A REGIONAL MODEL OF A HIGH PLAINS
AQUIFER, NORTH-CENTRAL MEXICO

By

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A REGIONAL MODEL OF A HIGH PLAINS AQUIFER, NORTH-CENTRAL MEXICO

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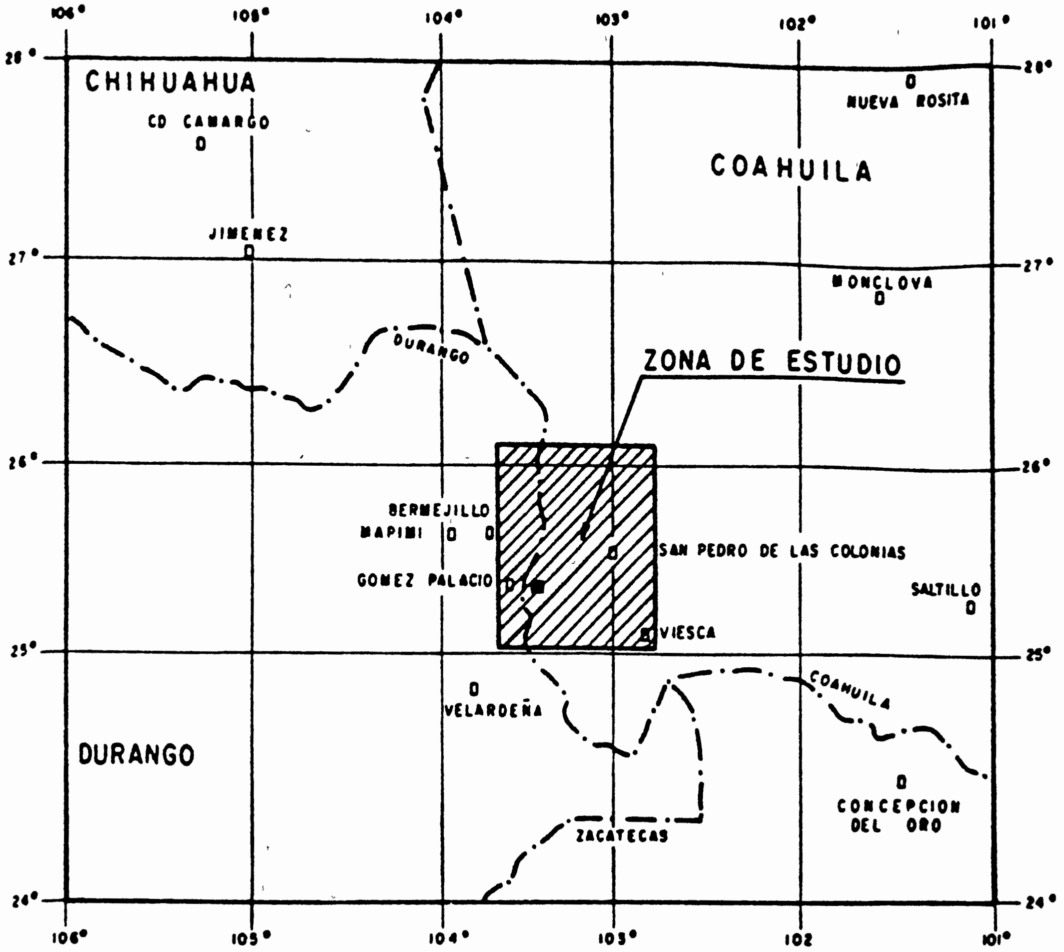
CHAPTER I

INTRODUCTION

General Overview

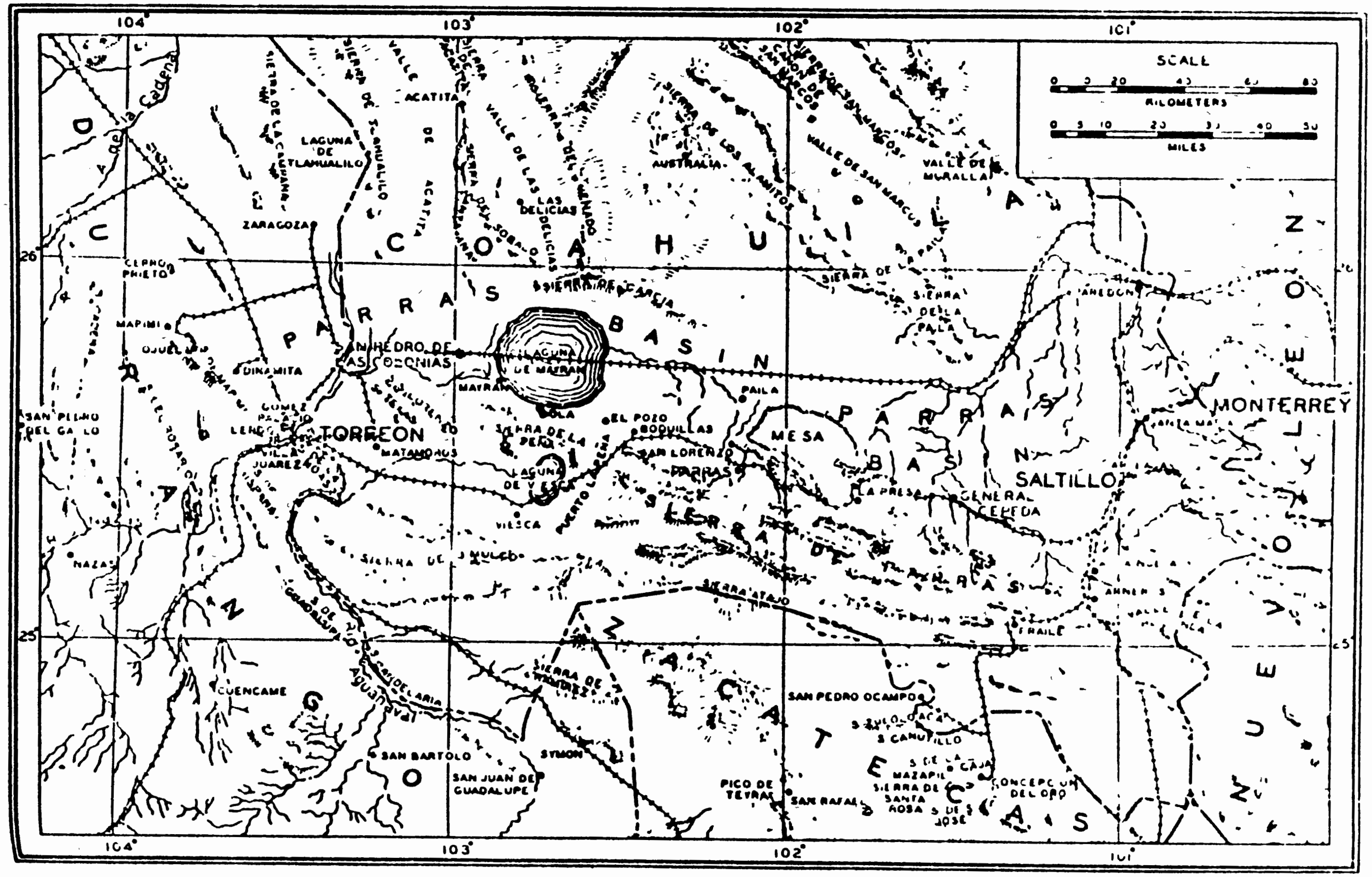
The Laguna (Desierto) de Mayran, also known as the Lagunera, is a structural basin situated in the states of Coahuila and Durango in the north-central high plains (Altiplano) of Mexico between 25 and 26 degrees north latitude and 101 to 104 degrees west longitude (Fig. 1). The study area (Fig. 2), a subset of the Parras Basin, lies in the western third of that region. The area is characterized by few high-density population centers, including Gomez Palacio, Lerdo, Matamoros, Tlahualilo de Zaragoza, and Torreon. Elsewhere the population is dispersed throughout a number of small farms, villages, towns, or "ejidos", which is a form of agricultural cooperative community (Cole, 1970).

Lagunera, which is located in Irrigation District Number 17 (Yates, 1981), is extensively irrigated by both ground water and surface water. In the subsurface the basin can be envisioned as a bathtub that, for all practical purposes, forms an isolated system. Ground water is derived from wells that range from about 250 to 1200 feet (80 to 400 meters) in depth. The water levels in



SOURCE: S.A.R.H., 1980, Nota Informativa: 8 p.

Figure 1. General Location of Study Area



SOURCE: Jones, 1938, Geol. Soc. Am. Bull., v.49, p. 72

Figure 2. Detailed Location of Study Area

these wells in the irrigated regions lie from 300 to 400 feet (90 to 120 meters) below land surface. Pumping greatly exceeds ground-water recharge and, as a result, water levels have been declining 3 to 10 feet (1 to 3 meters) per year since at least 1977.

Surface water used for irrigation is obtained from the Nazas and Aguanaval rivers, both of which enter the basin from the southwest. The Rio Aquanaval exits to the east, while the Rio Nazas, now largely controlled, formerly flowed out into the basin to a playa lake. Rio Nazas is controlled upstream by the Francisco Zarco dam, which is located about 60 kilometers southwest of Torreon. This river is the primary source of irrigation water for the approximately 222,390 acre (90,000 hectare) watershed (Secretaria de Recursos Hidraulicos, 1976).

Extensive irrigation in this area has made it possible to grow such crops as alfalfa, cotton, oilseeds, and wheat. These crops, which normally require much more water than otherwise could be obtained in a desert region, could not be raised were it not for the vast irrigation network instituted by the Mexican government.

Statement of the Problem

The study area receives an average of only 12.6 inches (32 centimeters) of precipitation per year (S.A.R.H, 1984). Only an exceedingly small fraction of the precipitation reaches the water table, which, in places, is deeper than

300 feet (90 meters) below land surface.

Although an extensive network of irrigation canals crosses the nearly flat lake plain in the vicinity of Torreon, the interconnected canals are lined with concrete to prevent leakage. Therefore, during the irrigation season the water-filled canals cannot be considered as a source of ground-water recharge to the underlying aquifer (Pettyjohn, 1987). The longevity of the ground-water system is placed further in jeopardy by the illegal, uncontrolled drilling of private water wells, which are used for both irrigation and domestic needs.

In addition to the ever-increasing exploitation of ground water for irrigation, population centers are also increasing at an exceedingly rapid pace, both in size and water demand. In fact, some well fields have been pumped so extensively that subsidence of the ground in the immediate vicinity of a few sites is evident (Pettyjohn, 1986).

Aggravating the current water crisis in the Lagunera region is the problem of ground-water quality. Chemical analyses of well water samples obtained in the vicinity of Tlahualilo indicate unacceptable levels of dissolved solids and naturally occurring arsenic (S.A.R.H., 1980). Throughout much of the Lagunera region the concentration of arsenic is of such a magnitude that the water cannot be used for any purpose, and the construction of wells in these areas is prohibited.

Purpose

The purpose of this study is to define, as accurately as the data allow, the present and near-future ground-water availability in the Lagunera region, and in so doing to predict to some degree the future of the regional water balance with respect to increasing stresses brought about by factors unique to the region. Factors affecting the Lagunera include: (1) minimal ground water recharge by infiltration from surface sources, (2) an arid climate, (3) lack of accurate data defining the rate of water-level decline, well discharge rates, and recharge to subsurface waters, and (4) a deterioration in water quality as a result of excess pumpage, which has increased concentrations of arsenic and dissolved solids.

Objectives

The objectives of this investigation include the formulation of (1) as complete a characterization of the distribution of intrabasinal lithologies as data allow, (2) the hydrologic nature of the basin fill, (3) a determination of regional recharge and discharge, and (4) computer simulations to predict future water-level trends and movement of the arsenic front.

Methods of Investigation

This investigation is based on data provided by the S.A.R.H., Lagunera Region, Mexico. Data include incomplete chemical analyses of waters derived from domestic and irrigation wells, driller's logs, and a water-level map. In some instances driller's logs were supplemented by electric logs.

Driller's logs made possible an evaluation of both the subsurface geologic and hydrogeologic nature of the basin. Using these data, maps were constructed of the basin geometry, lithologies, and aquifer characteristics. These data also permitted the construction of geologic cross-sections which served as aids in determining basin geometry.

Chemical data were used to map the distribution and magnitude of important chemical ground-water constituents. Water analyses for the study area and the region are in Appendix A.

Computer simulations of the aquifer were conducted using the Prickett Lonnquist Aquifer Simulation Model (PLASM) developed by T.A. Prickett and C.G. Lonnquist (1971). The model was calibrated using 1977 and 1980 water levels as known endpoints of a three-year continuum. Following calibration of the model, simulations of future water-level behavior were conducted using hypothetical water budgets.

Previous Investigations

The earliest investigations of the Parras Basin were conducted by Hill (1891, 1893, 1923) during the course of his study of the Cretaceous of Texas and northern Mexico. Bose (1906, 1913) studied the Permian stratigraphy of the region and published a general stratigraphic section of the Permian strata west of the Noria de Malascachas. Further research was conducted by Kellum, Imlay, and Kane (1936) as part of their research of the Coahuila Peninsula. During the course of their field work they established the general stratigraphy and structure of the Sierra de Tlahualilo range. It was during this investigation that Imlay first assigned the term "Difunta" to the Permian strata previously described by Bose.

Correlation of the upper member of the Lower Cretaceous Aurora Limestone, which is found in the Ojo de Agua area of the Sierra de Tlahuila range, with that of the Washita Group of Texas was based on biostratigraphic work by King (1944). Additional study of the Difunta Group of the Parras Basin was carried out by Murray and others (1962).

Hydrogeologic investigations of the basin have been made by the S.A.R.H., Office of the Secretary of the Laguna Region, the Department of Statistics and Economic Studies (a branch of the General Department of Irrigation Districts), and the Department for Investigation, Development, and Agricultural Health of the Laguna Region (S.A.R.H., 1980). Estimates of the rate of ground-water withdrawal during the agricultural seasons 1977-78 and 1978-79 vary substantially among these agencies.

Estimates of withdrawals during this period range from 12,345 to 43,573 million cubic feet (350 to 1,234 million cubic meters) with the upper range given by the S.A.R.H. considered to be the most accurate. This same study also states that recharge represents only 25 percent of the pumped water. The remaining 75 percent is thought to come from aquifer storage.

CHAPTER II

REGIONAL GEOGRAPHY AND GEOLOGY

Geography

Surface Waters

The Parras drainage basin is supplied by two water courses, the Nazas and Aguanaval rivers. These rivers enter the basin at its southwestern border, flow northeast to the east-west basinal axis and then take an easterly path down-gradient (Fig. 3). Specifically, the Rio Nazas enters the Parras Basin near the city of Lerdo, flows northeastward through Gomez Palacio and Torreon, which lie to the west of the Sierra de San Lorenzo mountains, and continues to the municipality of Sacramento. Upon reaching Sacramento, the Rio Nazas assumes an easterly course, which leads to the north of the San Lorenzo mountains and finally to the Laguna (desierto) de Mayran, a dry lake bed. Owing to control structures, only during unusual periods of extremely heavy rain does the Rio Nazas contain water below the main control structure at Gomez Palacio.

The Rio Aguanaval enters the Parras Basin south of Lerdo, near the city of Nazareno, and then flows northeastward between the cities of Matamoros and Gileta before

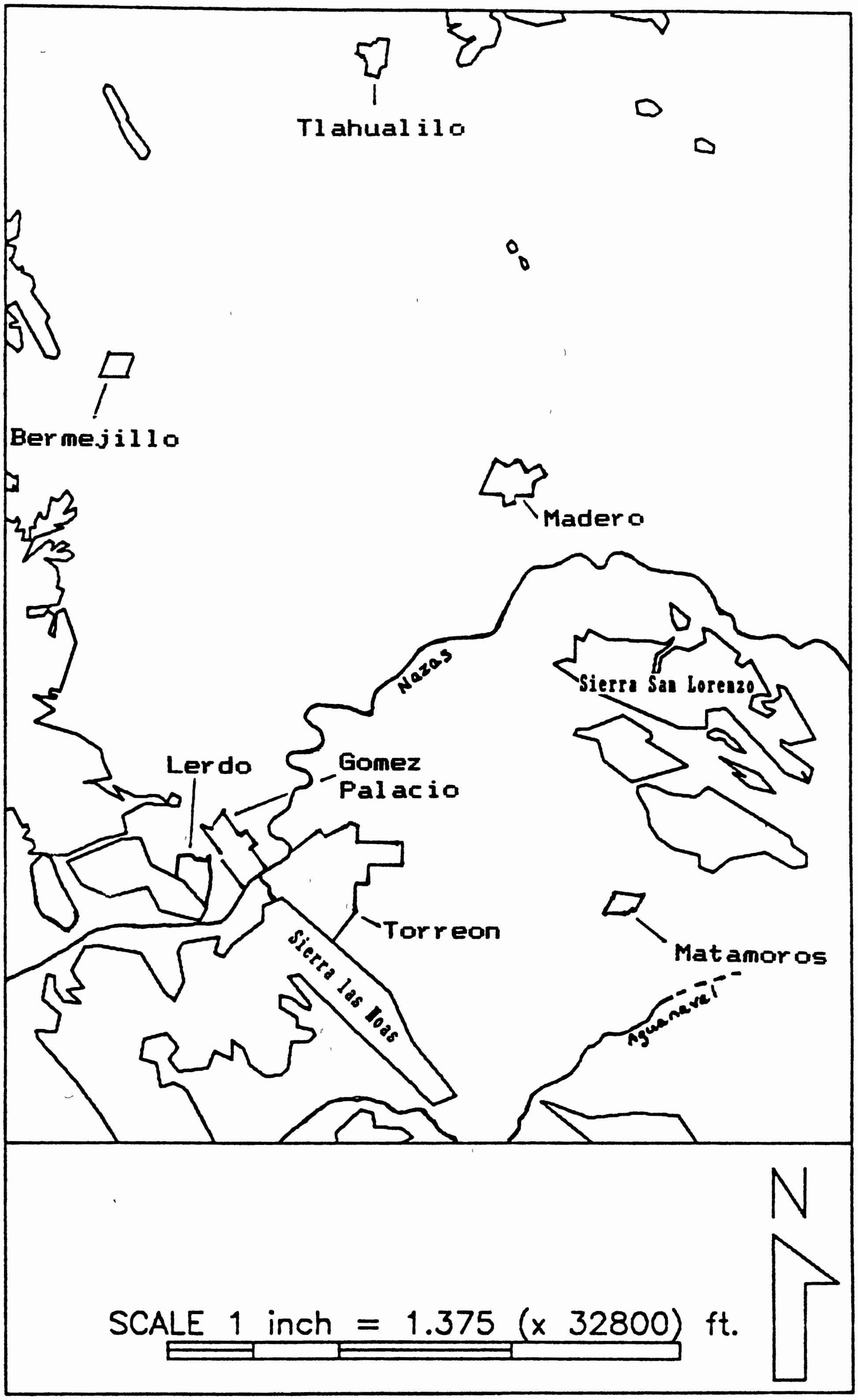


Figure 3. Geography of Study Area

turning east. It then meanders some 25 miles (40 kilometers) before entering the Laguna de Viesca. Laguna de Viesca is separated from the northern Laguna de Mayran by the Sierra de la Pena mountains.

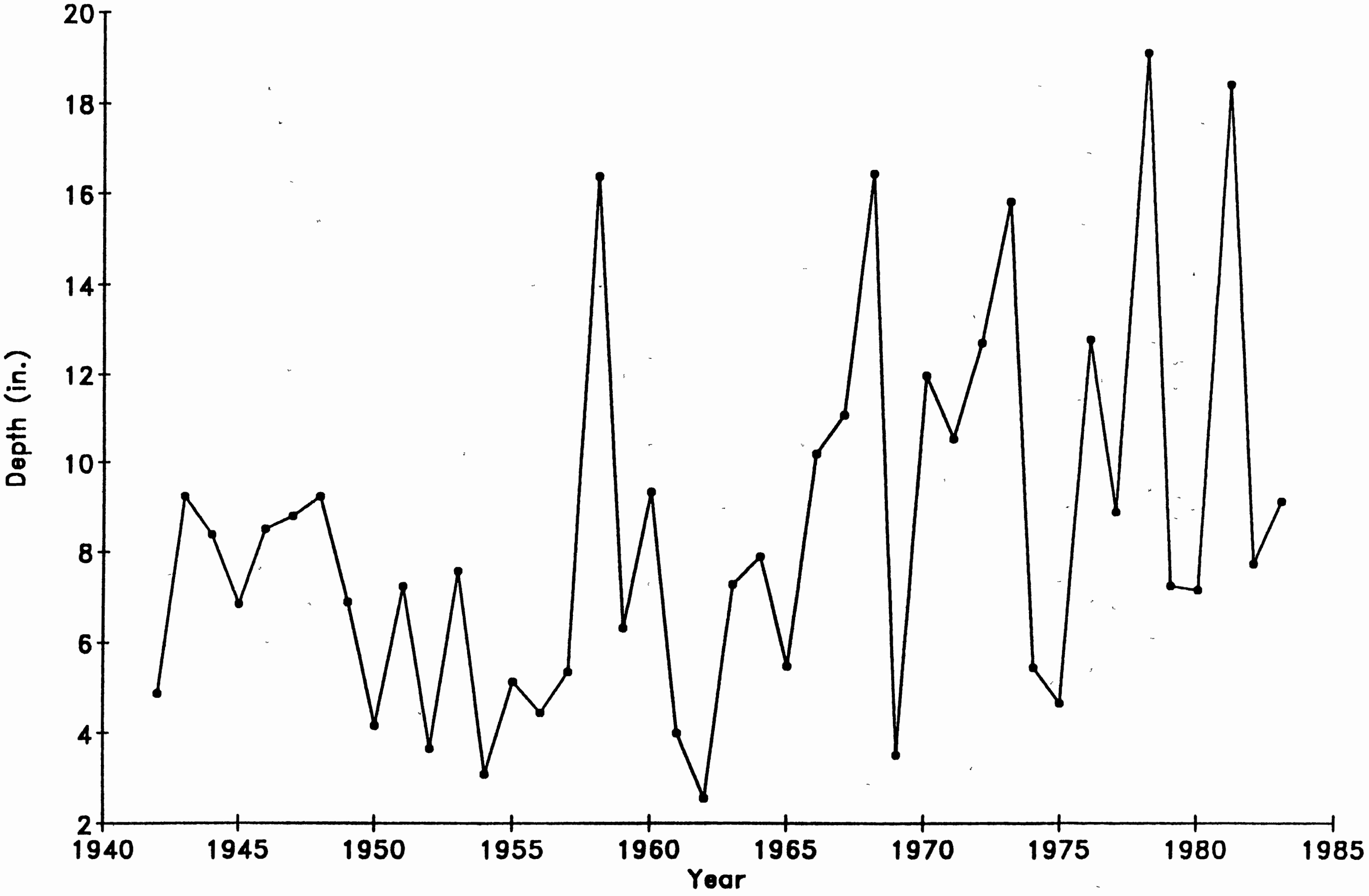
The northerly sloping topography upon which both rivers flow before turning east has a gradient of approximately 5.7 feet per mile (1.1 meters per kilometer), or a slope of 0.1 percent. The streams flow eastward on a gradient of 2.1 feet per mile (0.4 meters per kilometer), or a slope of 0.04 percent.

Climate

The climate in the study area is arid to semi-arid. Rainfall data recorded in Torreon over a 43-year period ending in December, 1983, indicate a mean annual precipitation of 8.7 inches per year (221 millimeters per year). These data are depicted graphically in Figure 4.

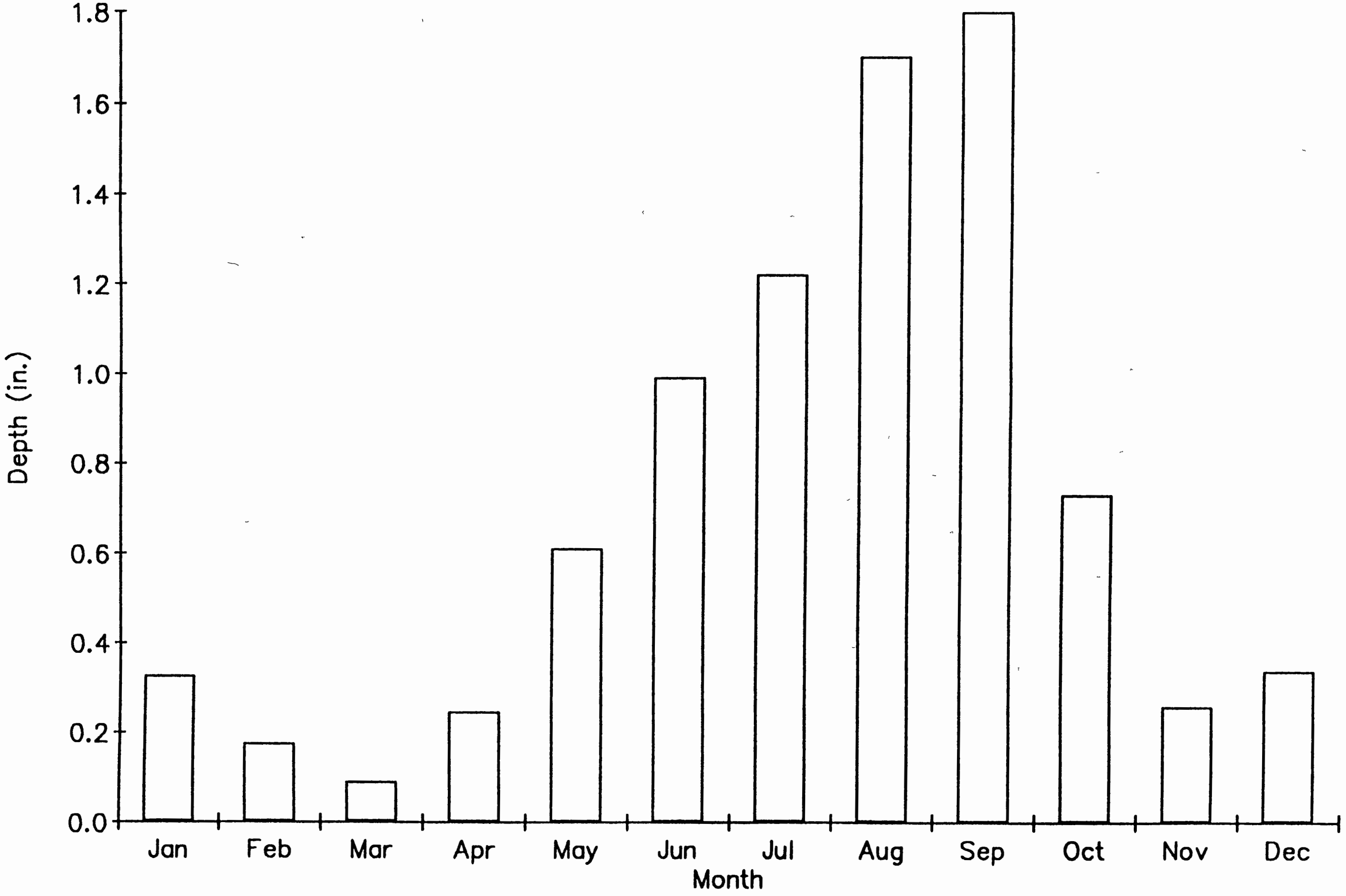
Approximately 83 percent of the annual precipitation occurs between May and October. Figure 5 illustrates the depths of mean monthly precipitation for the Torreon area for the same 43-year period. Additional data from nine other regional stations aid in delineating mean annual and mean monthly precipitation trends (Figs. 6 and 7). On a regional basis major precipitation events occur during the same time frame as in Torreon, while differing only in magnitude.

The mean annual temperature for Torreon for the period



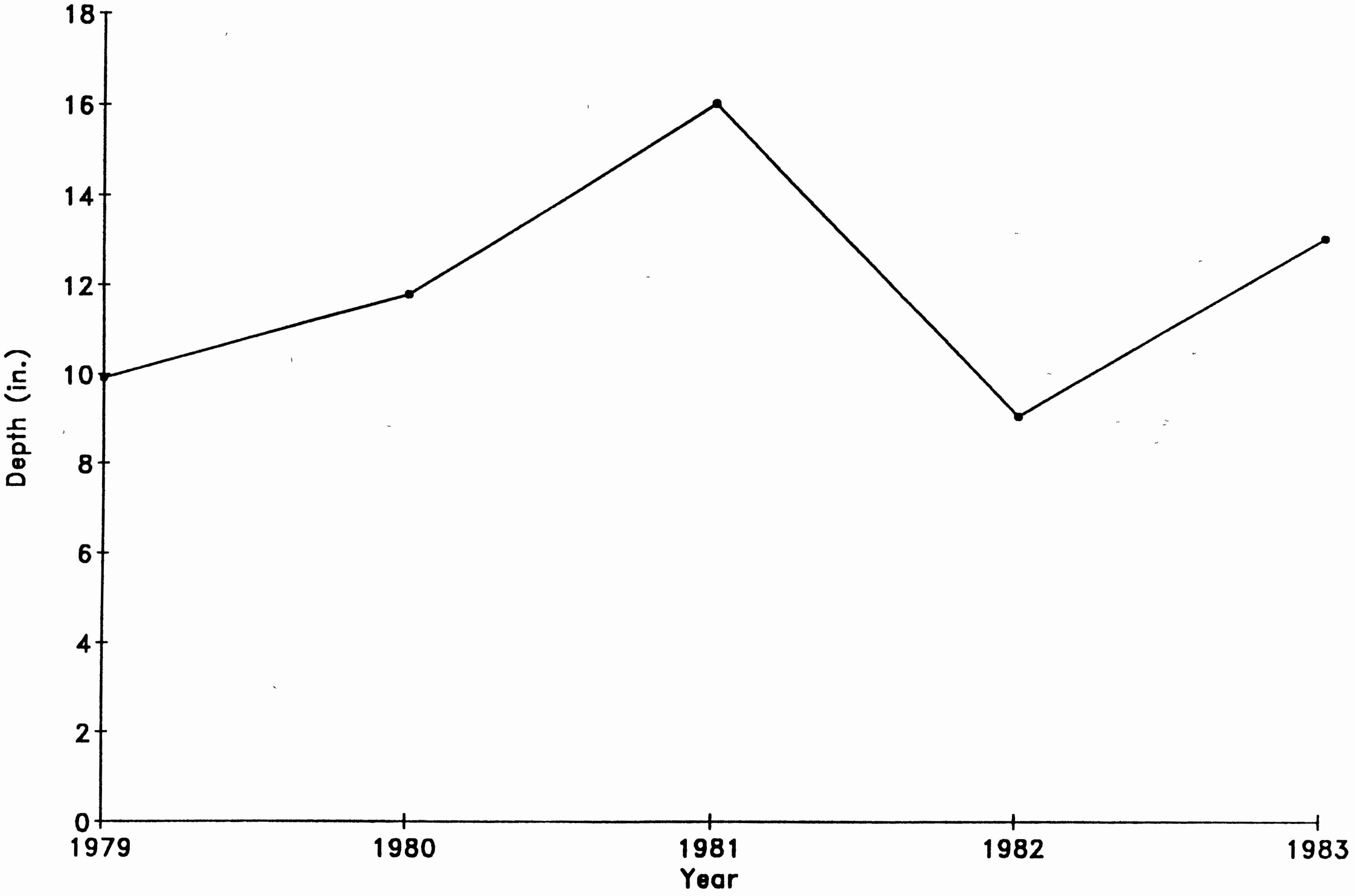
Data: S.A.R.H

Figure 4. Mean Annual Precipitation for Torreon



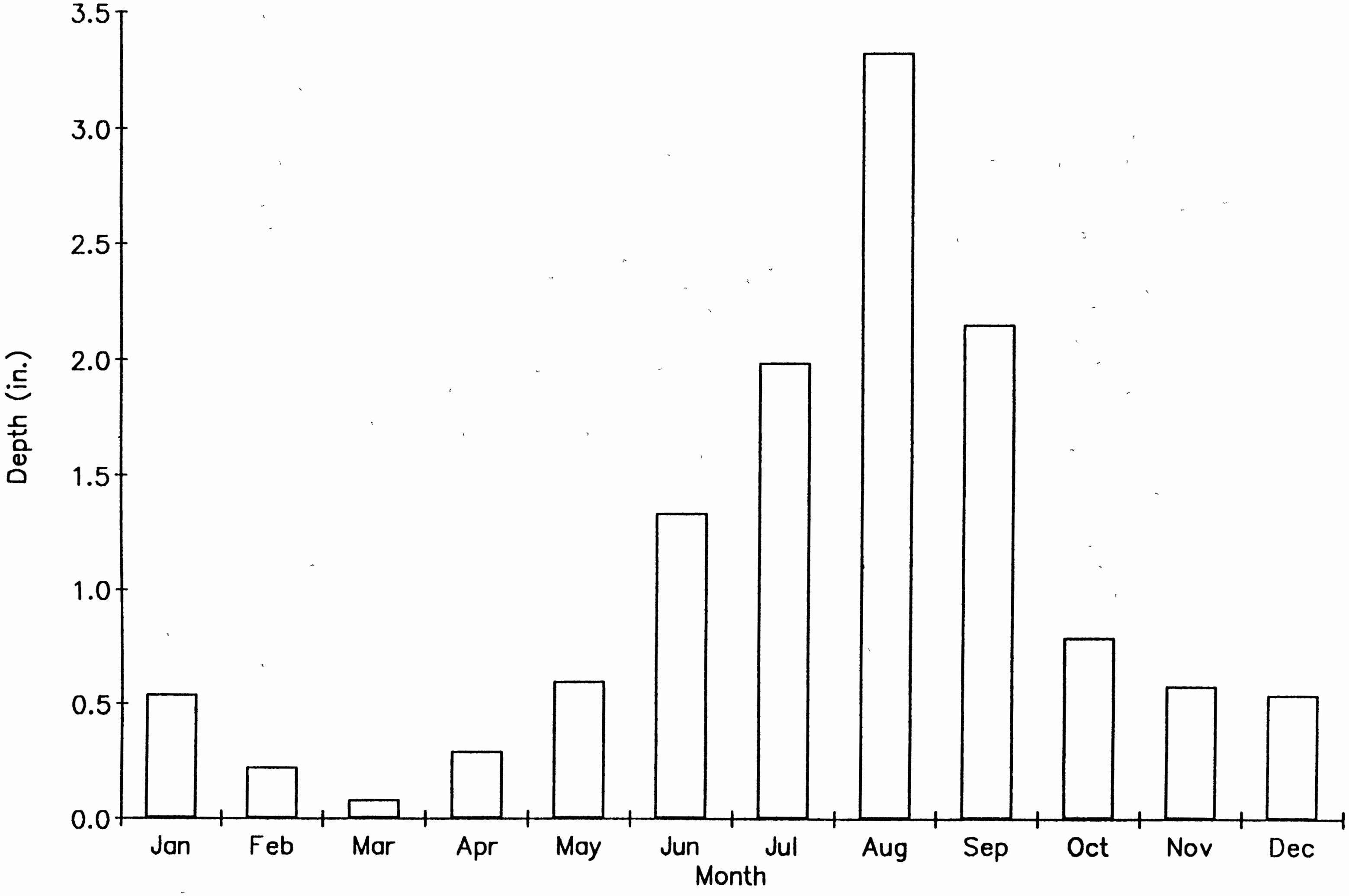
Data: S.A.R.H.

Figure 5. Mean Monthly Precipitation for Torreon



Data: S.A.R.H.

Figure 6. Regional Mean Annual Precipitation



Data: S.A.R.H.

Figure 7. Regional Mean Monthly Precipitation

1982-83 has been reported as 71.4 degrees F (21.9 degrees C) with a minimum of 57.1 degrees F (13.95 degrees C) and a maximum of 86 degrees F (30 degrees C). Prevailing winds are reported to be northeasterly at five miles per hour (1.8 meters per second) (Instituto Nacional de Estadistica Geografia e Informatica, 1985).

Regional Geology

The Parras Basin is surrounded by mountains that are composed of limestones and clastics ranging from Tithonian (Jurassic) to Cenomanian (Late Cretaceous). Resembling islands, isolated mountains of Cretaceous limestones and clastics rise from the valley floor north (Sierra de San Lorenzo) and east (Sierra de la Pena) of Matamoros.

The relief of the mountains surrounding the study area averages approximately 1900 feet (600 meters) above the valley floor. The Cretaceous limestones and clastics generally do not extend more than 640 feet (200 meters) above the valley floor.

Lower Tertiary intrusives, consisting of granite and granodiorite, are exposed near the village of Dinamite, which lies on the northeast flank of the Sierra de Mapimi mountains. These mountains are approximately 17 miles (27 kilometers) northwest of Torreon and Gomez Palacio. Middle Tertiary volcanics (rhyolite, andesite, basalt flows, and tuffs) form small, isolated mountains that rise from the valley floor in the northern half of the study area. Most are located approximately equidistant north, east, and west of the city of Tlahualilo. The stratigraphic section containing these units is summarized in Table I.

Surficial Depositional Units

The margin of the Parras Basin is composed of a series of Quaternary alluvial fans at the mountain-plain interface. Basinward the fans grade into alluvium. The alluvial fans that are exposed serve both as conduits and areas of ground-water recharge and feed water to the basin fill.

The grain size of the sediments and the distribution of the alluvium can be attributed for the most part to the Nazas and Aguanaval rivers and, to a lesser degree, ephemeral streams. Lacustrine deposits also are present, indicating that at one time the Parras Basin was a relatively large lake. The Laguna de Mayran and Laguna de Viesca are vestiges of this earlier (Pleistocene) large body of water. This implies that the water table was at ground surface when the lake began receding. This being the case, it must be emphasized that this subsurface reservoir can be considered, for all practical purposes, a non-renewable resource.

Subsurface Geology

Of the 104 driller's logs examined, only 27 can, with some degree of confidence, be said to represent wells whose whose total depth extend to basement rock, that is,

TABLE II

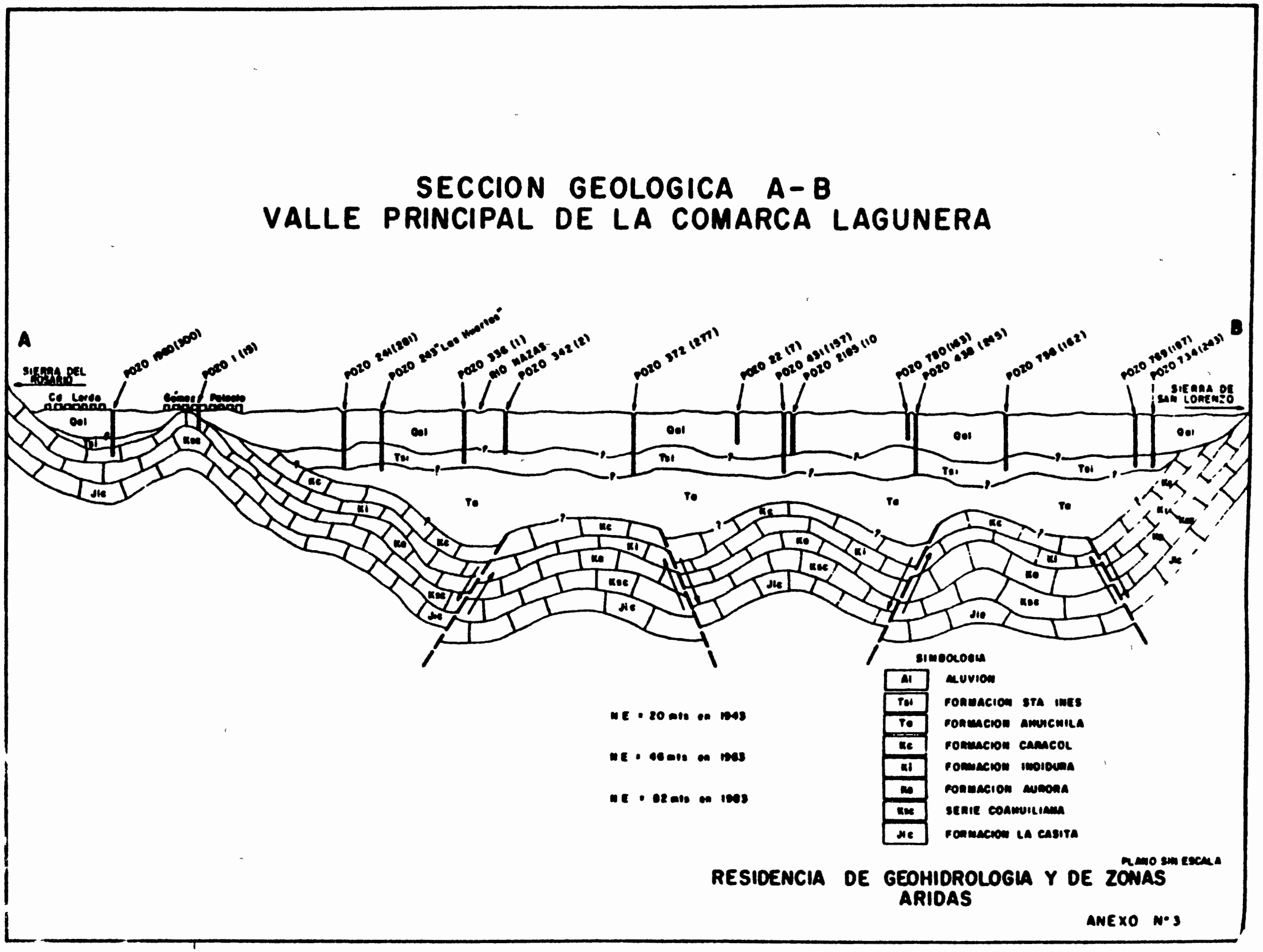
GENERALIZED STRATIGRAPHIC SECTION OF GEOLOGIC FORMATIONS

SYSTEM	SERIES	STRATIGRAPHIC UNIT
Quaternary		Alluvium, caliche, and evaporites
Tertiary	Upper Tertiary	
	Middle Tertiary	Volcanics
	Lower Tertiary	Intrusives Sta. Ines formation Anuichila formation
Cretaceous	Upper Cretaceous	Difunta formation Parras shale Caracol formation Indidura formation
	Lower Cretaceous	Cuesta del Cura Aurora limestone La Pena formation Parritas formation Cupido limestone Las Vigas Taraises formation Carbonera formation
Jurassic	Upper Jurassic	La Casita formation La Gloria formation

SOURCE: Adapted from R.W. Imlay, 1937, Lower Neocomian fossils from the Miquihuana region, Mexico: Jour. Paleontology, v. 11, pp. 552 - 574.

material other than alluvium. These wells penetrated limestone, basalt, rhyolite, and volcanic tuffs. Known depths of basement rock range from 266 to 998 feet (81 to 305 meters) below ground surface. The deepest well not penetrating basement rock, located near Matamoros, is deeper than 1400 feet (427 meters). A geologic cross-section (Fig. 8) constructed along a line between Gomez Palacio and the western edge of the Sierra de Lorenzo range shows that basement rocks are block-faulted and that the Rio Nazas is fault-controlled.

Subsurface mapping of the deposits within the basin is important for several reasons. To understand the subsurface structural features of the basin it is necessary to establish the absence or presence of faulting by determining the depth to basement strata throughout the region. The history of the Nazas and Aguanaval rivers can be traced by mapping the distribution of silt and sand units. The evolution of the basin perimeter can be deduced by constructing maps of the distribution of gravel and conglomerate, for these are associated with the high energy environments associated with alluvial fans at the mountain-valley floor interface. The geometry of these deposits is used to delineate fluvial from alluvial environments. Additionally, correlation of strata throughout the basin can be used to determine whether the various lithologic units are discrete aquifers or whether there is actual communication among aquifers as a result of faulting or facies



SOURCE: S.A.R.H., 1980, Nota Informativa: 8 p.

Figure 8. Geologic Cross-Section

changes. The manner in which the lithologic units interact under the stress of pumping has a direct bearing on the manner in which a ground-water model is implemented.

Whole interval isolith maps of clay (Fig. 9), silt (Fig. 10), sand (Fig. 11), gravel (Fig. 12), and conglomerate (Fig. 13) were constructed in order to determine the subsurface distribution of the various lithologic types. As illustrated by figures 9 and 10, clay and silt deposits generally tend to be thickest along the axis of the basin and flank the trends of the Nazas and Aguanaval rivers. The areas of maximum thickness of clay and silt appear to correspond to areas of major faulting where in most places the presence of basement rock can not be determined from driller's logs. Clay thicknesses range from 0 to 1,095 feet and are located throughout the study area; maximum thicknesses occur in the eastern one half. Silt thicknesses range from 0 to 700 feet with maximum thicknesses located in the southern one half of the region. Generally, areas of maximum clay thickness do not correspond exactly with those of silt, due of course to the different regimes associated with each grain size. Depending on location, as many as 18 clay and 17 silt units contributed to their respective total thickness.

Sand units are sheet-like deposits along the western and northern margins of the study area and thicken axially (Fig. 11). The sheet geometry probably can be attributed to deposition by coalescent ephemeral streams that were

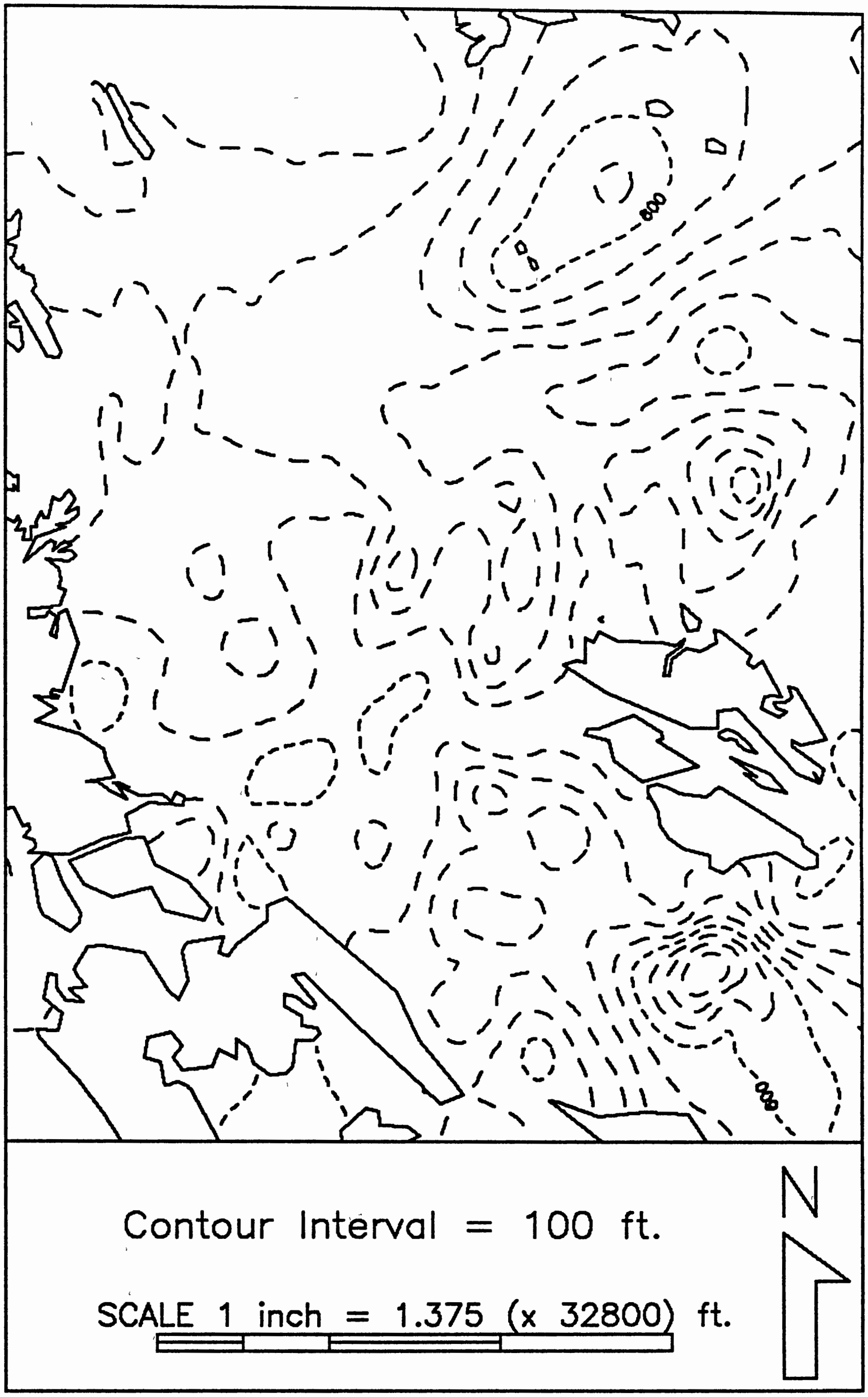


Figure 9. Subsurface Clay Distribution

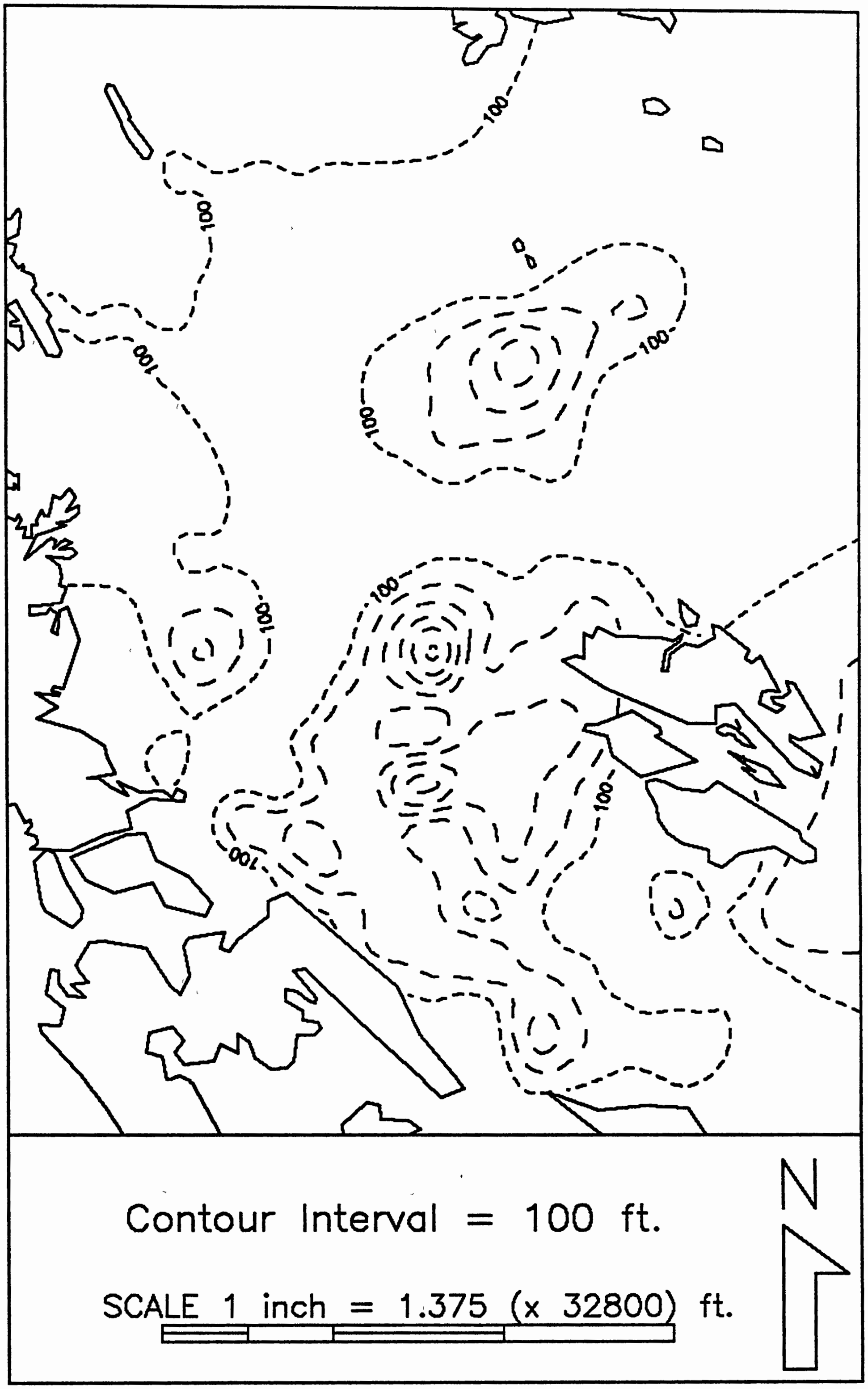


Figure 10. Subsurface Silt Distribution

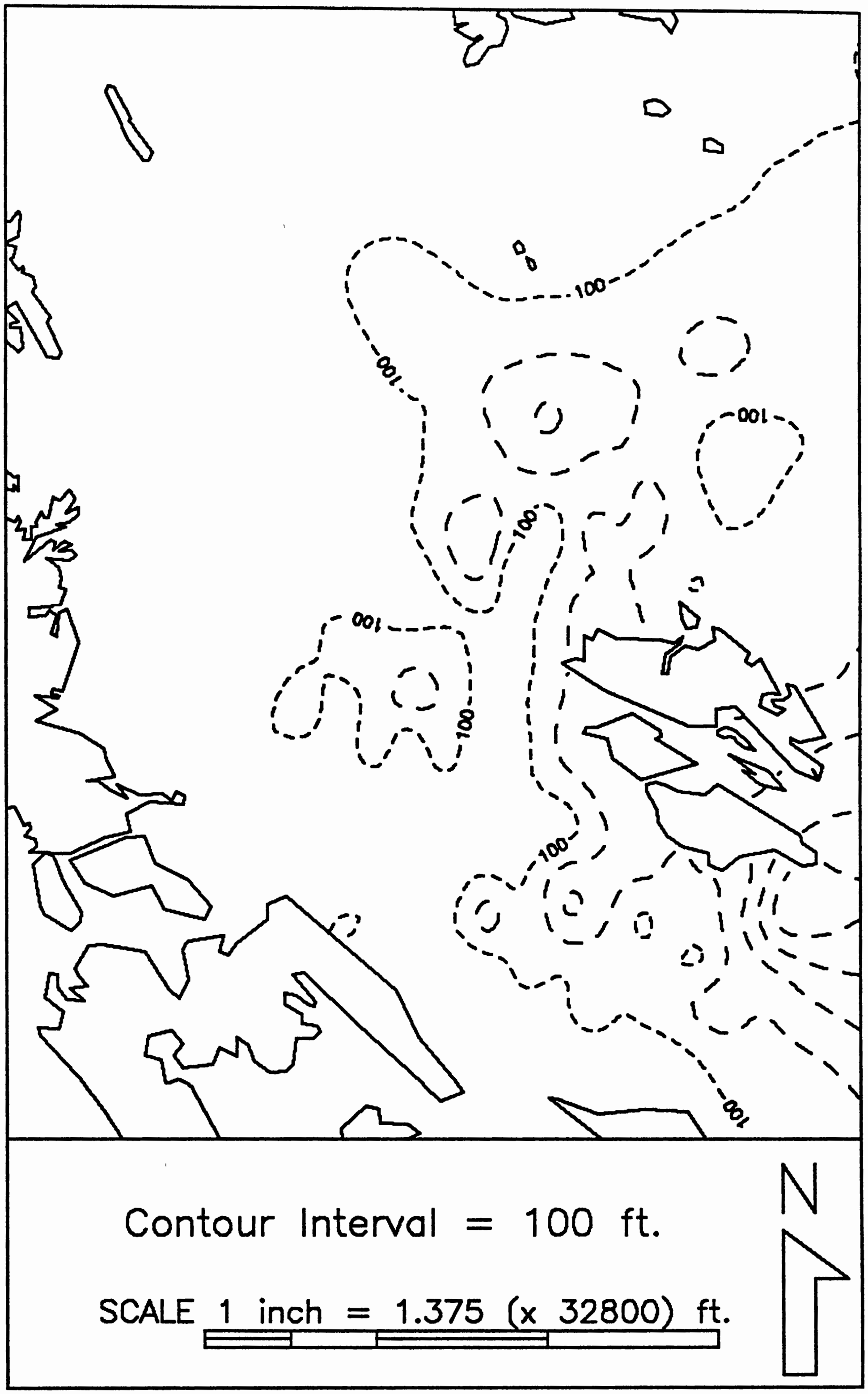


Figure 11. Subsurface Sand Distribution

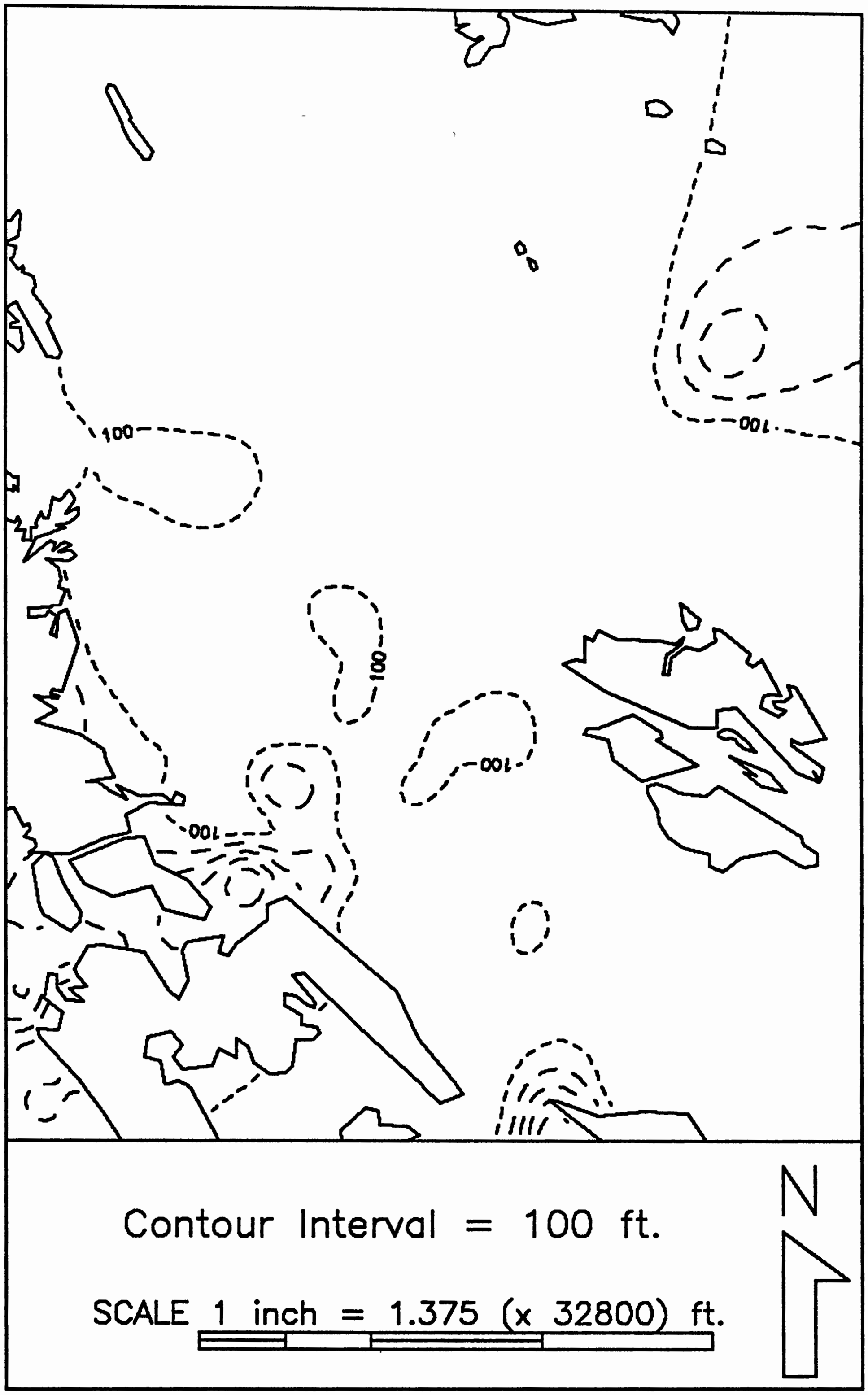


Figure 12. Subsurface Gravel Distribution

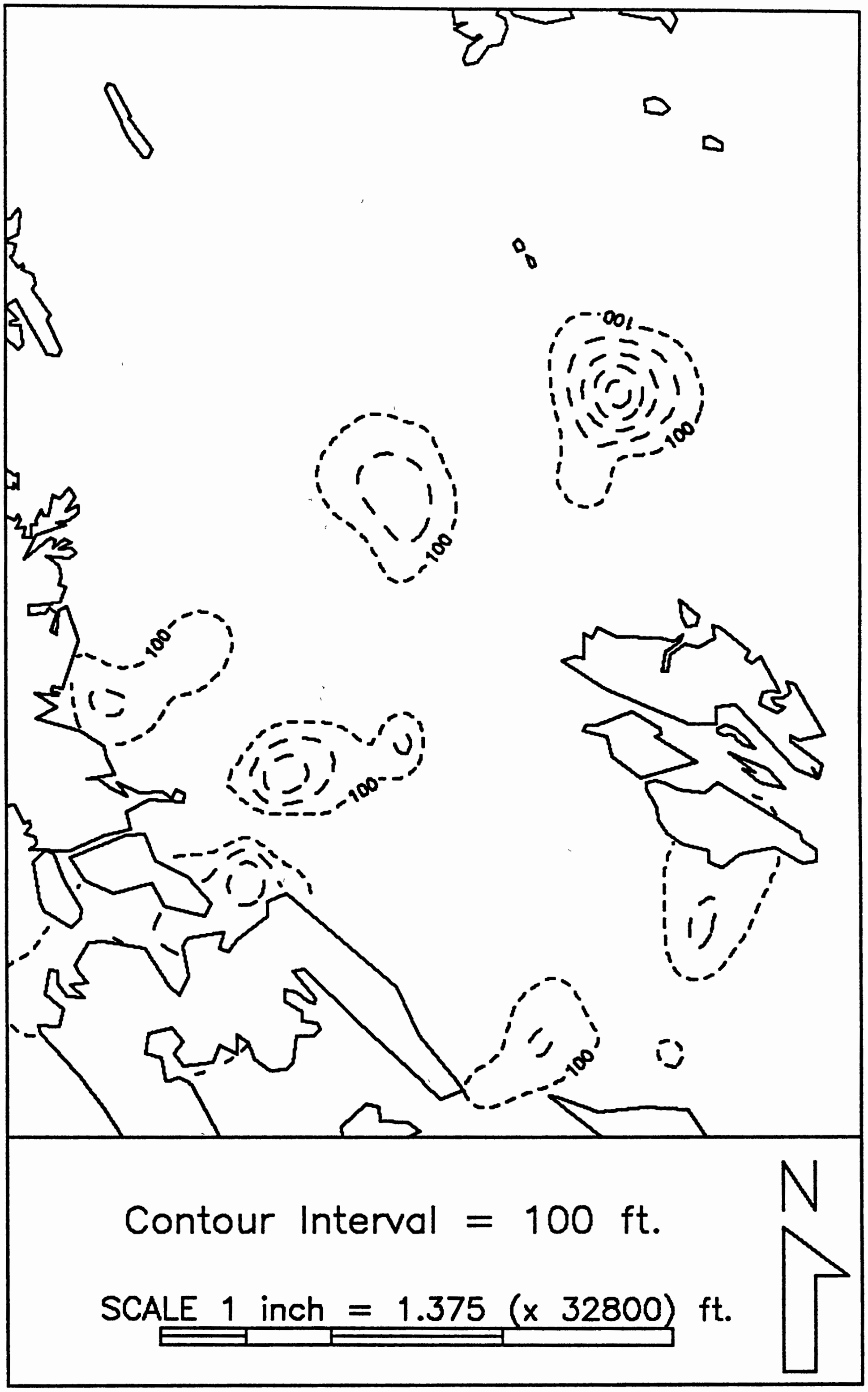


Figure 13. Subsurface Conglomerate Distribution

active during seasonal runoff events. Axial thickening of sand units in the vicinity of Rio Nazas could indicate a stacked paleochannel sequence that formed as the result of a fault-controlled, aggradational fluvial environment. Total sand thickness ranges from 0 to 615 feet. Some wells penetrated as many as 18 individual sand bodies.

The gravel and conglomerate maps (Figs. 12 and 13) show the presence and extent of buried alluvial fans along the mountain-plain interface. Considerable thicknesses of conglomerate also occur distally along the trend of the Rio Nazas and to a lesser extent, Aguanaval rivers. These depositional patterns, along with that of sand, indicate that the Rio Nazas at one time may have flowed farther to the northeast than it does presently and, due to additional faulting of basement rock, was forced to take a more easterly path. Strata form interfingering packets horizontally that thicken toward the basinal axis. Gravel thicknesses range from 0 to 584 feet with as many as 12 contributing layers. Maximum gravel concentrations occur near Gomez-Palacio and Torreon. Conglomerate thicknesses range from 0 to 410 feet with the maximum located near Francisco I. Madero. As many as eight conglomerate units are penetrated by some wells. Locations of data points are shown in Figure 14 and an idealized model of these processes is depicted in Figure 15.

As previously mentioned, the Laguna region had been a large lake in the Pleistocene. Ground water is thought to

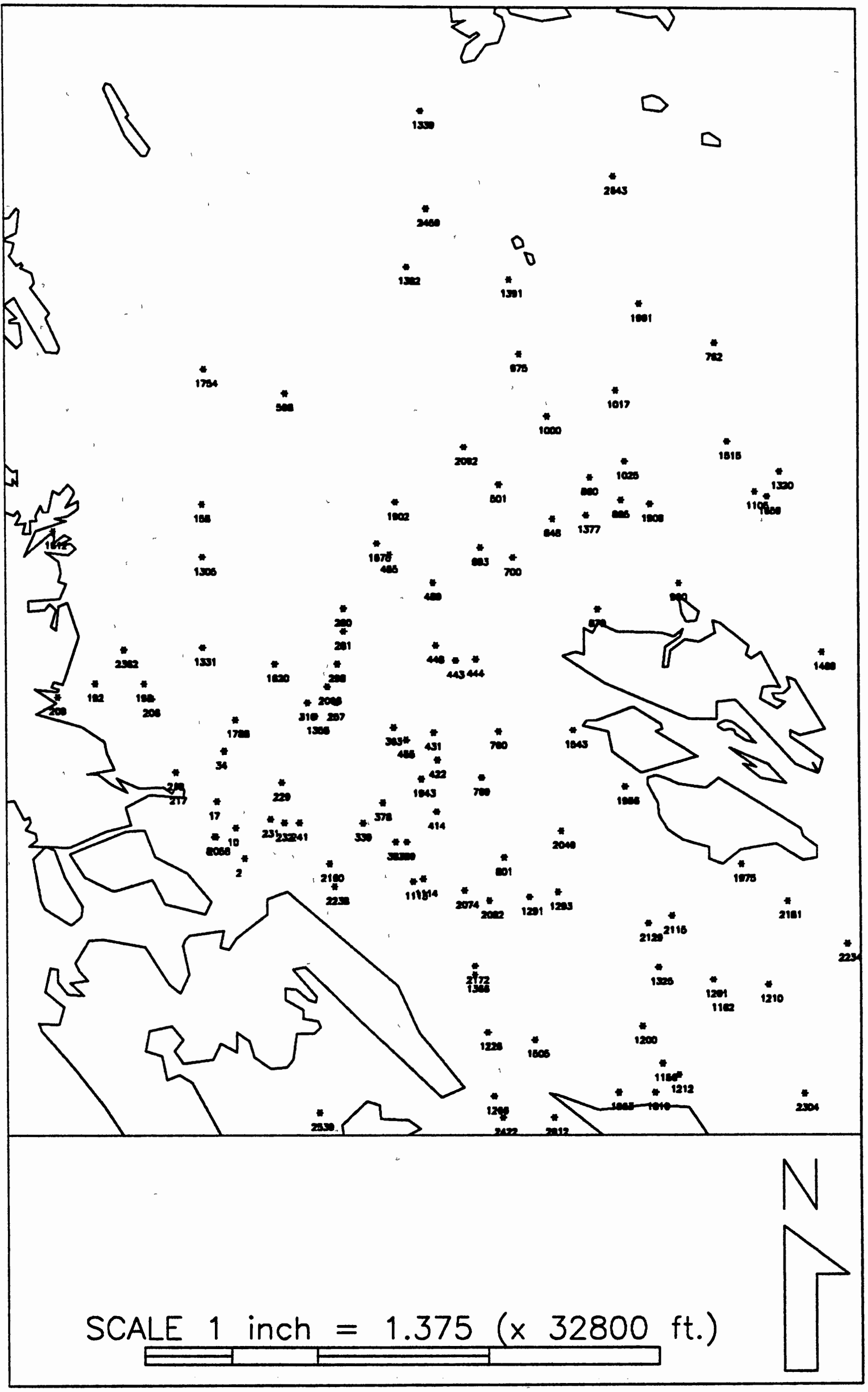
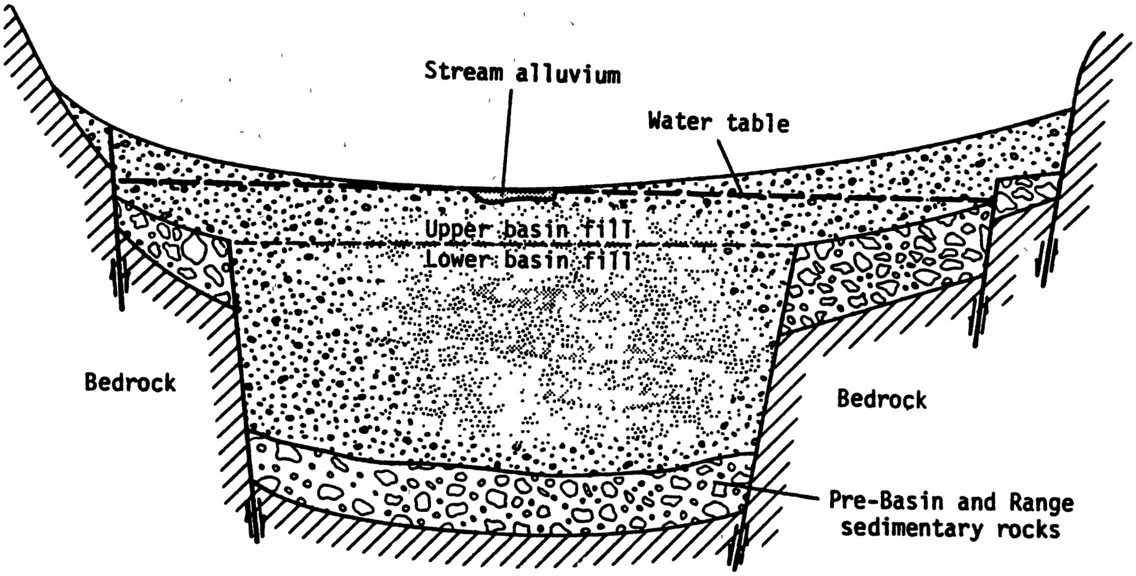


Figure 14. Location of Data Points



SOURCE: Freeze and Cherry, 1979, Groundwater: Prentice-Hall Inc., 604 p.

Figure 15. Idealized Cross-Section of Basin

have had the same chemical nature as the lake water and the inorganic constituents found today have probably always been there. The lake was eventually transformed into a playa because of changes in climate, but the ground water was probably relatively unchanged. Before extensive withdrawals, harmful constituents such as arsenic had been dilute enough so as to not pose any danger.

CHAPTER III

HYDROGEOLOGY AND WATER QUALITY

Hydrogeology

Evaluation and characterization of subsurface hydraulic properties were based on driller's logs and electric logs supplied by the S.A.R.H. In cases where both driller's logs and electric logs were available for a given well, an attempt was made to calibrate the written description (driller's log) with the visual (electric log). In this manner a more accurate depiction of subsurface strata and more indirect inferences related to hydraulic characteristics could be obtained than would be possible from driller's logs alone.

Estimating Hydraulic Conductivity

Given the lack of aquifer-test data, the lithology described for each well in the study area was used to estimate hydraulic parameters. To each grain-size interval encountered in any particular well, an estimate of homogeneity was made and a hydraulic conductivity (K) value assigned. The hydraulic conductivity of an aquifer is a measure of its ability to transmit water. With the exception of gravel, values used for each stratum present were adapted from a compendium of hydraulic conductivity ranges (Freeze and Cherry, 1979). Based on field observations, Pettyjohn (1988) suggested a K value of 10,000 gpd/ft^2 (gallons/day/foot^2) for gravels. Table II contains a summary of the ranges of estimated values.

TABLE II

VALUES OF HYDRAULIC CONDUCTIVITY FOR VARIOUS SEDIMENTS

	Hydraulic Conductivity (gpd/ft.^{2})	
Sediment	Lower Range	Upper Range
Clay	10^{-6}	10^{-2}
Silt	10^{-2}	10^{2}
Sand	10.0	500.0
Gravel	10^{3}	$> 10^{5}$

Because a hydrologic unit may be composed of more than one saturated lithology, a means of estimating the hydraulic conductivity of an entire interval for each well was derived. From a statistical view, this constitutes the weighting of hydraulic conductivity across a spectrum of values resulting in a whole interval value (K), such that a representative value of hydraulic conductivity for a given well exists. For the sake of brevity, this derived value will be referred to as the Thickness-Weighted Mean Hydraulic Conductivity (TWMHC). Mathematically, this relationship may be written as:

$$\text{TWMHC} = (K_i*C_i + K_j*C_j + \ldots + K_n*C_n)/m \qquad (1)$$

where $K_{i,j,n}$ are the K values for each lithology encountered, $C_{i,j,k}$ are constants equal to the saturated thickness of each respective unit, and m reflects the total saturated thickness of the aquifer. A summary of wells, coordinates, and corresponding hydraulic conductivities is presented in Appendix B.

Regional trends of aquifer properties may be evaluated with the aid of a hydraulic-conductivity map. The hydraulic-conductivity map (Fig. 16) is based on calculated TWMHC values that, when used in conjunction with known saturated thicknesses, may be utilized to calculate the transmissivity (T), in units of gallons/day/foot of each saturated section, using the following relationship:

$$T = \text{TWMHC}*b \qquad (2)$$

where b is the saturated thickness of the aquifer. Subsequent values of transmissivity were then used to construct an isotransmissivity map (Fig. 17). In the case of this study, the aquifer has been depleted to such an extent that it may be treated as an unconfined aquifer. The hydraulic-conductivity map can be used in conjunction with maps of the more permeable strata, that is, sand, gravel,

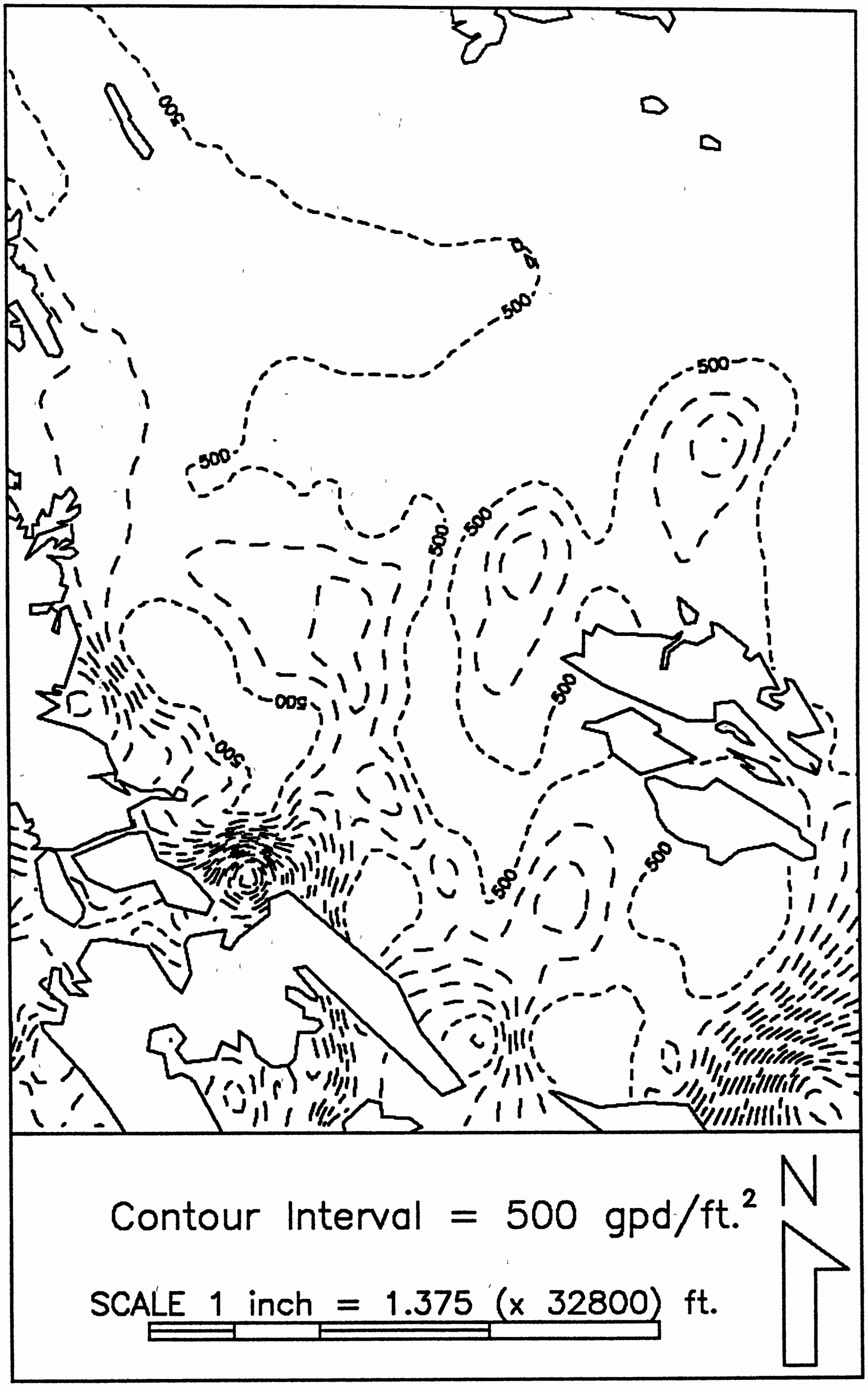


Figure 16. Hydraulic Conductivity

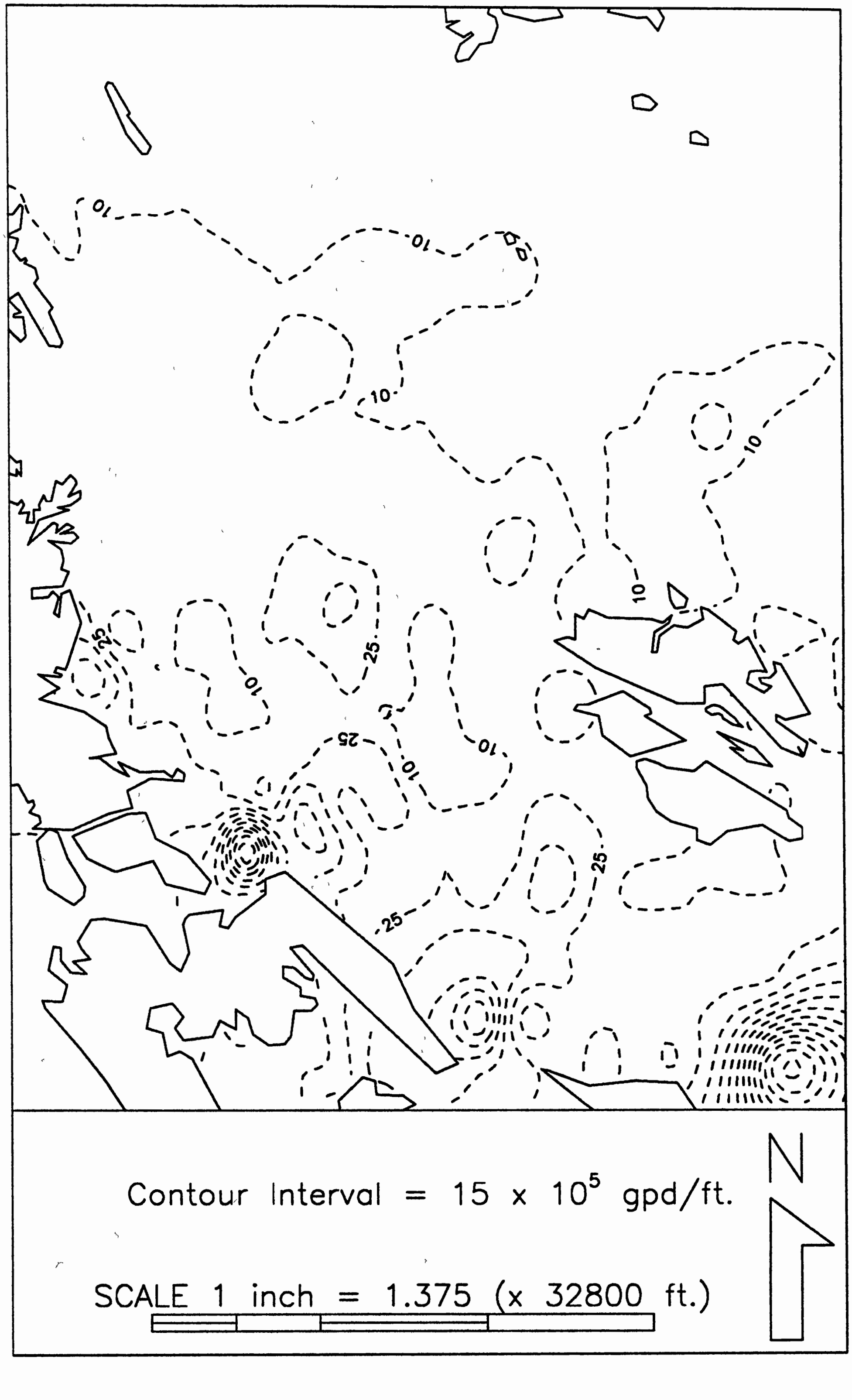


Figure 17. Isotransmissivity

and conglomerate (Figs. 11 - 13) and a composite map of all these strata (Fig. 18) to determine the subsurface extent of the hydraulic properties of the aquifers.

Values of hydraulic conductivity range from less than 500 to as much as 10,000 gpd/ft.^{2}. Values of K greater than 500 gpd/ft.^{2} are found in all but the northeast quarter of the study area. The highest values are located in the Gomez Palacio - Torreon area. If all wells had the same saturated thickness, fluctuations in transmissivity would mirror the fluctuations in hydraulic conductivity. Since saturated thickness varies from well to well there is not a direct correlation between the two. However, highest values of transmissivity do coincide with those of hydraulic conductivity. Values of transmissivity range from 3,548 to 8,166,690 gpd/ft. Mapping the distribution of hydraulic conductivity is important in that it outlines those areas which contain sediment capable of transmitting a practical amount of water. Transmissivity trends can be used to map the availability of water on a per foot basis in the saturated portion of each well.

Water Quality

Data used for mapping the areal distribution and concentration of important ground water constituents were extracted from 217 chemical analyses representing 50 wells. The analyses were conducted during the years 1977, and 1981 to 1983. Frequency of analysis for the wells tested during

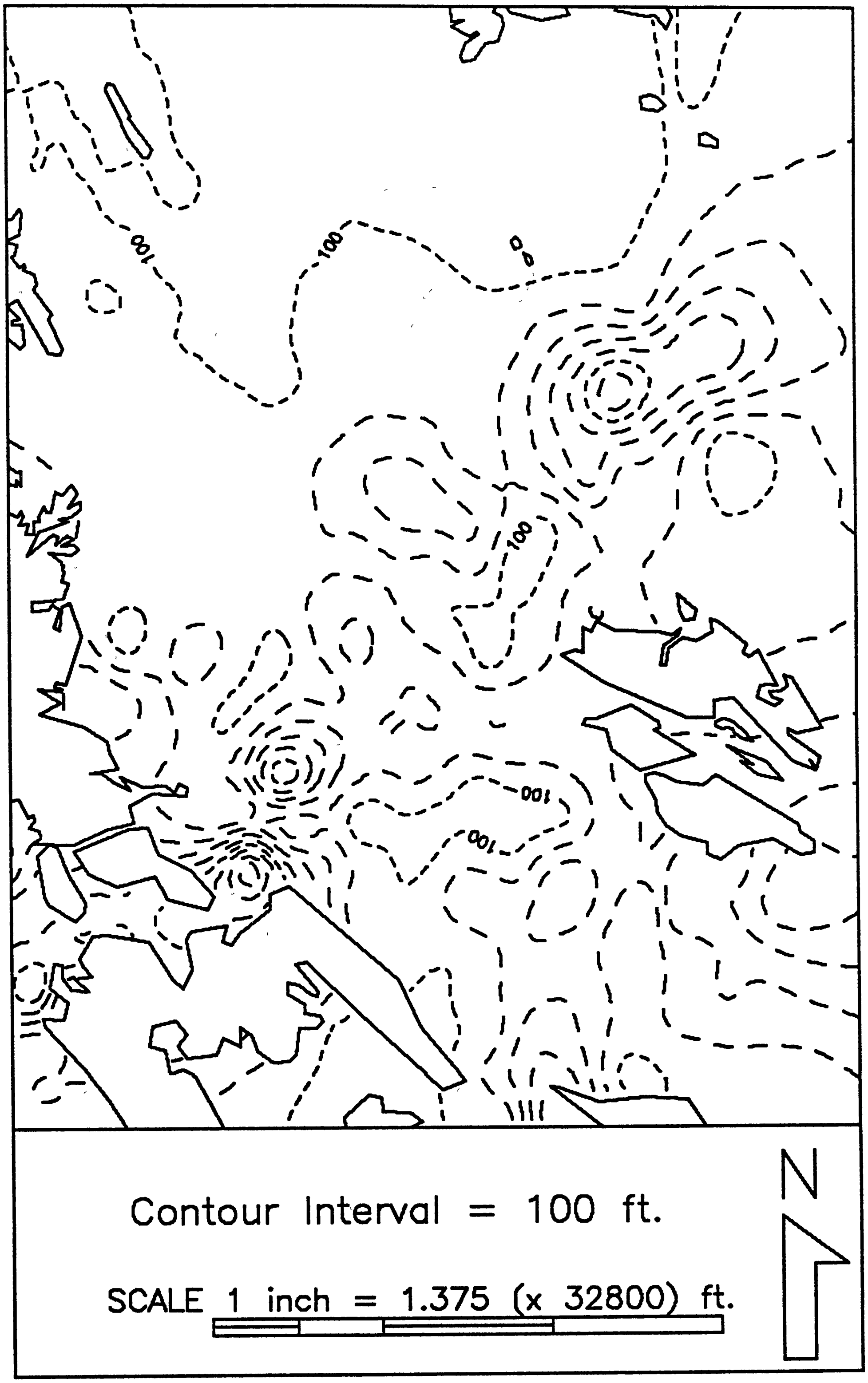


Figure 18. Composite Porous Media

this time frame range from as few as one per year for several wells to as many as 10 per year for others. Properties and constituents most commonly analyzed were pH, electrical conductivity, alkalinity, hardness, sulfate, chloride, and arsenic.

Water Standards for Public Consumption and Agriculture

Two categories of upper limits, based on direct and indirect health hazards, have been placed on organic and inorganic constituents in ground water by the U.S. Environmental Protection Agency (EPA, 1975). Components posing a direct threat to human health have been assigned maximum permissible concentrations and are deemed hazardous for for human consumption when exceeded. Arsenic is in this category. Recommended concentration limits are placed on those constituents that tend to detract from the taste of the water, result in staining, or lead to the formation of scale. Dissolved solids, sulfate, and chloride are placed in this category. A more complete listing concerning drinking water standards is presented in Table III.

Because the Lagunera is an extensively irrigated region with an agriculture-based economy, not only is it necessary to monitor ground-water quality in terms of public consumption, but in terms of crops and livestock as well. Recommended limits of selected constituents generally are less rigid with respect to agricultural use. Of primary importance for irrigation and crops is the

TABLE III

DRINKING WATER STANDARDS

Constituent	Recommended Concentration Limit (mg/l)
Total Dissolved Solids	500
Chloride (Cl)	250
Sulfate (SO_4^{2-})	250
Nitrate (NO_3-)	45
Iron (Fe)	0.3
Manganese (Mn)	0.05
Copper (Cu)	1.0
Zinc (Zn)	5.0
Boron (B)	1.0
Hydrogen Sulfide (H_2S)	0.05
	Maximum Permissible Concentration
Arsenic (As)	0.05
Barium (Ba)	1.0
Cadmium (Cd)	0.01
Chromium (Cr^{VI})	0.05
Lead (Pb)	0.05
Mercury (Hg)	0.002
Silver (Ag)	0.05

prolonged use of waters high in dissolved solids. Sprinkler irrigation components could become less efficient with time because of a buildup of carbonate-induced scale, and soil pH imbalances would require corrective actions in order to maintain crop productivity. Crops also could be subject to increased stress if the osmotic potential of the root systems were to be disrupted by applications of irrigation waters rich in salts. Of primary concern to livestock and small animals is the presence of arsenic, as well as other heavy metals, such as cadmium, selenium, lead, and mercury. Recommended limits for agricultural use are presented in Table IV.

Distribution and Concentration of Ground-Water Constituents

Because of the apparent sporadic collection of data, both in terms of time and space, few complete chemical analyses are available for any given well. The concentration of chemical constituents in ground water were mapped on the basis of rank and are independent of time. Consequently, with the exception of chloride and sulfate, the maps generated reflect composite minimum and maximum values for the years 1977 and 1981 through 1983. This method serves to delineate the minimum and maximum areal bounds of concentrations of all species for which analyses are available. With respect to composite minimum and maximum chloride and sulfate maps, the differences between the two for each case were sufficiently small so that the composite

TABLE IV

RECOMMENDED LIMITS FOR AGRICULTURAL USE

	Livestock: Recommended Limits (mg/l)	Irrigation Crops: Recommended Limits (mg/l)
TDS		
Small Animals	3000	700
Poultry	5000	-
Other Animals	7000	-
Nitrate	45	-
Arsenic	0.2	0.1
Boron	5	0.75
Cadmium	0.05	0.01
Chromium	1	0.1
Lead	0.1	5
Mercury	0.01	-

maximum distribution maps for each were sufficient i.e., there were minor changes in concentration for this period.

Arsenic. The composite minimum arsenic distribution map (Fig. 19) shows a northwest-southeast trending arsenic front, the leading edge of which is northeast of the Rio Nazas. The concentration gradient implies that the source is northeast of the study area. At all points located behind the 0.05 mg/l contour, water is unfit for human consumption. Close by the 0.05 mg/l contour are the 0.10 and 0.20 mg/l contours, which indicate the upper bounds for which the water is unfit for livestock and crops, respectively.

The composite maximum arsenic distribution map (Fig. 20) indicates that the 0.05 mg/l leading edge has crossed natural ground water divides (the Nazas and Aguanaval Rivers) that seem to have been converted into regional sinks, due to the withdrawal of water by well fields. When compared with the composite minimum arsenic map, the area bounded by the 0.05 mg/l contour has been reduced by about 75 percent and that of the 0.10 and 0.20 mg/l contours by approximately 10 percent each.

The source of arsenic in the ground water is thought to originate in the various regional volcanic and igneous bodies found in both surface and subsurface environments (S.A.R.H, 1980).

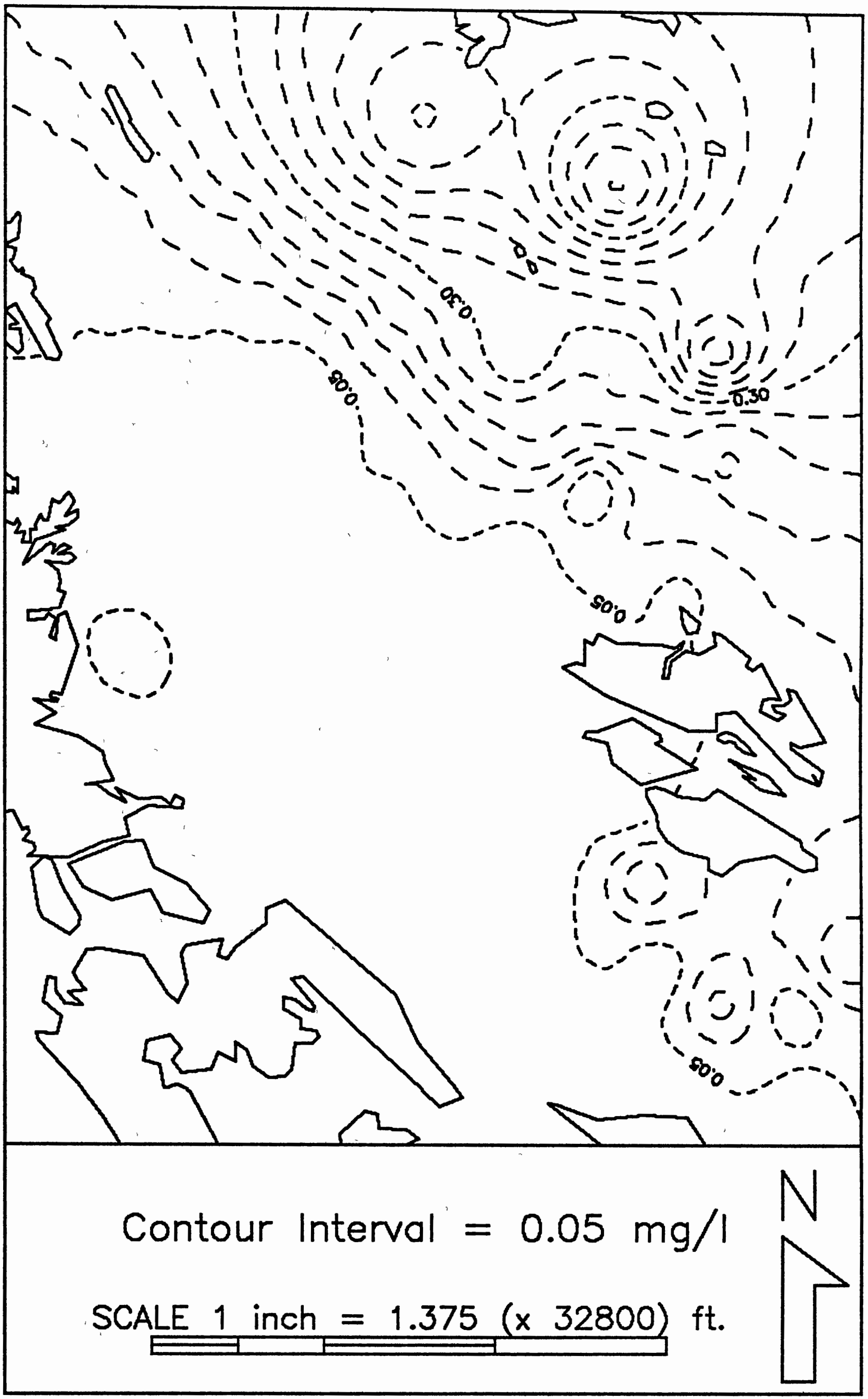


Figure 19. Variation of Minimum Arsenic

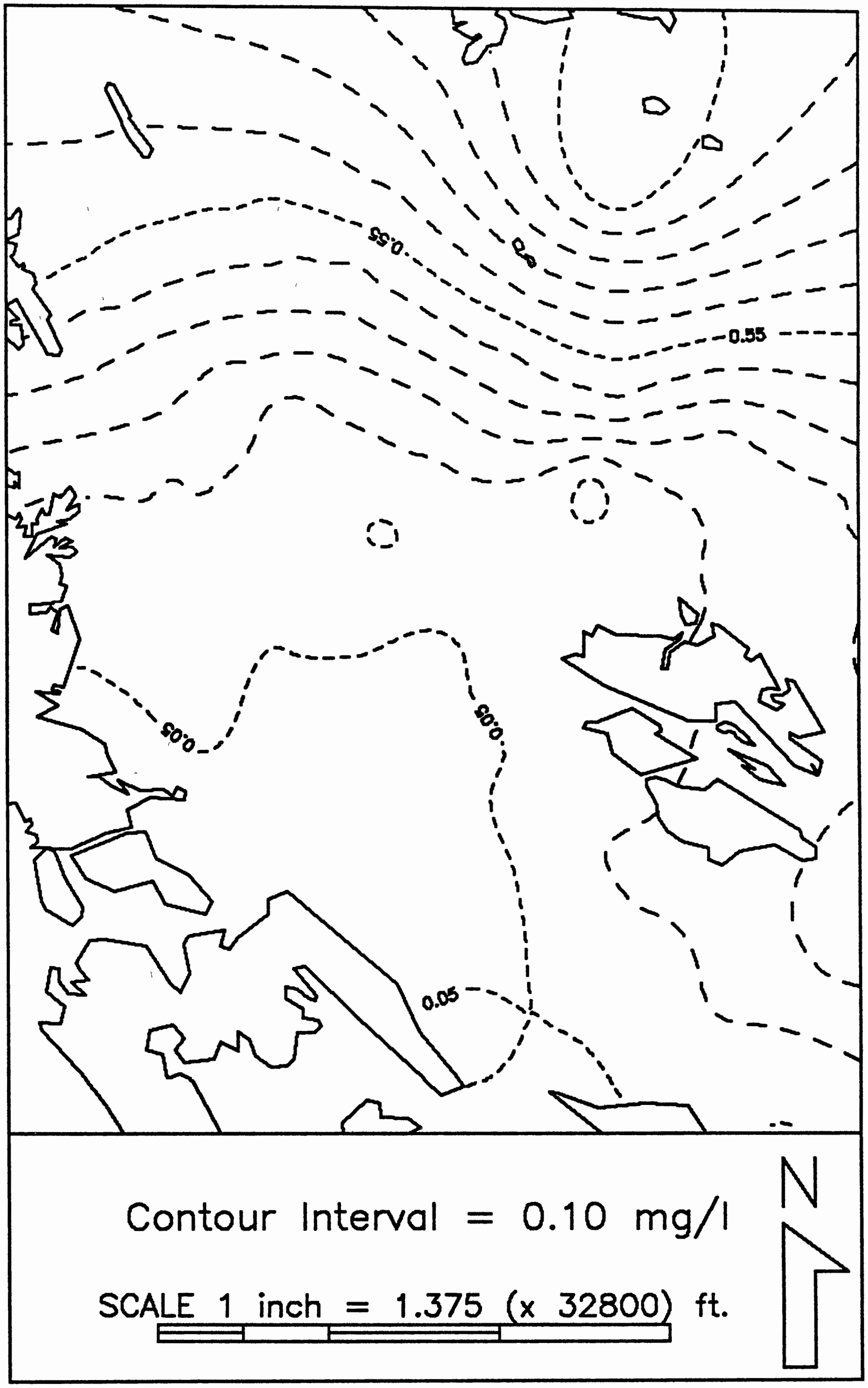


Figure 20. Variation of Maximum Arsenic

Chloride and Sulfate. Unlike arsenic, the distribution of chloride in excess of 250 mg/l occurs only in two relatively small areas (Fig. 21). One area is located between Matamoros and Torreon and another to the northwest of Gomez Palacio and Torreon. The latter forms a much steeper concentration gradient than the former although both are of approximately the same areal extent.

The map showing the maximum sulfate concentration (Fig. 22) indicates that sulfate equals or exceeds the recommended limit of 250 mg/l in all but approximately 15 percent of the study area. The area bounded by the 250 mg/l contour generally follows the trend of the Rio Nazas. The absence of high sulfate and chloride levels near Torreon and Gomez Palacio, despite the extremely high pumping rates, are attributed to dilution by recharge from the Nazas and Aquanaval rivers.

Electrical Conductivity, Dissolved Solids, and Hardness. As discussed earlier, the concentration of dissolved solids can be approximated if the electrical conductivity (EC) is known by means of the expression:

$$DS = EC * 0.67 \tag{3}$$

Figures 23 through 26 represent the minimum and maximum electrical conductivity maps and corresponding dissolved solids maps. Centers of highest concentration correlate rather well with those of the chloride distribution map. As with the sulfate map, the areas of lowest concentration lie in an area through which the Nazas

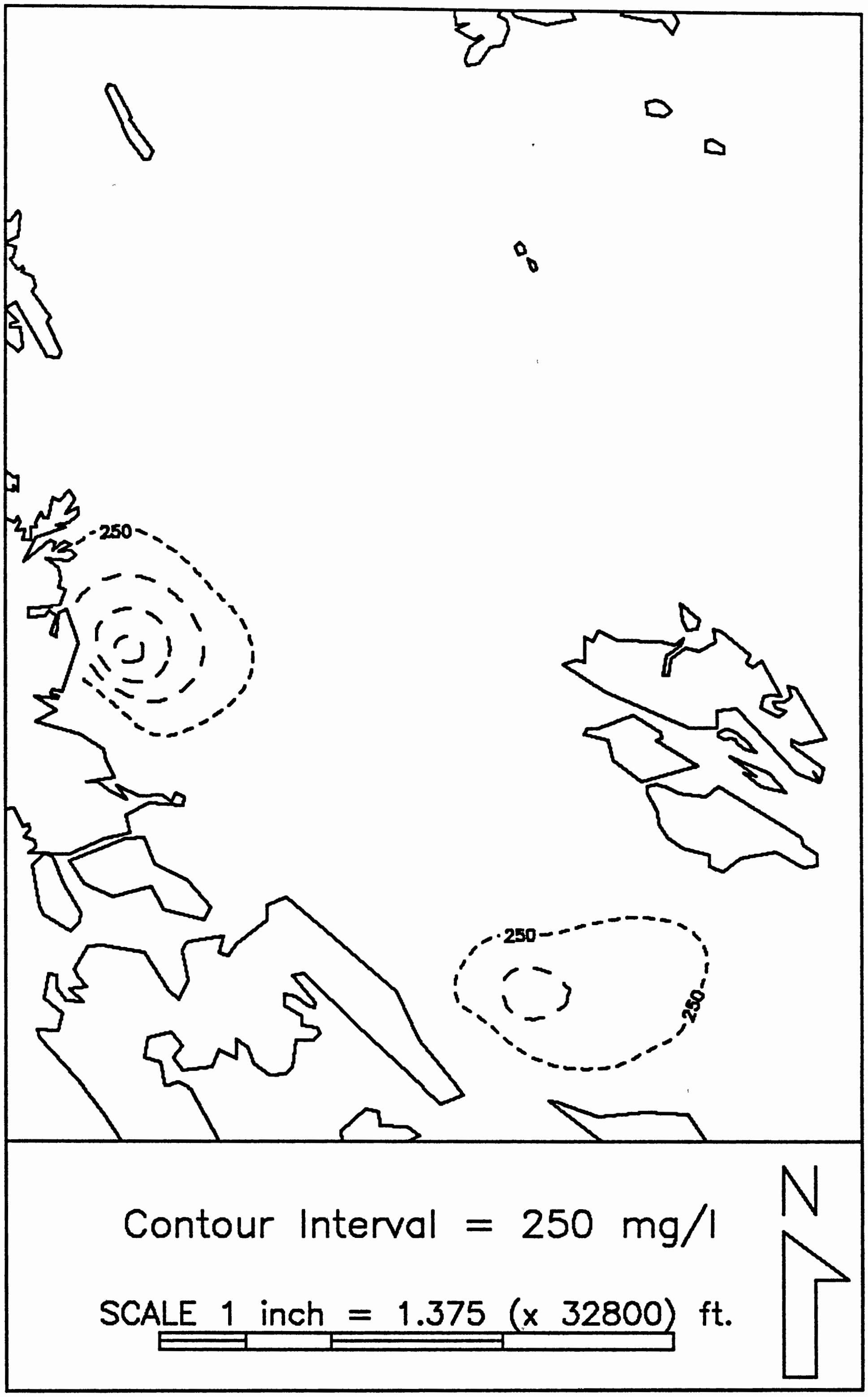


Figure 21. Chloride Distribution

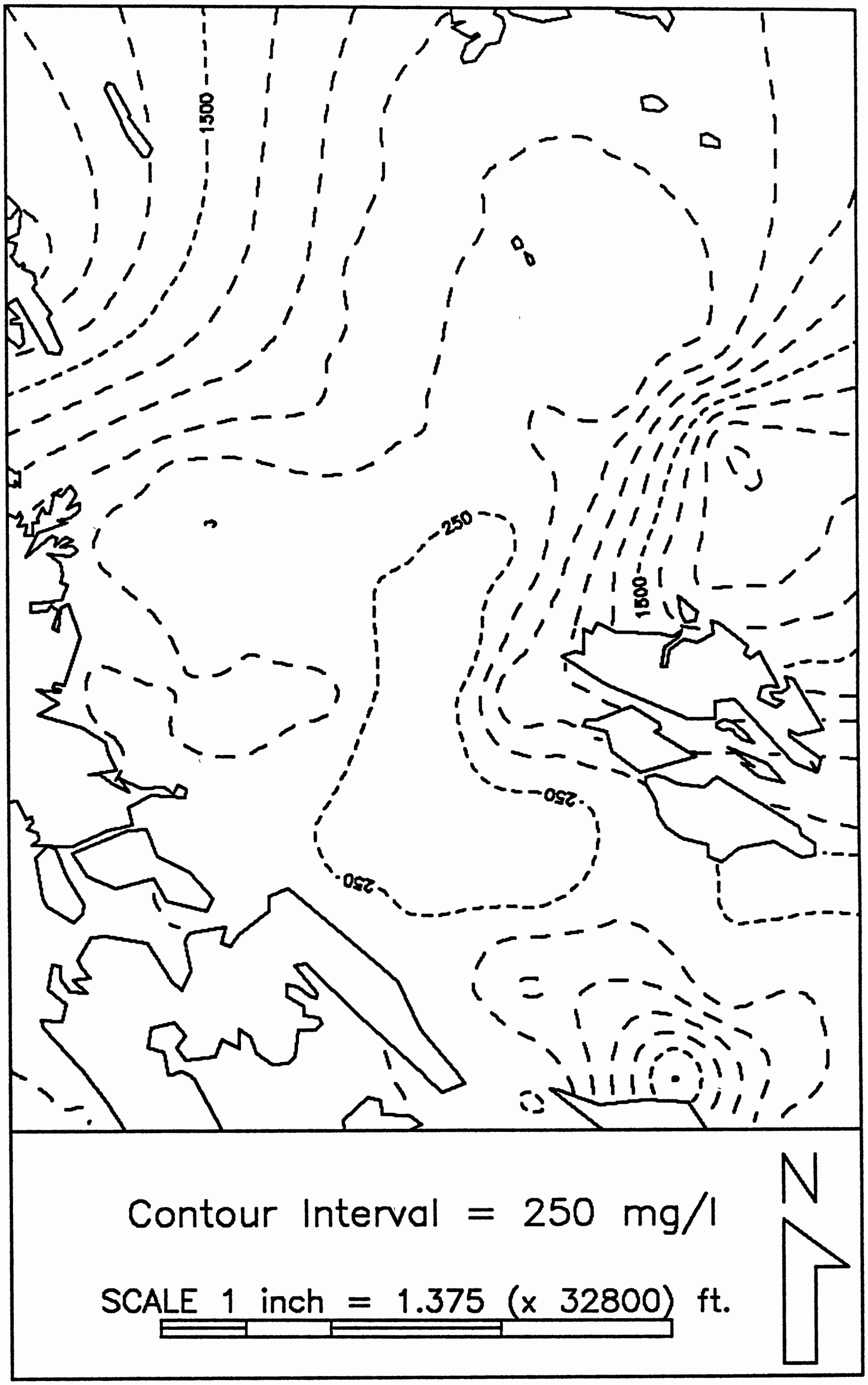


Figure 22. Sulfate Distribution

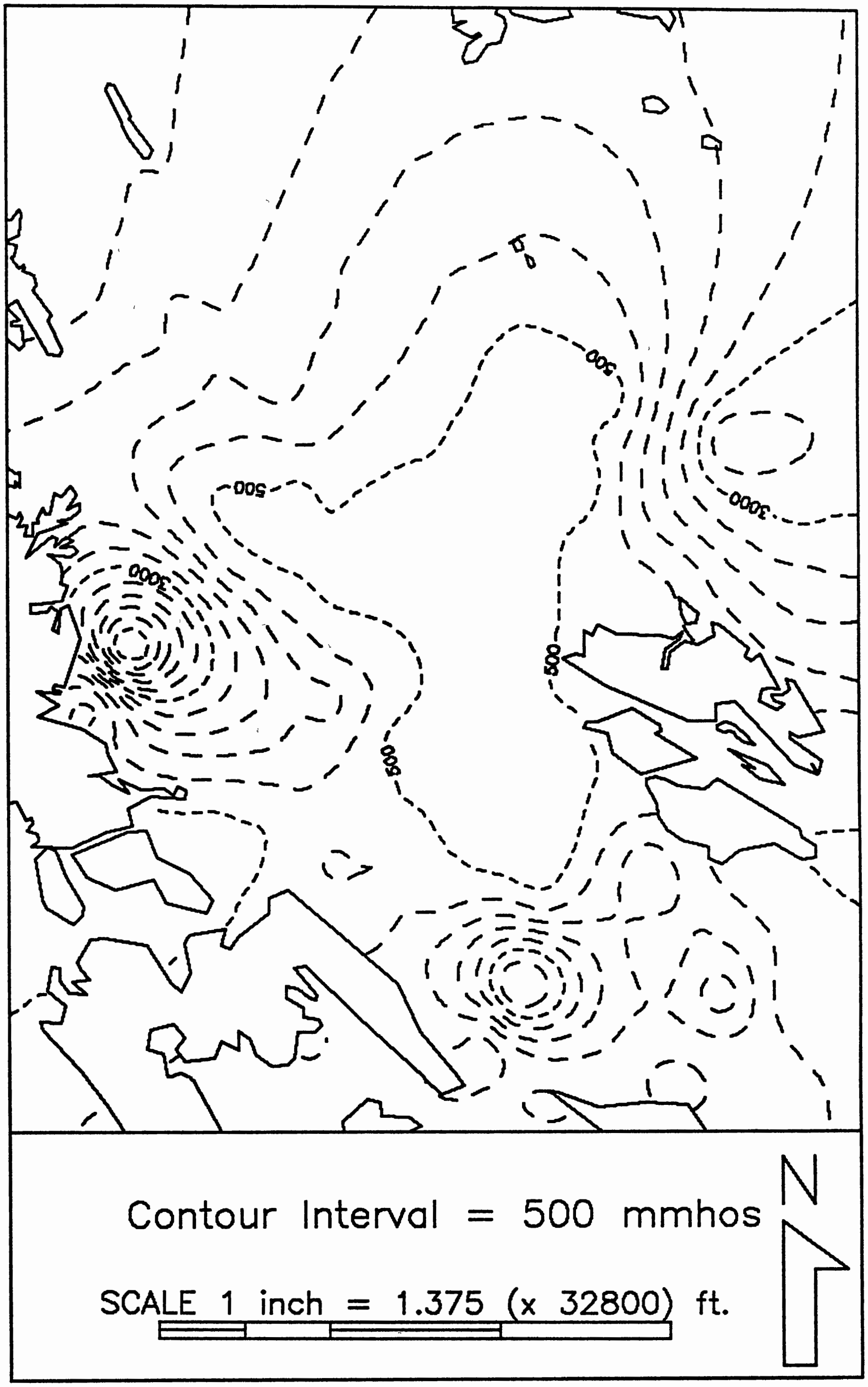


Figure 23. Variation of Minimum Electrical Conductivity

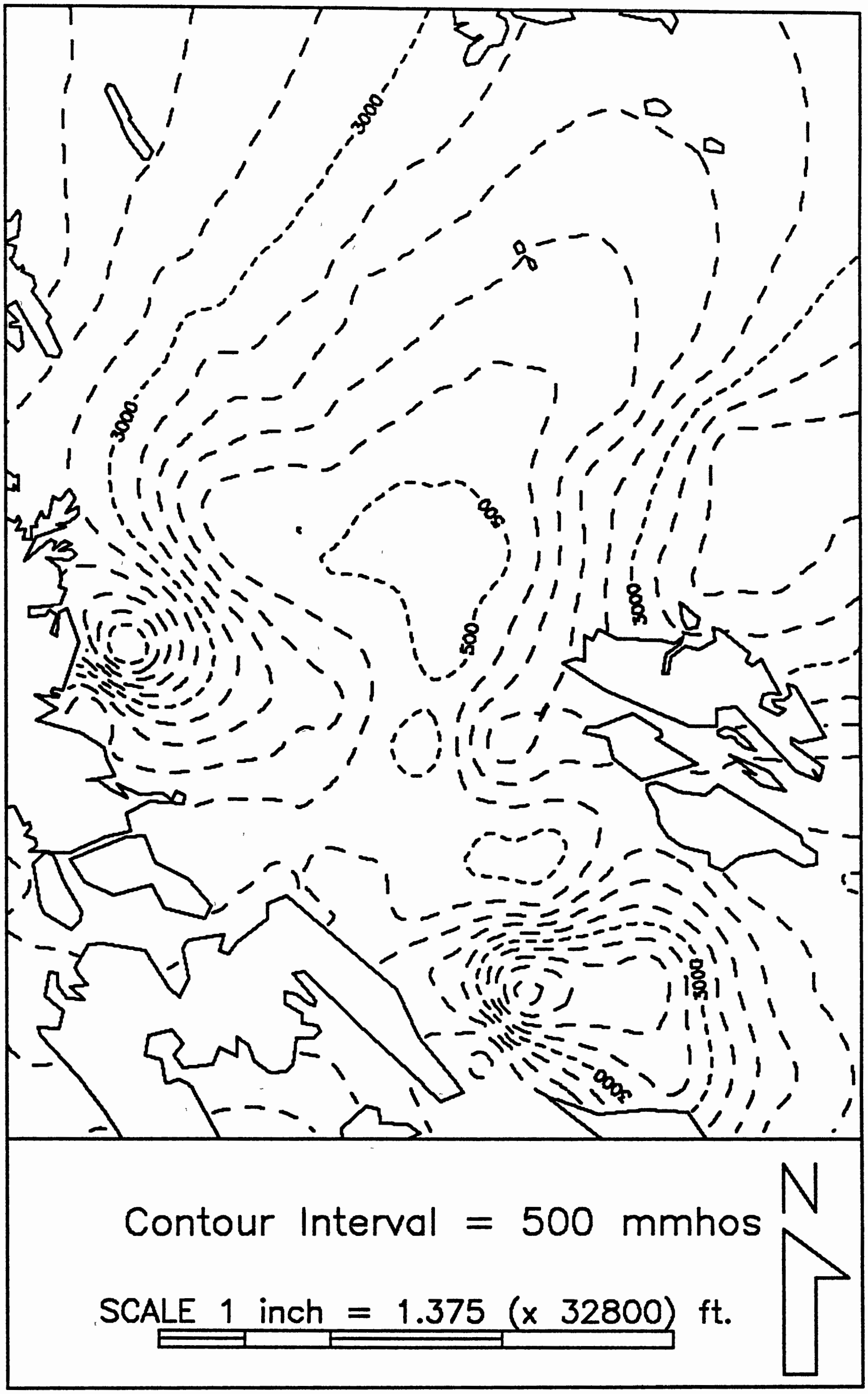


Figure 24. Variation of Maximum Electrical Conductivity

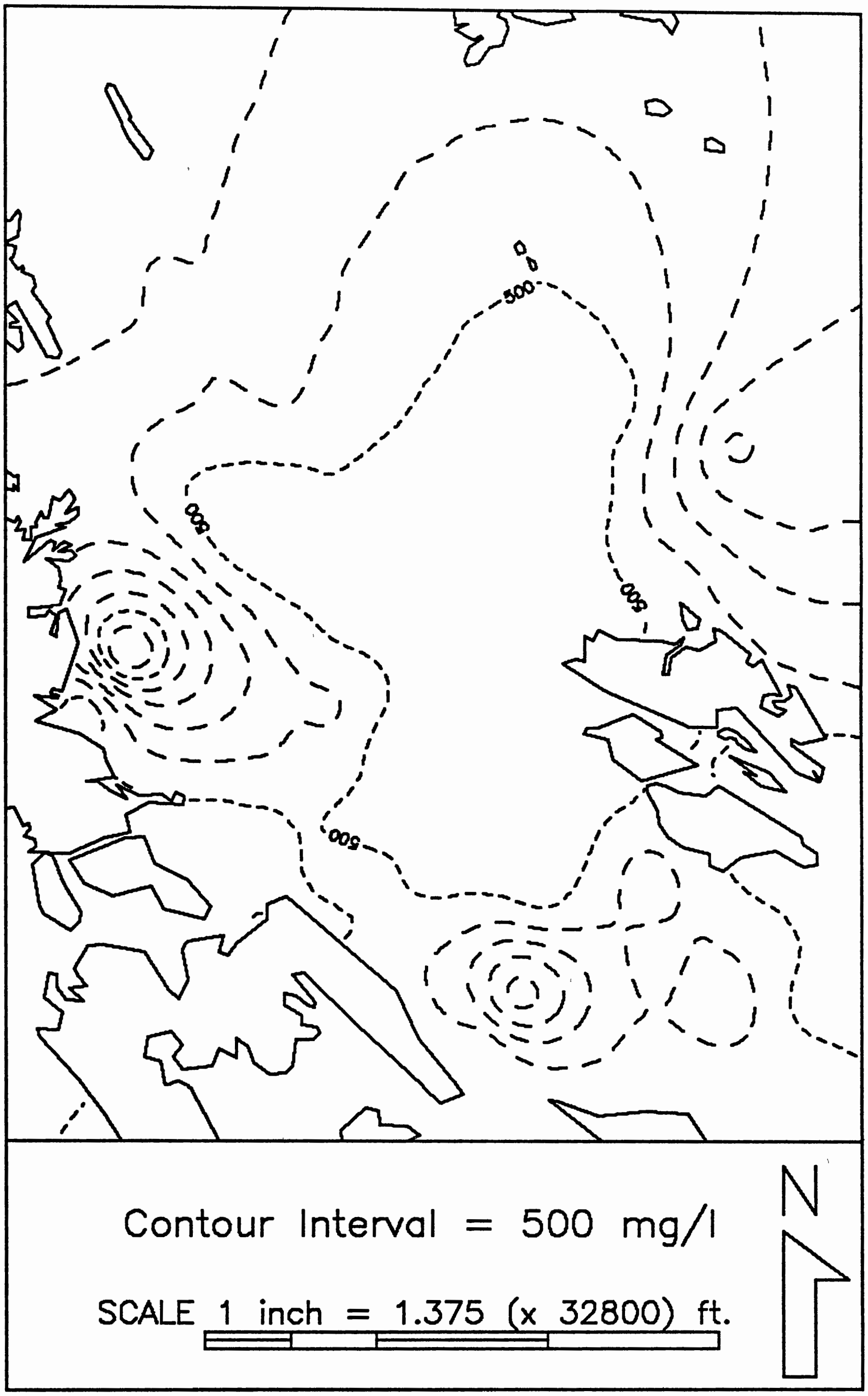


Figure 25. Variation of Minimum Total Dissolved Solids

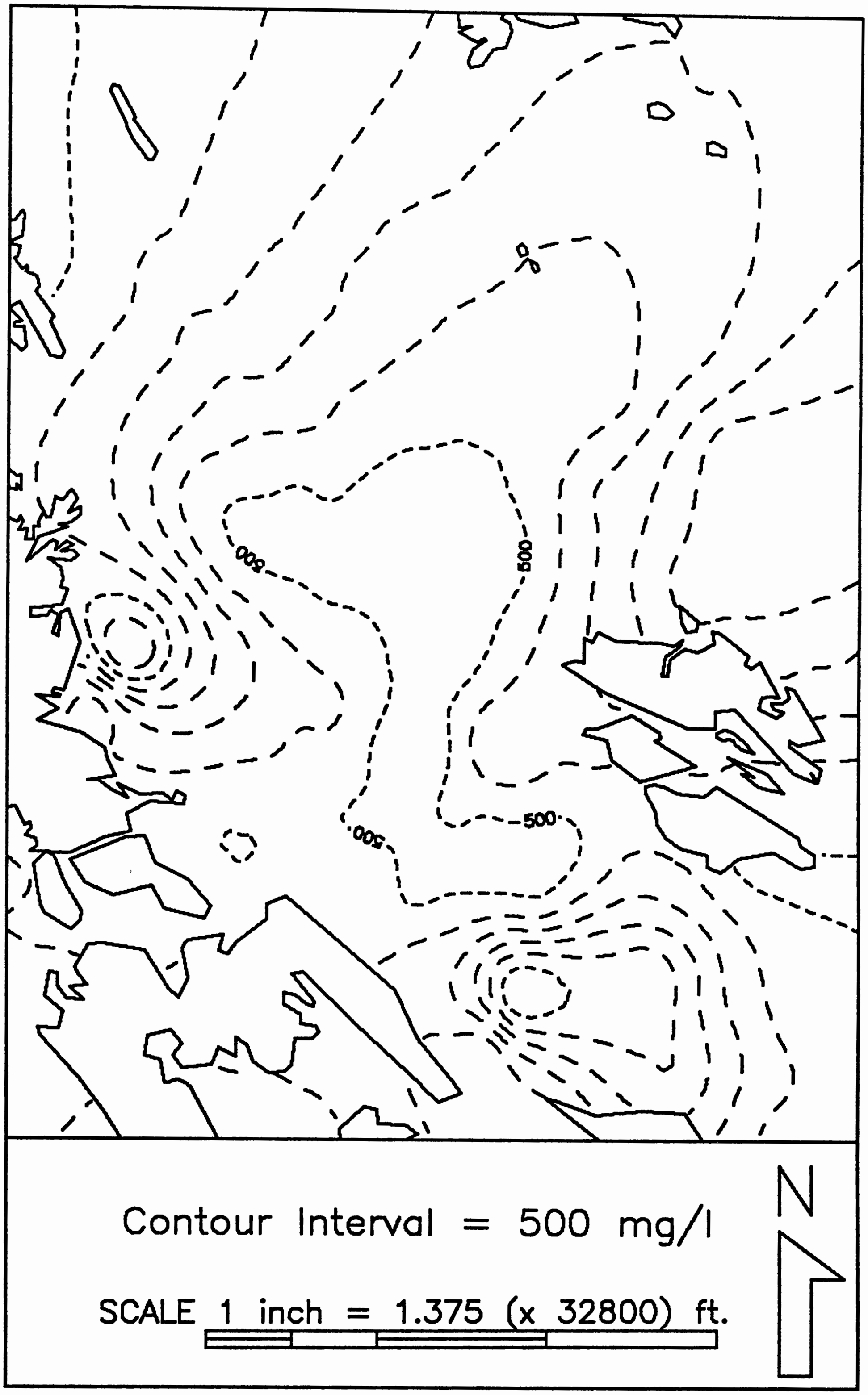


Figure 26. Variation of Maximum Total Dissolved Solids

River flows. These lower bounds are defined by the 1000 mg/l and 1000 umho contours of the dissolved solids and electrical conductivity maps, respectively. Increasing values in dissolved solids indicate an increase in salinity and increasing values in electrical conductivity reflect an increase in degree of mineralization of the water.

Hardness. The principal cause of hardness is calcium and magnesium dissolved in water (EPA, 1985). The U.S. Geological Survey has classified hardness, in terms of mg/l of CaCO3 as soft (0 - 60); moderately hard (61 - 120); hard (121 - 180); and very hard (greater than 180).

Composite minimum and maximum concentration maps of hardness show that the areas of highest hardness correspond to high sulfate, dissolved solids, and electrical conductivity centers (Figs. 27 and 28). Using the upper limit defining the transition from hard to very hard water (180 mg/l), it can be seen that the majority of the basin can be classified as having very hard water.

Lining of the Nazas and Aguanaval rivers has probably been the most detrimental factor concerning regional ground-water quality. On the one hand more water has been made available for irrigation, but this has been at the expense of the diluting effect of ground-water recharge. With too little recharge the inorganic ground-water constituents have been increasing in concentration; resulting in high-gradient fronts that are quickly degrading the quality of the remainder of the aquifer. There is not

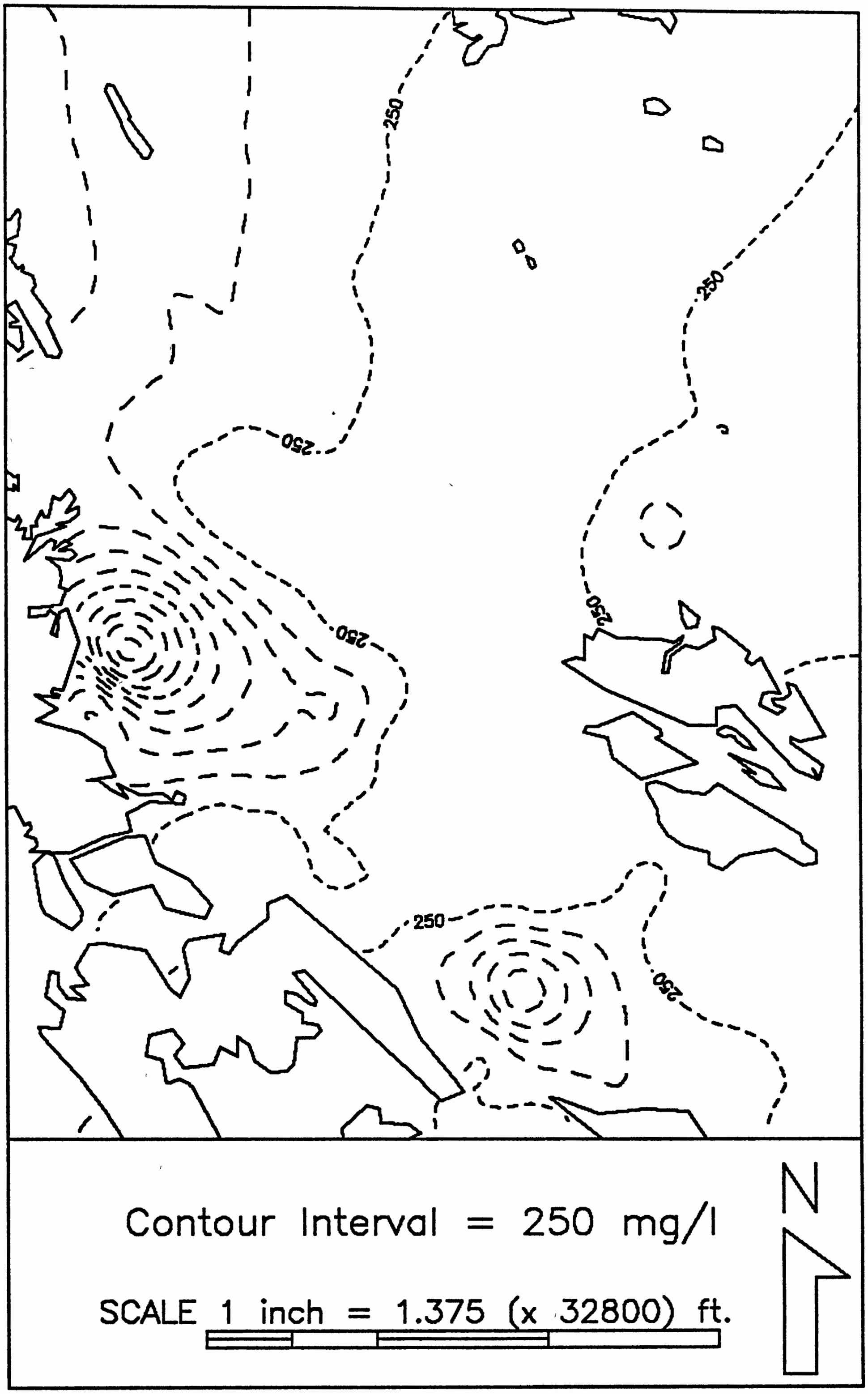


Figure 27. Variation of Minimum Hardness

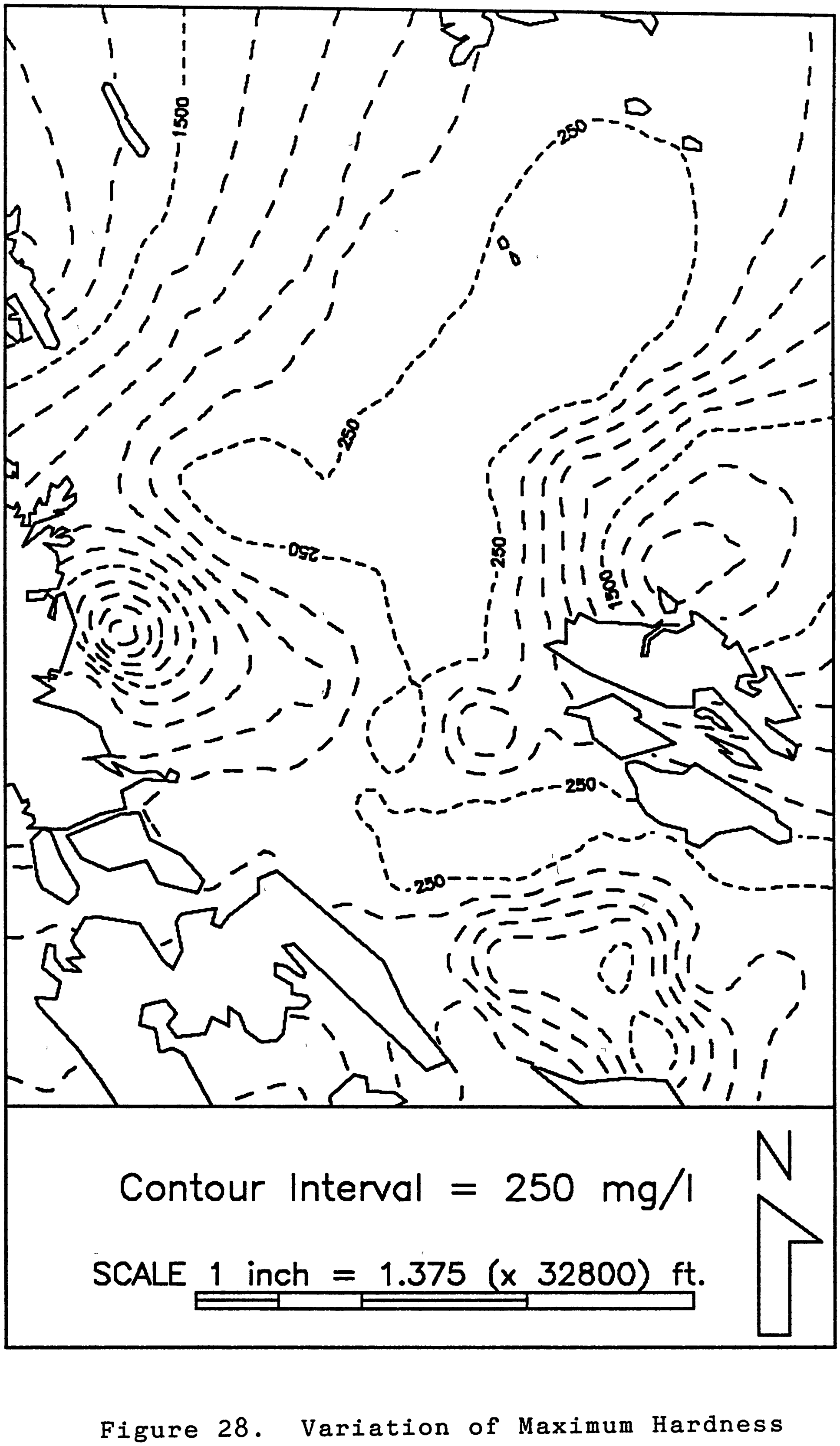


Figure 28. Variation of Maximum Hardness

enough leakage from the rivers and canals to prevent this from occurring.

The maps show that areas of poorest ground-water quality are areas which are located some distance from the Nazas and Aguanaval rivers. Recharge from precipitation in the surrounding mountains is not of quantity sufficient to make its way into the aquifer and dilute the system. It will be shown that this same recharge is also not of sufficient quantity to serve as a rejuvenating factor for the aquifer as a whole or in part. Before extensive agriculture with its demanding irrigation schedule was initiated, ground-water quality was certain to have been better, because there would have been a much lower discharge-to-recharge ratio.

CHAPTER IV

MODEL DEVELOPMENT

As an aid in evaluating the regional impact of widespread pumping throughout the Lagunera, it is necessary to develop a computer-implemented mathematical model that, with the proper site-dependent aquifer input parameters, can be used to study cause-and-effect relationships between pumpage and aquifer response. Critical to obtaining a realistic solution by means of computer modeling is the careful selection of input parameters that best describe the physical system representing the aquifer. Following calibration of the model to the field situation, it is possible to predict future trends in aquifer response to continued pumping.

Site selection is generally based on known problem areas, the end result often being the modeling of a highly localized subset of a hydrologic system. In the case of the Lagunera, however, the problem area encompasses the entire basin. For this reason, it is obligatory to take a regional approach in simulating the physical system.

Where the feasibility of artificial recharge is concerned, computer modeling provides an inexpensive and relatively quick solution to studying the effects that artificial recharge might have on the aquifer, as well as the implied economic impact.

Simulations of the Lagunera region began with the calibration of the model between two known end points. This process served to approximate the regional recharge and discharge (pumping) rates, as well as the establishment of any subregional variability in hydraulic conductivity - one of the prevailing factors in modeling a water table aquifer. This calibration run spanned a time frame of three years, representing conditions that were assumed to be static. That is, there was no change in the water budget for the calibration run.

Four subsequent simulations, each five years in duration, were performed under the same conditions. Eight additional simulations were devised utilizing: a) increases of pumpage of 2.5 percent initiated in 1980 and incremented there after every five years, and b) increases in recharge due to two artificial recharge nodes near the Gomez Palacio - Torreon area. Water-level maps generated by these models are based, of course, on the premise that the original calibration parameters indeed simulate the actual aquifer conditions.

PLASM

It is possible to evaluate ground-water flow through the use of the partial differential forms of equations that form the basis of fluid mechanics. These are the continuuity and energy equations which are based on the conservation of mass and the conservation of energy. These equations in two and three dimensions have general solutions; however, approximate solutions can be obtained through various analytical approaches. One such method is the finite-difference approach, which is based on the discretization and subsequent simultaneous solution of the system. Using this approach, the aquifer is subdivided into discrete nodes of given length and width. To each node is assigned the charactistics that best describe the properties of the aquifer at that location. These properties, upon substitution into the partial differential equations, then become the controlling factors governing the flow of ground water through each respective node. The simultaneous solution of these equations yields a map of head values that relate to a particular time step. Due to the complex nature of this approach, it has proven beneficial to implement this model by computer.

PLASM (Prickett-Lonnquist Aquifer Simulation Model) was originally developed by T.A. Prickett and C.G. Lonnquist for the Illinois State Water Survey (Prickett and Lonnquist, 1971). This model was chosen because (1) it has been widely used and documented, (2) it has been translated into BASIC at Oklahoma State University for microcomputer implementation, and (3) PLASM is extremely versatile.

Calibration of PLASM

Model Inputs

In order to have a means of assigning site-specific characteristics to an aquifer, one must devise a gridding system to superpose over the study area. This grid is composed of cells, which may be either square or rectangular; the size is a function of grid density and scale. The common point of any four cells is referred to as a node and it is to this location that aquifer characteristics are assigned. The perimeter of the grid can be subdivided into groups of nodes such that the boundary conditions of the aquifer, if applicable, are defined. Should the perimeter of the grid not coincide with natural boundaries, such as streams, ground water divides, or confining strata, one may expand the grid such that nodes along the perimeter do not affect those nodes internal to the system being modeled.

The grid constructed for the Lagunera represents a total area of 42.5 X 57.7 miles (68.4 X 92.8 km), which is divided into 924 nodes measuring 1.3 X 2.1 miles (2.1 X 3.4 km). The node size may appear large but, based on the regional scale of the study area and density of data points, is justifiable. Each node was assigned values of hydraulic conductivity, specific yield, head, depth to bottom of the aquifer, and recharge or discharge if applicable. Recharge nodes are generally located along the north, south, and west margins of the grid while discharge nodes reflect well fields. Surface features have been given no flow boundaries while the eastern margin is where underflow exits the region to the east. Interpolated values were used in regions of low well density. The grid is shown in Figure 29.

Initial head conditions (water levels) for the site were obtained from a published water level map (S.A.R.H., 1980). An interpolated water level map for 1977 was derived by subtracting from the 1980 data the change in water levels that had occurred since 1977 (Figs. 30, 31, and 32). Values for specific yield and hydraulic conductivity were assumed on the basis of the subsurface distriibution of lithologies.

Calibration Methods

The goal of calibrating a model to a specific site generally involves a trial-and-error establishment of equilibrium (steady-state) conditions. Upon reaching equilibrium, the system is stressed by changing certain input parameters, such as withdrawal and recharge. Under ideal conditions, data such as recharge, discharge, and specific yield derived from aquifer tests are available. Utilizing these data as input criteria, the model is then run for a period of time corresponding to the period required to reach calibration. If computed water levels match the actual head values within an acceptable range of

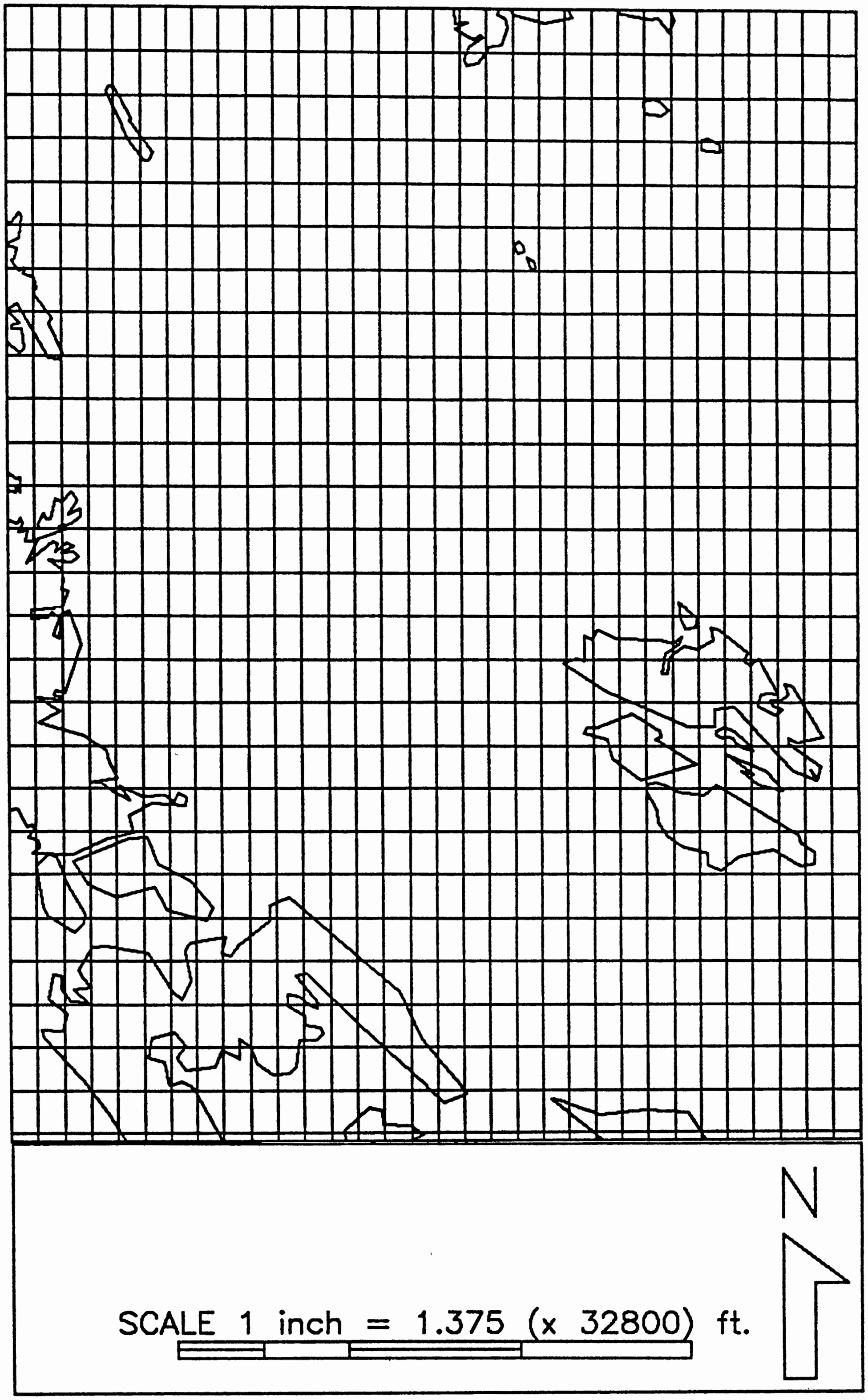


Figure 29. Location of PLASM Nodes

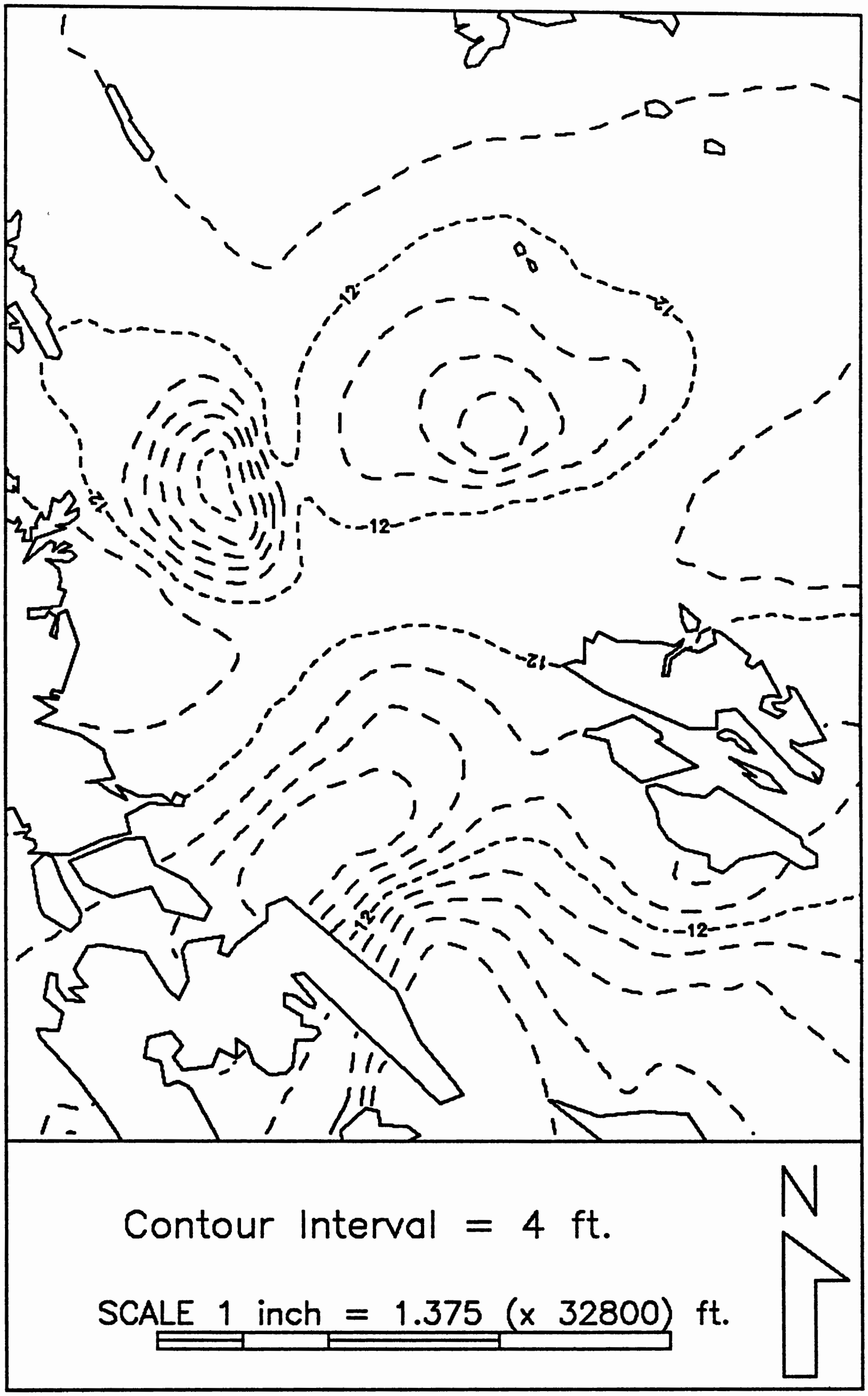


Figure 30. Change in Water Levels, 1977 - 1980

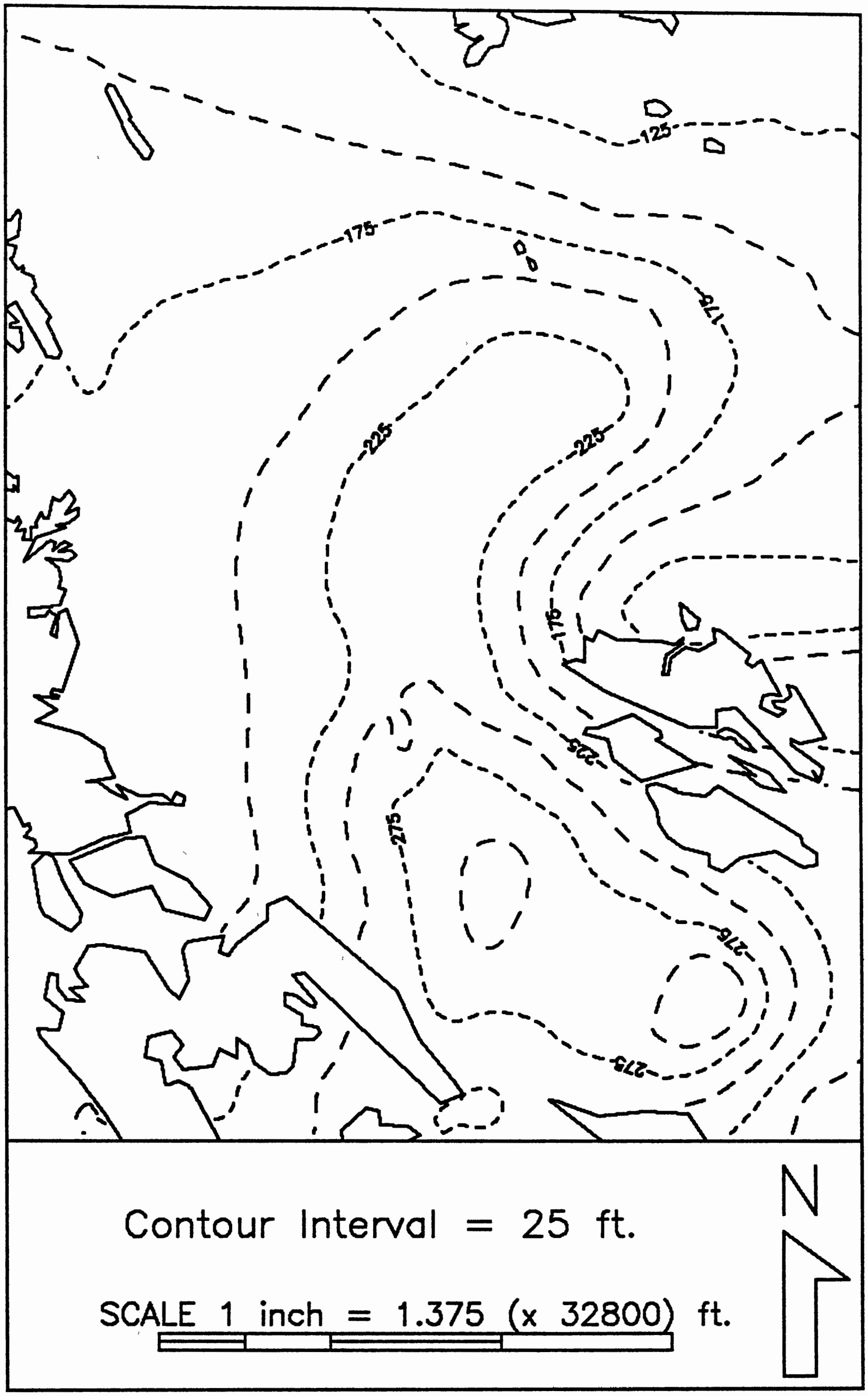


Figure 31. Depth to Water Table, 1980

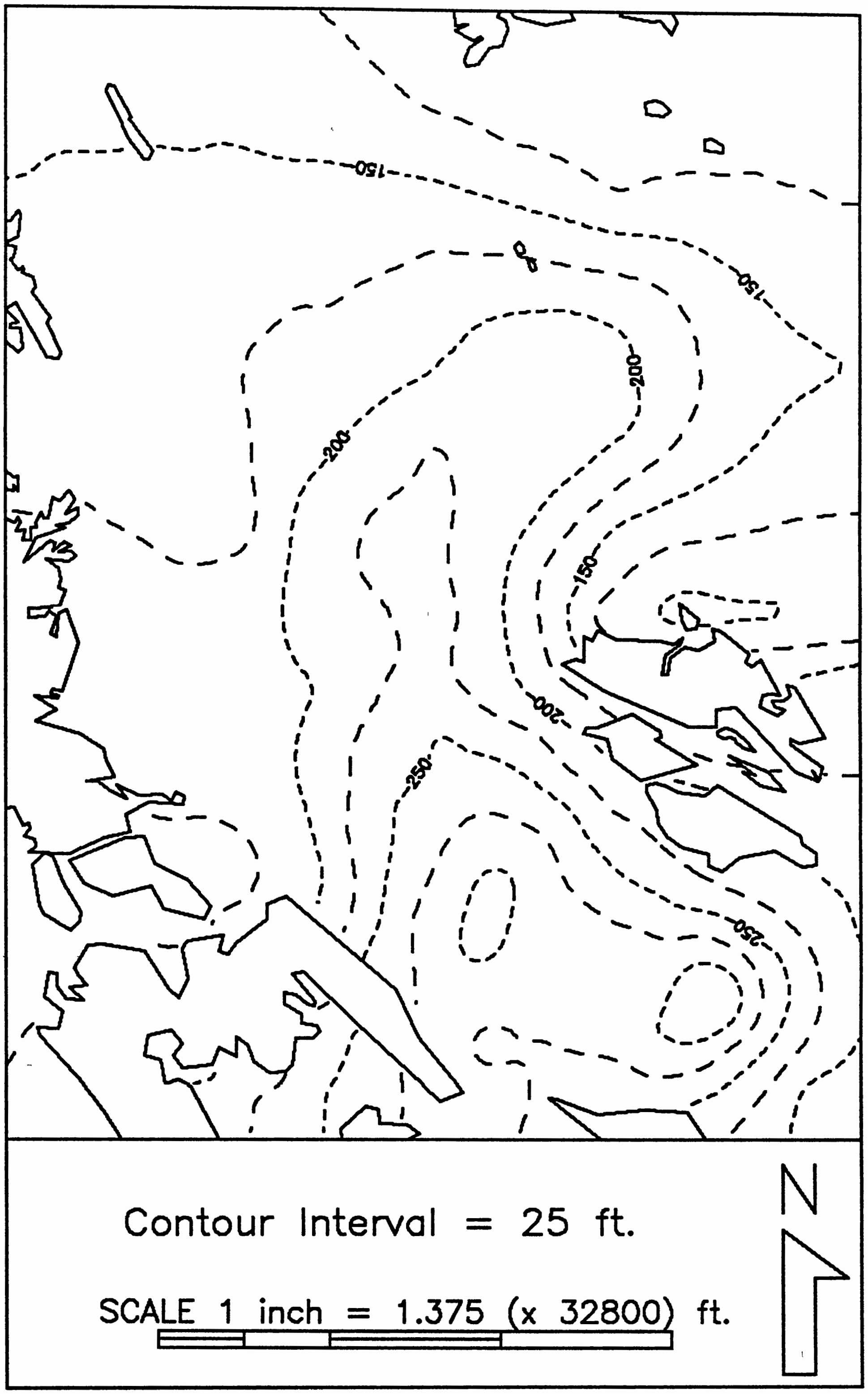


Figure 32. Interpolated Depth to Water Table, 1977

error the model is assumed to be calibrated.

When data are either not available or are insufficient to allow a "standard" calibration, other avenues must be explored. In the case of the Lagunera, the only known parameters in order of decreasing reliability are water levels for 1977 and 1980, lithology, and depth to the base of the aquifer. As previously mentioned, values for the the hydraulic conductivity of each lithology, with the exception of gravel, are assumed. A logical approach, therefore, entails performing a lithology-dependent calibration between two known water levels. This approach implies that if input parameters can be varied such that computed head values match observed head values, then recharge and discharge rates must necessarily fall within an order of magnitude of the actual recharge and discharge rates since they are dependent on the assumed hydraulic conductivities throughout the basin. In other words, this trial-and-error solution must be accepted as "unique" within the definition of the problem. Starting point withdrawal and recharge rates were based on data given by the various government agencies in the Lagunera District. This served to narrow the range of initial possibilities.

Model Projections

Water-level maps, based on the original 1977 - 1980 calibration water budget, were constructed in increments of five years through the year 2000. The evolution and modification of preexisting cones of depression, which represent major pumping centers, are shown in Figures 33 - 36. By visual inspection alone one can see that the basin is operating on a negative hydrologic budget. Figures 37 through 40 indicate that even modest increases in pumpage, amounting to only 2.5 percent implemented in segments of five years, have a discernible negative impact on water levels. Based on the calibration water budget the discharge and recharge rates were established to be approximately 20.8 billion ft.^{3} (590 million m^3) and 1,400 million ft.^{3} (39 million m^3), respectively. The modeled discharge rate is 2.1 billion ft.^{3} (60 million m^3) less than the 23 billion ft.^{3} (650 million m^3) reported by the Department for Investigation, Development and Agricultural Health for the Laguna Region and well below the 3.8 billion ft.^{3} (1100 million m^3) reported by the Office of the Secretary of the Laguna Region. Regional recharge appears to be only 20 per cent of the most conservative estimate by the same agency. Parameters used to calibrate PLASM for the 1977-1980 interval are found in Appendix C.

Natural Recharge

Typically, natural recharge to an aquifer entails a number of processes. In the plains regions, recharge can occur as infiltration into the ground and consequent percolation to the underlying aquifer. Recharge in these regions can also result from the seepage of water from

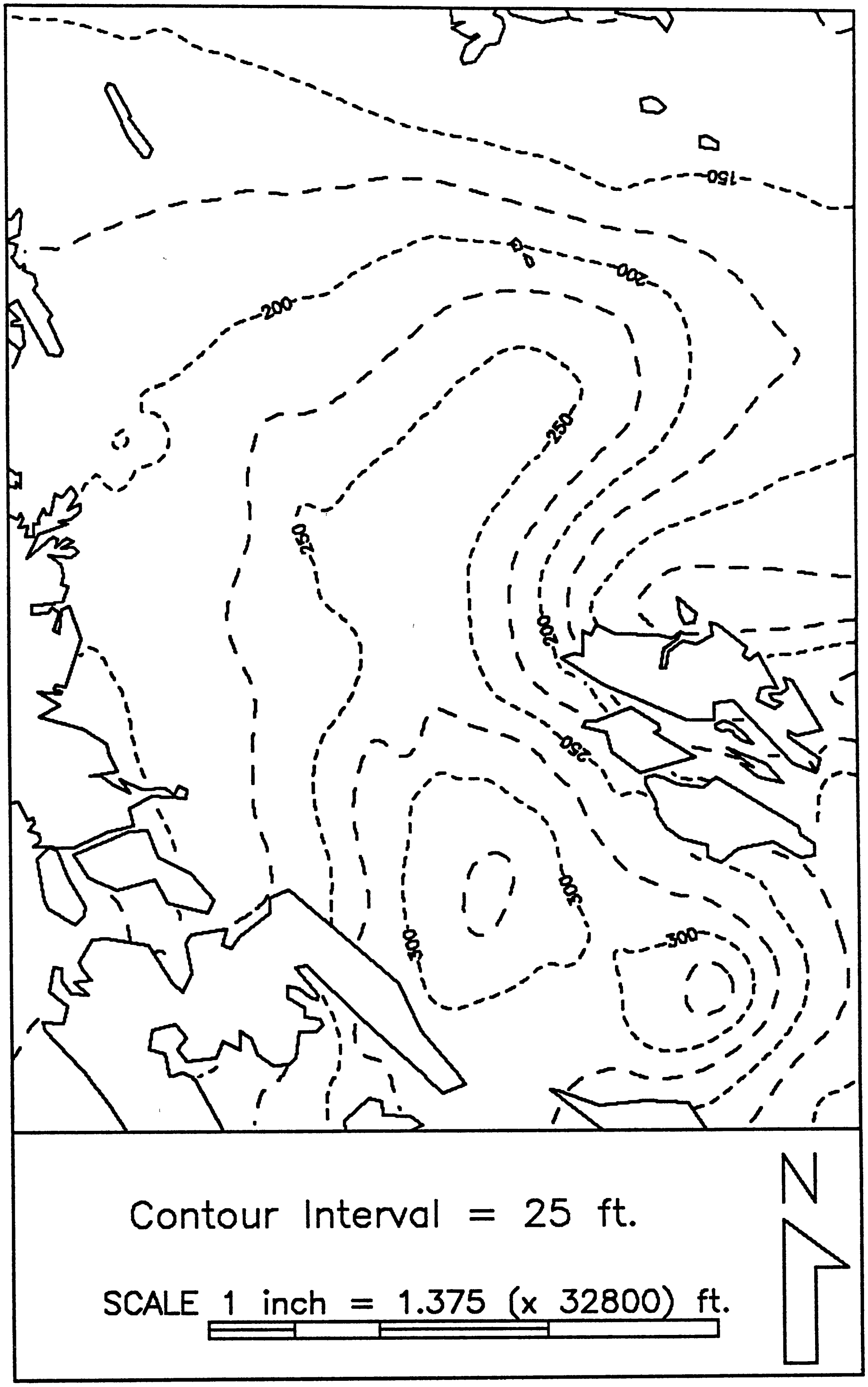


Figure 33. Projected Water Levels, 1985

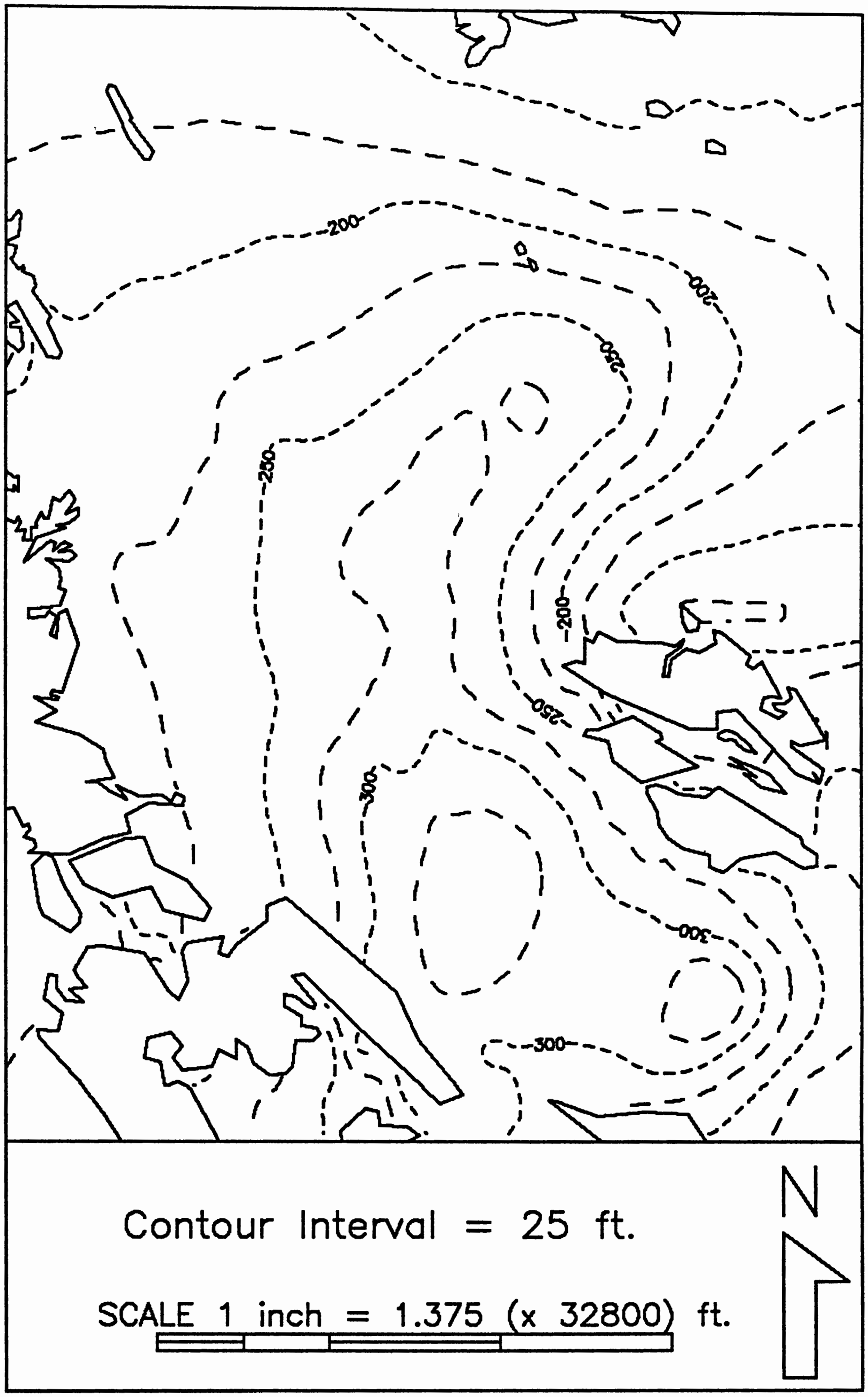


Figure 34. Projected Water Levels, 1990

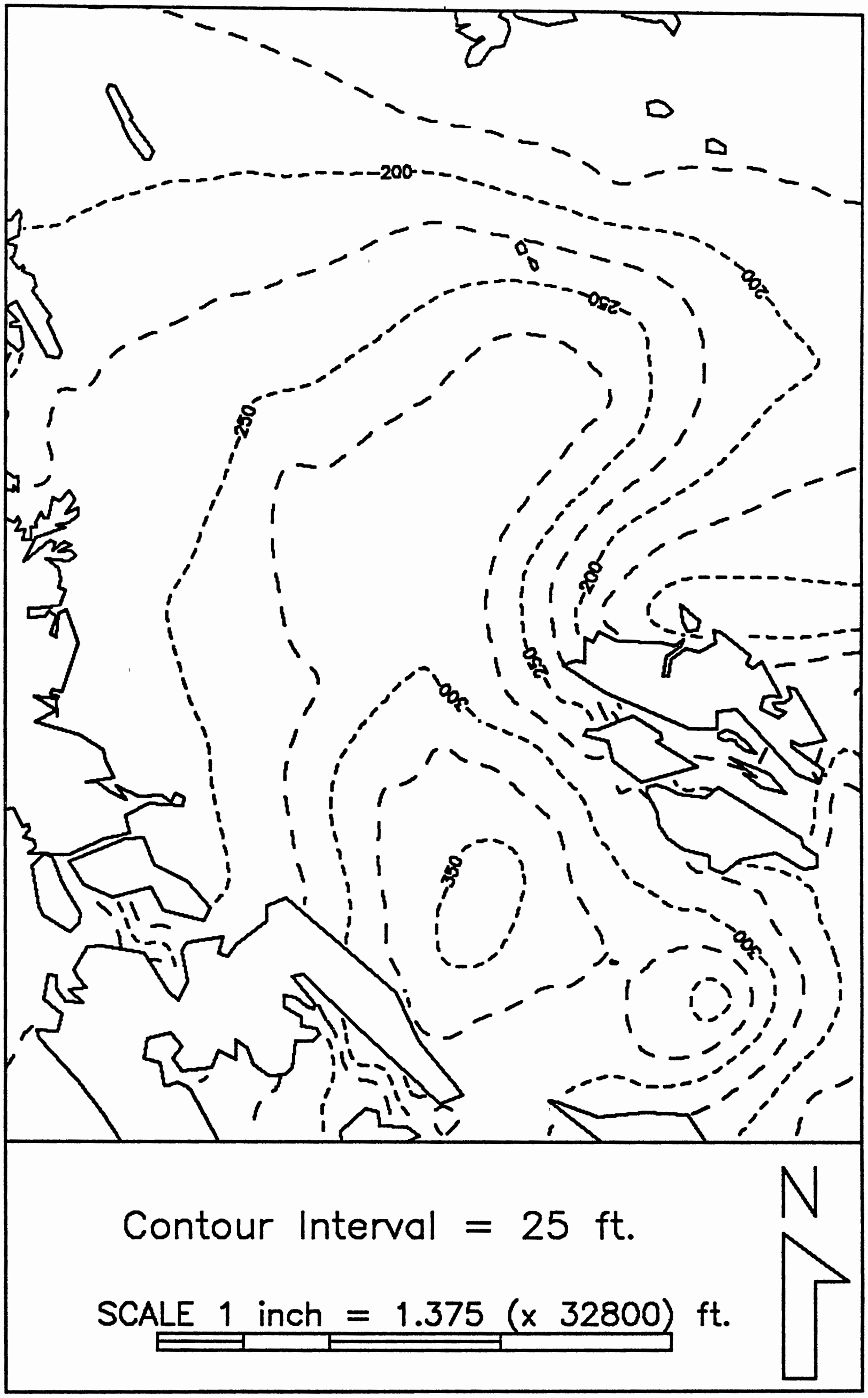


Figure 35. Projected Water Levels, 1995

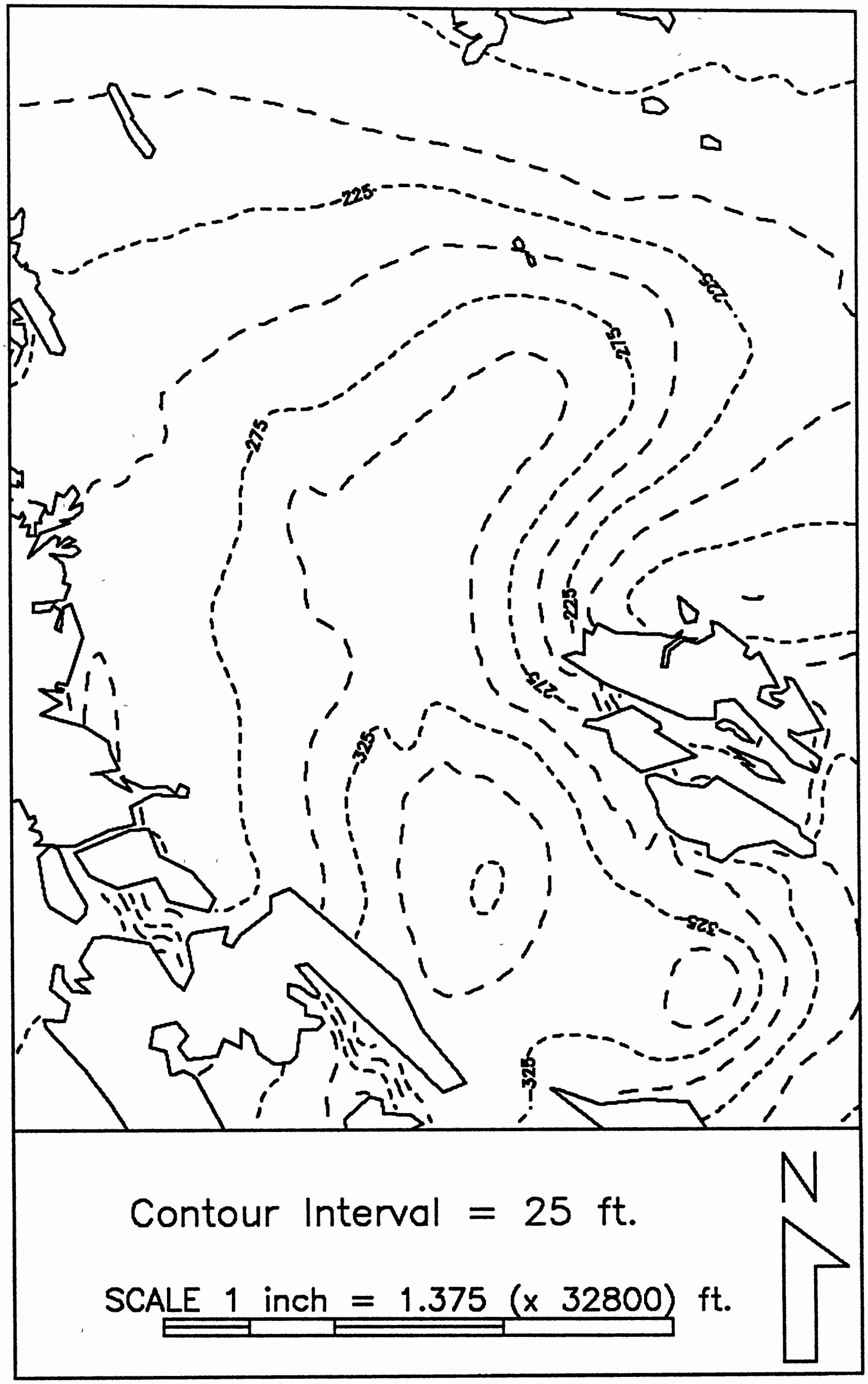
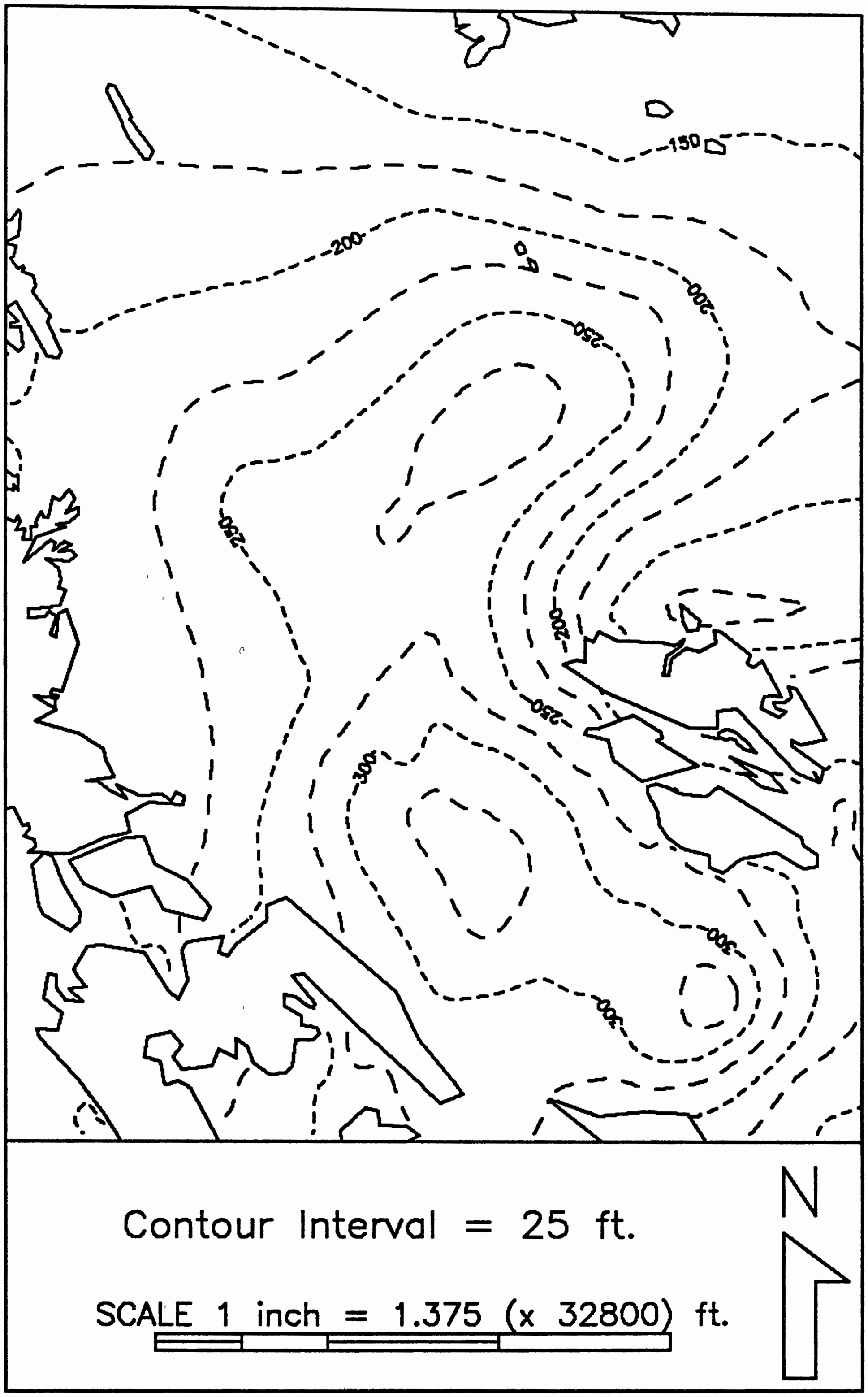
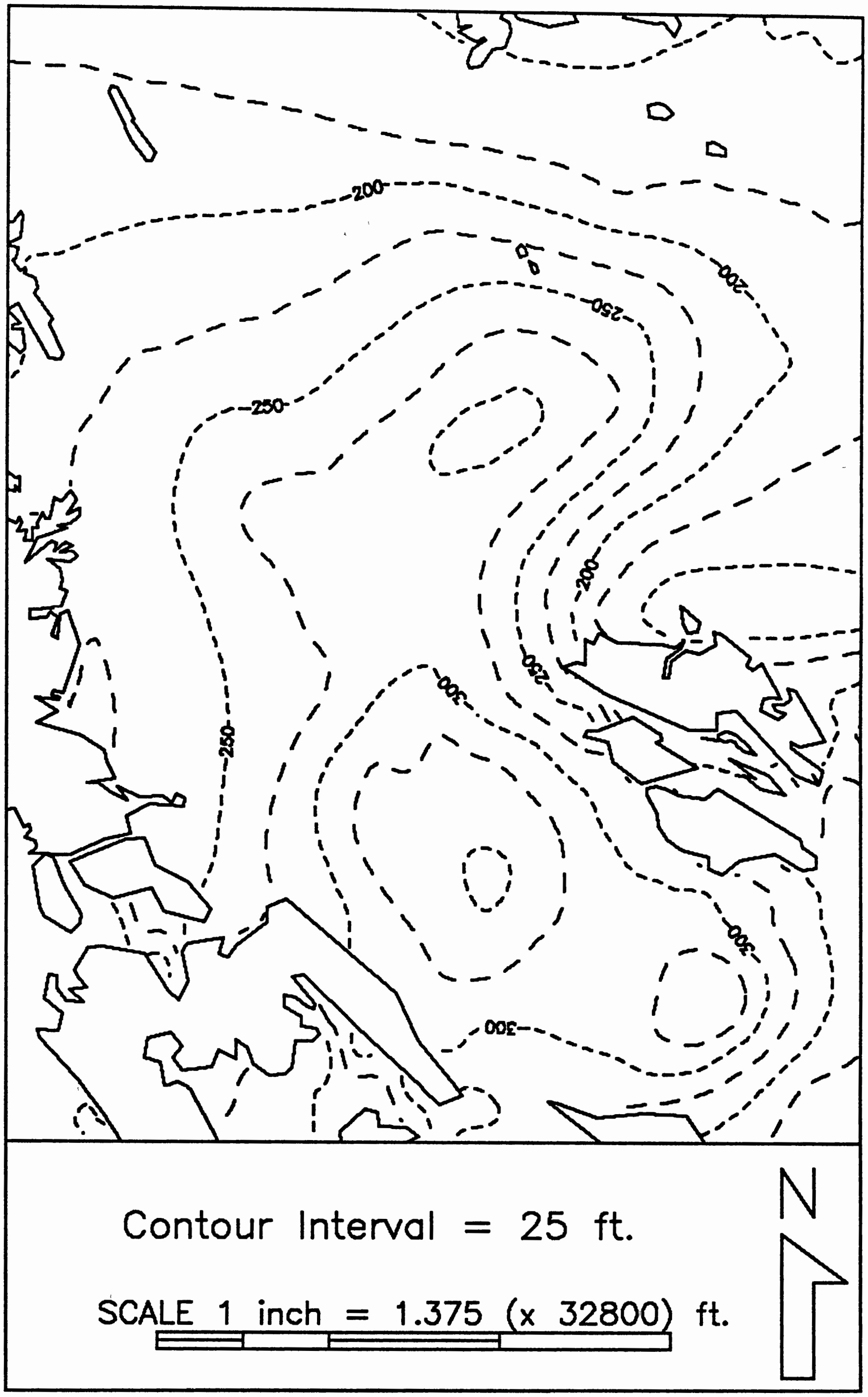


Figure 36. Projected Water Levels, 2000



.Figure 37. Projected Water Levels with Increased Pumpage, 1985



. Figure 38. Projected Water Levels with Increased Pumpage, 1990

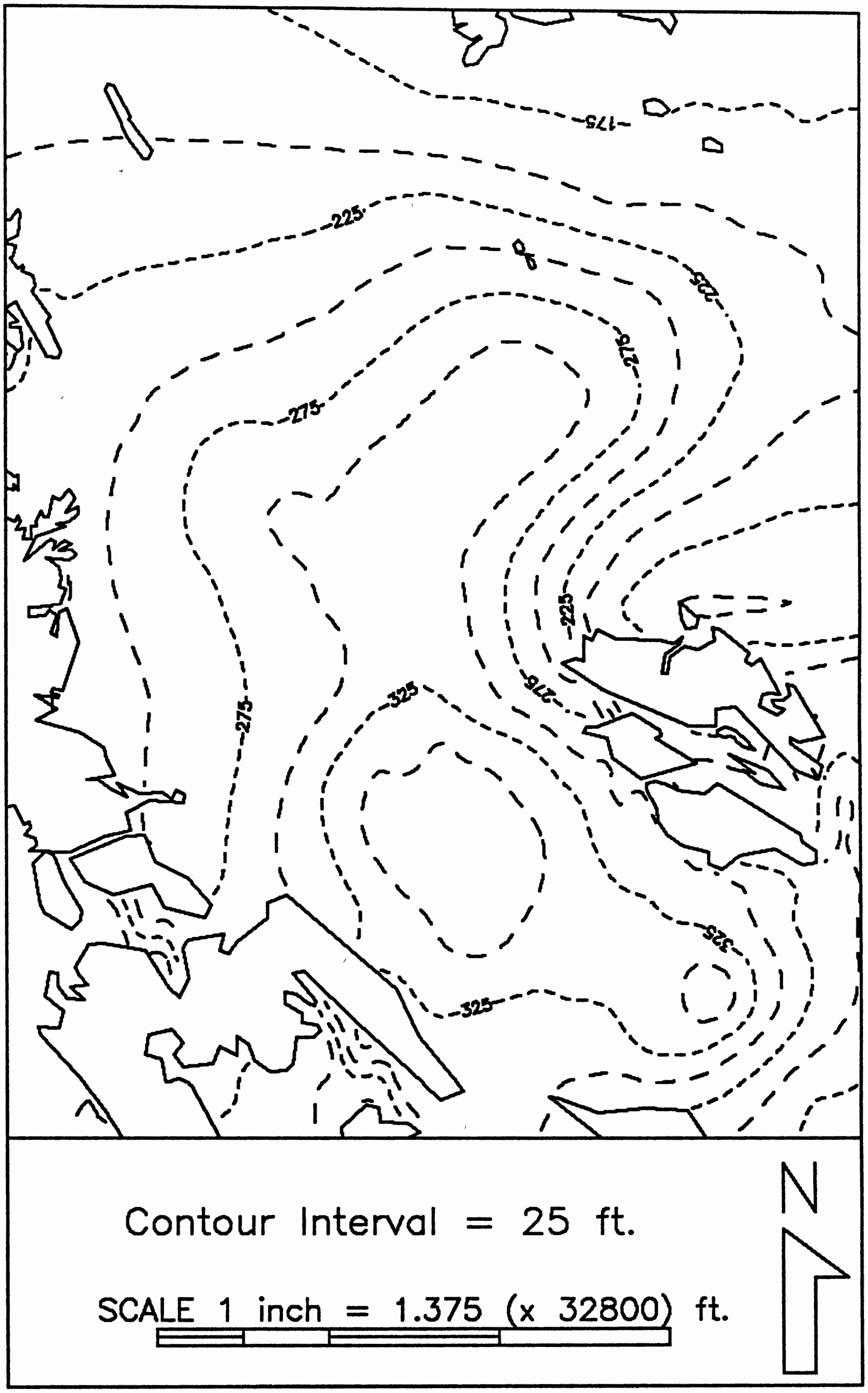


Figure 39. Projected Water Levels with Increased Pumpage, 1995

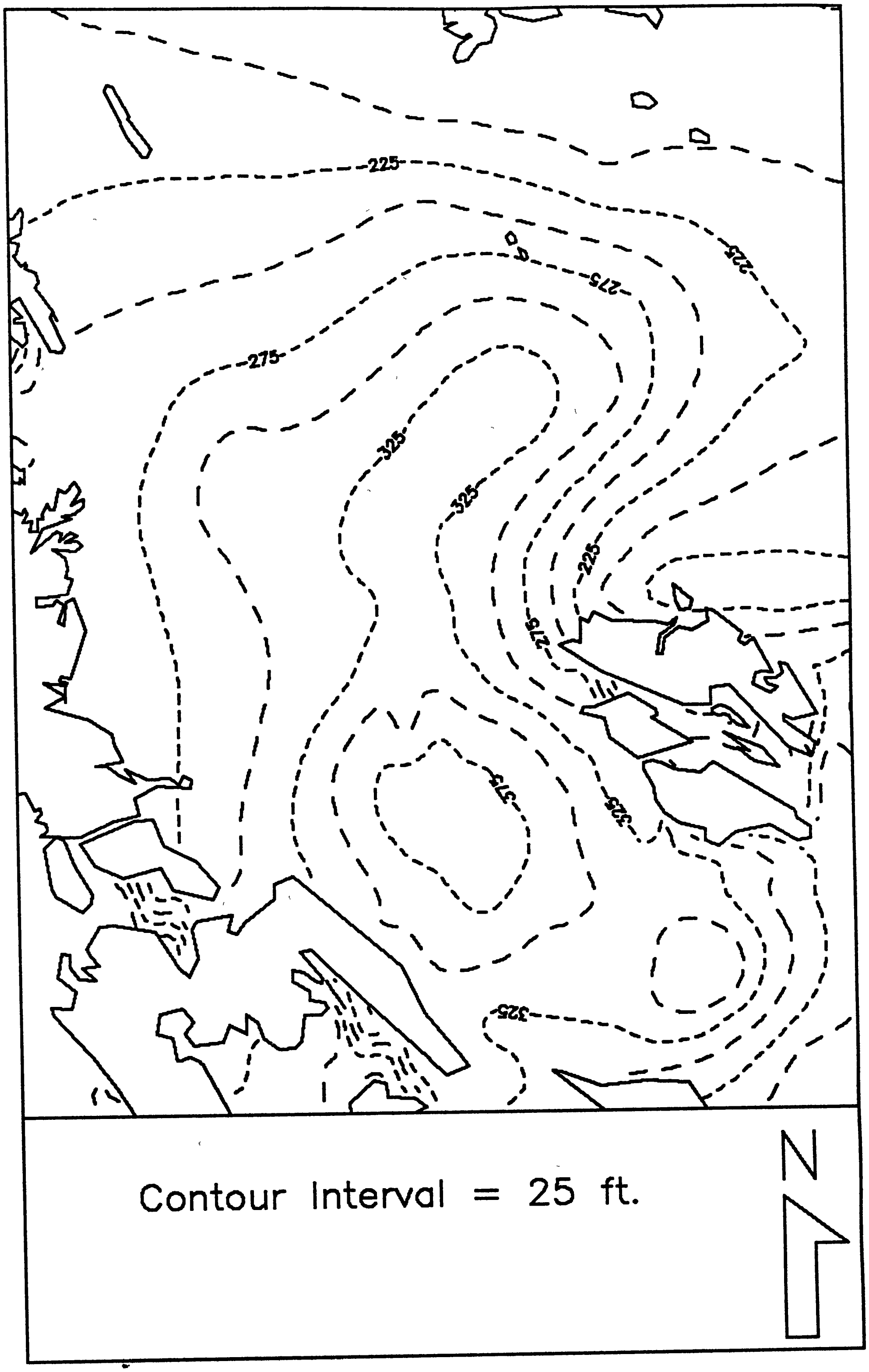


Figure 40. Projected Water Levels with Increased Pumpage, 2000

streams. Both of these are only effective when the aquifer is relatively shallow. In mountainous regions aquifer recharge can occur as a result of infiltration and consequent percolation of precipitation runoff into alluvial fans located at the mountain-plain interface. Of course, recharge by ephemeral streams follow the same processes as already outlined.

Effects of Artificial Recharge

As a test to determine the impact of artificial recharge at a specific area, two recharge nodes were established near Gomez Palacio (Fig. 41). To illustrate the magnitude of the ground-water deficit in the basin, the following scenario was constructed. Consider an annual rainfall total of 7.9 in. (200 mm.) occurring over a total area of 11.6 mi.^{2} (30 km.^{2}). Of this total area, approximately half can be represented by the Sierra el Sarnoso mountains, which lie to the northwest of Gomez Palacio, and the remainder being represented by the Sierra los Noas mountains to the southeast. Assume that 100 percent (the best case scenario) of the annual precipitation can be captured at each location and introduced into the recharge nodes at the rate of approximately 294,117 ft.^{3} (8,218 m^3) per day. This approach makes it possible to model the direct effect of artificial recharge by using two new nodes as input parameters to PLASM.

Four predictive runs were made assuming constant pump-

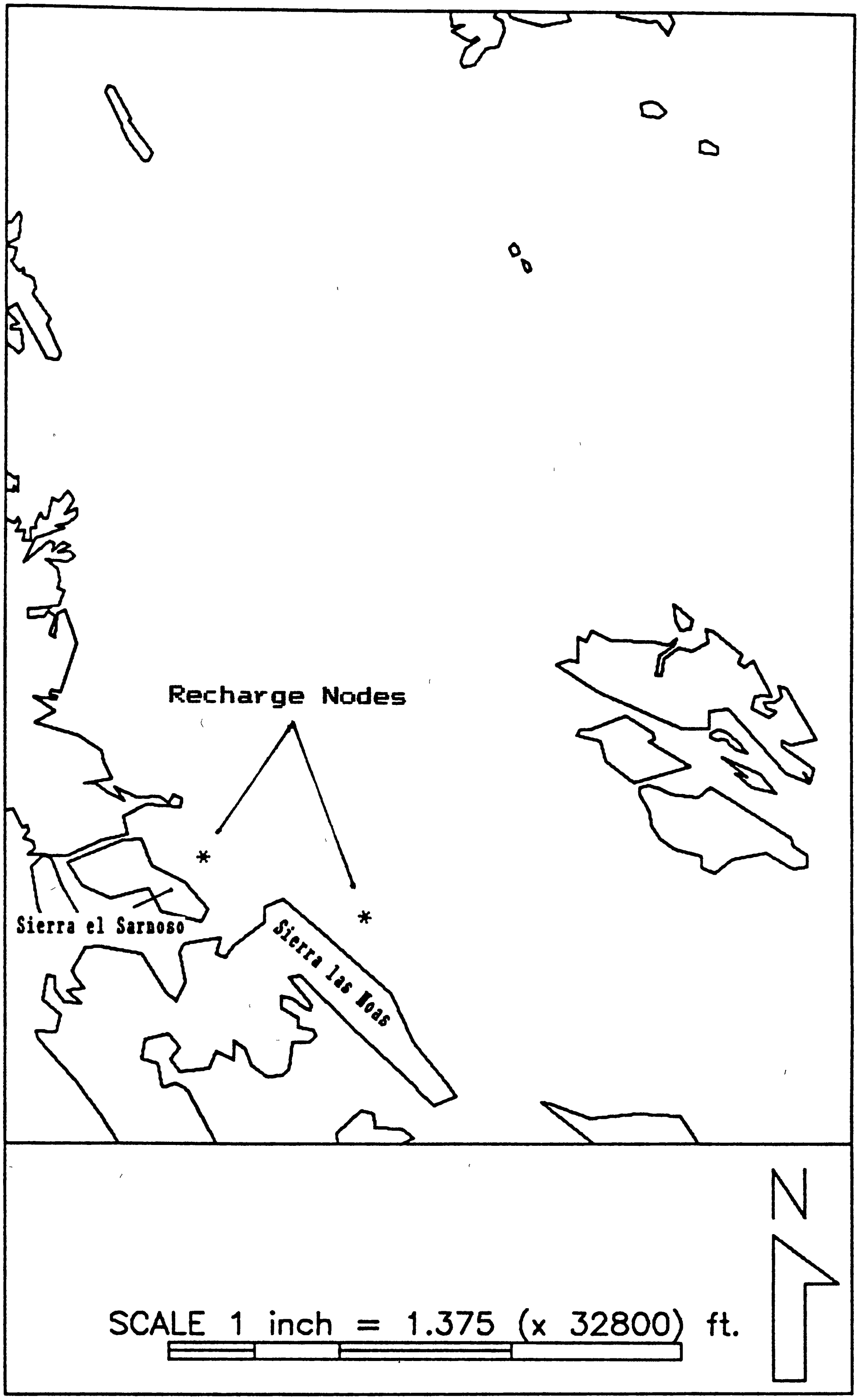


Figure 41. Location of Recharge Nodes

age (static) conditions in five year increments. As can be seen in Figures 42 to 45, the contribution made by artificial recharge is indiscernible. This then suggests that artificial recharge is not the sole answer to the groundwater deficit in the study area.

Summary of Model Projections

Calibration Budget Projections

Two major cones of depression can be seen in the 1977 and 1980 water level maps. These depressions correspond to the Gomez Palacio - Torreon and Matamoros well fields. They are of approximately the same areal extent and gradient. Model projections for 1985 indicate that the depression near Matomoros has decreased in size to approximately one half that of 1977 and has increased in gradient. The depression near Gomez Palacio and Torreon has increased about twofold in areal extent and decreased in gradient.

In 1990 projections an additional cone of depression has developed in the north-central portion of the basin near the city of Francisco I Madero. The areal extent of the Matamoros cone of depression has increased to approximately its 1980 size but has increased in its depth to water. The Gomez Palacio - Torreon cone of depression has continued to increase in extent, as well as depth to water, and is now linked to the Matamoros cone by the 300 foot contour level.

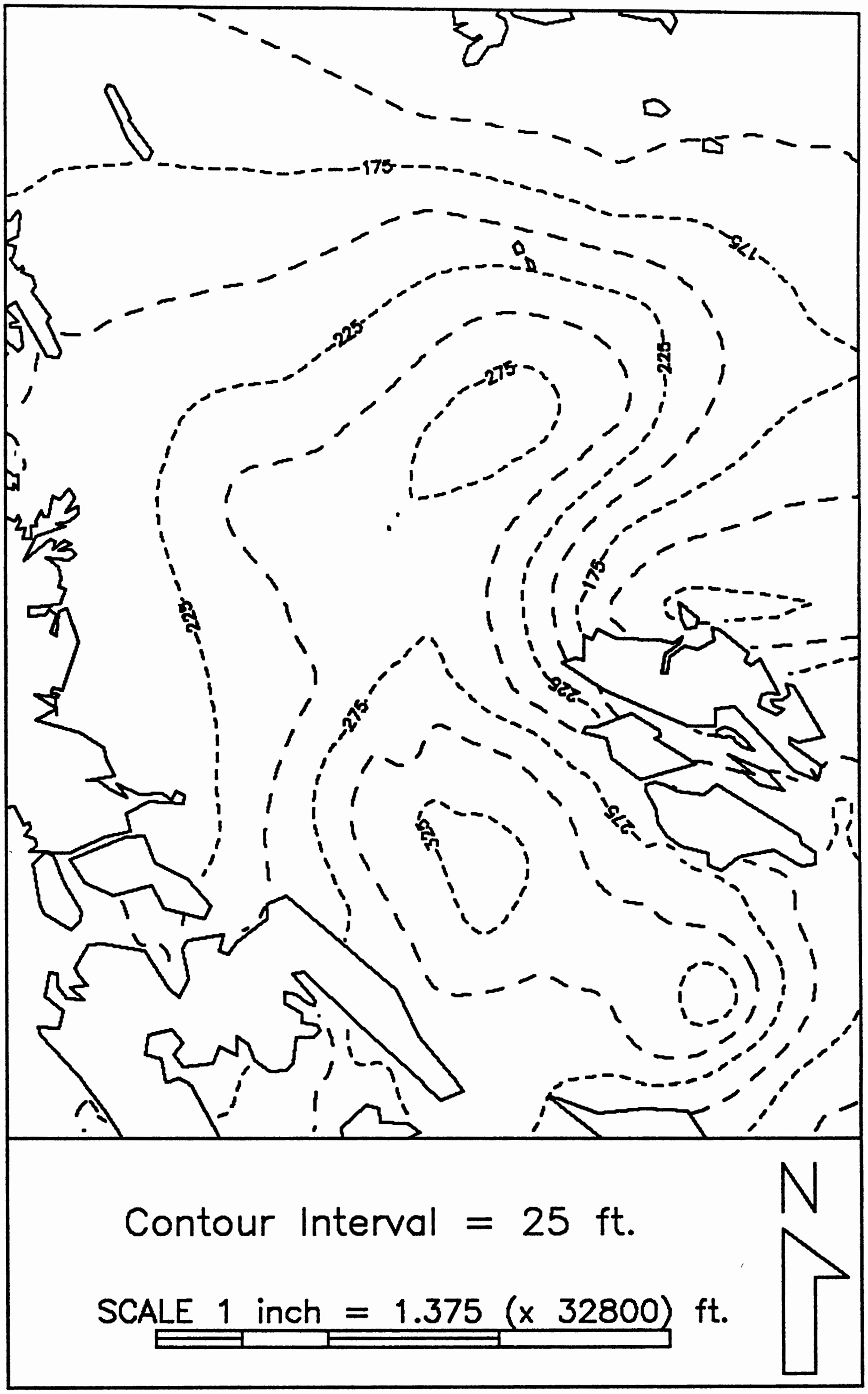
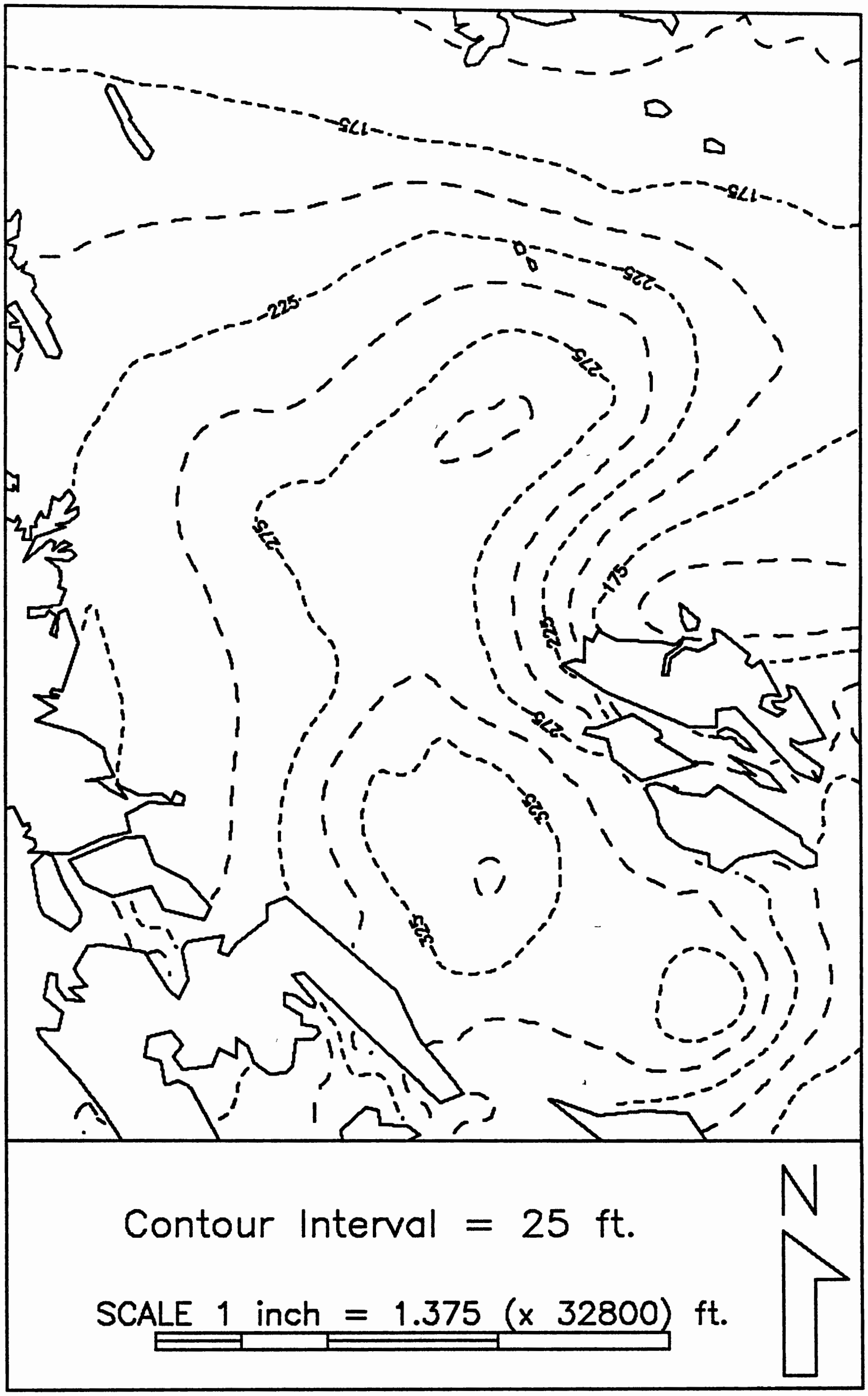
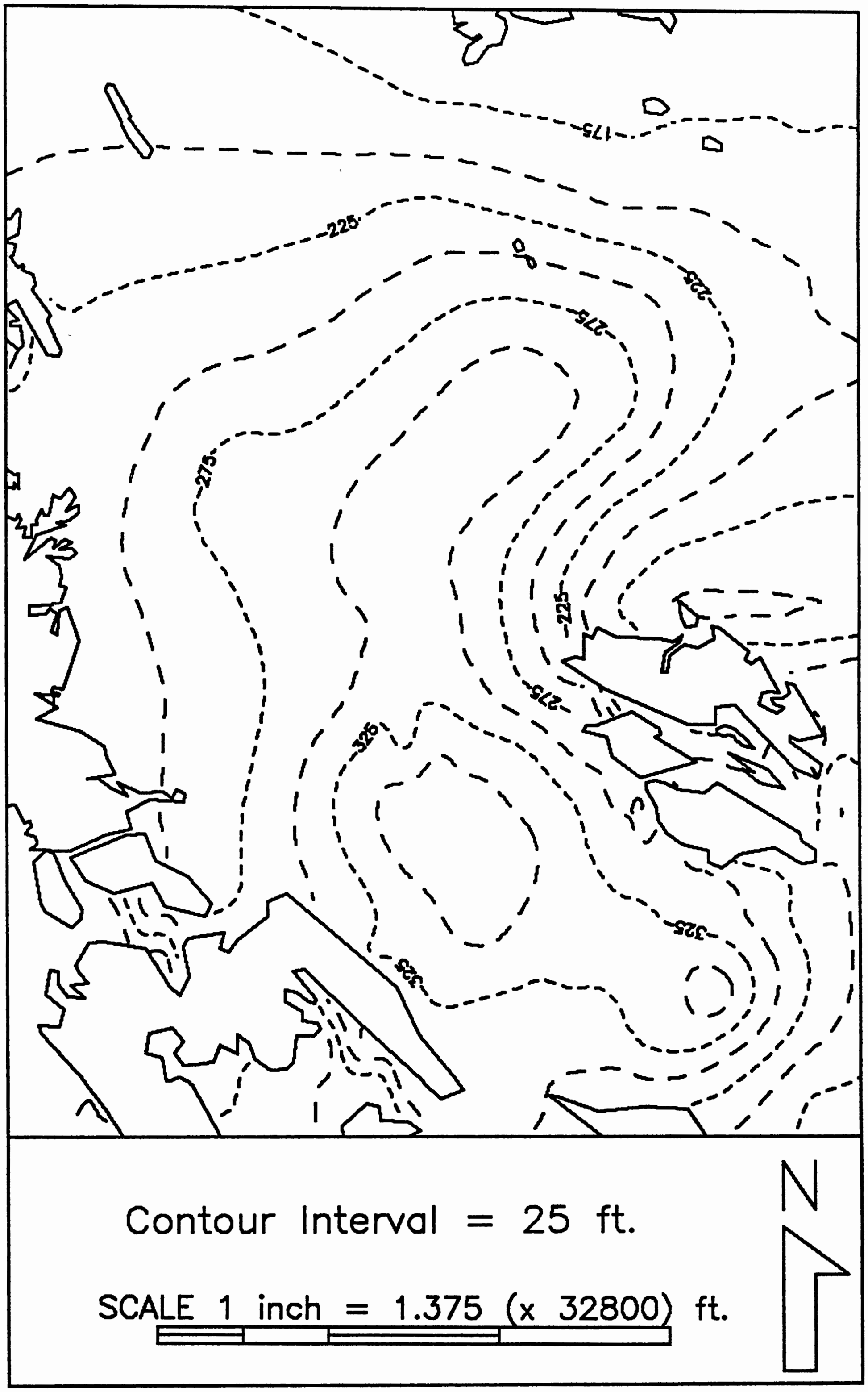


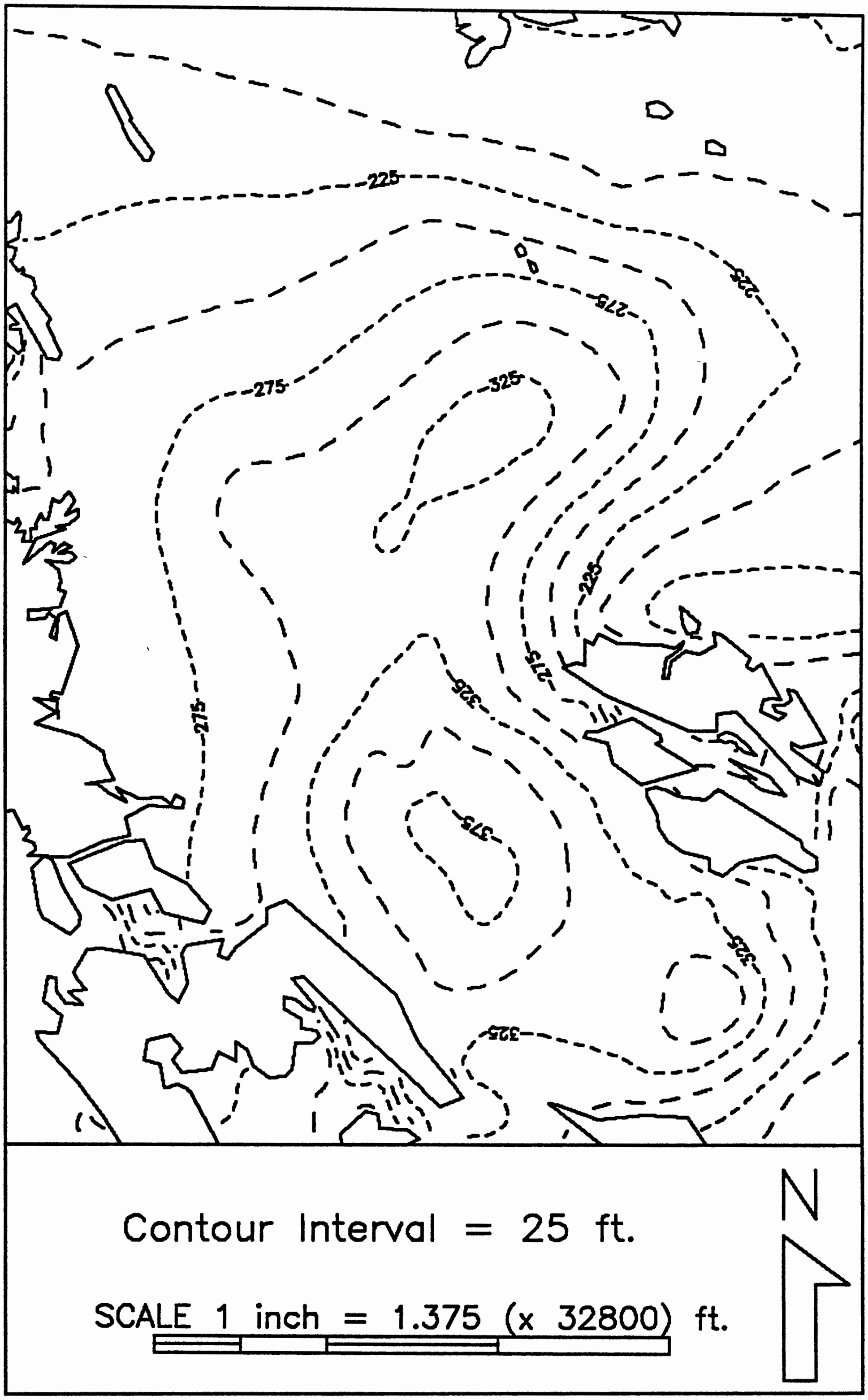
Figure 42. Projected Water Levels with Artificial Recharge, 1985



··Figure 43. Projected Water Levels with Artificial Recharge, 1990



. Figure 44. Projected Water Levels with Artificial Recharge, 1995



·Figure 45. Projected Water Levels with Artificial Recharge, 2000

The 1995 predictions show the constant increase in both size and gradient of the cones of depression in the southern portion of the basin while that in the north-central region has been incorporated into a large area outlined by the 300 foot contour. By the year 2000, the entire basin shows an increase in depth to water of almost 100 feet with depths exceeding 375 feet in places.

Increased Pumpage Projections

Projected water levels based on a modest increase in discharge rates indicate that the cone of depression appears earlier (1985 vs. 1990) in the north-central portion of the region. The Gomez Palacio - Torreon, and Matamoros depressions are more extensive and have increased in depth to water. For the year 2000, for example, the 375 foot contour near Gomez Palacio and Torreon is approximately 10 times that of the same year projection based on the calibration pumping rate. This indicates the fragile nature of the basin's water supply.

Artificial Recharge Projections

As previously mentioned, projections based on constant pumping with two artificial recharge nodes were modeled. The pumping rates used were those used for the increased pumpage projections. Results indicate that virtually no differences can be seen between the two sets of predicted water level maps. Not until the year 2000 can it be seen that the areal extent of the 375 foot contour level in the Gomez Palacio - Torreon cone of depression is approximately one half that of the predictions made without artificial recharge.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

The Lagunera district is in the western part of the Parras Basin in the high central plains of northern Mexico. Although the region is subject to an arid climate it is, nevertheless, extensively cultivated. This irrigated region relies primarily upon ground water and, to a lesser degree on surface water that is distributed through lined canals. Since the volume of water removed through wells exceeds the rate of natural recharge, an annual ground-water budget deficit exists. Among other things, ground-water recharge is inhibited by a low annual rainfall. Government agencies have estimated the rate of withdrawal for the agricultural seasons 1977-78 and 1978-79 at between 12,358 million to 43,573 million ft.^{3} (350 million to 1,234 million m^3). Calibration of PLASM places withdrawal and recharge at approximately 20,800 million and 1,371 million ft.^{3} (590 million m^3 and 39 million m^3), respectively. Aquifer recharge is only 20 percent of the most conservative estimate made by the Office of the Secretary of the Laguna Region.

At one time, Rio Nazas served as a major source of recharge to the basin fill as it flowed generally eastward through Torreon and then to the lowest part of the lake plain, where the water evaporated. The effect of this major water course is well represented by both the nature of the valley fill in the vicinity of its course and by the chemical quality of water in the same general area. Owing to the construction of upstream dams and irrigation canals, however, the river is now controlled to such an extent that only under the most severe weather conditions does water actually flow in its channel through or beyond Torreon. In addition, all of the irrigation canals are lined in order to prohibit leakage. Consequently, neither the river nor the canals presently serve as sources of recharge to the valley-fill deposits.

Computer simulations indicate that even with a zero population growth, the depth to water will continue to increase at the rate of approximately 10 feet (3 meters) per year. Furthermore, additional simulations of the regional ground water budget indicate that due to the small quantities of precipitation, artificial recharge would have little discernible effect on the declining water levels. With the annual increase in depth to ground water comes the complicating factor of decreased water quality on a regional basis. Water quality is being affected by excessive concentrations of several naturally occurring inorganic components. The most significant of these is arsenic, which has rendered many wells unusable even for irrigation. High concentrations of arsenic in the northern part of the study area have resulted in a ground-water source that is toxic to man, beast, and crops. The dilution of inorganic constituents via mixing from natural recharge is practically absent except in those areas flanking the Rio Nazas.

Conclusions

Computer modeling of the ground water and mapping of water quality led to the following conclusions:

1. ground-water withdrawals within the Lagunera region exceed regional natural recharge rates by a factor of 15 to 1
2. conservative increases in stress in the form of pumpage result in discernible changes in ground water levels
3. artificial-recharge techniques that depend on precipitation as a source would be ineffective because of the small amount of rain and degree of ground-water withdrawal
4. ground-water quality will continue to deteriorate with the progressive drawdown and the enlarging size of the major overlapping cones of depression
5. the areal extent of ground water with low mineral content will continue to decrease with time and pumpage

6. a pumpage-induced concentration gradient has enhanced the subsurface transport of arsenic into the northern portion of the basin

To summarize, the Lagunera region is operating with a negative ground-water budget which continues to worsen with time. With increasing pumpage and depth to ground water, the chemical quality of the water will suffer as well.

Due to the nature of the basin, it is not expected that the physical factors governing the supply of ground water will change. For all practical purposes the Lagunera is limited to the volume of water that is stored in the underlying basin.

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APPENDIX A

REGIONAL WATER ANALYSES

WELL NUMBER	DATE OF ANALYSIS	pH	CONDUCT. (M-MHOS)	TEMP. (DEG.C.)	ALKALINITY (CaCO3) (mg/l)
17	07-27-77	8.00	820	26	164
17	07-21-81	8.05	620	30	168
17	09-15-82	7.70	530	26	138
17	04-11-83	7.75	880	21	160
34	08-24-77	7.70	1600	29	148
34	06-08-82	7.87	1600	27.5	116
158	08-12-77	8.10	660	26	120
158	05-06-82	8.05	810	26	96
158	04-12-83	8.05	430	21	100
192	08-10-77	7.70	1250	27	148
192	07-21-81	7.95	640	30	152
192	04-11-83	7.95	1158	21	156
209	06-27-77	7.30	850	23	160
209	07-27-77	7.30	1850	27	164
209	08-30-77	8.00	1820	24	168
209	04-11-83	6.73	1740	21	162
257	07-29-77	7.50	1700	26	160
268	07-29-77	7.70	400	26	116
268	08-15-77	8.00	370	26	124
268	08-13-81	8.10	300	28	124
268	08-31-81	8.00	280	27	123
268	03-02-82	7.90	480	23	128
268	05-06-82	8.20	350	26	132
268	04-18-83	8.27	350	27	118
281	08-15-77	7.90	650	26	124
281	10-07-77	7.80	760	27	116
281	10-07-77	8.00	910	27	112
281	10-07-77	8.00	750	27	120
281	02-08-82	7.70	1100	20	-
281	04-28-82	7.66	950	25	128
281	05-06-82	8.14	840	26	128
281	06-04-82	7.66	950	25	128
281	07-13-82	6.35	815	28	114
281	04-18-83	7.84	1070	27	130
350	08-04-77	8.00	460	25	180
350	09-02-77	8.00	355	24	136
350	05-03-83	8.01	351	27	146
431	09-02-77	8.10	295	24	144
431	05-03-83	8.27	308	27	120
442	05-06-82	7.84	1570	26	168
442	12-13-82	6.90	1600	28	166
443	04-21-82	7.95	370	25.5	146
598	06-17-77	7.90	1600	25	80
598	06-28-77	7.60	1620	27	68
598	08-01-77	7.40	1680	27	60
598	09-14-77	7.90	1700	24	80
598	04-18-83	8.09	2000	27	56
752	07-15-77	7.70	440	26	120
752	08-05-77	8.10	430	26	104
752	09-22-81	7.95	410	28	91

WELL NUMBER	DATE OF ANALYSIS	pH	CONDUCT. (M-MHOS)	TEMP. (DEG.C.)	ALKALINITY (CaCO3) (mg/l)
752	10-26-81	7.00	450	21	100
752	03-11-82	8.02	1800	26	112
752	04-21-82	8.02	600	25.5	100
752	07-19-82	7.86	445	25	104
752	09-17-82	8.05	543	26	108
760	08-05-77	7.70	2500	26	236
760	04-20-82	8.13	280	25	106
760	09-17-82	8.25	291	26	116
762	08-18-77	7.70	2200	27	148
801	08-08-77	8.30	305	25	112
836	08-05-77	8.30	1950	26	156
852	08-24-81	8.65	230	29	106
852	08-25-81	8.65	230	29	107
852	10-29-81	7.30	-	21	112
852	11-16-81	8.30	280	22	112
852	03-11-82	8.15	460	26	122
852	04-15-82	8.20	395	27.5	110
852	09-17-82	8.30	232	26	118
852	04-20-83	8.40	260	27	116
860	05-31-77	7.30	2200	26	164
860	04-20-83	8.45	310	27	104
900	08-16-77	7.10	3400	28	144
900	08-24-81	7.50	4000	29	196
900	08-25-81	7.50	4000	29	196
900	09-25-81	8.20	980	28	160
900	10-30-81	7.20	3800	24	228
900	03-11-82	7.60	3800	26	196
900	04-14-82	7.20	3800	28	186
900	06-01-82	7.10	3800	30	168
900	07-20-82	7.30	4000	25	182
900	04-20-83	7.48	3400	27	194
975	05-31-77	8.10	690	26	132
975	04-27-82	8.36	450	26.5	136
975	05-25-82	8.35	420	29	128
975	10-08-82	8.19	375.1	26	132
975	05-03-83	8.04	1030	27	130
1000	06-22-77	7.90	660	28	100
1000	08-19-77	8.45	650	27	156
1000	08-24-81	9.60	760	29	92
1000	08-25-81	9.60	760	29	92
1000	09-24-81	8.00	950	28	108
1000	03-11-82		740	27	121
1000	04-28-82	8.40	700	26.5	108
1000	05-25-82	9.12	670	29	102
1000	10-08-82	8.60	542.3	26	98
1000	05-03-83	8.31	560	27	110
1017	08-19-77	8.15	1260	27	144
1017	04-15-82	7.58	285	27.5	106
1017	05-26-82	8.45	310	29	110
1097	12-01-77	8.00	980	16	100

WELL NUMBER	DATE OF ANALYSIS	pH	CONDUCT. (M-MHOS)	TEMP. (DEG.C.)	ALKALINITY (CaCO3) (mg/l)
1097	05-22-81	7.50	1105	22	177
1097	04-20-83	8.45	590	27	124
1162	11-23-77	8.10	2400	-	180
1165	07-14-77	7.50	6000	27	164
1165	08-09-77	7.70	4750	25	148
1212	07-19-77	7.70	1250	25	123
1212	08-08-77	8.30	775	25	136
1212	09-10-81	7.55	1750	28	110
1212	09-25-81	7.80	3800	28	166
1212	10-23-81	8.10	980	21	100
1212	02-25-82	7.95	1100	23	132
1212	04-29-82	7.76	1240	26	132
1212	10-06-82	7.60	1188	26	128
1212	04-28-83	8.05	1180	29	128
1228	07-22-77	7.79	1090	26	148
1228	08-09-77	7.20	1010	25	132
1228	04-18-83	8.25	1115	27	92
1271	07-14-77	7.50	1100	27	160
1271	04-28-83	7.89	1118	29	94
1271	04-28-83	8.09	1065	29	94
1325	08-04-77	7.30	4500	25	152
1325	09-29-77	7.30	4490	24	160
1325	04-30-82	7.66	1100	26	170
1339	07-28-77	8.00	2800	26	180
1339	08-23-77	8.00	2200	28	200
1339	04-18-83	8.16	1640	27	172
1515	08-16-77	7.50	3900	28	120
1515	04-14-82	7.34	4300	28	128
1515	05-31-82	7.25	4100	30	134
1515	07-20-82	7.50	4300	25	134
1612	07-27-77	8.00	3800	26	136
1612	07-27-77	8.00	3800	26	136
1612	08-10-77	7.80	1800	27	152
1612	10-01-77	7.50	1790	29	212
1612	11-04-77	7.40	1800	23	140
1612	04-11-83	8.00	1770	21	126
1856	07-14-77	7.60	2180	27	232
1856	07-14-77	7.80	3000	27	224
1856	09-07-81	7.45	1580	28	224
1856	09-09-81	7.45	1580	28	224
1856	10-23-81	7.95	1550	21	182
1856	12-14-81	7.75	1900	21	236
1856	02-15-82	7.70	1950	22	236
1856	04-28-82	7.30	1950	26	198
1856	05-26-82	7.90	1750	29	212
1856	06-02-82	7.34	1940	31.5	234
1902	08-24-77	8.10	300	29	128
1909	08-19-77	7.20	1700	27	100
1909	05-12-83	7.92	3000	27	68
1919	08-15-77	7.90	800	26	112

WELL NUMBER	DATE OF ANALYSIS	pH	CONDUCT. (M-MHOS)	TEMP. (DEG.C.)	ALKALINITY (CaCO3) (mg/l)
1919	04-12-83	8.14	620	21	112
1956	07-18-77	7.90	710	27	132
1956	08-04-77	8.40	650	25	120
1956	08-14-81	8.05	780	28	68
1956	09-22-81	7.70	900	28	99
1956	03-11-82	8.15	1190	26	100
1975	07-21-77	7.90	540	26	116
1975	04-20-83	8.31	640	27	128
1983	07-21-77	7.20	2240	26	244
1983	08-09-77	7.60	2150	25	228
1983	06-03-82	6.92	2900	29.5	260
1983	04-28-83	8.05	1204	29	156
1983	11-22-83	7.46	2640	26	300
2049	07-05-77	8.70	270	26	108
2049	07-18-77	7.90	270	27	124
2049	04-20-83	8.24	450	27	116
2074	04-30-82	7.60	750	26	108
2074	06-01-82	7.35	750	30	120
2234	06-27-77	8.00	875	26	336
2234	08-04-77	8.30	900	25	128
2234	04-20-83	8.05	590	27	128
2304	07-14-77	8.00	1400	27	88
2304	08-09-77	8.30	1120	25	121
2304	04-28-83	8.00	1100	29	90
2304	04-28-83	8.00	1117	29	90
2314	09-04-81	7.45	355	28	112
2314	03-09-82	7.94	645	26	120
2314	04-29-82	8.22	325	26	116
2314	06-01-82	7.78	350	30	116
2314	07-22-82	7.56	413	27	112
2362	08-10-77	7.40	6600	27	176
2422	06-23-77	7.70	1090	25	124
2422	07-22-77	7.67	1050	26	204
2422	04-18-83	8.01	1130	27	180
2504	09-29-77	7.20	4390	24	116
2504	11-04-77	7.20	4000	23	116
2504	12-16-77	7.50	3000	20	120
2504	05-08-81	8.90	3200	28	123
2504	04-12-83	8.22	4800	21	82
2539	06-27-77	7.60	1500	26	128
2539	01-27-81	7.40	1100	19	190
2539	03-02-81	7.06	1150	23	200
2539	04-14-81	8.10	1195	27	215
2539	05-22-81	7.50	1105	22	177
2539	06-26-81	7.25	1130	25	178
2539	07-24-81	8.00	1450	29	128
2539	09-21-81	7.75	1200	25	207
2539	10-20-81	8.10	1280	26	200
2539	10-29-81	7.30	1300	21	210
2539	12-14-81	8.00	1400	21	220

WELL NUMBER	DATE OF ANALYSIS	pH	CONDUCT. (M-MHOS)	TEMP. (DEG.C.)	ALKALINITY (CaCO3) (mg/l)
2539	01-27-82	7.70	1920	19	216
2539	02-15-82	7.60	1550	22	220
2539	03-23-82	7.64	1700	25	216
2539	04-28-82	7.30	1800	26	208
2539	05-20-82	7.90	1680	29	196
2539	05-26-82	8.06	1560	29	216
2539	06-22-82	7.24	1500	27	218
2539	07-14-82	7.45	2400	28	232
2539	08-02-82	7.67	1400	27	214
2539	08-09-82	7.72	1700	27	220
2574	04-28-83	8.14	2000	29	152
2643	06-28-77	7.40	1600	28	168
2643	08-19-77	8.20	1390	27	220
2812	06-23-77	7.60	810	25	152
2812	07-25-77	7.72	690	25	188
2812	08-22-77	7.95	750	29	172
2812	04-28-83	7.76	720	27	172

WELL No.	DATE OF ANALYSIS	HARDNESS ($CaCO_3$) (mg/l)	SULFATE (SO_4) (mg/l)	CHLORIDE (Cl) (mg/l)	CALCIUM (CaO) (mg/l)	MAGNES. (MgO) (mg/l)
17	07-27-77	340.343	228.626	19.996	-	-
17	07-21-81	380.000	316.800	21.995	100.200	31.605
17	09-15-82	170.000	34.060	16.000	58.110	6.070
17	04-11-83	400.000	249.759	23.750	117.034	26.987
34	08-24-77	766.700	364.800	51.900	-	-
34	06-08-82	700.000	551.940	52.000	200.400	48.620
158	08-12-77	105.623	162.562	9.998	-	-
158	05-06-82	135.000	225.600	20.000	48.090	3.640
158	04-12-83	143.000	115.273	15.951	57.314	-
192	08-10-77	864.551	44.742	51.989	-	-
192	07-21-81	460.000	364.800	51.896	124.248	29.174
192	04-11-83	561.000	355.427	54.945	221.242	2.188
209	06-27-77	899.760	633.269	41.991	-	-
209	07-27-77	931.055	550.689	53.989	-	-
209	08-30-77	907.500	473.100	39.900	-	-
209	04-11-83	981.000	744.476	53.881	312.625	48.869
257	07-29-77	841.079	550.689	71.985	-	-
268	07-29-77	172.127	51.079	19.996	-	-
268	08-15-77	109.535	18.047	15.996	-	-
268	08-13-81	100.000	28.818	11.697	40.080	-
268	08-31-81	130.000	24.976	14.533	48.096	2.431
268	03-02-82	250.000	254.590	11.997	60.120	24.312
268	05-06-82	120.000	9.600	20.000	40.080	4.860
268	04-18-83	143.000	14.409	12.761	32.064	15.317
281	08-15-77	222.983	146.459	37.992	-	-
281	10-07-77	262.100	196.900	43.900	-	-
281	10-07-77	293.400	214.800	55.900	-	-
281	10-07-77	262.100	179.100	41.900	-	-
281	02-08-82	440.000	208.453	95.710	91.783	51.300
281	04-28-82	305.000	230.547	55.654	106.212	9.725
281	05-06-82	275.000	249.600	62.000	92.184	10.940
281	06-04-82	305.000	230.500	55.760	106.210	96.130
281	07-13-82	335.000	160.770	56.000	116.230	10.940
281	04-18-83	493.000	350.624	81.885	99.799	59.324
350	08-04-77	160.391	30.021	9.998	-	-
350	09-02-77	160.300	41.500	25.900	-	-
350	05-03-83	139.000	.038	6.990	47.670	4.860
431	09-02-77	183.800	40.100	15.900	-	-
431	05-03-83	112.000	.250	9.980	28.850	9.720
442	05-06-82	680.000	624.500	60.000	214.420	35.250
442	12-13-82	680.000	580.630	58.000	220.440	31.660
443	04-21-82	130.000	24.000	12.000	46.090	3.640
598	06-17-77	379.463	591.979	33.993	-	-
598	06-28-77	453.791	633.269	51.989	-	-
598	08-01-77	399.024	550.689	49.990	-	-
598	09-14-77	422.400	375.100	45.900	-	-
598	04-18-83	448.000	869.356	53.881	131.863	28.932
752	07-15-77	125.183	55.208	17.996	-	-
752	08-05-77	97.800	75.027	11.997	-	-
752	09-22-81	175.000	93.179	35.094	58.116	-

WELL No.	DATE OF ANALYSIS	HARDNESS (CaCO3) (mg/l)	SULFATE (SO4) (mg/l)	CHLORIDE (Cl) (mg/l)	CALCIUM (CaO) (mg/l)	MAGNES. (MgO) (mg/l)
752	10-26-81	190.000	103.540	13.997	62.124	7.293
752	03-11-82	350.000	951.090	24.995	90.180	13.371
752	04-21-82	165.000	158.400	18.000	62.120	2.430
752	07-19-82	200.000	80.310	17.000	62.124	2.430
752	09-17-82	170.000	118.180	18.000	68.130	-
760	08-05-77	1154.040	591.979	191.962	-	-
760	04-20-82	70.000	9.600	22.000	26.052	1.215
760	09-17-82	80.000	6.920	12.000	28.050	2.430
762	08-18-77	344.255	509.399	67.966	-	-
801	08-08-77	31.295	30.434	9.998	-	-
836	08-05-77	293.400	468.109	69.983	-	-
852	08-24-81	56.000	59.558	9.925	22.444	-
852	08-25-81	56.000	11.803	9.930	22.444	-
852	10-29-81	140.000	49.545	9.998	40.080	9.724
852	11-16-81	110.000	26.206	9.998	18.036	12.156
852	03-11-82	190.000	76.800	11.997	34.068	7.293
852	04-15-82	65.000	14.400	10.000	26.052	-
852	09-17-82	60.000	23.170	12.000	24.040	-
852	04-20-83	81.000	.480	13.824	28.857	2.188
860	05-31-77	1107.095	633.269	51.990	-	-
860	04-20-83	151.000	63.400	13.824	32.464	17.019
900	08-16-77	2229.840	352.496	97.980	-	-
900	08-24-81	850.000	1965.898	118.752	168.336	104.303
900	08-25-81	850.000	1964.697	118.760	168.336	104.298
900	09-25-81	420.000	340.538	58.135	110.220	34.038
900	10-30-81	1900.000	1822.771	124.975	541.080	133.716
900	03-11-82	880.000	1934.400	106.978	106.202	149.518
900	04-14-82	1215.000	1401.600	102.000	394.790	55.940
900	06-01-82	2050.000	1978.080	106.000	521.040	182.340
900	07-20-82	1850.000	1658.810	100.000	587.170	93.600
900	04-20-83	1880.000	1972.142	109.890	568.737	112.326
975	05-31-77	-	121.272	11.997	-	-
975	04-27-82	30.000	52.800	15.000	10.020	1.210
975	05-25-82	30.000	50.410	14.000	12.020	-
975	10-08-82	30.000	29.090	12.000	12.020	-
975	05-03-83	179.000	326.400	23.990	51.700	12.150
1000	06-22-77	-	151.414	27.994	-	-
1000	08-19-77	97.800	166.691	25.994	-	-
1000	08-24-81	60.000	296.829	52.463	23.647	-
1000	08-25-81	60.000	593.712	52.140	47.294	-
1000	09-24-81	100.000	389.529	51.754	38.076	-
1000	03-11-82	130.000	182.400	25.994	14.028	8.509
1000	04-28-82	45.000	177.600	29.000	16.030	1.210
1000	05-25-82	25.000	163.380	32.000	10.020	-
1000	10-08-82	30.000	114.000	28.000	12.020	-
1000	05-03-83	67.000	154.560	25.990	20.840	3.640
1017	08-19-77	105.623	269.916	159.968	-	-
1017	04-15-82	25.000	14.400	12.000	10.020	-
1017	05-26-82	30.000	19.230	14.000	12.020	-
1097	12-01-77	234.700	348.400	45.900	-	-

WELL No.	DATE OF ANALYSIS	HARDNESS (CaCO3) (mg/l)	SULFATE (SO4) (mg/l)	CHLORIDE (Cl) (mg/l)	CALCIUM (CaO) (mg/l)	MAGNES. (MgO) (mg/l)
1097	05-22-81	620.000	530.597	90.972	141.549	61.196
1097	04-20-83	279.000	182.997	7.798	90.581	12.885
1162	11-23-77	222.900	286.000	123.900	-	-
1165	07-14-77	1697.808	839.720	695.862	-	-
1165	08-09-77	1678.248	633.269	479.905	-	-
1212	07-19-77	367.727	364.884	43.991	-	-
1212	08-08-77	352.080	381.400	41.991	-	-
1212	09-10-81	450.000	864.553	59.553	134.268	26.744
1212	09-25-81	1880.000	1880.883	108.117	589.178	125.212
1212	10-23-81	315.000	424.382	34.393	84.158	24.312
1212	02-25-82	401.000	348.250	33.993	86.973	44.734
1212	04-29-82	340.000	552.000	40.000	96.190	24.310
1212	10-06-82	345.000	361.848	35.000	96.190	25.520
1212	04-28-83	390.000	397.694	40.765	129.458	16.289
1228	07-22-77	352.080	220.368	99.980	-	-
1228	08-09-77	340.343	378.482	87.982	-	-
1228	04-18-83	359.000	249.759	109.890	88.577	33.552
1271	07-14-77	492.911	340.109	33.993	-	-
1271	04-28-83	229.000	438.040	12.761	80.160	7.050
1271	04-28-83	229.000	437.760	12.990	80.160	7.050
1325	08-04-77	1447.440	591.979	553.890	-	-
1325	09-29-77	1643.000	602.300	515.800	-	-
1325	04-30-82	190.000	297.600	67.000	52.100	14.580
1339	07-28-77	262.104	633.264	117.976	-	-
1339	08-23-77	207.300	344.200	77.900	-	-
1339	04-18-83	632.000	585.975	47.885	172.344	49.112
1515	08-16-77	250.097	406.174	89.982	-	-
1515	04-14-82	1570.000	2265.600	98.000	501.000	77.790
1515	05-31-82	350.000	2151.360	102.370	100.200	24.300
1515	07-20-82	1545.000	1808.740	96.000	523.040	60.780
1612	07-27-77	688.511	468.109	153.969	-	-
1612	07-27-77	688.511	468.109	153.969	-	-
1612	08-10-77	786.811	509.899	135.973	-	-
1612	10-01-77	629.800	428.600	147.900	-	-
1612	11-04-77	645.400	380.000	133.900	-	-
1612	04-11-83	846.000	557.156	152.782	266.533	44.006
1856	07-14-77	755.015	591.979	132.972	-	-
1856	07-14-77	1290.960	666.301	173.965	-	-
1856	09-07-81	650.000	610.470	101.737	154.308	63.214
1856	09-09-81	650.000	610.009	101.579	154.308	63.211
1856	10-23-81	600.000	613.502	101.979	144.288	58.348
1856	12-14-81	694.000	772.094	108.578	144.688	80.229
1856	02-15-82	632.000	623.928	158.168	160.720	56.160
1856	04-28-82	605.000	662.400	98.000	148.290	57.130
1856	05-26-82	560.000	587.896	97.837	128.256	58.351
1856	06-02-82	590.000	507.810	100.000	136.270	60.780
1902	08-24-77	160.300	389.600	13.900	-	-
1909	08-19-77	586.800	550.689	31.993	-	-
1909	05-12-83	1499.000	.600	73.980	440.470	97.240
1919	08-15-77	309.047	269.916	31.993	-	-

WELL No.	DATE OF ANALYSIS	HARDNESS (CaCO3) (mg/l)	SULFATE (SO4) (mg/l)	CHLORIDE (Cl) (mg/l)	CALCIUM (CaO) (mg/l)	MAGNES. (MgO) (mg/l)
1919	04-12-83	300.000	144.092	34.030	100.200	12.156
1956	07-18-77	113.447	146.045	11.997	-	-
1956	08-04-77	46.943	126.227	5.998	-	-
1956	08-14-81	120.000	355.200	19.996	40.080	4.862
1956	09-22-81	235.000	378.482	19.496	82.164	-
1956	03-11-82	315.000	436.800	22.995	72.144	19.449
1975	07-21-77	101.711	96.085	17.996	-	-
1975	04-20-83	119.000	173.871	21.978	36.072	7.050
1983	07-21-77	708.071	633.269	119.976	-	-
1983	08-09-77	856.727	633.269	125.975	-	-
1983	06-03-82	815.000	1070.040	145.000	200.400	76.580
1983	04-28-83	501.000	343.900	53.881	155.911	27.230
1983	11-22-83	895.000	1008.630	148.000	238.470	72.940
2049	07-05-77	-	26.718	7.998	-	-
2049	07-18-77	70.416	18.047	5.998	-	-
2049	04-20-83	50.000	.480	93.938	16.432	2.431
2074	04-30-82	185.000	168.000	50.000	64.128	6.008
2074	06-01-82	60.000	149.290	59.000	82.160	1.210
2234	06-27-77	375.551	294.690	25.994	-	-
2234	08-04-77	74.327	220.781	19.996	-	-
2234	04-20-83	101.000	150.336	21.978	28.456	7.293
2304	07-14-77	385.815	550.689	29.994	-	-
2304	08-09-77	277.751	406.174	15.996	-	-
2304	04-28-83	239.000	399.615	12.761	85.370	7.050
2304	04-28-83	239.000	399.360	12.970	84.160	7.050
2314	09-04-81	65.000	44.668	7.444	26.052	-
2314	03-09-82	170.000	153.600	11.997	28.056	29.174
2314	04-29-82	55.000	19.200	17.000	18.036	2.430
2314	06-01-82	50.000	34.760	12.000	22.044	1.210
2314	07-22-82	60.000	67.250	10.000	20.040	2.430
2362	08-10-77	2902.792	591.979	1207.761	-	-
2422	06-23-77	215.160	262.071	31.993	-	-
2422	07-22-77	320.783	282.303	39.992	-	-
2422	04-18-83	461.000	225.744	70.896	140.280	26.987
2504	09-29-77	1936.400	597.800	147.900	-	-
2504	11-04-77	932.200	562.200	135.900	-	-
2504	12-16-77	2073.300	503.900	145.900	-	-
2504	05-08-81	1772.000	1690.682	138.603	128.256	17.019
2504	04-12-83	2290.000	2353.506	165.898	616.833	182.591
2539	06-27-77	500.735	393.787	69.986	-	-
2539	01-27-81	631.000	500.000	89.980	132.300	60.780
2539	03-02-81	670.000	495.386	93.981	152.704	62.238
2539	04-14-81	460.000	420.000	73.380	96.190	53.480
2539	05-22-81	620.000	530.547	90.972	141.549	61.196
2539	06-26-81	625.000	515.950	92.981	138.394	69.527
2539	07-24-81	500.000	432.276	91.811	116.232	48.626
2539	09-21-81	460.000	414.985	86.139	124.248	36.469
2539	10-20-81	460.000	481.185	76.900	100.200	46.190
2539	10-29-81	440.000	441.556	77.984	108.216	46.192
2539	12-14-81	440.000	505.838	83.983	88.176	48.624

WELL No.	DATE OF ANALYSIS	HARDNESS ($CaCO_3$) (mg/l)	SULFATE (SO_4) (mg/l)	CHLORIDE (Cl) (mg/l)	CALCIUM (CaO) (mg/l)	MAGNES. (MgO) (mg/l)
2539	01-27-82	568.000	549.120	87.982	171.943	33.793
2539	02-15-82	462.000	428.174	83.783	115.430	42.302
2539	03-23-82	380.000	436.800	88.000	98.190	32.820
2539	04-28-82	480.000	480.000	90.000	128.250	38.890
2539	05-20-82	476.000	447.440	90.980	118.230	43.760
2539	05-26-82	475.000	379.442	90.747	120.240	42.548
2539	06-22-82	1270.000	363.370	88.000	126.250	36.460
2539	07-14-82	610.000	701.310	149.000	158.310	52.270
2539	08-02-82	360.000	273.775	195.675	120.240	14.587
2539	08-09-82	465.000	371.540	90.000	124.240	37.680
2574	04-28-83	300.000	815.561	62.743	64.929	33.552
2643	06-28-77	78.240	468.109	21.995	-	-
2643	08-19-77	129.095	315.335	23.995	-	-
2812	06-23-77	136.920	169.581	29.994	-	-
2812	07-25-77	156.480	108.885	39.992	-	-
2812	08-22-77	183.863	133.659	31.993	-	-
2812	04-28-83	221.000	149.375	38.638	72.545	9.725

WELL NO.	DATE OF ANALYSIS	ARSENIC (As) (mg/l)	BICARB. (HCO3) (mg/l)	CARBONATE (CO3) (mg/l)	SODIUM (Na) (mg/l)	POTASS. (K) (mg/l)
17	07-27-77	.0260	-	-	-	-
17	07-21-81	.0410	205.002	-	-	-
17	09-15-82	-	168.390	-	-	-
17	04-11-83	.0330	195.241	-	40.459	-
34	08-24-77	.0497	-	-	-	-
34	06-08-82	.0250	141.540	-	-	-
158	08-12-77	.1590	-	-	-	-
158	05-06-82	.0170	100.060	8.4	-	-
158	04-12-83	.0780	122.025	-	41.839	-
192	08-10-77	.0250	-	-	-	-
192	07-21-81	.0170	185.478	-	-	-
192	04-11-83	.0140	190.359	-	12.873	-
209	06-27-77	.0180	-	-	-	-
209	07-27-77	.0310	-	-	-	-
209	08-30-77	.0473	-	-	-	-
209	04-11-83	.0400	197.681	-	5.287	-
257	07-29-77	.0030	-	-	-	-
268	07-29-77	.0200	-	-	-	-
268	08-15-77	.0540	-	-	-	-
268	08-13-81	.0230	151.311	-	22.988	12.109
268	08-31-81	.0250	150.091	-	14.712	-
268	03-02-82	.0020	156.192	-	-	-
268	05-06-82	.0350	151.310	4.8	-	-
268	04-18-83	.0160	143.990	-	.459	-
281	08-15-77	.0520	-	-	-	-
281	10-07-77	.0289	-	-	-	-
281	10-07-77	.0125	-	-	-	-
281	10-07-77	.0542	-	-	-	-
281	02-08-82	-	158.633	-	17.931	-
281	04-28-82	.0750	2.320	7.2	59.540	-
281	05-06-82	.0300	126.910	14.4	-	-
281	06-04-82	.0750	141.540	7.2	-	-
281	07-13-82	-	139.100	-	-	-
281	04-18-83	.0000	158.633	-	47.356	-
350	08-04-77	.0050	-	-	-	-
350	09-02-77	.0195	-	-	-	-
350	05-03-83	-	178.150	-	-	-
431	09-02-77	.0086	-	-	-	-
431	05-03-83	.0080	141.540	2.4	-	-
442	05-06-82	.0200	205.000	-	-	-
442	12-13-82	-	202.560	-	-	-
443	04-21-82	.0380	165.950	-	-	-
598	06-17-77	.0780	-	-	-	-
598	06-28-77	.0100	-	-	-	-
598	08-01-77	.1460	-	-	-	-
598	09-14-77	.1466	-	-	-	-
598	04-18-83	.0700	117.144	-	279.080	-
752	07-15-77	.0140	-	-	-	-
752	08-05-77	.0500	-	-	-	-
752	09-22-81	.0200	111.043	-	37.931	1.17

WELL NO.	DATE OF ANALYSIS	ARSENIC (As) (mg/l)	BICARB. (HCO3) (mg/l)	CARBONATE (CO3) (mg/l)	SODIUM (Na) (mg/l)	POTASS. (K) (mg/l)
752	10-26-81	.0230	122.025	-	-	-
752	03-11-82	.1190	136.668	-	-	-
752	04-21-82	.0300	102.500	9.6	-	-
752	07-19-82	-	126.900	-	-	-
752	09-17-82	-	131.780	-	-	-
760	08-05-77	.0010	-	-	-	-
760	04-20-82	.0410	107.382	10.8	-	-
760	09-17-82	-	141.540	-	-	-
762	08-18-77	.5250	-	-	-	-
801	08-08-77	.0390	-	-	-	-
836	08-05-77	.1850	-	-	-	-
852	08-24-81	.0630	130.567	-	22.298	16.796
852	08-25-81	.0630	130.580	-	-	-
852	10-29-81	.0350	136.668	-	-	-
852	11-16-81	.0380	135.691	-	-	-
852	03-11-82	.0230	149.358	-	-	-
852	04-15-82	.0940	122.025	6.0	-	-
852	09-17-82	-	143.980	-	-	-
852	04-20-83	.0340	141.549	-	22.068	-
860	05-31-77	.0060	-	-	-	-
860	04-20-83	.0340	126.906	-	14.252	-
900	08-16-77	.1490	-	-	-	-
900	08-24-81	.1070	239.170	-	697.931	42.578
900	08-25-81	.1070	239.190	-	-	-
900	09-25-81	.0560	195.241	-	72.414	7.812
900	10-30-81	.1070	278.217	-	-	-
900	03-11-82	.1200	239.169	-	-	-
900	04-14-82	.1380	209.880	8.4	-	-
900	06-01-82	-	205.002	-	-	-
900	07-20-82	-	222.085	-	-	-
900	04-20-83	.0400	236.729	-	220.000	-
975	05-31-77	.3460	-	-	-	-
975	04-27-82	.4500	131.780	16.8	-	-
975	05-25-82	.3940	146.430	4.8	-	-
975	10-08-82	-	161.070	-	-	-
975	05-03-83	-	158.630	-	-	-
1000	06-22-77	.2410	-	-	-	-
1000	08-19-77	.3450	-	-	-	-
1000	08-24-81	.2350	102.501	4.8	162.988	38.671
1000	08-25-81	.2350	102.510	9.6	-	-
1000	09-24-81	.2450	131.787	-	197.471	37.5
1000	03-11-82	.2130	137.644	4.8	-	-
1000	04-28-82	.3060	109.820	10.8	-	-
1000	05-25-82	.2900	104.940	9.6	-	-
1000	10-08-82	-	119.580	-	-	-
1000	05-03-83	-	134.220	-	-	-
1017	08-19-77	.3020	-	-	-	-
1017	04-15-82	.4710	117.144	6.0	-	-
1017	05-26-82	.2460	119.580	7.2	-	-
1097	12-01-77	.1286	-	-	-	-

WELL NO.	DATE OF ANALYSIS	ARSENIC (As) (mg/l)	BICARB. (HCO3) (mg/l)	CARBONATE (CO3) (mg/l)	SODIUM (Na) (mg/l)	POTASS. (K) (mg/l)
1097	05-22-81	.0250	215.740	-	-	-
1097	04-20-83	.1890	147.651	4.8	19.080	-
1162	11-23-77	.1678	-	-	-	-
1165	07-14-77	.0310	-	-	-	-
1165	08-09-77	.0460	-	-	-	-
1212	07-19-77	.0370	-	-	-	-
1212	08-08-77	.0840	-	-	-	-
1212	09-10-81	.0260	134.228	-	271.724	28.125
1212	09-25-81	.1180	202.562	-	140.689	20.312
1212	10-23-81	.0380	129.346	-	-	-
1212	02-25-82	.0380	161.073	-	-	-
1212	04-29-82	.0470	141.550	9.6	-	-
1212	10-06-82	-	156.190	-	-	-
1212	04-28-83	-	146.430	4.8	89.885	-
1228	07-22-77	.0280	-	-	-	-
1228	08-09-77	.0610	-	-	-	-
1228	04-18-83	.0150	112.263	-	62.068	-
1271	07-14-77	.0430	-	-	-	-
1271	04-28-83	-	114.700	-	149.655	-
1271	04-28-83	-	114.760	-	-	-
1325	08-04-77	.0080	-	-	-	-
1325	09-29-77	.0171	-	-	-	-
1325	04-30-82	.1000	200.120	3.6	-	-
1339	07-28-77	.7270	-	-	-	-
1339	08-23-77	.7850	-	-	-	-
1339	04-18-83	.5540	209.884	-	116.551	-
1515	08-16-77	.2130	-	-	-	-
1515	04-14-82	.1610	136.660	9.6	-	-
1515	05-31-82	.1510	163.510	-	-	-
1515	07-20-82	-	163.510	-	-	-
1612	07-27-77	.0230	-	-	-	-
1612	07-27-77	.0230	-	-	-	-
1612	08-10-77	.0700	-	-	-	-
1612	10-01-77	.0688	-	-	-	-
1612	11-04-77	.0853	-	-	-	-
1612	04-11-83	.0220	153.752	-	25.747	-
1856	07-14-77	.0250	-	-	-	-
1856	07-14-77	.0080	-	-	-	-
1856	09-07-81	.0240	273.337	-	138.160	28.906
1856	09-09-81	.0240	273.336	-	-	-
1856	10-23-81	.0400	222.085	-	-	-
1856	12-14-81	.0310	287.979	-	-	-
1856	02-15-82	.0260	288.467	-	-	-
1856	04-28-82	.0300	217.200	9.6	-	-
1856	05-26-82	.0240	261.134	-	173.103	5.859
1856	06-02-82	.0440	285.530	-	-	-
1902	08-24-77	.0473	-	-	-	-
1909	08-19-77	.1120	-	-	-	-
1909	05-12-83	-	82.970	-	-	-
1919	08-15-77	.0630	-	-	-	-

WELL NO.	DATE OF ANALYSIS	ARSENIC (As) (mg/l)	BICARB. (HCO3) (mg/l)	CARBONATE (CO3) (mg/l)	SODIUM (Na) (mg/l)	POTASS. (K) (mg/l)
1919	04-12-83	.0040	136.668	-	.229	-
1956	07-18-77	.0140	-	-	-	-
1956	08-04-77	.1060	-	-	-	-
1956	08-14-81	.0600	82.977	-	-	-
1956	09-22-81	.0740	120.805	-	129.425	16.406
1956	03-11-82	.0700	122.029	-	-	-
1975	07-21-77	.0930	-	-	-	-
1975	04-20-83	.2010	156.192	1.2	97.931	-
1983	07-21-77	.0240	-	-	-	-
1983	08-09-77	.0480	-	-	-	-
1983	06-03-82	.0250	317.260	-	-	-
1983	04-28-83	-	178.157	6.0	34.482	-
1983	11-22-83	-	366.070	-	-	-
2049	07-05-77	.1470	-	-	-	-
2049	07-18-77	.0340	-	-	-	-
2049	04-20-83	-	141.549	-	87.126	-
2074	04-30-82	.0420	146.430	14.4	-	-
2074	06-01-82	.0140	146.430	-	-	-
2234	06-27-77	.2710	-	-	-	-
2234	08-04-77	.3130	-	-	-	-
2234	04-20-83	.1870	156.192	-	94.252	-
2304	07-14-77	.0360	-	-	-	-
2304	08-09-77	.0720	-	-	-	-
2304	04-28-83	.0320	104.942	2.4	123.678	-
2304	04-28-83	.0320	104.940	2.4	-	-
2314	09-04-81	.0370	136.668	-	44.138	6.25
2314	03-09-82	.0380	136.668	4.8	-	-
2314	04-29-82	.0430	117.140	12.0	-	-
2314	06-01-82	.0620	141.540	-	-	-
2314	07-22-82	-	126.900	4.8	-	-
2362	08-10-77	.0960	-	-	-	-
2422	06-23-77	.0100	-	-	-	-
2422	07-22-77	.0110	-	-	-	-
2422	04-18-83	.0450	219.646	-	18.850	-
2504	09-29-77	.5780	-	-	-	-
2504	11-04-77	.5780	-	-	-	-
2504	12-16-77	.0716	-	-	-	-
2504	05-08-81	.4410	150.091	-	713.103	39.062
2504	04-12-83	.2910	100.061	-	196.551	-
2539	06-27-77	.0180	-	-	-	-
2539	01-27-81	.0310	219.650	6.0	-	-
2539	03-02-81	.0270	268.455	-	-	-
2539	04-14-81	.0320	248.310	2.4	-	-
2539	05-22-81	.0250	215.740	-	-	-
2539	06-26-81	.0280	217.205	-	-	-
2539	07-24-81	.0240	195.241	-	103.448	6.25
2539	09-21-81	.0160	252.593	-	113.793	28.125
2539	10-20-81	.0190	244.050	-	-	-
2539	10-29-81	.0210	256.252	-	-	-
2539	12-14-81	.0220	268.455	-	-	-

WELL NO.	DATE OF ANALYSIS	ARSENIC (As) (mg/l)	BICARB. (HCO3) (mg/l)	CARBONATE (CO3) (mg/l)	SODIUM (Na) (mg/l)	POTASS. (K) (mg/l)
2539	01-27-82	.0340	263.574	-	-	-
2539	02-15-82	.0240	267.966	-	135.172	8.203
2539	03-23-82	.0290	263.600	-	-	-
2539	04-28-82	.0230	253.800	-	-	-
2539	05-20-82	.0250	214.760	12.0	-	-
2539	05-26-82	.0390	234.289	14.401	113.839	-
2539	06-22-82	.0220	266.020	-	-	-
2539	07-14-82	.0260	283.090	-	-	-
2539	08-02-82	.0320	261.134	-	181.609	-
2539	08-09-82	.0270	268.450	-	-	-
2574	04-28-83	-	175.716	4.8	305.287	-
2643	06-28-77	1.1550	-	-	-	-
2643	08-19-77	.7040	-	-	-	-
2812	06-23-77	.0060	-	-	-	-
2812	07-25-77	.0110	-	-	-	-
2812	08-22-77	-	-	-	-	-
2812	04-28-83	-	207.443	1.200	68.965	-

APPENDIX B

WELLS, LOCATIONS, AND HYDRAULIC CHARACTERISTICS

Range(X)=0.0 to 6.84 : Range(Y)=0.0 to 11.0
Origin = Bottom left corner.
K = Hydraulic Conductivity
T = Transmissivity

WELL No.	POSITION		DEPTH	SAT. DEPTH	K	T
	X	Y	(FEET)	(FEET)	(GPD/FT2)	(GPD/FT)
2	1.90	4.20		790.42	10000	8166690
8	1.66	4.37	1068	877.70	148	132813
10	1.83	4.44	720	526.42	1049	572866
17	1.68	4.65	449	258.70	2000	546933
34	1.74	5.05	532	338.42	10	3499
158	1.57	7.02	800	607.24	450	288023
192	0.71	5.59	475	291.26	4161	1225602
195	1.10	5.59	600	412.98	1155	484574
206	1.16	5.47	615	427.98	186	81283
217	1.37	4.77	532	343.34	10	3548
219	1.35	4.88	684	493.70	3487	1759294
229	2.20	4.80	800	586.74	460	278576
231	2.11	4.51	800	593.30	158	97370
232	2.22	4.48	1015	801.74	2470	2045118
241	2.34	4.48	712	492.17	2550	1324065
257	2.64	5.44	800	576.89	2000	1180032
280	2.70	6.19	752	525.61	2296	1229402
281	2.70	6.01	1000	775.25	508	399661
298	2.65	5.75	422	202.17	2530	544701
310	2.41	5.44	500	286.74	491	147231
339	2.85	4.48	500	237.52	502	132823
363	3.10	5.24	506	243.52	315	73608
378	3.01	4.64	600	327.68	2901	1029116
387	3.11	4.33	750	474.40	161	79547
389	3.20	4.33	400	121.12	1763	248232
414	3.44	4.57	600	311.27	88	29124
422	3.45	4.98	1000	721.12	115	85494
431	3.42	5.20	725	452.68	88	41741
443	3.60	5.78	806	568.13	227	132391
444	3.76	5.79	800	567.05	1212	704363
448	3.44	5.90	1058	811.93	91	75154
455	3.20	5.14	700	453.93	355	167550
485	3.07	6.62	1020	780.49	1260	994782
489	3.42	6.40	600	360.49	330	122209
501	3.95	7.18	900	667.05	311	211789
598	2.24	7.91	760	566.42	312	180306
693	3.80	6.68	723	496.61	473	239242
700	4.06	6.60	800	593.30	2016	1212623
760	3.94	5.21	800	544.08	979	550002
762	5.68	8.32	660	479.55	233	114333
769	3.80	4.84	1095	812.83	21	17483
801	3.98	4.21	800	488.31	70	34778
848	4.38	6.91	685	488.14	1396	695184
860	4.68	7.24	900	696.58	33	23393
879	4.74	6.19	670	538.76	255	139894
885	4.93	7.06	950	785.95	745	592377

WELL No.	POSITION		DEPTH	SAT. DEPTH	K	T
	X	Y	(FEET)	(FEET)	(GPD/FT2)	(GPD/FT)
900	5.39	6.40	650	541.73	1026	555812
975	4.12	8.23	1002	765.77	57	44771
1000	4.34	7.73	972	729.21	256	193060
1017	4.89	7.94	1000	767.05	22	17294
1025	4.96	7.37	877	680.14	545	359232
1105	6.00	7.13	1005	860.64	667	578421
1113	3.25	4.02	606	330.40	8	2725
1114	3.33	4.04	730	447.83	917	420292
1156	5.24	2.57	1075	779.71	953	739311
1162	5.70	3.13	1300	971.90	592	577696
1200	5.08	2.87	975	679.71	340	231659
1201	5.65	3.24	1968	1639.90	178	292778
1210	6.09	3.20	1401	1125.40	533	601585
1212	5.37	2.48	1082	812.96	10	8097
1228	3.84	2.82	740	477.52	3845	1807680
1291	4.18	3.90	1100	804.71	1323	1073313
1293	4.41	3.94	997	709.91	2212	1588470
1305	1.57	6.60	600	406.42	1297	544150
1320	6.20	7.29	610	465.64	122	57608
1325	5.21	3.34	1150	857.99	917	792043
1331	1.57	5.88	1010	816.42	12	9868
1339	3.34	10.17	591	459.76	25	11617
1358	2.47	5.33	711	491.17	94	47558
1366	3.74	3.28	850	557.99	1500	827144
1377	4.65	6.94	561	383.83	126	49520
1382	3.22	8.92	700	509.70	975	509755
1391	4.04	8.82	1000	794.94	764	618612
1505	4.22	2.76	1022	751.32	13	9724
1515	5.78	7.53	915	750.95	2106	1602230
1543	4.54	5.22	855	658.14	170	114115
1620	2.15	5.75	540	334.94	1348	465870
7659	6.10	7.09	722	584.20	290	171320
1678	2.97	6.71	370	130.49	33	4631
1754	1.59	8.10	600	414.62	880	374974
1788	1.83	5.30	417	220.14	101	23361
1810	5.18	2.34	1010	754.08	1100	825881
1902	3.12	7.04	1021	778.21	643	508825
1909	5.16	7.03	800	642.51	1000	650715
1943	3.32	4.83	1073	794.12	31	25360
1956	4.95	4.77	805	575.33	740	441526
1975	5.88	4.16	1000	770.33	383	302576
1983	4.89	2.34	1105	849.08	36	30449
1991	5.08	8.63	1000	795.76	162	130986
2049	4.44	4.42	1000	717.83	1000	730958
2058	1.67	4.37	550	359.70	2660	1001317
2074	3.66	3.95	1050	748.15	1170	879172
2082	3.86	3.87	1000	688.31	230	158499
2092	3.67	7.48	600	357.21	280	106448
2098	2.57	5.57	268	49.81	265	16678
2115	5.32	3.75	1129	853.40	200	173304

WELL No.	POSITION		DEPTH	SAT. DEPTH	K	T
	X	Y	(FEET)	(FEET)	(GPD/FT2)	(GPD/FT)
2129	5.13	3.69	1313	1025.91	50	51870
2160	2.58	4.16	830	600.33	2557	1602160
2172	3.74	3.35	800	504.71	1466	730766
2181	6.25	3.87	1050	820.33	347	276571
2238	2.62	3.98	600	370.33	266	103962
2304	6.38	2.33	1000	803.14	9900	7886122
2362	0.94	5.86	600	409.70	25	10407
2459	3.38	9.39	800	622.83	60	38019
2643	4.88	9.65	1020	888.76	25	22473

APPENDIX C

CALIBRATION PARAMETERS FOR PLASM

k(i,j) = 1: no flow boundary
Initial time step=5.865338 days

i max=33
j max=28

i	j	Q (GPD)	k(i) (GPD/FT2)	k(j) (GPD/FT2)	DEPTH (FEET)
1	1	-50000	1000	1000	-800
2	1	-50000	1000	1000	-800
3	1	-50000	1000	1000	-800
4	1	-50000	1000	1000	-800
5	1	-50000	1000	1000	-800
6	1	-50000	1000	1000	-800
7	1	0	.1	.1	-800
8	1	0	.1	.1	-800
9	1	0	.1	.1	-800
10	1	-50000	1000	1000	-800
11	1	-50000	1000	1000	-800
12	1	-50000	1000	1000	-800
13	1	0	1	1	-610
14	1	0	1	1	-610
15	1	0	1	1	-610
16	1	0	1	1	-610
17	1	0	1	1	-610
18	1	0	1	1	-610
19	1	0	1	1	-610
20	1	0	1	1	-610
21	1	0	1	1	-610
22	1	0	1	1	-610
23	1	0	1	1	-610
24	1	0	1	1	-610
25	1	0	1	1	-610
26	1	0	1	1	-610
27	1	0	1	1	-610
28	1	0	1	1	-610
29	1	-150000	1000	1000	-800
30	1	0	1200	1200	-700
31	1	0	1200	1200	-700
32	1	0	1200	1200	-700
33	1	0	1200	1200	-700
1	2	0	1200	1200	-700
2	2	0	1200	1200	-700
3	2	0	1200	1200	-700
4	2	0	500	500	-610
5	2	0	973.31	973.31	-610
6	2	0	973.31	973.31	-610
7	2	-441237	1000	1000	-610
8	2	0	1	1	-610
9	2	0	1	1	-610
10	2	0	1	1	-610
11	2	0	1	1	-610
12	2	0	1	1	-610
13	2	0	1	1	-610
14	2	0	1	1	-610
15	2	0	1	1	-610

i	j	Q (GPD)	k(i) (GPD/FT2)	k(j) (GPD/FT2)	DEPTH (FEET)
16	2	0	1	1	-610
17	2	0	1	1	-610
18	2	0	1	1	-610
19	2	0	1	1	-610
20	2	0	1	1	-610
21	2	0	1	1	-610
22	2	0	1	1	-610
23	2	0	1	1	-610
24	2	-100000	1000	1000	-700
25	2	0	1200	1200	-700
26	2	0	1200	1200	-700
27	2	0	1200	1200	-700
28	2	0	1200	1200	-700
29	2	0	1200	1200	-700
30	2	0	1200	1200	-700
31	2	0	1200	1200	-700
32	2	3750000	1200	1200	-800
33	2	3750000	1200	1200	-800
1	3	0	973.31	973.31	-610
2	3	-441237	1000	1000	-610
3	3	-100000	2000	2000	-610
4	3	-100000	2000	2000	-610
5	3	-100000	2000	2000	-610
6	3	-100000	2000	2000	-610
7	3	-100000	2000	2000	-610
8	3	-100000	2000	2000	-610
9	3	0	1	1	-610
10	3	0	1	1	-610
11	3	0	1	1	-610
12	3	0	1	1	-610
13	3	0	1	1	-610
14	3	0	1	1	-610
15	3	0	1	1	-610
16	3	0	1	1	-610
17	3	0	1	1	-610
18	3	0	973.31	973.31	-610
19	3	-100000	1000	1000	-700
20	3	0	1200	1200	-700
21	3	0	1200	1200	-700
22	3	0	1200	1200	-700
23	3	0	1200	1200	-700
24	3	0	1200	1200	-700
25	3	0	1200	1200	-700
26	3	0	1200	1200	-700
27	3	3750000	1200	1200	-800
28	3	3750000	1200	1200	-800
29	3	0	973.31	973.31	-610
30	3	0	973.31	973.31	-610
31	3	0	973.31	973.31	-610
32	3	0	973.31	973.31	-610
33	3	0	973.31	973.31	-610

i	j	Q (GPD)	k(i) (GPD/FT2)	k(j) (GPD/FT2)	DEPTH (FEET)
1	4	0	973.31	973.31	-610
2	4	0	973.31	973.31	-610
3	4	-441237	1000	1000	-610
4	4	-441237	1000	1000	-610
5	4	0	1	1	-610
6	4	0	1	1	-610
7	4	0	1	1	-610
8	4	0	1	1	-610
9	4	0	1	1	-610
10	4	0	1	1	-610
11	4	0	1	1	-610
12	4	0	1	1	-610
13	4	0	973.31	973.31	-610
14	4	-100000	1000	1000	-700
15	4	0	1200	1200	-700
16	4	0	1200	1200	-700
17	4	0	1200	1200	-700
18	4	0	1200	1200	-700
19	4	0	1200	1200	-700
20	4	0	1200	1200	-700
21	4	0	1200	1200	-700
22	4	3750000	1200	1200	-800
23	4	3750000	1200	1200	-800
24	4	0	973.31	973.31	-610
25	4	0	973.31	973.31	-610
26	4	0	973.31	973.31	-610
27	4	0	973.31	973.31	-610
28	4	0	973.31	973.31	-610
29	4	0	973.31	973.31	-610
30	4	0	973.31	973.31	-610
31	4	0	973.31	973.31	-610
32	4	-441237	1000	1000	-610
33	4	-441237	1000	1000	-610
1	5	0	1	1	-610
2	5	0	1	1	-610
3	5	0	1	1	-610
4	5	0	1	1	-610
5	5	0	1	1	-610
6	5	0	1	1	-610
7	5	0	1	1	-610
8	5	0	973.31	973.31	-610
9	5	-100000	1000	1000	-700
10	5	0	1200	1200	-700
11	5	0	1200	1200	-700
12	5	0	1200	1200	-700
13	5	0	1200	1200	-700
14	5	0	1200	1200	-700
15	5	0	1200	1200	-700
16	5	0	1200	1200	-700
17	5	3750000	1200	1200	-800
18	5	3750000	1200	1200	-800

i	j	Q (GPD)	k(i) (GPD/FT2)	k(j) (GPD/FT2)	DEPTH (FEET)
19	5	0	973.31	973.31	-610
20	5	0	973.31	973.31	-610
21	5	0	973.31	973.31	-610
22	5	0	973.31	973.31	-610
23	5	0	973.31	973.31	-610
24	5	0	973.31	973.31	-610
25	5	0	973.31	973.31	-610
26	5	0	973.31	973.31	-610
27	5	0	973.31	973.31	-610
28	5	-441237	1000	1000	-610
29	5	-441237	1000	1000	-610
30	5	0	1	1	-610
31	5	0	1	1	-610
32	5	0	1	1	-610
33	5	0	1	1	-610
1	6	0	1	1	-610
2	6	0	1	1	-610
3	6	0	973.31	973.31	-610
4	6	-100000	1000	1000	-700
5	6	0	1200	1200	-700
6	6	0	1200	1200	-700
7	6	0	1200	1200	-700
8	6	0	1200	1200	-700
9	6	0	1200	1200	-700
10	6	0	1200	1200	-700
11	6	0	1200	1200	-700
12	6	0	973.31	973.31	-610
13	6	0	973.31	973.31	-610
14	6	0	973.31	973.31	-610
15	6	0	973.31	973.31	-610
16	6	0	973.31	973.31	-610
17	6	0	973.31	973.31	-610
18	6	0	973.31	973.31	-610
19	6	0	973.31	973.31	-610
20	6	0	973.31	973.31	-610
21	6	0	973.31	973.31	-610
22	6	0	973.31	973.31	-610
23	6	0	973.31	973.31	-610
24	6	-441237	1000	1000	-610
25	6	0	1	1	-610
26	6	0	1	1	-610
27	6	0	1	1	-610
28	6	0	1	1	-610
29	6	0	1	1	-610
30	6	0	1	1	-610
31	6	0	973.31	973.31	-610
32	6	-100000	1000	1000	-700
33	6	0	1200	1200	-700
1	7	0	1200	1200	-700
2	7	0	1200	1200	-700
3	7	0	1200	1200	-700

i	j	Q (GPD)	k(i) (GPD/FT2)	k(j) (GPD/FT2)	DEPTH (FEET)
4	7	0	1200	1200	-700
5	7	0	1200	1200	-700
6	7	0	1200	1200	-700
7	7	0	973.31	973.31	-610
8	7	0	973.31	973.31	-610
9	7	6250000	750	750	-800
10	7	6250000	750	750	-800
11	7	6250000	750	750	-800
12	7	0	973.31	973.31	-610
13	7	0	973.31	973.31	-610
14	7	0	973.31	973.31	-610
15	7	0	973.31	973.31	-610
16	7	0	973.31	973.31	-610
17	7	0	973.31	973.31	-610
18	7	0	973.31	973.31	-610
19	7	-441237	1000	1000	-610
20	7	-600000	10000	10000	-700
21	7	0	1	1	-610
22	7	0	1	1	-610
23	7	0	1	1	-610
24	7	0	1	1	-610
25	7	0	1	1	-610
26	7	0	973.31	973.31	-610
27	7	-100000	1000	1000	-700
28	7	0	1200	1200	-700
29	7	0	1200	1200	-700
30	7	0	1200	1200	-700
31	7	0	1200	1200	-700
32	7	0	1200	1200	-700
33	7	0	1200	1200	-700
1	8	0	1200	1200	-700
2	8	0	973.31	973.31	-610
3	8	0	973.31	973.31	-610
4	8	6250000	750	750	-800
5	8	6250000	750	750	-800
6	8	6250000	750	750	-800
7	8	0	973.31	973.31	-610
8	8	0	973.31	973.31	-610
9	8	0	973.31	973.31	-610
10	8	0	973.31	973.31	-610
11	8	0	973.31	973.31	-610
12	8	0	973.31	973.31	-610
13	8	0	973.31	973.31	-610
14	8	0	973.31	973.31	-610
15	8	-600000	10000	10000	-700
16	8	0	1	1	-610
17	8	0	1	1	-610
18	8	0	1	1	-610
19	8	0	1	1	-610
20	8	0	1	1	-610
21	8	0	973.31	973.31	-610

i	j	Q (GPD)	k(i) (GPD/FT2)	k(j) (GPD/FT2)	DEPTH (FEET)
22	8	-100000	1000	1000	-700
23	8	0	1200	1200	-700
24	8	0	1200	1200	-700
25	8	0	1200	1200	-700
26	8	0	1200	1200	-700
27	8	0	1200	1200	-700
28	8	0	1200	1200	-700
29	8	0	1200	1200	-700
30	8	0	973.31	973.31	-610
31	8	0	973.31	973.31	-610
32	8	6250000	750	750	-800
33	8	6250000	750	750	-800
1	9	6250000	750	750	-800
2	9	0	973.31	973.31	-610
3	9	0	973.31	973.31	-610
4	9	0	973.31	973.31	-610
5	9	0	973.31	973.31	-610
6	9	0	973.31	973.31	-610
7	9	0	973.31	973.31	-610
8	9	6750000	10000	10000	-610
9	9	6750000	10000	10000	-610
10	9	-600000	10000	10000	-700
11	9	0	1	1	-610
12	9	0	1	1	-610
13	9	0	1	1	-610
14	9	0	1	1	-610
15	9	0	1	1	-610
16	9	0	973.31	973.31	-610
17	9	-100000	1000	1000	-700
18	9	0	1200	1200	-700
19	9	0	1200	1200	-700
20	9	0	1200	1200	-700
21	9	0	1200	1200	-700
22	9	0	1200	1200	-700
23	9	0	1200	1200	-700
24	9	0	1200	1200	-700
25	9	0	973.31	973.31	-610
26	9	0	973.31	973.31	-610
27	9	0	973.31	973.31	-610
28	9	5750000	750	750	-800
29	9	5750000	750	750	-800
30	9	0	973.31	973.31	-610
31	9	0	973.31	973.31	-610
32	9	0	973.31	973.31	-610
33	9	0	973.31	973.31	-610
1	10	0	973.31	973.31	-610
2	10	0	973.31	973.31	-610
3	10	6750000	10000	10000	-610
4	10	6750000	10000	10000	-610
5	10	-400000	973.31	973.31	-610
6	10	0	1	1	-610

i	j	Q (GPD)	k(i) (GPD/FT2)	k(j) (GPD/FT2)	DEPTH (FEET)
7	10	0	1	1	-610
8	10	0	1	1	-610
9	10	0	1	1	-610
10	10	0	1	1	-610
11	10	0	973.31	973.31	-610
12	10	-100000	1000	1000	-700
13	10	0	1200	1200	-700
14	10	0	1200	1200	-700
15	10	0	1200	1200	-700
16	10	0	1200	1200	-700
17	10	0	1200	1200	-700
18	10	0	1200	1200	-700
19	10	0	1200	1200	-700
20	10	0	973.31	973.31	-610
21	10	0	973.31	973.31	-610
22	10	0	973.31	973.31	-610
23	10	5750000	750	750	-800
24	10	5750000	750	750	-800
25	10	0	973.31	973.31	-610
26	10	0	973.31	973.31	-610
27	10	0	973.31	973.31	-610
28	10	0	973.31	973.31	-610
29	10	0	973.31	973.31	-610
30	10	0	973.31	973.31	-610
31	10	6750000	10000	10000	-610
32	10	6750000	10000	10000	-610
33	10	-400000	973.31	973.31	-610
1	11	0	1	1	-610
2	11	0	1	1	-610
3	11	0	1	1	-610
4	11	0	1	1	-610
5	11	0	1	1	-610
6	11	0	973.31	973.31	-610
7	11	-100000	1000	1000	-700
8	11	0	1200	1200	-700
9	11	0	1200	1200	-700
10	11	0	1200	1200	-700
11	11	0	1200	1200	-700
12	11	0	1200	1200	-700
13	11	0	1200	1200	-700
14	11	0	1200	1200	-700
15	11	0	973.31	973.31	-610
16	11	0	973.31	973.31	-610
17	11	0	973.31	973.31	-610
18	11	0	973.31	973.31	-610
19	11	0	973.31	973.31	-610
20	11	0	973.31	973.31	-610
21	11	0	973.31	973.31	-610
22	11	0	973.31	973.31	-610
23	11	0	973.31	973.31	-610
24	11	0	973.31	973.31	-610

i	j	Q (GPD)	k(i) (GPD/FT2)	k(j) (GPD/FT2)	DEPTH (FEET)
25	11	6750000	5000	5000	-610
26	11	6750000	5000	5000	-610
27	11	0	973.31	973.31	-610
28	11	-400000	973.31	973.31	-610
29	11	-441237	1000	1000	-610
30	11	0	1	1	-610
31	11	0	1	1	-610
32	11	0	1	1	-610
33	11	0	1	1	-610
1	12	0	973.31	973.31	-610
2	12	-100000	1000	1000	-700
3	12	0	1000	1000	-800
4	12	0	1000	1000	-800
5	12	0	500	500	-610
6	12	0	500	500	-610
7	12	0	500	500	-610
8	12	750000	750	750	-1000
9	12	750000	750	750	-1000
10	12	750000	750	750	-1000
11	12	750000	750	750	-1000
12	12	750000	750	750	-1000
13	12	0	973.31	973.31	-610
14	12	0	973.31	973.31	-610
15	12	0	973.31	973.31	-610
16	12	0	973.31	973.31	-610
17	12	0	973.31	973.31	-610
18	12	0	973.31	973.31	-610
19	12	0	973.31	973.31	-610
20	12	6750000	5000	5000	-610
21	12	6750000	5000	5000	-610
22	12	0	973.31	973.31	-610
23	12	0	973.31	973.31	-610
24	12	-441237	1000	1000	-610
25	12	-441237	1000	1000	-610
26	12	0	1	1	-610
27	12	0	1	1	-610
28	12	0	1	1	-610
29	12	0	973.31	973.31	-610
30	12	-100000	1000	1000	-700
31	12	0	1000	1000	-800
32	12	0	1000	1000	-800
33	12	0	500	500	-610
1	13	500000	1000	1000	-700
2	13	500000	1000	1000	-700
3	13	750000	750	750	-1000
4	13	750000	750	750	-1000
5	13	750000	750	750	-1000
6	13	750000	750	750	-1000
7	13	750000	750	750	-1000
8	13	0	973.31	973.31	-610
9	13	0	973.31	973.31	-610

i	j	Q (GPD)	k(i) (GPD/FT2)	k(j) (GPD/FT2)	DEPTH (FEET)
10	13	0	973.31	973.31	-610
11	13	0	973.31	973.31	-610
12	13	0	973.31	973.31	-610
13	13	0	973.31	973.31	-610
14	13	0	973.31	973.31	-610
15	13	6750000	5000	5000	-610
16	13	6750000	5000	5000	-610
17	13	0	973.31	973.31	-610
18	13	0	973.31	973.31	-610
19	13	0	973.31	973.31	-610
20	13	-441237	1000	1000	-610
21	13	0	1	1	-610
22	13	0	1	1	-610
23	13	0	1	1	-610
24	13	0	973.31	973.31	-610
25	13	-100000	1000	1000	-700
26	13	0	1000	1000	-800
27	13	0	1000	1000	-800
28	13	0	500	500	-610
29	13	500000	1000	1000	-700
30	13	500000	1000	1000	-700
31	13	750000	750	750	-1000
32	13	750000	750	750	-1000
33	13	750000	750	750	-1000
1	14	750000	750	750	-1000
2	14	750000	750	750	-1000
3	14	0	973.31	973.31	-610
4	14	0	973.31	973.31	-610
5	14	0	973.31	973.31	-610
6	14	0	973.31	973.31	-610
7	14	0	973.31	973.31	-610
8	14	0	973.31	973.31	-610
9	14	0	973.31	973.31	-610
10	14	6750000	5000	5000	-610
11	14	6750000	5000	5000	-610
12	14	0	973.31	973.31	-610
13	14	0	973.31	973.31	-610
14	14	0	973.31	973.31	-610
15	14	-650000	1000	1000	-610
16	14	-650000	1000	1000	-610
17	14	0	1	1	-610
18	14	0	1	1	-610
19	14	0	973.31	973.31	-610
20	14	-100000	1000	1000	-700
21	14	0	1000	1000	-800
22	14	0	1000	1000	-800
23	14	0	500	500	-610
24	14	500000	1000	1000	-700
25	14	500000	1000	1000	-700
26	14	750000	750	750	-1000
27	14	750000	750	750	-1000

i	j	Q (GPD)	k(i) (GPD/FT2)	k(j) (GPD/FT2)	DEPTH (FEET)
28	14	750000	750	750	-1000
29	14	750000	750	750	-1000
30	14	750000	750	750	-1000
31	14	0	973.31	973.31	-610
32	14	0	973.31	973.31	-610
33	14	0	973.31	973.31	-610
1	15	0	973.31	973.31	-610
2	15	0	973.31	973.31	-610
3	15	0	973.31	973.31	-610
4	15	0	973.31	973.31	-610
5	15	0	973.31	973.31	-610
6	15	0	973.31	973.31	-610
7	15	0	973.31	973.31	-610
8	15	0	973.31	973.31	-610
9	15	0	973.31	973.31	-610
10	15	0	973.31	973.31	-610
11	15	-650000	1000	1000	-610
12	15	-650000	1000	1000	-610
13	15	0	.1	.1	-610
14	15	0	973.31	973.31	-610
15	15	-100000	1000	1000	-700
16	15	0	1000	1000	-800
17	15	0	1000	1000	-800
18	15	0	500	500	-610
19	15	500000	1000	1000	-700
20	15	500000	1000	1000	-700
21	15	750000	750	750	-1000
22	15	750000	750	750	-1000
23	15	750000	750	750	-1000
24	15	5550000	750	750	-1000
25	15	5550000	750	750	-1000
26	15	0	973.31	973.31	-610
27	15	0	973.31	973.31	-610
28	15	0	973.31	973.31	-610
29	15	0	973.31	973.31	-610
30	15	0	973.31	973.31	-610
31	15	0	973.31	973.31	-610
32	15	0	973.31	973.31	-610
33	15	0	973.31	973.31	-610
1	16	0	973.31	973.31	-610
2	16	0	973.31	973.31	-610
3	16	0	973.31	973.31	-610
4	16	0	973.31	973.31	-610
5	16	0	973.31	973.31	-610
6	16	0	973.31	973.31	-610
7	16	-650000	1000	1000	-610
8	16	0	.1	.1	-610
9	16	0	973.31	973.31	-610
10	16	-50000	1000	1000	-700
11	16	0	1000	1000	-800
12	16	0	1000	1000	-800

i	j	Q (GPD)	k(i) (GPD/FT2)	k(j) (GPD/FT2)	DEPTH (FEET)
13	16	500000	750	750	-850
14	16	500000	750	750	-850
15	16	500000	750	750	-850
16	16	750000	750	750	-1000
17	16	750000	750	750	-1000
18	16	750000	750	750	-1000
19	16	5550000	750	750	-1000
20	16	5550000	750	750	-1000
21	16	0	973.31	973.31	-610
22	16	0	973.31	973.31	-610
23	16	0	973.31	973.31	-610
24	16	0	973.31	973.31	-610
25	16	0	973.31	973.31	-610
26	16	0	973.31	973.31	-610
27	16	2750000	750	750	-610
28	16	2750000	750	750	-610
29	16	0	973.31	973.31	-610
30	16	0	973.31	973.31	-610
31	16	0	973.31	973.31	-610
32	16	0	973.31	973.31	-610
33	16	0	973.31	973.31	-610
1	17	0	973.31	973.31	-610
2	17	-650000	1000	1000	-610
3	17	0	.1	.1	-610
4	17	0	973.31	973.31	-610
5	17	-50000	1000	1000	-700
6	17	0	1000	1000	-800
7	17	0	1000	1000	-800
8	17	500000	750	750	-850
9	17	500000	750	750	-850
10	17	500000	750	750	-850
11	17	750000	750	750	-1000
12	17	750000	750	750	-1000
13	17	750000	750	750	-1000
14	17	5550000	750	750	-1000
15	17	5550000	750	750	-1000
16	17	0	973.31	973.31	-610
17	17	0	973.31	973.31	-610
18	17	0	973.31	973.31	-610
19	17	0	973.31	973.31	-610
20	17	0	973.31	973.31	-610
21	17	0	973.31	973.31	-610
22	17	2750000	750	750	-610
23	17	2750000	750	750	-610
24	17	0	973.31	973.31	-610
25	17	0	973.31	973.31	-610
26	17	0	973.31	973.31	-610
27	17	0	973.31	973.31	-610
28	17	0	973.31	973.31	-610
29	17	0	973.31	973.31	-610
30	17	-650000	1000	1000	-610

i	j	Q (GPD)	k(i) (GPD/FT2)	k(j) (GPD/FT2)	DEPTH (FEET)
31	17	0	.1	.1	-610
32	17	0	973.31	973.31	-610
33	17	-50000	1000	1000	-700
1	18	0	1000	1000	-800
2	18	0	1000	1000	-800
3	18	500000	750	750	-850
4	18	500000	750	750	-850
5	18	500000	750	750	-850
6	18	750000	750	750	-1000
7	18	750000	750	750	-1000
8	18	750000	750	750	-1000
9	18	5550000	750	750	-1000
10	18	5550000	750	750	-1000
11	18	0	973.31	973.31	-610
12	18	0	973.31	973.31	-610
13	18	0	973.31	973.31	-610
14	18	0	973.31	973.31	-610
15	18	0	973.31	973.31	-610
16	18	0	973.31	973.31	-610
17	18	2750000	750	750	-610
18	18	2750000	750	750	-610
19	18	0	973.31	973.31	-610
20	18	0	973.31	973.31	-610
21	18	0	973.31	973.31	-610
22	18	0	973.31	973.31	-610
23	18	0	973.31	973.31	-610
24	18	0	973.31	973.31	-610
25	18	-650000	1000	1000	-610
26	18	0	.1	.1	-610
27	18	0	973.31	973.31	-610
28	18	-50000	1000	1000	-700
29	18	0	1000	1000	-800
30	18	0	1000	1000	-800
31	18	500000	750	750	-850
32	18	500000	750	750	-850
33	18	500000	750	750	-850
1	19	750000	750	750	-1000
2	19	750000	750	750	-1000
3	19	750000	750	750	-1000
4	19	750000	750	750	-1000
5	19	750000	750	750	-1000
6	19	0	973.31	973.31	-610
7	19	0	973.31	973.31	-610
8	19	0	973.31	973.31	-610
9	19	0	973.31	973.31	-610
10	19	0	973.31	973.31	-610
11	19	0	973.31	973.31	-610
12	19	2750000	750	750	-610
13	19	2750000	750	750	-610
14	19	0	973.31	973.31	-610
15	19	0	973.31	973.31	-610

i	j	Q (GPD)	k(i) (GPD/FT2)	k(j) (GPD/FT2)	DEPTH (FEET)
16	19	0	973.31	973.31	-610
17	19	0	973.31	973.31	-610
18	19	0	973.31	973.31	-610
19	19	0	973.31	973.31	-610
20	19	-650000	1000	1000	-610
21	19	-550000	973.31	973.31	-610
22	19	0	973.31	973.31	-610
23	19	-50000	1000	1000	-700
24	19	0	1000	1000	-800
25	19	0	1000	1000	-800
26	19	500000	750	750	-850
27	19	500000	750	750	-850
28	19	500000	750	750	-850
29	19	750000	750	750	-1000
30	19	750000	750	750	-1000
31	19	750000	750	750	-1000
32	19	750000	750	750	-1000
33	19	750000	750	750	-1000
1	20	0	973.31	973.31	-610
2	20	0	973.31	973.31	-610
3	20	0	973.31	973.31	-610
4	20	0	973.31	973.31	-610
5	20	0	1	1	-610
6	20	0	1	1	-610
7	20	2750000	750	750	-610
8	20	2750000	750	750	-610
9	20	0	973.31	973.31	-610
10	20	0	973.31	973.31	-610
11	20	0	973.31	973.31	-610
12	20	0	973.31	973.31	-610
13	20	0	973.31	973.31	-610
14	20	0	973.31	973.31	-610
15	20	0	973.31	973.31	-610
16	20	-550000	973.31	973.31	-610
17	20	0	973.31	973.31	-610
18	20	-50000	1000	1000	-700
19	20	0	1000	1000	-800
20	20	0	1000	1000	-800
21	20	500000	750	750	-850
22	20	500000	750	750	-850
23	20	500000	750	750	-850
24	20	750000	750	750	-1000
25	20	750000	750	750	-1000
26	20	750000	750	750	-1000
27	20	750000	750	750	-1000
28	20	750000	750	750	-1000
29	20	0	973.31	973.31	-610
30	20	0	973.31	973.31	-610
31	20	0	973.31	973.31	-610
32	20	0	973.31	973.31	-610
33	20	0	1	1	-610

i	j	Q (GPD)	k(i) (GPD/FT2)	k(j) (GPD/FT2)	DEPTH (FEET)
1	21	0	1	1	-610
2	21	0	1	1	-610
3	21	2750000	750	750	-610
4	21	0	973.31	973.31	-610
5	21	0	973.31	973.31	-610
6	21	0	973.31	973.31	-610
7	21	0	973.31	973.31	-610
8	21	0	973.31	973.31	-610
9	21	0	973.31	973.31	-610
10	21	0	973.31	973.31	-610
11	21	-550000	973.31	973.31	-610
12	21	0	973.31	973.31	-610
13	21	-50000	1000	1000	-700
14	21	0	1000	1000	-800
15	21	0	1000	1000	-800
16	21	500000	750	750	-850
17	21	500000	750	750	-850
18	21	500000	750	750	-850
19	21	750000	750	750	-1000
20	21	750000	750	750	-1000
21	21	750000	750	750	-1000
22	21	750000	750	750	-1000
23	21	750000	750	750	-1000
24	21	0	973.31	973.31	-610
25	21	0	973.31	973.31	-610
26	21	0	973.31	973.31	-610
27	21	0	973.31	973.31	-610
28	21	0	1	1	-610
29	21	0	1	1	-610
30	21	0	1	1	-610
31	21	0	1	1	-610
32	21	3250000	750	750	-610
33	21	0	973.31	973.31	-610
1	22	0	973.31	973.31	-610
2	22	0	973.31	973.31	-610
3	22	0	973.31	973.31	-610
4	22	0	973.31	973.31	-610
5	22	0	973.31	973.31	-610
6	22	-550000	973.31	973.31	-610
7	22	0	973.31	973.31	-610
8	22	-50000	973.31	973.31	-610
9	22	0	1000	1000	-610
10	22	750000	1000	1000	-1000
11	22	750000	1000	1000	-1000
12	22	750000	1000	1000	-1000
13	22	750000	1000	1000	-1000
14	22	750000	1000	1000	-1000
15	22	750000	1000	1000	-1000
16	22	750000	1000	1000	-1000
17	22	0	973.31	973.31	-610
18	22	0	973.31	973.31	-610

i	j	Q (GPD)	k(i) (GPD/FT2)	k(j) (GPD/FT2)	DEPTH (FEET)
19	22	0	973.31	973.31	-610
20	22	0	973.31	973.31	-610
21	22	0	973.31	973.31	-610
22	22	0	973.31	973.31	-610
23	22	0	1	1	-610
24	22	0	1	1	-610
25	22	0	1	1	-610
26	22	0	1	1	-610
27	22	0	1	1	-610
28	22	5000000	750	750	-610
29	22	0	973.31	973.31	-610
30	22	0	973.31	973.31	-610
31	22	0	973.31	973.31	-610
32	22	0	973.31	973.31	-610
33	22	0	973.31	973.31	-610
1	23	-550000	973.31	973.31	-610
2	23	0	973.31	973.31	-610
3	23	-50000	973.31	973.31	-610
4	23	0	1000	1000	-610
5	23	750000	1000	1000	-1000
6	23	750000	1000	1000	-1000
7	23	750000	1000	1000	-1000
8	23	750000	1000	1000	-1000
9	23	750000	1000	1000	-1000
10	23	750000	1000	1000	-1000
11	23	750000	1000	1000	-1000
12	23	0	973.31	973.31	-610
13	23	0	973.31	973.31	-610
14	23	0	973.31	973.31	-610
15	23	0	973.31	973.31	-610
16	23	0	973.31	973.31	-610
17	23	0	973.31	973.31	-610
18	23	0	1	1	-610
19	23	0	1	1	-610
20	23	0	1	1	-610
21	23	0	1	1	-610
22	23	0	1	1	-610
23	23	5000000	750	750	-610
24	23	0	973.31	973.31	-610
25	23	0	973.31	973.31	-610
26	23	0	973.31	973.31	-610
27	23	0	973.31	973.31	-610
28	23	0	973.31	973.31	-610
29	23	-550000	973.31	973.31	-610
30	23	-500000	973.31	973.31	-610
31	23	-50000	973.31	973.31	-610
32	23	0	1000	1000	-610
33	23	750000	1000	1000	-1000
1	24	750000	1000	1000	-1000
2	24	750000	1000	1000	-1000
3	24	750000	1000	1000	-1000

i	j	Q (GPD)	k(i) (GPD/FT2)	k(j) (GPD/FT2)	DEPTH (FEET)
4	24	750000	1000	1000	-1000
5	24	750000	1000	1000	-1000
6	24	750000	1000	1000	-1000
7	24	0	973.31	973.31	-610
8	24	0	973.31	973.31	-610
9	24	0	973.31	973.31	-610
10	24	0	973.31	973.31	-610
11	24	0	973.31	973.31	-610
12	24	0	973.31	973.31	-610
13	24	0	1	1	-610
14	24	0	1	1	-610
15	24	0	1	1	-610
16	24	0	1	1	-610
17	24	0	1	1	-610
18	24	5000000	750	750	-610
19	24	0	973.31	973.31	-610
20	24	0	973.31	973.31	-610
21	24	0	973.31	973.31	-610
22	24	0	973.31	973.31	-610
23	24	0	973.31	973.31	-610
24	24	0	973.31	973.31	-610
25	24	-500000	973.31	973.31	-610
26	24	-50000	973.31	973.31	-610
27	24	0	1000	1000	-610
28	24	750000	1000	1000	-1000
29	24	750000	1000	1000	-1000
30	24	750000	1000	1000	-1000
31	24	750000	1000	1000	-1000
32	24	750000	1000	1000	-1000
33	24	750000	1000	1000	-1000
1	25	750000	1000	1000	-1000
2	25	0	973.31	973.31	-610
3	25	0	973.31	973.31	-610
4	25	0	973.31	973.31	-610
5	25	0	973.31	973.31	-610
6	25	0	973.31	973.31	-610
7	25	0	973.31	973.31	-610
8	25	0	1	1	-610
9	25	0	1	1	-610
10	25	0	1	1	-610
11	25	0	1	1	-610
12	25	0	1	1	-610
13	25	5000000	750	750	-610
14	25	0	973.31	973.31	-610
15	25	0	973.31	973.31	-610
16	25	0	973.31	973.31	-610
17	25	0	973.31	973.31	-610
18	25	0	973.31	973.31	-610
19	25	0	973.31	973.31	-610
20	25	-500000	973.31	973.31	-610
21	25	-50000	973.31	973.31	-610

i	j	Q (GPD)	k(i) (GPD/FT2)	k(j) (GPD/FT2)	DEPTH (FEET)
22	25	0	1000	1000	-610
23	25	750000	1000	1000	-1000
24	25	750000	1000	1000	-1000
25	25	750000	1000	1000	-1000
26	25	750000	1000	1000	-1000
27	25	750000	1000	1000	-1000
28	25	750000	1000	1000	-1000
29	25	750000	1000	1000	-1000
30	25	0	973.31	973.31	-610
31	25	0	973.31	973.31	-610
32	25	0	973.31	973.31	-610
33	25	0	973.31	973.31	-610
1	26	0	973.31	973.31	-610
2	26	0	973.31	973.31	-610
3	26	0	973.31	973.31	-610
4	26	0	973.31	973.31	-610
5	26	0	1	1	-610
6	26	0	1	1	-610
7	26	0	1	1	-610
8	26	5000000	750	750	-610
9	26	0	973.31	973.31	-610
10	26	0	973.31	973.31	-610
11	26	0	973.31	973.31	-610
12	26	0	973.31	973.31	-610
13	26	0	973.31	973.31	-610
14	26	0	973.31	973.31	-610
15	26	-500000	973.31	973.31	-610
16	26	-50000	973.31	973.31	-610
17	26	0	1000	1000	-610
18	26	750000	1000	1000	-1000
19	26	750000	1000	1000	-1000
20	26	750000	1000	1000	-1000
21	26	750000	1000	1000	-1000
22	26	750000	1000	1000	-1000
23	26	750000	1000	1000	-1000
24	26	750000	1000	1000	-1000
25	26	0	973.31	973.31	-610
26	26	0	973.31	973.31	-610
27	26	0	973.31	973.31	-610
28	26	0	973.31	973.31	-610
29	26	0	973.31	973.31	-610
30	26	0	973.31	973.31	-610
31	26	0	973.31	973.31	-610
32	26	0	1	1	-610
33	26	0	1	1	-610
1	27	0	1	1	-610
2	27	0	1	1	-610
3	27	0	973.31	973.31	-610
4	27	0	973.31	973.31	-610
5	27	0	973.31	973.31	-610
6	27	0	973.31	973.31	-610

i	j	Q (GPD)	k(i) (GPD/FT2)	k(j) (GPD/FT2)	DEPTH (FEET)
7	27	0	973.31	973.31	-610
8	27	0	973.31	973.31	-610
9	27	0	973.31	973.31	-610
10	27	-500000	973.31	973.31	-610
11	27	-50000	973.31	973.31	-610
12	27	0	1000	1000	-610
13	27	750000	1000	1000	-1000
14	27	750000	1000	1000	-1000
15	27	750000	1000	1000	-1000
16	27	750000	1000	1000	-1000
17	27	750000	1000	1000	-1000
18	27	750000	1000	1000	-1000
19	27	750000	1000	1000	-1000
20	27	0	973.31	973.31	-610
21	27	0	973.31	973.31	-610
22	27	0	973.31	973.31	-610
23	27	0	973.31	973.31	-610
24	27	0	973.31	973.31	-610
25	27	0	973.31	973.31	-610
26	27	0	973.31	973.31	-610
27	27	0	973.31	973.31	-610
28	27	0	973.31	973.31	-610
29	27	0	973.31	973.31	-610
30	27	0	973.31	973.31	-610
31	27	0	973.31	973.31	-610
32	27	0	973.31	973.31	-610
33	27	0	973.31	973.31	-610
1	28	0	973.31	973.31	-610
2	28	0	973.31	973.31	-610
3	28	0	973.31	973.31	-610
4	28	0	973.31	973.31	-610
5	28	-500000	973.31	973.31	-610
6	28	-50000	973.31	973.31	-610
7	28	0	.1	.1	-610
8	28	750000	1000	1000	-1000
9	28	750000	1000	1000	-1000
10	28	750000	1000	1000	-1000
11	28	750000	1000	1000	-1000
12	28	750000	1000	1000	-1000
13	28	750000	1000	1000	-1000
14	28	750000	1000	1000	-1000
15	28	0	1000	1000	-1000
16	28	0	1000	1000	-1000
17	28	0	1000	1000	-1000
18	28	0	1000	1000	-1000
19	28	0	1000	1000	-1000
20	28	1000000	750	750	-610
21	28	1000000	750	750	-610
22	28	1000000	750	750	-610
23	28	1000000	1000	1000	-1000
24	28	1000000	1000	1000	-1000

i	j	Q (GPD)	k(i) (GPD/FT2)	k(j) (GPD/FT2)	DEPTH (FEET)
25	28	1000000	1000	1000	-1000
26	28	1000000	1000	1000	-1000
27	28	1000000	1000	1000	-1000
28	28	1000000	1000	1000	-1000
29	28	1000000	1000	1000	-1000
30	28	1000000	1000	1000	-1000
31	28	-441237	1000	1000	-610
32	28	-441237	1000	1000	-610

VITA

Jack E. Gazin

Candidate for the Degree of

Master of Science

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