions in the aquifer created as bacteria oxidize the BTX plumes (Freeze and Cherry, 1979 and Appendix D). Ground water beneath Champion is aerated. Levels of dissolved oxygen are between 2 and 4 mg/l (Table 4). But I believe that in order to sustain biodegradation of the BTX, bacteria fulfill their increased oxygen needs by reducing iron and manganese oxides. This process provides the necessary oxygen for aerobic degradation of the BTX and results in reduced and more soluble metal species.

Potential for Future Contamination

I believe that the northwest migration path of the BTX plumes remains consistent to the present, and that future plumes will continue to migrate along a northwest path that will carry them under the field between Idaho and River Roads. Assuming no more spills, I do not believe that future plumes present a health risk to the residents of the California-Montana Street area because, during my study, maximum BTX levels off-site of Champion property have been at such low levels that advection and dispersion would quickly reduce a plume to below detection levels. Also, well intakes are all deeper than 68 feet below land surface (21 m), and my data indicate that water quality remains excellent deeper than 55 feet (17 m). It is possible that the vertical component of the ground water flow gradient may mix the dissolved phase of a gasoline spill to at least a depth of 67 feet (21 m), which occurred in the summer of 1985 with well 3091, but I believe that the layer of clay, sand and gravel beneath the study area (Figure 5) would adsorb the contaminant and lessen the chances of mixing to a greater depth.

CONCLUSION

The gasoline spill at the Champion Missoula Sawmill in May of 1985 still persists within the Missoula Aquifer three years later. Dissolved gasoline plumes continually flush through the spill site, but concentrations downgradient of the spill well are below detection until spring and early summer. During this time of year, the water table across the Missoula Valley is rising from recharge by the Clark Fork River. As the water table rises, it contacts a larger volume of contaminated soil and creates dissolved plumes with higher BTX concentrations.

Migration of the plumes is to the northwest as a result of highly transmissive aquifer zones along the southern bank of the river that act as conduits for ground water flow. Vertical mixing and adverse effects to water quality are restricted to the upper 37 saturated feet (11 m) of the aquifer. Total BTX concentrations over this three year time period have decreased by approximately 65% through dispersion and advection by groundwater flow and by biodegradation carried out by the indigenous population of bacteria.

Increased levels of hydrocarbons support larger populations of bacteria across the Champion site. Oxidation reactions, which are enzymatically catalyzed by hydrocarbon degrading bacteria, have produced a reducing environment beneath the spill site and reduced manganese and iron metallic oxides. Elevated levels of both metals appear in monitoring wells 3002-S and 3003-S and domestic wells 1020-S and 1018, with manganese consistently above drinking water standards.

RECOMMENDATIONS

Mr. Brandt, owner of well 1005, still complains of periodic petroleum odors in his water. This well, located within the boundaries of the contaminant plume that migrated through the California Street area in the summer of 1985, is the only original well still in use along the northwest migration path. It was never replaced because the presence of BTX could never be documented. At the time of my study, I believed that well 1005 was 84-100 (30 m) feet deep, and at that depth, I did not believe that Mr. Brandt's water quality was affected by BTX contamination. However, in May, 1988, I discovered well log data for this well that indicated a completed depth of only 68 feet (23 m). I was also unable to pass a tape measure past a depth of 51 feet (16 m) (most likely due to the pump). A review of water quality analyses for the summer of 1985 indicates that well 1005 was not sampled until September, 4 months after the spill, at a time when BTX concentrations were diminishing across the study area. Given the depth of this well and its location within the contaminated zone, I believe that it may have been contaminated during the summer of 1985 and that repeated attempts to document organic contamination have failed because of inappropriate sampling frequency and diminished BTX concentrations. As a result of these new data, I recommend well 1005 be included in the group of wells replaced by Champion as a result of the May 1985 spill.

Water quality at well 1037 (Mrs. Chaussee) remains poor. Water samples from this well have a "rotten egg" smell that I associate with H_2S. Her poor water quality has persisted throughout my study, and Mrs. Chaussee claims that it began after the spill in May, 1985. I could not document organic or metallic contamination. In May, 1987, I noticed the smell in well 1036 (Mr. Rice), and in May, 1988 the smell had returned to this well. Though water quality for some wells along River Road is poor, I can not definitely relate the problem to the May 17, 1985 Champion spill. I believe concentrations of BTX plumes three years after the spill should be insufficient to contaminate wells 2200 feet (750 m) downgradient and support bacterial growth (Newsom, 1986). I recommend four steps: 1) investigate other sources on Champion that are nearer the river (if they exist), 2) investigate the auto paint shop located 300 feet (100 m) east of wells 1037 and 1036 (in the field between River and Idado Roads), 3) tracer tests be conducted on septic fields in the River Road area, and 4) bacterial analyses be conducted on those wells with H_2S odors.

Documentation of the dimensions of the dissolved plume beneath Champion are not possible because of a lack of monitoring wells north of the Orchard Homes ditch. Placement of multiple level sampling wells north of the ditch on Champion property and in the residential area would provide evidence for the northern extent of the plume and document its presence in the River Road area. The possibility of excavating and removing the remaining contaminated vadose zone material at the spill site should be explored.

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APPENDIX A

WELL INVENTORY

Well No.	Owner/Address	Surveyed Elevation (ft.)
3001	Champion International	3177.80
3002	Champion International	3175.78
3003	Champion International	3170.95
3004	Champion International	3173.88
3091	Champion-Factory	3174.15
3092	Champion-East Scales	3179.08
3093	Champion-Timberlands	3173.37
McPark	Missoula-McCormick Park	3175.78
1001	Williams-210 N. California	3172.36
1003	Worth-1136 Montana	3169.02
1004	Veitenheimer-1138 Montana	3169.63
1005	Brandt-1200 Montana	3164.27
1006	Ibey-1203 Montana	3168.83
1008-S	Larson-1228 Montana	3162.76
1008-D	Larson-1228 Montana	3168.93
1009	Thrasher-1244 Montana	3169.08
1010	Matye-1301 Montana	3155.43
1011	Damron-1011 Montana	3168.85
1012	C.R.Price-1330 Montana	3167.99
1013	Beckwith-1332 Montana	3159.71
1014	Earling-1345 Montana	3172.61
1016-S	Boschert-1400 Montana	3163.98
1016-D	Boschert-1400 Montana	3170.72
1017	Bert's Repair-1414 Montana	3169.11

WELL INVENTORY

Well No.	Owner/Address	Surveyed Elevation (ft.)
1018	Rose-1127 Idaho	3161.61
1020-S	Chaussee-1131 Idaho	3170.66
1020-D	Chaussee-1131 Idaho	3170.17
1021	Bowers-1205 Idaho	3169.22
1022-S	Ritchlie-1309 Idaho	3169.04
1022-D	Ritchlie-1309 Idaho	3169.56
1023	Thornburg-1311 Idaho	3167.84
1024	Anderson-1321 Prince	3167.93
1025	Car Lot-Idaho and Russell	3160.36
1026	Fred's Car Wash-321 N. Russell	3170.73
1027	TownPump-Idaho and Russell	3171.17
1029	Cotta-1509 River Road	3167.82
1030	Cotta-1509 River Road	3167.29
1034	Patton-401 California	3161.42
1035	Might-1201 River Road	3161.88
1037	Chaussee-1319 River Road	3160.22
1039	Pederdon-1321 River Road	3166.64
1040	OK Corral Bar-407 California	3168.37
1041	Olsen-1268 South 1st West	3168.31
1042	Neal-1613 Montana	3169.81
1043	Sticht-217 Catlin	3167.79
1044	Green-1629 Idaho	3166.40
1045	Malcom-1931 River Road	3161.63
1046	Siegford-1822 Hunton Lane	3163.66

WELL INVENTORY

1047	Western Mtn. Clinic-501 Front	3195.97
1048	Rancho Motel-1010 W. Broadway	3179.58

Ditches	Location	Surveyed Elevation (ft.)
D-1	small walk bridge over Orchard Homes Ditch, inside east gate of Champion yard, measured to blue arrow	3175.22
D-2	car bridge over Orchard Homes Ditch, west side of Champion yard, measured to blue arrow on west side	3170.08
D-3	Orchard Homes Ditch head-gate, west side of Champion yard, measured to blue arrow	3169.24
D-4	Orchard Homes Ditch culvert, Idaho and California Streets, measured to top of concrete on west side	3168.21*
D-5	Orchard Homes Ditch culvert, Russell Street, measured to blue mark on lower lip of steel on east side	3168.25
D-6	Missoula Ditch culvert, southeast side of Champion yard beneath railroad track, measured to top of concrete on west side	3188.21
D-7	Missoula Ditch culvert, California Street, measured to top of north culvert on west side	3176.34

* - surveyed elevation is probably inaccurate

Unadjusted Monthly Water Level Measurements from Monitoring Program
Champion Missoula Sawmill Spill - July, 1986 to June, 1987

WELL # MONTH>	JULY	SEPT.	OCT.	NOV.	JAN.	FEB.	MAR.	APRIL	MAY	JUNE
McPARK	3146.37	3143.79	3141.33	3140.16	3138.36	3137.49	3137.65	3138.91	3144.38	3145.82
3091*	3144.15	3141.09	3138.93	3138	3136.02		3135.5	3137.11	3142.47	3143.65
3092*	3145.18	3142.61	3140.52	3139.17	3137.25	3136.59	3136.76	3138	3143.44	3144.73
3093	3143.53	3140.85	3138.69	3137.4	3135.44	3134.87	3135.12	3136.57	3141.95	3143
S-3001	3145.17	3142.56	3140.51	DRY	DRY	DRY	DRY	DRY	3143.51	3144.67
D-3001	3145.17	3142.68	3140.59	3139.25	3137.37	3136.71	3136.87	3138.1	3143.54	3144.8
S-3002	3144.96	3142.35	3140.13	3138.96	DRY	DRY	DRY	DRY	3143.25	3144.43
D-3002	3144.58	3141.99	3139.84	3138.53	3136.58	3135.97	3136.18	3137.45	3142.93	3144.14
S-3003	3143.99	3141.31	3139.11	3137.81	DRY	DRY	DRY	3136.81	3142.34	3143.49
D-3003*	3143.78	3141.03	3138.85	3137.55	3135.52	3134.97	3135.24	3136.56	3142.04	3143.22
S-3004	3143.99	3141.24	3139.03	3137.73	DRY	DRY	DRY	3136.82	3142.31	3143.45
D-3004	3143.79	3140.98	3138.8	3137.51	3135.43	3134.88	3135.18	3136.52	3141.96	3143.14
1001*	3143.97	3141.27	3138.16	3137.79	3135.8	3135.28	3135.55	3136.82	3142.37	3143.44
1003*	3143.72	3140.96	3138.75	3137.44	3135.45	3134.88	3135.16	3136.5	3142	3143.09
1004*	3143.65	3140.93	3138.73	3137.43	3135.43	3134.85	3135.15	3136.46	3141.99	3143.1
1005*	3143.72	3140.97		3137.43			3135.19	3136.5	3142.06	3143.13
1006*	3143.78	3141.07	3138.84	3137.54	3135.57	3135	3135.28	3136.6	3142.13	3143.16
S-1008	3143.64	3140.92	3138.62	3137.38				3136.45	3142	3143.05
D-1008	3143.42		3138.43	3137.17	3135.15	3134.63	3134.88	3136.25	3141.78	3142.75
1009*	3143.21	3140.52	3138.28	3136.98	3135	3134.44	3134.73	3136.11	3141.58	3142.48
1010	3143.39	3140.72	3138.43	3137.18	3135.2	3134.62	3134.88	3136.22	3141.8	3142.82
1011*	3143.22	3140.51	3138.21	3136.99	3134.87	3134.4	3134.7	3136.03	3141.6	3142.56

WELL # MONTH>	JULY	SEPT.	OCT.	NOV.	JAN.	FEB.	MAR.	APRIL	MAY	JUNE
1012*	3143.15	3140.45	3138.16	3136.92	3134.91	3134.35	3134.65	3136	3141.54	3142.5
1013	3143.43	3140.69	3138.41	3137.18	3135.18	3134.61	3134.91	3136.25	3141.88	3142.86
1014	3143.11	3140.82	3138.56	3137.33			3134.81		3141.72	
S-1016	3143.28	3140.57	3138.31	3137.11	3135.02	3134.48	3134.77	3136.13	3141.66	3142.7
D-1016	3142.91	3140.31	3138.01	3136.78	3134.72	3134.18	3134.5	3135.87	3141.38	3142.38
1017	3143.44	3140.7	3138.83	3137.41	3135.2			3136.36		3142.94
1018	3143.95	3141.11	3138.97	3137.74	3135.73	3135.07	3135.42	3136.79	3142.32	3143.43
S-1020	3143.94	3141.21	3138.96	3137.7	3135.71	3135.14	3135.41	3136.76	3142.31	3143.4
D-1020	3143.69	3140.96	3138.73	3137.45	3135.44	3134.87	3135.16	3136.55	3141.96	3143.08
1021*	3143.46	3140.87	3138.66	3137.42	3135.35	3134.8	3135.08	3136.41	3141.9	3143.02
S-1022	3143.54	3140.77	3138.49	3137.25	3135.22	3134.67	3134.94	3136.3	3141.93	3142.96
D-1022	3143.2	3140.42	3138.18	3136.96	3134.89	3134.37	3134.66	3136.04	3141.55	3142.59
1023*	3143.1	3140.39	3138.08	3136.85	3134.81	3134.25	3134.56	3135.91	3141.44	3142.48
1024*	3143.05	3140.3	3138.03	3136.8	3134.72	3134.22	3134.53	3135.9	3141.42	3142.44
1025			3138.29	3137	3134.96	3134.45	3134.73	3136.07	3141.64	3142.69
1026	3143.08	3140.3	3138.1	3136.79	3134.75	3134.23	3134.52	3136.03	3141.45	3142.47
1027	3142.83	3140	3137.11	3136.49	3134.47	3133.93	3134.2	3135.72	3141.23	3142.19
1028	3143.82	3140.94	3138.93	3137.64	3135.83	3135.12	3135.35	3136.65	3142.23	3143.26
1029	3142.89		3137.26			3133.9	3134.26	3135.79	3141.19	3142.18
1030*			3137.31	3136.01	3134.09	3133.43	3133.79	3135.34	3140.79	3141.75
1034*		3140.45	3138.24	3136.77	3134.87	3134.37	3134.65	3136	3141.49	3142.01
1035	3143.42	3140.56	3138.4	3137.08	3135.01					
1037	3143.43	3140.59	3138.38	3137.06	3134.95	3134.47	3134.8	3136.21	3141.79	3142.82
1039	3143.32	3140.57	3138.28	3136.98	3134.92	3134.42	3134.74	3136.12	3141.74	3142.7
1040*	3143.48	3140.73	3138.55	3137.25	3135.16	3134.65	3134.94	3136.28	3141.74	3142.91

WELL #	MONTH>	JULY	SEPT.	OCT.	NOV.	JAN.	FEB.	MAR.	APRIL	MAY	JUNE
1041		3144.2	3141.58	3139.37	3138.08	3136.13	3135.57	3135.79	3137.05	3142.64	3143.66
1042				3137.94	3136.63	3134.63	3134.11	3134.44	3135.94	3141.4	3142.32
1043				3136.34	3135.08	3133.04	3132.58	3132.91	3134.39	3139.9	3140.57
1044				3137.3	3135.98	3133.93	3133.43	3133.79	3135.32	3140.74	3141.68
1045				3135.71	3134.5						
1046				3136.68	3135.39	3133.24	3132.66	3133.18	3134.81	3140.13	3141.03
1047		3145.5	3143.53	3141.02	3139.48	3137.62	3136.9	3137.06	3138.26	3143.36	3144.94
1048		3144.98	3141.94	3139.76	3136.76	3136.21	3135.66	3136.03	3137.44	3142.78	3144.18

---wells deeper than 60 feet

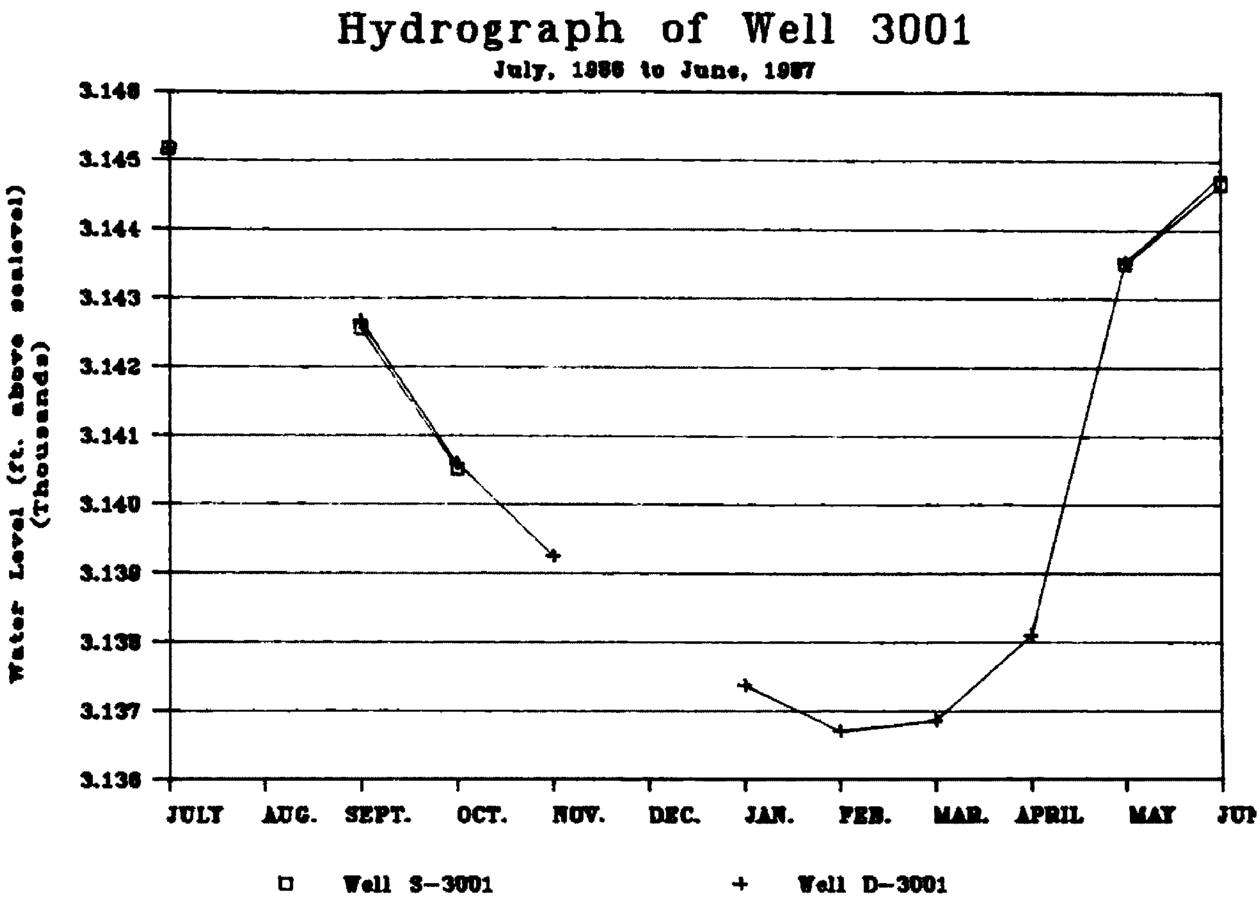
RIVER STAGE	MONTH>	JULY	SEPT.	OCT.	NOV.	JAN.	FEB.	MAR.	APRIL	MAY	JUNE
RAILRD BRIDGE		3163.66	3163.62	3163.44	3163.52	ICE	3163.11	3163.34	3164.01	3164.45	3163.4
RUSSELL ST.BRDGE	-	3155.87	3155.77	3155.63		3156.19	3155.13	3155.46	3156.14	3156.86	3155.44
DITCHES	-										
D-1		3163.7	3168.76	DRY	DRY	DRY	DRY	DRY	3168.38	3168.83	3168.65
D-2		3165.99	3166.2	DRY	DRY	DRY	DRY	DRY	3165.65	3166.04	3165.85
D-3		3166.08									
D-4		3165.24	3165.49	DRY	DRY	DRY	DRY	DRY	DRY	3165.25	3164.88
D-5		3165.18	3165.37	DRY	DRY	DRY	DRY	DRY	DRY	3165.2	3164.91
D-6		3177.67		DRY	DRY	DRY	DRY	DRY	DRY	3183.2	3177.87
D-7		3174.23	3173.62	DRY	DRY	DRY	DRY	DRY	DRY	3174.72	3174.45

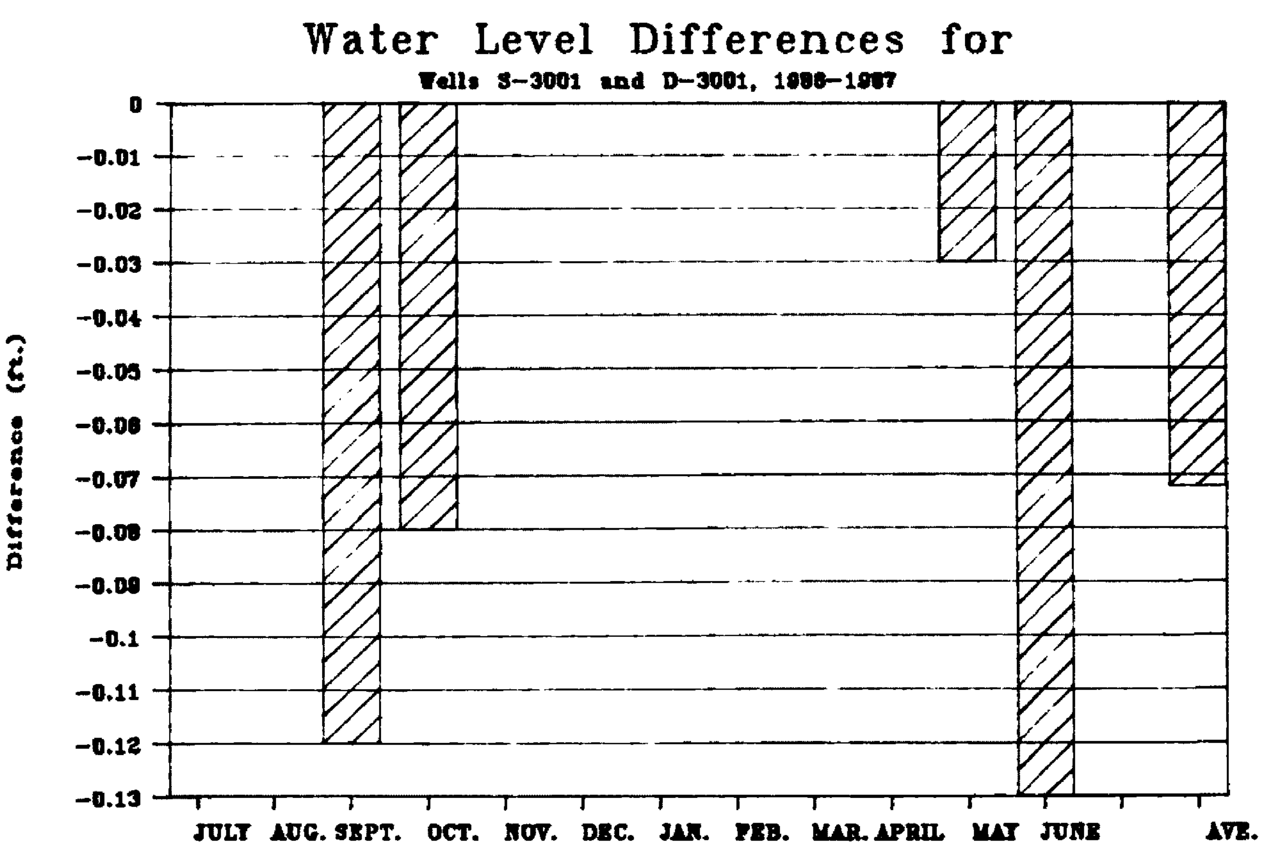
Monthly Water Level Adjustments to Wells Deeper than 60 Feet (+ ft.)

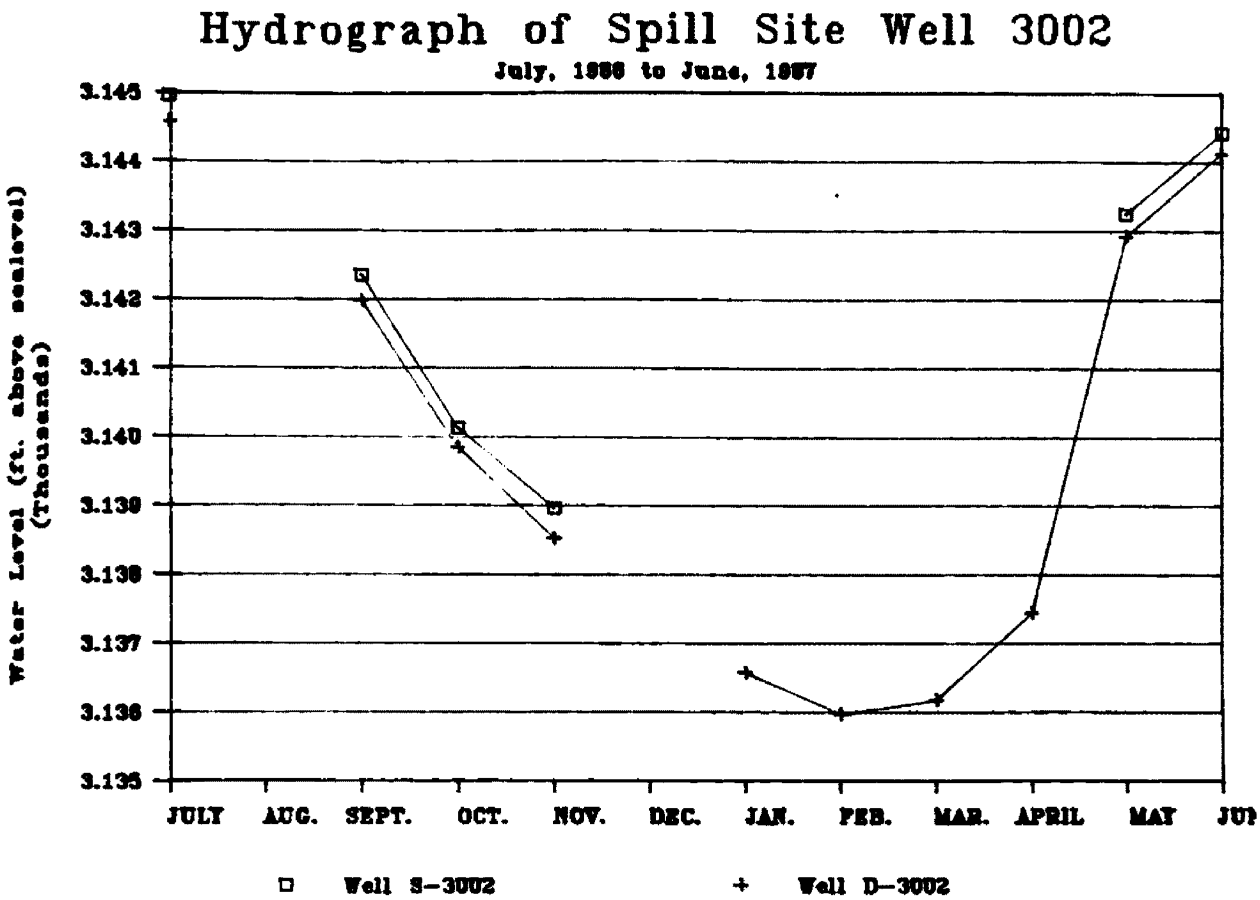
July	0.28
Sept	0.29
Oct	wells east of well 1008 0.24, wells west 0.3
Nov	wells east of well 1008 0.23, wells west 0.31
Jan	0.3
Feb	0.29
March	0.26
April	0.23
May	0.32
June	0.32

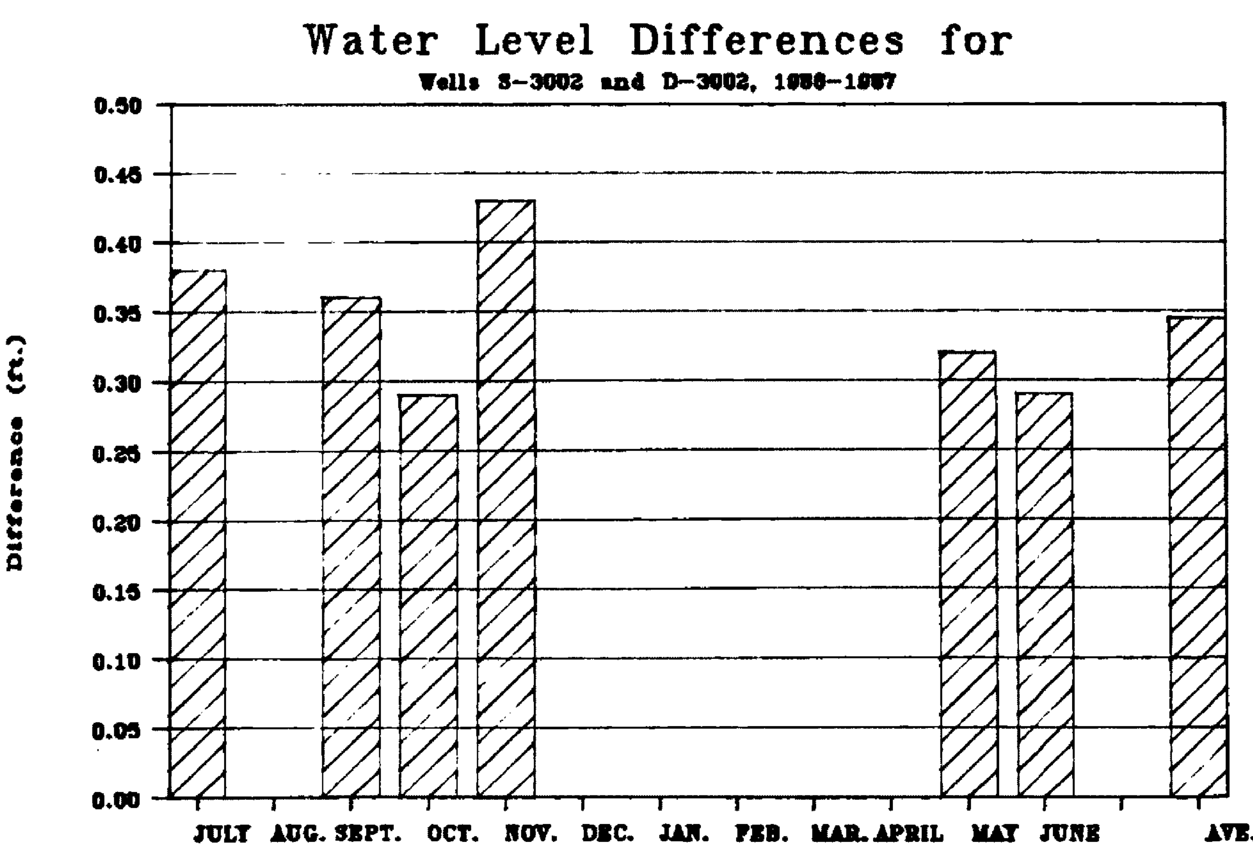
Water Level Differences Between Shallow and Deep Wells in Double Well groups

WELL # MONTH>	JULY	SEPT.	OCT.	NOV.	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	Average
3001	0	-0.12	-0.08						-0.03	-0.13	-0.07
3002	0.38	0.36	0.29	0.43					0.32	0.29	0.34
3003	0.21	0.28	0.26	0.26				0.25	0.3	0.27	0.26
3004	0.2	0.26	0.23	0.22				0.3	0.35	0.31	0.27
1008	0.22		0.19	0.21				0.2	0.22	0.3	0.22
1016	0.37	0.26	0.3	0.33	0.3	0.3	0.27	0.26	0.28	0.32	0.3
1020	0.25	0.25	0.23	0.25	0.27	0.27	0.25	0.21	0.35	0.32	0.26
1022	0.34	0.35	0.31	0.29	0.33	0.3	0.28	0.26	0.38	0.37	0.32
Average	0.28	0.29	0.26	0.28	0.3	0.29	0.27	0.25	0.31	0.31	


Hydrograph of Well 3001
July, 1986 to June, 1987
Water Level (ft. above sealevel) (Thousands)
3.146
3.145
3.144
3.143
3.142
3.141
3.140
3.139
3.138
3.137
3.136
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APRIL
MAY
Well S-3001
Well D-3001

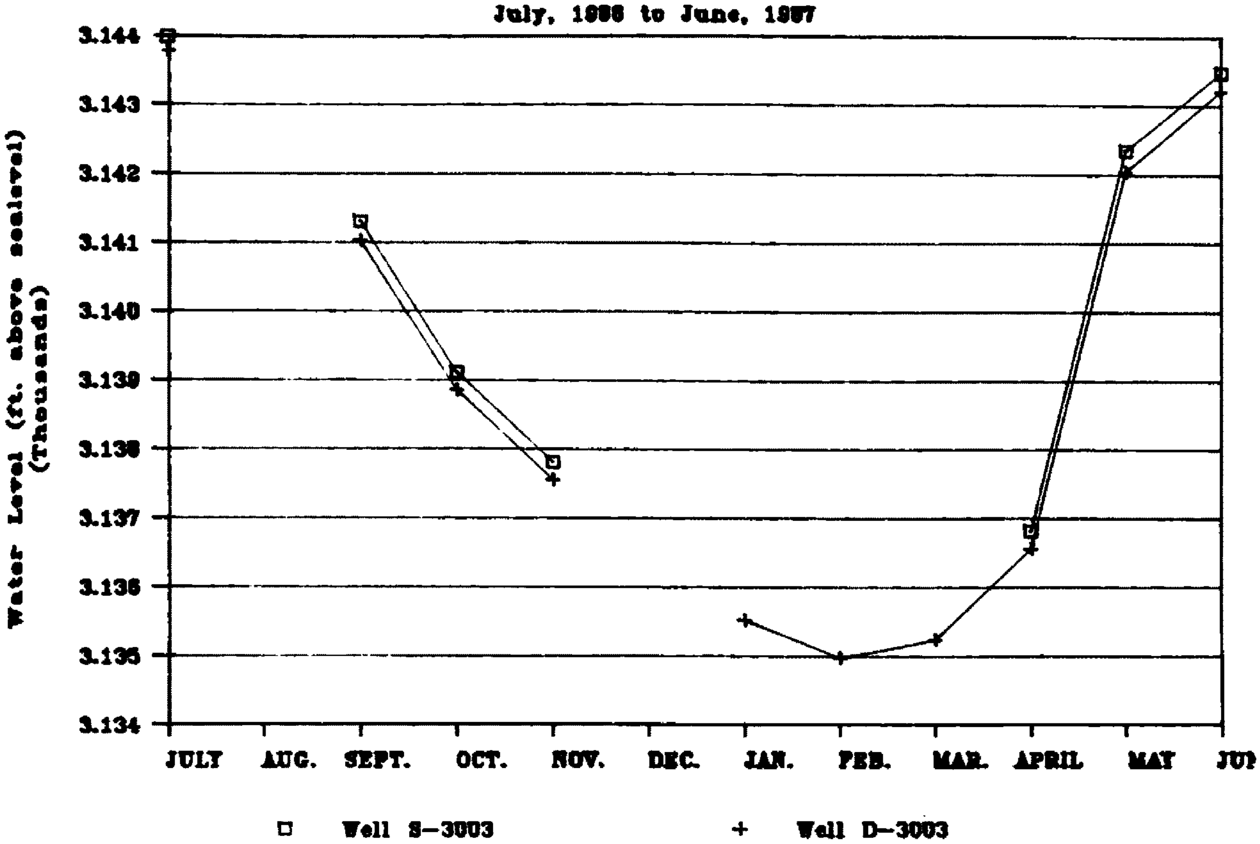

Water Level Differences for
Wells S-3001 and D-3001, 1986-1987
Difference (ft.)
0
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
-0.07
-0.08
-0.09
-0.1
-0.11
-0.12
-0.13
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APRIL
MAY
JUNE
AVE.


Hydrograph of Spill Site Well 3002
July, 1986 to June, 1987
Water Level (ft. above sealevel)
(Thousands)
3.145
3.144
3.143
3.142
3.141
3.140
3.139
3.138
3.137
3.136
3.135
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APRIL
MAY
Well S-3002
Well D-3002


Water Level Differences for
Wells S-3002 and D-3002, 1986-1987
Difference (ft.)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APRIL
MAY
JUNE
AVE.

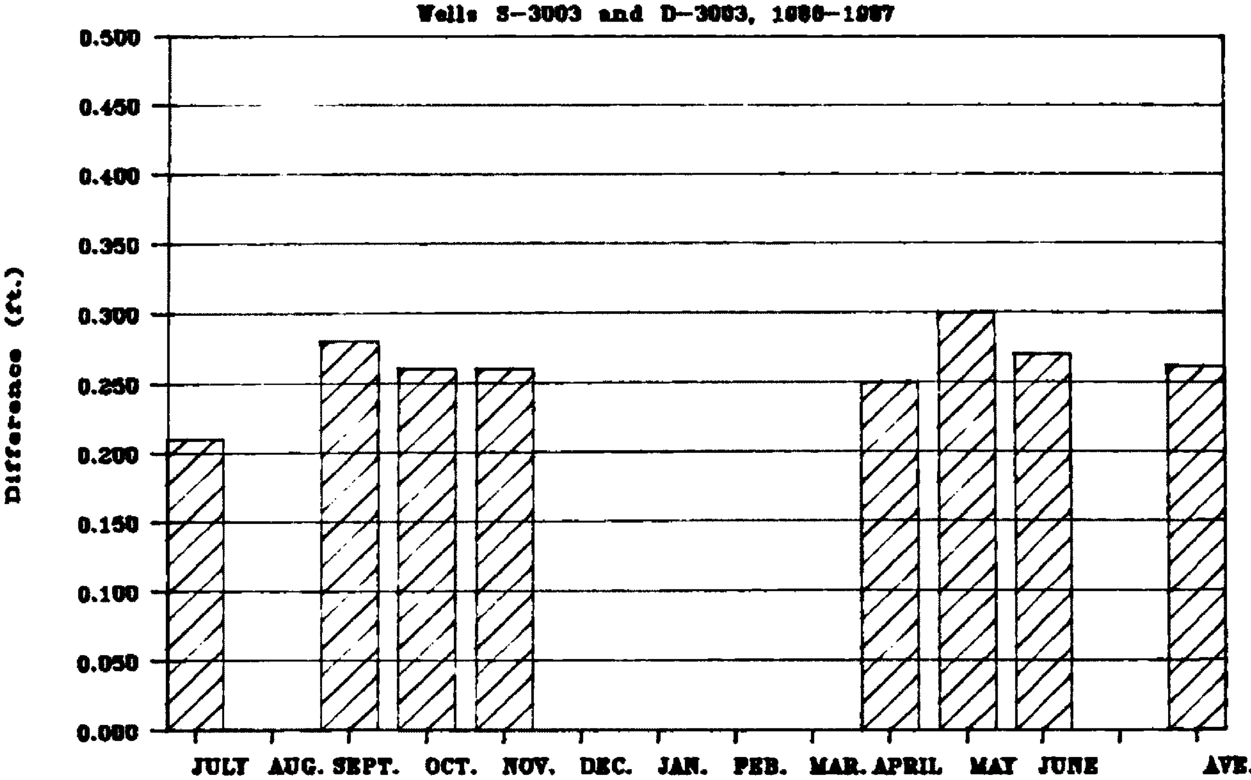
Hydrograph of Well 3003

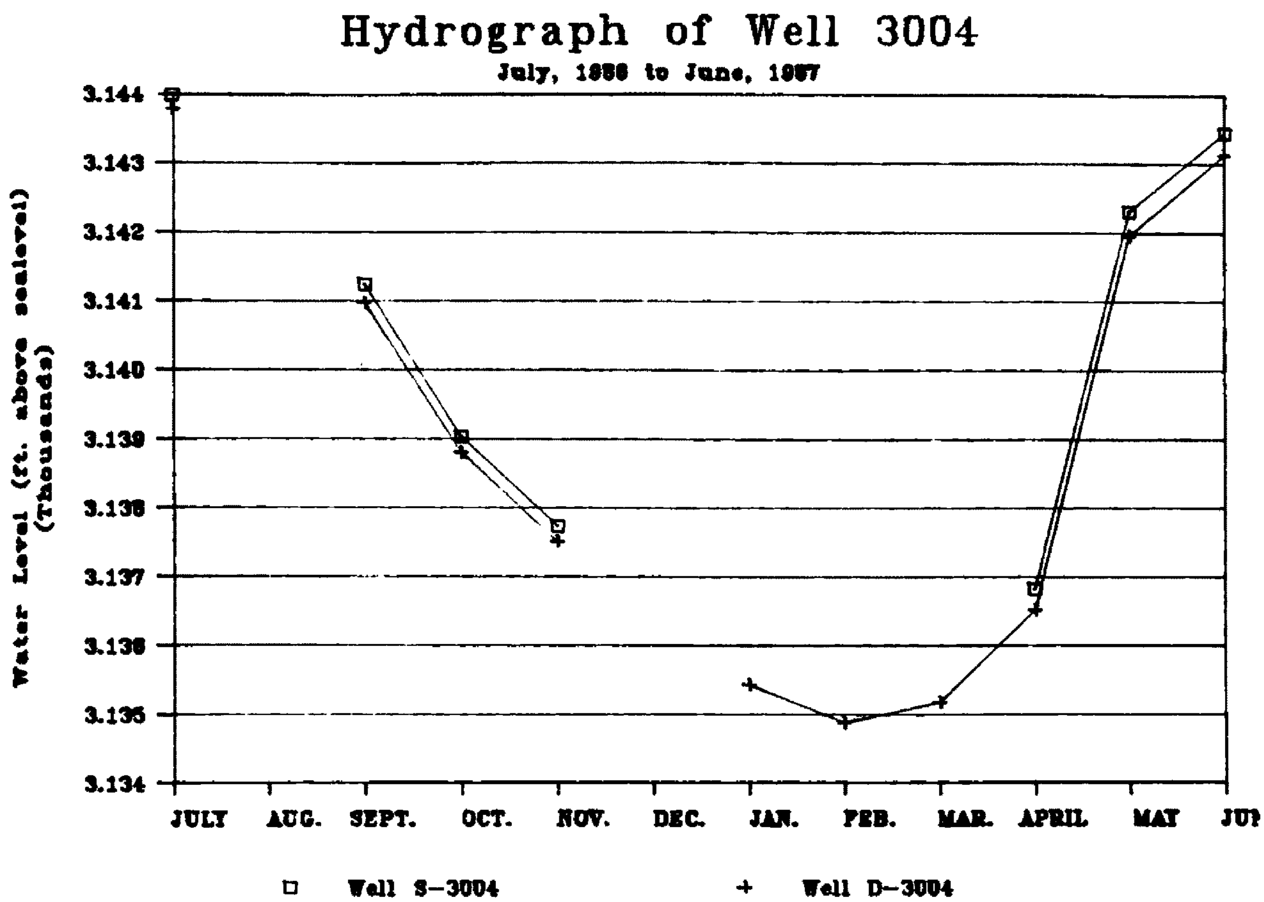
July, 1986 to June, 1987

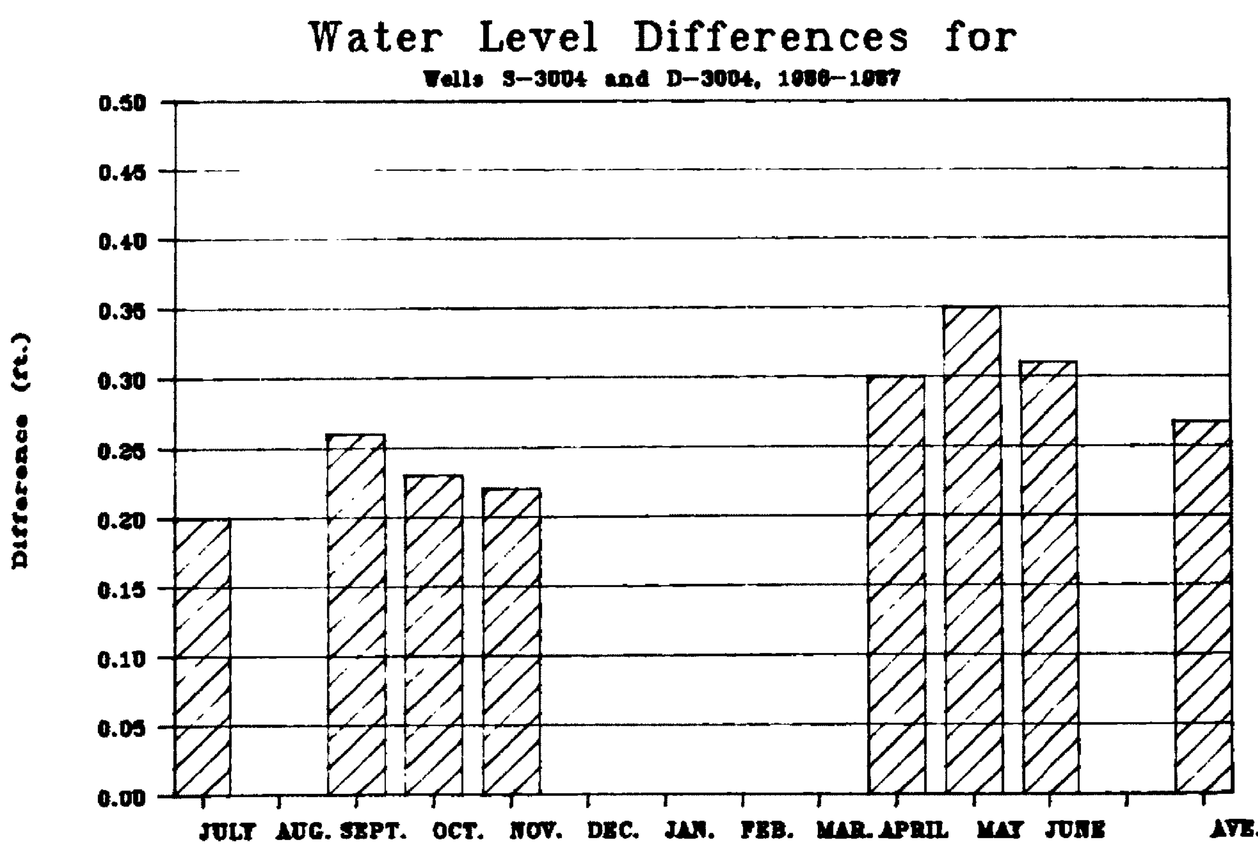


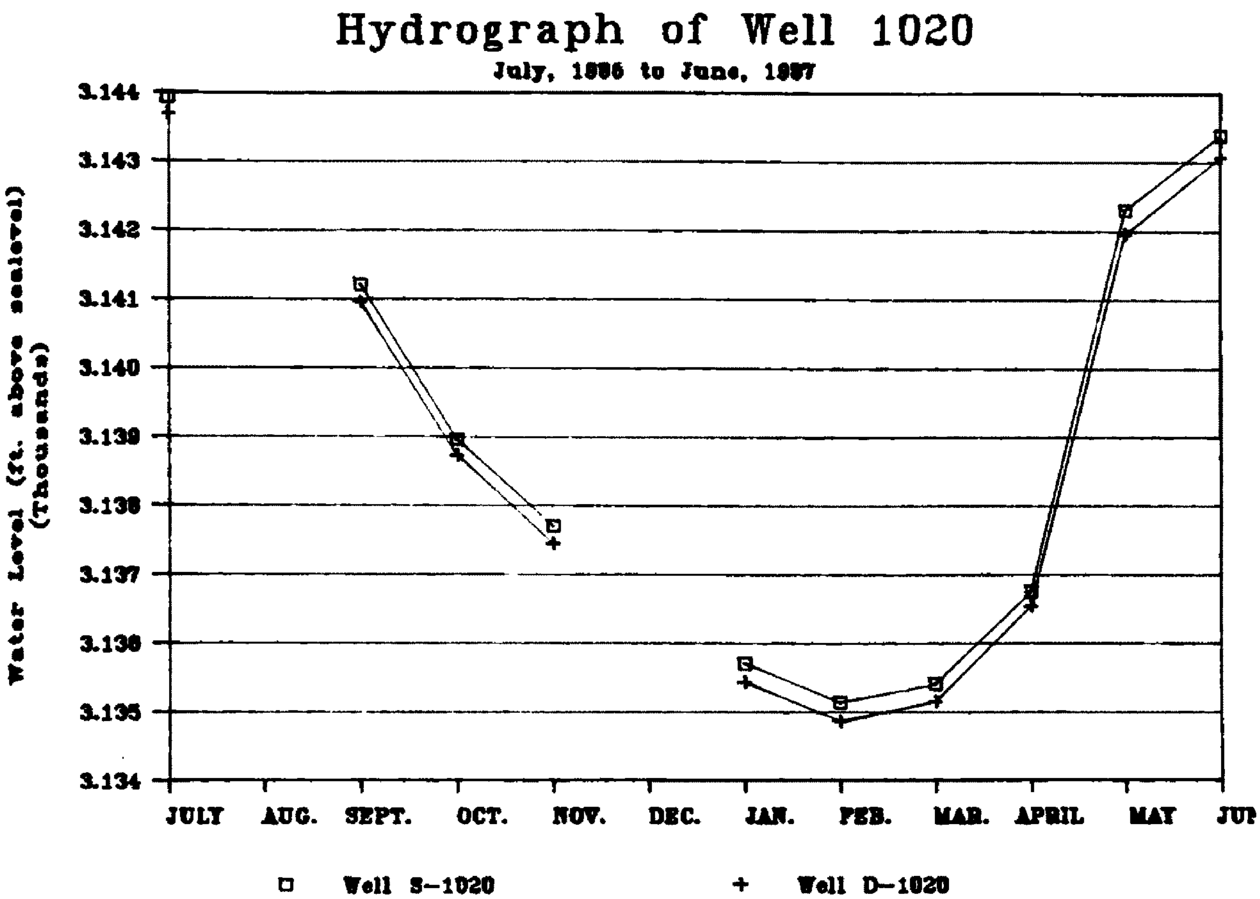
Water Level Differences for

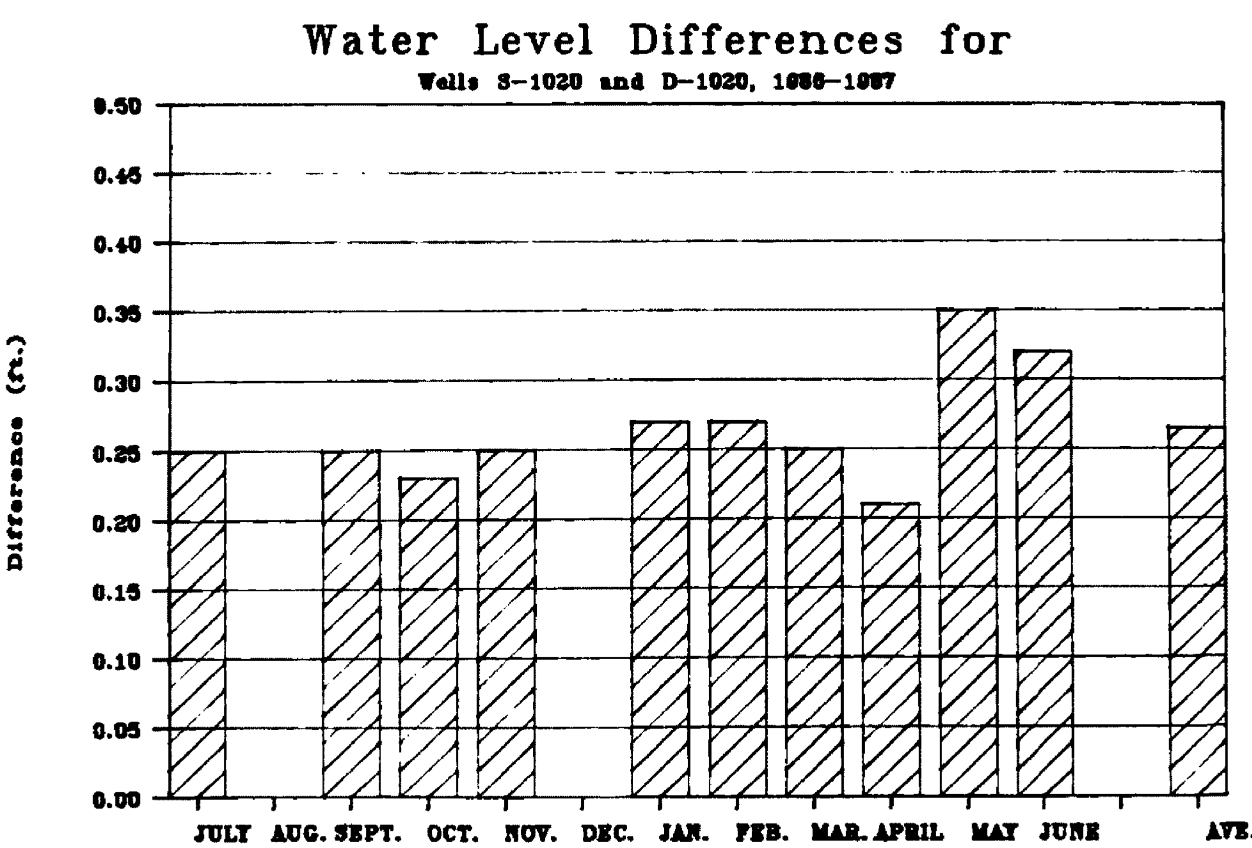
Wells S-3003 and D-3003, 1986-1987

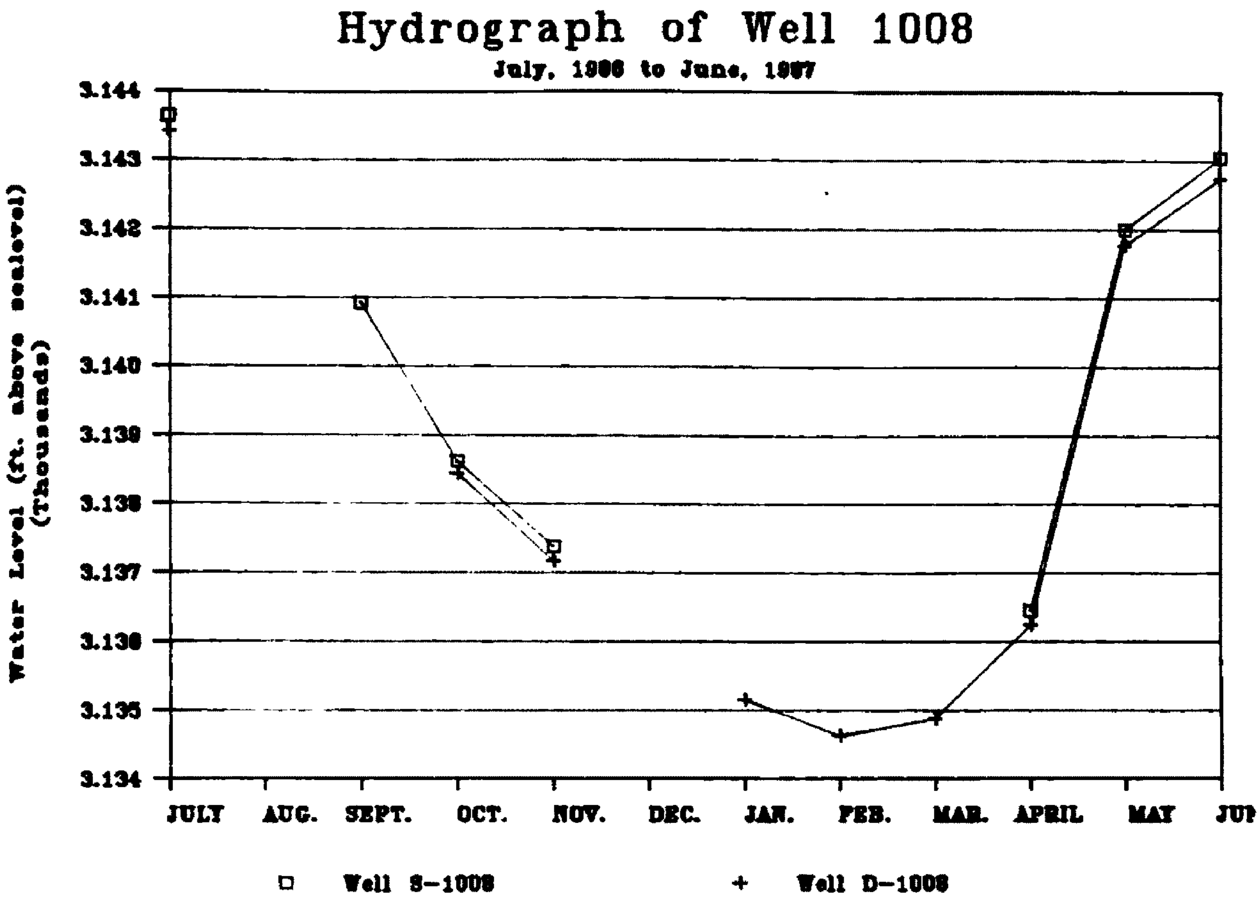


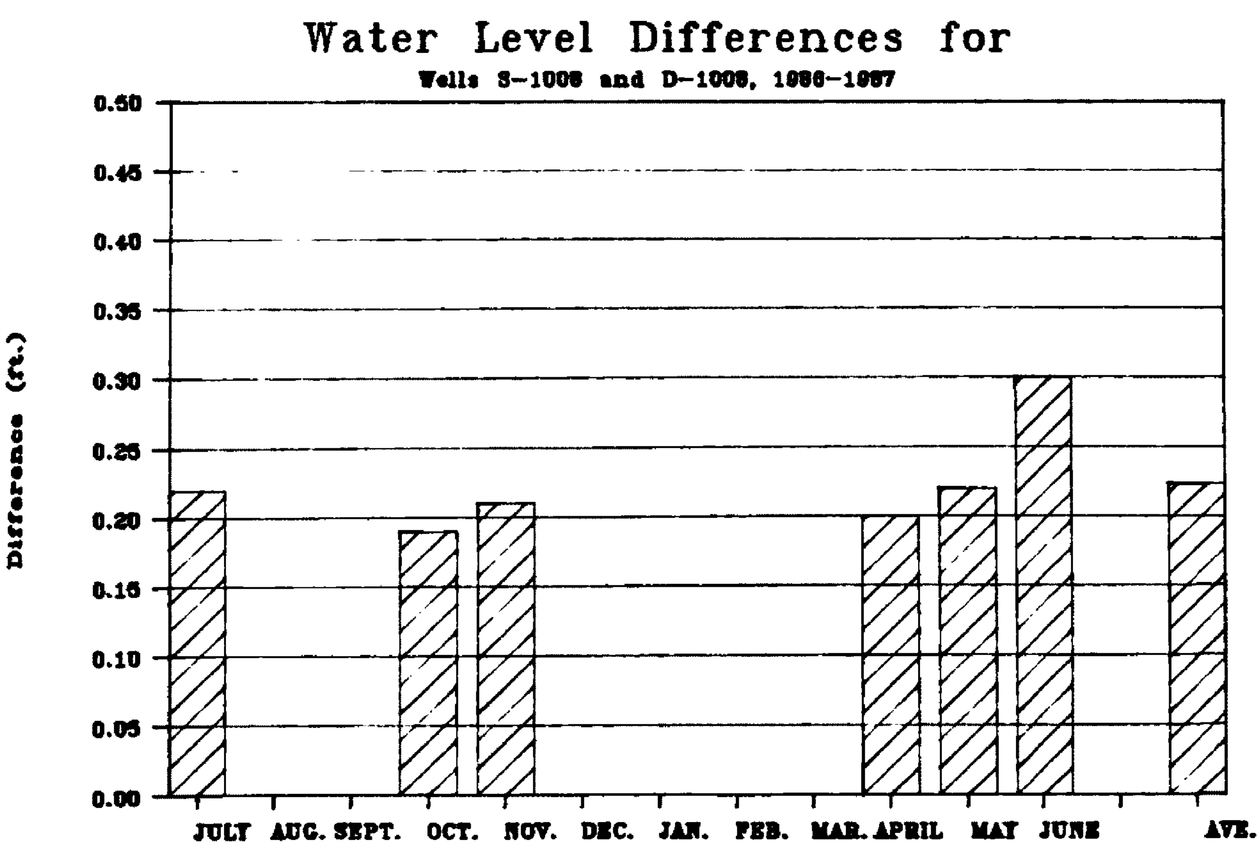

Hydrograph of Well 3004
July, 1986 to June, 1987
Water Level (ft. above sealevel) (Thousands)
3.144
3.143
3.142
3.141
3.140
3.139
3.138
3.137
3.136
3.135
3.134
JULY AUG. SEPT. OCT. NOV. DEC. JAN. FEB. MAR. APRIL MAY JU
Well S-3004
Well D-3004


Water Level Differences for
Wells S-3004 and D-3004, 1986-1987
Difference (ft.)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
JULY AUG. SEPT. OCT. NOV. DEC. JAN. FEB. MAR. APRIL MAY JUNE AVE.


Hydrograph of Well 1020
July, 1986 to June, 1987
Water Level (ft. above sealevel)
(Thousands)
3.144
3.143
3.142
3.141
3.140
3.139
3.138
3.137
3.136
3.135
3.134
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APRIL
MAY
JUN
Well S-1020
Well D-1020

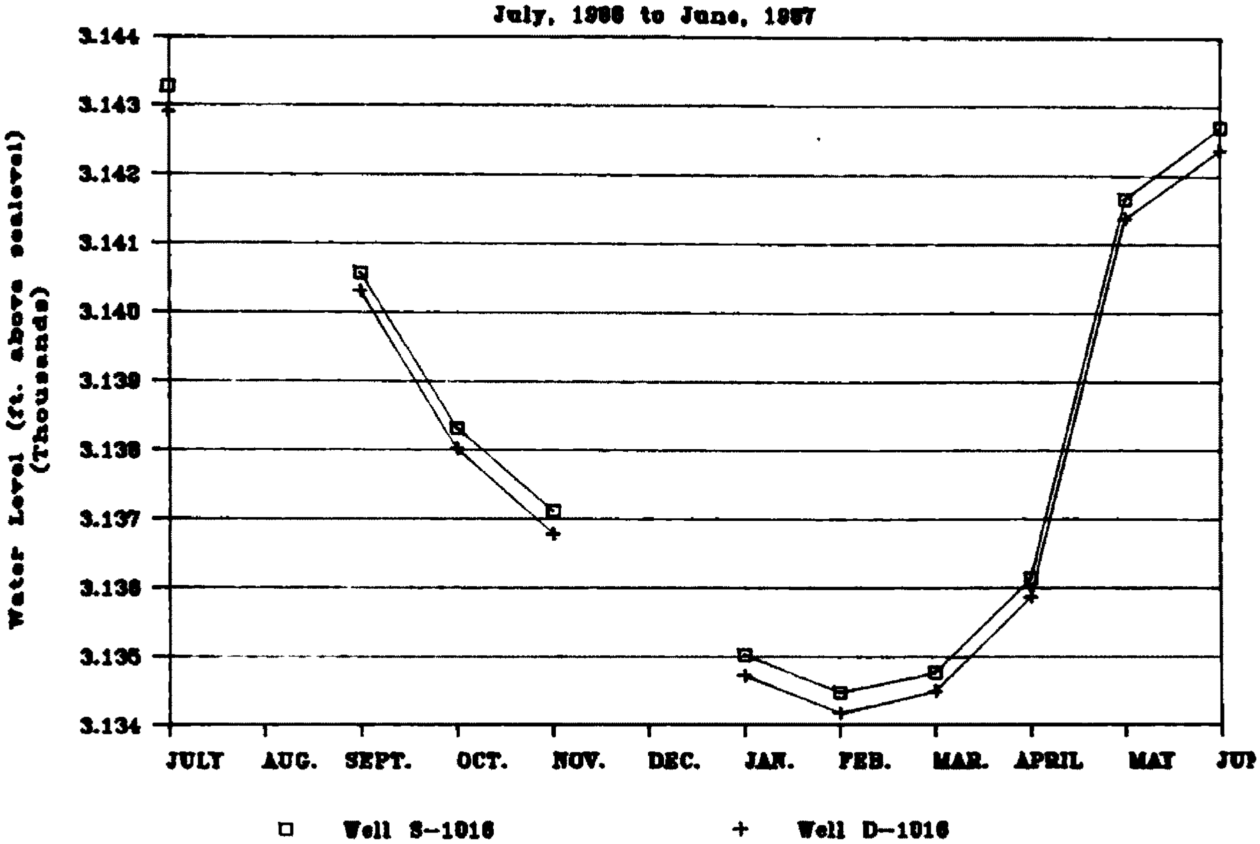

Water Level Differences for
Wells S-1020 and D-1020, 1986-1987
Difference (ft.)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APRIL
MAY
JUNE
AVE.


Hydrograph of Well 1008
July, 1986 to June, 1987
Water Level (ft. above sealevel)
(Thousands)
3.144
3.143
3.142
3.141
3.140
3.139
3.138
3.137
3.136
3.135
3.134
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APRIL
MAY
Well S-1008
Well D-1008


Water Level Differences for
Wells S-1008 and D-1008, 1986-1987
Difference (ft.)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APRIL
MAY
JUNE
AVE.

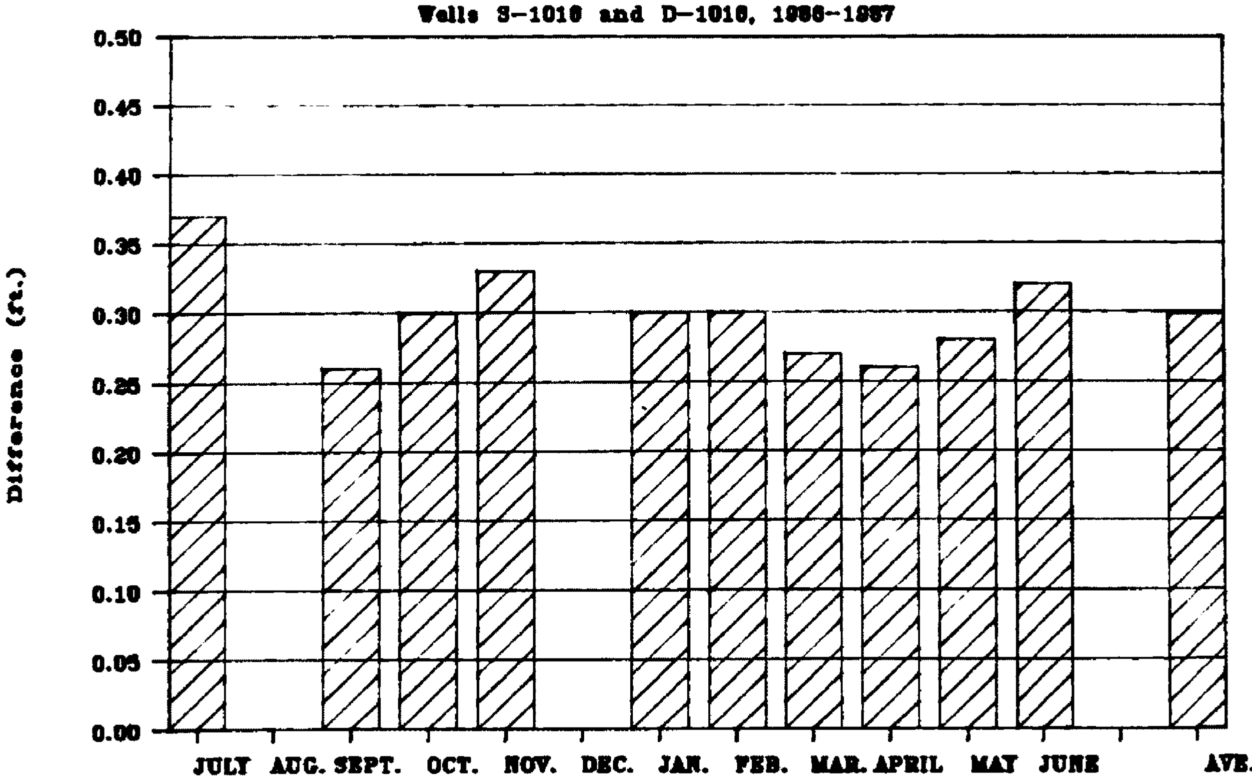
Hydrograph of Well 1016

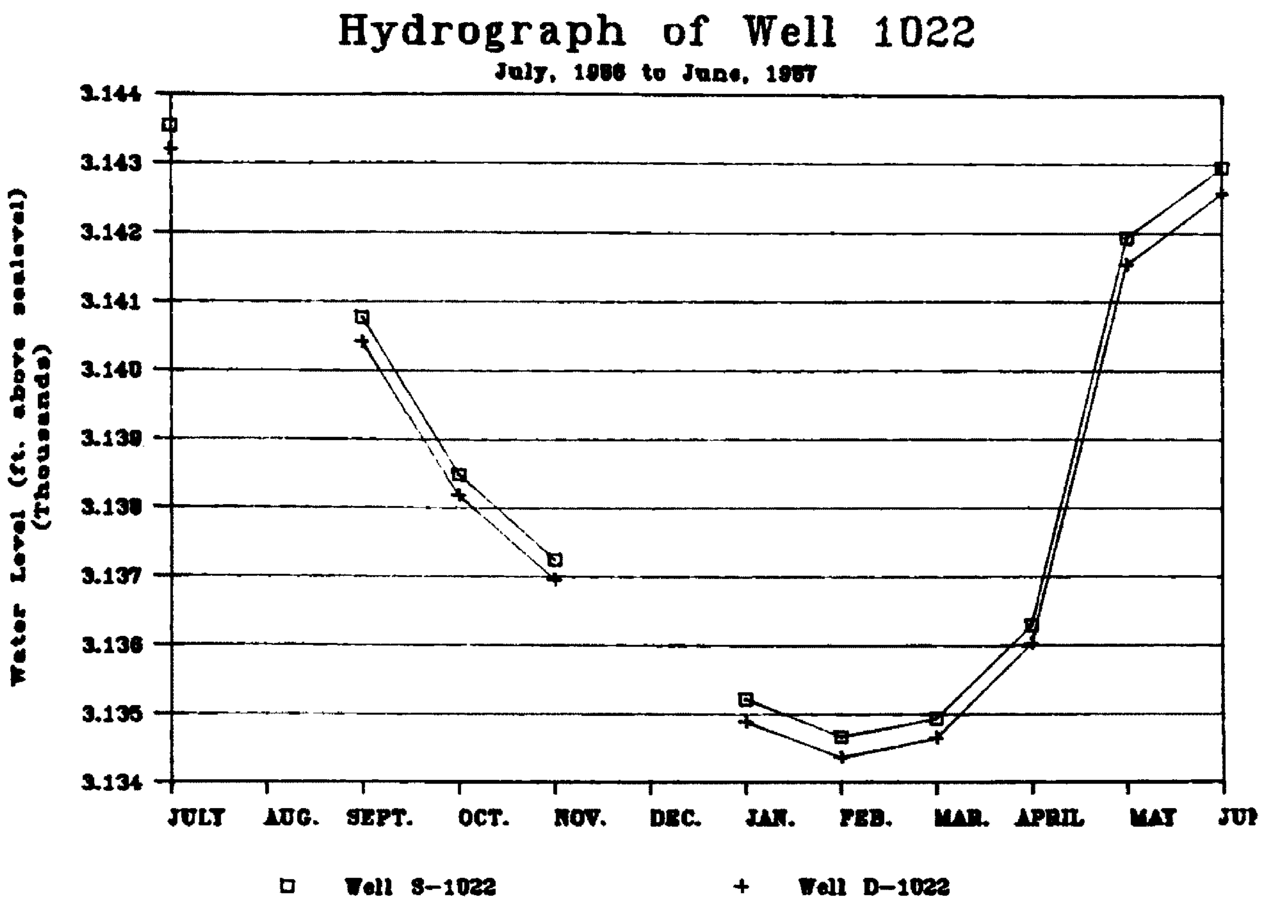
July, 1986 to June, 1987

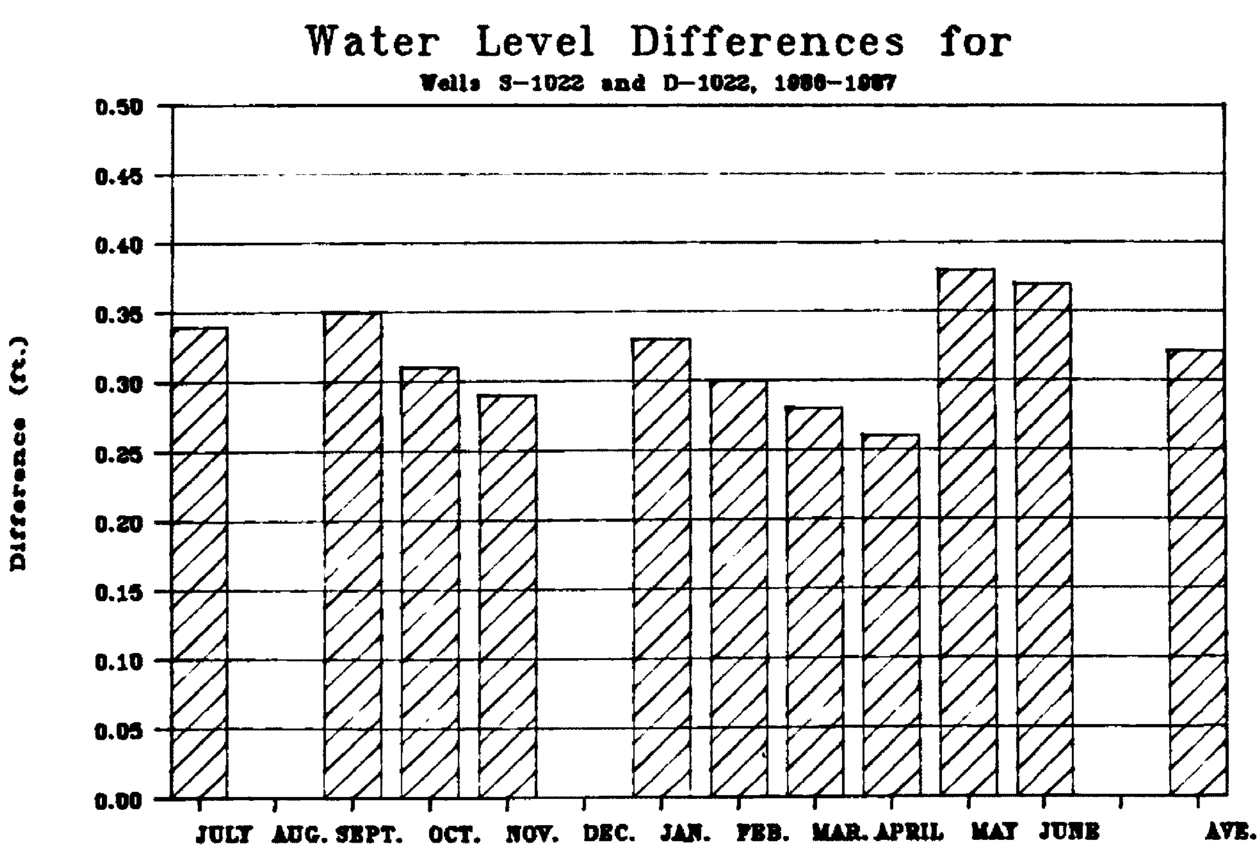


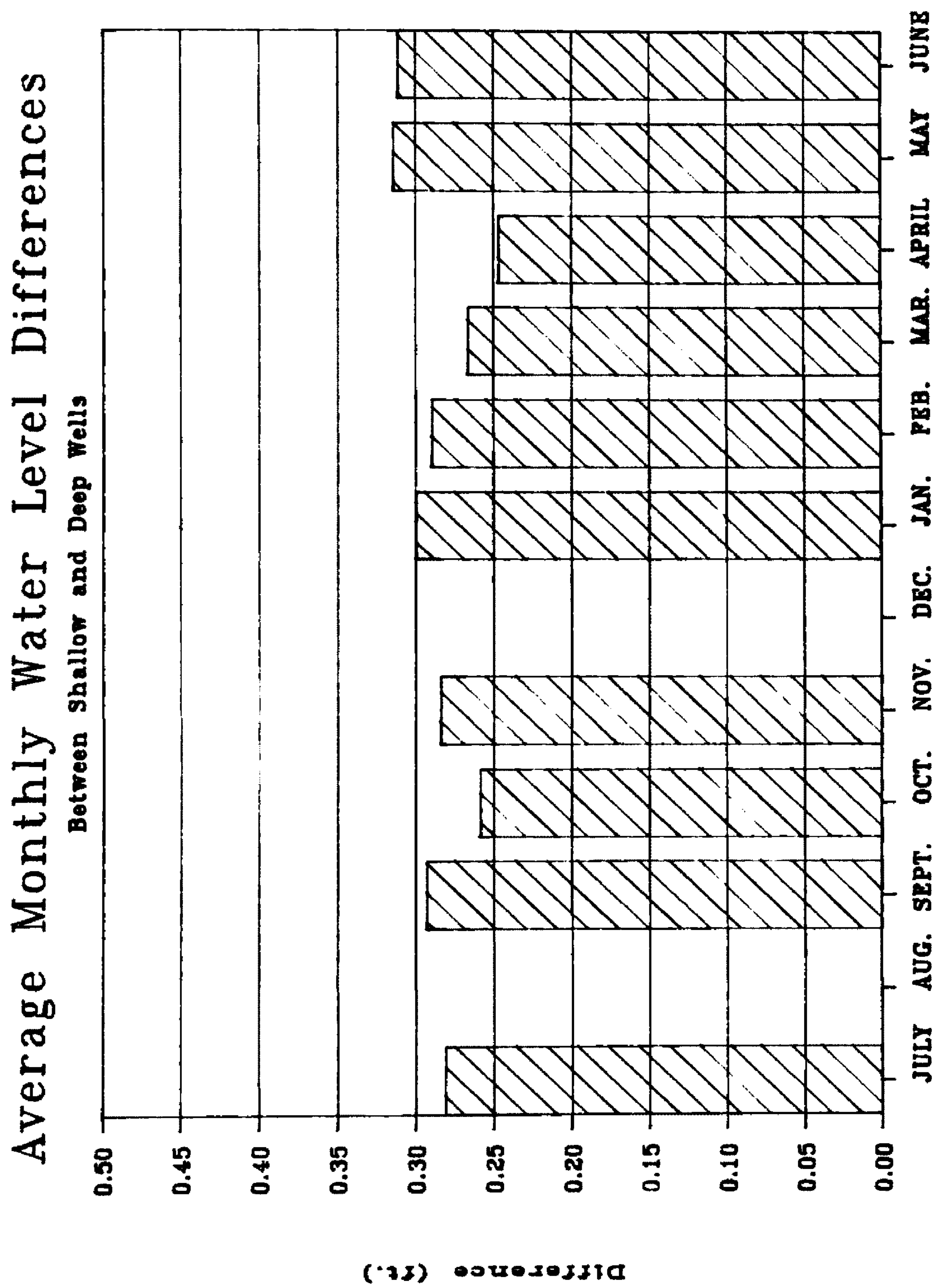
Water Level Differences for

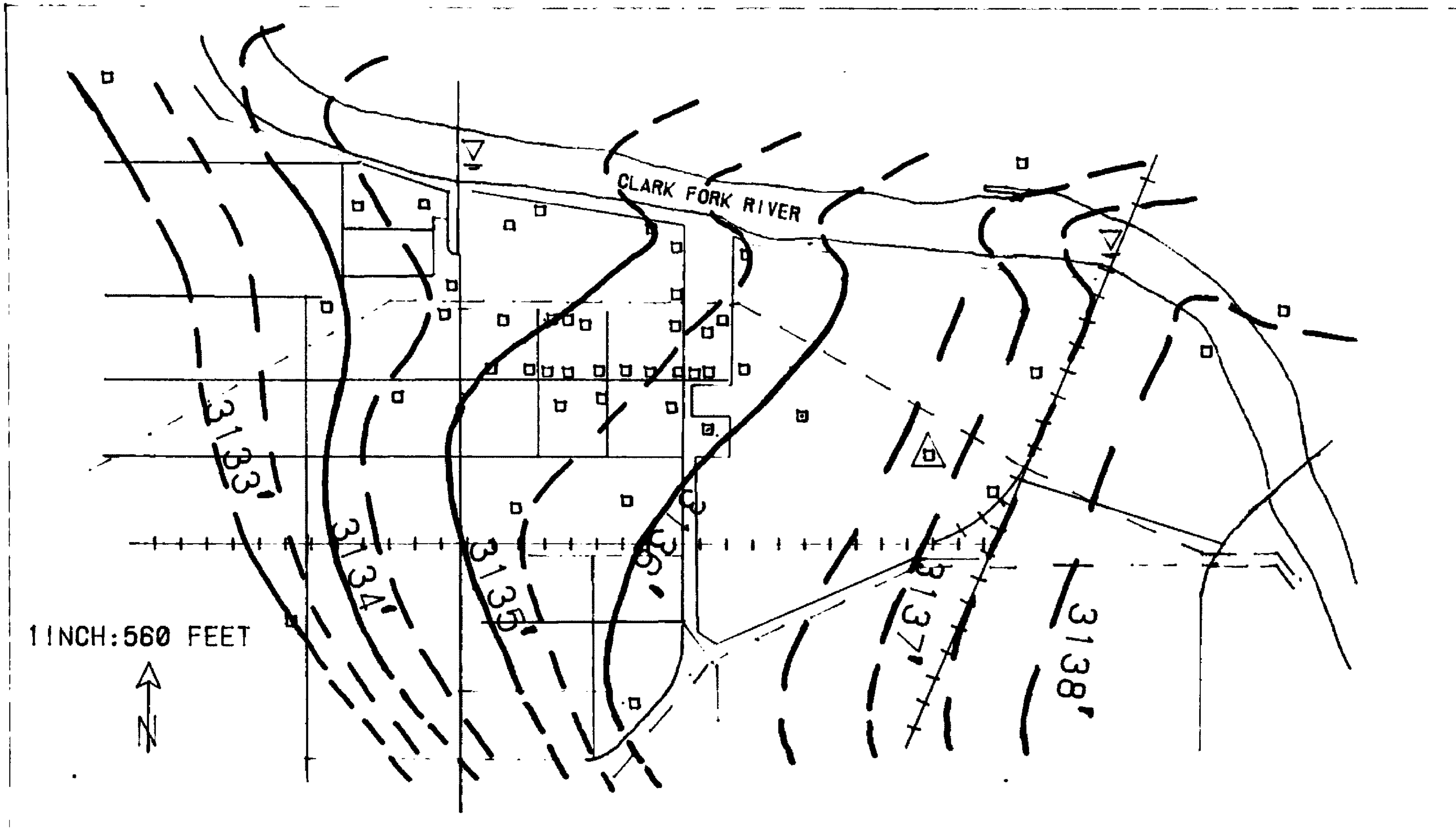
Wells S-1016 and D-1016, 1986-1987



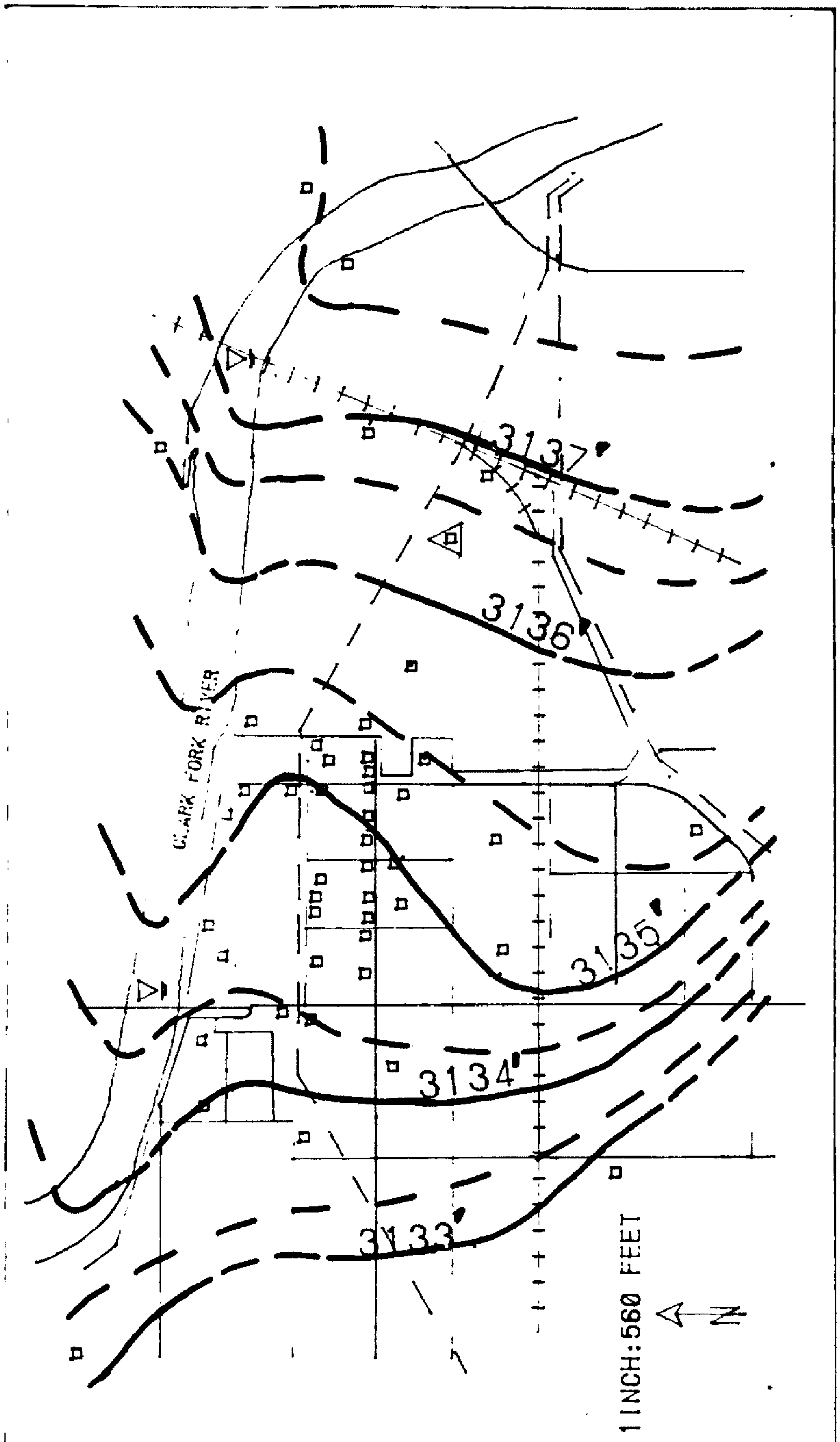

Hydrograph of Well 1022
July, 1986 to June, 1987
Water Level (ft. above sealevel) (Thousands)
3.144
3.143
3.142
3.141
3.140
3.139
3.138
3.137
3.136
3.135
3.134
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APRIL
MAY
Well S-1022
Well D-1022


Water Level Differences for
Wells S-1022 and D-1022, 1986-1987
Difference (ft.)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APRIL
MAY
JUNE
AVE.

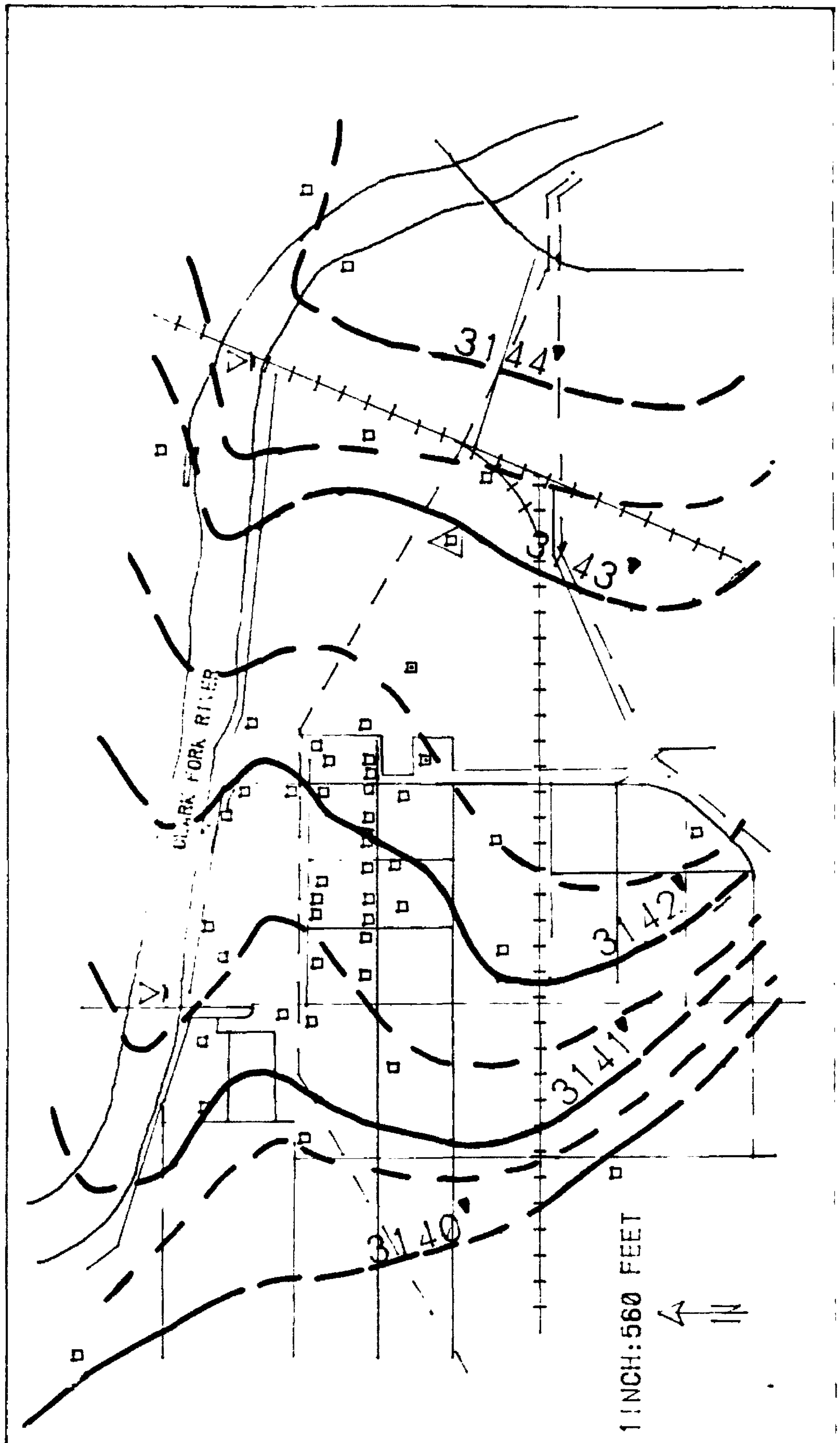

Average Monthly Water Level Differences
Between Shallow and Deep Wells
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Difference (ft.)
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APRIL
MAY
JUNE



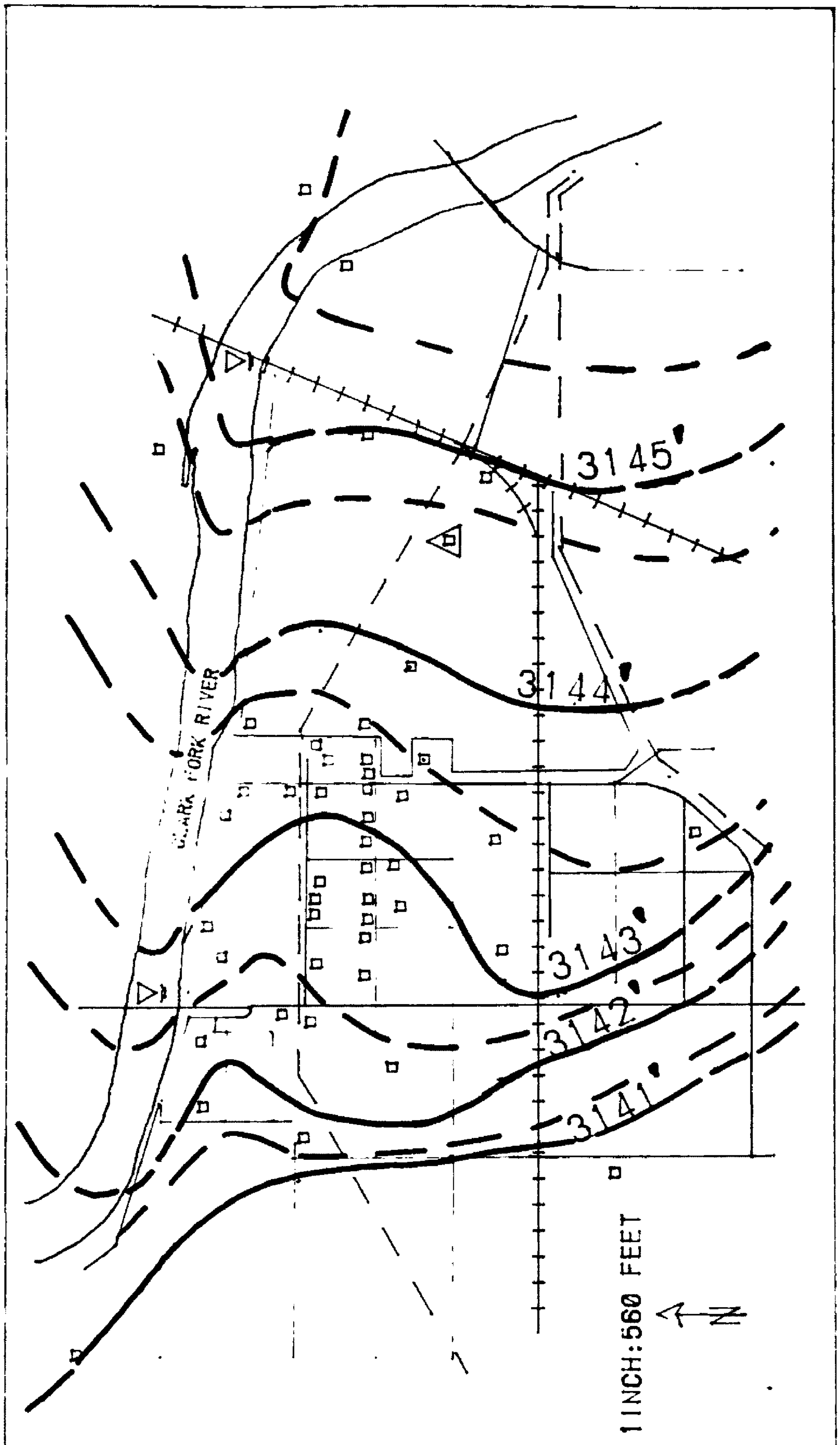
Potentiometric Surface - January, 1987



Potentiometric Surface - March, 1987



Potentiometric Surface - May, 1987



Potentiometric Surface - June, 1987

APPENDIX B

Depth of Wells Used in Water Quality Analyses

Well	Depth(ft.)	Well Dia.(in.)	Completion	Interval(ft.)
McPark	50	6	open bottom	50
3001-S	34	2	screen	28-34
3001-D	58	2	screen	55-58
3002-S	35	2	screen	29-35
3002-D	59	2	screen	56-59
3003-S	32	2	screen	26-32
3003-D	93	2	screen	90-93
3091	67	6	open bottom	67
1005	68	6	?	68
1008-S	35?	4	?	?
1018	?	4	?	?
1020-S	50	6	open bottom	60
1022-S	48	6	?	48
1037	?	6	?	?
1039	60	6	open bottom	60

August 19, 1986

Ms. Sara Weinstock
Montana Dept. of Health &
Environmental Sciences
Solid Waste Mng. Bureau
Room A-104
Cogswell Bldg.
Helena, MT 59620

F.I.T. ANALYSES
JULY, 1986
(3001-3004; 1005;
oil sump.)

Re: Champion International (Hart Oil) Analytical Results,
TDD R8-8509-07.

Dear Sara:

Enclosed are analytical results for groundwater and soil samples taken at Champion International (Hart Oil Refinery), Missoula, Montana by the MDHES. I have taken the liberty of tabulating some of the sample documentation information for easy reference to the data sheets (Table 1).

A cursory review of the data indicated that only a few HSL compounds were detected, and most of these were also detected in the blanks. Xylenes were tentatively identified in several samples. Lead was detected in a few samples, with values as high as 30 mg/l. In general, the organic data were found to be acceptable for use. Some qualifications for certain parameters were noted for inorganic data.

Please feel free to contact myself, Randy Greaves (organic QA) or Lynn Roberts (inorganic QA) if you have any questions regarding these data.

Sincerely,

Robert G. Smith, Jr.
Region VIII FIT

Following are our findings:

Chromatograms and mass spectra were inspected for all of the samples and blanks and were found be of good quality. All of the identified compounds were confirmed by the mass spectra and retention times provided in the data package. Response factors, % RSD, % D, recoveries of surrogates and the concentration calculations were checked and were found to be correct. Samples HC 326 and HC 328 had to be re-extracted and re-analyzed because two of the acid surrogates were outside the QC limits.

Upon re-extraction and analysis the acid surrogates were still outside QC limits, indicating a sample matrix effect, rather than a difficulty in laboratory quality control.

Over all this was a well organized and complete data package. Only a small number of compounds were detected in any one sample and most of these compounds were also detected in the blanks. (i.e, methylene chloride, butylbenzyl phthalate and bis (2-ethylhexyl) phthalate).

DATA QUALIFIER DEFINITIONS
Region 8

For the purposes of this data review document the following code letters and associated definitions are provided.

U - The material was analyzed for, but was not detected. The associated numerical value is the estimated sample quantitation limit.

J - The associated numerical value is an estimated quantity because the amount detected is below the required limits or because quality control criteria were not met.

UB - Estimated sample quantitation limit increased. Amount found in sample reported. Compound detected at <5 X the amount in blank (<10 X for methylene chloride, acetone, toluene and phthalates).

UJ - Detection limit is estimated because quality control criteria were not met.

JB - The value is an estimated amount detected below required limits and also detected in the blank.

B - Compound was detected in the blank. Quantity reported is >5 X the amount found in the blank (>10 X for methylene chloride, acetone, toluene, and phthalates).

R - Quality Control indicates that data is not usable (compound may or may not be present). Resampling and reanalysis is necessary for verification.

Z - No analytical result.

N - Presumptive evidence of presence of material (tentative identification).

COMPOUNDS IDENTIFIED

Sample No. HC 322 - water 3001-S

Hazardous Substances List (HSL) Compounds Detected:

	Compound Name	Amount (µg/l)	Qualifier (if needed)	Comments
VOA	Methylene chloride	18	WB	
	Acetone	210	J	
BNA	butylbenzylphthalate	3	JB	
	Bis(2-Ethylhexyl)phthalate	3	JB	
PEST	None Detected	—	—	

Tentatively Identified Compounds Detected: see the attached sheet # 00126

No VOA compounds detected			
Aldol Condens. Prod			
" "			
Xylenes			

Spectra Matching Quality

✓ The spectra were examined and found to be of good matching quality.
___ The spectra were examined and found to be of poor matching quality due to:

Remarks:

COMPOUNDS IDENTIFIED

Sample No. HC 323 - water 3001-D

Hazardous Substances List (HSL) Compounds Detected:

	Compound Name	Amount (µg/l)	Qualifier (if needed)	Comments
VOA	Methylene chloride	5	JB	
BNA	None Detected.	—	—	
PEST	None Detected.			

Tentatively Identified Compounds Detected: see the attached page # 0157

No VOA TIC's identified.

Spectra Matching Quality

✓ The spectra were examined and found to be of good matching quality.

___ The spectra were examined and found to be of poor matching quality due to:

Remarks:

COMPOUNDS IDENTIFIED

Sample No. HC329

3003-S

Hazardous Substances List (HSL) Compounds Detected:

	Compound Name	Amount (µg/l)	Qualifier (if needed)	Comments
VOA.	Methylene chloride	2	JB	
BNA				
	bis(2-ethylhexyl)phthalate	2	JB	
	Butylbenzylphthalate	2	JB	
PEST.	None Detected.	—		

Tentatively Identified Compounds Detected: see the attached sheet # 0312

Spectra Matching Quality

✓ The spectra were examined and found to be of good matching quality.

___ The spectra were examined and found to be of poor matching quality due to:

Remarks:

COMPOUNDS IDENTIFIED

Sample No. HC 328 3003-S DUPLICATE

Hazardous Substances List (HSL) Compounds Detected:

	Compound Name	Amount (µg/l)	Qualifier (if needed)	Comments
VOA	Methylene chloride	2	JB	
BNA				
	Butylbenzylphthalate	2	JB	
	Bis(2-ethylhexyl)phthalate	5	J	
PEST	None Detected.			

Tentatively Identified Compounds Detected: see the attached sheet # 0274

Spectra Matching Quality

✓ The spectra were examined and found to be of good matching quality.
___ The spectra were examined and found to be of poor matching quality due to:

Remarks:

COMPOUNDS IDENTIFIED

Sample No. HC 271 - water sample 3003-D

Hazardous Substances List (HSL) Compounds Detected:

	Compound Name	Amount (µg/L)	Qualifier (if needed)	Comments
VOA	Methylene Chloride	3	JB	
BNA	Bis(2-ethylhexyl) phthalate	8	JB	
PEST	None Detected.			

Tentatively Identified Compounds Detected: see the attached page # 0061

No Volatiles Found

ONLY two BNA compounds, Xylenes, Aldol Condens. Prod.

Spectra Matching Quality

✓ The spectra were examined and found to be of good matching quality.

___ The spectra were examined and found to be of poor matching quality due to:

Remarks:

COMPOUNDS IDENTIFIED

Sample No. HC 327 - water 3004-S

Hazardous Substances List (HSL) Compounds Detected:

	Compound Name	Amount (µg/l)	Qualifier (if needed)	Comments
VOA	None Detected.	—	—	
BNA	None Detected			
PEST.	None Detected.			

Tentatively Identified Compounds Detected: see the attached pages #254

Compound Name	Amount	Qualifier	Comments
No VOA Compounds Detected.			
Xylene	20		

Spectra Matching Quality

✓ The spectra were examined and found to be of good matching quality.

___ The spectra were examined and found to be of poor matching quality due to:

Remarks:

COMPOUNDS IDENTIFIED

Sample No. HC 326 3004-D

Hazardous Substances List (HSL) Compounds Detected:

	Compound Name	Amount (μg/l)	Qualifier (if needed)	Comments
VOA	None Detected	—	—	
BNA	bis(2-ethylhexyl)phthalate	2	JB	
PEST	None Detected	—		

Tentatively Identified Compounds Detected: see the attached sheet #0219

Spectra Matching Quality

✓ The spectra were examined and found to be of good matching quality.
___ The spectra were examined and found to be of poor matching quality due to:

Remarks:

COMPOUNDS IDENTIFIED

Sample No. HC 324 - water 1005

Hazardous Substances List (HSL) Compounds Detected:

	Compound Name	Amount (µg/l)	Qualifier (if needed)	Comments
VOA	Methylene chloride	6	5B	
BNA	None Detected.	—	—	
PEST	None Detected.			

Tentatively Identified Compounds Detected: see the attached page # 0178

NO VOA Compounds.			

Spectra Matching Quality

✓ The spectra were examined and found to be of good matching quality.
___ The spectra were examined and found to be of poor matching quality due to:

Remarks:

COMPOUNDS IDENTIFIED

Sample No. HC 272 — Soil   oil sump by garage (Champion site)

Hazardous Substances List (HSL) Compounds Detected:

	Compound Name	Amount (μg/kg)	Qualifier (if needed)	Comments
VOA	Methylene Chloride	52	UB	
	Acetone	117	J	
	Toluene	75		
BNA	Di-n-octyl phthalate	1400	B	
PEST	None Detected.			

Tentatively Identified Compounds Detected: see the attached page # 0095

Several saturated Hydrocarbons.

Spectra Matching Quality

✓ The spectra were examined and found to be of good matching quality.
___ The spectra were examined and found to be of poor matching quality due to:

Remarks:

COMPOUNDS IDENTIFIED

Sample No. HC 325 – water BLANK ?

Hazardous Substances List (HSL) Compounds Detected:

	Compound Name	Amount (µg/l)	Qualifier (if needed)	Comments
VOA	Methylene Chloride	10	JB	
	Acetone	17	J	
BNA	None Detected	—		
PEST	None Detected.	—		

Tentatively Identified Compounds Detected: see the attached page # 0197

No VOA Compounds –

Spectra Matching Quality

✓ The spectra were examined and found to be of good matching quality.
___ The spectra were examined and found to be of poor matching quality due to:

Remarks:

COMPOUNDS IDENTIFIED

Sample No. HC 270 — water BLANK?

Hazardous Substances List (HSL) Compounds Detected:

	Compound Name	Amount (μg/l)	Qualifier (if needed)	Comments
VOA	Methylene Chloride	12	uB	Blank Compound.
	Acetone	100	J	initial calibration >30%.
	1,1,1-Trichloroethane	4	J	Below Det. lim.
	Toluene			
BNA	Bis(2-ethylhexyl) phthalate	7	JB	Blank Compound
PEST	None Detected			

Tentatively Identified Compounds Detected: see the attached page # 0029

No Volatiles found.

Spectra Matching Quality

✓ The spectra were examined and found to be of good matching quality.
___ The spectra were examined and found to be of poor matching quality due to:

Remarks:

U.S. EPA CONTR T LABORATORY PROGRAM
SAMPLE MANAGEMENT OFFICE
P.O. BOX 818 ALEXANDRIA, VA 22313
703/557-2490 FTS:8-557-2490

EPA SAMPLE NO:
MHB 348
DATE:5-15-86

INORGANIC ANALYSIS SHEET

LAB NAME: CALIF.ANAL.LAB. CASE NO:5852
SOW NO.: 784 QC RPT.#5852
LAB.SAMPLE NO.: P3774

ELEMENTS IDENTIFIED AND MEASURED

CONC.: LOW: XX MEDIUM
MATRIX: WATER: XX

3001-S

ELEMENTS..METHOD		UG/L	
1. ALUMINIUM...P		2179	
2. ANTIMONY....P		19 U	
3. ARSENIC.....F		10 U	
4. BARIUM......P		290	E
5. BERYLLIUM...P		0.1 U	
6. CADMIUM.....P		3.0 U	
7. CALCIUM.....P		109900	
8. CHROMIUM....P		19	
9. COBALT......P		2.6 U	
10.COPPER......P	[	15]	
11.IRON........P		3438	
12.LEAD........F		5.8	
13.MAGNESIUM...P		19740	
14.MANGANESE...P		1098	
15.MERCURY....CV		0.2 U	
16.NICKEL......P		18 U	
17.POTASSIUM...P	[	2997]	
18.SELENIUM....F		25U	
19.SILVER......P		1.6 U	
20.SODIUM......P		10550	[illegible]
21.THALLIUM....F		10 U	
22.TIN.........P		19 U	
23.VANADIUM....P	[	5.3]	
24.ZINC........P		25	
25.CYANIDE.....C		N/R	

COMMENTS:

LAB MANAGER: JRB

U.S. EPA CONTF T LABORATORY PROGRAM
SAMPLE MANAGEMENT OFFICE
P.O. BOX 818 ALEXANDRIA, VA 22313
703/557-2490 FTS:8-557-2490

EPA SAMPLE NO:
MHB 346
DATE:5-15-86

INORGANIC ANALYSIS SHEET

LAB NAME: CALIF.ANAL.LAB. CASE NO:5852
SOW NO.: 784 QC RPT.#5852
LAB.SAMPLE NO.: P3772

ELEMENTS IDENTIFIED AND MEASURED

CONC.: LOW: XX MEDIUM
MATRIX: WATER: XX

ELEMENTS..METHOD		UG/L	
1. ALUMINIUM...P		410	3001-D
2. ANTIMONY....P		19 U	
3. ARSENIC.....F		10 U	
4. BARIUM......P	[	197]	B no flag
5. BERYLLIUM...P		0.1 U	
6. CADMIUM.....P		3.0 U	
7. CALCIUM.....P		53720	
8. CHROMIUM....P		35	
9. COBALT......P		2.6 U	
10.COPPER......P		1.7 U	
11.IRON........P		675	
12.LEAD........F		5.0 U	
13.MAGNESIUM...P		11030	
14.MANGANESE...P		19	
15.MERCURY....CV		0.2 U	
16.NICKEL......P	[	27]	
17.POTASSIUM...P	[	1077]	
18.SELENIUM....F		25U	
19.SILVER......P		1.6 U	
20.SODIUM......P		5707	E no flag
21.THALLIUM....F		10 U	
22.TIN.........P		19 U	
23.VANADIUM....P	[	2.7]	
24.ZINC........P	[	11]	
25.CYANIDE.....C		N/R	

COMMENTS:

LAB MANAGER: JRB

U.S. EPA CONTR T LABORATORY PROGRAM
SAMPLE MANAGEM T OFFICE
P.O. BOX 818 ALEXANDRIA,VA 22313
703/557-2490 FTS:8-557-2490

EPA SAMPLE NO:
MHC 246
DATE:5-15-86

INORGANIC ANALYSIS SHEET

LAB NAME: CALIF.ANAL.LAB. CASE NO:5852
SOW NO.: 784 QC RPT.#5852
LAB.SAMPLE NO.: P3467

ELEMENTS IDENTIFIED AND MEASURED

CONC.: LOW: XX MEDIUM
MATRIX: WATER: XX

ELEMENTS..METHOD		UG/L	
1. ALUMINIUM...P		10260	3003-S
2. ANTIMONY....P		19 U	
3. ARSENIC.....F		13.0	
4. BARIUM......P		659	E no flag
5. BERYLLIUM...P	[	1.3]	
6. CADMIUM.....P		3.0 U	
7. CALCIUM.....P		64570	
8. CHROMIUM....P		50	
9. COBALT......P	[	11]	
10.COPPER......P		77	
11.IRON........P		17110	
12.LEAD........F		30.0	
13.MAGNESIUM...P		20590	
14.MANGANESE...P		9022	
15.MERCURY....CV		.2U	
16.NICKEL......P		47	
17.POTASSIUM...P	[	4877]	
18.SELENIUM....F		25U	E
19.SILVER......P	[	3.1]	
20.SODIUM......P		7251	E no flag
21.THALLIUM....F		10 U	
22.TIN.........P		19 U	
23.VANADIUM....P	[	18.5]	
24.ZINC........P		80	
25.CYANIDE.....C		N/R	

COMMENTS:

LAB MANAGER: JRB

U.S. ZPA CONTR T LABORATORY PROGRAM
SAMPLE MANAGEMENT OFFICE
P.O. BOX 818 ALEXANDRIA,VA 22313
703/557-2490 FTS:8-557-2490

EPA SAMPLE NO:
MHC 245
DATE:5-15-86

INORGANIC ANALYSIS SHEET

LAB NAME: CALIF.ANAL.LAB. CASE NO:5852
SOW NO.: 784 QC RPT.#5852
LAB.SAMPLE NO.: P3766

ELEMENTS IDENTIFIED AND MEASURED

CONC.: LOW: XX MEDIUM
MATRIX: WATER: XX

3003-D

ELEMENTS..METHOD		UG/L	
1. ALUMINIUM...P		3179	
2. ANTIMONY....P		19 U	
3. ARSENIC.....F		~~15.0~~	10 U JR 5/21/86
4. BARIUM......P		324	E no flag
5. BERYLLIUM...P	[	0.6]	
6. CADMIUM.....P		3.0 U	
7. CALCIUM.....P		44630	
8. CHROMIUM....P		18	
9. COBALT......P		2.6 U	
10.COPPER......P	[	11]	
11.IRON........P		5244	
12.LEAD........F		5.0 U	
13.MAGNESIUM...P		13180	
14.MANGANESE...P		248	
15.MERCURY....CV		0.2 U	
16.NICKEL......P		18 U	
17.POTASSIUM...P	[	1381]	
18.SELENIUM....F		25U	
19.SILVER......P		1.6 U	
20.SODIUM......P		5486	E no flag
21.THALLIUM....F		10U	
22.TIN.........P		19 U	
23.VANADIUM....P	[	5.0]	
24.ZINC........P		22	
25.CYANIDE.....C		N/R	

COMMENTS:

LAB MANAGER: JRB

U.S. EPA CONTR' T LABORATORY PROGRAM
SAMPLE MANAGEM...T OFFICE — EPA SAMPLE NO: MHB 344
P.O. BOX 818 ALEXANDRIA,VA 22313
703/557-2490 FTS:8-557-2490 — DATE:5-15-86

INORGANIC ANALYSIS SHEET

LAB NAME: CALIF.ANAL.LAB. — CASE NO:5852
SOW NO.: 784 — QC RPT.#5852
LAB.SAMPLE NO.: P3770

ELEMENTS IDENTIFIED AND MEASURED

CONC.: LOW: XX MEDIUM
MATRIX: WATER: XX

ELEMENTS..METHOD		UG/L	
1. ALUMINIUM...P		4718	3004-S
2. ANTIMONY....P		19 U	
3. ARSENIC.....F		10 U	
4. BARIUM......P		440	
5. BERYLLIUM...P	[	0.4]	
6. CADMIUM.....P		3.0 U	
7. CALCIUM.....P		38810	
8. CHROMIUM....P		22	
9. COBALT......P		2.6 U	
10.COPPER......P	[	21]	
11.IRON........P		7418	
12.LEAD........F		7.1	
13.MAGNESIUM...P		12570	
14.MANGANESE...P		224	
15.MERCURY....CV		0.2 U	
16.NICKEL......P		18 U	
17.POTASSIUM...P	[	2765]	
18.SELENIUM....F		25U	
19.SILVER......P		1.6 U	
20.SODIUM......P		6853	
21.THALLIUM....F		10 U	
22.TIN.........P		19 U	
23.VANADIUM....P	[	7.5]	
24.ZINC........P		38	
25.CYANIDE.....C		N/R	

COMMENTS:

LAB MANAGER: JRB

U.S. EPA CONTR T LABORATORY PROGRAM
SAMPLE MANAGEMENT OFFICE
P.O. BOX 818 ALEXANDRIA,VA 22313
703/557-2490 FTS:8-557-2490

EPA SAMPLE NO:
MHB 345
DATE:5-15-86

INORGANIC ANALYSIS SHEET

LAB NAME: CALIF.ANAL.LAB. CASE NO:5852
SOW NO.: 784 QC RPT.#5852
LAB.SAMPLE NO.: P3771

ELEMENTS IDENTIFIED AND MEASURED

CONC.: LOW: XX MEDIUM
MATRIX: WATER: XX

ELEMENTS..METHOD		UG/L	
1. ALUMINIUM...P		487	7004-D
2. ANTIMONY....P		19 U	
3. ARSENIC.....F		10 U	E no flag
4. BARIUM......P		346	
5. BERYLLIUM...P		0.1 U	
6. CADMIUM.....P		3.0 U	
7. CALCIUM.....P		72880	
8. CHROMIUM....P		17	
9. COBALT......P		2.6 U	
10.COPPER......P	[	6]	
11.IRON........P		1670	
12.LEAD........F		5.0 U	
13.MAGNESIUM...P		15550	
14.MANGANESE...P		832	
15.MERCURY....CV		0.2 U	
16.NICKEL......P		18 U	
17.POTASSIUM...P	[	2341]	
18.SELENIUM....F		25U	
19.SILVER......P		1.6 U	
20.SODIUM......P		27840	E no flag
21.THALLIUM....F		10 U	
22.TIN.........P	[	20]	
23.VANADIUM....P	[	1.8]	
24.ZINC........P	[	11]	
25.CYANIDE.....C		N/R	JK

COMMENTS:

LAB MANAGER: JRB

U.S. EPA CONTRACT LABORATORY PROGRAM
SAMPLE MANAGEMENT OFFICE
P.O. BOX 818 ALEXANDRIA,VA 22313
703/557-2490 FTS:8-557-2490

EPA SAMPLE NO:
MHB 343
DATE:5-15-86

INORGANIC ANALYSIS SHEET

LAB NAME: CALIF.ANAL.LAB. CASE NO:5852
SOW NO.: 784 QC RPT.#5852
LAB.SAMPLE NO.: P3769

ELEMENTS IDENTIFIED AND MEASURED

CONC.: LOW: XX MEDIUM
MATRIX: WATER: XX

ELEMENTS..METHOD		UG/L	
1. ALUMINIUM...P		15 U	1005
2. ANTIMONY....P		19 U	
3. ARSENIC.....F		10 U	
4. BARIUM......P		255	E no flag
5. BERYLLIUM...P		0.1 U	
6. CADMIUM.....P		3.0 U	
7. CALCIUM.....P		50780	
8. CHROMIUM....P	[	3]	
9. COBALT......P		2.6 U	
10.COPPER......P	[	2]	
11.IRON........P		118	
12.LEAD........F		5.0 U	
13.MAGNESIUM...P		12590	
14.MANGANESE...P	[	5]	
15.MERCURY....CV		0.2 U	
16.NICKEL......P		18 U	
17.POTASSIUM...P	[	1037]	
18.SELENIUM....F		25U	
19.SILVER......P		1.6 U	
20.SODIUM......P		5949	E no flag
21.THALLIUM....F		10 U	
22.TIN.........P	[	20]	
23.VANADIUM....P		1.7 U	
24.ZINC........P		24	
25.CYANIDE.....C		N/R	

COMMENTS:

LAB MANAGER: JRB

LOG #	: 86-340	DATE REC D: 4/18/86	ASSIGNED TO: JP
REQUESTOR	: J. PRICE		PROJECT # : 02503-BF53
ANALYSIS TYPE	: VOA--3001-1(S)		LOCATION : BONNER, MT

VOLATILE ORGANIC ANALYSIS

EPA 601

BROMODICHLOROMETHANE	: <1	1,2 DICHLOROETHANE	: 1
BROMOFORM	: <1	1,1 DICHLOROETHYLENE	: 1
BROMOMETHANE	: <1	TRANS-1,2 DICHLOROETHYLENE	: <1
CARBON TETRACHLORIDE	: <1	1,2 DICHLOROPROPANE	: <1
CHLOROBENZENE	: <1	CIS-1,3 DICHLOROPROPENE	: <1
CHLOROETHANE	: <1	TRANS-1,3 DICHLOROPROPENE	: <1
2-CHLOROETHYLVINYL ETHER	: <1	METHYLENE CHLORIDE	: <1
CHLOROFORM	: <1	1,1,2,2-TETRACHLOROETHANE	: <1
CHLOROMETHANE	: <1	TETRACHLOROETHYLENE	: <1
DIBROMOCHLOROMETHANE	: <1	1,1,1 TRICHLOROETHANE	: <1
1,2 DICHLOROBENZENE	: <1	1,1,2 TRICHLOROETHANE	: <1
1,3 DICHLOROBENZENE	: <1	TRICHLOROETHYLENE	: <1
1,4 DICHLOROBENZENE	: <1	TRICHLOROFLUOROMETHANE	: <1
DICHLORODIFLUOROMETHANE	: <1	VINYL CHLORIDE	: <1
1,1 DICHLOROETHANE	:		

EPA 602

BENZENE	: <1
CHLOROBENZENE	: <1
ETHYLBENZENE	: <1
TOLUENE	: <1
XYLENES	: <1
1,2 DICHLOROBENZENE	: <1
1,3 DICHLOROBENZENE	: <1
1,4 DICHLOROBENZENE	: <1

ALL PARAMETERS REPORTED IN UG/L OR PPB

LOG # : 86-340   DATE REC'D: 4/18/86   ASSIGNED TO: JFM
REQUESTOR : J. PRICE   PROJECT # : 02503-BP53
ANALYSIS TYPE : VOA--3001-2(D)   LOCATION : BONNER, MT

VOLATILE ORGANIC ANALYSIS

EPA 601

BROMODICHLOROMETHANE	: <1
BROMOFORM	: <1
BROMOMETHANE	: <1
CARBON TETRACHLORIDE	: <1
CHLOROBENZENE	: <1
CHLOROETHANE	: <1
2-CHLOROETHYLVINYL ETHER	: <1
CHLOROFORM	: <1
CHLOROMETHANE	: <1
DIBROMOCHLOROMETHANE	: <1
1,2 DICHLOROBENZENE	: <1
1,3 DICHLOROBENZENE	: <1
1,4 DICHLOROBENZENE	: <1
DICHLORODIFLUOROMETHANE	: <1
1,1 DICHLOROETHANE	:
1,2 DICHLOROETHANE	: <1
1,1 DICHLOROETHYLENE	: <1
TRANS-1,2 DICHLOROETHYLENE	: <1
1,2 DICHLOROPROPANE	: <1
CIS-1,3 DICHLOROPROPENE	: <1
TRANS-1,3 DICHLOROPROPENE	: <1
METHYLENE CHLORIDE	: <1
1,1,2,2-TETRACHLOROETHANE	: <1
TETRACHLOROETHYLENE	: <1
1,1,1 TRICHLOROETHANE	: <1
1,1,2 TRICHLOROETHANE	: <1
TRICHLOROETHYLENE	: <1
TRICHLOROFLUOROMETHANE	: <1
VINYL CHLORIDE	: <1

EPA 602

BENZENE	: <1
CHLOROBENZENE	: <1
ETHYLBENZENE	: <1
TOLUENE	: 1
XYLENES	: <1
1,2 DICHLOROBENZENE	: 1
1,3 DICHLOROBENZENE	: <1
1,4 DICHLOROBENZENE	: <1

ALL PARAMETERS REPORTED IN UG/L OR PPB

LOG #	: 86-240	DATE REC D: 4/18/86	ASSIGNED TO:	JPH
REQUESTOR	: J. PRICE		PROJECT #	: 02503-BP53
ANALYSIS TYPE	: VOA--3003-1(S)		LOCATION	: BONNER, MT

VOLATILE ORGANIC ANALYSIS

EPA 601

BROMODICHLOROMETHANE	: <1	1,2 DICHLOROETHANE	: <1
BROMOFORM	: <1	1,1 DICHLOROETHYLENE	: <1
BROMOMETHANE	: <1	TRANS-1,2 DICHLOROETHYLENE	: <1
CARBON TETRACHLORIDE	: <1	1,2 DICHLOROPROPANE	: <1
CHLOROBENZENE	: <1	CIS-1,3 DICHLOROPROPENE	: <1
CHLOROETHANE	: <1	TRANS-1,3 DICHLOROPROPENE	: <1
2-CHLOROETHYLVINYL ETHER	: <1	METHYLENE CHLORIDE	: <1
CHLOROFORM	: <1	1,1,2,2-TETRACHLOROETHANE	: <1
CHLOROMETHANE	: <1	TETRACHLOROETHYLENE	: <1
DIBROMOCHLOROMETHANE	: <1	1,1,1 TRICHLOROETHANE	: <1
1,2 DICHLOROBENZENE	: <1	1,1,2 TRICHLOROETHANE	: <1
1,3 DICHLOROBENZENE	: <1	TRICHLOROETHYLENE	: <1
1,4 DICHLOROBENZENE	: <1	TRICHLOROFLUOROMETHANE	: <1
DICHLORODIFLUOROMETHANE	: <1	VINYL CHLORIDE	: <1
1,1 DICHLOROETHANE	:		

EPA 602

BENZENE	: <1
CHLOROBENZENE	: <1
ETHYLBENZENE	: <1
TOLUENE	: <1
XYLENES	: <1
1,2 DICHLOROBENZENE	: <1
1,3 DICHLOROBENZENE	: <1
1,4 DICHLOROBENZENE	: <1

ALL PARAMETERS REPORTED IN UG/L OR PPB

LOG #	: 86-340	DATE REC'D: 4/18/86	ASSIGNED TO: JPH
REQUESTOR	: J. PRICE		PROJECT # : 02503-BP53
ANALYSIS TYPE	: VOA--3003-2 (D)		LOCATION : BONNER, MT

VOLATILE ORGANIC ANALYSIS

EPA 601

BROMODICHLOROMETHANE	: <1	1,2 DICHLOROETHANE	: <1
BROMOFORM	: <1	1,1 DICHLOROETHYLENE	: <1
BROMOMETHANE	: <1	TRANS-1,2 DICHLOROETHYLENE	: <1
CARBON TETRACHLORIDE	: <1	1,2 DICHLOROPROPANE	: <1
CHLOROBENZENE	: <1	CIS-1,3 DICHLOROPROPENE	: <1
CHLOROETHANE	: <1	TRANS-1,3 DICHLOROPROPENE	: <1
2-CHLOROETHYLVINYL ETHER	: <1	METHYLENE CHLORIDE	: <1
CHLOROFORM	: <1	1,1,2,2-TETRACHLOROETHANE	: <1
CHLOROMETHANE	: <1	TETRACHLOROETHYLENE	: <1
DIBROMOCHLOROMETHANE	: <1	1,1,1 TRICHLOROETHANE	: <1
1,2 DICHLOROBENZENE	: <1	1,1,2 TRICHLOROETHANE	: <1
1,3 DICHLOROBENZENE	: <1	TRICHLOROETHYLENE	: <1
1,4 DICHLOROBENZENE	: <1	TRICHLOROFLUOROMETHANE	: <1
DICHLORODIFLUOROMETHANE	: <1	VINYL CHLORIDE	: <1
1,1 DICHLOROETHANE	:		

EPA 602

BENZENE	: <1
CHLOROBENZENE	: <1
ETHYLBENZENE	: <1
TOLUENE	: <1
XYLENES	: <1
1,2 DICHLOROBENZENE	: <1
1,3 DICHLOROBENZENE	: <1
1,4 DICHLOROBENZENE	: <1

ALL PARAMETERS REPORTED IN UG/L OR PPB

LOG # : 86-240 DATE REC'D: 4/16/86 ASSIGNED TO: JM
REQUESTOR : J. PRICE PROJECT # : 02503-BP53
ANALYSIS TYPE : VOA--3004-1(3) LOCATION : BONNER, MT

VOLATILE ORGANIC ANALYSIS

EPA 601

BROMODICHLOROMETHANE	: <1	1,2 DICHLOROETHANE	: <1
BROMOFORM	: <1	1,1 DICHLOROETHYLENE	: <1
BROMOMETHANE	: <1	TRANS-1,2 DICHLOROETHYLENE	: <1
CARBON TETRACHLORIDE	: 1	1,2 DICHLOROPROPANE	: <1
CHLOROBENZENE	: <1	CIS-1,3 DICHLOROPROPENE	: <1
CHLOROETHANE	: 1	TRANS-1,3 DICHLOROPROPENE	: <1
2-CHLOROETHYLVINYL ETHER	: <1	METHYLENE CHLORIDE	: <1
CHLOROFORM	: <1	1,1,2,2-TETRACHLOROETHANE	: <1
CHLOROMETHANE	: <1	TETRACHLOROETHYLENE	: <1
DIBROMOCHLOROMETHANE	: <1	1,1,1 TRICHLOROETHANE	: <1
1,2 DICHLOROBENZENE	: <1	1,1,2 TRICHLOROETHANE	: <1
1,3 DICHLOROBENZENE	: <1	TRICHLOROETHYLENE	: <1
1,4 DICHLOROBENZENE	: <1	TRICHLOROFLUOROMETHANE	: <1
DICHLORODIFLUOROMETHANE	: <1	VINYL CHLORIDE	: <1
1,1 DICHLOROETHANE	:		

EPA 602

BENZENE	: <1
CHLOROBENZENE	: <1
ETHYLBENZENE	: <1
TOLUENE	: <1
XYLENES	: <1
1,2 DICHLOROBENZENE	: <1
1,3 DICHLOROBENZENE	: <1
1,4 DICHLOROBENZENE	: <1

ALL PARAMETERS REPORTED IN UG/L OR PPB

LOG #	: 86-340	DATE REC'D: 4/18/86	ASSIGNED TO: JFF
REQUESTOR	: J. PRICE		PROJECT # : 02503-BP53
ANALYSIS TYPE	: VOA--3004-2(D)		LOCATION : BONNER, MT

VOLATILE ORGANIC ANALYSIS

EPA 601

BROMODICHLOROMETHANE	: <1	1,2 DICHLOROETHANE	: <1
BROMOFORM	: <1	1,1 DICHLOROETHYLENE	: <1
BROMOMETHANE	: <1	TRANS-1,2 DICHLOROETHYLENE	: <1
CARBON TETRACHLORIDE	: <1	1,2 DICHLOROPROPANE	: <1
CHLOROBENZENE	: <1	CIS-1,3 DICHLOROPROPENE	: <1
CHLOROETHANE	: <1	TRANS-1,3 DICHLOROPROPENE	: <1
2-CHLOROETHYLVINYL ETHER	: <1	METHYLENE CHLORIDE	: <1
CHLOROFORM	: <1	1,1,2,2-TETRACHLOROETHANE	: <1
CHLOROMETHANE	: <1	TETRACHLOROETHYLENE	: <1
DIBROMOCHLOROMETHANE	: <1	1,1,1 TRICHLOROETHANE	: <1
1,2 DICHLOROBENZENE	: <1	1,1,2 TRICHLOROETHANE	: <1
1,3 DICHLOROBENZENE	: <1	TRICHLOROETHYLENE	: <1
1,4 DICHLOROBENZENE	: <1	TRICHLOROFLUOROMETHANE	: <1
DICHLORODIFLUOROMETHANE	: <1	VINYL CHLORIDE	: <1
1,1 DICHLOROETHANE	:		

EPA 602

BENZENE	: <1
CHLOROBENZENE	: <1
ETHYLBENZENE	: <1
TOLUENE	: <1
XYLENES	: <1
1,2 DICHLOROBENZENE	: <1
1,3 DICHLOROBENZENE	: <1
1,4 DICHLOROBENZENE	: <1

ALL PARAMETERS REPORTED IN UG/L OR PPB

LOG # : 86-340   DATE REC'D: 4/18/86   ASSIGNED TO: JPK
REQUESTOR : J. PRICE   PROJECT # : 02503-BF53
ANALYSIS TYPE : VOA--1005   LOCATION : BONNER, MT

VOLATILE ORGANIC ANALYSIS

EPA 601

BROMODICHLOROMETHANE	: <1	1,2 DICHLOROETHANE	: <1
BROMOFORM	: <1	1,1 DICHLOROETHYLENE	: <1
BROMOMETHANE	: <1	TRANS-1,2 DICHLOROETHYLENE	: <1
CARBON TETRACHLORIDE	: <1	1,2 DICHLOROPROPANE	: <1
CHLOROBENZENE	: <1	CIS-1,3 DICHLOROPROPENE	: <1
CHLOROETHANE	: <1	TRANS-1,3 DICHLOROPROPENE	: <1
2-CHLOROETHYLVINYL ETHER	: <1	METHYLENE CHLORIDE	: <1
CHLOROFORM	: <1	1,1,2,2-TETRACHLOROETHANE	: <1
CHLOROMETHANE	: <1	TETRACHLOROETHYLENE	: <1
DIBROMOCHLOROMETHANE	: <1	1,1,1 TRICHLOROETHANE	: <1
1,2 DICHLOROBENZENE	: <1	1,1,2 TRICHLOROETHANE	: <1
1,3 DICHLOROBENZENE	: <1	TRICHLOROETHYLENE	: <1
1,4 DICHLOROBENZENE	: <1	TRICHLOROFLUOROMETHANE	: <1
DICHLORODIFLUOROMETHANE	: <1	VINYL CHLORIDE	: <1
1,1 DICHLOROETHANE	:		

EPA 602

BENZENE	: <1
CHLOROBENZENE	: <1
ETHYLBENZENE	: <1
TOLUENE	: <1
XYLENES	: <1
1,2 DICHLOROBENZENE	: <1
1,3 DICHLOROBENZENE	: <1
1,4 DICHLOROBENZENE	: <1

ALL PARAMETERS REPORTED IN UG/L OR PPB

NPDES ANALYTICAL SERVICES REPORT

BONNER, MONTANA — APRIL 10, 1986

	ug/l ACENAPHTHENE	ug/l ACENAPHTHYLENE	ug/l ANTHRACENE	ug/l BENZIDINE
3001-1	<10	<10	<10	<10
3001-2	<10	<10	<10	<10
3004-1	<10	<10	<10	<10

	ug/l BENZO(a)ANTHRACENE	ug/l BENZO(a)PYRENE	ug/l 3,4-BENZOFLUORANTHENE	ug/l BENZO(ghi)PERYLENE
3001-1	<10	<10	<10	<10
3001-2	<10	<10	<10	<10
3004-1	<10	<10	<10	<10

	ug/l BENZO(k)FLUORANTHENE	ug/l BIS(2-CHLOROETHOXY)METH.	ug/l BIS(2-CHLOROETHYL)ETHER	ug/l BIS(2-CHLOROISOPROPYL)ETHer
3001-1	<10	<10	<10	<10
3001-2	<10	<10	<10	<10
3004-1	<10	<10	<10	<10

	ug/l BIS(2-ETHYLHEXYL)PHTHALATE	ug/l 4-BROMOPHENYL PHENYL ETHER	ug/l BUTYL BENZYL PHTHALATE	ug/l 2-CHLORONAPHTHALENE
3001-1	<10	<10	<10	<10
3001-2	<10	<10	<10	<10
3004-1	<10	<10	<10	<10

	ug/l 4-CHLOROPHENYL PHENYL ETHER	ug/l CHRYSENE	ug/l DIBENZO(a,h)ANTHRACENE	ug/l 1,2-DICHLOROBENZENE
3001-1	<10	<10	<10	<10
3001-2	<10	<10	<10	<10
3004-1	<10	<10	<10	<10

	ug/l 1,3-DICHLOROBENZENE	ug/l 1,4-DICHLOROBENZENE	ug/l 3,3'-DICHLOROBENZIDINE	ug/l DIETHYL PHTHALATE
3001-1	<10	<10	<10	<10
3001-2	<10	<10	<10	<10
3004-1	<10	<10	<10	<10

NPDES ANALYTICAL SERVICES REPORT

	ug/l DIMETHYL PHTHALATE	ug/l DI-N-BUTYL PHTHALATE	ug/l 2,4-DINITROTOLUENE	ug/l 2,6-DINITROTOLUENE
3001-1	<10	<10	<10	<10
3001-2	<10	<10	<10	<10
3004-1	<10	<10	<10	<10

	ug/l DI-N-OCTYL PHTHALATE	ug/l 1,2-DIPHENYLHYDRAZINE	ug/l FLUORANTHENE	ug/l FLUORENE
3001-1	<10	<10	<10	<10
3001-2	<10	<10	<10	<10
3004-1	<10	<10	<10	<10

	ug/l HEXACHLOROBENZENE	ug/l HEXACHLOROBUTADIENE	ug/l HEXACHLOROCYCLOPENTADIENE	ug/l HEXACHLOROETHANE
3001-1	<10	<10	<10	<10
3001-2	<10	<10	<10	<10
3004-1	<10	<10	<10	<10

	ug/l INDENO(1,2,3cd)PYRENE	ug/l ISOPHORONE	ug/l NAPHTHALENE	ug/l NITROBENZENE
3001-1	<10	<10	<10	<10
3001-2	<10	<10	<10	<10
3004-1	<10	<10	<10	<10

	ug/l N-NITROSODIMETHYLAMINE	ug/l N-NITROSODI-N-PROPYLAMINE	ug/l N-NITROSODIPHENYLAMINE	ug/l PHENANTHRENE
3001-1	<10	<10	<10	<10
3001-2	<10	<10	<10	<10
3004-1	<10	<10	<10	<10

	ug/l PYRENE	ug/l 1,2,4-TRICHLOROBENZENE
3001-1	<10	<10
3001-2	<10	<10
3004-1	<10	<10

NPDES ANALYTICAL SERVICES REPORT

BONNER, MONTANA

APRIL 18, 1986

	ug/l ACENAPHTHENE	ug/l ACENAPHTHYLENE	ug/l ANTHRACENE	ug/l BENZIDINE
3004-2	<10	<10	<10	<10
3003-1	<10	<10	<10	<10
3003-2	<10	<10	<10	<10

	ug/l BENZO(a)ANTHRACENE	ug/l BENZO(a)PYRENE	ug/l 3,4-BENZOFLUORANTHENE	ug/l BENZO(ghi)PERYLENE
3004-2	<10	<10	<10	<10
3003-1	<10	<10	<10	<10
3003-2	<10	<10	<10	<10

	ug/l BENZO(k)FLUORANTHENE	ug/l BIS(2-CHLOROETHOXY)METH.	ug/l BIS(2-CHLOROETHYL)ETHER	ug/l BIS(2-CHLOROISOPROPYL)ETH.
3004-2	<10	<10	<10	<10
3003-1	<10	<10	<10	<10
3003-2	<10	<10	<10	<10

	ug/l BIS(2-ETHYLHEXYL)PHTHALATE	ug/l 4-BROMOPHENYL PHENYL ETHER	ug/l BUTYL BENZYL PHTHALATE	ug/l 2-CHLORONAPHTHALENE
3004-2	<10	<10	<10	<10
3003-1	<10	<10	<10	<10
3003-2	<10	<10	<10	<10

	ug/l 4-CHLOROPHENYL PHENYL ETHE	ug/l CHRYSENE	ug/l DIBENZO(a,h)ANTHRACENE	ug/l 1,2-DICHLOROBENZENE
3004-2	<10	<10	<10	<10
3003-1	<10	<10	<10	<10
3003-2	<10	<10	<10	<10

	ug/l 1,3-DICHLOROBENZENE	ug/l 1,4-DICHLOROBENZENE	ug/l 3,3'-DICHLOROBENZIDINE	ug/l DIETHYL PHTHALATE
3004-2	<10	<10	<10	<10
3003-1	<10	<10	<10	<10
3003-2	<10	<10	<10	<10

NPDES ANALYTICAL SERVICES REPORT

	ug/l DIMETHYL PHTHALATE	ug/l DI-N-BUTYL PHTHALATE	ug/l 2,4-DINITROTOLUENE	ug/l 2,6-DINITROTOLUENE
3004-2	<10	<10	<10	<10
3003-1	<10	<10	<10	<10
3003-2	<10	<10	<10	<10

	ug/l DI-N-OCTYL PHTHALATE	ug/l 1,2-DIPHENYLHYDRAZINE	ug/l FLUORANTHENE	ug/l FLUORENE
3004-2	<10	<10	<10	<10
3003-1	<10	<10	<10	<10
3003-2	<10	<10	<10	<10

	ug/l HEXACHLOROBENZENE	ug/l HEXACHLOROBUTADIENE	ug/l HEXACHLOROCYCLOPENTADIENE	ug/l HEXACHLOROETHANE
3004-2	<10	<10	<10	<10
3003-1	<10	<10	<10	<10
3003-2	<10	<10	<10	<10

	ug/l INDENO(1,2,3cd)PYRENE	ug/l ISOPHORONE	ug/l NAPHTHALENE	ug/l NITROBENZENE
3004-2	<10	<10	<10	<10
3003-1	<10	<10	<10	<10
3003-2	<10	<10	<10	<10

	ug/l N-NITROSODIMETHYLAMINE	ug/l N-NITROSODI-N-PROPYLAMINE	ug/l N-NITROSODIPHENYLAMINE	ug/l PHENANTHRENE
3004-2	<10	<10	<10	<10
3003-1	<10	<10	<10	<10
3003-2	<10	<10	<10	<10

	ug/l PYRENE	ug/l 1,2,4-TRICHLOROBENZENE
3004-2	<10	<10
3003-1	<10	<10
3003-2	<10	<10

NPDES ANALYTICAL SERVICES REPORT

BONNER, MONTANA

APRIL 18, 1986

	ug/l ACENAPHTHENE	ug/l ACENAPHTHYLENE	ug/l ANTHRACENE	ug/l BENZIDINE
1005	<10	<10	<10	<10

	ug/l BENZO(a)ANTHRACENE	ug/l BENZO(a)PYRENE	ug/l 3,4-BENZOFLUORANTHENE	ug/l BENZO(ghi)PERYLENE
1005	<10	<10	<10	<10

	ug/l BENZO(k)FLUORANTHENE	ug/l BIS(2-CHLOROETHOXY)METH.	ug/l BIS(2-CHLOROETHYL)ETHER	ug/l BIS(2-CHLOROISOPROPYL)ETH.
1005	<10	<10	<10	<10

	ug/l BIS(2-ETHYLHEXYL)PHTHALATE	ug/l 4-BROMOPHENYL PHENYL ETHER	ug/l BUTYL BENZYL PHTHALATE	ug/l 2-CHLORONAPHTHALENE
1005	<10	<10	<10	<10

	ug/l 4-CHLOROPHENYL PHENYL ETHE	ug/l CHRYSENE	ug/l DIBENZO(a,h)ANTHRACENE	ug/l 1,2-DICHLOROBENZENE
1005	<10	<10	<10	<10

	ug/l 1,3-DICHLOROBENZENE	ug/l 1,4-DICHLOROBENZENE	ug/l 3,3'-DICHLOROBENZIDINE	ug/l DIETHYL PHTHALATE
1005	<10	<10	<10	<10

NPDES ANALYTICAL SERVICES REPORT

	ug/l DIMETHYL PHTHALATE	ug/l DI-N-BUTYL PHTHALATE	ug/l 2,4-DINITROTOLUENE	2,6-'
1005	<10	<10	<10	

	ug/l DI-N-OCTYL PHTHALATE	ug/l 1,2-DIPHENYLHYDRAZINE	ug/l FLUORANTHENE
1005	<10	<10	<10

	ug/l HEXACHLOROBENZENE	ug/l HEXACHLOROBUTADIENE	ug/l HEXACHLOROCYCLOPENTADIENE
1005	<10	<10	<10

	ug/l INDENO(1,2,3cd)PYRENE	ug/l ISOPHORONE	ug/l NAPHTHALENE
1005	<10	<10	<10

	ug/l N-NITROSODIMETHYLAMINE	ug/l N-NITROSODI-N-PROPYLAMINE	ug/l N-NITROSODIPHENYLAMINE
1005	<10	<10	<10

	ug/l PYRENE	ug/l 1,2,4-TRICHLOROBENZENE
1005	<10	<10

NPDES ANALYTICAL SERVICES REPORT

BONNER, MONTANA APRIL 18, 1986

	ug/l 2-CHLOROPHENOL	ug/l 2,4-DICHLOROPHENOL	ug/l 2,4-DIMETHYLPHENOL	ug/l 2,4-DINITROPHENOL
3001-1	<10	<10	<10	<10
3001-2	<10	<10	<10	<10
3004-1	<10	<10	<10	<10

	ug/l 4,6-DINITRO-O-CRESOL	ug/l 2-NITROPHENOL	ug/l 4-NITROPHENOL	ug/l p-CHLORO-m-CRESOL
3001-1	<10	<10	<10	<10
3001-2	<10	<10	<10	<10
3004-1	<10	<10	<10	<10

	ug/l PENTACHLOROPHENOL	ug/l PHENOL	ug/l 2,4,6-TRICHLOROPHENOL
3001-1	<10	<10	<10
3001-2	<10	<10	<10
3004-1	<10	<10	<10

NPDES ANALYTICAL SERVICES REPORT

BONNER, MONTANA

APRIL 18, 1986

	ug/l 2-CHLOROPHENOL	ug/l 2,4-DICHLOROPHENOL	ug/l 2,4-DIMETHYLPHENOL	ug/l 2,4-DINITROPHENOL
3004-2	<10	<10	<10	<10
3003-1	<10	<10	<10	<10
3003-2	<10	<10	<10	<10

	ug/l 4,6-DINITRO-O-CRESOL	ug/l 2-NITROPHENOL	ug/l 4-NITROPHENOL	ug/l p-CHLORO-m-CRESOL
3004-2	<10	<10	<10	<10
3003-1	<10	<10	<10	<10
3003-2	<10	<10	<10	<10

	ug/l PENTACHLOROPHENOL	ug/l PHENOL	ug/l 2,4,6-TRICHLOROPHENOL
3004-2	<10	<10	<10
3003-1	<10	<10	<10
3003-2	<10	<10	<10

NPDES ANALYTICAL SERVICES REPORT

BONNER, MONTANA

APRIL 18, 1986

	ug/l 2-CHLOROPHENOL	ug/l 2,4-DICHLOROPHENOL	ug/l 2,4-DIMETHYLPHENOL	ug/l 2,4-DINITROPHENOL
1005	<10	<10	<10	<10

	ug/l 4,6-DINITRO-O-CRESOL	ug/l 2-NITROPHENOL	ug/l 4-NITROPHENOL	ug/l p-CHLORO-m-CRESOL
1005	<10	<10	<10	<10

	ug/l PENTACHLOROPHENOL	ug/l PHENOL	ug/l 2,4,6-TRICHLOROPHENOL
1005	<10	<10	<10

Private well numbers.

WELL. NO.	NAME	ADDRESS
1001	Williams, C.R.	210 N. California
1002	Hunter	1134 Montana
1003	Worth, L.	1136 Montana
1004	Veitenheimer, C.	1138 Montana
1005	Brandt, C.M.	1200 Montana
1006	Ibey, C.	1203 Montana
1007	Ruff	1224 Montana
1008	Larson, R.P.	1228 Montana
1009	Thrasher, B.	1244 Montana
1010	Matye, J.	1301 Montana
1011	Damron, D.E.	1302 Montana
1012	Price, C.R.	1320 Montana
1013	Beckwith, J.	1332 Montana
1014	Earling, R.E.	1345 Montana
1015	Mocko	214 Prince
1016	Boschert, K.E.	1400 Montana
1017	Berts Automotive Repair	1414 Montana
1018	Rose, R.S.	1127 1/2 Idaho
1019	Parrish, M.	1125 XL
1020	Chaussee, E. (Owner - two rentals)	1131 Idaho, Rice Marra
1021	Bowers, E.V.	1205 Idaho
1022	Richlie, W.	1309 Idaho
1023	Thornburg, D.	1311 Idaho
1024	Anderson, L.	1321 Idaho
1025	Car Lot/Povsha	300 N. Russell
1026	Freds Car Wash	321 N. Russell
1027	Town Pump	401 N. Russell
1028	Metal Fabricators	109 N. California
1029	Mobile City Trailer Park Well 1	1509 River Road
1030	Mobile City Trailer Park Well 3	1509 River Road
1031	McCormick Park Pool	100 Hickory
1032	Tilton	1303 Idaho
1033	Photo Formulary	400 California
1034	Might (Patten)	401 California
1035	Might, L.	1201 River Road
1036	Rice, Sr.	1315 River Road
1037	Chaussee, E.	1319 River Road
1038	Ranstrom (Utley)	1405 River Road

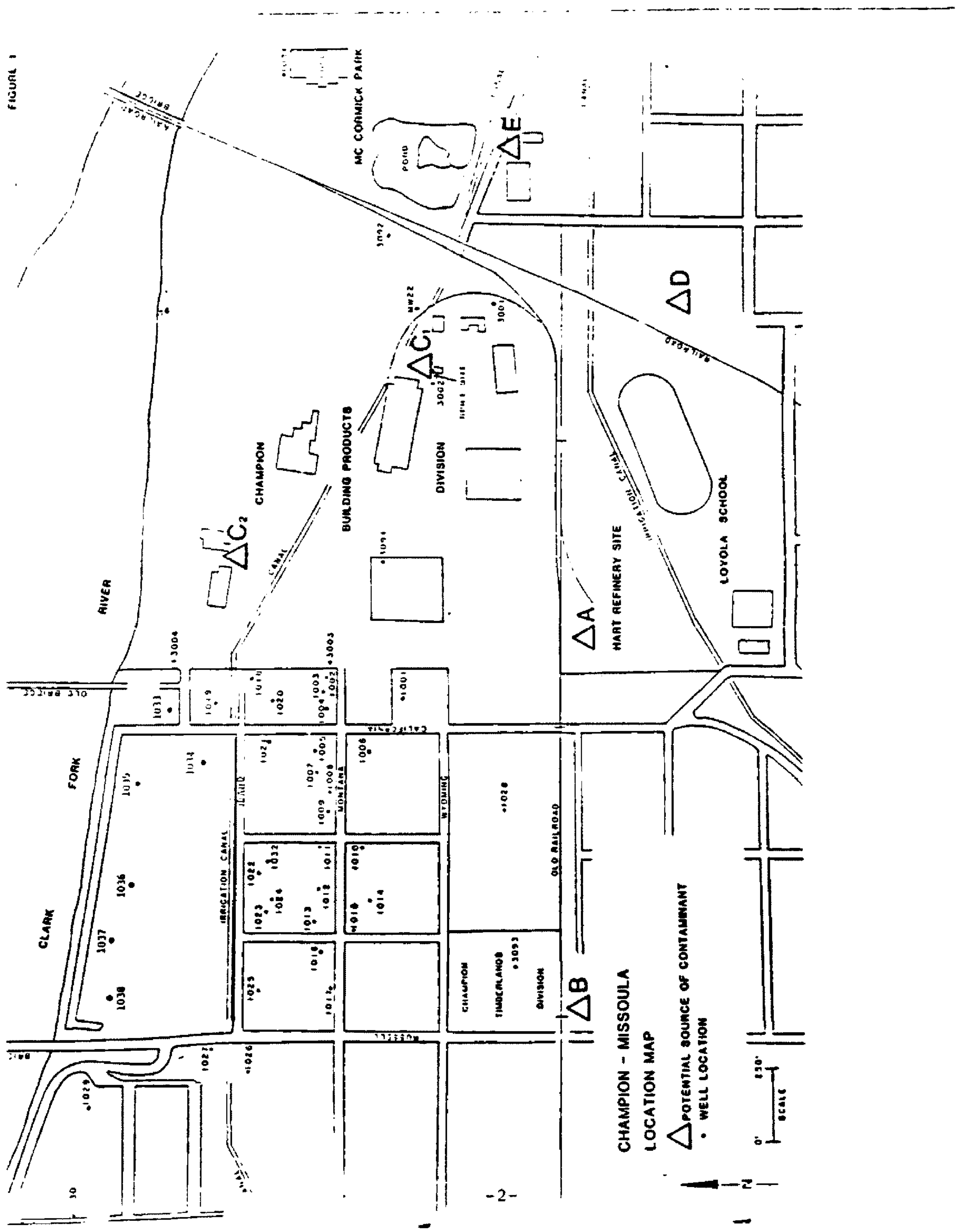


FIGURE 1
CLARK
FORK
RIVER
MC CORMICK PARK
POND
CHAMPION
BUILDING PRODUCTS
DIVISION
HART REFINERY SITE
LOYOLA SCHOOL
IRRIGATION CANAL
OLD RAILROAD
MONTANA
WYOMING
CHAMPION
TIMBERLANDS
DIVISION
A
B
C
C2
D
E
CHAMPION - MISSOULA
LOCATION MAP
POTENTIAL SOURCE OF CONTAMINANT
• WELL LOCATION
SCALE
N

-2-

RESULTS OF DHES ANALYSIS OF GROUNDWATER FROM CALIFORNIA STREET AREA WELLS SAMPLED ON APRIL 3 & 4, 1986
(all concentrations in mg/l (ppm) unless otherwise specified)

Well No.	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Chloride (Cl)	Sulfate (SO_4)	Nitrate ($NO_3 + NO_2$)	Lead (Pb)	Silver (Ag)	Manganese (Mn)	Zinc (Zn)	Iron (Fe)	pH (Std. Units)	Conductivity (umhos)	Total Organic Carbon (TOC)	Hardness (mg/l $CaCO_3$)
1004	52.4	12.4	6.4	1.8	197.6	0.0	4.3	27	.07	<.05	<.01	.02	.048	.05	7.73	373	<.5	182
1005	50.0	12.4	6.0	1.6	174.5	0.0	4.3	27	.46	<.05	<.01	.01	.072	.75	8.02	215	<.5	176
1006	47.3	11.9	6.0	1.6	164.7	0.0	4.4	26	.67	<.05	<.01	<.005	.015	<.01	7.92	205	<.5	167
1007	49.3	12.2	5.9	1.6	168.4	0.0	4.5	28	.54	<.05	<.01	<.005	.039	.08	7.96	205	<.5	173
1008	49.6	12.2	6.0	1.6	164.2	0.0	4.5	25	.72	<.05	<.01	<.005	.013	.03	7.83	210	<.5	174
1010	41.7	11.1	5.9	1.4	161.0	0.0	2.9	21	.79	<.05	<.01	.01	.018	.02	7.88	195	<.5	157
1011	47.0	11.6	6.0	1.5	175.7	0.0	3.6	21	.83	<.05	<.01	<.005	.010	.01	7.83	210	<.5	165
1016	44.0	11.5	5.9	1.6	167.1	0.0	3.7	23	.23	<.05	<.01	1.12	2.86	16.1	8.01	165	1.8	157
1016N	45.3	11.6	5.8	1.4	176.9	0.0	3.1	19	.68	<.05	<.01	.10	.01	.007	7.95	195	<.5	161
1018	55.6	13.2	6.4	1.8	201.3	0.0	4.5	31	.43	<.05	<.01	.05	.019	.05	7.84	225	<.5	193
1019	60.1	13.9	8.6	1.9	217.2	0.0	5.9	26	.08	<.05	<.01	<.005	<.005	.12	7.75	430	<.5	207
1020	36.2	10.3	9.0	1.8	146.4	0.0	3.5	16	<.01	<.05	<.01	.41	.015	2.58	7.78	135	2.21	133
1020N	40.4	11.2	5.5	1.1	147.6	0.0	2.9	19	.80	<.05	<.01	.005	.019	.07	7.85	175	<.5	147
1022	33.9	11.0	6.4	1.6	133.0	0.0	4.0	18	.03	<.05	<.01	.19	.023	3.81	8.01	170	3.1	130
1022N	46.4	11.6	5.8	1.4	176.9	0.0	3.1	20	.66	<.05	<.01	.005	.009	.05	8.02	331	<.5	164
1033	58.7	13.6	9.3	1.8	205.0	0.0	8.3	27	.45	<.05	<.01	<.005	.010	<.01	7.97	422	<.5	203
1034	56.9	13.6	8.1	1.7	206.2	0.0	6.8	23	.15	<.05	<.01	<.005	.046	<.01	7.94	406	<.5	198
1035	60.8	14.2	21.0	2.5	235.5	0.0	22.9	29	.12	<.05	<.01	.005	.204	.13	7.43	521	<.5	225
1036	70.4	16.7	14.6	2.2	244.0	0.0	31.5	27	.30	<.05	<.01	<.005	.039	.10	7.38	531	<.5	245
1037	62.6	15.1	8.6	2.0	220.8	0.0	9.7	29	.55	<.05	<.01	.02	.243	.02	7.44	452	<.5	218
1038	53.1	12.9	6.5	1.7	185.4	0.0	4.9	27	.42	<.05	<.01	<.005	.020	.01	7.77	378	<.5	186
3001-2	25.8	9.2	6.1	1.9	90.3	0.0	4.2	30	.66	<.05	<.01	.02	.026	.81	8.49	236	<.5	102
3003-1	58.6	13.9	7.9	2.7	230.6	0.0	5.3	21	<.01	<.05	<.01	8.49	.031	1.04	7.34	442	3.3	202
3004-1	41.6	9.8	9.6	1.9	150.1	0.0	4.8	32	.11	<.05	<.01	.03	.006	.19	7.11	320	2.6	104
3091	53.5	12.3	6.2	1.7	181.8	0.0	3.8	28	.32	<.05	<.01	.02	<.005	.11	7.92	374	<.5	184

Results of analysis of ground water samples
for benzene, xylene and toluene.

OWNER	OLD WELL	NEW WELL	SAMPLE DATE	SAMPLED BY	LAB.	BENZENE UG/L	TOLUENE UG/L	XYLENES UG/L
WILLIAMS	1001		09/18/85	C	A	<1	<1	<1
HUNTER	1002		07/16/85	C	E	-	-	-
	1002		07/26/85	C	L	182.0	6.2	32.0
	1002		09/19/85	C	A	107.0	5.9	28.6
	1002		09/18/85	C	L	157.0	15.0	26.0
	1002		10/01/85	C	A	148.0	7.0	49.9
VIETEN-HEIMER (NORTH)	1003		07/13/85	C	E	3.0	<1	<1
	1003		07/26/85	C	L	<1	<1	<1
	1003		09/18/85	C	A	112.0	6.9	25.6
		1003N	04/25/86	C	C	<1	<1	<1
VIETEN-HEIMER	1004		07/26/85	C	L	202.0	12.0	37.0
	1004		09/18/85	C	A	62.1	3.0	13.7
	1004		04/02/86	SM	CAL	<1	<1	<1
	1004		04/02/86	SM	CAL	<1	<1	<1
	1004		04/02/86	C	C	<1	<1	<1
		1004N	04/28/86	C	C	<1	<1	<1
BRANDT	1005		09/18/85	C	A	<1	<1	<1
	1005		02/10/86	C	C	<1	<1	<1
	1005		04/02/86	SM	CAL	<1	<1	<1
	1005		04/02/86	C	C	<1	<1	<1
	1005		04/07/86	C	C	<1	<1	<1
	1005		04/15/86	C	C	<1	<1	<1
	1005		08/07/86	C	C	<1	<1	<1
	1005		08/07/86	SM	SM	<1	<1	<1
IBEY	1006		05/21/85	SM	MSU	77.0	61.0	128.0

CHAMPION INTERNATIONAL CORPORATION
WATER QUALITY DATA
PROJECT #B-001
MISSOULA, MONTANA
9/3/86

OWNER	OLD WELL	NEW WELL	SAMPLE DATE	SAMPLED BY	LAB.	BENZENE UG/L	TOLUENE UG/L	XYLENES UG/L
	1006		09/18/85	C	L	<1	<1	<1
	1006		09/18/85	C	A	<1	<1	<1
	1006		04/02/86	SM	SM	<1	<1	<1
		1006N	04/28/86	C	C	<1	<1	<1
VIETEN-	1007		07/18/85	C	E	67.0	3.0	18.0
HEIMER	1007		07/26/85	C	L	25.0	<1	3.0
(RUFF)	1007		09/19/85	C	A	<1	<1	<1
	1007		10/01/85	C	A	<1	<1	<1
	1007		04/02/86	SM	CAL	<1	<1	<1
		1007N	04/28/86	C	C	<1	<1	<1
LARSON	1008		07/18/85	C	E	3.0	<1	<1
	1008		07/26/85	C	L	<1	<1	<1
	1008		09/19/85	C	A	<1	<1	<1
	1008		04/02/86	SM	CAL	<1	<1	<1
	1008		04/02/86	C	C	<1	<1	<1
		1008N	04/28/86	C	C	<1	<1	<1
THRASHER	1009		07/14/85	SM	MSU	66.0	<1	<1
	1009		07/18/85	C	E	58.0	<1	5.0
	1009		07/26/85	C	L	<1	<1	<1
	1009		09/18/85	C	A	<1	<1	<1
		1009N	04/03/86	C	C	<1	<1	<1
MAYTE	1010		09/19/85	C	A	<1	<1	<1
	1010		04/03/86	SM	CAL	<1	<1	<1
	1010		04/03/86	C	C	<1	<1	<1
RICHLIE	1011		05/21/85	MS	MSU	<1	<1	<1

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OWNER	OLD WELL	NEW WELL	SAMPLE DATE	SAMPLED BY	LAB.	BENZENE UG/L	TOLUENE UG/L	XYLENES UG/L
(DAMRON)	1011		06/11/85	MS	MSU	<1	<1	<1
	1011		09/18/85	C	A	<1	<1	<1
	1011		04/03/86	SM	CAL	<1	<1	<1
	1011		04/03/86	C	C	<1	<1	<1
		1011N	04/28/86	C	C	<1	<1	<1
PRICE	1012		09/18/85	C	A	<1	<1	<1
		1012N	02/17/86	C	C	<1	<1	<1
BECKWITH	1013		09/18/85	C	A	<1	<1	<1
EARLING	1014		09/18/85	C	A	1	<1	<1
MOCKO	1015		09/18/85	C	A	<1	<1	<1
MINCH (BOSHERT)	1016		09/18/85	C	A	<1	<1	<1
	1016		04/03/86	SM	CAL	<1	<1	<1
		1016N	04/03/86	SM	CAL	<1	<1	<1
		1016N	04/03/86	C	C	<1	<1	<1
	1016		04/03/86	C	C	<1	<1	<1
		1016N	04/07/86	C	C	<1	<1	<1
BERTS AUTO	1017		09/18/85	C	A	<1	<1	<1

CHAMPION INTERNATIONAL CORPORATION
WATER QUALITY DATA
PROJECT #8-001
MISSOULA, MONTANA
9/3/86

OWNER	OLD WELL	NEW WELL	SAMPLE DATE	SAMPLED BY	LAB.	BENZENE UG/L	TOLUENE UG/L	XYLENES UG/L
ROSE	1018		09/18/85	C	A	<1	<1	<1
	1018		02/10/86	C	C	<1	<1	<1
	1018		02/13/86	SM	SM	<1	<1	<1
	1018		04/02/86	SM	CAL	<1	<1	<1
	1018		04/02/86	C	C	<1	<1	<1
	1018		03/07/86	C	C	<1	<1	<1
	1018		08/07/86	SM	SM	<1	<1	<1
MIGHT (PARRISH)	1019		07/08/85	C	E	<1	<1	<1
	1019		07/26/85	C	L	<1	<1	<1
	1019		09/18/85	C	A	<1	<1	<1
	1019		04/02/86	SM	CAL	<1	<1	<1
CHALSSEE	1020		07/26/85	C	L	221.0	9.2	21.0
	1020		09/18/85	C	A	54.8	4.7	4.5
		1020N	01/20/85	C	C	<1	<1	<1
	1020		04/03/86	SM	CAL	<1	<1	<1
		1020N	04/03/86	SM	CAL	<1	<1	<1
	1020		04/03/86	C	C	<1	<1	<1
		1020N	04/03/86	C	C	<1	<1	<1
BOWERS	1021		07/18/85	C	E	-	-	-
	1021		07/18/85	C	E	-	-	-
	1021		07/26/85	C	L	221.0	14.0	41.0
	1021		09/18/85	C	A	25.5	11.7	4.3
	1021		09/18/85	C	L	142.0	8.0	48.0
	1021		10/01/85	C	A	71.5	5.1	21.0
		1021N	02/10/86	C	C	<1	<1	<1
RICHLIE	1022		09/18/85	C	A	<1	<1	<1
		1022N	02/10/86	C	C	<1	<1	<1
		1022N	02/17/86	C	C	<1	<1	<1

CHAMPION INTERNATIONAL CORPORATION
WATER QUALITY DATA
PROJECT #2-001
MISSOULA, MONTANA
9/3/86

OWNER	OLD WELL	NEW WELL	SAMPLE DATE	SAMPLED BY	LAB.	BENZENE UG/L	TOLUENE UG/L	XYLENES UG/L
	1022		04/03/86	SM	CAL	<1	<1	<1
		1022N	04/03/86	SM	CAL	<1	<1	<1
	1022		04/03/86	C	C	<1	<1	<1
THORNBURG	1023		09/19/85	C	A	<1	<1	<1
		1023N	04/03/86	C	C	<1	<1	<1
ANDERSON	1024		09/18/85	C	A	<1	<1	<1
		1024N	02/13/86	C	C	<1	<1	<1
		1024N	02/17/86	C	C	<1	<1	<1
POVSHA (CAR LOT)	1025		09/18/85	C	L	<1	<1	<1
	1025		09/18/85	C	A	<1	<1	<1
	1025		10/01/85	C	A	<1	<1	<1
	1025		02/10/86	C	C	<1	<1	<1
	1025		02/17/86	C	C	<1	<1	<1
FRED'S	1026		07/25/85	C	L	<1	<1	<1
	1026		09/19/85	C	L	<1	<1	<1
TOWN PUMP	1027		09/19/85	C	L	<1	<1	<1
MTL. FAB.	1028		09/18/85	C	L	<1	<1	<1
							<1	0

CHAMPION INTERNATIONAL CORPORATION
WATER QUALITY DATA
PROJECT #B-001
MISSOULA, MONTANA
9/3/86

OWNER	OLD WELL	NEW WELL	SAMPLE DATE	SAMPLED BY	LAB.	BENZENE UG/L	TOLUENE UG/L	XYLENES UG/L
MOBILE CITY	1029		OUT OF SERVICE		-	-	-	-
MOBILE CITY	1030		09/19/85	C	A	<1	<1	<1
McCormick POOL	1031		[illegible]	C	A	<1	1	<1
RICHIE	1032		[illegible]	C	A	<1	<1	<1
[illegible]		[illegible]	[illegible]	C	C	<1	1	<1
PHOTO	1033		04/02/86	C	MC	<1	<1	<1
LAB	1033		04/02/86	C	C	<1	<1	<1
MIGHT	1034		04/02/86	SM	CAL	<1	<1	<1
(PATTEN)	1034		04/02/86	C	C	<1	<1	<1
MIGHT	1035		04/02/86	SM	CAL	<1	<1	<1
	1035		04/02/86	C	C	<1	<1	<1
RICE	1036		12/17/85	C	A	<1	<1	<1
	1036		12/17/85	C	A	<1	<1	<1
	1036		04/02/86	SM	CAL	<1	<1	<1

CHAMPION INTERNATIONAL CORPORATION
WATER QUALITY DATA
PROJECT #6-001
MISSOULA, MONTANA
9/3/86

OWNER	OLD WELL	NEW WELL	SAMPLE DATE	SAMPLED BY	LAB.	BENZENE UG/L	TOLUENE UG/L	XYLENES UG/L
CHAUSSEE	1037		12/03/85	C	A	<1	<1	<1
	1037		01/13/86	C	A	<1	<1	<1
	1037		04/02/86	SM	CAL	<1	<1	<1
	1037		04/02/86	SM	CAL	<1	<1	<1
	1037		04/02/86	C	C	<1	<1	<1
UTLEY	1038		04/02/86	SM	CAL	<1	<1	<1
	1038		04/02/86	C	C	<1	<1	<1
CHAMPION	2001-1		08/01/85	C	L	<1	<1	<1
	2001-1		09/20/85	C	A	<1	<1	<1
	2001-1		09/20/85	C	L	16.0	4.0	7.7
	2001-1		04/15/86	C	C	<1	<1	<1
CHAMPION	2001-2		08/01/65	C	L	<1	<1	<1
	2001-2		09/19/95	C	A	10.7	16.5	20.4
	2001-2		09/19/65	C	L	2.0	2.0	<1
	2001-2		04/03/86	SM	CAL	<1	<1	<1
	2001-2		04/03/86	SM	CAL	<1	<1	<1
	2001-2		04/03/86	C	C	<1	<1	<1
	2001-2		04/15/86	C	C	<1	<1	<1
CHAMPION	2002-1		08/18/65	C	L	2720.0	5450.0	6030.0
	2002-1		09/20/85	C	A	2270.0	6180.0	6370.0
	2002-1		09/20/85	C	L	1750.0	2650.0	4200.0
	2002-1		10/01/85	C	A	1540.0	2780.0	4710.0
	2002-1		08/07/86	C	C	488	410	+
	2002-1		08/07/86	SM	SM	215.0	252.0	783.0

CHAMPION INTERNATIONAL CORPORATION
WATER QUALITY DATA
PROJECT #8-001
MISSOULA, MONTANA
9/3/86

OWNER	OLD WELL	NEW WELL	SAMPLE DATE	SAMPLED BY	LAB.	BENZENE UG/L	TOLUENE UG/L	XYLENES UG/L
CHAMPION	3002-2		08/16/85	C	L	<1	2.5	32.0
	3002-2		09/20/65	C	A	<1	<1	<1
	3002-2		09/20/85	C	L	1.6	<1	<1
	3002-2		08/07/86	C	C	<1	<1	<1
	3002-2		08/07/86	SM	SM	<1	<1	<1
CHAMPION	3003-1		08/17/85	C	L	195.0	14.0	33.0
	3003-1		09/20/85	C	A	58.9	<1	7.3
	3003-1		09/20/85	C	L	3.5	3.3	<1
	3003-1		04/03/86	SM	CAL	<1	<1	<1
	3003-1		04/03/86	C	C	<1	<1	<1
	3003-1		04/15/86	C	C	<1	<1	<1
	3003-1		08/07/86	C	C	<1	<1	<1
	3003-1		08/07/86	SM	SM	4.8	<1	<1
CHAMPION	3003-2		08/17/85	C	L	<1	<1	<1
	3003-2		09/20/85	C	A	<1	<1	<1
	3003-2		09/20/85	C	L	<1	<1	<1
	3003-2		04/15/86	C	C	<1	<1	<1
	3003-2		08/07/86	C	C	<1	<1	1
	3003-2		08/07/86	SM	SM	<1	<1	<1
CHAMPION	3004-1		08/17/85	C	L	<1	<1	<1
	3004-1		09/19/85	C	A	<1	<1	<1
	3004-1		09/19/85	C	L	<1	<1	<1
	3004-1		04/03/86	SM	CAL	<1	<1	<1
	3004-1		04/03/86	C	C	<1	<1	<1
	3004-1		04/15/86	C	C	<1	<1	<1
CHAMPION	3004-2		08/17/85	C	L	<1	2.4	2.8
	3004-2		09/19/85	C	A	<1	<1	<1

CHAMPION INTERNATIONAL CORPORATION
WATER QUALITY DATA
PROJECT #8-001
MISSOULA, MONTANA
9/3/86

OWNER	OLD WELL	NEW WELL	SAMPLE DATE	SAMPLED BY	LAB.	BENZENE UG/L	TOLUENE UG/L	XYLENES UG/L
	3004-2		09/19/85	C	L	<1	<1	<1
	3004-2		04/15/86	C	C	<1	<1	<1
CHAMPION (FACTORY)	3091		08/01/85	C	L	<1	<1	<1
	3091		09/19/85	C	A	19.4	1.5	2.9
	3091		09/19/85	C	L	2.0	2.0	<1
	3091		04/03/86	SM	CAL	<1	<1	<1
CHAMPION (SCALE HOUSE)	3092		09/19/85	C	A	<1	<1	<1
	3092		09/19/85	C	L	2.0	2.0	<1
CHAMPION (C.T.L.)	3092		09/18/85	C	A	<1	<1	<1

SAMPLER AND LAB IDENTIFICATION

A - ANALYTICAL TECHNOLOGIES - A
C - CHAMPION TECHNICAL CENTER - C
E - E.P.A. - E
L - LAUCKS - L
MC - MISSOULA COUNTY - 1 - MC
SM - STATE OF MONTANA - SM
MSU - MONTANA STATE UNIVERSITY - MSU
CAL - CALIFORNIA ANALYTICAL LAB INC. - CAL

COLIFORM BACTERIA

CONT. = MEANS NOT SUITABLE FOR DRINKING

Results of examination of ground water for coliform bacteria.

OWNER	OLD WELL	NEW WELL	SAMPLE DATE	SAMPLED BY	LAB.	COLIFORM BACTERIA
VIETEN-	1003		10/16/85	MC	MC	CONT.
HEIMER		1003N	04/28/86	C	MC	<1
(NORTH)						
VIETEN-	1004		10/16/85	C	MC	CONT.
HEIMER	1004		04/02/86	C	MC	<1
	1004		04/02/86	SM	SM	<1
		1004N	04/28/86	MC	MC	<1
BRANDT	1005		03/31/86	C	MC	<1
	1005		04/02/86	C	MC	<1
	1005		04/02/86	SM	SM	<1
ISE	1006		10/16/85	C	MC	<1
	1006		03/13/86	C	MC	<1
	1006		04/02/86	C	MC	<1
	1006		04/02/86	SM	SM	<1
		1006N	04/23/86	C	MC	<1
VIETEN-	1007		10/16/85	C	MC	<1
HEIMER	1007		04/02/86	C	MC	CONT.
(RUFF)	1007		04/02/86	SM	SM	CONT.
		1007N	04/28/86	C	MC	<1
LARSON	1008		10/16/85	C	MC	<1
	1008		04/02/86	C	MC	<1
	1008		04/02/86	SM	SM	<1
		1008N	04/28/86	C	MC	<1

CHAMPION INTERNATIONAL CORPORATION
WATER QUALITY DATA
PROJECT #8-001
MISSOULA, MONTANA
4/3/86

OWNER	OLD WELL	NEW WELL	SAMPLE DATE	SAMPLED BY	LAB.	COLIFORM BACTERIA
THRASHER	1009		10/16/85	C	MC	<1
		1009N	03/19/86	C	MC	<1
		1009N	03/31/86	C	MC	<1
WAYTE	1010		04/03/86	C	SM	<1
	1010		04/03/86	SM	SM	<1
RICHLIE	1011		10/16/85	C	MC	CONT.
(DAMRON)	1011		04/03/86	C	SM	CONT.
	1011		04/03/86	SM	SM	CONT.
		1011N	04/28/86	C	MC	<1
PRICE		1012N	02/17/86	C	MC	<1
MINCH	1016		10/16/85	C	MC	<1
(BOSHERT)	1016		04/03/86	C	SM	CONT.
		1016N	04/03/86	SM	SM	<1
		1016N	04/03/86	SM	SM	<1
	1016		04/03/86	SM	SM	CONT.
		1016N	04/04/86	C	SM	<1
		1016N	04/10/86	C	MC	<1
ROSE	1018		10/16/85	C	MC	CONT.
	1018		03/11/86	SM	SM	CONT.
	1018		03/11/86	SM	SM	<1
	1018		04/02/86	C	MC	<1
	1018		04/02/86	SM	SM	<1

CHAMPION INTERNATIONAL CORPORATION
WATER QUALITY DATA
PROJECT #8-001
MISSOULA, MONTANA
9/[illegible]/86

OWNER	OLD WELL	NEW WELL	SAMPLE DATE	SAMPLED BY	LAB.	COLIFORM BACTERIA
NIGHT (PARRISH)	1019		04/02/86	SM	SM	<1
CHAUSSEE	1020		10/16/85	C	MC	CONT.
		1020N	01/31/86	C	MC	<1
		1020N	04/03/86	C	SM	<1
	1020		04/03/86	SM	SM	CONT.
	1020		04/03/86	SM	SM	<1
		1020N	04/03/86	SM	SM	<1
	1020		04/03/86	C	SM	CONT.
BOWERS		1021N	02/10/86	C	MC	<1
RICHLIE	1022		10/16/85	C	MC	<1
		1022N	02/10/86	C	MC	CONT.
		1022N	02/17/86	C	MC	<1
		1022N	02/24/86	C	MC	<1
	1022		04/03/86	C	SM	CONT.
		1022N	04/03/86	C	MC	<1
	1022		04/03/86	SM	SM	CONT.
		1022N	04/03/86	SM	SM	<1
	1022		04/03/86	SM	SM	CONT.
THORNBURG	1023		10/16/85	C	MC	<1
		1023N	03/31/86	C	MC	<1
ANDERSON	1024		10/16/85	C	MC	<1

CHAMPION INTERNATIONAL CORPORATION
WATER QUALITY DATA
PROJECT #8-001
MISSOULA, MONTANA
9/[illegible]/86

OWNER	OLD WELL	NEW WELL	SAMPLE DATE	SAMPLED BY	LAB.	COLIFORM BACTERIA
		1024N	02/17/86	C	MC	<1
POVSHA	1025		10/16/85	C	MC	<1
(CAR LOT)	1025		04/28/86	C	MC	<1
RICHLIE (TILTON)		1032N	02/17/86	C	MC	<1
PHOTO	1033		04/02/86	C	MC	<1
LAB	1033		04/02/86	SM	SM	<1
WIGHT	1034		04/02/86	C	MC	<1
(PATTEN)	1034		04/02/86	SM	SM	<1
WIGHT	1035		04/02/86	C	MC	<1
	1035		04/02/86	SM	SM	<1
RICE	1036		04/02/86	C	MC	<1
	1036		04/02/86	SM	SM	<1
CHAUSSEE	1037		12/03/85	C	MC	CONT.
	1037		12/27/85	C	MC	CONT.
	1037		04/02/86	C	MC	CONT.
	1037		04/02/86	SM	SM	<1

CHAMPION INTERNATIONAL CORPORATION
WATER QUALITY DATA
PROJECT #8-001
MISSOULA, MONTANA
9/3/86

OWNER	OLD WELL	NEW WELL	SAMPLE DATE	SAMPLED BY	LAB.	COLIFORM BACTERIA
UTLEY	1038		04/02/86	C	MC	<1
	1038		04/02/86	SM	SM	<1
CHAMPION	2001-2		04/03/86	C	SM	<1
CHAMPION	2003-1		04/03/86	SM	SM	<1
	2003-1		04/03/86	C	SM	CONT.
CHAMPION	2004-1		04/03/86	SM	SM	CONT.
	2004-1		04/03/86	C	SM	CONT.
CHAMPION	2091		04/03/86	SM	SM	<1
	2091		04/03/86	C	SM	<1

SAMPLER AND LAB IDENTIFICATION

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L - LAUCKS
MC - MISSOULA COUNTY - 1
SM - STATE OF MONTANA
MSU - MONTANA STATE UNIVERSITY
CAL - CALIFORNIA ANALYTICAL LAB INC.

Date of Report: 10/17/86

MISSOULA CITY-COUNTY HEALTH DEPARTMENT
301 West Alder Missoula, Mt. 59802, Phone 721-5700

LABORATORY WATER REPORT

Water Source: WELL 10B
Location: 1127 IDAHO ST.

Owner: LENA ROSE
Address: 1127 IDAHO ST.
MISSOULA, MT 59801

Type of Analysis: Fecal Coliform Membrane Filter

Date Collected: 10/09/86 TIME: 0935 By: BILL PEERY

Date Tested: 10/09/86 TIME: 1230 By: TINA BRIGHT

Type of Sample: Followup

Sample Number: 226166 Analysis Result: <1/100ml
NOT CONTAMINATED

The above water sample was not collected by a Registered Sanitarian. Thus, the source of the sample cannot be verified by the Health Department.

The laboratory examination of this sample showed no evidence of coliform bacteria contamination. This indicated that, as far as can be determined by a laboratory examination, the water was safe for drinking at the time the sample was taken.

However, these results cannot be relied upon as indicating the safety of the water at all times unless the source is properly located and maintained.

Any well construction which does not positively exclude all surface and subsurface contamination must be considered as dangerous to health. All dust, pump spillage, surface drainage, soil, etc., must be prevented from entering the well.

This examination does not include tests for hardness, minerals, iron, florides, etc., nor does it include tests to determine suitability for irrigation or for stock purposes.

BILL PEERY
538 EDDY ST.
MISSOULA, MT 59801

Date of Report: 10/17/86

MISSOULA CITY-COUNTY HEALTH DEPARTMENT
301 West Alder Missoula, Mt. 59802, Phone 721-5700

LABORATORY WATER REPORT

Water Source: WELL 1035 | Owner: LEO NIGHT
Location: 1201 RIVER RD. | Address: 1201 RIVER RD.
MISSOULA, MT 59801

Type of Analysis: Fecal Coliform Membrane Filter

Date Collected: 10/09/86 TIME: 0948 By: BILL PEERY

Date Tested: 10/09/86 TIME: 1630 By: TINA BRIGHT

Type of Sample: Followup

Sample Number: 227986 Analysis Result: <1/100ml
NOT CONTAMINATED

The above water sample was not collected by a Registered Sanitarian. Thus, the source of the sample cannot be verified by the Health Department.

The laboratory examination of this sample showed no evidence of coliform bacteria contamination. This indicated that, as far as can be determined by a laboratory examination, the water was safe for drinking at the time the sample was taken.

However, these results cannot be relied upon as indicating the safety of the water at all times unless the source is properly located and maintained.

Any well construction which does not positively exclude all surface and subsurface contamination must be considered as dangerous to health. All dust, pump spillage, surface drainage, soil, etc., must be prevented from entering the well.

This examination does not include tests for hardness, minerals, iron, florides, etc., nor does it include tests to determine suitability for irrigation or for stock purposes.

BILL PEERY
538 EDDY ST.
MISSOULA, MT 59801

Date of Report: 10/17/86

MISSOULA CITY-COUNTY HEALTH DEPARTMENT
301 West Alder Missoula, Mt. 59802, Phone 721-5700

LABORATORY WATER REPORT

Water Source: WELL 1037
Location: 1319 RIVER RD.

Owner: ELLEN CHAUSSEE
Address: 1319 RIVER RD.
MISSOULA, MT 59801

Type of Analysis: Fecal Coliform Membrane Filter

Date Collected: 10/09/86 TIME: 1000 By: BILL PEERY

Date Tested: 10/09/86 TIME: 1230 By: TINA BRIGHT

Type of Sample: Routine

Sample Number: 228086 Analysis Result: <1/100ml
NOT CONTAMINATED

The above water sample was not collected by a Registered Sanitarian. Thus, the source of the sample cannot be verified by the Health Department.

The laboratory examination of this sample showed no evidence of coliform bacteria contamination. This indicated that, as far as can be determined by a laboratory examination, the water was safe for drinking at the time the sample was taken.

However, these results cannot be relied upon as indicating the safety of the water at all times unless the source is properly located and maintained.

Any well construction which does not positively exclude all surface and subsurface contamination must be considered as dangerous to health. All dust, pump spillage, surface drainage, soil, etc., must be prevented from entering the well.

This examination does not include tests for hardness, minerals, iron, florides, etc., nor does it include tests to determine suitability for irrigation or for stock purposes.

BILL PEERY
538 EDDY ST.
MISSOULA, MT 59801

DEPARTMENT OF HEALTH AND ENVIRONMENTAL SCIENCES
WATER QUALITY BUREAU
Analytical Report

Site: Champion Sawmill and California Street, Missoula
Sampled by: John Arrigo, Bill Clark
Dates sampled: November 5 & 6, 1986

Results of Analysis

Location	Benzene ug/l	Toluene ug/l	Xylene ug/l	Lead (Pb) mg/l	Total Organic Carbon (TOC) mg/l
1005 Brandt	< 1.0	< 1.0	< 1.0	< .005	NA
1008-1 Larson	< 1.0	< 1.0	< 1.0	< .005	NA
1018 Rose	< 1.0	< 1.0	< 1.0	< .005	NA
1020-1 Chaussee	1.19	< 1.0	< 1.0	< .005	2.3
1022-1 Richlie	< 1.0	< 1.0	< 1.0	< .005	NA
McCormick Park	< 1.0	< 1.0	< 1.0	< .005	1.6
1037 E. Chaussee	< 1.0	< 1.0	< 1.0	NA	NA
3001-2	< 1.0	< 1.0	< 1.0	< .005	NA
3002-1	134.96	83.22	248.32	.012	> 50*
3002-1 (Duplicate)	NA	NA	NA	NA	> 50*
3002-2	< 1.0	< 1.0	< 1.0	< .005	NA
3002-2 (Duplicate)	< 1.0	< 1.0	< 1.0	< .005	NA
3003-1	< 1.0	< 1.0	< 1.0	< .005	3.2*
3003-2	< 1.0	< 1.0	< 1.0	< .005	NA
3091 Factory	< 1.0	< 1.0	< 1.0	< .005	NA
3011 (Blank)	< 1.0	< 1.0	< 1.0	< .005	.5

Explanation:
NA = not analyzed
< 1.0 = less than 1.0 ug/l detection limit of test
ug/l = parts per billion
mg/l = parts per million
*sample was turbid therefore TOC values are elevated

ANALYSIS REPORT

Lancaster Laboratories

INCORPORATED
2425 NEW HOLLAND PIKE, LANCASTER, PA 17601

University of Montana
Department of Geology
Missoula, MT 59812

Date Reported 5/26/87
Date Submitted 5/ 8/87
Discard Date 6/ 3/87
Collected by C
P.O. 28144
Rel.

#1018 Water Sample
Collected 05/06/87 by WP

ANALYSIS	RESULT AS RECEIVED		LIMIT OF DETECTION	LAB CODE
Phenols	< 0.004	mg/l	0.004	043403500
Volatiles in Groundwater		attached		051510500

1 COPY TO University of Montana ATTN: William Peery

The American Association for Laboratory Accreditation Chemical & Biological Fields of Testing

03893 0.00 014000

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

Respectfully Submitted
Lancaster Laboratories, Inc.
Reviewed and Approved by:

Richard C. Entz, B.A.
Group Leader, Organic Analysis

ANALYSIS REPORT

Lancaster Laboratories

INCORPORATED
NEW HOLLAND PIKE, LANCASTER, PA 17601

University of Montana
Department of Geology
Missoula, MT 59812

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P.O. 28144
Rel.

#1018 Water Sample
Collected 05/06/87 by WP

Volatiles in Groundwater	RESULT AS RECEIVED		LIMIT OF DETECTION	LAB CODE
Benzene	< 1.	ug/l	1.	070300000N
Toluene	< 1.	ug/l	1.	070400000N
Chlorobenzene	< 1.	ug/l	1.	070500000N
Ethylbenzene	< 1.	ug/l	1.	070600000N
Chloromethane	< 5.	ug/l	5.	071100000N
Bromomethane	< 5.	ug/l	5.	071200000N
2-Chloroethylvinyl ether	< 10.	ug/l	10.	071300000N
Vinyl chloride	< 1.	ug/l	1.	071400000N
Chloroethane	< 1.	ug/l	1.	071500000N
Methylene chloride	< 1.	ug/l	1.	071600000N
1,1-Dichloroethene	< 1.	ug/l	1.	071700000N
1,1-Dichloroethane	< 1.	ug/l	1.	071800000N
trans-1,2-Dichloroethene	< 1.	ug/l	1.	071900000N
Chloroform	< 1.	ug/l	1.	072000000N
1,2-Dichloroethane	< 1.	ug/l	1.	072100000N
1,1,1-Trichloroethane	< 1.	ug/l	1.	072200000N
Carbon tetrachloride	< 1.	ug/l	1.	072300000N
Dichlorobromomethane	< 1.	ug/l	1.	072400000N
1,2-Dichloropropane	< 1.	ug/l	1.	072500000N
trans-1,3-Dichloropropene	< 1.	ug/l	1.	072600000N
Trichloroethene	< 1.	ug/l	1.	072700000N
Dibromochloromethane	< 1.	ug/l	1.	072800000N
1,1,2-Trichloroethane	< 1.	ug/l	1.	072900000N
cis-1,3-Dichloropropene	< 1.	ug/l	1.	073000000N
Bromoform	< 2.	ug/l	2.	073100000N
1,1,2,2-Tetrachloroethane	< 2.	ug/l	2.	073200000N
Tetrachloroethene	< 1.	ug/l	1.	073300000N

1 COPY TO University of Montana ATTN: William Peery

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Richard C. Entz, B.A.
Group Leader, Organic Analysis

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

ANALYSIS REPORT

Lancaster Laboratories

2425 NEW HOLLAND PIKE LANCASTER PA 17601

University of Montana
Department of Geology
Missoula, MT 59812

Date Reported	5/26/87
Date Submitted	5/ 8/87
Discard Date	6/ 3/87
Collected by	C
P.O.	28144
Rel.	

#1037 Water Sample
Collected 05/06/87 by WP

ANALYSIS	RESULT AS RECEIVED		LIMIT OF DETECTION	LAB CODE
Phenols	< 0.004	mg/l	0.004	043403500
Volatiles in Groundwater		attached		051510500

1 COPY TO University of Montana ATTN: William Peery

The American Association for Laboratory Accreditation Chemical & Biological Fields of Testing

03893 0.00 014000

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Richard C. Entz, B.A.
Group Leader, Organic Analysis

ANALYSIS REPORT

Lancaster Laboratories
INCORPORATED
2425 NEW HOLLAND PIKE, LANCASTER, PA 17601
(717) 656-2301

University of Montana
Department of Geology
Missoula, MT 59812

Date Reported 5/26/87
Date Submitted 5/ 8/87
Discard Date 6/ 3/87
Collected by C
P.O. 28144
Rel.

#1037 Water Sample
Collected 05/06/87 by WP

Volatiles in Groundwater	RESULT AS RECEIVED		LIMIT OF DETECTION	LAB CODE
Benzene	< 1.	ug/l	1.	070300000N
Toluene	< 1.	ug/l	1.	070400000N
Chlorobenzene	< 1.	ug/l	1.	070500000N
Ethylbenzene	< 1.	ug/l	1.	070600000N
Chloromethane	< 5.	ug/l	5.	071100000N
Bromomethane	< 5.	ug/l	5.	071200000N
2-Chloroethylvinyl ether	< 10.	ug/l	10.	071300000N
Vinyl chloride	< 1.	ug/l	1.	071400000N
Chloroethane	< 1.	ug/l	1.	071500000N
Methylene chloride	< 1.	ug/l	1.	071600000N
1,1-Dichloroethene	< 1.	ug/l	1.	071700000N
1,1-Dichloroethane	< 1.	ug/l	1.	071800000N
trans-1,2-Dichloroethene	< 1.	ug/l	1.	071900000N
Chloroform	< 1.	ug/l	1.	072000000N
1,2-Dichloroethane	< 1.	ug/l	1.	072100000N
1,1,1-Trichloroethane	< 1.	ug/l	1.	072200000N
Carbon tetrachloride	< 1.	ug/l	1.	072300000N
Dichlorobromomethane	< 1.	ug/l	1.	072400000N
1,2-Dichloropropane	< 1.	ug/l	1.	072500000N
trans-1,3-Dichloropropene	< 1.	ug/l	1.	072600000N
Trichloroethene	< 1.	ug/l	1.	072700000N
Dibromochloromethane	< 1.	ug/l	1.	072800000N
1,1,2-Trichloroethane	< 1.	ug/l	1.	072900000N
cis-1,3-Dichloropropene	< 1.	ug/l	1.	073000000N
Bromoform	< 2.	ug/l	2.	073100000N
1,1,2,2-Tetrachloroethane	< 2.	ug/l	2.	073200000N
Tetrachloroethene	< 1.	ug/l	1.	073300000N

1 COPY TO University of Montana ATTN: William Peery

Respectfully Submitted
Lancaster Laboratories, Inc.
Reviewed and Approved by:

Richard C. Entz, B.A.
Group Leader, Organic Analysis

The American Association for Laboratory Accreditation Chemical & Biological Fields of Testing

SEE REVERSE SIDE FOR EXPLANATION OF SYMBOLS AND ABBREVIATIONS

120543

CHEMISTRY LABORATORY BUREAU
Management Services Division
Montana Department of Health and Environmental Sciences

ANALYSIS REPORT

OWNER: Champion - California St.

ADDRESS: Missoula MT

SOURCE INFORMATION: Ground water samples from domestic wells & mon. wells near fuel leak

DATE COLLECTED: 5/26-27/87 DATE RECEIVED: 5/29/87 SAMPLER: J. Arrigo

LABORATORY SAMPLE NUMBER

ANALYSIS	87 W 1074 McCormick Park Well	RESULT	87 W 1075 Well 3001-1	UNITS
Tot. Phenols	.011		.001	mg/l
Dis. Al	<.03		.08	mg/L
Dis. Fe	.18		.04	mg/L
Dis. Mn	<.005		.03	mg/L
Dis. Ba	.08		.22	mg/L
Benzene	<.5		<.5	µg/L
Toluene	<.5		<.5	µg/L
Xylene	<1.0		<1.0	µg/L

REMARKS:

87 W 1075

Date Analyzed: 6/12/87
Analyst: LAD

87 W 1074

120543

CHEMISTRY LABORATORY BUREAU
Management Services Division
Montana Department of Health and Environmental Sciences

ANALYSIS REPORT

OWNER: Champion - California St.

ADDRESS: Missoula MT

SOURCE INFORMATION: Ground water samples from domestic wells & mon. wells near fuel leak

DATE COLLECTED: 5/26-27/87 DATE RECEIVED: 5/29/87 SAMPLER: J. Arrigo

LABORATORY SAMPLE NUMBER

ANALYSIS	87 W 1076 Well 3002-1	RESULT	87 W 1077 Well 3002-2	UNITS
Tot. Phenols	.023		.004	mg/l
Dis. Al	<.03		<.03	mg/L
Dis. Fe	1.14		<.01	mg/L
Dis. Mn	10.1		.01	mg/L
Dis. Ba	.52		.23	mg/L
Benzene	437		<.5	µg/L
Toluene	1930		<.5	µg/L
Xylene	2373		<1.0	µg/L

REMARKS:

Date Analyzed: 6/12/87
Analyst: LAB

87 W 1076 87 W 1077

120543

CHEMISTRY LABORATORY BUREAU
Management Services Division
Montana Department of Health and Environmental Sciences

ANALYSIS REPORT

OWNER: Champion - California St.

ADDRESS: Missoula MT

SOURCE INFORMATION: Ground water samples from domestic wells & mon. wells near fuel leak

DATE COLLECTED: 5/26-27/87 DATE RECEIVED: 5/29/87 SAMPLER: J. Arrigo

LABORATORY SAMPLE NUMBER

ANALYSIS	87 W 1078 Well 3003-1	RESULT	87 W 1079 Well 3004-1	UNITS
Tot. Phenols	.007		.005	mg/l
Dis. Al	<.03		<.03	mg/L
Dis. Fe	<.01		.04	mg/L
Dis. Mn	3.22		.27	mg/L
Dis. Ba	.29		.10	mg/L
Benzene	1801		<.5	µg/L
Toluene	.94		<.5	µg/L
Xylene	54.7		<1.0	µg/L

REMARKS:

Date Analyzed: 6/12/87
Analyst: LAB

87 W 1078 87 W 1079

120543

CHEMISTRY LABORATORY BUREAU
Management Services Division
Montana Department of Health and Environmental Sciences

ANALYSIS REPORT

OWNER: Champion - California St.

ADDRESS: Missoula MT

SOURCE INFORMATION: Ground water samples from domestic wells & mon. wells near fuel leak

DATE COLLECTED: 5/26-27/87 DATE RECEIVED: 5/29/87 SAMPLER: J. Arrigo

LABORATORY SAMPLE NUMBER

ANALYSIS	87 W 1087 Well 1018	RESULT 87 W 1088 Well 1005	UNITS
Tot. Phenols	.001	.003	mg/l
Dis. Al	<.03	<.03	mg/L
Dis. Fe	.21	<.01	mg/L
Dis. Mn	.92	<.005	mg/L
Dis. Ba	.25	.29	mg/L
Benzene	<.5	<.5	µg/L
Toluene	<.5	<.5	µg/L
Xylene	<1.0	<1.0	µg/L

REMARKS:

Date Analyzed: 6/12/87
Analyst: LAB

87 W 1087 87 W 1088

120543

CHEMISTRY LABORATORY BUREAU
Management Services Division
Montana Department of Health and Environmental Sciences

ANALYSIS REPORT

OWNER: Champion - California St.

ADDRESS: Missoula MT

SOURCE INFORMATION: Ground water samples from domestic and monitoring wells near fuel leak

DATE COLLECTED: 5/20/87 DATE RECEIVED: 5/29/87 SAMPLER: J. Arrigo

LABORATORY SAMPLE NUMBER -

ANALYSIS	87 W 1080 Well # 1018	87 W 1081 Well # 1037	87 W 1082 Well # 1039		UNITS
Dis. Al	<.03	<.03	<.03		mg/L
Dis. Fe	.18	<.01	.08		mg/L
Dis. Mn	.55	<.005	<.005		mg/L
Dis. Ba	.26	.21	.24		mg/L

REMARKS:

Date Analyzed: 6/4/87
Analyst: DB

87 W 1080 87 W 1081 87 W 1082

120543

CHEMISTRY LABORATORY BUREAU
Management Services Division
Montana Department of Health and Environmental Sciences

ANALYSIS REPORT

OWNER: Champion - California St.

ADDRESS: Missoula MT

SOURCE INFORMATION: Ground water samples from domestic wells & mon. wells near fuel leak

DATE COLLECTED: 5/26-27/87 DATE RECEIVED: 5/29/87 SAMPLER: J. Arrigo

LABORATORY SAMPLE NUMBER

87 W 1085 87 W 1086

ANALYSIS	Well 1022	RESULT Well 1020	UNITS
Tot. Phenols	.074	.005	mg/l
Dis. Al	<.03	<.03	mg/L
Dis. Fe	.04	.15	mg/L
Dis. Mn	<.005	.98	mg/L
Dis. Ba	.27	.30	mg/L
Benzene	<.5	<.5	µg/L
Toluene	<.5	<.5	µg/L
Xylene	<1.0	2.92	µg/L

REMARKS:

Date Analyzed: 6/2/87
Analyst: LAD

87 W 1085 87 W 1086

120543

CHEMISTRY LABORATORY BUREAU
Management Services Division
Montana Department of Health and Environmental Sciences

ANALYSIS REPORT

OWNER: Champion · California St

ADDRESS: Missoula MT

SOURCE INFORMATION: QA/QC check sample for ground water pumping decon

DATE COLLECTED: 5/27/87 DATE RECEIVED: 5/29/87 SAMPLER: J. Arrigo

LABORATORY SAMPLE NUMBER

87 W 1089

ANALYSIS	Pump Blank	RESULT	UNITS
Benzene	<.5		ug/L
Toluene	<.5		"
Xylene	<1.0		"

REMARKS:

Date Analyzed:

Analyst:

87 W 1089

analyses for November, 1986

Title: The Determination of Bacterial Species Isolated from Well Waters Contaminated by Leaded Gasoline and Their Ability to Utilize Hydrocarbons

Test Wells: (1) Test Well I.D., 3002-1; (2) Test Well I.D., 3003-1; (3) Control-MCP-B

Objectives:

1. Determine the bacterial population of test well samples and the control well sample.
2. Isolate bacterial types by streak plate method, describe colony types and transfer to "Pure" culture.
3. Gram Stain isolates, describe, and identify species were possible.
4. Inoculate isolates into a "Nutritionally Deficient" medium.
5. If any type(species) grows, reisolate by streak plate method, Gram Stain, describe and compare to the origional type(species).

Media:

1.	Single and double strength	Tryptic soy broth(TSB 1x & 2x)
2.	Single and double strength	Lauryl sulfate tryptose broth, (LSTB 1x & 2x)
3.	Standard Plate Count Medium Agar	SPCM
4.	Brain-Heart Infusion Broth & Agar	BHI, and BHIA
5.	Minimal Nutrient Medium	(MNM), Tween 80 water, pH 7.2, 1600 μ/grams filtered leaded gasoline, plus 1700μ/grams KNO_3

Sample Population:

MCP-B, Per 100ml.	3002-1, Per 100ml.	3003-1, Per 100ml.
Less than 30/100ml.(*)	Greater than 220,(*) Less than 7,000	Greater than 200,(*) Less than 2,100

(*) By MPN Method(95% confidence limits)

Plate Count:

MCP-B	3002-1	3003-1
No growth	726/ml.	180/ml.

Isolation of Bacterial Types:

a. Bacterial colonies of distinct morphology were picked to "Pure Cultures" from streak plates.
b. Pure cultures were described, Gram stained, and used to culture the MNM.
c. Any MNM culture showing changes in the gasoline layer were then subcultured in BHI medium.
d. If growth occured, the surviving species was again Gram stained and compared to the origional isolate.
e. Sample MCP-B (3 species isolated), 3002-1(24 isolates), 3003-1 (20 isolates). Results follow-

Sample I.D.	Isolate #	Gram Stain	Cell Morphology	Utilization of MNM duplicate tubes	Time required	Reisolation Growth +, -	Remarks
MCP-B	1	- rods	cocco-bacilli	+ homogenized -	30 da.	neg (-)	sediment, no viable cells
	2	+ rods spores	rods, single, pairs & clusters	+ homogenized +	30 da.	+ spores germinated	no vegetative cells
	3	- cocci	2-4-8 cells, capsulated.	+ not homogen- - ized	30 da.	neg.(-)	
3002-1	1	+ cocci	Staphylococci clusters	+ slight homog- - enization	15-30 da.	+	sediment, with viable cells
	2	+ rods	single, pairs, with capsule	+ " -	15-30 da.	-	no vegetative cells
	3-8	neg.	n.a.	n.a.	n.a.	n.a.	n.a.
	9	+ rods	spore-forming in long chains	+ homogenized + "	15 da.	+ spores germinated	no vegetative cells
	10	+ rods	non-spore forming	- -	30 da.	-	
	11	+ rods	non-spore forming in capsules	+ slight homogen- - ization	30 da.	+	some cells found
	12-14	neg.	n.a.	n.a.	n.a.	n.a.	
	15	neg.	neg.	- slight homog- + enization	30 da.	neg(-)	
	16	neg.	neg.	+ slight homog- + enization	30 da.	neg(-)	
	17	+ rods	non-spore forming singles, short chains	+ slight homog- + enization	30 da.	neg.(-)	

	Isolate #	Gram / Stain	Cell Type / Morphology	Utilization of MNM / duplicate tubes	Time / required	Reisolation / Growth +, -	Remarks
3002-1, cont.	18	+ rods	short, spore forming, 2-6 cells	+ homogenized +	30 da.	spores germinated	no vegetative cells
	19	+ rods	short, spore forming, 2-6 cells	+ homogenized +	15 da.	spores remain	no vegetative cells
	20	+ rods	long rods with spores, chains	+ homogenized +	15 da.	spores remain	no vegetative cells(B.Meg.?)
	21-22	neg.	n.a.	- Slight homogenization +	10 da.	n.a.	
	23	+ rods	short, spore forming, long chains	+ no homogenization +	15 da.	spores remain	no vegetative cells
	24	neg.	n.a.	- Slight homogenization +	30 da.	n.a.	
3003-1	1	rods	sporforming single & short chains	+ homogenized +	15 d	spores germinated	B. Subt. var. niger
	2-6	neg.	n.a.	n.a.	30 da.	n.a.	
	7.	+ cocci	Staph-like grouping	+ homogenized +	15 da.	+	Staph. sp.
	8.	+ rods	short rods in chains & singles with spores present	+ homogenized +	15 da.	+ spores germinated	no vegetative cells, B.Subt.
	9.	+ cocci	2-4-8 groups	- no homogenization -	30 da.	n.a	Sarcina sp.
	10.	+ rods	non-sporforming, single & pairs	+ homogenized +	10 da.	n.a.	capsulated rods
	11.	- rods	short rods single & pairs	+ homogenized -	15 da.	n.a.	neg. gas prod. Ent. sp(coli?.)
	12.	+ rods	sporeforming in singles & chains	+ homogenized +	15-30 da.	spores germinated	no vegetative cells, B.Subt.sp.
	13.	+ rods	sporforming in chains	+ homogenized	15 da.	spores germinated	no vegetative cells, B.Subt.sp.
	14.	no gr.	n.a.	- no homogenization -	30 da.	n.a.	no growth
	15.	+ cocci	pairs with capsule	+ no homogenization -	30 da.	n.a.	diplococci with capsule
	16.	+ rods	Large spore-forming chains	+ homogenized +	15-30 da.	spores remain	no vegetative cells, B.Meg.
	17.	+ rods	Large spore-forming chains	+ homogenized +	15-30 da.	spores remain	no vegetative cells, B.Meg.
	18.	+ cocci	pairs	+ no homogenization -	15-30 da.	n.a.	diplococci with capsule
	19-20	no gr.	n.a.	- no homogenization -	n.a.	n.a.	no growth

SUMMARY

MCP_A, Control:

1. Population, Less than 30/100ml by Multiple tube method, Less than 1/ml by plate count method.
2. Three species isolated from tube culture(TSB)
3. One cocco-bacillary rod, one spore-forming Gram + rod, one coccus of uncertain I.D.

3002-1

1. Population, 724/ml, by plate count, Greater than 200 but less than 7,000/100ml. by multiple tube method.
2. Twenty four species isolated from steak plates, some expected to be duplicates.
3. Three(3) Gram + spore forming rod species, Possibley B. Subt., B. Supt.var.niger & B. megaterium .

SUMMARY CONT.

3002-1

4. Six Gram - , non-spore-forming rod species, one species suggests a coliform (non-gas-forming species, possible and Enterobacter sp.
5. One Gram + coccus species, morphology suggests a Staphylococcus sp.
6. One Gram + coccus species, suggest a Diplococcus sp.
7. Homogenization indicated suggests microbial activity but isn't always followed by growth in the MNM culture. The tendency of growth conditions to be anaerobic or microaerophillic may exclude the aerobes but not the facultatives

3003-1

1. Population, 180/ml. by plate count. Greater than 200 but less than 2100/100ml. by multiple tube method.
2. Twenty species isolated from streak plates, some expected to be duplicates.
3. Five Gram positive spore-forming rod species, morphology suggests, B.subt., B. subtilis, var. niger, and B. megaterium sp.
4. One Gram + non-spore-forming rod sp.
5. One Gram - non-spore-forming rod, morphology suggest a non-gas forming Coliform species, probably Enterobacter sp.
6. One Gram + coccus sp., morphology suggests a Staphylococcus sp.
   One Gram + coccus sp., morphology suggests a Sarcina sp.
   Two Diplococcus sp., , both were capsulated.
7. Homogenization indicates microbial activity but wasn't always followed by growth in MNM culture. The tendency of growth conditions to be anaerobic or microaerophillic may have excluded the aerobes but not the facultatives.
8. Coliforms, sometimes present in well waters, were largely not in evidence.

CONCLUSIONS:

This study gives some support to the thesis that certain bacterial species found in ground water may be able to utilize the carbon of hydrocarbons in gasoline. The nitrogen source provided in this study was Nitrate(Nitrogen). In nature, other nitrates would be available and might better support the hydrocarbon utilizing bacteria.

This study further indicates that some aerobic species present might not have had optimal conditions for growth. The surface layer of gasoline largely excluded oxygen. Dispite this, some species did survive.

Arthur G. Davidson, Assoc. Director, M.S., M.B., Emeritus

. . . . or microaerophillic may have excluded the aerobes but not the facultatives

The Determination of Bacterial Species Isolated From
Well Waters Contaminated by Leaded Gasoline
and Their Ability to Utilize Hydrocarbons

analysis for May 1987

Test Wells: (1) 3002-1A, (2) 3002-1B, (3) 3003-1B, (4) 3004-1A, (5) 3004-1B
Date Recd: May 28, 1987

Objectives:

1. To determine the bacterial population of test well samples.
2. To isolate bacterial types by streak plate method, describe colony type, and transfer to pure culture.
3. Gram stain isolates, describe, and identify species where possible.
4. Inoculate isolates into, "Nutritionally Deficient Medium"(NDF).
5. If any isolate grows in the NDM, reisolate by streak plate method, Gram Stain, and compare to the origional species isolated.
6. Comparisons were made with EXXON Bio-Pond (#3) isolates and to some common known bacterial species from laboratory stock cultures. (some of these are common to well waters).

Media:

1. Tryptic Soy Broth and Agar (1x and 2x)
2. Lauryl sulfate Tryptone broth(1x and 2x)
3. Standard Plate Count Medium
4. Brain Heart Infusion broth & Agar
5. TSA with 5% sheep blood
6. NDM, Tween 80 water, pH 7.2, 1600 u/grams filtered leaded gasoline, 1200 u/g. NH_4Ac.

Sample #---	3002-1B	/ 3002-2B	/ 3003-1B	/ 3004-1A	/ 3004-2B
Population: per 100ml.	70,000	74,000	5,600	4,600	61,000

Isolation of Bacterial Types

a; Bacterial colonies of "distinct morphology"were picked to "Pure Culture" from streak plates.
b. Pure cultures were described, Gram Stained, and cultured in the NDM above.
c. Any NDM culture showing changes in the gasoline layer were then subcultured in BHI broth.
d. If growth occured, the surviving species was again Gram Stained and compared to the origional isolate.
e. EXXON Biopond isolates and known species noted is #6 objective above were similarly cultured in the NDM, Gram Stained and described.

Sample I.D.	Isolate #	Grams Stain	Cell Morphology	Utilization of NDM duplicate tubes	Time Required	Reisolation Growth: +,-	Remarks, & or Species I.D.
3002-1B	1.	- rods	short	Homog. below gas partial layer	6 da/ 4 mo.	+ +	Enterobacter sp.
	3.	+ oval to round	Yeast-like	no homog.	10da 4 mo.	+ -	Spore-forming yeast
	4.	- rods	short rods in clusters	Partial Homog. below gas layer	2 da. 4 mo.	+ +	remains viable over long term
	5.	+ cocci	Staph-like clusters	No homog.	2 da.-1mo 4mo.	+ -	Staph sp.
	7.	+ cocci	Micrococcus-like clusters	partial Homog. under gas layer	2 da.-1mo. 4 mo.	+ +	Micrococcus sp.
	8.	+ cocci	cocci in 2-4 & short chains	Homog. partial Almost complete	2 da.-1mo. 4 mo.	+	Strep-like or Diplococci-like
3002-2B	1.	- capsul. rods	short capsulated rods in pairs	no homog.,no growth	4 da. 4 mo.	- -	nonviable invitro culture
	3.	± rods	short appear to jointed variable	partial homog under gas layer	4 da. 4 mo.	+ +	viable over long term culture
	4.	- rods	short variable rods	partial to good Homog.	2 da.(p) 4 mo.(g)	+ +	Ent. or Arthrobacter sp.(?)
	5.	- rods	short caps.rods 1-2 cells	no apparent chg. to gas layer(-)homog.	4da. 4mo.	+ +,-	survives but no effect on gas.
	6.	- rods	short rods in clusters	partial homog.	2da. 4mo.	+ +	grows under gas layer.
3003-1B	1.	+ plump rods	no group morph. single cells	partial Homog.	4da.. 4mo.	+ +	survives over long term. Sp.?

	Isolate #	Grams Stain	Cell Morphology	Utilization of NDM duplicate tubes	Time Required	Reisolation Growth +,-	Remarks, & or Species I.D.
3003-1B(cont	2.	rods c̄ + spores	short chains of long rods	no homog. partial homog.	4 da. 4mo.	+,- +,-	little or no chg. to gas layer
	3.	+ rods	long caps. rods variable(capsid)	homog good growth almost compl.homog.	4da. 4mo.	+ +	white col.on n.a. Arthrobacter sp.?
	5.	+ cocci	irregular clust.	Growth at top of gas layer	4da/ 4mo.	+,- +,good hom.	cocci in irregular clusters
	6.	+ cocci	appear to be diplococci	medium to good hom. entire gas layer	2da. 4mo.	+ +	cocci in pairs c̄ capsule
	7.	- rods	med. rods in clusters	medium to good hom. entire gas layer	4da. 4mo.	+,- +	slow to grow morph.uncertain
	8.	+ cocci	staph-like groups some 4-8 cells	partial homog.	4da. 4mo.	+,- +	slow growth c̄ uncertain morph.
3004-1B	1.	+ rods	short caps. rods 2-4cell groups	partial hom. below gas layer	4da, 4mo.	+ +	light growth under gas layer
	3.	+ cocci	diplococci in clusters	slight hom under gas layer,homog.+	4da, 4mo.	+ +	slow to grow,little homog.
	5.	+ rods	random grouping	ring of growth at top contact c̄ glass	4da. 4mo.	+ +	growth slow but survives long term
	6.	- rods	short rods in random groups	partial homog. under gas layer	4da, 4mo.	+ +	growth light but survives long term
3004-2B	2.	? lost	----	Med,-good homog.	2da. light 4mo. good	+ +	active growth over long term
	3.	+ s.f.r	long spore-forming rods in chains	partial hom.	4da. light 4mo. good	+ +	spore-forming Bacillus spp.
--	4.	+ rods	nonspore forming rods random grps.	partial to good homog.	2da. light 4mo. good	+ +	ring of growth at top edge c̄ glass
	5.	+ cocci	tetracoccoid in groups-clusters	partial homog.	4da. light 4mo. medium-good	+	ring of growth at glass edge
	6.	+ rods	short rods in random gorups	partial to good homog.	4da, light 4mo. good	+ +	ring of growth at glass edge
	7.	- rods	short rods in random groups	medium to good homog.	2da. light 4mo. med to good	+	headed growth at glass edge
EXXON-Bio Pond-3 Isol.	1.	- rods	rods in circular patterns	no apparent homog.	4da. 4mo.	- +,-(?)	yellow-gold col. survives but n.g.
	2.	+ rods	semi vibrio-like in circ. groups	partial homog. good homog.	4da. 4mo.	+ +	from white colony good survival & g
	4.	- rods	very small rods	good homog. good homog.	4da. 4mo.	+ +	form irridescent col.)Pseudomonas
	6.	- rods	short rods	med. homog. good homog.	4da. 4m.	+ +	Pseudomonas-like morph.
	7.	var. +,- rods	short rods of variable morph.	partial homog. good homog.	4da. 4mo.	+ ++	I.D.uncertain(?) (Arthrobacter)
	9.	var. +,- rods	long rods of var. morph.	medium to good homog.	4da. 4mo.	+ ++	I.D.uncertain(?)
	10.	var. +,- rods	short rods in circular clusters	partial to good homog.	4da. 4mo.	+ ++	active growth Over long term
Known Species	B.meg.	+ rods	spore-forming rod	no growth no homog.	3mo.	-	2ml.TSB added to tube revived spores
	E.coli (fecal)	- rods	short rods	growth below gas layer	2-4da. 3mo.	+ -	no homog.(TSB added 2ml. no growth in 48hr.
	M roseus	+ cocci	small cocci in clusters	good homog.	2da.-3mo.	++	active growth
	E.aerog.	+ cocci	cocci in clusters	excellent homog.	2da. 3mo.	+++	previously g.+ in l

SUMMARY:

Sample, 3002-1B:
1. The population by Standard Plate Count was 30,000(reported to the nearest two significant figures) / 100ml.(340/1ml.).
2. Ten isolates were picked from streak plates and put into Pure Culture on BHI(brain heart infusion). Of the ten isolates, 6 isolates were selelted for culturing in NDM.
3. Five of the six cultures produced at least partial homogenization of the gasoline layer. One did not produce any change but seemed to grow just under the gasoline layer.
4. A variety of morphologic cell types were found but Gram + cocci were most common.

Sample 3002-2B:
1. The population reported is 34,000/100ml.(340/ml.).
2. Ten of themost prominent types of colonies representing 94% of the population were picked to Pure Culture on BHI.
3. Of the ten colonies in Pure Culture, five were selected for culture in the NDM.
4. Four of the cultures were Gram- rods and one was a gram variable rod.

Sample 3003-1B:
1. The population reported is 5,600/100ml.(56/ml.).
2. Ten of the most common colony types representing 92% of the population were picked to Pure Culture on BHI.
3. Of the ten cultures,eight were selected for culture in the NDM.
4. Three were Gram + rods, two were Gram - rods, and three were Gram + cocci
5. One species failed to produce homogenization of the gasoline layer but the remaining seven species gave partial to good homogenization over the long period of incubation.

Sample 3004-1B:
1. The population reportes is 4,600/100ml.(46/ml).
2. Eight colonies were picked to Pure Culture.
3. Of these, 6 were selected for culture in NDM.
4. Two were Gram + rods, one was a Gram - rod, and one was a Gram + coccus.
5. All of the cultures developed slowly, survived to some degree, and yielded partial to no homogenization.

Sample 3004-2B:
1. The population reported is 61,000/100ml. (610/ml.).
2. Ten colonies were picked to Pure Culture.
3. Of these, six were selected for culture in the NDM.
4. One was lost due to a lab accident. One was a long Gram + spore forming rod(sfr) probably a species of the genus Bacillus. Two were Gram + spore forming rods, and one was a Gram - rod. One was a Gram + coccus.
5. All produced partial to good homogenization and survived the long incubation period. The Gram + sfr was recovered in subsequent culture because of regeneration of the spores.

EXXON BIOPOND #3: The Exxon BioPond system is a functioning ecosystem designed to utilize bact-

bacteria for the biodegradation of phenols and other related phenolic hydrocarbons in refinery waste water which is ultimately discharged into the Yellowstone River east of Billings, MT.

1. Ten isolates were prepared from EBP-3 water and carried along with the experimental well waters.
2. Seven of the ten biopond isolates are herewith reported.
3. All isolates, except for one vibrio-like(comma shaped) species, were gram valable or gram - rods.
4. All produced partial to good and very good homogenization of the gasoline layer over the long period of incubation.

KNOWN SPECIES: Five know species, common to ground and well waters were carried along in the same manner as the above experimental species. Results follow:
1. Staphylococcus aureus(-), Gram + cocci, No homogenization, failed to survive long term incubation.
2. Bacillus subtilus, Gram + spore forming rods, No homogenization, spores survived & grew on TSB after 3 months.
3. E coli, Gram - rods(from a fecal source), slight homogenization, grew under the gasoline layer, were viable after long incubation.
4. Micrococcus sp., Gram + cocci, produced good homogenization survived long incubation.
5. Enterococcus(from a water sample that produced gas in lactose), Gram + coccus, Excellent homogenization remained viable over long period of incubation.

CONCLUSIONS: This, the second study, of wells contaminated by gasoline strengthens the first study by being more inclusive, somewhat more supported by comparison with (1) Known species of bacteria often found in well, groun and surface waters, and (2) by some limited comparison with the EXXON BioPond system Pond #3.

APPENDIX C

Page

name:C:\BILL\JAN.PLA EXTERNAL FILE FOR PLASM MODEL
U
N
N
0

V
21 192.6138 0.09 7.48052
22 17 0 0 0

1	1	1110000	1110000	1.0E+23	3141	0	0	0	0	3030	10000	10000
1	2	1110000	1110000	1.0E+23	3141	0	0	0	0	3030	10000	10000
1	3	1110000	1110000	1.0E+23	3141	0	0	0	0	3030	10000	10000
1	4	7770000	7770000	1.0E+23	3141	0	0	0	0	3030	70000	70000
1	5	7770000	7770000	1.0E+23	3141	0	0	0	0	3030	70000	70000
1	6	7770000	0	1.0E+23	3141	0	0	0	0	3030	70000	0
1	7	0	0	0.106	3145	0	0	0	0	3030	0	0
1	8	0	0	0.106	3145	0	0	0	0	3030	0	0
1	9	0	0	0.106	3145	0	0	0	0	3030	0	0
1	10	0	0	0.106	3145	0	0	0	0	3030	0	0
1	11	0	0	0.106	3145	0	0	0	0	3030	0	0
1	12	0	0	0.106	3145	0	0	0	0	3030	0	0
1	13	0	0	0.106	3145	0	0	0	0	3030	0	0
1	14	0	0	0.106	3145	0	0	0	0	3030	0	0
1	15	0	0	0.106	3145	0	0	0	0	3030	0	0
1	16	0	0	0.106	3145	0	0	0	0	3030	0	0
1	17	0	0	0.106	3145	0	0	0	0	3030	0	0
2	1	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
2	2	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
2	3	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
2	4	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
2	5	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
2	6	7770000	7770000	1.0E+23	3141	0	0	0	0	3030	70000	70000
2	7	7770000	7770000	1.0E+23	3141	0	0	0	0	3030	70000	70000
2	8	3885000	0	1.0E+23	3141	0	0	0	0	3030	35000	0
2	9	0	0	0.106	3145	0	0	0	0	3030	0	0
2	10	0	0	0.106	3145	0	0	0	0	3030	0	0
2	11	0	0	0.106	3145	0	0	0	0	3030	0	0
2	12	0	0	0.106	3145	0	0	0	0	3030	0	0
2	13	0	0	0.106	3145	0	0	0	0	3030	0	0
2	14	0	0	0.106	3145	0	0	0	0	3030	0	0
2	15	0	0	0.106	3145	0	0	0	0	3030	0	0
2	16	0	0	0.106	3145	0	0	0	0	3030	0	0
2	17	0	0	0.106	3145	0	0	0	0	3030	0	0
3	1	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
3	2	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
3	3	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
3	4	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
3	5	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
3	6	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
3	7	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
3	8	3885000	3885000	1.0E+23	3141	0	0	0	0	3030	35000	35000

Col i	Row j	Ti	Tj	S	H	Q	R	RH	RD	Bottom	Ki	Kj
3	9	111000	111000	1.0E+23	3141	0	0	0	0	3030	1000	1000
3	10	111000	111000	1.0E+23	3141	0	0	0	0	3030	1000	1000
3	11	111000	111000	1.0E+23	3141	0	0	0	0	3030	1000	1000
3	12	244200	244200	1.0E+23	3141	0	0	0	0	3030	2200	2200
3	13	244200	244200	1.0E+23	3141	0	0	0	0	3030	2200	2200
3	14	244200	0	1.0E+23	3141	0	0	0	0	3030	2200	0
3	15	0	0	0.106	3145	0	0	0	0	3030	0	0
3	16	0	0	0.106	3145	0	0	0	0	3030	0	0
3	17	0	0	0.106	3145	0	0	0	0	3030	0	0
4	1	0	1150000	0.106	3145	0	1.1	3153.21	3149.21	3030	0	10000
4	2	1150000	1150000	0.106	3145	0	1.1	3153.21	3149.21	3030	10000	10000
4	3	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
4	4	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
4	5	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
4	6	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
4	7	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
4	8	4025000	4025000	0.106	3145	0	0	0	0	3030	35000	35000
4	9	115000	115000	0.106	3145	0	0	0	0	3030	1000	1000
4	10	115000	115000	0.106	3145	0	0	0	0	3030	1000	1000
4	11	115000	115000	0.106	3145	0	0	0	0	3030	1000	1000
4	12	253000	253000	0.106	3145	0	0	0	0	3030	2200	2200
4	13	253000	253000	0.106	3145	0	0	0	0	3030	2200	2200
4	14	244200	244200	1.0E+23	3141	0	0	0	0	3030	2200	2200
4	15	244200	0	1.0E+23	3141	0	0	0	0	3030	2200	0
4	16	0	0	0.106	3145	0	0	0	0	3030	0	0
4	17	0	0	0.106	3145	0	0	0	0	3030	0	0
5	1	0	0	0.106	3145	0	0	0	0	3030	0	0
5	2	1150000	1150000	0.106	3145	0	1.1	3153.59	3149.59	3030	10000	10000
5	3	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
5	4	3450000	3450000	0.106	3145	0	0	0	0	3030	30000	30000
5	5	3450000	3450000	0.106	3145	0	0	0	0	3030	30000	30000
5	6	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
5	7	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
5	8	4025000	4025000	0.106	3145	0	0	0	0	3030	35000	35000
5	9	115000	115000	0.106	3145	0	0	0	0	3030	1000	1000
5	10	115000	115000	0.106	3145	0	0	0	0	3030	1000	1000
5	11	115000	115000	0.106	3145	0	0	0	0	3030	1000	1000
5	12	253000	253000	0.106	3145	0	0	0	0	3030	2200	2200
5	13	253000	253000	0.106	3145	0	0	0	0	3030	2200	2200
5	14	253000	253000	0.106	3145	0	0	0	0	3030	2200	2200
5	15	244200	0	1.0E+23	3141	0	0	0	0	3030	2200	0
5	16	0	0	0.106	3145	0	0	0	0	3030	0	0
5	17	0	0	0.106	3145	0	0	0	0	3030	0	0
6	1	0	0	0.106	3145	0	0	0	0	3030	0	0
6	2	0	1150000	0.106	3145	0	1.1	3154.16	3150.16	3030	0	10000
6	3	1150000	1150000	0.106	3145	0	1.1	3154.16	3150.16	3030	10000	10000
6	4	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
6	5	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
6	6	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
6	7	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000

Col i	Row j	Ti	Tj	S	H	Q	R	RM	RD	Bottom	Ki	Kj
6	8	4025000	4025000	0.106	3145	0	0	0	0	3030	35000	35000
6	9	115000	115000	0.106	3145	0	0	0	0	3030	1000	1000
6	10	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
6	11	253000	253000	0.106	3145	0	0	0	0	3030	2200	2200
6	12	253000	253000	0.106	3145	0	0	0	0	3030	2200	2200
6	13	253000	253000	0.106	3145	0	0	0	0	3030	2200	2200
6	14	253000	253000	0.106	3145	0	0	0	0	3030	2200	2200
6	15	244200	244200	1.0E+23	3141	0	0	0	0	3030	2200	2200
6	16	244200	0	1.0E+23	3141	0	0	0	0	3030	2200	0
6	17	0	0	0.106	3141	0	0	0	0	3030	0	0
7	1	0	0	0.106	3145	0	0	0	0	3030	0	0
7	2	0	0	0.106	3145	0	0	0	0	3030	0	0
7	3	0	1150000	0.106	3145	0	1.1	3155.68	3151.68	3030	0	10000
7	4	1150000	1150000	0.106	3145	0	1.1	3155.68	3151.68	3030	10000	10000
7	5	920000	920000	0.106	3145	0	0	0	0	3030	8000	8000
7	6	920000	920000	0.106	3145	0	0	0	0	3030	8000	8000
7	7	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
7	8	4025000	4025000	0.106	3145	0	0	0	0	3030	35000	35000
7	9	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
7	10	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
7	11	253000	253000	0.106	3145	0	0	0	0	3030	2200	2200
7	12	253000	253000	0.106	3145	0	0	0	0	3030	2200	2200
7	13	253000	253000	0.106	3145	0	0	0	0	3030	2200	2200
7	14	253000	253000	0.106	3145	0	0	0	0	3030	2200	2200
7	15	253000	253000	0.106	3145	0	0	0	0	3030	2200	2200
7	16	244200	244200	1.0E+23	3141	0	0	0	0	3030	2200	2200
7	17	244200	0	1.0E+23	3141	0	0	0	0	3030	2200	0
8	1	0	0	0.106	3145	0	0	0	0	3030	0	0
8	2	0	0	0.106	3145	0	0	0	0	3030	0	0
8	3	0	0	0.106	3145	0	0	0	0	3030	0	0
8	4	1150000	1150000	0.106	3145	0	1.1	3156.63	3152.63	3030	10000	10000
8	5	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
8	6	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
8	7	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
8	8	4025000	4025000	0.106	3145	0	0	0	0	3030	35000	35000
8	9	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
8	10	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
8	11	253000	253000	0.106	3145	0	0	0	0	3030	2200	2200
8	12	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
8	13	253000	253000	0.106	3145	0	0	0	0	3030	2200	2200
8	14	253000	253000	0.106	3145	0	0	0	0	3030	2200	2200
8	15	253000	253000	0.106	3145	0	0	0	0	3030	2200	2200
8	16	253000	253000	0.106	3145	0	0	0	0	3030	2200	2200
8	17	253000	0	0.106	3145	0	0	0	0	3030	2200	0
9	1	0	0	0.106	3145	0	0	0	0	3030	0	0
9	2	0	0	0.106	3145	0	0	0	0	3030	0	0
9	3	0	0	0.106	3145	0	0	0	0	3030	0	0
9	4	1150000	1150000	0.106	3145	0	1.1	3157.2	3153.2	3030	10000	10000
9	5	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
9	6	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000

Col i	Row j	Ti	Tj	S	H	Q	R	RH	RD	Bottom	Ki	Kj
9	7	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
9	8	4025000	4025000	0.106	3145	0	0	0	0	3030	35000	35000
9	9	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
9	10	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
9	11	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
9	12	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
9	13	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
9	14	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
9	15	253000	253000	0.106	3145	0	0	0	0	3030	2200	2200
9	16	253000	253000	0.106	3145	0	0	0	0	3030	2200	2200
9	17	253000	0	0.106	3145	0	0	0	0	3030	2200	0
10	1	0	0	0.106	3145	0	0	0	0	3030	0	0
10	2	0	0	0.106	3145	0	0	0	0	3030	0	0
10	3	0	0	0.106	3145	0	0	0	0	3030	0	0
10	4	1150000	1150000	0.106	3145	0	1.1	3157.67	3153.67	3030	10000	10000
10	5	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
10	6	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
10	7	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
10	8	4025000	4025000	0.106	3145	0	0	0	0	3030	35000	35000
10	9	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
10	10	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
10	11	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
10	12	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
10	13	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
10	14	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
10	15	253000	253000	0.106	3145	0	0	0	0	3030	2200	2200
10	16	253000	253000	0.106	3145	0	0	0	0	3030	2200	2200
10	17	253000	0	0.106	3145	0	0	0	0	3030	2200	0
11	1	0	0	0.106	3145	0	0	0	0	3030	0	0
11	2	0	0	0.106	3145	0	0	0	0	3030	0	0
11	3	0	0	0.106	3145	0	0	0	0	3030	0	0
11	4	1150000	1150000	0.106	3145	0	1.1	3158.15	3154.15	3030	10000	10000
11	5	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
11	6	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
11	7	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
11	8	4025000	4025000	0.106	3145	0	0	0	0	3030	35000	35000
11	9	4025000	4025000	0.106	3145	0	0	0	0	3030	35000	35000
11	10	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
11	11	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
11	12	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
11	13	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
11	14	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
11	15	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
11	16	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
11	17	1150000	0	0.106	3145	0	0	0	0	3030	10000	0
12	1	0	0	0.106	3145	0	0	0	0	3030	0	0
12	2	0	0	0.106	3145	0	0	0	0	3030	0	0
12	3	0	0	0.106	3145	0	0	0	0	3030	0	0
12	4	0	1150000	0.106	3145	0	1.1	3158.72	3154.72	3030	0	10000
12	5	1150000	1150000	0.106	3145	0	1.1	3158.72	3154.72	3030	10000	10000

Col i	Row j	Ti	Tj	S	H	Q	R	RH	RD	Bottom	Ki	Kj
12	6	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
12	7	8050000	8050000	0.106	3145	0	0	0	0	3030	70000	70000
12	8	4025000	4025000	0.106	3145	0	0	0	0	3030	35000	35000
12	9	4025000	4025000	0.106	3145	0	0	0	0	3030	35000	35000
12	10	4025000	4025000	0.106	3145	0	0	0	0	3030	35000	35000
12	11	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
12	12	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
12	13	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
12	14	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
12	15	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
12	16	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
12	17	1150000	0	0.106	3145	0	0	0	0	3030	10000	0
13	1	0	0	0.106	3145	0	0	0	0	3030	0	0
13	2	0	0	0.106	3145	0	0	0	0	3030	0	0
13	3	0	0	0.106	3145	0	0	0	0	3030	0	0
13	4	0	0	0.106	3145	0	0	0	0	3030	0	0
13	5	0	1150000	0.106	3145	0	1.1	3159.86	3155.86	3030	0	10000
13	6	1150000	1150000	0.106	3145	0	1.1	3159.86	3155.86	3030	10000	10000
13	7	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
13	8	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
13	9	4025000	4025000	0.106	3145	0	0	0	0	3030	35000	35000
13	10	4025000	4025000	0.106	3145	0	0	0	0	3030	35000	35000
13	11	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
13	12	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
13	13	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
13	14	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
13	15	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
13	16	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
13	17	1150000	0	0.106	3145	0	0	0	0	3030	10000	0
14	1	0	0	0.106	3145	0	0	0	0	3030	0	0
14	2	0	0	0.106	3145	0	0	0	0	3030	0	0
14	3	0	0	0.106	3145	0	0	0	0	3030	0	0
14	4	0	0	0.106	3145	0	0	0	0	3030	0	0
14	5	0	0	0.106	3145	0	0	0	0	3030	0	0
14	6	1150000	1150000	0.106	3145	0	1.1	3161.38	3157.38	3030	10000	10000
14	7	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
14	8	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
14	9	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
14	10	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
14	11	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
14	12	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
14	13	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
14	14	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
14	15	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
14	16	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
14	17	1150000	0	0.106	3145	0	0	0	0	3030	10000	0
15	1	0	0	0.106	3145	0	0	0	0	3030	0	0
15	2	0	0	0.106	3145	0	0	0	0	3030	0	0
15	3	0	0	0.106	3145	0	0	0	0	3030	0	0
15	4	0	0	0.106	3145	0	0	0	0	3030	0	0

Col i	Row j	Ti	Tj	S	H	G	R	RH	RD	Bottom	Ki	Kj
15	5	0	0	0.106	3145	0	0	0	0	3030	0	0
15	6	1150000	1150000	0.106	3145	0	1.1	3162.04	3158.04	3030	10000	10000
15	7	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
15	8	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
15	9	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
15	10	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
15	11	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
15	12	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
15	13	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
15	14	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
15	15	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
15	16	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
15	17	1150000	0	0.106	3145	0	0	0	0	3030	10000	0
16	1	0	0	0.106	3145	0	0	0	0	3030	0	0
16	2	0	0	0.106	3145	0	0	0	0	3030	0	0
16	3	0	0	0.106	3145	0	0	0	0	3030	0	0
16	4	0	0	0.106	3145	0	0	0	0	3030	0	0
16	5	0	0	0.106	3145	0	0	0	0	3030	0	0
16	6	1150000	1150000	0.106	3145	0	1.1	3162.61	3158.61	3030	10000	10000
16	7	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
16	8	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
16	9	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
16	10	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
16	11	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
16	12	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
16	13	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
16	14	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
16	15	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
16	16	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
16	17	1150000	0	0.106	3145	0	0	0	0	3030	10000	0
17	1	0	0	0.106	3145	0	0	0	0	3030	0	0
17	2	0	0	0.106	3145	0	0	0	0	3030	0	0
17	3	0	0	0.106	3145	0	0	0	0	3030	0	0
17	4	0	0	0.106	3145	0	0	0	0	3030	0	0
17	5	0	0	0.106	3145	0	0	0	0	3030	0	0
17	6	0	1150000	0.106	3145	0	1.1	3163.66	3159.66	3030	0	10000
17	7	1150000	1150000	0.106	3145	0	1.1	3163.66	3159.66	3030	10000	10000
17	8	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
17	9	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
17	10	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
17	11	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
17	12	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
17	13	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
17	14	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
17	15	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
17	16	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
17	17	1150000	0	0.106	3145	0	0	0	0	3030	10000	0
18	1	0	0	0.106	3145	0	0	0	0	3030	0	0
18	2	0	0	0.106	3145	0	0	0	0	3030	0	0
18	3	0	0	0.106	3145	0	0	0	0	3030	0	0

Col i	Row j	Ti	Tj	S	H	Q	R	RH	RD	Bottom	Ki	Kj
18	4	0	0	0.106	3145	0	0	0	0	3030	0	0
18	5	0	0	0.106	3145	0	0	0	0	3030	0	0
18	6	0	0	0.106	3145	0	0	0	0	3030	0	0
18	7	0	1150000	0.106	3145	0	1.1	3164.42	3160.42	3030	0	10000
18	8	1150000	1150000	0.106	3145	0	1.1	3164.42	3160.42	3030	10000	10000
18	9	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
18	10	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
18	11	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
18	12	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
18	13	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
18	14	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
18	15	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
18	16	0	1150000	0.106	3145	0	0	0	0	3030	0	10000
18	17	0	0	0.106	3145	0	0	0	0	3030	0	0
19	1	0	0	0.106	3145	0	0	0	0	3030	0	0
19	2	0	0	0.106	3145	0	0	0	0	3030	0	0
19	3	0	0	0.106	3145	0	0	0	0	3030	0	0
19	4	0	0	0.106	3145	0	0	0	0	3030	0	0
19	5	0	0	0.106	3145	0	0	0	0	3030	0	0
19	6	0	0	0.106	3145	0	0	0	0	3030	0	0
19	7	0	0	0.106	3145	0	0	0	0	3030	0	0
19	8	0	1150000	0.106	3145	0	1.1	3165.27	3161.27	3030	0	10000
19	9	1150000	1150000	0.106	3145	0	1.1	3165.27	3161.27	3030	10000	10000
19	10	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
19	11	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
19	12	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
19	13	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
19	14	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
19	15	1150000	0	0.106	3145	0	0	0	0	3030	10000	0
19	16	0	0	0.106	3145	0	0	0	0	3030	0	0
19	17	0	0	0.106	3145	0	0	0	0	3030	0	0
20	1	0	0	0.106	3145	0	0	0	0	3030	0	0
20	2	0	0	0.106	3145	0	0	0	0	3030	0	0
20	3	0	0	0.106	3145	0	0	0	0	3030	0	0
20	4	0	0	0.106	3145	0	0	0	0	3030	0	0
20	5	0	0	0.106	3145	0	0	0	0	3030	0	0
20	6	0	0	0.106	3145	0	0	0	0	3030	0	0
20	7	0	0	0.106	3145	0	0	0	0	3030	0	0
20	8	0	0	0.106	3145	0	0	0	0	3030	0	0
20	9	0	1150000	0.106	3145	0	1.1	3165.75	3161.75	3030	0	10000
20	10	0	1150000	0.106	3145	0	1.1	3165.75	3161.75	3030	0	10000
20	11	0	1150000	0.106	3145	0	1.1	3165.75	3161.75	3030	0	10000
20	12	1150000	1150000	0.106	3145	0	1.1	3165.75	3161.75	3030	10000	10000
20	13	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
20	14	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
20	15	1150000	0	0.106	3145	0	0	0	0	3030	10000	0
20	16	0	0	0.106	3145	0	0	0	0	3030	0	0
20	17	0	0	0.106	3145	0	0	0	0	3030	0	0
21	1	0	0	0.106	3145	0	0	0	0	3030	0	0
21	2	0	0	0.106	3145	0	0	0	0	3030	0	0

Col i	Row j	Ti	Tj	S	H	Q	R	RH	RD	Bottom	Ki	Kj
21	3	0	0	0.106	3145	0	0	0	0	3030	0	0
21	4	0	0	0.106	3145	0	0	0	0	3030	0	0
21	5	0	0	0.106	3145	0	0	0	0	3030	0	0
21	6	0	0	0.106	3145	0	0	0	0	3030	0	0
21	7	0	0	0.106	3145	0	0	0	0	3030	0	0
21	8	0	0	0.106	3145	0	0	0	0	3030	0	0
21	9	0	0	0.106	3145	0	0	0	0	3030	0	0
21	10	0	0	0.106	3145	0	0	0	0	3030	0	0
21	11	0	0	0.106	3145	0	0	0	0	3030	0	0
21	12	0	1150000	0.106	3145	0	1.1	3166.22	3162.22	3030	0	10000
21	13	1150000	1150000	0.106	3145	0	1.1	3166.22	3162.22	3030	10000	10000
21	14	1150000	1150000	0.106	3145	0	0	0	0	3030	10000	10000
21	15	1150000	0	0.106	3145	0	0	0	0	3030	10000	0
21	16	0	0	0.106	3145	0	0	0	0	3030	0	0
21	17	0	0	0.106	3145	0	0	0	0	3030	0	0
22	1	0	0	0.106	3145	0	0	0	0	3030	0	0
22	2	0	0	0.106	3145	0	0	0	0	3030	0	0
22	3	0	0	0.106	3145	0	0	0	0	3030	0	0
22	4	0	0	0.106	3145	0	0	0	0	3030	0	0
22	5	0	0	0.106	3145	0	0	0	0	3030	0	0
22	6	0	0	0.106	3145	0	0	0	0	3030	0	0
22	7	0	0	0.106	3145	0	0	0	0	3030	0	0
22	8	0	0	0.106	3145	0	0	0	0	3030	0	0
22	9	0	0	0.106	3145	0	0	0	0	3030	0	0
22	10	0	0	0.106	3145	0	0	0	0	3030	0	0
22	11	0	0	0.106	3145	0	0	0	0	3030	0	0
22	12	0	0	0.106	3145	0	0	0	0	3030	0	0
22	13	0	1150000	0.106	3145	0	1.1	3166.7	3162.7	3030	0	10000
22	14	0	1150000	0.106	3145	0	1.1	3166.7	3162.7	3030	0	10000
22	15	0	0	0.106	3145	0	0	0	0	3030	0	0
22	16	0	0	0.106	3145	0	0	0	0	3030	0	0
22	17	0	0	0.106	3145	0	0	0	0	3030	0	0

287
287
164
369
164
246
656
410
246
205
205
246 Column Spacing
492
656
287
246
451
328

Bottom - bottom elevation of aquifer
Ki - conductivity in i direction
Kj - conductivity in j direction
Q - areal recharge rate
R - leakance factor
RD - confining bed head
RH - source bed head
S - storage factor
H - default head
Ti - transmissivity in i direction
Tj - transmissivity in j direction

369
205
205
205
205
369
369
246
205
164
123
123
328
246
164 Row Spacing
205
205
410
369
451
328
328
328

River Level and Leakance Data for Transient PLASM Runs

Month	Col i	Row j	River	Leakance	River Depth + 1 Foot River Bottom Thickness
8	4	1	3153.15	0.95	4
8	4	2	3153.15	0.95	4
8	5	2	3153.53	0.95	4
8	6	2	3154.1	0.95	4
8	6	3	3154.1	0.95	4
8	7	3	3155.63	0.95	4
8	7	4	3155.63	0.95	4
8	8	4	3156.58	0.95	4
8	9	4	3157.15	0.95	4
8	10	4	3157.63	0.95	4
8	11	4	3158.11	0.95	4
8	12	4	3158.68	0.95	4
8	12	5	3158.68	0.95	4
8	13	5	3159.82	0.95	4
8	13	6	3159.82	0.95	4
8	14	6	3161.35	0.95	4
8	15	6	3162.01	0.95	4
8	16	6	3162.58	0.95	4
8	17	6	3163.64	0.95	4
8	17	7	3163.64	0.95	4
8	18	7	3164.4	0.95	4
8	18	8	3164.4	0.95	4
8	19	8	3165.26	0.95	4
8	19	9	3165.26	0.95	4
8	20	9	3165.74	0.95	4
8	20	10	3165.74	0.95	4
8	20	11	3165.74	0.95	4
8	20	12	3165.74	0.95	4
8	21	12	3166.21	0.95	4
8	21	13	3166.21	0.95	4
8	22	13	3166.69	0.95	4
8	22	14	3166.69	0.95	4
9	4	1	3153.09	0.95	4
9	4	2	3153.09	0.95	4
9	5	2	3153.47	0.95	4
9	6	2	3154.05	0.95	4
9	6	3	3154.05	0.95	4
9	7	3	3155.58	0.95	4
9	7	4	3155.58	0.95	4
9	8	4	3156.53	0.95	4
9	9	4	3157.11	0.95	4
9	10	4	3157.59	0.95	4
9	11	4	3158.07	0.95	4
9	12	4	3158.64	0.95	4
9	12	5	3158.64	0.95	4
9	13	5	3159.79	0.95	4
9	13	6	3159.79	0.95	4
9	14	6	3161.32	0.95	4
9	15	6	3161.99	0.95	4

Month	Col i	Row j	River	Leakance	River Bottom	Thickness
9	16	6	3162.57	0.95	4	
9	17	6	3163.62	0.95	4	
9	17	7	3163.62	0.95	4	
9	18	7	3164.39	0.95	4	
9	18	8	3164.39	0.95	4	
9	19	8	3165.25	0.95	4	
9	19	9	3165.25	0.95	4	
9	20	9	3165.73	0.95	4	
9	20	10	3165.73	0.95	4	
9	20	11	3165.73	0.95	4	
9	20	12	3165.73	0.95	4	
9	21	12	3166.2	0.95	4	
9	21	13	3166.2	0.95	4	
9	22	13	3166.68	0.95	4	
9	22	14	3166.68	0.95	4	
10	4	1	3152.96	0.9	4	
10	4	2	3152.96	0.9	4	
10	5	2	3153.34	0.9	4	
10	6	2	3153.92	0.9	4	
10	6	3	3153.92	0.9	4	
10	7	3	3155.44	0.9	4	
10	7	4	3155.44	0.9	4	
10	8	4	3156.39	0.9	4	
10	9	4	3156.96	0.9	4	
10	10	4	3157.44	0.9	4	
10	11	4	3157.92	0.9	4	
10	12	4	3158.49	0.9	4	
10	12	5	3158.49	0.9	4	
10	13	5	3159.63	0.9	4	
10	13	6	3159.63	0.9	4	
10	14	6	3161.15	0.9	4	
10	15	6	3161.82	0.9	4	
10	16	6	3162.39	0.9	4	
10	17	6	3163.44	0.9	4	
10	17	7	3163.44	0.9	4	
10	18	7	3164.2	0.9	4	
10	18	8	3164.2	0.9	4	
10	19	8	3165.06	0.9	4	
10	19	9	3165.06	0.9	4	
10	20	9	3165.54	0.9	4	
10	20	10	3165.54	0.9	4	
10	20	11	3165.54	0.9	4	
10	20	12	3165.54	0.9	4	
10	21	12	3166.01	0.9	4	
10	21	13	3166.01	0.9	4	
10	22	13	3166.49	0.9	4	
10	22	14	3166.49	0.9	4	
11	4	1	3152.99	1	4	
11	4	2	3152.99	1	4	
11	5	2	3153.37	1	4	

Month	Col i	Row j	River	Leakance	River Bottom Thickness
11	6	2	3153.95	1	4
11	6	3	3153.95	1	4
11	7	3	3155.48	1	4
11	7	4	3155.48	1	4
11	8	4	3156.44	1	4
11	9	4	3157.01	1	4
11	10	4	3157.49	1	4
11	11	4	3157.97	1	4
11	12	4	3158.54	1	4
11	12	5	3158.54	1	4
11	13	5	3159.69	1	4
11	13	6	3159.69	1	4
11	14	6	3161.22	1	4
11	15	6	3161.89	1	4
11	16	6	3162.47	1	4
11	17	6	3163.52	1	4
11	17	7	3163.52	1	4
11	18	7	3164.29	1	4
11	18	8	3164.29	1	4
11	19	8	3165.15	1	4
11	19	9	3165.15	1	4
11	20	9	3165.63	1	4
11	20	10	3165.63	1	4
11	20	11	3165.63	1	4
11	20	12	3165.63	1	4
11	21	12	3166.1	1	4
11	21	13	3166.1	1	4
11	22	13	3166.58	1	4
11	22	14	3166.58	1	4
12	4	1	3153.27	1	4
12	4	2	3153.27	1	4
12	5	2	3153.65	1	4
12	6	2	3154.22	1	4
12	6	3	3154.22	1	4
12	7	3	3155.74	1	4
12	7	4	3155.74	1	4
12	8	4	3156.69	1	4
12	9	4	3157.26	1	4
12	10	4	3157.74	1	4
12	11	4	3158.21	1	4
12	12	4	3158.78	1	4
12	12	5	3158.78	1	4
12	13	5	3159.92	1	4
12	13	6	3159.92	1	4
12	14	6	3161.45	1	4
12	15	6	3162.11	1	4
12	16	6	3162.68	1	4
12	17	6	3163.73	1	4
12	17	7	3163.73	1	4
12	18	7	3164.49	1	4

Month	Col i	Row j	River	Leakance	River Bottom Thickness
12	18	8	3164.49	1	4
12	19	8	3165.35	1	4
12	19	9	3165.35	1	4
12	20	9	3165.82	1	4
12	20	10	3165.82	1	4
12	20	11	3165.82	1	4
12	20	12	3165.82	1	4
12	21	12	3166.3	1	4
12	21	13	3166.3	1	4
12	22	13	3166.77	1	4
12	22	14	3166.77	1	4
1	4	1	3153.54	1	4
1	4	2	3153.54	1	4
1	5	2	3153.92	1	4
1	6	2	3154.49	1	4
1	6	3	3154.49	1	4
1	7	3	3156	1	4
1	7	4	3156	1	4
1	8	4	3156.95	1	4
1	9	4	3157.51	1	4
1	10	4	3157.99	1	4
1	11	4	3158.46	1	4
1	12	4	3159.03	1	4
1	12	5	3159.03	1	4
1	13	5	3160.16	1	4
1	13	6	3160.16	1	4
1	14	6	3161.68	1	4
1	15	6	3162.34	1	4
1	16	6	3162.91	1	4
1	17	6	3163.95	1	4
1	17	7	3163.95	1	4
1	18	7	3164.71	1	4
1	18	8	3164.71	1	4
1	19	8	3165.56	1	4
1	19	9	3165.56	1	4
1	20	9	3166.03	1	4
1	20	10	3166.03	1	4
1	20	11	3166.03	1	4
1	20	12	3166.03	1	4
1	21	12	3166.5	1	4
1	21	13	3166.5	1	4
1	22	13	3166.98	1	4
1	22	14	3166.98	1	4
2	4	1	3152.41	0.95	4
2	4	2	3152.41	0.95	4
2	5	2	3152.79	0.95	4
2	6	2	3153.38	0.95	4
2	6	3	3153.38	0.95	4
2	7	3	3155.12	0.95	4
2	7	4	3155.12	0.95	4

Month	Col i	Row j	River	Leakance	River Bottom Thickness
2	8	4	3155.91	0.95	4
2	9	4	3156.49	0.95	4
2	10	4	3156.98	0.95	4
2	11	4	3157.46	0.95	4
2	12	4	3158.05	0.95	4
2	12	5	3158.05	0.95	4
2	13	5	3159.22	0.95	4
2	13	6	3159.22	0.95	4
2	14	6	3160.77	0.95	4
2	15	6	3161.45	0.95	4
2	16	6	3162.04	0.95	4
2	17	6	3163.11	0.95	4
2	17	7	3163.11	0.95	4
2	18	7	3163.89	0.95	4
2	18	8	3163.89	0.95	4
2	19	8	3164.76	0.95	4
2	19	9	3164.76	0.95	4
2	20	9	3165.25	0.95	4
2	20	10	3165.25	0.95	4
2	20	11	3165.25	0.95	4
2	20	12	3165.25	0.95	4
2	21	12	3165.74	0.95	4
2	21	13	3165.74	0.95	4
2	22	13	3166.22	0.95	4
2	22	14	3166.22	0.95	4
3	4	1	3152.77	0.95	4
3	4	2	3152.77	0.95	4
3	5	2	3153.15	0.95	4
3	6	2	3153.73	0.95	4
3	6	3	3153.73	0.95	4
3	7	3	3155.27	0.95	4
3	7	4	3155.27	0.95	4
3	8	4	3156.23	0.95	4
3	9	4	3156.81	0.95	4
3	10	4	3157.29	0.95	4
3	11	4	3157.77	0.95	4
3	12	4	3158.34	0.95	4
3	12	5	3158.34	0.95	4
3	13	5	3159.5	0.95	4
3	13	6	3159.5	0.95	4
3	14	6	3161.03	0.95	4
3	15	6	3161.71	0.95	4
3	16	6	3162.28	0.95	4
3	17	6	3163.34	0.95	4
3	17	7	3163.34	0.95	4
3	18	7	3164.11	0.95	4
3	18	8	3164.11	0.95	4
3	19	8	3164.97	0.95	4
3	19	9	3164.97	0.95	4
3	20	9	3165.45	0.95	4

Month	Col i	Row j	River	Leakance	River Bottom Thickness
3	20	10	3165.45	0.95	4
3	20	11	3165.45	0.95	4
3	20	12	3165.45	0.95	4
3	21	12	3165.93	0.95	4
3	21	13	3165.93	0.95	4
3	22	13	3166.42	0.95	4
3	22	14	3166.42	0.95	4
4	4	1	3153.45	1.05	4
4	4	2	3153.45	1.05	4
4	5	2	3153.84	1.05	4
4	6	2	3154.41	1.05	4
4	6	3	3154.41	1.05	4
4	7	3	3155.95	1.05	4
4	7	4	3155.95	1.05	4
4	8	4	3156.91	1.05	4
4	9	4	3157.48	1.05	4
4	10	4	3157.96	1.05	4
4	11	4	3158.44	1.05	4
4	12	4	3159.02	1.05	4
4	12	5	3159.02	1.05	4
4	13	5	3160.17	1.05	4
4	13	6	3160.17	1.05	4
4	14	6	3161.71	1.05	4
4	15	6	3162.38	1.05	4
4	16	6	3162.95	1.05	4
4	17	6	3164.01	1.05	4
4	17	7	3164.01	1.05	4
4	18	7	3164.78	1.05	4
4	18	8	3164.78	1.05	4
4	19	8	3165.64	1.05	4
4	19	9	3165.64	1.05	4
4	20	9	3166.12	1.05	4
4	20	10	3166.12	1.05	4
4	20	11	3166.12	1.05	4
4	20	12	3166.12	1.05	4
4	21	12	3166.6	1.05	4
4	21	13	3166.6	1.05	4
4	22	13	3167.08	1.05	4
4	22	14	3167.08	1.05	4
5	4	1	3154.27	1.25	4
5	4	2	3154.27	1.25	4
5	5	2	3154.64	1.25	4
5	6	2	3155.19	1.25	4
5	6	3	3155.19	1.25	4
5	7	3	3156.67	1.25	4
5	7	4	3156.67	1.25	4
5	8	4	3157.6	1.25	4
5	9	4	3158.15	1.25	4
5	10	4	3158.62	1.25	4
5	11	4	3159.08	1.25	4

Month	Col i	Row j	River	Leakance	River Bottom Thickness
5	12	4	3159.64	1.25	4
5	12	5	3159.64	1.25	4
5	13	5	3160.75	1.25	4
5	13	6	3160.75	1.25	4
5	14	6	3162.23	1.25	4
5	15	6	3162.87	1.25	4
5	16	6	3163.43	1.25	4
5	17	6	3164.45	1.25	4
5	17	7	3164.45	1.25	4
5	18	7	3165.19	1.25	4
5	18	8	3165.19	1.25	4
5	19	8	3166.02	1.25	4
5	19	9	3166.02	1.25	4
5	20	9	3166.49	1.25	4
5	20	10	3166.49	1.25	4
5	20	11	3166.49	1.25	4
5	20	12	3166.49	1.25	4
5	21	12	3166.95	1.25	4
5	21	13	3166.95	1.25	4
5	22	13	3167.41	1.25	4
5	22	14	3167.41	1.25	4
6	4	1	3152.72	1.15	4
6	4	2	3152.72	1.15	4
6	5	2	3153.11	1.15	4
6	6	2	3153.69	1.15	4
6	6	3	3153.69	1.15	4
6	7	3	3155.25	1.15	4
6	7	4	3155.25	1.15	4
6	8	4	3156.22	1.15	4
6	9	4	3156.8	1.15	4
6	10	4	3157.28	1.15	4
6	11	4	3157.77	1.15	4
6	12	4	3158.35	1.15	4
6	12	5	3158.35	1.15	4
6	13	5	3159.18	1.15	4
6	13	6	3159.18	1.15	4
6	14	6	3161.07	1.15	4
6	15	6	3161.75	1.15	4
6	16	6	3162.33	1.15	4
6	17	6	3163.4	1.15	4
6	17	7	3163.4	1.15	4
6	18	7	3164.18	1.15	4
6	18	8	3164.18	1.15	4
6	19	8	3165.05	1.15	4
6	19	9	3165.05	1.15	4
6	20	9	3165.54	1.15	4
6	20	10	3165.54	1.15	4
6	20	11	3165.54	1.15	4
6	20	12	3165.54	1.15	4
6	21	12	3166.02	1.15	4

Month	Col i	Row j	River	Leakance	River Bottom Thickness
6	21	13	3166.02	1.15	4
6	22	13	3166.51	1.15	4
6	22	14	3166.51	1.15	4

Constant Head Boundary Data for Transient PLASM Runs

Month	Col i	Row j	Head
8	1	1	3139.25
8	1	2	3139.25
8	1	3	3139.25
8	1	4	3139.25
8	1	5	3139.25
8	1	6	3139.25
8	2	6	3139.25
8	2	7	3139.25
8	2	8	3139.25
8	3	8	3139.25
8	3	9	3139.25
8	3	10	3139.25
8	3	11	3139.25
8	3	12	3139.25
8	3	13	3139.25
8	3	14	3139.25
8	4	14	3139.25
8	4	15	3139.25
8	5	15	3139.25
8	6	15	3139.25
8	6	16	3139.25
8	7	16	3139.25
8	7	17	3139.25
9	1	1	3138.5
9	1	2	3138.5
9	1	3	3138.5
9	1	4	3138.5
9	1	5	3138.5
9	1	6	3138.5
9	2	6	3138.5
9	2	7	3138.5
9	2	8	3138.5
9	3	8	3138.5
9	3	9	3138.5
9	3	10	3138.5
9	3	11	3138.5
9	3	12	3138.5
9	3	13	3138.5
9	3	14	3138.5
9	4	14	3138.5
9	4	15	3138.5
9	5	15	3138.5
9	6	15	3138.5
9	6	16	3138.5
9	7	16	3138.5
9	7	17	3138.5
10	1	1	3136.2
10	1	2	3136.2
10	1	3	3136.2

Month	Col i	Row j	Head
10	1	4	3136.2
10	1	5	3136.2
10	1	6	3136.2
10	2	6	3136.2
10	2	7	3136.2
10	2	8	3136.2
10	3	8	3136.2
10	3	9	3136.2
10	3	10	3136.2
10	3	11	3136.2
10	3	12	3136.2
10	3	13	3136.2
10	3	14	3136.2
10	4	14	3136.2
10	4	15	3136.2
10	5	15	3136.2
10	6	15	3136.2
10	6	16	3136.2
10	7	16	3136.2
10	7	17	3136.2
11	1	1	3134.8
11	1	2	3134.8
11	1	3	3134.8
11	1	4	3134.8
11	1	5	3134.8
11	1	6	3134.8
11	2	6	3134.8
11	2	7	3134.8
11	2	8	3134.8
11	3	8	3134.8
11	3	9	3134.8
11	3	10	3134.8
11	3	11	3134.8
11	3	12	3134.8
11	3	13	3134.8
11	3	14	3134.8
11	4	14	3134.8
11	4	15	3134.8
11	5	15	3134.8
11	6	15	3134.8
11	6	16	3134.8
11	7	16	3134.8
11	7	17	3134.8
12	1	1	3133.8
12	1	2	3133.8
12	1	3	3133.8
12	1	4	3133.8
12	1	5	3133.8
12	1	6	3133.8
12	2	6	3133.8

Month	Col i	Row j	Head
12	2	7	3133.8
12	2	8	3133.8
12	3	8	3133.8
12	3	9	3133.8
12	3	10	3133.8
12	3	11	3133.8
12	3	12	3133.8
12	3	13	3133.8
12	3	14	3133.8
12	4	14	3133.8
12	4	15	3133.8
12	5	15	3133.8
12	6	15	3133.8
12	6	16	3133.8
12	7	16	3133.8
12	7	17	3133.8
1	1	1	3132.8
1	1	2	3132.8
1	1	3	3132.8
1	1	4	3132.8
1	1	5	3132.8
1	1	6	3132.8
1	2	6	3132.8
1	2	7	3132.8
1	2	8	3132.8
1	3	8	3132.8
1	3	9	3132.8
1	3	10	3132.8
1	3	11	3132.8
1	3	12	3132.8
1	3	13	3132.8
1	3	14	3132.8
1	4	14	3132.8
1	4	15	3132.8
1	5	15	3132.8
1	6	15	3132.8
1	6	16	3132.8
1	7	16	3132.8
1	7	17	3132.8
2	1	1	3132.4
2	1	2	3132.4
2	1	3	3132.4
2	1	4	3132.4
2	1	5	3132.4
2	1	6	3132.4
2	2	6	3132.4
2	2	7	3132.4
2	2	8	3132.4
2	3	8	3132.4
2	3	9	3132.4

Month	Col i	Row j	Head
2	3	10	3132.4
2	3	11	3132.4
2	3	12	3132.4
2	3	13	3132.4
2	3	14	3132.4
2	4	14	3132.4
2	4	15	3132.4
2	5	15	3132.4
2	6	15	3132.4
2	6	16	3132.4
2	7	16	3132.4
2	7	17	3132.4
3	1	1	3132.8
3	1	2	3132.8
3	1	3	3132.8
3	1	4	3132.8
3	1	5	3132.8
3	1	6	3132.8
3	2	6	3132.8
3	2	7	3132.8
3	2	8	3132.8
3	3	8	3132.8
3	3	9	3132.8
3	3	10	3132.8
3	3	11	3132.8
3	3	12	3132.8
3	3	13	3132.8
3	3	14	3132.8
3	4	14	3132.8
3	4	15	3132.8
3	5	15	3132.8
3	6	15	3132.8
3	6	16	3132.8
3	7	16	3132.8
3	7	17	3132.8
4	1	1	3134.2
4	1	2	3134.2
4	1	3	3134.2
4	1	4	3134.2
4	1	5	3134.2
4	1	6	3134.2
4	2	6	3134.2
4	2	7	3134.2
4	2	8	3134.2
4	3	8	3134.2
4	3	9	3134.2
4	3	10	3134.2
4	3	11	3134.2
4	3	12	3134.2
4	3	13	3134.2

Month	Col i	Row j	Head
4	3	14	3134.2
4	4	14	3134.2
4	4	15	3134.2
4	5	15	3134.2
4	6	15	3134.2
4	6	16	3134.2
4	7	16	3134.2
4	7	17	3134.2
5	1	1	3139.8
5	1	2	3139.8
5	1	3	3139.8
5	1	4	3139.8
5	1	5	3139.8
5	1	6	3139.8
5	2	6	3139.8
5	2	7	3139.8
5	2	8	3139.8
5	3	8	3139.8
5	3	9	3139.8
5	3	10	3139.8
5	3	11	3139.8
5	3	12	3139.8
5	3	13	3139.8
5	3	14	3139.8
5	4	14	3139.8
5	4	15	3139.8
5	5	15	3139.8
5	6	15	3139.8
5	6	16	3139.8
5	7	16	3139.8
5	7	17	3139.8
6	1	1	3140.6
6	1	2	3140.6
6	1	3	3140.6
6	1	4	3140.6
6	1	5	3140.6
6	1	6	3140.6
6	2	6	3140.6
6	2	7	3140.6
6	2	8	3140.6
6	3	8	3140.6
6	3	9	3140.6
6	3	10	3140.6
6	3	11	3140.6
6	3	12	3140.6
6	3	13	3140.6
6	3	14	3140.6
6	4	14	3140.6
6	4	15	3140.6
6	5	15	3140.6

Month	Col i	Row j	Head
6	6	15	3140.6
6	6	16	3140.6
6	7	16	3140.6
6	7	17	3140.6

Leakance Computation
A Comparison with Clark (1986)

Estimate the Clark Fork river to be 8 miles long from Hellgate canyon to the river's confluence with the Bitterroot river at a width of 300 feet. Area of riverbed:

$$42,240 \text{ ft} \times 300 \text{ ft} = 12,670,000 \text{ ft}^2$$

from Clark:

$$Q/\text{Area} = 36,000,000 \text{ gpd}/12,670,000 \text{ ft}^2 = 2.84 \text{ gpd/ft}^2$$

if model riverbed area = As = 2,107,604 ft^2
then $Q = 2.84 \text{ gpd/ft}^2 \times 2,107,604 \text{ ft}^2 = 5,985,595 \text{ gpd}$

from PLASM:

$$Q = P/m(As)hmax$$

P/m = leakance = let it be 1 gpd/ft^3
As = 2,107,604 ft^2
hmax = head difference between river level and bottom of riverbed = 4 ft in model

then Q = 8,430,416 gpd, this is a 41% increase over Clark's average estimate

Time = [illegible] days

HEAD (ft) or a MONTH= [illegible] TIME STEP = 10

[illegible]	3141.31	3141.54	3141.99	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
[illegible]	[illegible]	3141.53	3142.03	3142.22	3142.56	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
[illegible]	3141.24	3141.43	3141.83	[illegible]	3142.55	3142.67	3145.00	3145.00	3145.00	[illegible]	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
[illegible]	3141.16	3141.31	3141.62	[illegible]	[illegible]	3142.53	[illegible]	[illegible]	[illegible]	3143.81	[illegible]	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
[illegible]	3141.11	[illegible]	[illegible]	[illegible]	3142.24	3142.45	[illegible]	[illegible]	[illegible]	[illegible]	3144.88	3144.56	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3142.22	3142.52	3143.13	[illegible]	3143.52	[illegible]	3143.09	3144.55	3145.21	3145.49	3146.00	3146.66	3145.00	3145.00	3145.00	3145.00	3145.00
[illegible]	[illegible]	3141.34	3141.59	3141.89	3142.24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3144.24	3145.01	3145.34	3145.85	3146.58	3146.82	3145.00	3145.00	3145.00	3145.00
145.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3144.20	3144.87	3145.20	3145.68	3146.32	3146.67	3146.86	3145.00	3145.00	3145.00
[illegible]	[illegible]	[illegible]	3141.57	3141.60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3144.45	3144.74	3145.08	3145.55	3146.13	3146.45	3146.75	3146.82	3145.00	3145.00
[illegible]	[illegible]	[illegible]	[illegible]	3141.88	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3144.50	3144.72	3145.05	3145.48	3146.01	3146.31	3146.62	3146.77	3145.00	3145.00
[illegible]	[illegible]	[illegible]	3141.52	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3144.25	3144.51	3144.67	3145.09	3145.45	3145.93	3146.22	3146.55	[illegible]	3145.00	3145.00
[illegible]	[illegible]	[illegible]	[illegible]	3141.62	3142.24	3142.66	[illegible]	[illegible]	[illegible]	3144.01	3144.25	3144.62	3144.95	3145.13	3145.44	3145.80	3146.15	[illegible]	3146.81	[illegible]	3145.00
[illegible]	[illegible]	[illegible]	3141.24	3141.44	[illegible]	[illegible]	[illegible]	3143.56	[illegible]	3144.06	3144.34	3144.57	3144.98	3145.15	3145.43	3145.83	3146.10	3146.44	3146.69	3147.07	3147.24
[illegible]	[illegible]	[illegible]	3141.00	[illegible]	[illegible]	[illegible]	[illegible]	3143.52	[illegible]	3144.12	3144.40	[illegible]	3145.01	[illegible]	3145.41	3145.78	3146.02	3146.35	3146.57	3146.84	3147.05
[illegible]	[illegible]	[illegible]	3141.00	3141.00	[illegible]	3141.91	3142.59	[illegible]	[illegible]	[illegible]	3144.17	[illegible]	3145.02	3145.16	3145.38	3145.70	3145.92	3146.27	3146.48	3146.70	3146.83
3145.00	3145.00	3145.00	3145.00	3145.00	3141.00	3141.00	[illegible]	3142.92	3143.62	3144.31	3144.50	3144.77	3145.02	3145.15	3145.35	3145.60	3145.72	3145.00	3145.00	3145.00	3145.00
3145.00	3145.00	3145.00	3145.00	3145.00	3141.00	3141.00	[illegible]	[illegible]	3143.54	[illegible]	3144.52	[illegible]	3145.02	3145.14	3145.32	3145.53	3145.67	3145.00	3145.00	3145.00	3145.00

Head values for calibration wells 1 24 are as follows:

3146.45 3145.48 3145.13 3144.62 [illegible] 3144.00 3144.03 [illegible] [illegible] 3143.13 3144.15 3143.57 3143.06 3142.45 3142.24 3141.22 3142.66 3142.25 3141.30 3143.75 3144.12 3143.28 3143.09 3143.30

Time = 5030.335 days

HEAD (ft) or a MONTH= 8 TIME STEP = 11

3139.25	3139.54	3139.75	3140.15	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3139.25	3139.52	3139.74	3140.19	3140.37	3140.68	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3139.25	3139.47	3139.65	3140.03	3140.20	3140.68	3140.99	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3139.25	3139.41	3139.55	3139.84	3139.97	3140.46	3140.70	3141.22	3141.51	3141.74	3141.94	3142.09	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3139.25	3139.36	3139.51	3139.83	3139.96	3140.44	3140.64	3141.35	3141.49	3141.68	3141.87	3142.02	3142.65	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3139.25	3139.25	3139.45	3139.83	3140.01	3140.43	3140.72	3141.32	3141.48	3141.69	3141.89	3142.04	3142.65	3143.28	3143.55	3144.02	3144.63	3145.00	3145.00	3145.00	3145.00	3145.00
3145.00	3139.25	3139.39	3139.82	3140.03	3140.45	3140.98	3141.26	3141.47	3141.69	3141.92	3142.16	3142.39	3143.11	3143.42	3143.89	3144.55	3144.77	3145.00	3145.00	3145.00	3145.00
3145.00	3139.25	3139.25	3139.80	3140.03	3140.46	3141.00	3141.25	3141.47	3141.71	3141.97	3142.20	3142.43	3142.99	3143.30	3143.75	3144.33	3144.65	3144.82	3145.00	3145.00	3145.00
3145.00	3145.00	3139.25	3139.61	3140.03	3140.48	3141.09	3141.29	3141.50	3141.75	3142.09	3142.32	3142.61	3142.85	3143.20	3143.64	3144.17	3144.46	3144.74	3144.61	3145.00	3145.00
3145.00	3145.00	3139.25	3139.64	3140.14	3140.90	3141.17	3141.37	[illegible]	3141.84	3142.12	3142.42	3142.67	3142.88	3143.19	3143.59	3144.08	3144.35	3144.63	3144.76	3145.00	3145.00
3145.00	3145.00	3139.25	3139.80	[illegible]	3140.83	3141.18	3141.42	[illegible]	3141.93	3142.17	3142.44	3142.71	3143.03	3143.25	3143.59	3144.03	3144.29	3144.59	3144.76	3145.00	3145.00
3145.00	3145.00	3139.25	3139.66	3139.90	3140.53	3141.14	3141.55	3141.76	3141.78	3142.23	3142.50	3142.81	3143.12	3143.30	3143.59	3144.00	3144.25	3144.57	3144.83	3145.10	3145.00
3145.00	3145.00	3139.25	3139.51	3139.73	[illegible]	3140.58	3141.40	3141.81	3142.02	3142.29	3142.57	3142.89	3143.18	3143.34	3143.60	3143.97	3144.21	3144.51	3144.74	3145.07	3145.22
3145.00	3145.00	3139.25	3139.75	3139.48	[illegible]	3140.71	3141.23	3141.76	3142.04	3142.36	3142.63	3142.95	3143.22	3143.36	3143.59	3143.93	3144.15	3144.44	3144.63	3144.87	3145.05
3145.00	3145.00	3145.00	3139.25	[illegible]	3139.25	3140.19	3140.67	3141.56	3142.02	3142.52	3142.72	3142.99	3143.24	3143.37	3143.58	3143.87	3144.07	3144.38	3144.55	3144.75	3144.87
3145.00	3145.00	3145.00	3145.00	3145.00	3139.25	3139.25	3140.40	3141.19	3141.69	3142.56	3142.75	3143.01	3143.25	3143.37	3143.55	3143.78	3143.89	3145.00	3145.00	3145.00	3145.00
3145.00	3145.00	3145.00	3145.00	3145.00	3141.00	[illegible]	3140.23	3141.02	3141.81	3142.57	3142.77	3143.03	3143.25	3143.36	3143.53	3143.73	3143.80	3145.00	3145.00	3145.00	3145.00

Head values for calibration wells 1 24 are as follows:

3144.45 3143.59 3143.30 3143.03 [illegible] 3142.16 3142.20 3141.92 3141.97 3141.32 3142.32 3141.75 3141.25 3140.64 3140.44 3139.48 3140.90 3140.46 3139.52 3141.98 3142.36 3141.47 3141.29 3141.55

HEAD [illegible] MONTH [illegible] TIME STEP = 1

[illegible]	3138.78	3138.99	3139.39	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.06	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3138.50	3138.77	3138.98	3139.43	3139.60	3139.91	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3138.50	3138.72	3138.89	3139.26	3139.44	3139.91	3140.20	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3138.50	3138.65	3138.79	3139.08	3139.20	3139.68	3139.91	3140.41	3140.66	3140.91	3141.11	3141.25	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3138.50	3138.60	3138.75	3139.06	3139.19	3139.65	3139.84	3140.52	3140.66	3140.85	3141.03	3141.17	3141.80	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3138.50	3138.50	3138.69	3139.06	3139.24	3139.64	3139.92	3140.49	3140.65	3140.85	3141.04	3141.19	3141.79	3142.40	3142.66	3143.13	3143.73	3145.00	3145.00	3145.00	3145.00	3145.00
3145.00	3138.50	3138.63	3139.05	3139.25	3139.66	3140.16	3140.43	3140.67	3140.85	3141.07	3141.30	3141.52	3142.23	3142.53	3142.99	3143.65	3143.87	3145.00	3145.00	3145.00	3145.00
3145.00	3138.50	3138.50	3139.03	3139.25	3139.67	3140.18	3140.43	3140.63	3140.87	3141.11	3141.33	3141.56	3142.11	3142.41	3142.85	3143.43	3143.75	3143.92	3145.00	3145.00	3145.00
3145.00	3145.00	3138.50	3139.03	3139.25	3139.68	3140.26	3140.46	3140.66	3140.90	3141.23	3141.45	3141.73	3141.96	3142.30	3142.74	3143.26	3143.55	3143.83	3143.89	3145.00	3145.00
3145.00	3145.00	3138.50	3139.05	3139.34	3140.07	3140.34	3140.53	3140.75	3140.98	3141.25	3141.54	3141.78	3141.98	3142.29	3142.68	3143.16	3143.43	3143.71	3143.84	3145.00	3145.00
3145.00	3145.00	3138.50	3139.01	3139.28	3140.00	3140.34	3140.57	3140.87	3141.06	3141.29	3141.55	3141.82	3142.13	3142.34	3142.67	3143.10	3143.36	3143.66	3143.84	3145.00	3145.00
3145.00	3145.00	3138.50	3138.87	3139.10	3139.69	3140.28	3140.69	3140.89	3141.19	3141.34	3141.60	3141.91	3142.20	3142.38	3142.67	3143.06	3143.32	3143.64	3143.90	3144.17	3145.00
3145.00	3145.00	3138.50	3138.74	3138.94	3139.43	3140.13	3140.61	3140.93	3141.14	3141.40	3141.66	3141.97	3142.25	3142.41	3142.66	3143.03	3143.27	3143.58	3143.60	3144.13	3144.29
3145.00	3145.00	3138.50	3138.50	3138.71	3139.11	3139.86	3140.37	3140.96	3141.15	3141.46	3141.72	3142.02	3142.28	3142.43	3142.66	3142.98	3143.21	3143.50	3143.69	3143.93	3144.12
3145.00	3145.00	3145.00	3138.50	3138.50	3138.50	3139.38	3140.02	3140.69	3141.12	3141.60	3141.80	3142.06	3142.30	3142.43	3142.63	3142.92	3143.12	3143.43	3143.61	3143.81	3143.93
3145.00	3145.00	3145.00	3145.00	3145.00	3138.50	3138.50	3139.58	3140.33	3141.06	3141.64	3141.83	3142.08	3142.30	3142.42	3142.60	3142.83	3142.94	3145.00	3145.00	3145.00	3145.00
3145.00	3145.00	3145.00	3145.00	3145.00	3141.00	3138.50	3139.42	3140.17	3140.92	3141.65	3141.84	3142.09	3142.30	3142.42	3142.58	3142.78	3142.85	3145.00	3145.00	3145.00	3145.00

Head values for calibration wells 1-24 are as follows:

3143.55 3142.66 [illegible] 3142.13 [illegible] 3141.30 3141.33 3141.07 3141.11 3140.49 3141.45 3140.90 3140.43 3139.84 3139.65 3136.71 3140.07 3139.67 3138.77 3141.10 3141.46 3140.63 3140.46 3140.69

Time = [illegible] days

HEAD [illegible] MONTH [illegible] TIME STEP = 13

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3145.00	3145.00	3145.00	3145.00	[illegible]	[illegible]	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3136.20	[illegible]	3136.50	[illegible]	[illegible]	[illegible]	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3135.20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3137.91	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3139.41	3138.63	3136.88	3139.02	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3138.43	[illegible]	3136.61	3138.95	3139.57	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3138.42	[illegible]	3138.83	3138.98	3139.57	3140.20	3140.46	3140.93	3141.52	3145.00	3145.00	3145.00	3145.00	3145.00
3145.00	[illegible]	3136.34	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3138.41	[illegible]	3136.86	3139.09	3139.32	3140.03	3140.34	3140.60	3141.45	3141.66	3145.00	3145.00	3145.00	3145.00
3145.00	3136.20	3136.20	3136.75	3136.93	3137.41	[illegible]	3138.20	3138.41	3138.65	3138.90	3139.13	3139.37	3139.92	3140.22	3140.66	3141.23	3141.55	3141.72	3145.00	3145.00	3145.00
3145.00	3145.00	3136.20	3136.75	3136.98	3137.42	3138.03	3138.22	3138.44	3138.70	3139.03	3139.26	3139.55	3139.79	3140.13	3140.56	3141.08	3141.37	3141.64	3141.71	3145.00	3145.00
3145.00	3145.00	3136.20	3136.80	3137.09	[illegible]	3138.12	3138.32	3138.55	3138.79	3139.06	3139.36	3139.60	3139.81	3140.12	3140.51	3140.99	3141.26	3141.54	3141.67	3145.00	3145.00
3145.00	3145.00	3136.20	3136.70	3137.05	3137.79	3138.13	3138.37	3138.60	3138.87	3139.12	3139.38	3139.65	3139.97	3140.18	3140.51	3140.95	3141.20	3141.50	3141.67	3145.00	3145.00
3145.00	3145.00	3136.20	3136.62	[illegible]	3137.49	3138.10	3138.51	[illegible]	3138.93	3139.18	3139.45	3139.76	3140.06	3140.24	3140.52	3140.92	3141.17	3141.48	3141.73	3142.00	3145.00
3145.00	3145.00	3136.20	3136.47	3136.69	3137.22	3137.95	3138.44	3138.77	3138.98	3139.24	3139.52	3139.83	3140.12	3140.28	3140.53	3140.89	3141.13	3141.43	3141.64	3141.97	3142.12
3145.00	3145.00	3136.20	3136.20	3136.44	3136.87	3137.67	3138.19	3138.74	3139.00	3139.31	3139.58	3139.89	3140.15	3140.30	3140.53	3140.85	3141.07	3141.36	3141.54	3141.78	3141.96
3145.00	3145.00	3145.00	3136.20	3136.20	3136.20	3137.15	3137.83	3138.52	3138.97	3139.47	3139.67	3139.94	3140.18	3140.31	3140.51	3140.60	3140.99	3141.30	3141.47	3141.66	3141.78
3145.00	3145.00	3145.00	3145.00	3145.00	3136.20	3136.20	3137.36	3138.15	3138.85	3139.51	3139.70	3139.96	3140.19	3140.31	3140.49	3140.72	3140.82	3145.00	3145.00	3145.00	3145.00
3145.00	3145.00	3145.00	3145.00	3145.00	3141.00	3136.20	3137.19	3137.96	3138.77	3139.53	3139.72	3139.97	3140.19	3140.31	3140.47	3140.66	3140.74	3145.00	3145.00	3145.00	3145.00

Head values for calibration wells 1-24 are as follows:

[illegible] 3140.51 3140.24 3139.97 3139.60 [illegible] 3139.13 [illegible] [illegible] 3136.26 3139.26 3138.70 3138.20 3137.58 3137.38 3136.44 3137.86 3137.41 3136.47 3138.93 3139.31 3138.41 3138.23 3138.51

Time = [illegible] days

HEAD (ft) of MONTH= 11 TIME STEP = 14

3134.80	3135.11	3135.34	3135.78	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3134.90	3135.10	3135.33	3135.82	3136.01	3136.35	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3134.80	3135.04	3135.23	3135.64	3135.83	3136.35	3136.67	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3134.80	3134.97	3135.12	3135.44	3135.57	3136.16	3136.36	3136.91	3137.21	3137.46	3137.68	3137.84	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3134.80	3134.92	3135.07	3135.42	3135.56	3136.07	3136.28	3137.04	3137.19	3137.39	3137.59	3137.75	3138.43	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3134.80	3134.80	3135.01	3135.42	3135.61	3136.06	3136.37	3137.00	3137.18	3137.40	3137.61	3137.77	3138.42	3139.09	3139.37	3139.88	3140.53	3145.00	3145.00	3145.00	3145.00	3145.00
3145.00	3134.80	3134.94	3135.41	3135.63	3136.08	3136.64	3136.94	3137.16	3137.40	3137.65	3137.69	3138.14	3138.90	3139.24	3139.74	3140.45	3140.68	3145.00	3145.00	3145.00	3145.00
3145.00	3134.80	3134.80	3135.59	3135.63	[illegible]	3136.65	3136.93	3137.16	3137.42	3137.67	3137.93	3138.18	3138.77	3139.10	3139.58	3140.20	3140.55	3140.74	3145.00	3145.00	3145.00
3145.00	3145.00	3134.80	3135.59	3135.63	3136.11	3136.75	3136.97	3137.19	3137.46	3137.82	3138.05	3136.36	3138.62	3138.99	3139.46	3140.03	3140.34	3140.64	3140.71	3145.00	3145.00
3145.00	3145.00	3134.80	3135.42	[illegible]	3136.55	3136.84	3137.05	3137.29	3137.55	3137.84	3138.16	3138.42	3138.54	3138.97	3139.40	3139.92	3140.21	3140.52	3140.66	3145.00	3145.00
3145.00	3145.00	3134.60	3135.37	3135.68	3136.47	3136.84	3137.10	3137.43	3137.63	3137.67	3138.17	3138.46	3138.80	3139.03	3139.38	3139.86	3140.14	3140.46	3140.65	3145.00	3145.00
3145.00	3145.00	3134.80	3135.22	3135.48	3136.14	3136.78	3137.23	3137.45	3137.68	3137.95	[illegible]	3138.56	3138.88	3139.08	3139.39	3139.82	3140.09	3140.44	3140.72	3141.01	3145.00
3145.00	3145.00	3134.80	3135.07	3135.30	3135.65	3136.62	3137.14	3137.50	3137.72	3138.01	3138.29	3138.63	3138.93	3139.11	3139.38	3139.78	3140.04	3140.37	3140.61	3140.97	3141.14
3145.00	3145.00	3134.80	3134.80	3135.04	3135.49	3136.32	3136.88	3137.46	3137.74	3138.07	3138.36	3138.69	3138.97	3139.13	3139.38	3139.73	3139.97	3140.29	3140.49	3140.76	3140.96
3145.00	3145.00	3145.00	3134.80	3134.80	3134.00	[illegible]	3136.50	3137.23	3137.71	3138.23	3136.44	3138.73	3138.99	3139.13	3139.35	3139.66	3139.88	3140.22	3140.41	3140.62	3140.75
3145.00	3145.00	3145.00	3145.00	3145.00	3134.60	3134.80	3136.01	3136.84	3137.57	3138.27	3139.48	3136.75	3139.00	3139.13	3139.32	3139.57	3139.69	3145.00	3145.00	3145.00	3145.00
3145.00	3145.00	3145.00	3145.00	3145.00	3141.00	3134.80	3135.62	3136.66	3137.48	3138.29	3138.49	3138.76	3139.00	3139.12	3139.29	3139.51	3139.59	3145.00	3145.00	3145.00	3145.00

Head values for calibration wells 1-24 are as follows:

3141.34 3135.40 [illegible] 3136.80 3136.42 [illegible] 3137.93 3137.65 3137.69 3137.00 3138.05 3137.46 3136.93 3136.28 3136.07 3135.04 3136.55 3136.69 3135.10 3137.68 3138.07 3137.16 3136.97 3137.23

Time = [illegible] days

HEAD (ft) of MONTH= 12 TIME STEP = 15

[illegible]	3134.11	3134.24	[illegible]	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3133.80	3134.10	[illegible]	[illegible]	3135.02	3135.35	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3133.60	3134.04	3134.23	3134.64	3134.83	3135.35	3135.68	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3133.80	3133.97	3134.12	3134.44	3134.57	3135.10	3135.36	3135.71	3136.21	3136.45	3136.67	3136.84	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3133.60	3133.92	3134.07	3134.42	3134.56	3135.07	3135.28	3136.03	3136.19	3136.39	3136.59	3136.75	3137.43	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3133.80	3133.80	3134.01	3134.42	3134.61	3135.05	3135.36	3136.00	3136.17	3136.39	3136.61	3136.77	3137.42	3138.10	3138.38	3138.89	3139.54	3145.00	3145.00	3145.00	3145.00	3145.00
3145.00	3133.80	3133.94	3134.41	3134.63	3135.06	3135.63	3135.54	3136.16	3136.40	3136.64	3136.89	3137.13	3137.91	3138.24	3138.74	3139.46	3139.70	3145.00	3145.00	3145.00	3145.00
3145.00	3133.80	3133.80	3134.39	3134.63	3135.09	3135.66	3135.93	3136.15	3136.41	3136.68	3136.93	3137.18	3137.78	3138.11	3138.59	3139.21	3139.57	3139.75	3145.00	3145.00	3145.00
3145.00	3145.00	3133.60	3134.35	3134.63	3135.10	3135.75	3135.76	3136.19	3136.46	3136.81	3137.05	3137.36	3137.62	3137.99	3138.46	3139.04	3139.35	3139.65	3139.73	3145.00	3145.00
3145.00	3145.00	3133.80	3134.41	3134.73	3135.54	3135.83	3136.04	3136.29	3136.54	3136.83	3137.16	3137.41	3137.64	3137.97	3138.40	3138.93	3139.22	3139.53	3139.67	3145.00	3145.00
3145.00	3145.00	3133.80	3134.36	3134.67	3135.46	3135.83	3136.09	3136.42	[illegible]	3136.88	3137.16	3137.46	3137.80	3138.03	3138.39	3138.86	3139.15	3139.47	3139.67	3145.00	3145.00
3145.00	3145.00	3133.80	3134.21	[illegible]	3135.12	[illegible]	3136.21	3136.44	3136.67	3136.94	3137.22	3137.56	3137.88	3138.07	3138.39	3138.82	3139.10	3139.45	3139.73	3140.03	3145.00
3145.00	3145.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3136.13	3136.45	3136.41	[illegible]	3137.29	3137.63	3137.93	3138.11	3138.38	3136.78	3139.04	3139.38	3139.63	3139.99	3140.16
3145.00	3145.00	3133.80	3133.60	3134.04	3134.43	3135.31	3135.86	3136.45	[illegible]	[illegible]	[illegible]	[illegible]	3137.97	3138.13	3138.38	3138.73	3138.98	3139.30	3139.51	3139.77	3139.97
3145.00	3145.00	3145.00	3133.80	3133.80	3133.80	[illegible]	3135.48	3136.21	[illegible]	3137.22	3137.45	3137.72	3137.79	3138.13	3138.35	3138.67	3138.88	3139.22	3139.42	3139.54	3139.77
3145.00	3145.00	3145.00	3145.00	3145.00	3133.80	3133.89	3135.00	3135.83	3135.56	3137.26	3137.47	3137.74	3137.99	3138.12	3138.32	3138.57	3138.69	3145.00	3145.00	3145.00	3145.00
3145.00	3145.00	3145.00	3145.00	3145.00	3141.00	3133.60	3134.81	3135.64	3136.47	3137.28	3137.48	3137.75	3137.99	3138.12	3138.29	3138.51	3138.59	3145.00	3145.00	3145.00	3145.00

Head values for calibration wells 1-24 are as follows:

3139.35 3138.40 3138.07 [illegible] 3137.41 3136.69 3136.93 3136.64 3136.68 3136.00 3137.05 3136.46 3135.93 3135.28 3135.07 3134.04 3135.54 3135.09 3134.10 3136.67 3137.06 3136.16 3135.96 3136.21

Time = 718.[illegible] days

HEAD [illegible] OF [illegible]MONTH= 1 TIME STEP = 16

3132.80	3133.11	3133.34	3133.79	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3135.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3132.80	3133.10	3133.33	3133.83	3134.03	3134.37	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3132.80	3133.04	3133.24	3133.65	3133.84	3134.37	3134.69	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3132.80	3132.9[illegible]	3133.12	3133.44	3133.55	3134.11	[illegible]	[illegible]	[illegible]	3135.48	3135.70	3135.96	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3132.80	3132.92	3133.08	3133.43	3133.57	3134.08	3134.29	3135.05	3135.21	3135.41	3135.61	3135.78	3136.46	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3132.80	3132.80	3133.01	3133.42	3133.62	3134.07	3134.38	3135.02	3135.19	3135.41	3135.53	3135.79	3136.45	3137.13	3137.42	3137.93	3138.59	3145.00	3145.00	3145.00	3145.00	3145.00
3145.00	3132.80	3132.95	3133.41	3133.63	3134.09	3134.65	3134.95	3135.18	3135.42	3135.66	3135.91	3136.16	3136.94	3137.28	3137.78	3138.51	3138.74	3145.00	3145.00	3145.00	3145.00
3145.00	3132.80	3132.80	3133.39	3133.64	3134.10	3134.67	3134.94	3135.18	3135.43	[illegible]	3135.95	3136.20	3136.81	3137.14	3137.62	3138.26	3138.61	3138.60	3145.00	3145.00	3145.00
3145.00	3145.00	3132.80	3133.59	3133.64	3134.11	3134.76	3134.98	3135.20	3135.40	3135.84	3136.08	3136.39	3136.65	3137.02	3137.50	3138.08	3138.39	3138.70	3138.77	3145.00	3145.00
3145.00	3145.00	3132.80	[illegible]	[illegible]	3134.55	3134.84	3135.06	3135.31	[illegible]	[illegible]	[illegible]	3136.44	3136.67	3137.00	3137.44	3137.97	3138.26	3138.57	3138.72	3145.00	3145.00
3145.00	3145.00	3132.80	3133.37	3133.68	3134.47	3134.85	3135.11	3135.44	[illegible]	3135.91	3136.19	3136.49	3136.83	3137.06	3137.42	3137.90	3138.19	3138.52	3138.71	3145.00	3145.00
3145.00	3145.00	3132.80	[illegible]	3133.47	3134.13	3134.78	[illegible]	3135.46	[illegible]	3135.96	3136.25	3136.58	3136.91	3137.10	3137.42	3137.86	3138.14	3138.49	3138.78	3137.08	3145.00
3145.00	3145.00	3132.80	3133.07	3133.29	3133.84	[illegible]	3135.15	3135.51	[illegible]	3136.02	3136.31	3136.65	3136.96	3137.14	3137.42	3137.82	3138.08	3138.42	3138.67	3139.03	3139.21
3145.00	3145.00	3132.80	[illegible]	[illegible]	[illegible]	[illegible]	3134.88	3135.47	[illegible]	[illegible]	3136.38	3136.71	3137.00	3137.16	3137.41	3137.77	3138.01	3138.34	3138.55	3138.81	3139.02
3145.00	3145.00	3145.00	3132.80	3132.80	3132.80	[illegible]	3134.50	[illegible]	[illegible]	[illegible]	3136.46	3136.75	3137.02	3137.16	3137.38	3137.70	3137.92	3138.26	3138.46	3138.68	3138.81
3145.00	3145.00	3145.00	3145.00	3145.00	[illegible]	3132.80	3134.01	3134.04	3135.57	3135.29	3136.49	3136.77	3137.02	3137.15	3137.35	3137.60	3137.72	3145.00	3145.00	3145.00	3145.00
3145.00	3145.00	3145.00	3145.00	3145.00	[illegible]	3132.80	3133.82	3134.66	3135.49	3135.36	3136.51	3136.76	3137.02	3137.14	3137.32	3137.54	3137.62	3145.00	3145.00	3145.00	3145.00

Head values for calibration wells 1-24 are as follows:

3138.39 3137.44 3137.10 3136.03 3136.44 [illegible] 3135.55 3135.56 [illegible] [illegible] 3136.08 3135.48 3134.94 3134.29 3134.08 3133.04 3134.55 3134.10 3133.10 3135.69 3136.09 3135.18 3134.98 3135.23

Time = 5212.[illegible] days

HEAD [illegible] OF [illegible]MONTH= 2 TIME STEP = 1[illegible]

3132.40	[illegible]	[illegible]	3133.34	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3132.40	3132.56	3132.70	3133.39	[illegible]	[illegible]	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3132.40	3132.62	3132.81	3133.20	3133.36	3133.88	3134.19	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3132.40	3132.56	[illegible]	[illegible]	[illegible]	[illegible]	3133.88	3134.40	3134.68	3134.92	3135.12	3135.28	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3132.40	3132.51	3132.66	[illegible]	[illegible]	3133.60	3133.60	3134.51	3134.66	3134.85	3135.04	3135.20	3135.85	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3132.40	3132.40	3132.60	3132.58	[illegible]	3133.59	3133.88	3134.48	3134.64	3134.85	3135.06	3135.21	3135.84	3136.48	3136.75	3137.24	3137.87	3145.00	3145.00	3145.00	3145.00	3145.00
3145.00	3132.40	3132.54	3132.97	3133.18	3133.61	3134.12	3134.42	3134.63	3134.85	3135.09	3135.32	3135.56	3136.29	3136.62	3137.10	3137.79	3138.02	3145.00	3145.00	3145.00	3145.00
3145.00	3132.40	[illegible]	[illegible]	3133.10	3133.62	3134.15	3134.41	3134.63	[illegible]	3135.12	3135.36	3135.59	3136.17	3136.48	3136.94	3137.55	3137.89	3138.06	3145.00	3145.00	3145.00
3145.00	3145.00	3132.40	3132.95	3133.18	3133.63	3134.24	3134.44	3134.65	3134.91	3135.25	3135.47	3135.77	3136.01	3136.37	3136.82	3137.38	3137.68	3137.97	3138.04	3145.00	3145.00
3145.00	3145.00	3132.40	3132.97	[illegible]	[illegible]	3134.31	3134.52	3134.74	[illegible]	[illegible]	3135.57	3135.82	3136.03	3136.35	3136.76	3137.27	3137.55	3137.84	3137.98	3145.00	3145.00
3145.00	3145.00	3132.40	3132.92	3133.21	3133.55	3134.31	3134.56	[illegible]	3135.06	3135.31	3135.58	3135.86	3136.18	3136.40	3136.75	3137.20	3137.48	3137.79	3137.98	3145.00	3145.00
3145.00	3145.00	3132.40	3132.78	[illegible]	3133.63	3134.24	3134.67	3134.88	3135.11	[illegible]	3135.63	3135.95	3136.26	3136.44	3136.74	3137.16	3137.43	3137.76	3138.04	3138.32	3145.00
3145.00	3145.00	3132.40	3132.64	3132.85	3133.36	3134.08	3134.59	3134.93	3135.14	3135.41	3135.69	3136.91	3136.30	3136.47	3136.74	3137.12	3137.37	3137.70	3137.93	3138.28	3138.45
3145.00	3145.00	3132.40	3132.40	3132.62	3133.03	3133.81	3134.32	3134.89	3135.15	3135.47	3135.75	3136.06	3136.34	3136.49	3136.73	3137.07	3137.30	3137.61	3137.81	3138.07	3138.26
3145.00	3145.00	3145.00	3132.40	3132.40	[illegible]	3133.31	3133.98	3134.67	3135.13	3135.62	3135.82	3136.10	3136.35	3136.49	3136.70	3137.00	3137.21	3137.54	3137.73	3137.94	3138.07
3145.00	3145.00	3145.00	3145.00	3145.00	3132.40	3132.40	3133.52	3134.30	3134.79	3135.66	3135.86	3136.12	3136.35	3136.46	3136.67	3136.91	3137.02	3145.00	3145.00	3145.00	3145.00
3145.00	3145.00	3145.00	3145.00	3145.00	3141.00	3132.40	3133.35	3134.13	3134.91	3135.67	3135.87	3136.13	3136.35	3136.47	3136.64	3136.85	3136.93	3145.00	3145.00	3145.00	3145.00

Head values for calibration wells 1-24 are as follows:

[illegible] 3136.76 3136.44 3136.18 3135.62 3135.32 3135.36 3135.09 3135.12 3134.48 3135.47 3134.91 3134.41 3133.80 3133.60 3132.62 3134.03 3133.62 3132.68 3135.11 3135.47 3134.63 3134.44 3134.67

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Time =  5242.669  days
                     HEAD (ft or m)MONTH=  3 TIME STEP =  18
3132.80 3133.09 3133.30 3133.72 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00
3132.80 3133.07 3133.29 3133.75 3133.93 3134.25 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00
3132.80 3133.02 3133.20 3133.57 3133.75 3134.24 3134.53 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00
3132.80 3132.95 3133.09 3133.37 3133.50 3133.97 3134.22 3134.70 3134.97 3135.19 3135.39 3135.54 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00
3132.80 3132.90 3133.05 3133.36 3133.48 3133.94 3134.13 3134.80 3134.94 3135.12 3135.30 3135.45 3136.09 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00
3132.80 3132.80 3132.99 3133.35 3133.53 3133.93 3134.20 3134.76 3134.92 3135.12 3135.31 3135.46 3136.07 3136.68 3136.94 3137.42 3138.03 3145.00 3145.00 3145.00 3145.00 3145.00
3145.00 3132.80 3132.93 3133.34 3133.54 3133.94 3134.43 3134.70 3134.90 3135.12 3135.34 3135.56 3135.79 3136.49 3136.60 3137.27 3137.95 3138.17 3145.00 3145.00 3145.00 3145.00
3145.00 3132.80 3132.80 3133.32 3133.54 3133.95 3134.45 3134.69 3134.90 3135.13 3135.37 3135.59 3135.82 3136.37 3136.67 3137.12 3137.71 3138.04 3138.21 3145.00 3145.00 3145.00
3145.00 3145.00 3132.80 3133.32 3133.54 3133.96 3134.53 3134.7[illegible] 3134.92 3135.17 3135.49 3135.70 3135.97 3136.21 3136.55 3136.99 3137.53 3137.82 3138.11 3138.17 3145.00 3145.00
3145.00 3145.00 3132.80 3133.33 3133.61 3134.32 3134.59 3134.78 3135.00 3135.23 3135.50 3135.79 3136.02 3136.22 3136.53 3136.92 3137.41 3137.69 3137.98 3138.12 3145.00 3145.00
3145.00 3145.00 3132.80 3133.27 3133.54 3134.25 3134.56 3134.82 3135.11 3135.29 3135.53 3135.79 3136.05 3136.35 3136.57 3136.90 3137.34 3137.61 3137.92 3138.1[illegible] 3145.00 3145.00
3145.00 3145.00 3132.80 3133.14 3133.36 3133.93 3134.50 3134.91 3135.12 3135.33 3135.57 3135.82 3136.12 3136.42 3136.60 3136.89 3137.29 3137.55 3137.89 3138.16 3138.44 3145.00
3145.00 3145.00 3132.80 3133.01 3133.20 3133.67 3134.34 3134.83 3135.15 3135.35 3135.61 3135.67 3136.17 3136.45 3136.62 3136.87 3137.24 3137.49 3137.81 3138.05 3138.40 3138.56
3145.00 3145.00 3132.80 3132.80 3132.99 3133.37 3134.09 3134.58 3135.11 3135.36 3135.66 3135.92 3136.22 3136.48 3136.63 3136.88 3137.19 3137.42 3137.73 3137.93 3138.18 3138.36
3145.00 3145.00 3145.00 3132.80 3132.80 3132.80 3133.63 3134.25 3134.90 3135.33 3135.80 3135.99 3136.25 3136.49 3136.62 3136.85 3137.12 3137.33 3137.66 3137.84 3138.05 3138.19
3145.00 3145.00 3145.00 3145.00 3145.00 3132.80 3132.80 3133.83 3134.55 3135.20 3135.83 3136.01 3136.26 3136.49 3136.61 3136.79 3137.03 3137.14 3145.00 3145.00 3145.00 3145.00
3145.00 3145.00 3145.00 3145.00 3145.00 3141.00 3132.80 3133.67 3134.39 3135.12 3135.84 3136.03 3136.27 3136.49 3136.69 3136.77 3136.97 3137.05 3145.00 3145.00 3145.00 3145.00
Head values for calibration wells 1-24 are as follows:
3137.82 3136.92 3136.60 3136.35 3136.02 3135.56 3135.59 3135.34 3135.37 3134.76 3135.70 3135.17 3134.69 3134.13 3133.94 3132.99 3134.32 3133.95 3133.07 3135.33 3135.66 3134.90 3134.72 3134.91
Time =  5273.003  days
                     HEAD (ft or m)MONTH=  4 TIME STEP =  19
3134.20 3134.50 3134.73 3135.19 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00
3134.20 3134.49 3134.72 3135.22 3135.41 3135.74 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00
3134.20 3134.43 3134.62 3135.01 3135.20 3135.72 3136.02 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00
3134.20 3134.36 3134.50 3134.80 3134.92 3135.42 3135.67 3136.17 3136.44 3136.67 3136.87 3137.03 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00
3134.20 3134.31 3134.45 3134.78 3134.91 3135.38 3135.58 3136.25 3136.39 3136.58 3136.77 3136.93 3137.61 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00 3145.00
3134.20 3134.20 3134.39 3134.77 3134.95 3135.36 3135.64 3136.21 3136.37 3136.57 3136.78 3136.93 3137.58 3138.21 3138.47 3138.98 3139.64 3145.00 3145.00 3145.00 3145.00 3145.00
3145.00 3134.20 3134.33 3134.76 3134.96 3135.37 3135.87 3136.15 3136.35 3136.57 3136.80 3137.03 3137.26 3138.00 3138.33 3138.82 3139.55 3139.78 3145.00 3145.00 3145.00 3145.00
3145.00 3134.20 3134.20 3134.74 3134.96 3135.38 3135.89 3136.14 3136.35 3136.58 3136.83 3137.05 3137.29 3137.86 3138.18 3138.65 3139.28 3139.63 3139.82 3145.00 3145.00 3145.00
3145.00 3145.00 3134.20 3134.74 3134.96 3135.39 3135.96 3136.16 3136.36 3136.61 3136.94 3137.15 3137.44 3137.69 3138.05 3138.51 3139.08 3139.39 3139.70 3139.77 3145.00 3145.00
3145.00 3145.00 3134.20 3134.72 3135.00 3135.73 3136.01 3136.21 3136.43 3136.67 3136.94 3137.24 3137.47 3137.69 3138.01 3138.42 3138.94 3139.24 3139.55 3139.70 3145.00 3145.00
3145.00 3145.00 3134.20 3134.66 3134.93 3135.65 3136.00 3136.24 3136.53 3136.72 3136.97 3137.23 3137.51 3137.82 3138.04 3138.39 3138.86 3139.14 3139.48 3139.66 3145.00 3145.00
3145.00 3145.00 3134.20 3134.52 3134.74 3135.31 3135.89 3136.31 3136.52 3136.74 3136.99 3137.26 3137.56 3137.87 3138.05 3138.36 3138.79 3139.07 3139.43 3139.73 3140.03 3145.00
3145.00 3145.00 3134.20 3134.40 3134.58 3135.04 3135.72 3136.22 3136.55 3136.76 3137.02 3137.29 3137.60 3137.89 3138.06 3138.34 3138.73 3139.00 3139.35 3139.60 3139.98 3140.16
3145.00 3145.00 3134.20 3134.20 3134.38 3134.74 3135.46 3135.97 3136.51 3136.76 3137.06 3137.33 3137.64 3137.91 3138.07 3138.31 3138.67 3138.92 3139.25 3139.47 3139.74 3139.96
3145.00 3145.00 3145.00 3134.20 3134.20 3134.20 3135.01 3135.63 3136.29 3136.73 3137.20 3137.39 3137.66 3137.92 3138.06 3138.27 3138.59 3138.81 3139.17 3139.37 3139.60 3139.74
3145.00 3145.00 3145.00 3145.00 3145.00 3134.20 3134.20 3135.21 3135.74 3136.59 3137.23 3137.42 3137.67 3137.91 3138.04 3138.23 3138.48 3138.66 3145.00 3145.00 3145.00 3145.00
3145.00 3145.00 3145.00 3145.00 3145.00 3141.00 3134.20 3135.05 3135.77 3136.51 3137.24 3137.43 3137.68 3137.91 3138.03 3138.20 3138.41 3138.50 3145.00 3145.00 3145.00 3145.00
Head values for calibration wells 1-24 are as follows:
3139.[illegible] 3138.4[illegible] 3138.0[illegible] 3137.82 3137.47 3137.03 3137.05 3136.80 3136.83 3136.21 3137.15 3136.61 3136.14 3135.58 3135.38 3134.38 3135.73 3135.18 3134.49 3136.74 3137.06 3136.75 3136.16 3136.31
```

530336

HEAD [illegible] 5 TIME STEP [illegible]

3139.80	3140.11	3140.36	3140.87	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3139.80	3140.10	3140.34	3140.89	3141.09	3141.45	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3139.80	3140.03	3140.22	3140.64	3140.84	3141.39	3141.70	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3139.80	3139.95	3140.09	3140.39	3140.52	3141.01	3141.27	3141.77	3141.98	3142.20	3142.40	3142.57	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3139.80	3139.90	3140.05	3140.36	3140.49	3140.95	3141.14	3141.76	3141.69	3142.07	3142.26	3142.44	3143.16	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3139.80	3139.80	3139.98	3140.35	3140.52	3140.92	3141.17	3141.71	3141.86	3142.06	3142.26	3142.41	3143.11	3143.72	3143.98	3144.52	3145.23	3145.00	3145.00	3145.00	3145.00	3145.00
3145.00	3139.80	3139.92	3140.33	3140.52	3140.91	3141.38	3141.64	3141.84	3142.05	3142.27	3142.48	3142.73	3143.47	3143.81	3144.33	3145.13	3145.38	3145.00	3145.00	3145.00	3145.00
3145.00	3139.80	3139.80	3140.31	3140.51	3140.91	3141.39	3141.62	3141.83	3142.05	3142.29	3142.50	3142.73	3143.30	3143.63	3144.13	3144.80	3145.19	3145.38	3145.00	3145.00	3145.00
3145.00	3145.00	3139.80	3140.30	3140.51	3140.91	3141.44	3141.63	3141.83	3142.07	3142.37	3142.58	3142.85	3143.10	3143.47	3143.95	3144.55	3144.90	3145.23	3145.30	3145.00	3145.00
3145.00	3145.00	3139.80	3140.23	3140.48	3141.15	3141.44	3141.64	3141.85	3142.09	3142.36	3142.64	3142.86	3143.07	3143.40	3143.83	3144.38	3144.70	3145.04	3145.21	3145.00	3145.00
3145.00	3145.00	3139.80	3140.14	3140.38	3141.05	3141.40	3141.64	3141.91	3142.10	3142.34	3142.61	3142.87	3143.17	3143.39	3143.75	3144.25	3144.56	3144.93	3145.16	3145.00	3145.00
3145.00	3145.00	3139.80	3140.00	3140.18	3140.68	3141.22	3141.64	3141.86	3142.08	3142.32	3142.58	3142.87	3143.17	3143.37	3143.69	3144.15	3144.45	3144.86	3145.19	3145.53	3145.00
3145.00	3145.00	3139.80	3139.91	3140.05	3140.42	3141.02	3141.54	3141.66	3142.06	3142.32	3142.57	3142.87	3143.16	3143.34	3143.63	3144.05	3144.34	3144.74	3145.03	3145.46	3145.65
3145.00	3145.00	3139.80	3139.80	3139.92	3140.19	3141.01	3141.28	[illegible]	3142.04	3142.33	3142.56	3142.88	3143.16	3143.32	3143.58	3143.96	3144.24	3144.61	3144.86	3145.17	3145.42
3145.00	3145.00	3145.00	3139.80	3139.80	3139.80	3140.44	[illegible]	[illegible]	[illegible]	[illegible]	3142.62	3142.88	3143.14	3143.29	3143.52	3143.86	3144.11	3144.51	3144.74	3145.00	3145.16
3145.00	3145.00	3145.00	3145.00	3145.00	3139.80	3139.80	3140.52	3141.26	[illegible]	3142.45	3142.63	3142.88	3143.12	3143.25	3143.46	3143.72	3143.86	3145.00	3145.00	3145.00	3145.00
3145.00	3145.00	3145.00	3145.00	3145.00	3141.00	3139.80	3140.49	3141.11	[illegible]	3142.46	3142.63	3142.87	3143.10	3143.23	3143.42	3143.64	3143.73	3145.00	3145.00	3145.00	3145.00

Head values for calibration wells 1-24 are as follows:

3144.[illegible] 3143.83 3143.37 3143.1[illegible] 3142.85 3142.90 3142.50 3142.[illegible] 3142.29 3141.[illegible] 3142.58 3142.07 3141.62 3141.14 3140.95 3139.92 3141.15 3140.91 3140.10 3142.08 3142.33 3141.83 3141.63 3141.64

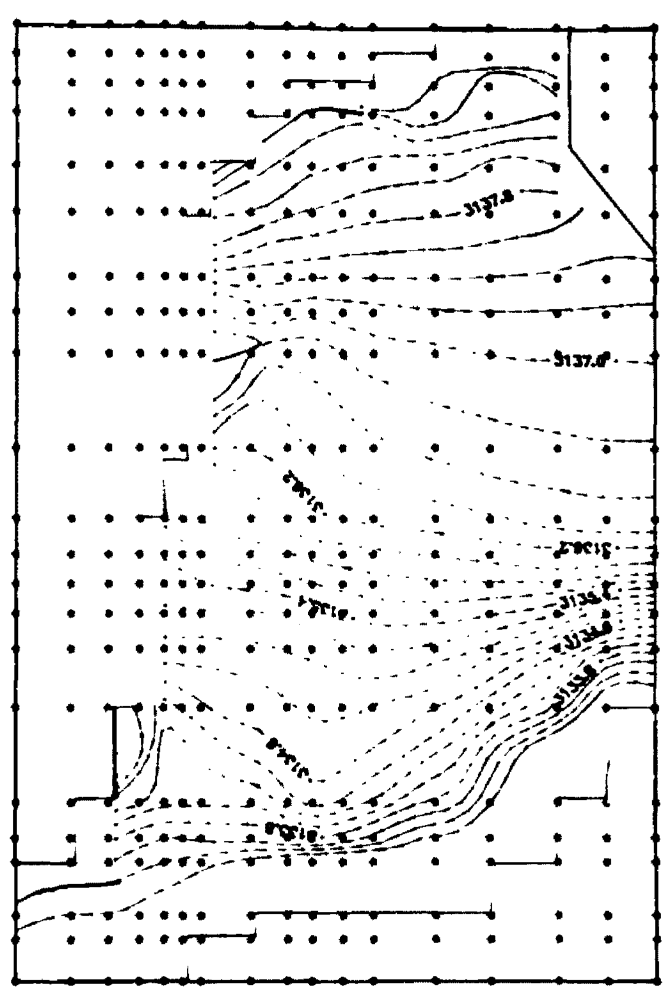
[illegible] 0a

HEAD [illegible] TIME STEP [illegible] 21

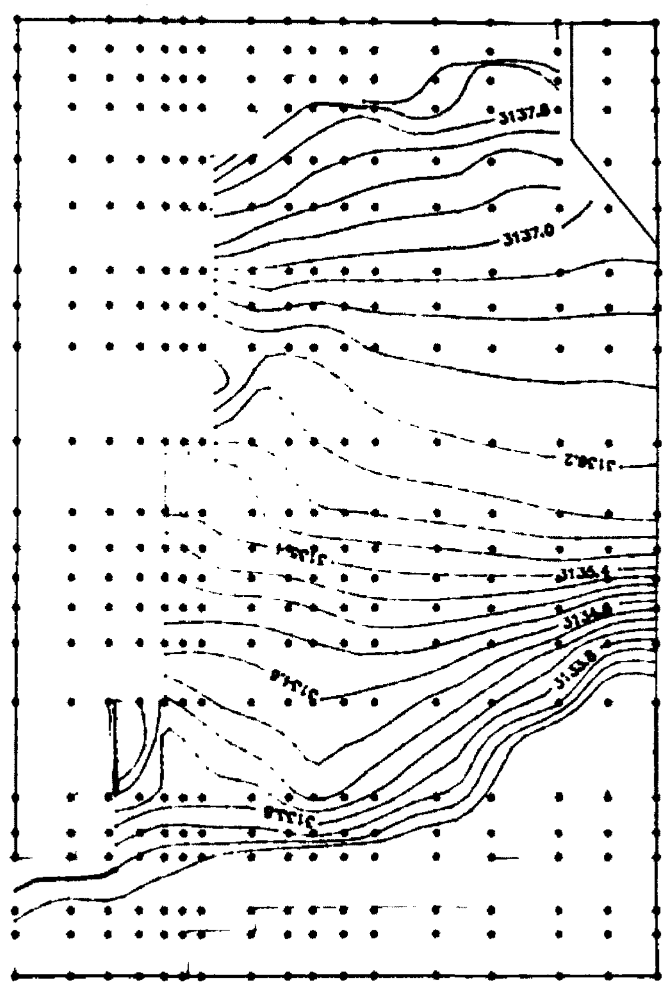
[illegible]	[illegible]	3141.15	[illegible]	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
[illegible]	3140.90	3141.14	3141.60	3141.95	3142.20	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
[illegible]	3140.84	3141.03	3141.45	3141.64	3142.10	3142.50	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3140.50	[illegible]	3140.91	[illegible]	3141.75	3141.80	3142.14	[illegible]	3142.94	3143.10	3143.39	3143.56	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
3140.60	3140.71	3140.87	3141.20	3141.34	3141.83	3142.04	[illegible]	3142.69	3143.09	3143.29	3143.46	3144.16	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00	3145.00
[illegible]	3140.60	3140.80	3141.29	3141.38	3141.81	3142.10	[illegible]	3142.87	3143.09	3143.30	3143.46	3144.14	3144.79	3145.07	3145.60	3146.28	3145.00	3145.00	3145.00	3145.00	3145.00
3145.00	3140.60	3140.74	3141.18	3141.39	3141.82	3142.25	3142.64	3142.85	3143.09	3143.32	3143.56	3143.61	3144.58	3144.92	3145.44	3146.19	3146.43	3145.00	3145.00	3145.00	3145.00
3145.00	3140.60	3140.60	3141.16	3141.27	3141.83	[illegible]	3142.63	3142.85	3143.10	3143.36	3143.59	3143.84	3144.43	3144.77	3145.26	3145.91	3146.28	3146.47	3145.00	3145.00	3145.00
3145.00	3145.00	3140.60	3141.16	3141.39	3141.84	3142.45	3142.65	3142.87	3143.13	3143.47	3143.70	3144.00	3144.26	3144.63	3145.11	3145.71	3146.03	3146.35	3146.42	3145.00	3145.00
3145.00	3145.00	3140.60	3141.16	3141.45	3142.21	3142.50	3142.71	3142.95	3143.20	3143.48	3143.79	3144.04	3144.26	3144.60	3145.03	3145.57	3145.88	3146.20	3146.35	3145.00	3145.00
3145.00	3145.00	3140.60	3141.09	3141.38	3142.13	3142.49	3142.74	3143.05	3143.25	3143.51	3143.79	3144.07	3144.40	3144.63	3144.99	3145.48	3145.78	3146.12	3146.33	3145.00	3145.00
3145.00	3145.00	3140.60	3140.95	3141.18	3141.78	3142.39	3142.82	3143.05	3143.28	3143.54	3143.81	3144.13	3144.45	3144.65	3144.97	3145.42	3145.70	3146.08	3146.36	3146.70	3145.00
3145.00	3145.00	3140.60	3140.82	3141.01	3141.50	3142.21	3142.73	3143.08	3143.30	3143.57	3143.85	3144.18	3144.48	3144.66	3144.94	3145.35	3145.63	3145.99	3146.25	3146.65	3146.83
3145.00	3145.00	3140.60	3140.60	3140.80	3141.18	3141.94	3142.47	3143.03	3143.30	3143.62	3143.89	3144.21	3144.50	3144.66	3144.92	3145.29	3145.55	3145.89	3146.11	3146.40	3146.62
3145.00	3145.00	3145.00	3140.60	3140.60	3140.60	3141.46	3142.12	3142.61	3143.26	3143.76	3143.96	3144.24	3144.51	3144.65	3144.88	3145.21	3145.44	3145.81	3146.02	3146.25	3146.39
3145.00	3145.00	3145.00	3145.00	3145.00	3140.60	3140.60	3141.67	3142.44	3143.12	3143.79	3143.98	3144.25	3144.50	3144.63	3144.83	3145.10	3145.22	3145.00	3145.00	3145.00	3145.00
3145.00	3145.00	3145.00	3145.00	3145.00	3141.00	3140.60	3141.50	3142.26	3143.03	3143.80	3144.00	3144.26	3144.50	3144.62	3144.80	3145.03	3145.11	3145.00	3145.00	3145.00	3145.00

Head values for calibration wells 1-24 are as follows:

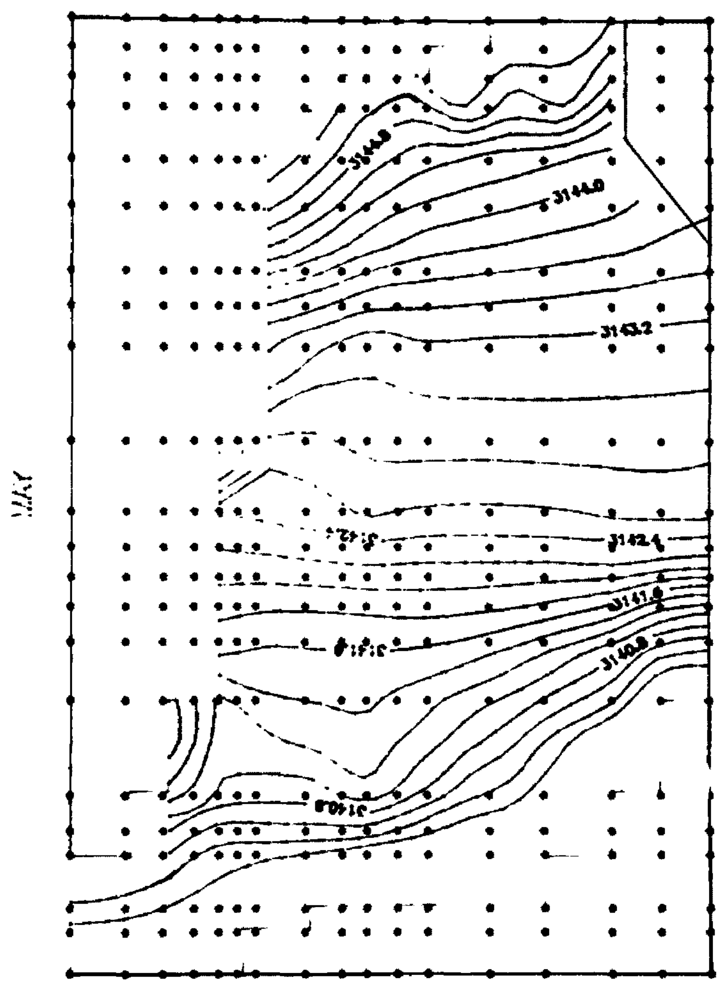
3146.03 3145.03 3144.65 3144.40 3144.04 3143.56 3143.59 3143.32 3143.35 3142.71 3143.70 3143.13 3142.63 3142.04 3141.83 3140.80 3142.21 3141.83 3140.90 3143.28 3143.62 3142.85 3142.65 3142.82



JANUARY



MARCH


3144.0
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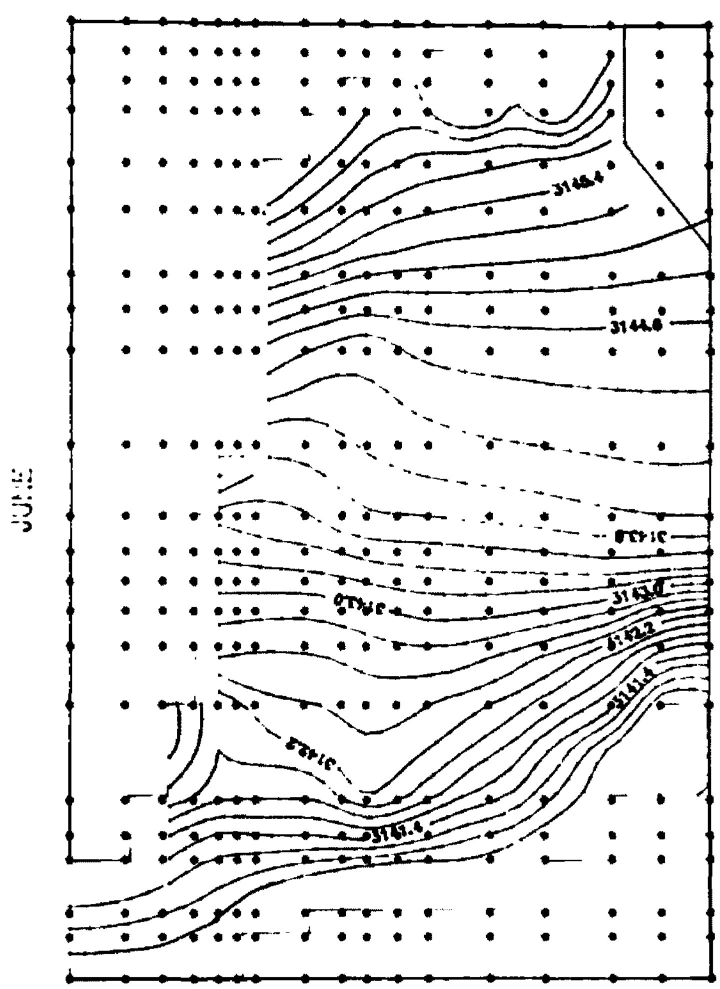
3142.4



Calibration of PLASM

I compared simulated versus actual water levels generated after each monthly time step during a transient run for 24 nodes that corresponded with actual well locations (Figure 8 and Table 5). By adjusting the configuration and values of the different K zones between succeeding runs, I attempted to calibrate simulated head levels for these nodes to within 0.2 feet (0.06 m) of actual field data. Figures 15A-D are hydrographs of four wells throughout the study area comparing actual vs. simulated heads.

Table 5: Wells used for calibration of transient PLASM model

Well	#	Node (i,j)	Comments
McPark	1	18,9	actual well 180 ft. to NE
3092	2	16,10	
3001-D	3	15,12	
3002-D	4	14,11	
3091	5	13,10	
3004-D	6	12,7	actual well 160 ft. to E
1018	7	12,8	
1040	8	11,7	actual well 60 ft. to E
1021	9	11,8	
1039	10	8,6	
1003&4	11	12,9	actual wells 60 ft. to N
1009&11	12	10,9	actual wells 60 ft. E & W
1025	13	8,8	actual well 82 ft. to W
1029	14	7,5	actual well 82 ft. to W
1030	15	6,5	actual well 120 ft. to E
1043	16	5,14	
1042	17	6,10	
1044	18	6,8	
1046	19	2,2	
1028	20	10,12	actual well 82 ft. to E
1041	21	11,14	actual well 82 ft. to E
1023	22	9,8	
1016-D	23	8,9	
3093	24	8,12	

Figure 15A: Hydrograph of Well 3002-D

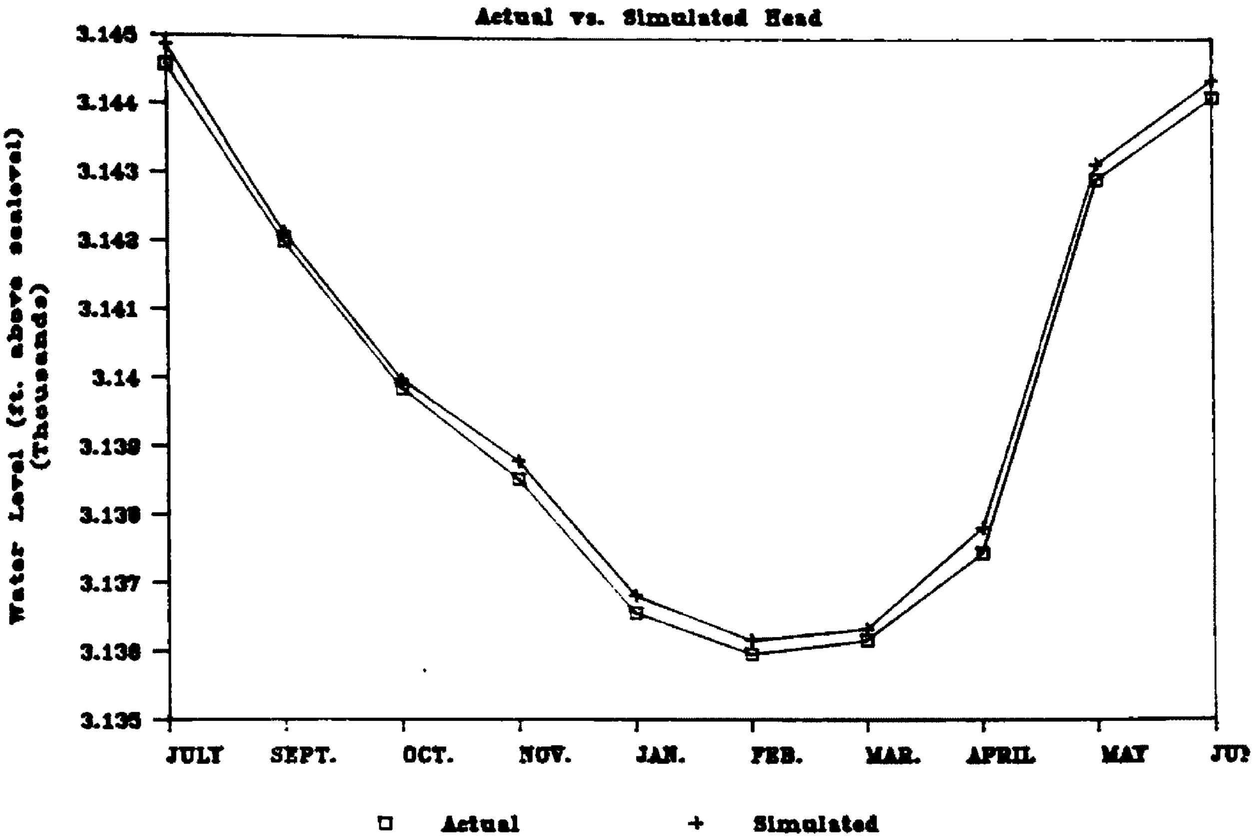


Figure 15B: Hydrograph of Well 1021

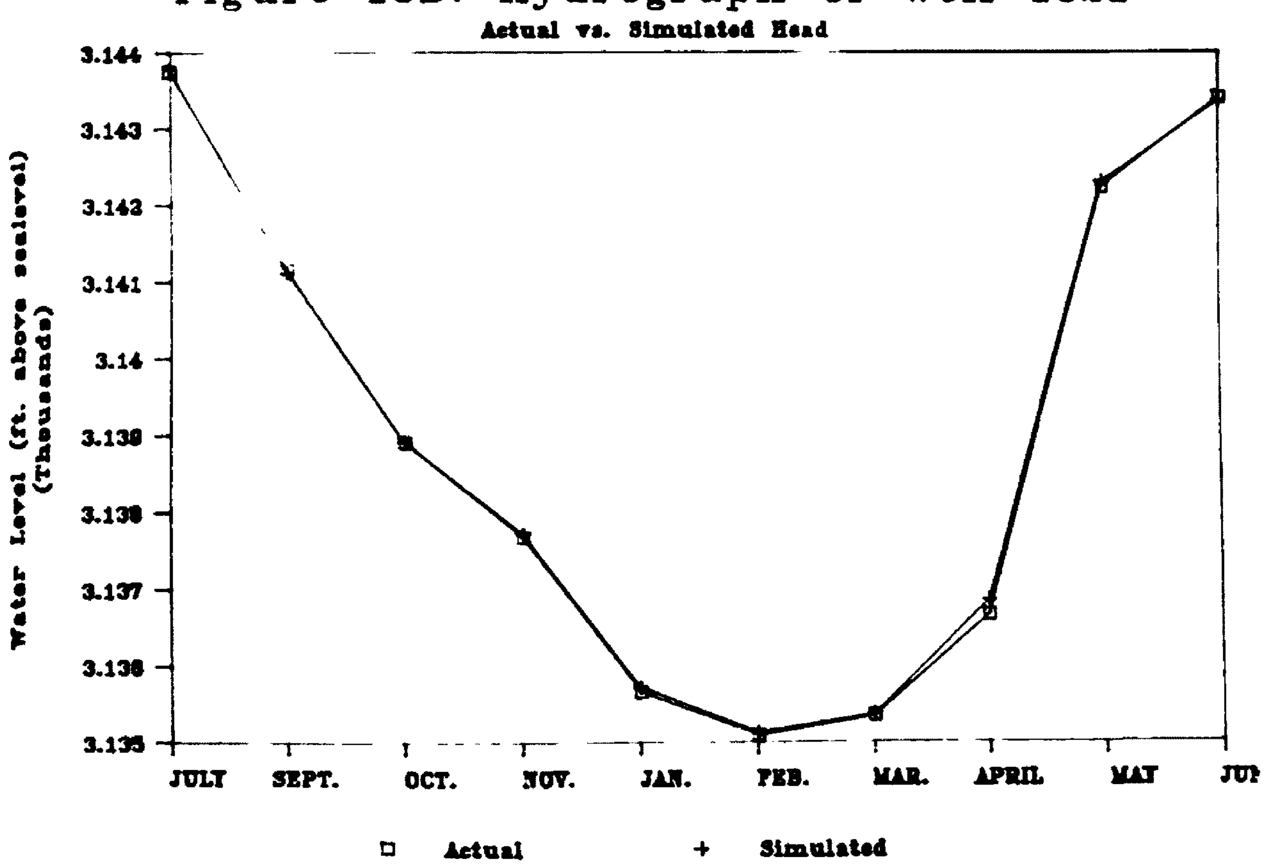


Figure 15C: Hydrograph of Well 1039

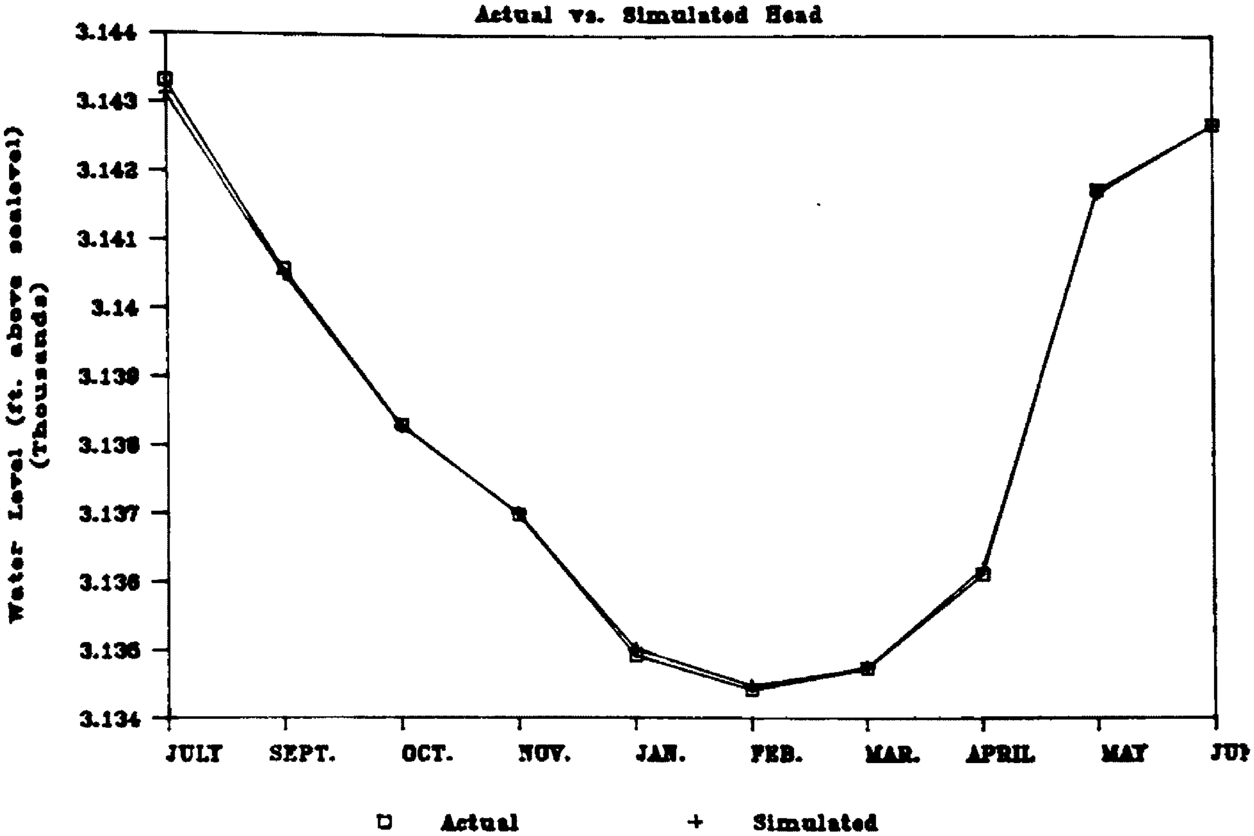
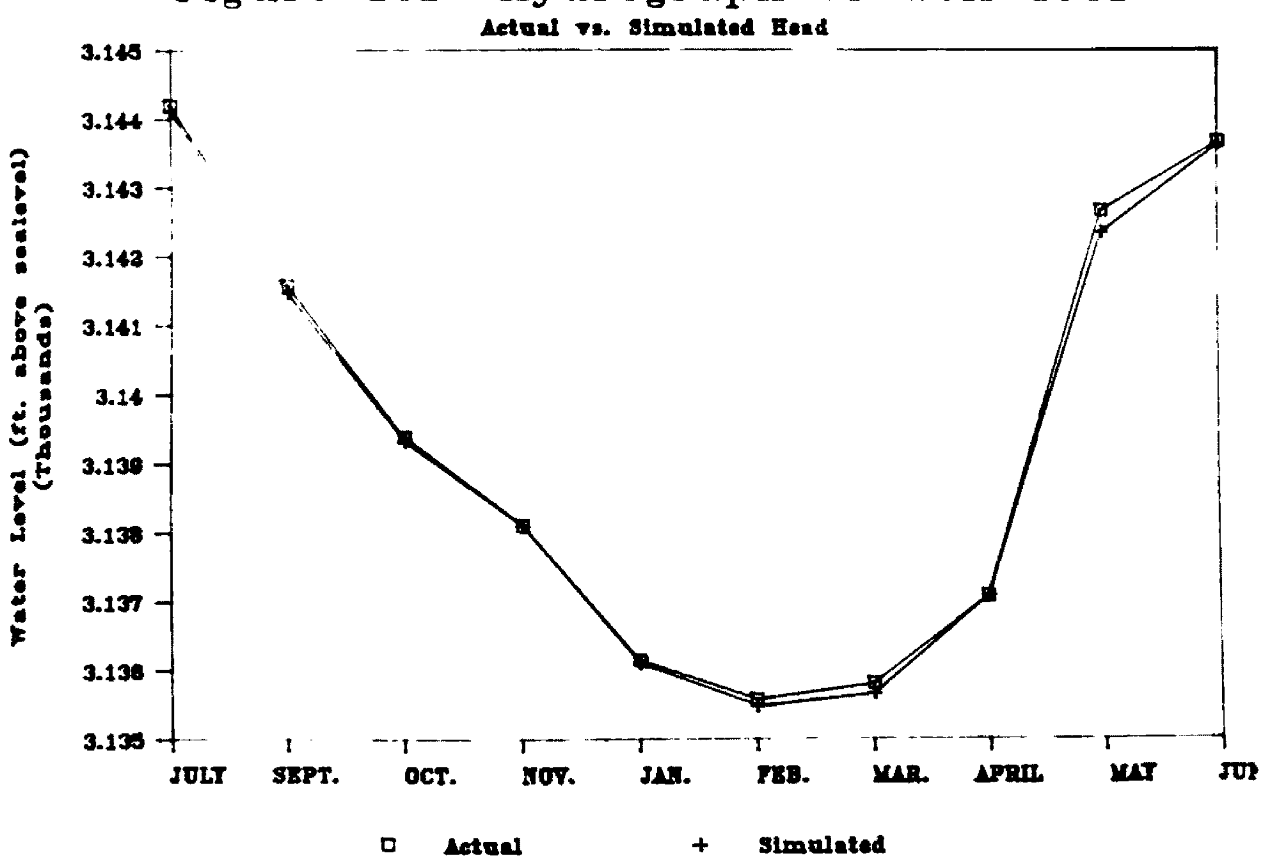


Figure 15D: Hydrograph of Well 1041



I used a composite error tolerance of plus or minus 0.2 feet (0.06 m) during calibration, because I felt that a higher tolerance would have made it more difficult to reproduce the actual potentiometric surface. Figure 16 illustrates the range of differences between actual and simulated head values for the month of October, 1986. This plot is typical of the plots for the other nine months (Appendix C). All plots exhibit a high degree of correlation (r> 97%) with some scatter attributable to location error between model node position and actual well location, field error (error in measuring the static water level), and the inability of the model to assimilate sudden high recharge within the 30.33 day time limit. This latter source of error occurs in April and May.

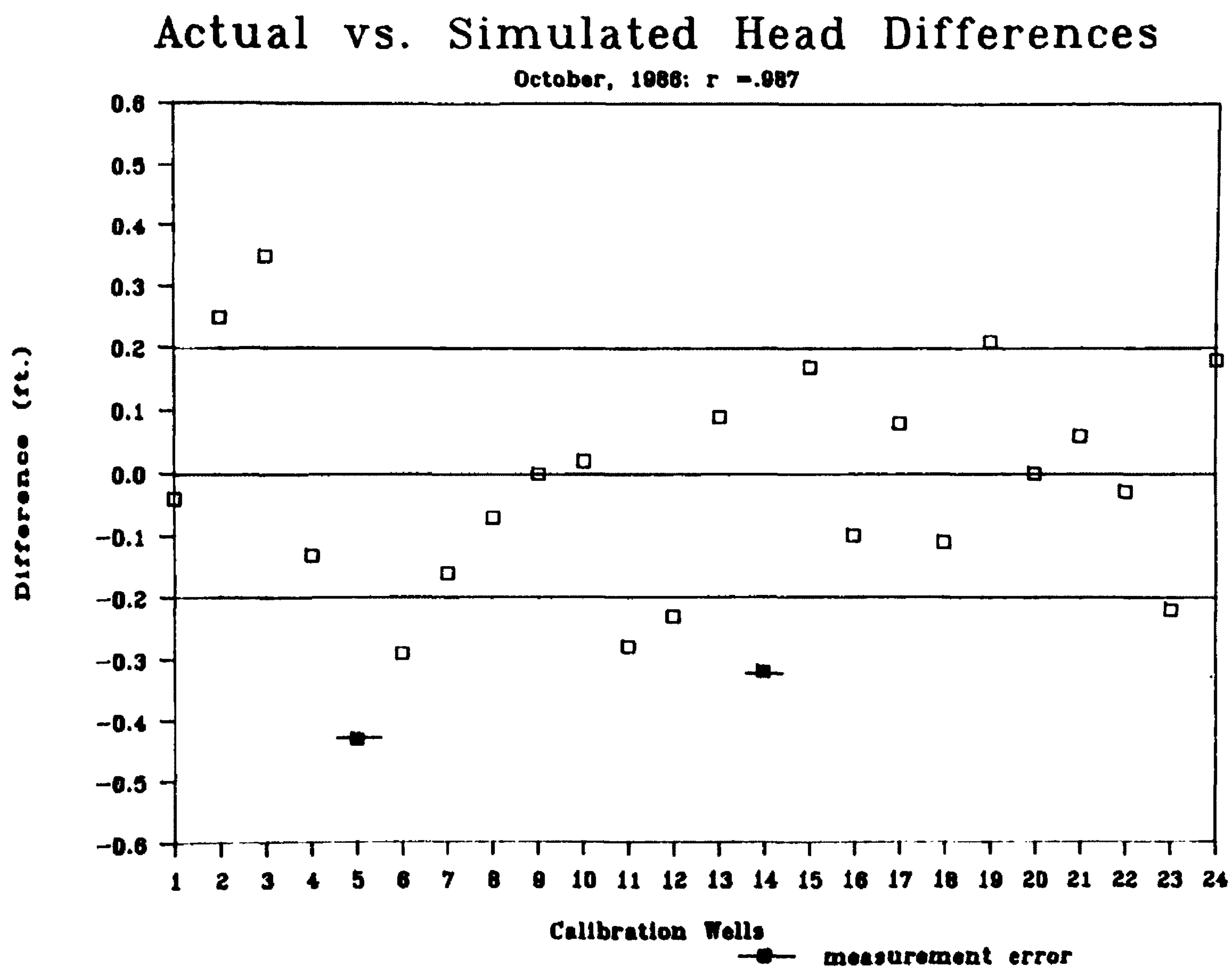


Figure 16: Plot of differences between actual vs. simulated heads at calibration wells.

Regression Analyses of Model Generated Head D

Month	Well #	Actual	Model	Diff.
7	1	3146.37	3146.45	-0.08
7	2	3145.46	3145.48	-0.02
7	3	3145.17	3145.13	0.04
7	4	3144.58	3144.87	-0.29
7	5	3144.41	3144.5	-0.09
7	6	3143.79	3144	-0.21
7	7	3143.95	3144.03	-0.08
7	8	3143.74	3143.76	-0.02
7	9	3143.75	3143.79	-0.04
7	10	3143.32	3143.13	0.19
7	11	3144	3144.15	-0.15
7	12	3143.5	3143.57	-0.07
7	14	3142.89	3142.45	0.44
7	20	3143.82	3143.75	0.07
7	21	3144.2	3144.12	0.08
7	22	3143.39	3143.28	0.11
7	23	3143.28	3143.09	0.19
7	24	3143.53	3143.3	0.23

Regression Output:

Constant	-299.458
Std Err of Y Est	0.158313
R Squared	0.974650
No. of Observations	18
Degrees of Freedom	16

X Coefficient(s)	1.095240
Std Err of Coef.	0.044157

Month	Well #	Actual	Model	Diff.
9	1	3143.79	3143.55	0.24
9	2	3142.9	3142.68	0.22
9	3	3142.68	3142.38	0.3
9	4	3141.99	3142.13	-0.14
9	5	3141.38	3141.78	-0.4
9	6	3140.98	3141.3	-0.32
9	7	3141.11	3141.33	-0.22
9	8	3141.02	3141.07	-0.05
9	9	3141.16	3141.11	0.05
9	10	3140.59	3140.49	0.1
9	11	3141.23	3141.45	-0.22
9	12	3141	3140.9	0.1
9	20	3141.23	3141.1	0.13
9	21	3141.58	3141.46	0.12
9	22	3140.69	3140.63	0.06
9	23	3140.57	3140.46	0.11
9	24	3140.84	3140.69	0.15

Regression Output:

Constant	271.3946
Std Err of Y Est	0.195081
R Squared	0.949174
No. of Observations	17
Degrees of Freedom	15

X Coefficient(s)	0.913604
Std Err of Coef.	0.054585

Month	Well #	Actual	Model	Diff.
10	1	3141.33	3141.37	-0.04
10	2	3140.76	3140.51	0.25
10	3	3140.59	3140.24	0.35
10	4	3139.84	3139.97	-0.13
10	5	3139.17	3139.6	-0.43
10	6	3138.8	3139.09	-0.29
10	7	3138.97	3139.13	-0.16
10	8	3138.79	3138.86	-0.07
10	9	3138.9	3138.9	0
10	10	3138.28	3138.26	0.02
10	11	3138.98	3139.26	-0.28
10	12	3138.47	3138.7	-0.23
10	13	3138.29	3138.2	0.09
10	14	3137.26	3137.58	-0.32
10	15	3137.55	3137.38	0.17
10	16	3136.34	3136.44	-0.1
10	17	3137.94	3137.86	0.08
10	18	3137.3	3137.41	-0.11
10	19	3136.68	3136.47	0.21
10	20	3138.93	3138.93	0
10	21	3139.37	3139.31	0.06
10	22	3138.38	3138.41	-0.03
10	23	3138.01	3138.23	-0.22
10	24	3138.69	3138.51	0.18

Regression Output:

Constant	83.75844
Std Err of Y Est	0.198462
R Squared	0.973395
No. of Observations	24
Degrees of Freedom	22

X Coefficient(s)	0.973327
Std Err of Coef.	0.034306

Month	Well #	Actual	Model	Diff.
11	1	3140.16	3140.34	-0.18
11	2	3139.4	3139.4	0
11	3	3139.25	3139.08	0.17
11	4	3138.53	3138.8	-0.27
11	5	3138.23	3138.42	-0.19
11	6	3137.51	3137.89	-0.38
11	7	3137.74	3137.93	-0.19
11	8	3137.48	3137.65	-0.17
11	9	3137.65	3137.69	-0.04
11	10	3136.98	3137	-0.02
11	11	3137.66	3138.05	-0.39
11	12	3137.3	3137.46	-0.16
11	13	3137	3136.93	0.07
11	15	3136.24	3136.07	0.17
11	16	3135.08	3135.04	0.04
11	17	3136.63	3136.55	0.08
11	18	3135.98	3136.09	-0.11
11	19	3135.39	3135.1	0.29
11	20	3137.64	3137.68	-0.04
11	21	3138.03	3138.07	-0.04
11	22	3137.16	3137.16	0
11	23	3137.11	3136.97	0.14
11	24	3137.4	3137.23	0.17

Regression Output:

Constant	-166.448
Std Err of Y Est	0.170772
R Squared	0.982775
No. of Observations	23
Degrees of Freedom	21

X Coefficient(s)	1.053066
Std Err of Coef.	0.030422

Month	Well #	Actual	Model	Diff.
1	1	3138.36	3138.39	-0.03
1	2	3137.55	3137.44	0.11
1	3	3137.37	3137.1	0.27
1	4	3136.58	3136.83	-0.25
1	5	3136.32	3136.44	-0.12
1	6	3135.43	3135.91	-0.48
1	7	3135.73	3135.95	-0.22
1	8	3135.46	3135.66	-0.2
1	9	3135.65	3135.71	-0.06
1	10	3134.92	3135.02	-0.1
1	11	3135.74	3136.08	-0.34
1	12	3135.22	3135.48	-0.26
1	13	3134.96	3134.94	0.02
1	15	3134.39	3134.08	0.31
1	16	3133.04	3133.04	0
1	17	3134.63	3134.55	0.08
1	18	3133.93	3134.1	-0.17
1	19	3133.24	3133.1	0.14
1	20	3135.83	3135.69	0.14
1	21	3136.13	3136.09	0.04
1	22	3135.11	3135.18	-0.07
1	23	3135.02	3134.98	0.04
1	24	3135.44	3135.23	0.21

Regression Output:

Constant	-10.5202
Std Err of Y Est	0.202694
R Squared	0.976139
No. of Observations	23
Degrees of Freedom	21

X Coefficient(s)	1.003368
Std Err of Coef.	0.034232

Month	Well #	Actual	Model	Diff.
2	1	3137.49	3137.68	-0.19
2	2	3136.88	3136.76	0.12
2	3	3136.77	3136.44	0.33
2	4	3135.97	3136.18	-0.21
2	6	3134.88	3135.32	-0.44
2	7	3135.07	3135.36	-0.29
2	8	3134.74	3135.09	-0.35
2	9	3135.09	3135.12	-0.03
2	10	3134.42	3134.48	-0.06
2	11	3135.15	3135.47	-0.32
2	12	3134.7	3134.91	-0.21
2	13	3134.45	3134.41	0.04
2	14	3133.9	3133.8	0.1
2	15	3133.72	3133.6	0.12
2	16	3132.58	3132.62	-0.04
2	17	3134.11	3134.03	0.08
2	18	3133.43	3133.62	-0.19
2	19	3132.66	3132.68	-0.02
2	20	3135.12	3135.11	0.01
2	21	3135.57	3135.47	0.1
2	22	3134.54	3134.63	-0.09
2	23	3134.48	3134.44	0.04
2	24	3134.87	3134.67	0.2

Regression Output:

Constant	18.82929
Std Err of Y Est	0.196441
R Squared	0.975074
No. of Observations	23
Degrees of Freedom	21

X Coefficient(s)	0.994011
Std Err of Coef.	0.034680

Month	Well #	Actual	Model	Diff.
3	1	3137.65	3137.82	-0.17
3	2	3137.02	3136.92	0.1
3	3	3136.87	3136.6	0.27
3	4	3136.18	3136.35	-0.17
3	5	3135.76	3136.02	-0.26
3	6	3135.18	3135.56	-0.38
3	7	3135.42	3135.59	-0.17
3	8	3135.2	3135.34	-0.14
3	9	3135.34	3135.37	-0.03
3	10	3134.74	3134.76	-0.02
3	11	3135.4	3135.7	-0.3
3	12	3134.97	3135.17	-0.2
3	13	3134.73	3134.69	0.04
3	14	3134.26	3134.13	0.13
3	15	3134.05	3133.94	0.11
3	16	3132.91	3132.99	-0.08
3	17	3134.44	3134.32	0.12
3	18	3133.79	3133.95	-0.16
3	19	3133.18	3133.07	0.11
3	20	3135.35	3135.33	0.02
3	21	3135.79	3135.66	0.13
3	22	3134.82	3134.9	-0.08
3	23	3134.77	3134.72	0.05
3	24	3135.22	3134.91	0.31

Regression Output:

Constant	-29.3460
Std Err of Y Est	0.180489
R Squared	0.976026
No. of Observations	24
Degrees of Freedom	22

X Coefficient(s)	1.009370
Std Err of Coef.	0.033726

Month	Well #	Actual	Model	Diff.
4	1	3138.91	3139.39	-0.48
4	2	3138.23	3138.42	-0.19
4	3	3138.1	3138.05	0.05
4	4	3137.45	3137.82	-0.37
4	5	3137.34	3137.47	-0.13
4	6	3136.52	3137.03	-0.51
4	7	3136.79	3137.05	-0.26
4	8	3136.51	3136.8	-0.29
4	9	3136.64	3136.83	-0.19
4	10	3136.12	3136.21	-0.09
4	11	3136.7	3137.15	-0.45
4	12	3136.3	3136.61	-0.31
4	13	3136.07	3136.14	-0.07
4	14	3135.79	3135.58	0.21
4	15	3135.57	3135.38	0.19
4	16	3134.39	3134.38	0.01
4	17	3135.94	3135.73	0.21
4	18	3135.32	3135.38	-0.06
4	19	3134.81	3134.49	0.32
4	20	3136.65	3136.74	-0.09
4	21	3137.05	3137.06	-0.01
4	22	3136.14	3136.35	-0.21
4	23	3136.13	3136.16	-0.03
4	24	3136.57	3136.31	0.26

24 Regression Output:

Constant	-357.555
Std Err of Y Est	0.208575
R Squared	0.969438
No. of Observations	24
Degrees of Freedom	22

X Coefficient(s)	1.114031
Std Err of Coef.	0.042171

Month	Well #	Actual	Model	Diff.
5	1	3144.38	3144.9	-0.52
5	2	3143.76	3143.83	-0.07
5	3	3143.54	3143.37	0.17
5	4	3142.93	3143.17	-0.24
5	5	3142.79	3142.86	-0.07
5	6	3141.96	3142.48	-0.52
5	7	3142.32	3142.5	-0.18
5	8	3142.06	3142.27	-0.21
5	9	3142.22	3142.29	-0.07
5	10	3141.74	3141.71	0.03
5	11	3142.3	3142.58	-0.28
5	12	3141.9	3142.07	-0.17
5	13	3141.64	3141.62	0.02
5	14	3141.19	3141.14	0.05
5	15	3141.11	3140.95	0.16
5	16	3139.9	3139.92	-0.02
5	17	3141.4	3141.15	0.25
5	18	3140.74	3140.91	-0.17
5	19	3140.13	3140.1	0.03
5	20	3142.23	3142.08	0.15
5	21	3142.64	3142.33	0.31
5	22	3141.76	3141.83	-0.07
5	23	3141.66	3141.63	0.03
5	24	3141.95	3141.64	0.31

Regression Output:

Constant	-178.552
Std Err of Y Est	0.217316
R Squared	0.964145
No. of Observations	24
Degrees of Freedom	22

X Coefficient(s)	1.056841
Std Err of Coef.	0.043450

Month	Well #	Actual	Model	Diff.
6	1	3145.82	3146.03	-0.21
6	2	3145.05	3145.03	0.02
6	3	3144.8	3144.65	0.15
6	4	3144.14	3144.4	-0.26
6	5	3143.97	3144.04	-0.07
6	6	3143.14	3143.56	-0.42
6	7	3143.43	3143.59	-0.16
6	8	3143.23	3143.32	-0.09
6	9	3143.4	3143.36	0.04
6	10	3142.7	3142.71	-0.01
6	11	3143.4	3143.7	-0.3
6	12	3142.84	3143.13	-0.29
6	13	3142.69	3142.63	0.06
6	14	3142.18	3142.04	0.14
6	15	3142.07	3141.83	0.24
6	16	3140.57	3140.8	-0.23
6	17	3142.32	3142.21	0.11
6	18	3141.68	3141.83	-0.15
6	19	3141.03	3140.9	0.13
6	20	3143.26	3143.28	-0.02
6	21	3143.66	3143.62	0.04
6	22	3142.8	3142.85	-0.05
6	23	3142.7	3142.65	0.05
6	24	3143	3142.82	0.18

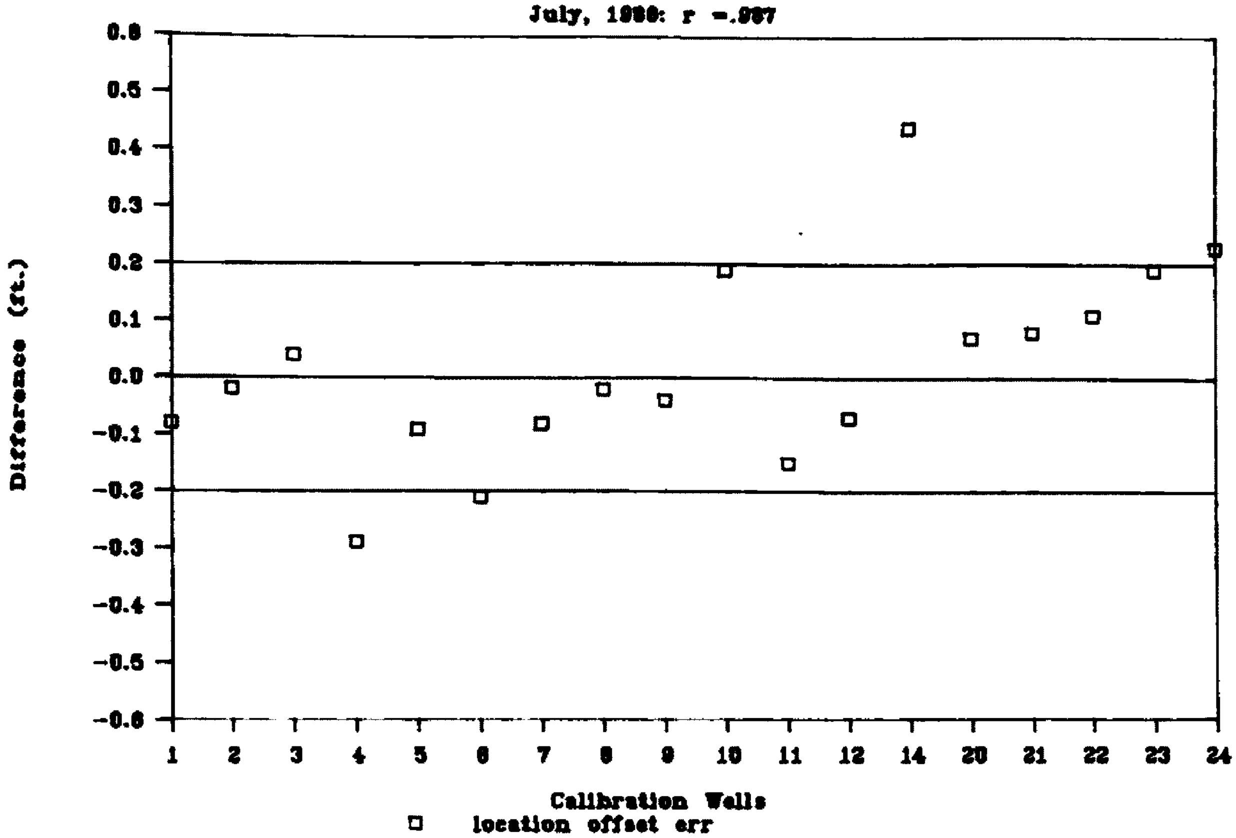
Regression Output:

Constant	-65.5158
Std Err of Y Est	0.176515
R Squared	0.980126
No. of Observations	24
Degrees of Freedom	22

X Coefficient(s)	1.020859
Std Err of Coef.	0.030992

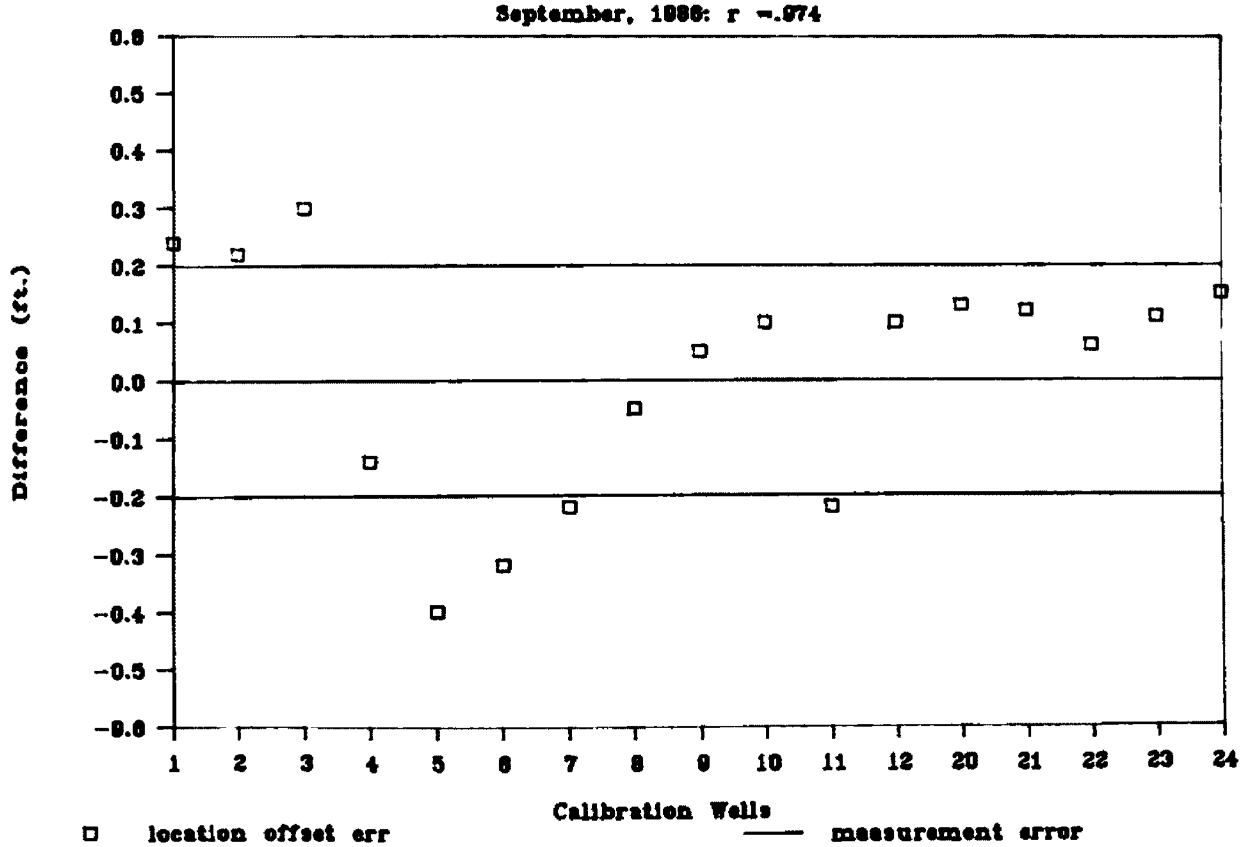
Actual vs. Simulated Head Differences

July, 1988: r =.987



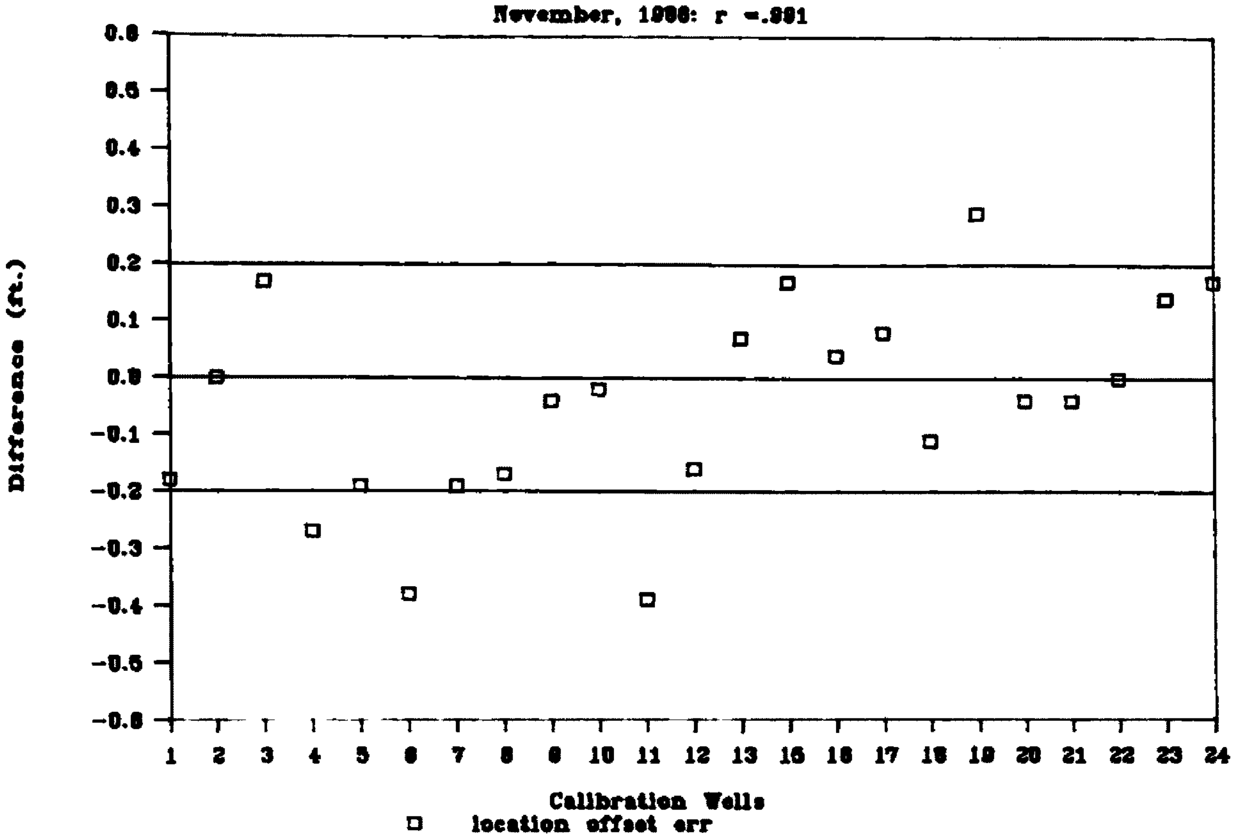
Actual vs. Simulated Head Differences

September, 1988: r =.974



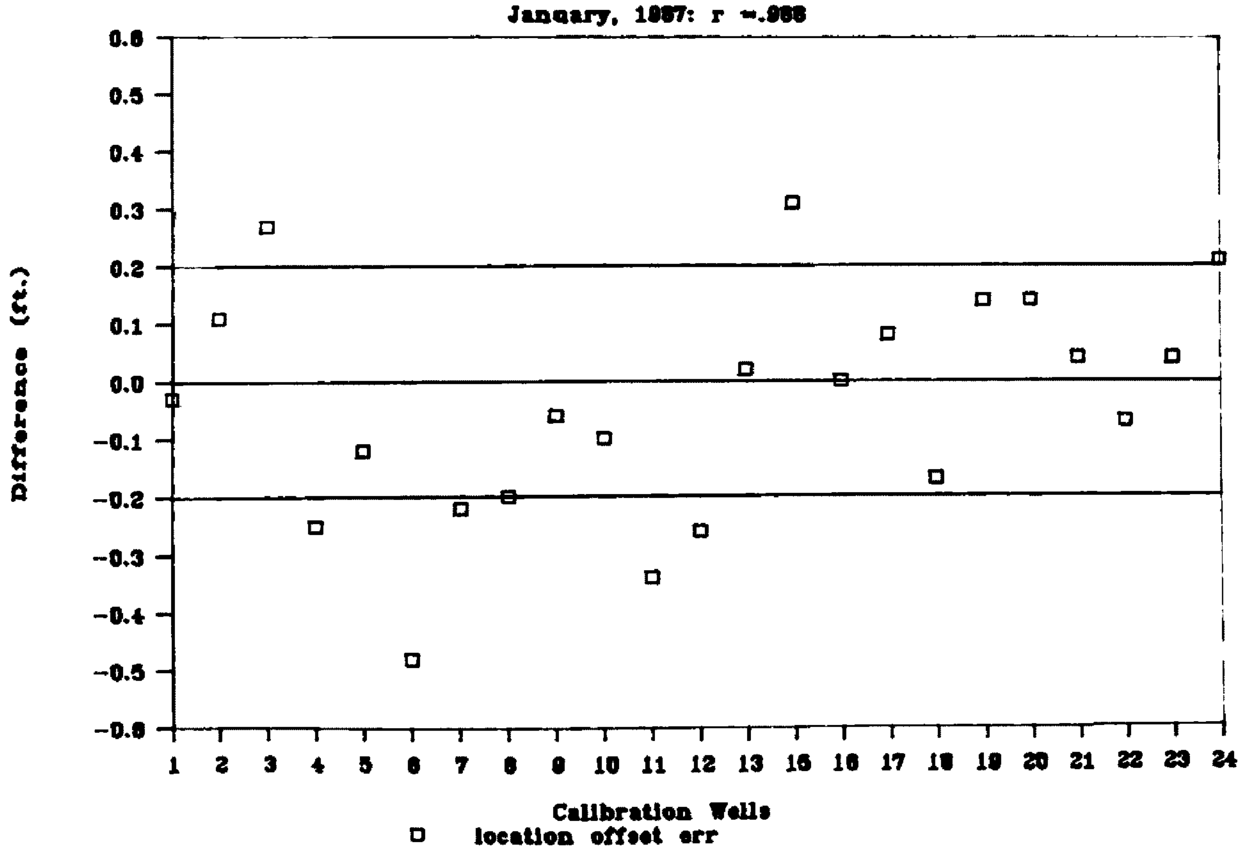
Actual vs. Simulated Head Differences

November, 1986: r =.991



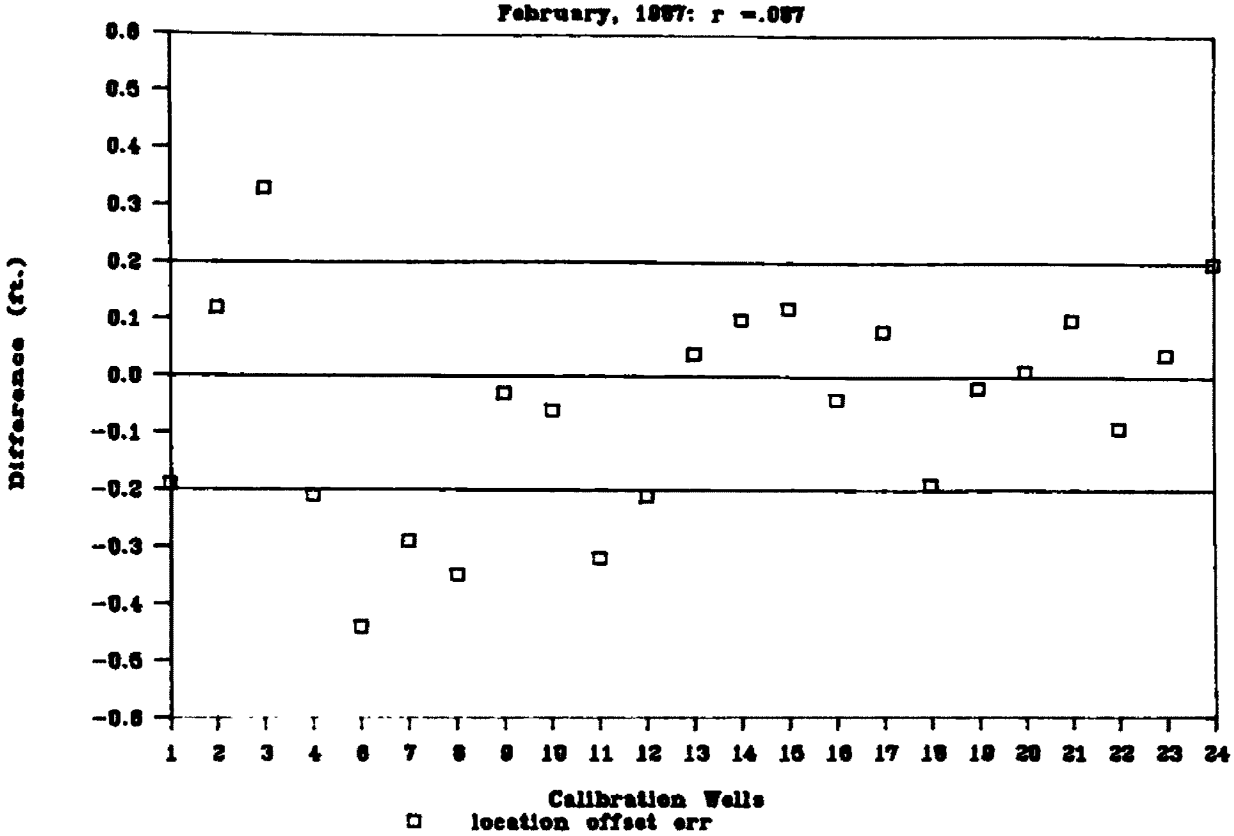
Actual vs. Simulated Head Differences

January, 1987: r =.988



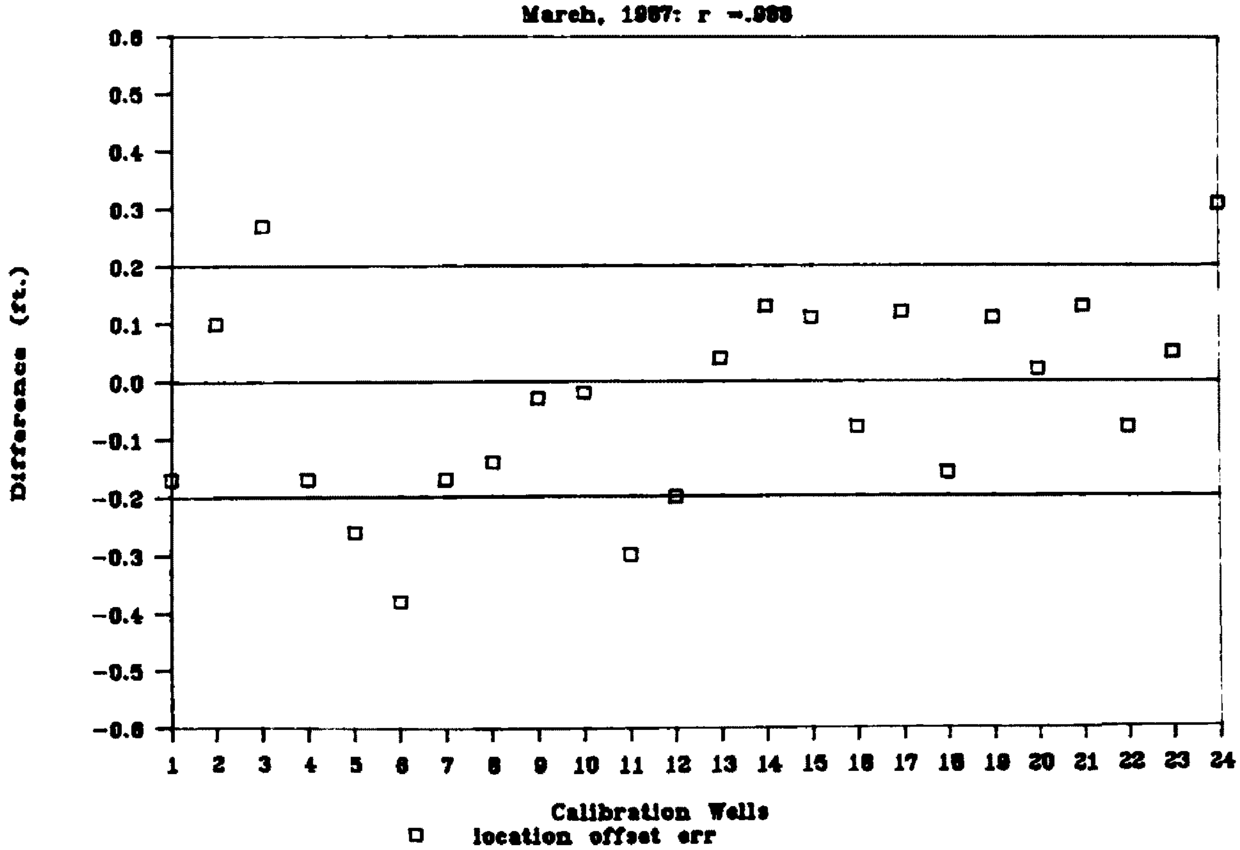
Actual vs. Simulated Head Differences

February, 1987: r =.987



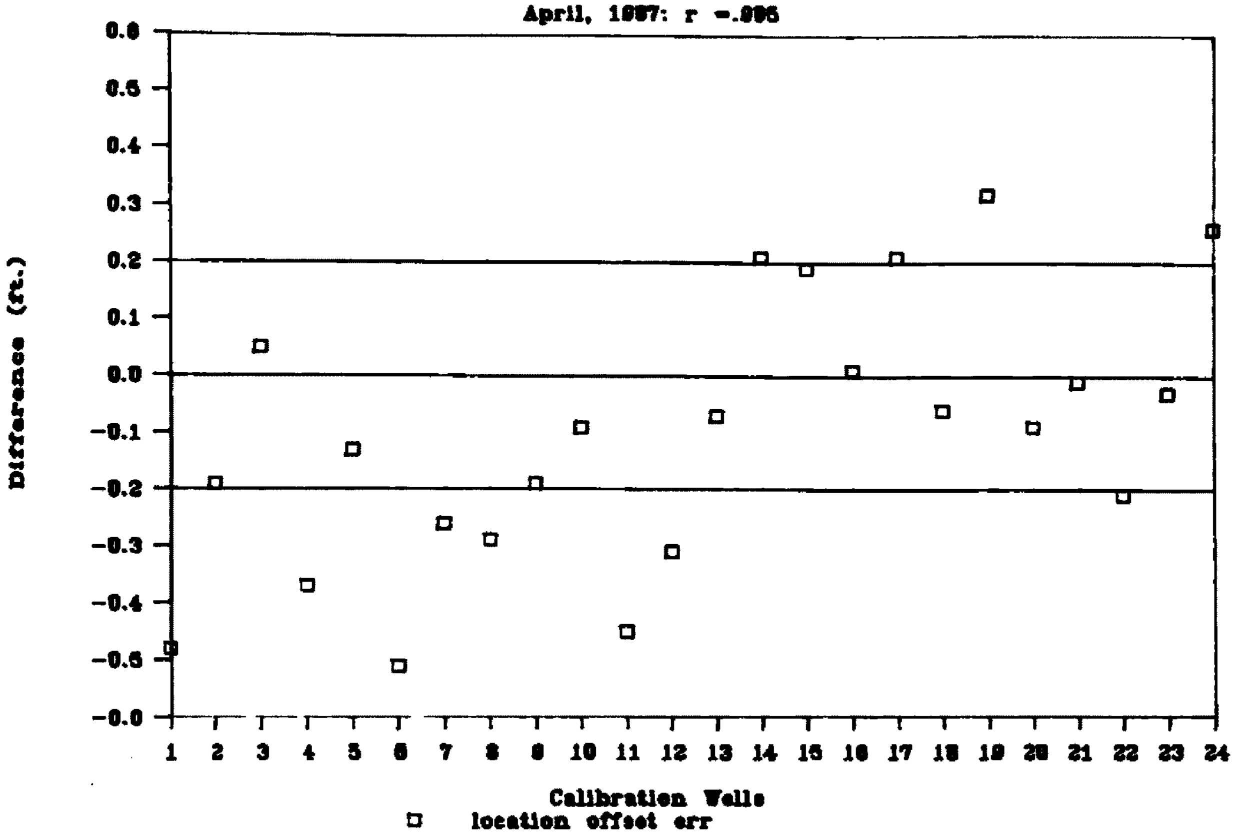
Actual vs. Simulated Head Differences

March, 1987: r =.988



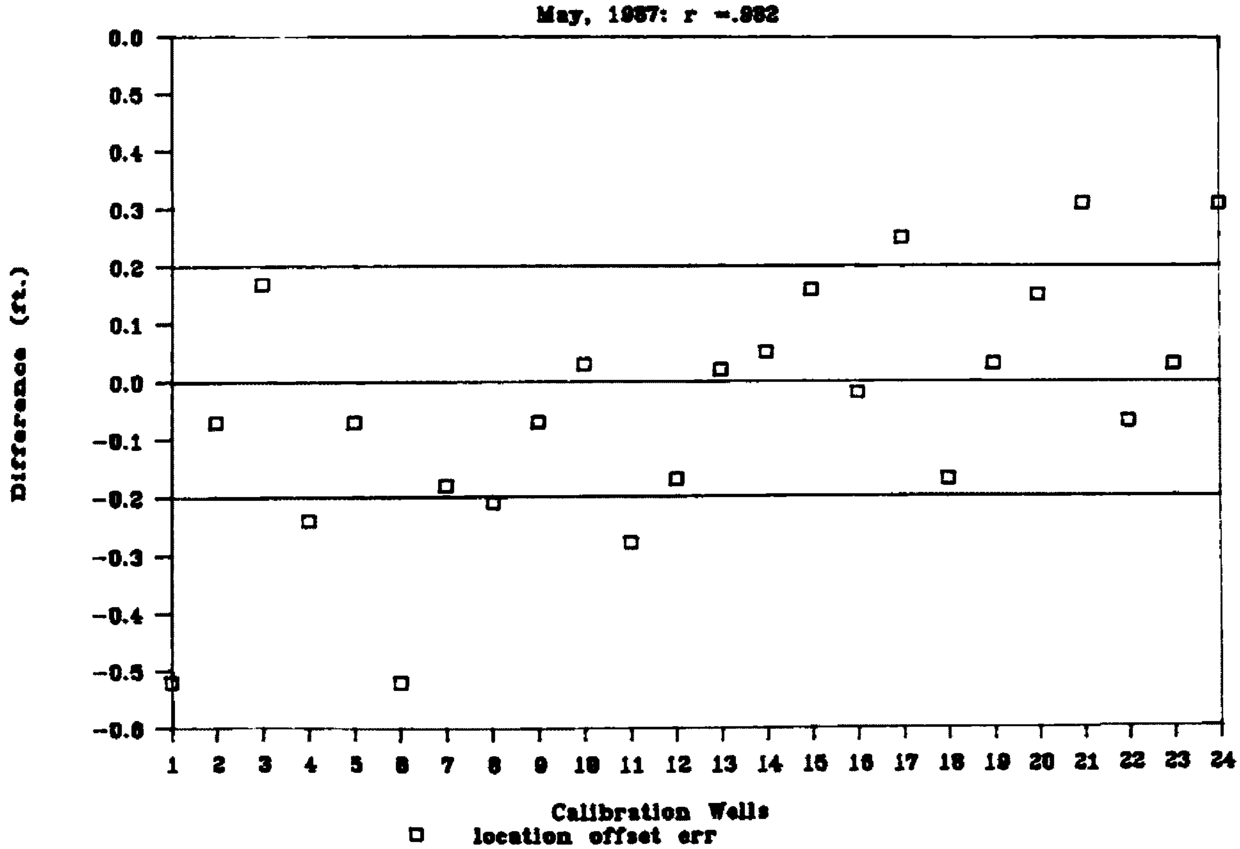
Actual vs. Simulated Head Differences

April, 1987: r =.896



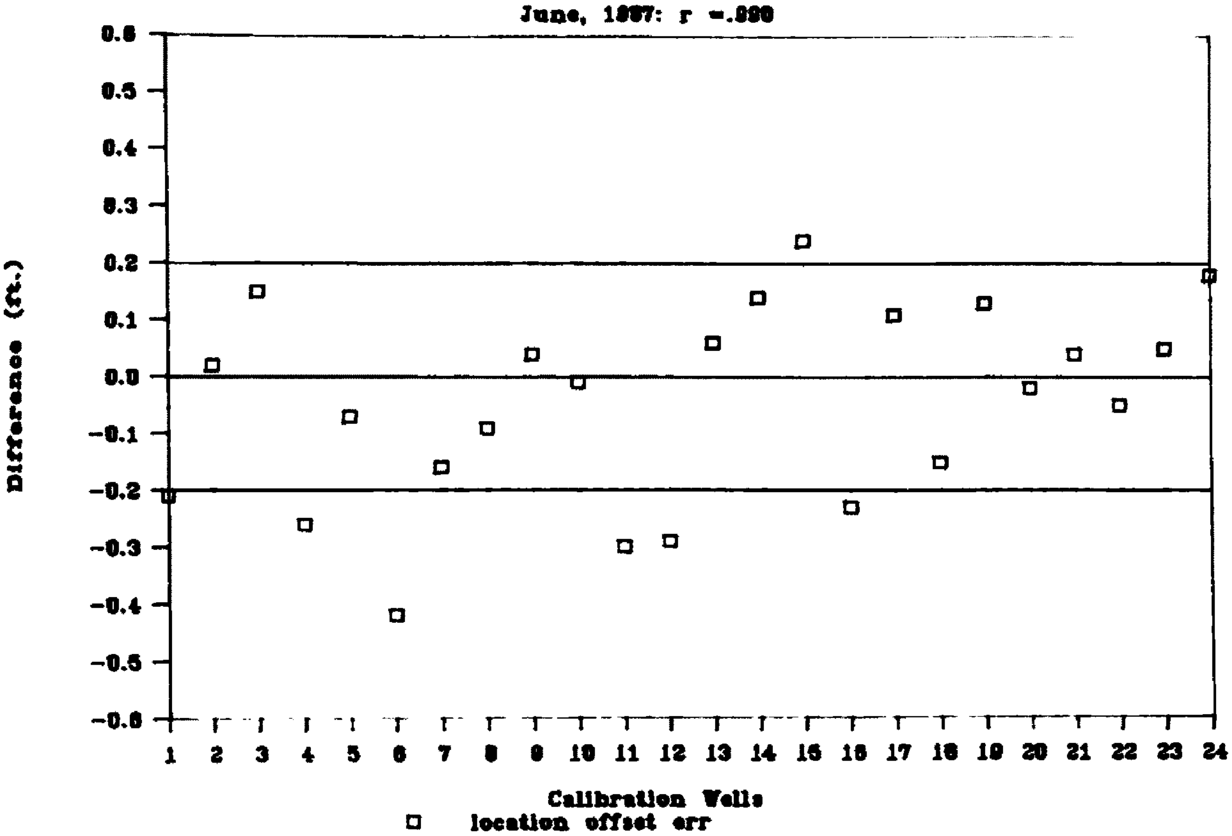
Actual vs. Simulated Head Differences

May, 1987: r =.882



Actual vs. Simulated Head Differences

June, 1997: r =.990



RANDOMWALK MOVES
MAY-AUGUST, 1985

```
\\\\\\BASIC TRANSPORT COEFFICIENTS\\\\\\

   POROSITY = .197
   LONGITUDINAL DISPERSIVITY = [illegible]
   TRANSVERSE DISPERSIVITY (FT) = [illegible]
   RETARDATION COEFFICIENT = 1
   PARTICLE MASS (LBS) = [illegible]

[illegible]


There are [illegible] sinks

Sink #        X coordinate  Y coordinate   withdrawal rate



     STARTING TIME OF SIMULATION (DAYS) = [illegible]


     \\\\\\\\\\PARTICLES\\\\\\\\\\

PARTICLES IN A CIRCLE
  CIRCLE NUMBER 1
     CIRCLE CENTER COORDINATES (I,J) = 14 , 7 GRID
     CIRCLE RADIUS = [illegible] GRID
     NUMBER OF PARTICLES = [illegible]

   TOTAL SYSTEM PARTICLES = [illegible]
```

— START OF MAY, 1985 MOVE —

```
ACCUMULATED TIME = [illegible] DAYS      PARTICLES = [illegible]
PARTICLE MAP
------------------------------
        COORDINATES ARE IN FEET
      ---------------------------------------------
 14      +   -   +   -   +   -   -   -   +   -   +
 13      -   +   +   +   +   +   -   -   +   -   -
 12      +   -   +   -   -   +   -   +   -   -   +
 11      +   +   +   -   -   +   -   -   -   +   +
 10      -   -   +   +   -   -   +   -   -   -   +
  9      -   +   +   +   +   +   +   +   -   +   +
  8      +   -   -   +   +   +   -   -   -   -   +
  7      -   -   +   -   -   -   -   -  500  +   +
  6      -   -   -   +   +   +   +   +   -   +   +
  5      -   +   -   +   -   -   -   -   -   -   +
  4      -   -   -   -   -   +   -   +   -   -   +
      ---------------------------------------------
         6   7   8   9  10  11  12  13  14  15  16
```

ACCUMULATED TIME = [illegible] DAYS PARTICLES = [illegible]
PARTICLE MAP

COORDINATES ARE IN FEET

14	+	+	+	+	+	+	+	+	+	+	+
[illegible]	+	+	+	+	+	+	+	+	+	+	+
[illegible]	+	+	+	+	+	+	+	+	+	+	+
[illegible]	+	+	+	+	+	+	+	+	+	+	+
[illegible]	+	+	+	+	+	+	+	[illegible]	+	+	+
[illegible]	+	+	+	+	+	+	[illegible]	[illegible]	[illegible]	+	+
[illegible]	+	+	+	+	+	+	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	+	+	+	+	+	+	[illegible]	[illegible]	[illegible]	[illegible]	+
[illegible]	+	+	+	+	+	+	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	+	+	+	+	+	+	+	+	+	+	+
[illegible]	+	+	+	+	+	+	+	+	+	+	+
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

END OF MAY MOVE

[illegible] TIME = [illegible] DAYS PARTICLES = [illegible]
PARTICLE MAP

COORDINATES ARE IN FEET

[illegible]	+	+	+	+	+	+	+	+	+	+	+
[illegible]	+	+	+	+	+	+	+	+	+	+	+
[illegible]	+	+	[illegible]	+	+	+	+	+	+	+	+
[illegible]	+	+	[illegible]	+	+	+	[illegible]	+	+	+	+
[illegible]	+	+	[illegible]	+	[illegible]	[illegible]	[illegible]	[illegible]	+	+	+
[illegible]	+	+	+	+	+	+	[illegible]	[illegible]	[illegible]	+	+
[illegible]	+	+	+	+	+	[illegible]	[illegible]	[illegible]	[illegible]	+	+
[illegible]	+	+	+	+	+	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	+	+	+	+	+	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	+	+	+	+	+	+	+	[illegible]	+	[illegible]	+
[illegible]	+	+	+	+	+	+	+	+	+	+	+
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

END OF JUNE MOVE

ACCUMULATED TIME = [illegible]6.49 DAYS   PARTICLES = 6[illegible]

PARTICLE MAP

COORDINATES ARE IN FEET

14	+	+	+	+	+	+	+	+	+	+	+
13	+	+	+	+	+	+	+	+	+	+	+
12	+	+	+	+	+	+	1	+	+	+	+
11	3	4	10	2	7	2	3	+	1	+	+
10	2	11	1	[illegible]	[illegible]	6	32	41	1	+	+
9	+	+	1	1	+	+	11	48	4	+	+
8	+	+	1	1	+	2	12	63	17	+	+
7	+	+	+	+	2	1	9	67	32	2	4
6	+	+	+	+	1	+	+	47	70	11	3
5	+	+	+	+	+	+	+	2	10	+	1
4	+	+	+	+	+	+	+	+	+	+	+
	6	7	8	9	10	11	12	13	14	15	16

END OF JULY MOVE

PARTICLE MAP

COORDINATES ARE IN FEET

14	+		1	+	+	+	+	+	+	+	+
13	+		+	+	+	1	+	1	+	+	+
12				+	+	1	+	[illegible]	+	+	+
11		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	+	
10				[illegible]	+	[illegible]	[illegible]	[illegible]	+	+	+
9			+	+	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	+
8	+		[illegible]		+	+	[illegible]	[illegible]	[illegible]	+	[illegible]
7			+	[illegible]	[illegible]	+	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	+	+	+	[illegible]	+	+	[illegible]	[illegible]	[illegible]	[illegible]	+
5	[illegible]		[illegible]	[illegible]	+	+	+	+	[illegible]	[illegible]	[illegible]
4	+	+	+	+	+	+	+	+	+	+	+
	6	7	8	9	10	11	12	13	14	15	16

END OF AUGUST MOVE

APPENDIX D

Bacterial Oxidation of Hydrocarbons

Bacterial Oxidation of Hydrocarbons

The subsurface environment is host to wide variety of microbial flora, of which bacteria play the most important role (Freeze and Cherry, 1979). Many of the important redox reactions in ground water are catalyzed by bacterial enzymes which interact with molecular structures of redox reactions between the reactants and products, and lower the activation energies of the reactions. Bacteria require energy in order to build new cell mass and maintain cellular functions. The main source of this energy is the oxidation of organic matter (Freeze and Cherry, 1979).

Gasoline is a mixture of alkanes, cycloalkanes, and aromatics, as well as compounds containing halogens and other functional groups (Bruell and Hoag, 1984; and Suflita, 1985). The oxidation of these hydrocarbons provides carbon and energy to bacteria, which allows them to sustain their growth and maintenance processes. These bacterial processes ultimately result in the detoxification of the organic contaminant by forming CO_2 and H_2O (Brown et al., 1985).

All hydrocarbons have similar oxidation pathways. This is particularly true for the aromatics, such as benzene, toluene, and phenol, whose pathways eventually merge and follow a common route to complete oxidation (Marr and Stone, 1960). Alkane metabolism is a common biological process that begins with the oxidation of a terminal methyl group forming a fatty acid. In the metabolism of fatty acids, the carboxylic acid functional group is first converted to a thioester by reaction with coenzyme A. Subsequent reactions involve beta oxidation of the fatty acid and cleavage with the formation of acetylcoenzyme A. The new fatty acid with the shorter alkane chain is recycled through the fatty acid cycle. The acetylcoenzyme A molecules, in turn, are converted to CO_2 and H_2O through the citric acid cycle.

Oxidation pathways for hydrocarbons may be reviewed in Gibson et al. (1968); Marr and Stone (1960); Suflita (1985); and Fessenden and Fessenden (1986). Based on these reviews, I have presented a synthesis of the possible oxidation pathways for benzene, toluene, xylene, phenols, and alkanes in Figure 17A-D.

The initial step in the oxidation of hydrocarbon molecules by bacteria is the cleavage of a carbon-hydrogen bond. This process, which requires molecular oxygen (O_2), is difficult to initiate in subsurface environments (Brown et al., 1985; Fessenden, 1988; and Shelton, 1988). Only a few bacterial species are able to initiate a C-H cleavage. The majority of these bacteria are found in the genus Pseudomonas (P. aeruginosa, P. sepacia, P. putida, and P. fluorescens). Certain Mycobacterium and Arthrobacter species may also be able to oxidize C-H bonds (Marr and Stone, 1961; and Shelton, 1988). After cleavage of a C-H bond, additional oxidation pathways are available because a larger variety of bacteria are able to react with the C-O bonds (Shelton, 1988).

The rate at which the redox reactions proceed depends upon the availability of nutrients (oxygen, nitrogen, phosphorous, sulfur, and trace elements) in the subsurface environment and upon the physiology of the bacteria (Suflita, 1985). If the concentration of molecular oxygen should diminish so that the environment becomes reducing, oxidation of the organic matter will continue, but only by those bacterial species capable of reducing metallic oxides. Reactions involving the reduction of metal oxides are shown below (Freeze and Cherry, 1979).

$$(CH_2O)_x + 2\ MnO_2(s) + 3\ H^+ = 2\ Mn^{2+} + HCO_3^- + 2\ H_2O$$

Manganese(VII) Reduction

$$(CH_2O)_x + 4\ Fe(OH)_3(s) + 7\ H^+ = 4\ Fe^{2+} + HCO_3^- + 10\ H_2O$$

Iron(III) Reduction

$(CH_2O)_x$ = simple carbohydrate (s) = solid

These oxidation-reduction reactions result in reduced, more soluble metal complexes. The hydrocarbons, in turn, are oxidized to CO_2 and H_2O. An increase in the bacterial population of both hydrocarbon degraders and nondegraders will also be observed (Alexander, 1981; and Brubaker and Crokett, 1986).

Bacterial samples taken from monitoring wells on Champion property show an increase in bacterial population from November, 1986 to May, 1987, which corresponds to an increase in total BTX contamination across the site (Table 3). Bacterial identification of isolates from ground water samples (Appendix B) are inconclusive beyond the genus level, but there appear to be species of Micrococcus and Enterococcus capable of utilizing hydrocarbons as a food source.

The population increase of both degraders and non-degraders supports my belief that oxidation of the gasoline is taking place. I am skeptical of the increased bacterial populations in May that show up in the deep wells (> 55 ft. (>17 m)), 3002-D and 3004-D, because these wells do not appear to have a food source as is found in their shallower counterparts. It was suggested that the elevated populations in the deeper wells are a result of bacterial contamination from the shallower zones, along the well casing, but water quality differences between the shallow and deep wells do not support this suggestion.

Redox reactions that consume organic matter proceed through a series of five processes as conditions become increasingly anaerobic: denitrification, manganese reduction, iron reduction, sulfate reduction, and finally methane fermentation. Figure 14 shows high levels of dissolved manganese and iron in wells 3002-S, 3003-S, 1020-S, and 1018. I believe that these high levels indicate that the second and third redox processes are taking place across the Champion site, and that reducing conditions diminish across the site until California Street. Beyond California Street, aerobic oxidation conditions dominate and dissolved metal levels return to background levels.

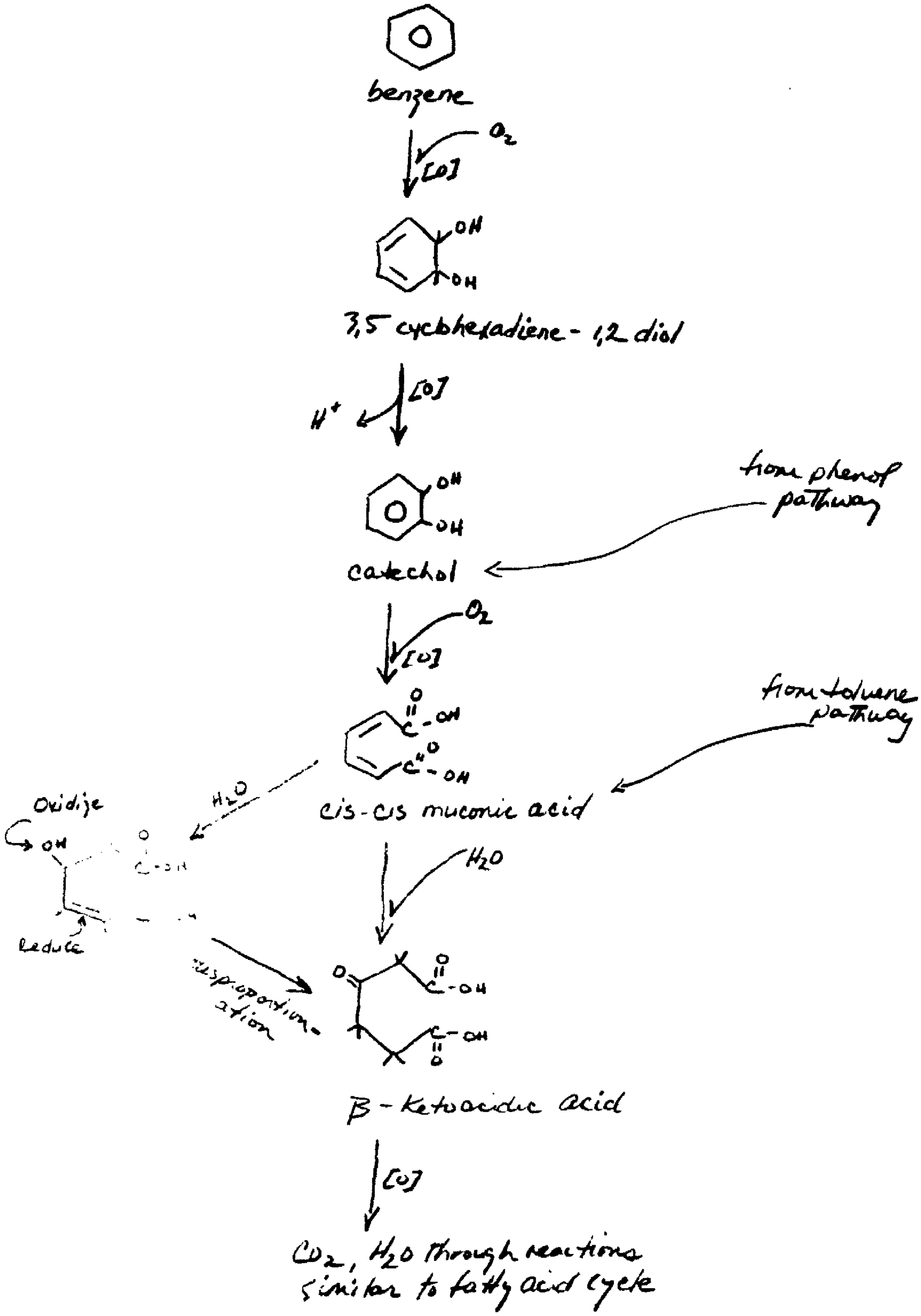


Figure 17A: Oxidation pathways of benzene.

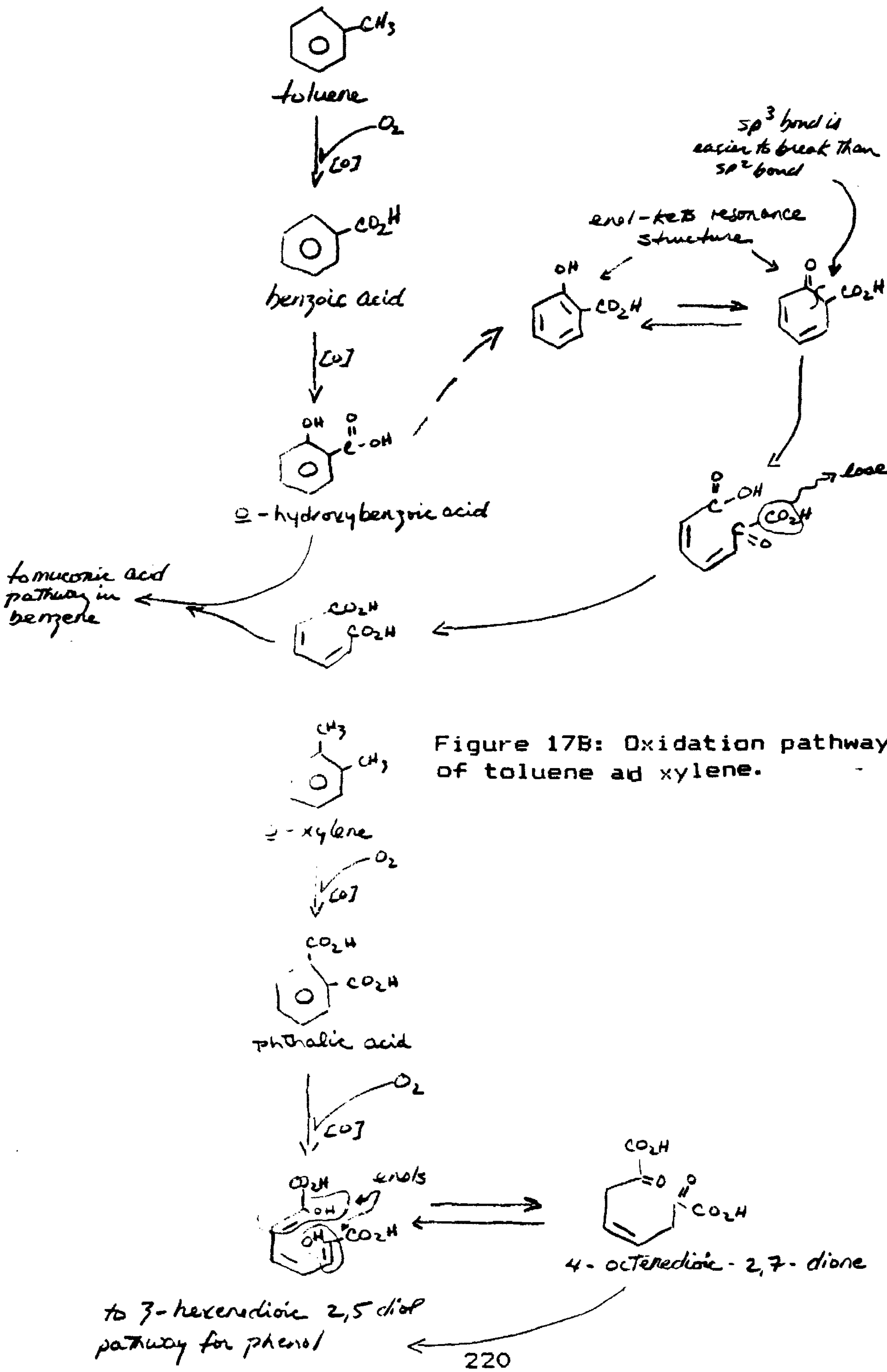


Figure 17B: Oxidation pathways of toluene ad xylene.

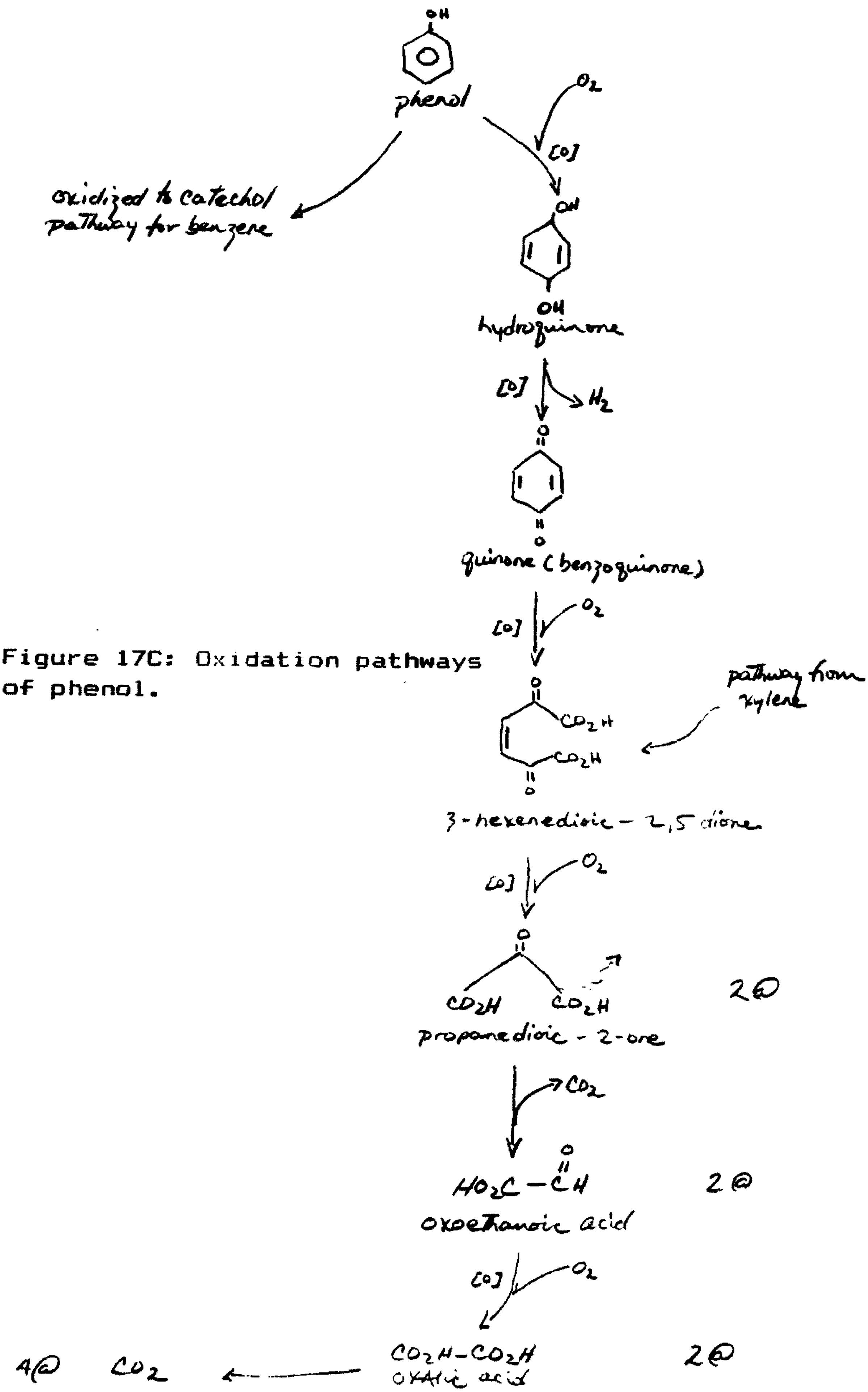


Figure 17C: Oxidation pathways of phenol.

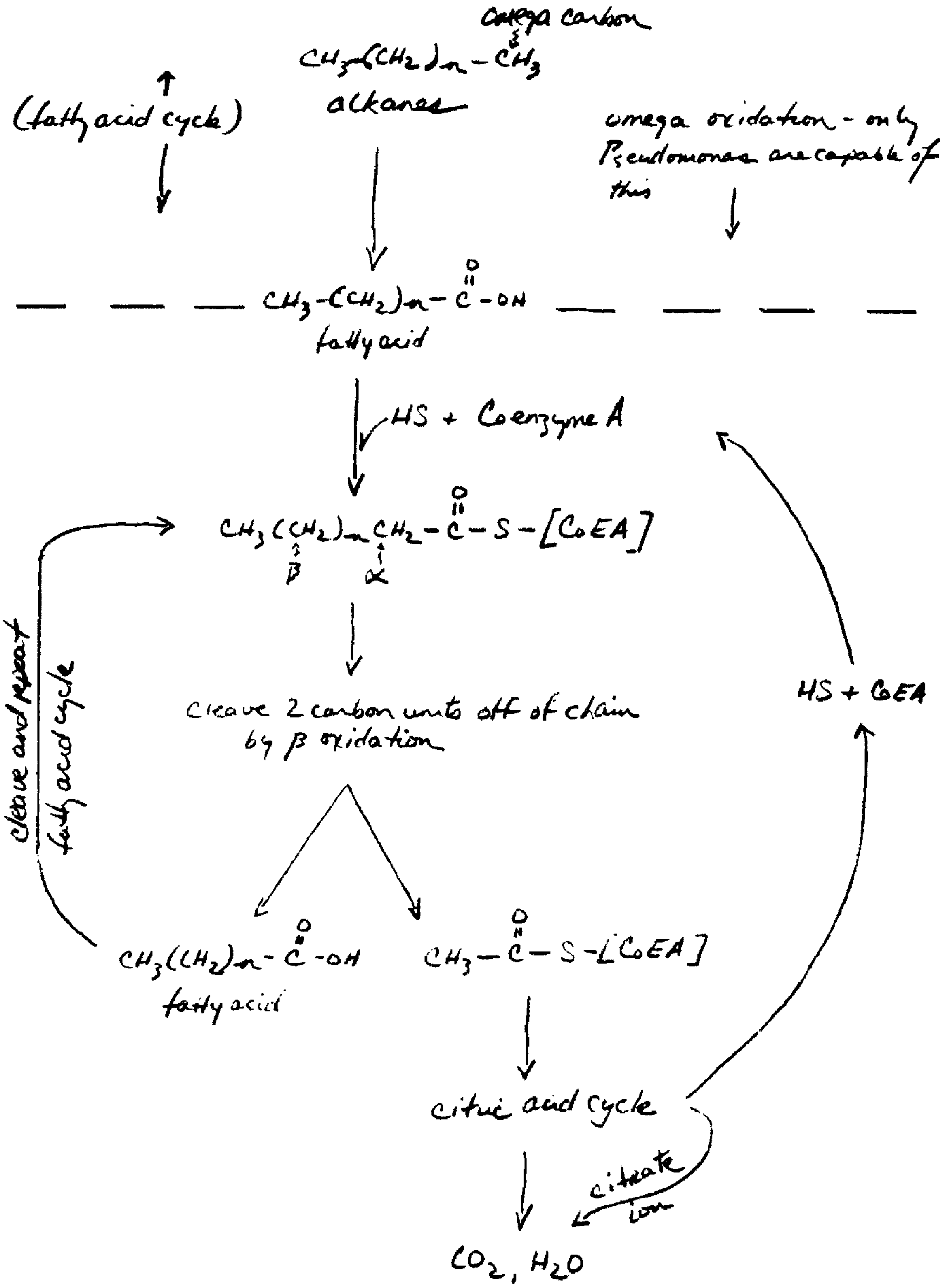


Figure 17D: Oxidation pathways of alkanes.