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# Simulation of ground water flow in a coarse grained alluvial aquifer in the Jocko Valley Flathead Indian Reservation Montana

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# SIMULATION OF GROUND WATER FLOW IN A COARSE GRAINED ALLUVIAL AQUIFER IN THE JOCKO VALLEY, FLATHEAD INDIAN RESERVATION, MONTANA

By

Seth V. Makepeace

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**ABSTRACT**

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Decreases in winter water table elevations over the last four years have caused a number of wells penetrating the unconfined Jocko Fan aquifer to go dry. The goal of this project is to identify the cause of water table declines and, through use of a numerical model, to evaluate the effect of varied surface water management schemes on the aquifer. I used seismic refraction, drillers' logs, monitoring well drilling, and outcrops to delineate aquifer geometry and trends in geologic facies. I developed an observation well network to monitor spring recharge. Both the Jocko River and selected irrigation ditches were gauged to calculate leakage rates through the streambed of these channels.

The late Quaternary age Jocko Fan aquifer is comprised of coarse gravel and cobbles with silt and sand matrix. Sources of recharge to the aquifer include leakage through the streambed of the Jocko River and irrigation ditches, and lateral inflow from Jocko Canyon and Agency Fan.

I used the USGS three dimensional flow model (MODFLOW) to calibrate a steady state and a one year transient model to measured water table elevations, water balance calculations, and the position of the gaining reach of the river. I then used the model to examine the effects of three surface water management scenarios to the Jocko Fan water table.

Adjustments were made to spring - early summer flows in the river and irrigation ditches. Results showed water table elevations deviated from calibrated values during summer months, but in all predictive scenarios water levels recovered to the same elevation as calibrated values during winter months.

I concluded that, although surface water leakage is important as a seasonal recharge source, lateral inflow from Agency Fan is the dominant source of recharge during winter months. I believe drought conditions which reduced overall recharge since 1983 are responsible for winter water level declines observed over the last four years.

**ACKNOWLEDGEMENTS**

Formal support for this project has been provided by the U. S. Bureau of Indian Affairs. The U. S. Geological Survey performed much of the field work for this project. In particular, I thank Dave Briar of the Geological Survey for his enthusiasm and support. The Confederated Salish and Kootenai Tribes provided me with equipment and data collected by their staff. These three organizations were supportive throughout the project.

I would particularly like to thank residents of the Jocko Valley. They provided me with access to their wells and land, and showed real interest in the project.

My thesis committee members, Don Potts, Steve Sheriff, and Bill Woessner, all willingly gave help when I asked for it. In particular, I am grateful to Bill Woessner. Not only is he a excellent and dedicated teacher, but as director of this project he provided me with help every step of the way.

Finally, I appreciate the opportunity to thank my parents, John and Marion Makepeace, and my wife Alexandra. My parents have a firm belief in the importance of education, both to the individual and to society, which they instilled in all of their children. Alexandra has been my best friend for 10 years, and has kept my goals in sight, in spite of my wandering ways.

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# CHAPTER ONE: INTRODUCTION.

Montana, and most of the western United States, has undergone a succession of low precipitation years. In 1985, this catalyzed conflict on the Flathead Indian Reservation over allocation of surface water between irrigation and fishery needs. The result, to date, has been mandated increases in instream flow during summer months to protect fisheries. Following this decision irrigation water, the priority surface water allotment since the early 1900's, has been insufficient to complete the full growing season.

Interactions between surface and ground water further complicate water management issues on the Flathead Indian Reservation. Previous work (Thompson, 1988) showed that the Jocko River and irrigation canals are important sources of recharge in the Jocko Valley on the southern Flathead Indian Reservation (Figure 1). In 1985 and possibly earlier, previously productive water wells went "dry" in parts of the Jocko Valley as the water table dropped below pump levels during winter months. Although valley aquifers are the sole source of potable water within the Jocko Valley, there is no water resource management scheme integrating surface and ground water.

In this study, I focus upon the high hydraulic conductivity, unconfined Jocko Fan aquifer. This aquifer, comprised of coarse grained sediments of the Jocko Fan, is

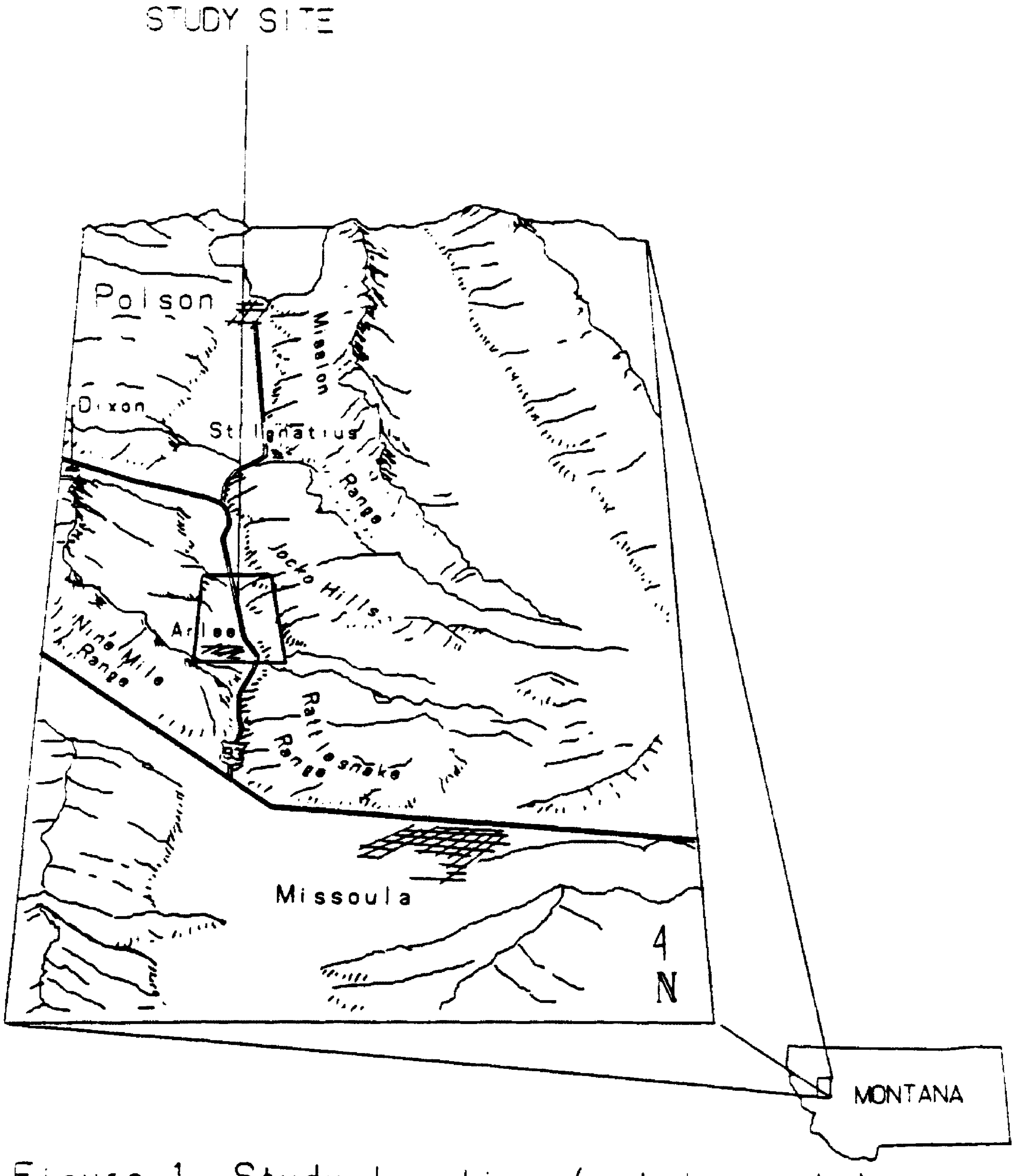


Figure 1. Study location (not to scale)
(Thompson,1988)

the principal ground water resource in the Jocko Valley (Figure 2). Of particular interest is the upper Jocko Fan where symptoms of water shortage have been manifested in recent years. On the upper Jocko Fan, seasonal water level changes are large, several wells have been deepened to maintain water supplies.

## PURPOSE AND SCOPE:

The goal of this study is to determine the cause of annual and seasonal declines in water table elevations in the unconfined Jocko Fan aquifer. To test Thompson's (1988) suggestion that leakage from surface water is the main source of aquifer recharge, I examined interactions between surface and ground water in the Jocko Fan aquifer and the effect of adjusting surface water flows to the aquifer. Numerical modeling proved the best method to investigate surface water - ground water interactions. Prior to model construction, I developed a framework for the surface and ground water hydrology of the Jocko Fan aquifer. Specifically, this involved: 1) Construction of a conceptual model for the depositional history of the Jocko Fan; 2) Determination of aquifer properties; and 3) Accounting for inflows to, and outflows from, the Jocko Fan aquifer.

Numerical modeling of the Jocko Fan aquifer consists of two components; 1) development and testing of the conceptual model of the hydrologic system, and 2) following model

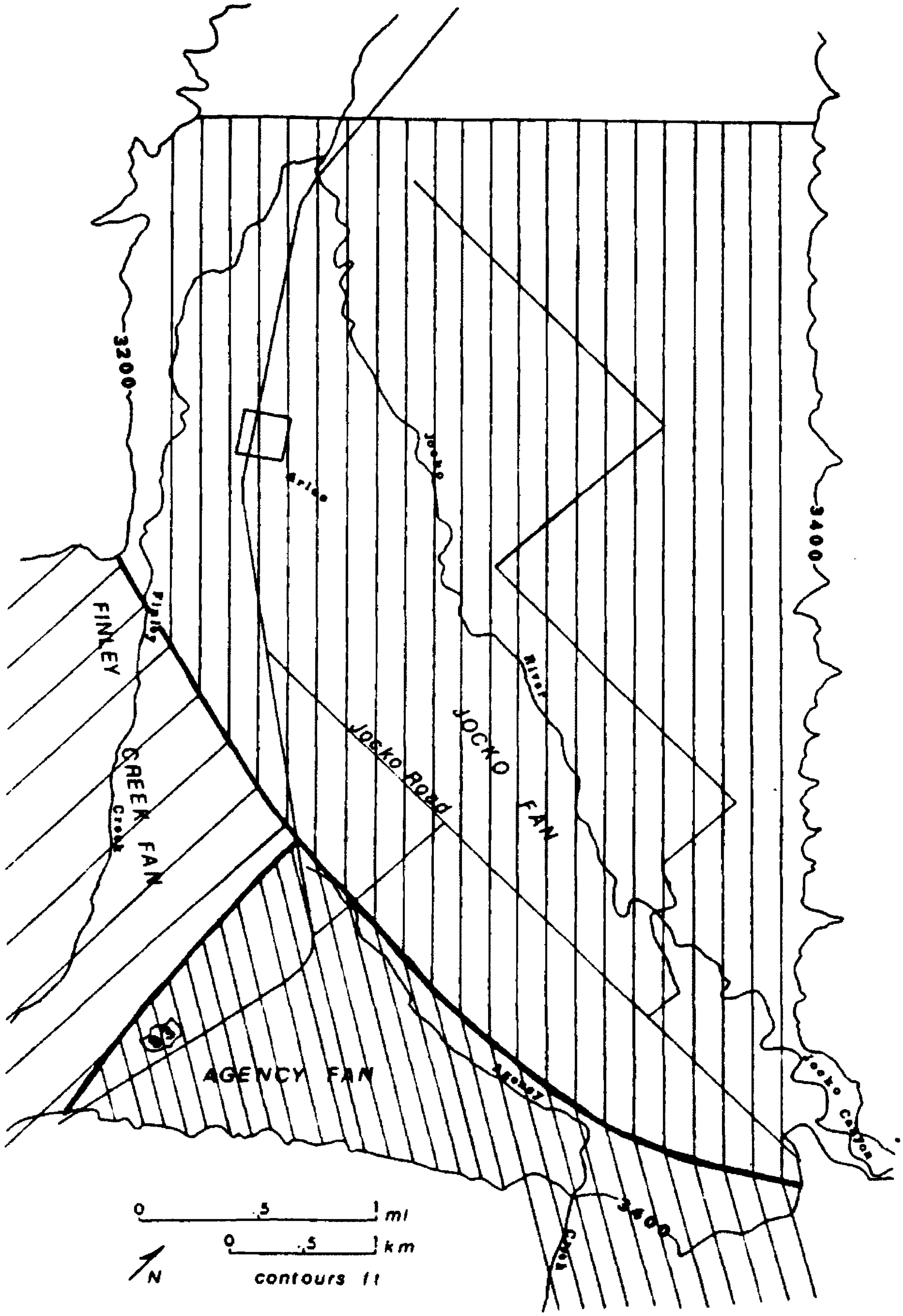


FIGURE 2: Map of study area and boundary of Jocko Fan.

calibration, evaluation of the consequences of various surface water management scenarios on the aquifer. Specific scenarios modeled include the effect on the aquifer of; 1) increased instream flows, and consequently, lowered irrigation flows, 2) complete diversion of surface water into irrigation ditches, and 3) supplementing Jocko River flows with water normally diverted into the Mission Valley.

To enhance report readability, some detail is excluded from the main text, and is presented in appendices. The remainder of the introductory chapter reviews salient features of the Jocko Valley including climate, geology, hydrology, and hydrogeology.

## CLIMATE:

On the floor of the Jocko Valley, the climate is semiarid. Precipitation averages 15 inches (38 cm) a year, principally as rain. Seasonal variations in rainfall are evident in Figure 3 (SCS, 1984-1988) which shows monthly rain gauge data for nearby St. Ignatius for the period January, 1984 through July, 1988. Precipitation increases with elevation, snowfall becomes more important. Snowpack data for the north fork Jocko River snowcourse are presented in Figure 4 (NCDC, 1984-1988). Snowpack recorded for the last several years is below average.

## GEOLOGY:

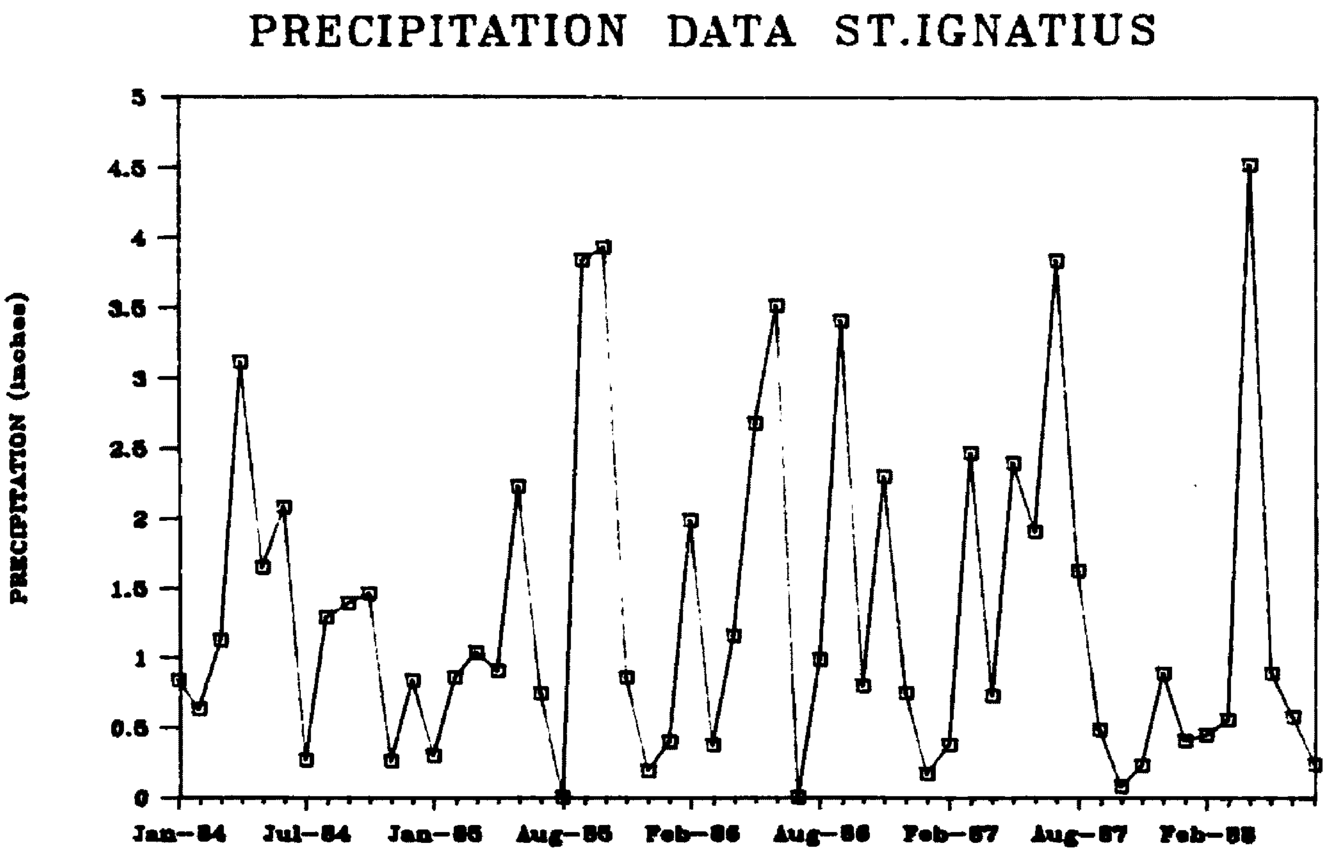


FIGURE 3: Precipitation data, St Ignatius (1984-1988).

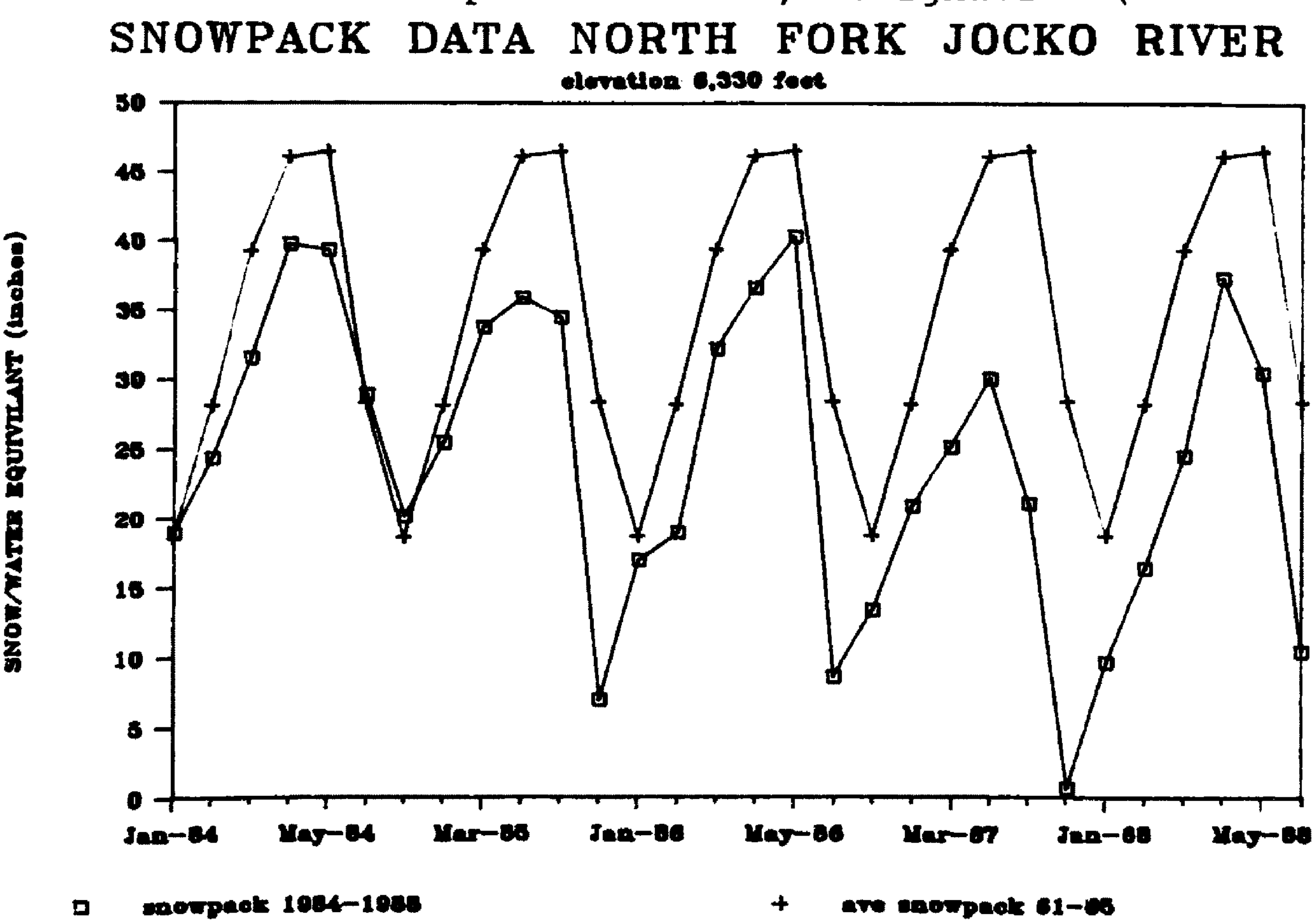


FIGURE 4: Snowpack data, north fork Jocko River (1984-1988).

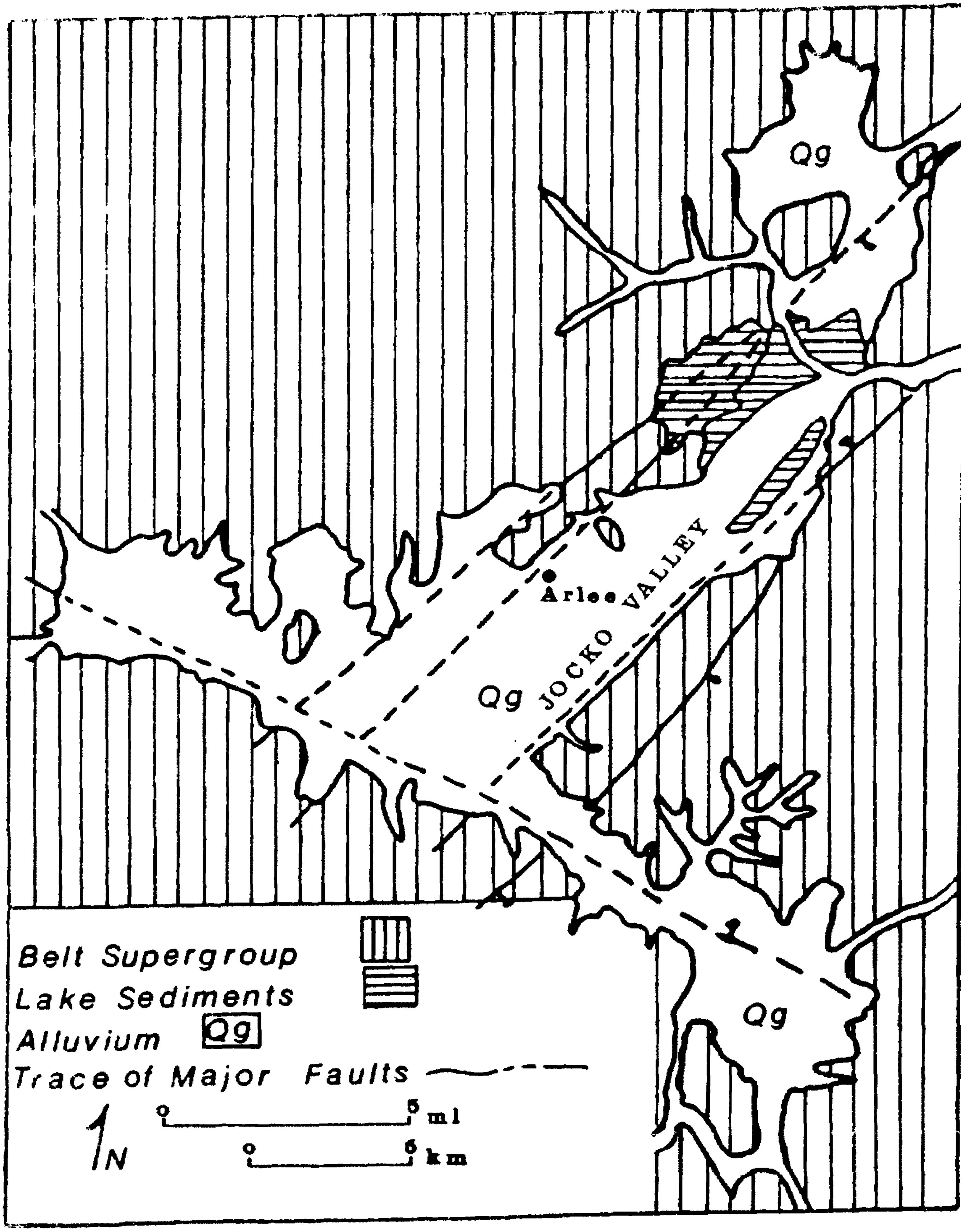


FIGURE 5: Geologic map of Jocko Valley.

Both bedrock and structural geology in the Jocko Valley (Figure 5) area are described in Harrison and others (1986) and Mudge and others (1982). The Jocko Valley is underlain by a northwest trending, downdropped fault block (Harrison et al., 1986). Although few Tertiary exposures exist, much of the Quaternary fill in the Jocko Valley may be underlain by Tertiary sediments (Slagle, 1988). Stoffel (1980) described normally faulted, unconsolidated early-Pleistocene sediments in the northern Jocko Valley. Alden (1953) described intermittent benches and pediment gravels of Pliocene age, preserved at elevations ranging from 3,750 to 4,400 feet (1,143 to 1,341 m) in the Jocko Valley.

Glacially derived sediments form the Jocko Fan aquifer, therefore glacial events which may have affected the study area are highlighted. Appendix A, and Figure 6, contain further information on the glacial history of northwest Montana. Alden (1953) described several lines of evidence indicating that Pleistocene alpine glaciers occupied much of the upper Jocko watershed. Piedmont glaciers reaching into northwest Montana (Flathead lobe) and northern Idaho (Purcell Trench lobe) were frontal lobes of the Cordilleran ice sheet. Although evidence suggest (Curry et al., 1977) that continental ice did not directly overly the Jocko Valley, by damming the Clark Fork River and creating Glacial Lake Missoula, southward expansion of continental ice did impact the depositional environment of the valley.

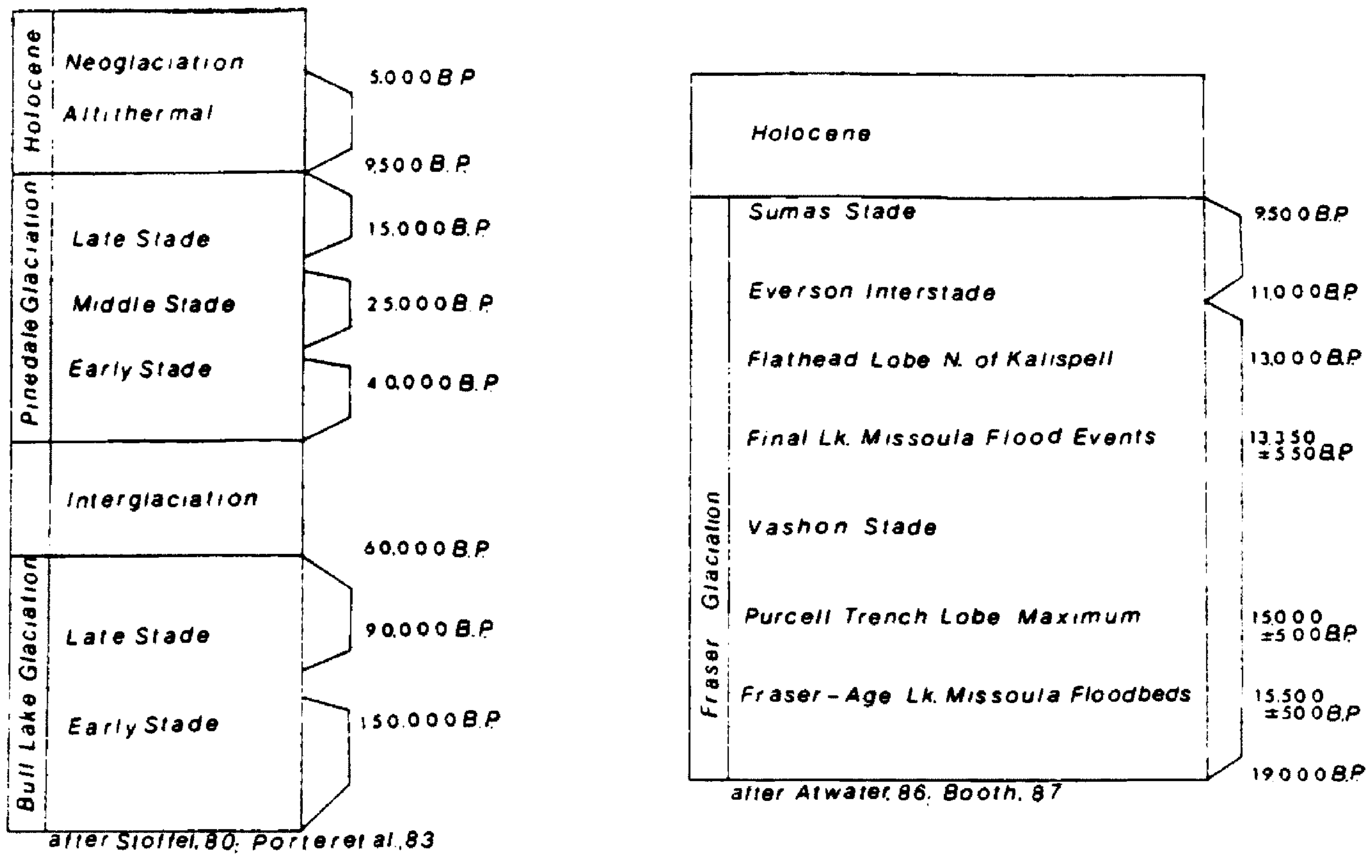


FIGURE 6: Alpine and continental glacial chronolgy, northwest Montana.

## HYDROLOGY:

The Jocko River, Finley Creek, Agency Creek, and Spring Creek are the main tributaries in the upper Jocko Valley (Figure 7). The Jocko River drains 80 square miles (207 square km) and has estimated average flow of between 60 and 90 cfs (1.7 - 2.5 cms). Finley Creek catchment is comparable in size to the Jocko drainage, but the catchment is at a lower elevation. Estimated average flow of Finley Creek is 15 cfs (0.42 cms). Agency Creek flows year round, however it loses most of its water prior to reaching the Jocko Fan. As Agency Creek leaves the Rattlesnake

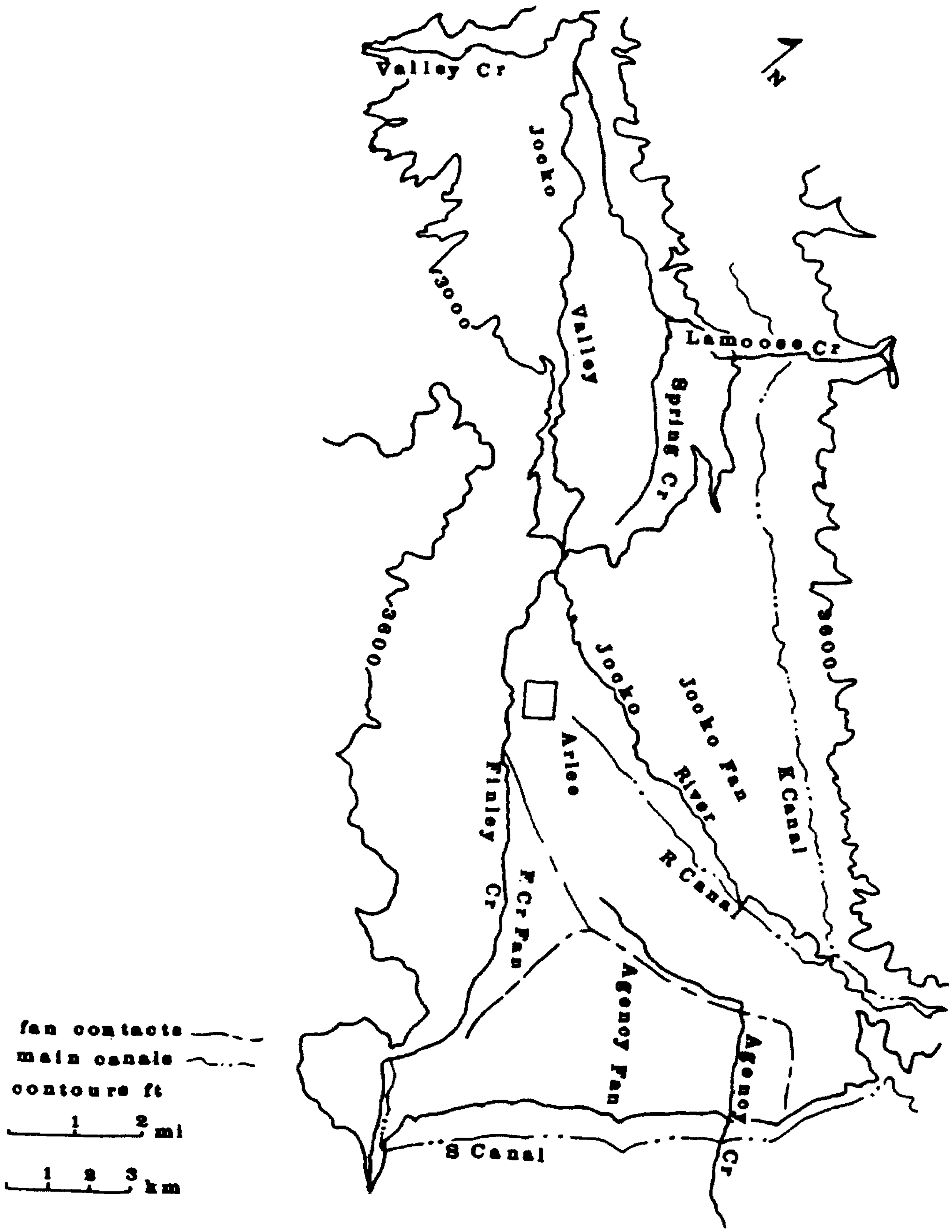


FIGURE 7: Surface water features in the Jocko Valley.

Mountains, estimated average flow is 10 cfs (0.28 cms). Spring Creek flows due to ground water recharge; it begins mid-valley and joins the Jocko River near the valley terminus. No data were available on Spring Creek, however estimated average flow is below 15 cfs (0.42 cms). Several smaller intermittent streams and springs also drain into the valley.

Figure 8 (hydrograph for site C1, Figure 11; provisional CSKT data) is included to show seasonal distribution of discharge in the Jocko River. Finley Creek and Agency Creek have similarly shaped hydrographs but much lower discharges.

Water is diverted into K canal from the Jocko River from April through early winter. Water from K canal is routed to supply all irrigation ditches flowing over the Jocko Fan. Most of the ditches are small diversions not included in Figure 7. During spring runoff, K canal flows exceed 100 cfs (3.0 cms); later in the irrigation season, flows of 60 to 80 cfs (1.7-2.3 cms) are more common.

At present, a major issue in surface water management in the Jocko Valley, and Montana, is defining the instream flow needed to maintain a productive fishery and a stable channel configuration. Available surface water in the lower Jocko drainage is apportioned for two primary purposes; 1) agricultural water use, and 2) maintenance of a productive fishery. Current surface water management also includes annual diversion of 25,000 to 40,000 acre-feet of spring runoff from the two headwater storage reservoirs in the Jocko watershed into the Mission Valley (B.I.A., 1987).

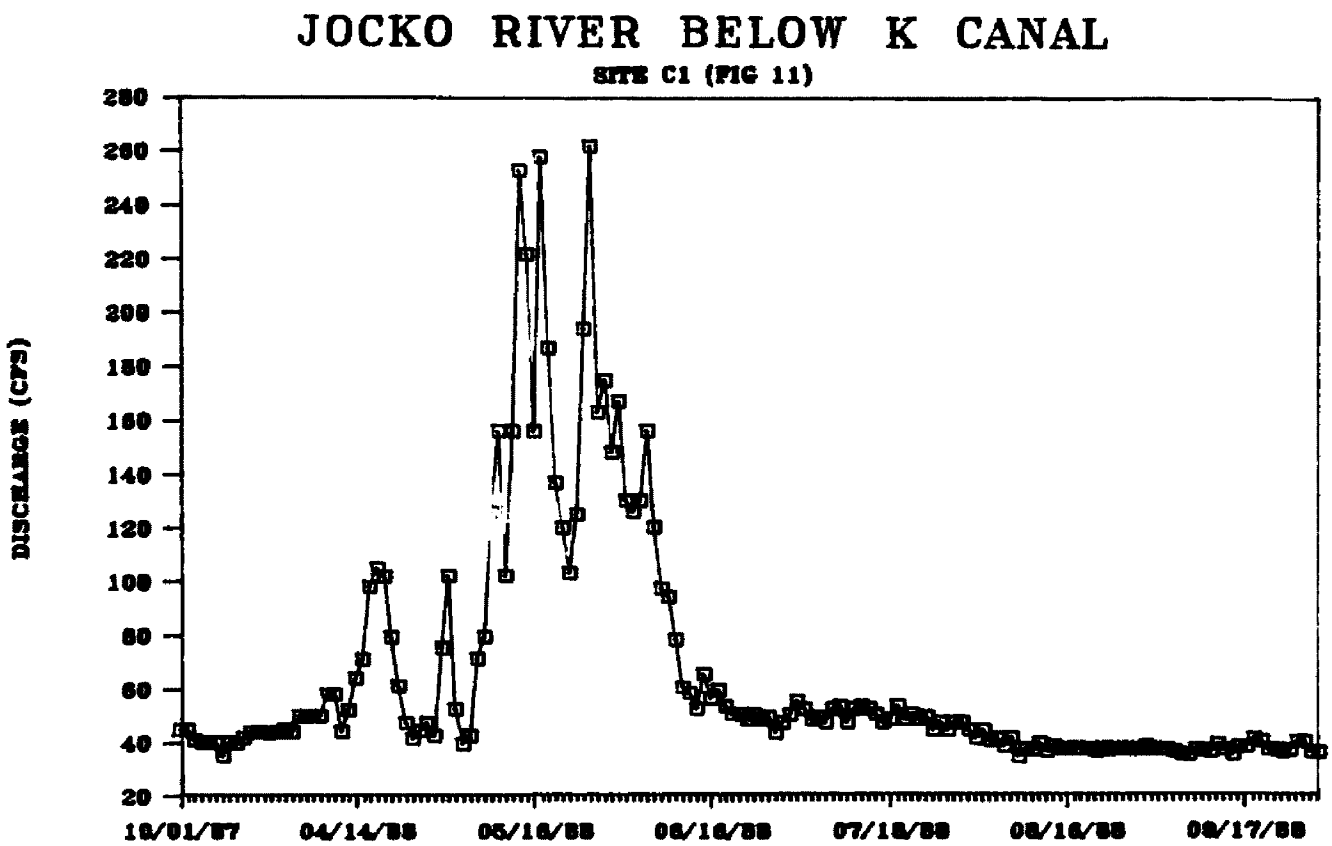


FIGURE 8: Hydrograph for Jocko River below K canal.

## HYDROGEOLOGY:

Boettcher (1982), Thompson (1988), and Slagle (1988) have described hydrogeology in the southern Flathead Indian Reservation. They note the presence of three main types of aquifers: fractured bedrock aquifers; fine grained, commonly Tertiary age aquifers; and sand, silt, and gravel Quaternary age aquifers. By far, Quaternary age aquifers are the most productive and widely exploited. Three adjacent fans form the main surficial features and the main aquifer systems in the upper Jocko Valley (Figure 2). I focus upon the late Quaternary age Jocko Fan aquifer in this study.

The boundaries of the Jocko Fan aquifer (Figure 2) accord to natural borders of the Jocko Fan, except the north-northwest boundary. Along this boundary, the fan interfingers with other valley-fill, including lake silts. The aquifer is confined where overlain by lake silts (Thompson, 1988). In this report, the north-northwest boundary of the Jocko Fan aquifer (Figure 2) corresponds to the transition between unconfined and partly confined conditions. The Jocko Fan aquifer is dominantly gravel with silt and sand matrix; the coarse fraction causes the aquifer to be highly transmissive. Thompson's (1988) contour map of the water table shows a regular down-fan decrease in elevation and slope of the water table.

Agency Fan is not a single aquifer system. Drill logs indicate that Agency Fan is over 500 feet (153 m) thick in places and is composed of Quaternary age sand and gravel overlying probable Tertiary age interbedded sediments (Thompson, 1988). Agency Fan is upgradient from Jocko Fan and lateral flow from Agency Fan recharges the Jocko Fan aquifer.

Finley Creek Fan, the smallest of the three fans, appears to be a latest Pleistocene deposit. Drill logs indicate that Finley Creek Fan is 100 to 150 feet thick (30 - 46 m), and that it is finer grained than Jocko Fan.

# CHAPTER TWO: METHODS.

The methods used in this report are designed to accomplish four major goals: 1) Determination of the depositional framework and geometry of the Jocko Fan; 2) Quantification of aquifer properties; 3) Calculation of the balance of inflows to, and outflows from, the Jocko Fan aquifer; and 4) Development of a calibrated numerical model for the Jocko Fan aquifer.

## DEPOSITIONAL FRAMEWORK and GEOMETRY:

Through analysis of drill logs, aerial photographs, pertinent literature, and inspection of outcrops, I interpreted the stratigraphy and depositional setting of the Jocko Fan. Determination of aquifer properties is difficult in high hydraulic conductivity aquifers, and I used geologic interpretation to bound the range and distribution of potential values of aquifer properties, in particular hydraulic conductivity.

The U. S. Geological Survey completed three seismic refraction profiles in the Jocko Valley (Figure 9) for this project. The layout of equipment, designed to facilitate interpretation with the seismic refraction modeling program SIPT1 (Scott et al., 1972; Haeni et al., 1987), is described in Appendix B.

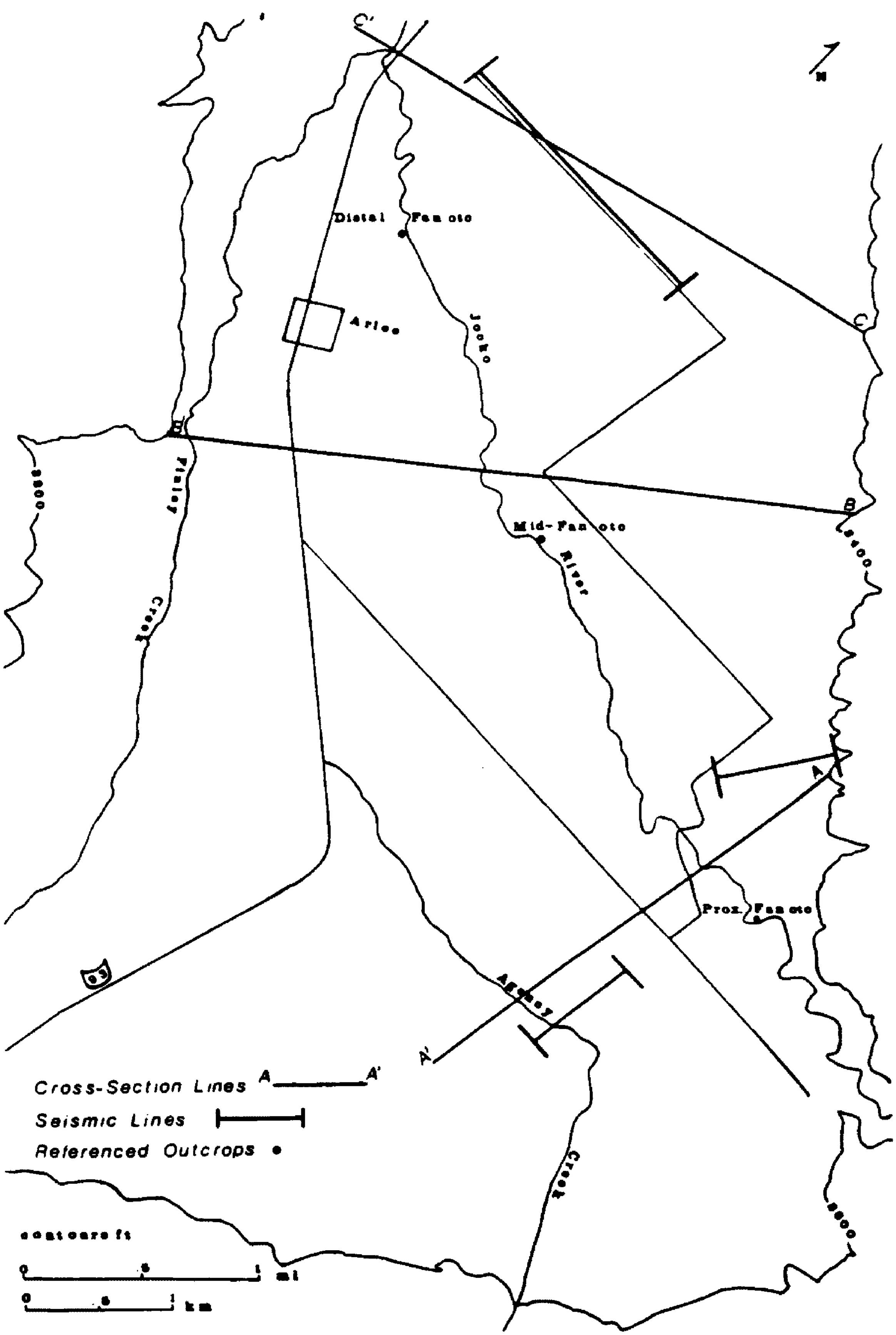


FIGURE 9: Location of seismic lines, cross-sections, and referenced outcrops.

Appendix B also contains an algorithm for SIPT1 and specific problems encountered using seismic refraction in the Jocko Valley. Seismic data, modeled using SIPT1, predicted depth to base of the sand and gravel aquifer.

The U. S. Geological Survey drilled one monitoring well to calibrate seismic refraction data and to determine aquifer thickness (well MW, Figure 10). During drilling, I collected cuttings at five feet (1.5 m) intervals, and wherever a lithologic change occurred. The Geological Survey completed a gamma log to 334 feet (102 M). Appendix A contains details of drilling and a well log for well MW.

Seismic refraction facilitated definition of the surface and slope of the base of the aquifer and the contact between Jocko and Agency Fans. Cuttings from the monitoring well improved stratigraphic interpretation of the Jocko Fan.

## AQUIFER PROPERTIES:

Using domestic wells, I performed constant discharge pump tests on several wells penetrating the Jocko Fan aquifer. Maximum discharges from wells ranged from eight to twelve gpm (0.5 to 0.8 l/s). This range in discharge proved insufficient to cause measurable drawdown.

The Geological Survey performed step drawdown (Walton, 1962) and constant discharge (Lohman, 1979) pumping tests on the monitoring well (well MW). The discharge used in the step drawdown test ranged from 109 to 228 gpm (6.9 to 14.4

1/s). After allowing the well to recover overnight, the Geological Survey performed a constant discharge test. The test lasted for 110 minutes at a constant discharge of 224 gpm (14.1 l/s). I collected recovery data but the well returned to pre-pumping conditions almost instantaneously. Field data from aquifer tests are found in Appendix G. As an alternative to pumping tests, Thompson (1988) used specific capacity data from drill logs to estimate aquifer transmissivities. Using test data and Thompson's specific capacity data, I attempted to assign hydraulic conductivity values across the Jocko Fan aquifer.

I established a network of 46 observation wells (Figure 10). Measurements were taken weekly beginning April, 6 1988, prior to spring runoff and the irrigation season and continued through early July; twice monthly to late August, and then approximately monthly after this through March, 1989. I made all measurements with a steel tape following standard procedures.

Three wells had continuous recorders positioned to monitor water levels. I placed a Stevens recorder in an abandoned well adjacent to R canal (well 7). Data are recorded in continuous format on 32 day strip charts. Well 12, adjacent to the Jocko River, and Well 15, one half mile south of the river, had data pods (OMNIDATA INTERNATIONAL, INC., 1982) with pressure transducers installed.

While in the field, I developed a linear relation between

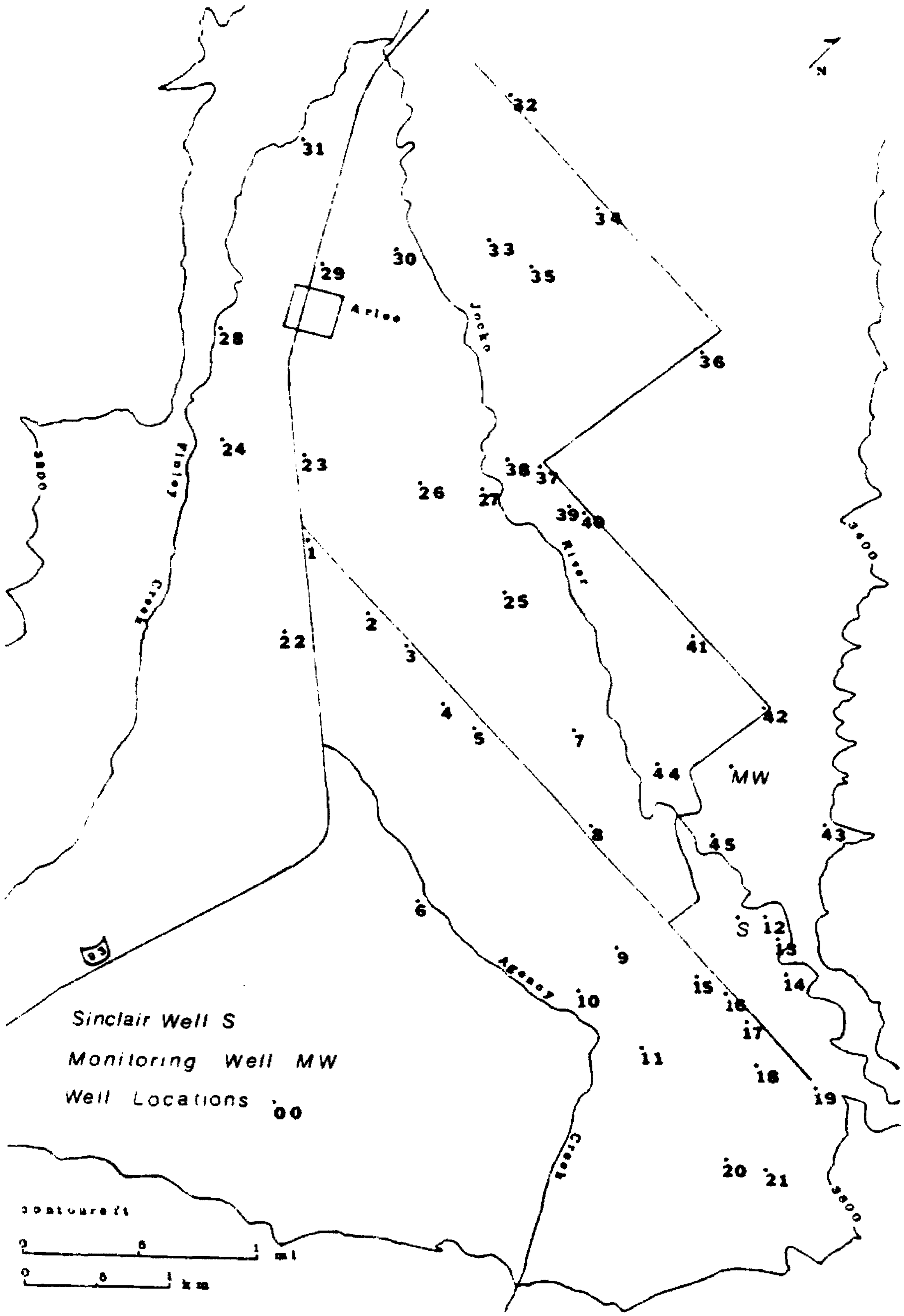


FIGURE 10: Location of observation wells.

head and voltage for each transducer. After storage on microchips is filled with voltage values, data are transferred to computer disk and converted to water table elevation data.

The Geological Survey and Bureau of Indian Affairs surveyed all wells to mean sea level. I adjusted water level measurements to absolute elevations and stored data on a computer for manipulation. Surveying was not done in closed loops because benchmarks are not readily available. Therefore, no error range is established for the surveying; however, the Jocko Valley is relatively level and a total error of less than one foot (.3 m) may be reasonable.

I constructed seasonal water table contour maps and well hydrographs and used these data to evaluate; 1) ground water flow within the Jocko Fan aquifer, 2) timing of recharge events, and 3) changes in aquifer storage. I also used water level data to calibrate the numerical model.

## GROUND WATER BALANCE:

Balancing inflows to, and outflows from, the Jocko Fan aquifer is important for this study because it; 1) constrains the range of hydraulic conductivities used in the numerical model, 2) quantifies recharge to, and discharge from, the Jocko Fan aquifer, and 3) is an additional model calibration tool. Throughout, I concentrated the water balance on flow through the Jocko Fan aquifer, therefore only surface water channels which recharge or receive discharge from the aquifer are considered. The water balance is:

Inflows = Outflows ± Changes in Storage.

The applicable inflows to, and outflows from, the Jocko Fan aquifer include; 1) lateral inflow from adjacent aquifers (ex. Agency Fan), 2) surface water recharge, 3) discharge from Jocko Fan aquifer to the Jocko River, 4) pumping and evapotranspiration, and 5) direct precipitation infiltration.

Lateral inflow and outflow are calculated using Darcy's Law. Pumping, evapotranspiration, and precipitation are evaluated from literature sources and change in storage is estimated from hydrographs.

I gauged flow within selected irrigation ditches and the Jocko River with a Price AA current meter to quantify leakage rates from surface water channels (Buchanan and Somers, 1969). I chose six sites on K and R canals for gauging and seven sites on the Jocko River (Figure 11). Measurement sites for selected provisional surface water data, made available by the Water Resources Division, Confederated Salish and Kootenai Tribes (CSKT), are shown in Figure 11. All surface water sites are surveyed to mean sea level.

K canal flows over colluvium believed to be hydraulically connected to the Jocko Fan aquifer. It

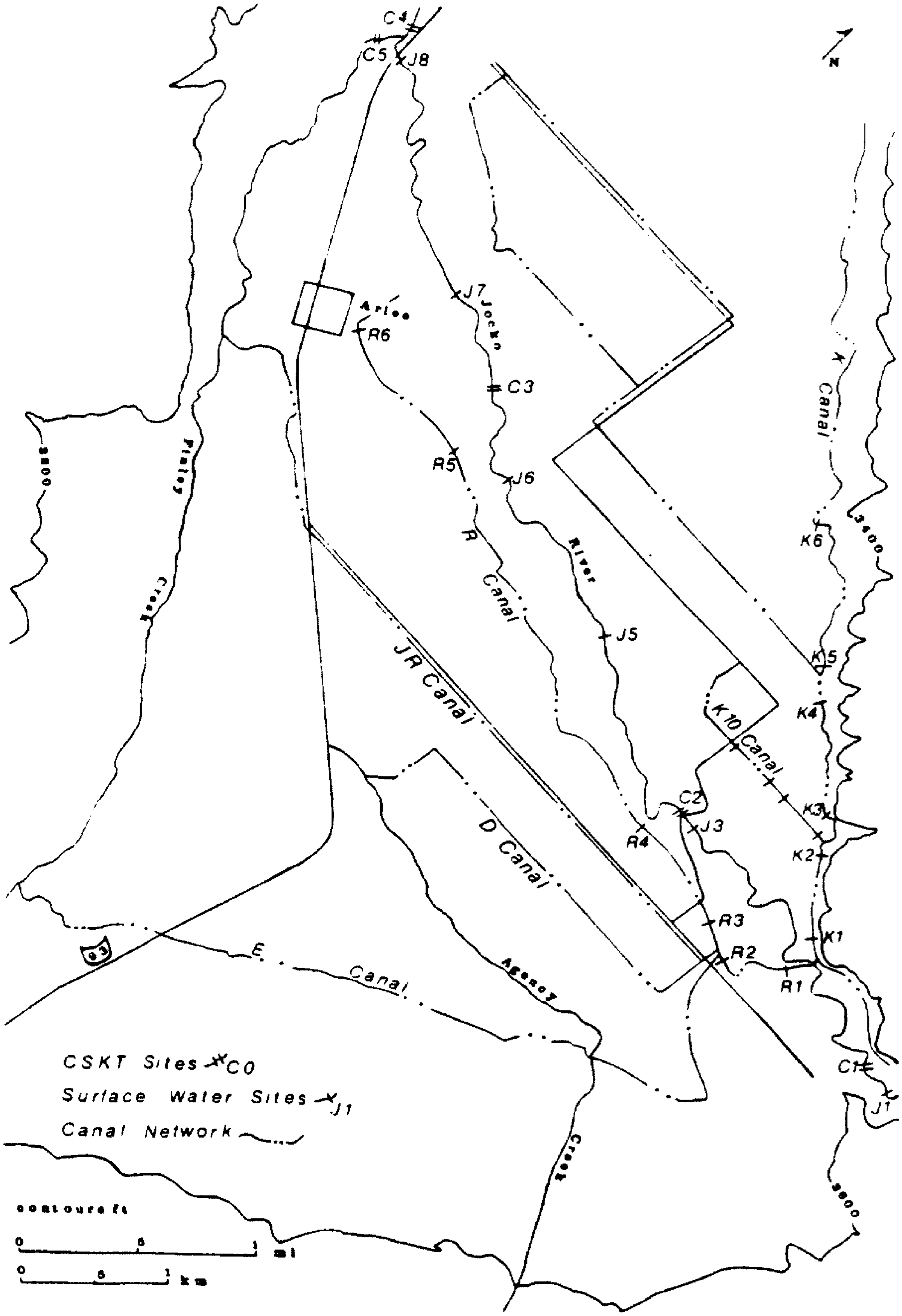


FIGURE 11: Location of surface water gauge sites.

carries the greatest flow in the ditch system, making it an important source of aquifer recharge. I selected R canal for gauging because it is representative of the main distributary canals flowing over the Jocko Fan aquifer. To mitigate the effects of flow regulation and surface evaporation on gauging results, I chose ditch sites in pairs and gauged sites as close in time as possible, usually less than one hour apart.

Using provisional CSKT data and discharge data collected during this study, I calculated leakage from, and gain across, the streambed of the Jocko River. Criteria for choosing gauge sites on the river included channel stability and access to the site. Specific surface water data collected during this study, and review of measurement error, are found in Appendix C.

## GROUND WATER MODEL:

After forming a conceptual geologic model of the Jocko Fan aquifer, I initiated a numerical model of ground water flow within the Jocko Fan aquifer. The USGS three-dimensional ground water flow model (MODFLOW) is used because of its versatility, excellent documentation, and reported application to a wide variety of ground water problems (McDonald and Harbaugh, 1984).

MODFLOW can be used to model three dimensional flow by assigning different aquifer properties to vertically stacked layers. However, I treated the Jocko Fan aquifer as a one layer, two-dimensional problem because; 1) well MW is the only detailed stratigraphic data available, and 2) other drill log data indicates that, although fine grained interbeds do occur, the Jocko Fan aquifer remains coarse grained through its entire thickness. The principal limitation of assuming two-dimensional flow is that vertical flow paths cannot be simulated.

After calibrating the steady state model to early April, 1988, I calibrated the transient simulation for the period April, 1988 through March, 1989. I then performed sensitivity analysis and model predictions.

## CHAPTER THREE: RESULTS and DISCUSSION.

This chapter focuses upon study goals established in Chapter One. Discussion of results, as they apply to the hydrogeology of the Jocko Fan aquifer are included within this chapter.

### CONCEPTUAL GEOLOGIC MODEL OF THE JOCKO FAN:

Tertiary geologic events which occurred in the Jocko Valley influence the hydrogeology of the Jocko Fan aquifer. I used geologic facies concepts to develop a hydrogeologic facies model for the Jocko Fan aquifer. This approach to developing flow models has been advocated in a recent article by Anderson (1989). The magnitude and distribution of aquifer hydraulic conductivity and storage properties are discussed in this section. Ultimately, I used geologic reasoning to assign values to these aquifer properties.

#### Aquifer Geometry:

On the northeast and southwest the Jocko Fan aquifer is bounded by bedrock. To the south, the boundary of the aquifer occurs where the Jocko Fan overlaps Agency and Finley Creek Fans. As previously stated, the northwest boundary of the aquifer is defined as the area where sediments of the Jocko Fan overlap and interfinger with other valley-fill. The Jocko Fan aquifer thins from 310 feet (94 m) beneath well MW to less than 200 feet (61 m) on the northwest boundary of the fan. South of well MW, the aquifer thins to less than 100 feet (30 m) as it overlaps Agency Fan.

Cross-sectional profiles are based on seismic refraction and well log interpretation; the cross-sections are intended to show the shape and depth of the base of the aquifer (Figure 12; locations Figure 9). The base of the aquifer has a concave-up profile everywhere except along Agency Fan. The convex-up interface between Jocko and Agency Fans (cross-section A-A') is supported by seismic interpretation. The shape suggests Agency Fan forms the base of the Jocko Fan aquifer on the south side of the valley. This is not surprising when onlapping relations (Figure 2) between Jocko and Agency Fan are considered.

Cross-sections B-B' and C-C' show a more symmetrical aquifer profile. Near the valley margins fine grained Tertiary-Pliocene sediment may interfinger with Jocko Fan sediments. Also, within the Jocko Fan aquifer, discontinuous silt and clay intervals are reported on drill logs. These features are not included in cross-sections because their spatial distribution is not constrained.

Approximately 100 feet (30 m) of Tertiary clay was drilled in well MW (307 to 400 feet; 94 to 122 m). The interpreted seismic velocity of the Tertiary sediments beneath well MW

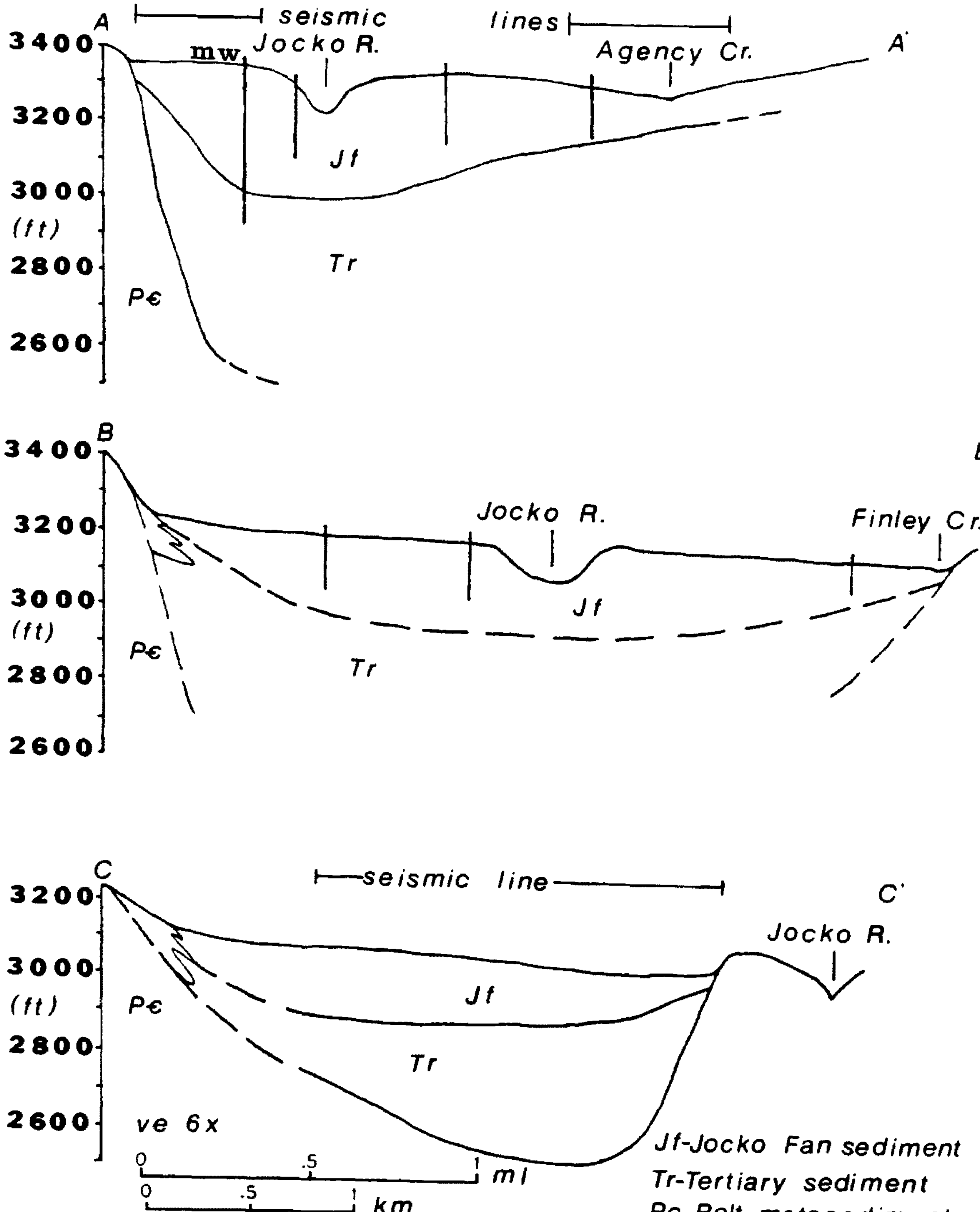


FIGURE 12: Cross-sections through Jocko Fan.

is 7,500 ft/s (2,286 m/s); this value is within the range of velocities cited for clays (Dobrin, 1976). In the other two seismic profiles (Figure 9), a 7,500 ft/s (2,286 m/s) velocity interface was intercepted at depth. Based upon drilling and seismic data, Tertiary clay is thought to underlay the Jocko Fan aquifer everywhere except along Agency Fan boundary.

Throughout the drilled interval, the clay is not indurated, and therefore, does not form an impermeable aquifer base. However; 1) clays have very low hydraulic conductivities (Freeze and Cherry, 1979), and 2) the well produced less than 10 gpm (.6 l/s) with 100 feet (30 m) of open hole through this interval. Vertical flow between the Jocko Fan aquifer and the underlying clay is believed small and is neglected in the numerical model.

## Jocko Fan Sediments:

Both geologic and gamma logs (Appendix A) for well MW record a homogeneous section of coarse gravel intermixed with sand and silt to 230 feet (70 m). At 230 feet (70 m), and continuing to the base of the aquifer, indurated, gritty siltstone chips show up in well cuttings. In the interval from 230 feet to 307 feet (70 to 94 m), the average cps in the gamma log decreases, distinctive bedded intervals occur, and the percent sand in well cuttings increases. Also in this interval, drilling was easier and the well produced more water. The siltstone chips appear too soft to have been preserved in a high energy fluvial environment. The section from 230 to 307 feet (70 to 94 m) may record Pliocene fan deposition, interglacial period deposition, or possibly Altithermal (Holocene) deposition.

In the following discussion, and in the numerical model, the entire sand and gravel interval is treated as one unit. Well MW has the only detailed log for a well penetrating the Jocko Fan aquifer, therefore, the spatial distribution of the siltstone bearing layer is not known. Also, on a macroscopic scale, the sediment package remains very similar to the base of the aquifer.

Three stratigraphic sections recording proximal to distal trends on the Jocko Fan are presented in Figure 13. The location of these outcrops are found in Figure 9. Reference Figure 13 and Mialls (1978, 1981) classification scheme for stratigraphic details of each section.

Two shared features of proximal to distal outcrops deserve mention:

1) Silt accounts for over 50 percent of matrix material throughout the Jocko Fan. The silt is probably reworked Glacial Lake Missoula silt and silt liberated when glacial deposits in the Jocko watershed were reworked.

2) Some down-fan fining is evident on the Jocko Fan, however, the fan remains coarse grained along its entire length. The coarse gravels are derived from the Jocko

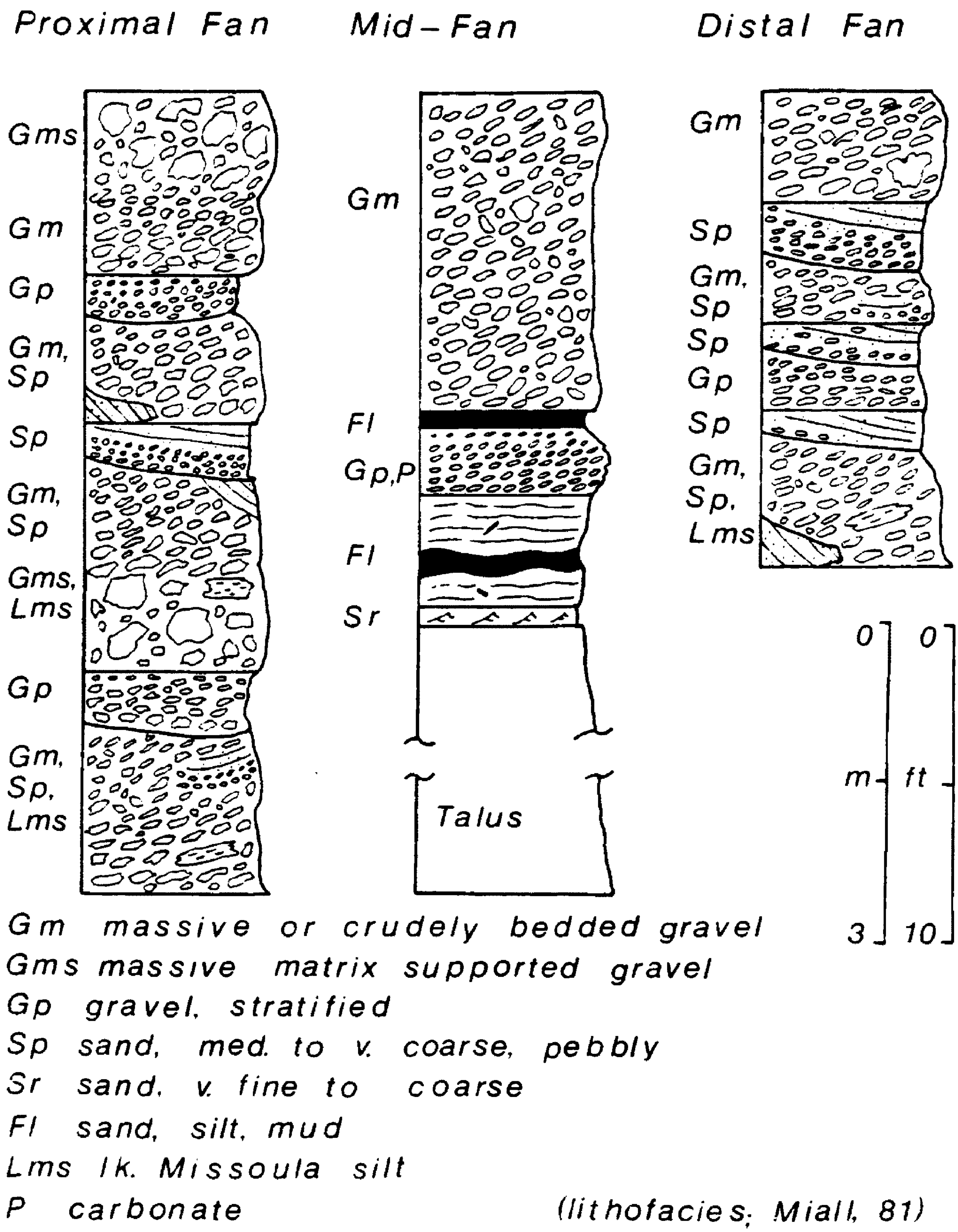


FIGURE 13: Proximal to distal fan outcrops.

catchment, they indicate transport in a high energy fluvial environment.

## Depositional Environment and Timing:

Jocko fan fits a braided outwash fan facies model (Botthroyd and Ashly, 1975; Boothroyd and Nummedal, 1978; Church and Gilbert, 1975; Miall, 1982), therefore, the sections in Figure 13 are keyed to a braided stream lithofacies system developed by Miall (1978, 1981). Figure 14 is a schematic of the depositional setting of the Jocko Fan. The longitudinal profile of the fan matches reported

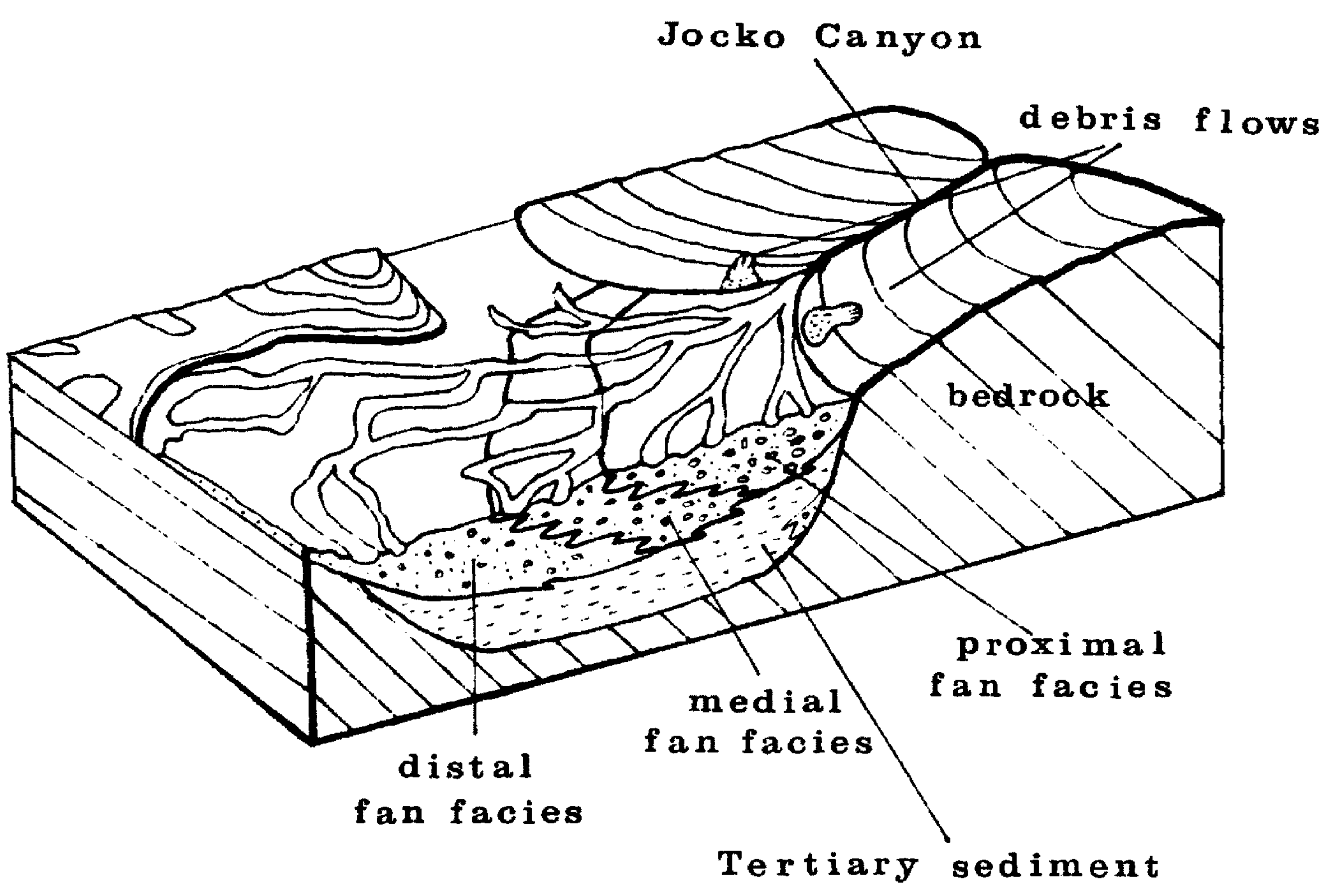


FIGURE 14: Depositional setting of the Jocko Fan.

fan profiles (54 feet/.62miles; 15.5 m/1.0 km; Boothroyd and Nummedal, 1978, p. 649). Proximal fan material, deposited as low relief longitudinal bars (Rust, 1975; Boothroyd and Ashly, 1975), contains thin tabular gravel beds with pebble to coarse sand interbeds. Debris flows deposited the boulder material capping upper fan outcrops.

Aerial photography shows multiple ancestral, low relief, low sinuosity channels radiating out from Jocko Canyon into the mid-fan area. Braided channels carried sediment down-fan and laterally to the fan margins. Decrease in grain size of sediments is detectable, but cobbles still dominate outcrops. Debris flow material is not found. The fine sand, silt, and mud in the mid-fan section (Figure 13) may be overbank material deposited in an abandoned channel.

Less can be said about distal portions of the Jocko Fan. Boothroyd and Ashly (1975) did not detect a major decrease in clast size in the first 3 miles (5 km) of fans they studied; this fits observations on the Jocko Fan.

Interstitial silt and exotic blocks of varved silt found throughout Jocko Fan indicate fan sedimentation postdates deposition of Glacial Lake Missoula silts. Onlapping relations the Jocko Fan exhibits with Agency and Finley Creek Fans (Figure 2) demonstrate deposition of the Jocko Fan continued after the other two fans became inactive. Two points suggest rapid deposition of the Jocko Fan; 1) overall vertical homogeneity of sediments implies uniform environmental conditions during deposition, and 2) seismic interpretation indicates that the buried Agency Fan surface was not incised by ancestral channels of the Jocko River. I contend that Jocko Fan is a paraglacial feature (Church and Ryder, 1972; Jackson et al., 1982) deposited during rapid flushing of drift deposits from the Jocko drainage some time after deglaciation but prior to the Altithermal maximum (Figure 6).

## Hydrogeologic Facies:

Depending upon the scale of examination, the Jocko Fan aquifer is composed of; 1) complexly interbedded coarse to fine sediments, or 2) homogeneous packages of sediment whose properties change in recognizable trends down-fan and laterally away from the fan axis. This report focuses on overall flow within the aquifer and effects of timing and volumes of recharge to the aquifer, not small-scale heterogeneities within the aquifer. Therefore, aquifer materials are examined on outcrop-scale and aquifer properties are assigned based upon down-fan and lateral fan trends.

Two points suggest that two dimensional modeling of the Jocko Fan aquifer does not impose unrealistic constraints on the physical system:

1) Although vertically, there is variation in grain size and degree of bedding within the Jocko Fan, no recognizable

vertical trends exist across the fan. Values for aquifer properties are assigned to gravel, sand, and silt beds grouped together as single units ( equivalent homogeneous porous medium; Anderson, 1989).

2) Weak, but prevalent, clast imbrication and horizontally bedded sediments cause ground water within the Jocko Fan aquifer to preferentially follow horizontal flow paths.

Hydraulic Conductivity:

Data collected during a constant discharge aquifer test on well MW are presented in Figure 15. The curve shape represents all pump tests conducted in the Jocko Valley. The aquifer stabilized to steady state within the first minute of pumping. Because of the small instantaneous

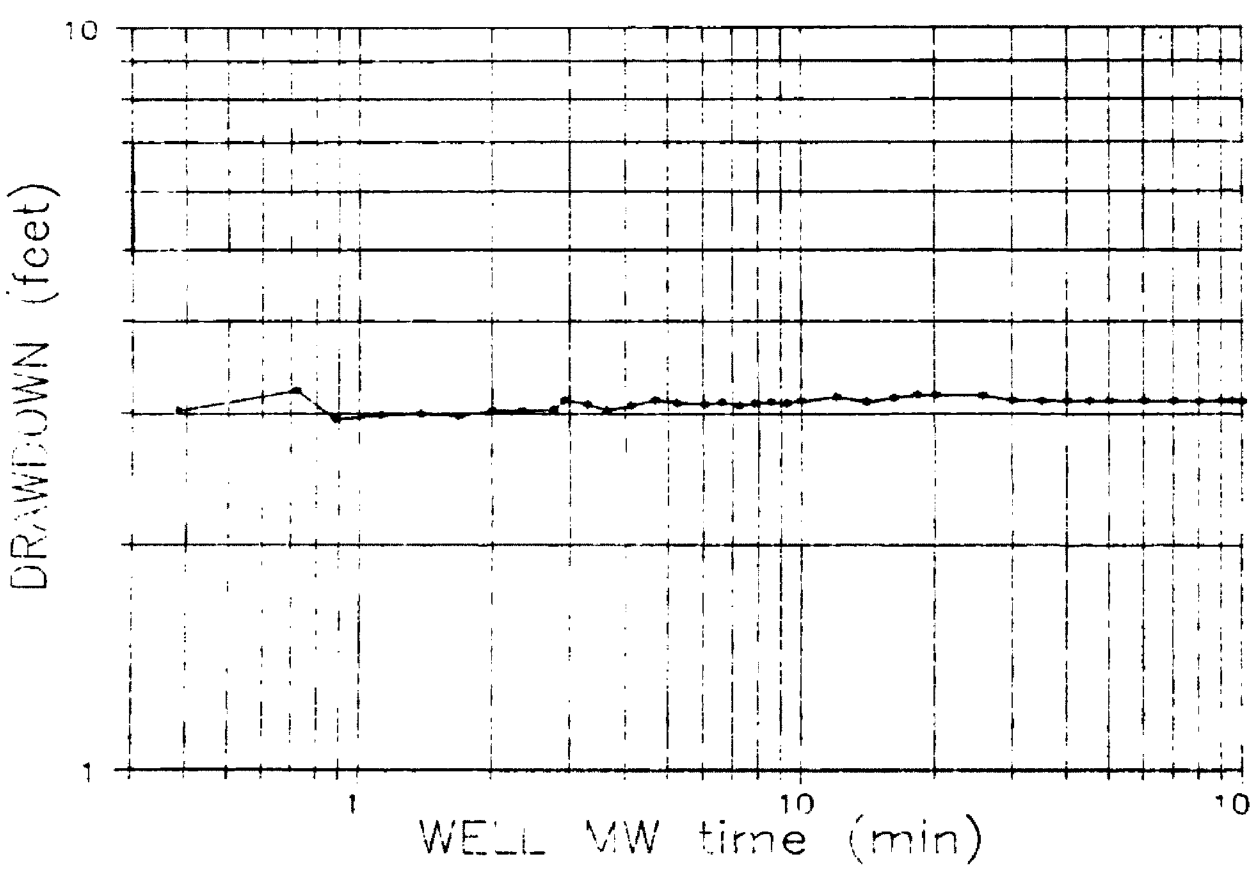


FIGURE 15: Constant discharge pump test results, well MW.

drawdown response, curve matching techniques could not be employed. Instead, I attempted a steady state solution approach.

Drawdown was only 2.2 percent of aquifer thickness, therefore, I used the Theim equation for a confined aquifer (Lohman, 1979) to calculate hydraulic conductivity:

$$T = (Q/2pi)*\ln(r2/r1)*(1/s)$$

Q = 224 gpm (14.1 l/s), pumping rate
s = 3.11 ft (.95 m), drawdown
r2 = 400 ft (122 m), distance to drawdown equal to zero
r1 = .25 ft (0.08 m), well radius

The value of r2 is taken from Driscoll (1986). The solution is not overly sensitive to r2 because the natural logarithm of the quotient of r1 and r2 is used. Step drawdown test data indicate that the well is efficient (the well was perforated across 100 feet (30 m) of the aquifer); therefore, I made no corrections for well effects. The calculated hydraulic conductivity value is 53 ft/d (16.1 m/d) using an aquifer thickness of 307 feet (94 m). The average of all specific capacity derived hydraulic conductivity values (Thompson, 1988) for the Jocko Fan aquifer is 267 ft/d (81 m/d).

I was unable to calibrate the numerical model using either specific capacity or field derived hydraulic conductivity values, the values were consistently too low.

Few data exist on hydraulic conductivity in coarse valley-fill aquifers. Slagle (1988) reported average hydraulic conductivity values of 500 ft/d (152 m/d) in the southern Flathead Valley, and Woessner (1988) reported hydraulic conductivities in excess of 1,000 ft/d (305 m/d) in the Missoula aquifer, an aquifer similar in character to the Jocko Fan aquifer. I used model calibration to assign aquifer hydraulic conductivity.

Ground Water Storage:

For unconfined aquifers, specific yield is used to measure aquifer storage. Coarse gravels range from 0.1 to 0.26, silts from 0.03 to 0.19 (Johnson, 1967). The Jocko Fan aquifer is silt-rich, it is also poorly sorted. Clark (1986), using data from permeameter tests, calculated a specific yield of 0.12 for Missoula Valley aquifer materials. The specific yield value applied to the Jocko Fan aquifer is 0.1.

## GROUND WATER MOVEMENT:

Water table maps for July, 1988 and March, 1989 (Figures 16 and 17) show down-fan flow is maintained throughout the year. March represents low water table elevations, July estimated high water table elevations.

On the valley floor and in terrace cuts along the entire lower portion of the Jocko channel, springs return ground water to the river year-round. Elevations of survey points on the lower Jocko channel are above the water table year-round, indicating that the lower Jocko channel gains water from the aquifer throughout the year. The Jocko River drains seasonal buildups in the water table moderating variations in water table elevations in the mid and lower Jocko Fan aquifer.

North of the river, ground water flow parallels the river and leaves the Jocko Fan as lateral outflow. Some of this ground water supplies Spring Creek which begins flowing 5.5 miles (8.8 km) down-fan.

Steep gradients in the water table, caused by aquifer thinning as the Jocko Fan overlaps Agency Fan, are preserved year-round on the upper Jocko Fan. Thickening of the aquifer to the north of Agency Fan results in a decrease in hydraulic gradient in the mid and lower Jocko Fan aquifer.

Bedrock flanks the northeast margin of the Jocko Fan, this boundary is a no-flow boundary. Data used to plot the 3,075 foot (937 m) equipotential line on the northwest margin of the fan (wells 24 and 28) indicate that the aquifer is recharged by lateral inflow (Figures 16 and 17). The sediments on this boundary are low permeability clays and silts which do not transmit water readily. In the numerical model, this boundary is treated as no-flow.

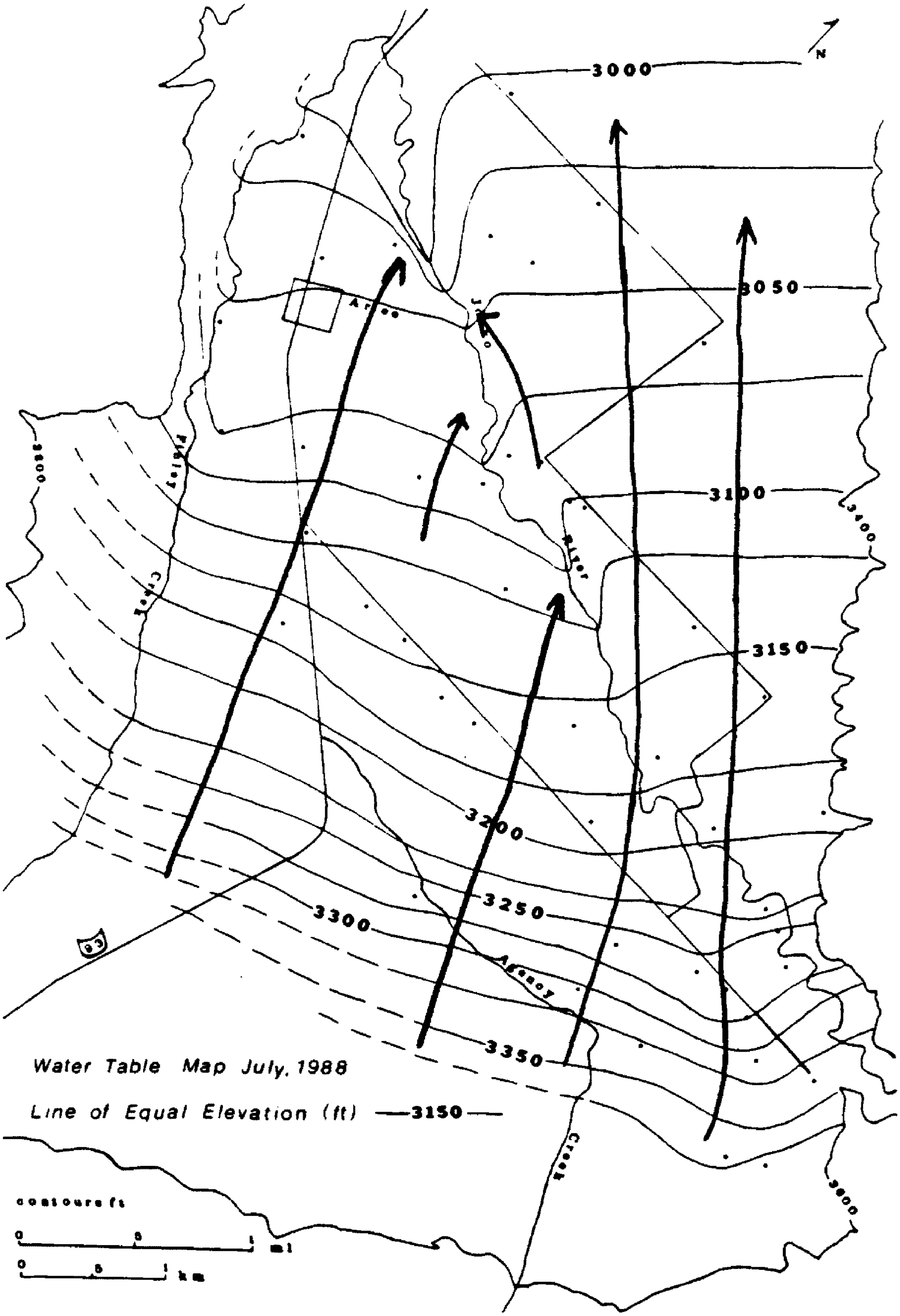


FIGURE 16: Water table map, July, 1988.

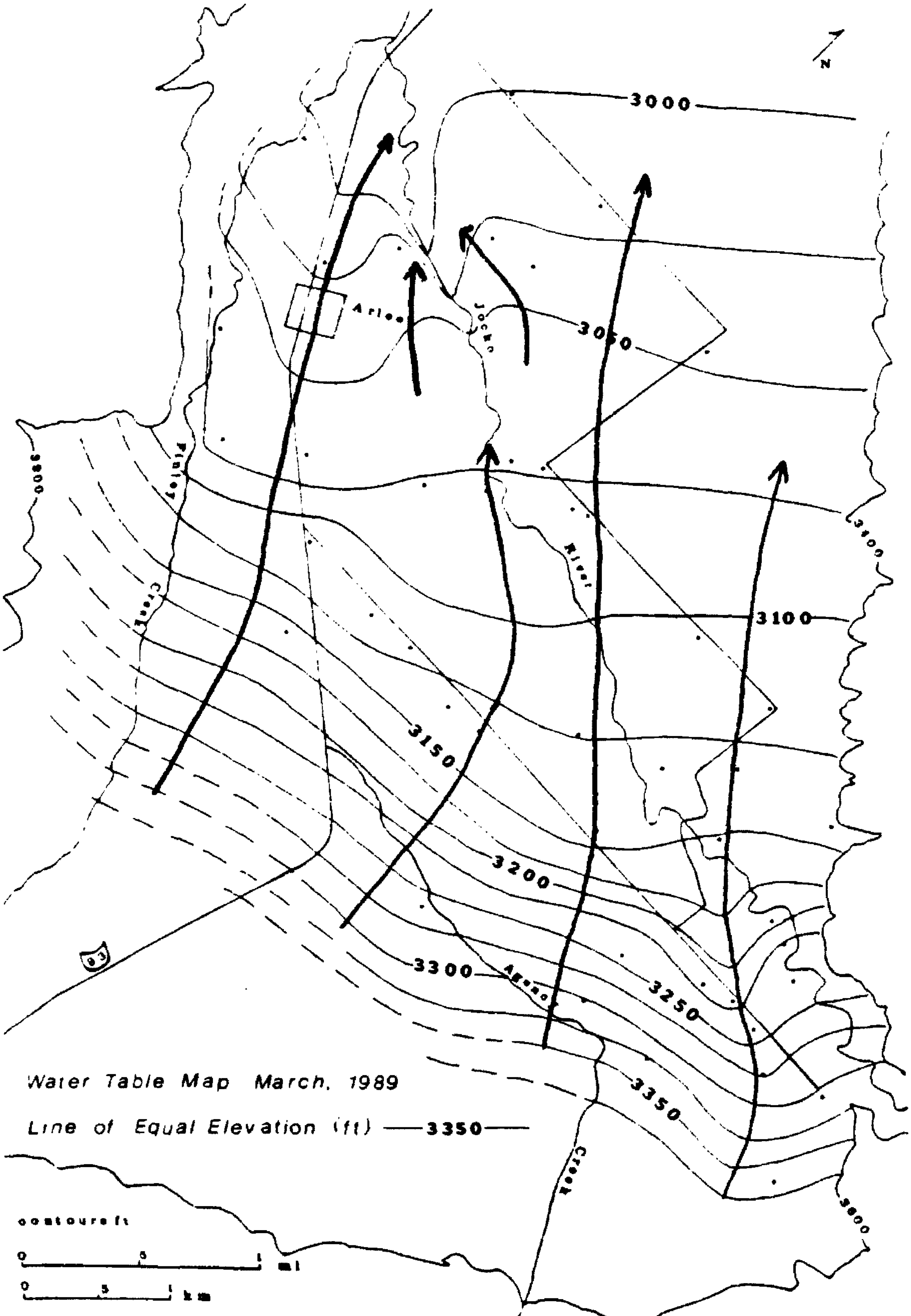


FIGURE 17: Water table map, March, 1989.

## TIMING OF RECHARGE:

Three sources of recharge, leakage through the channel of the Jocko River, irrigation ditches, and lateral ground water flow from Agency Fan, supply most water to the Jocko Fan aquifer. Discrimination of each recharge event is difficult because they overlap in time. Figure 18 (Well 8) is a hydrograph for a well one mile (1.6 km) from Jocko Canyon. This hydrograph illustrates well response to recharge in the central and northeast part of Jocko Fan. Following a sharp mid-April rise in the water table and subsequent break in slope in early June, there is a water table rise peaking in early July. Further down-fan the same pattern is evident, but each event is delayed (Well 33, Figure 19). Hydrograph responses (Figures 18 and 19) are generated by initial recharge from irrigation seepage, followed by recharge corresponding to peak river discharges (Figure 24). Lateral flow from Agency Fan cannot be discerned.

Figure 20 (well 20) is a hydrograph for a well one mile (1.6 km) south of Jocko Canyon on the Agency Fan boundary. Figure 21 (well 6) is a hydrograph for a well on the Agency Fan boundary midway between Jocko Canyon and Finley Creek. Neither well receives recharge from the Jocko River. Both hydrographs show detectable increases in recharge in mid-May. I suggest that initial recharge is from spring melt in

## WELL 8 (16N19W8CDD)

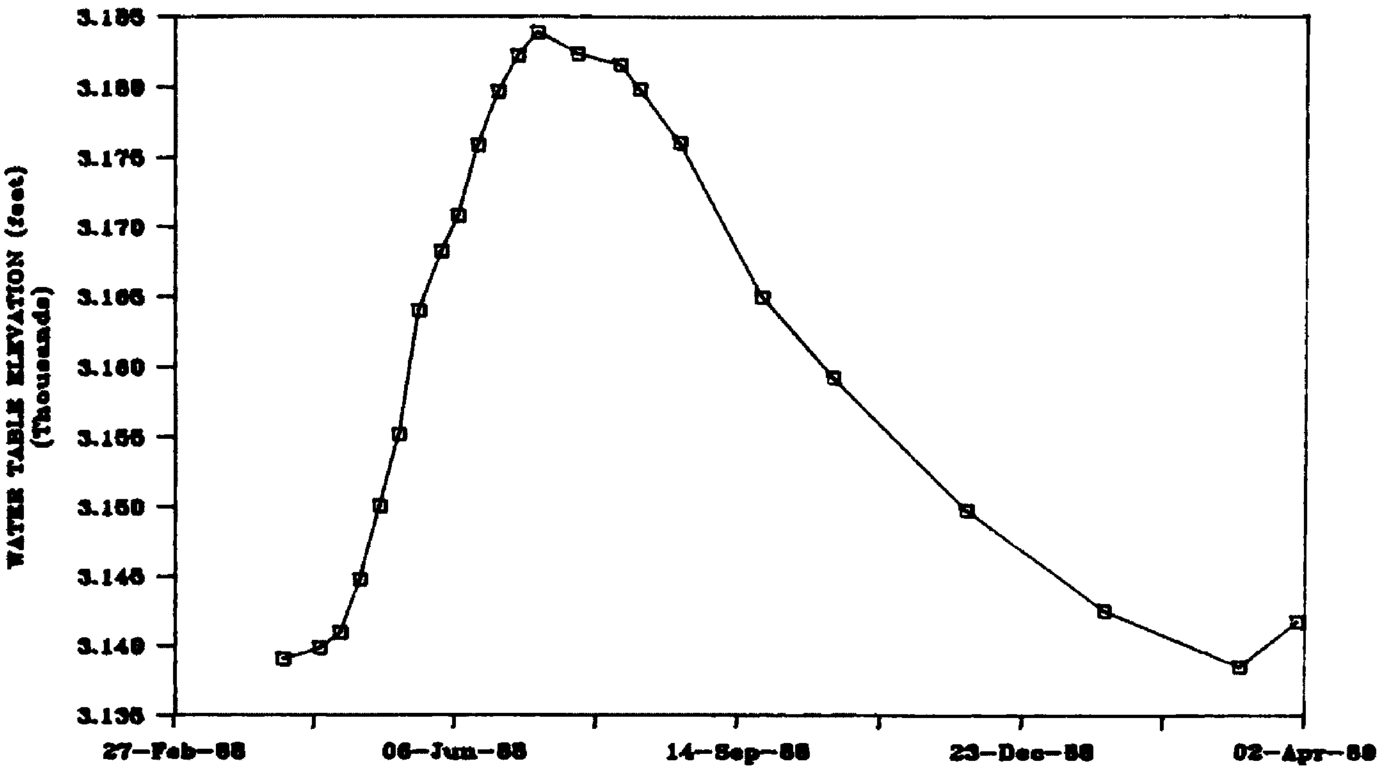


FIGURE 18: Hydrograph for well 8.

## WELL 33 (16N20W1BCC)

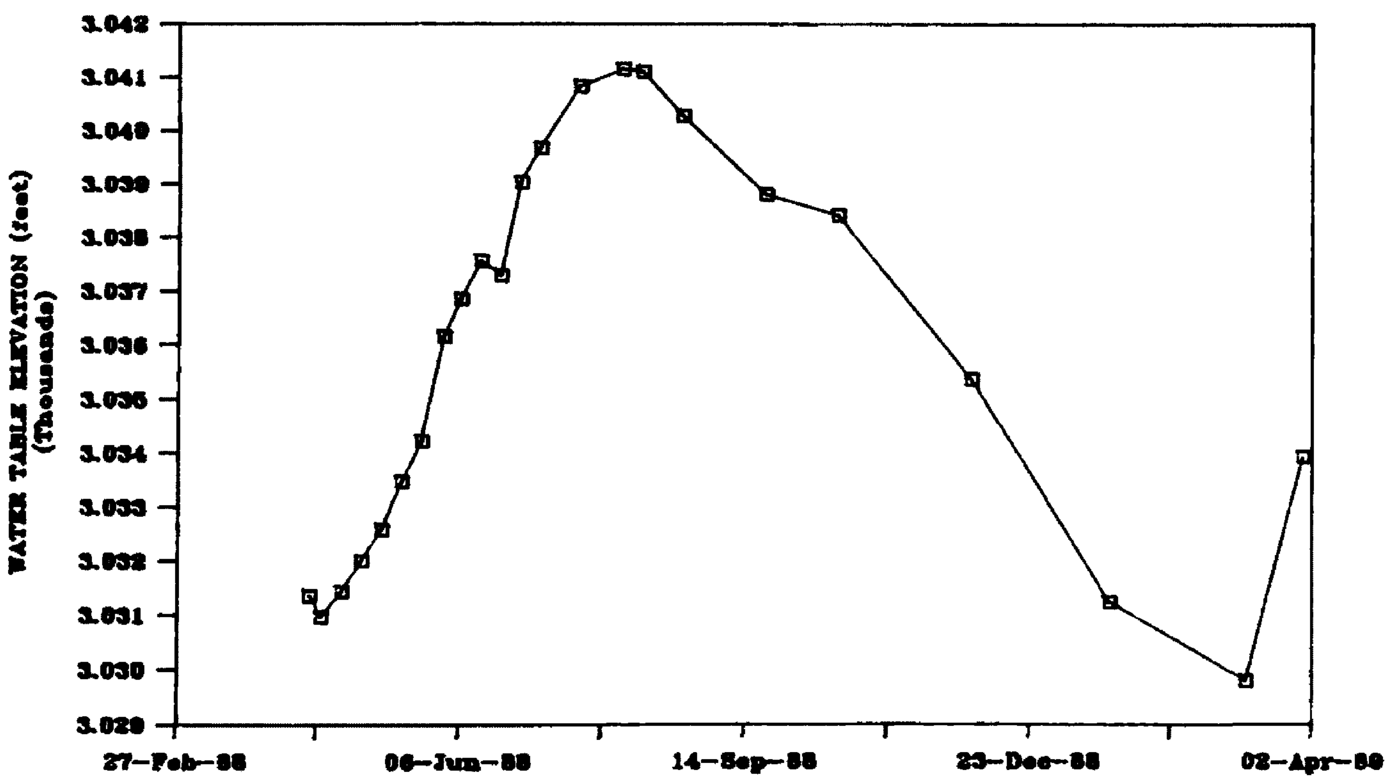


FIGURE 19: Hydrograph for well 33.

## WELL 20 (16N19W15CBA)

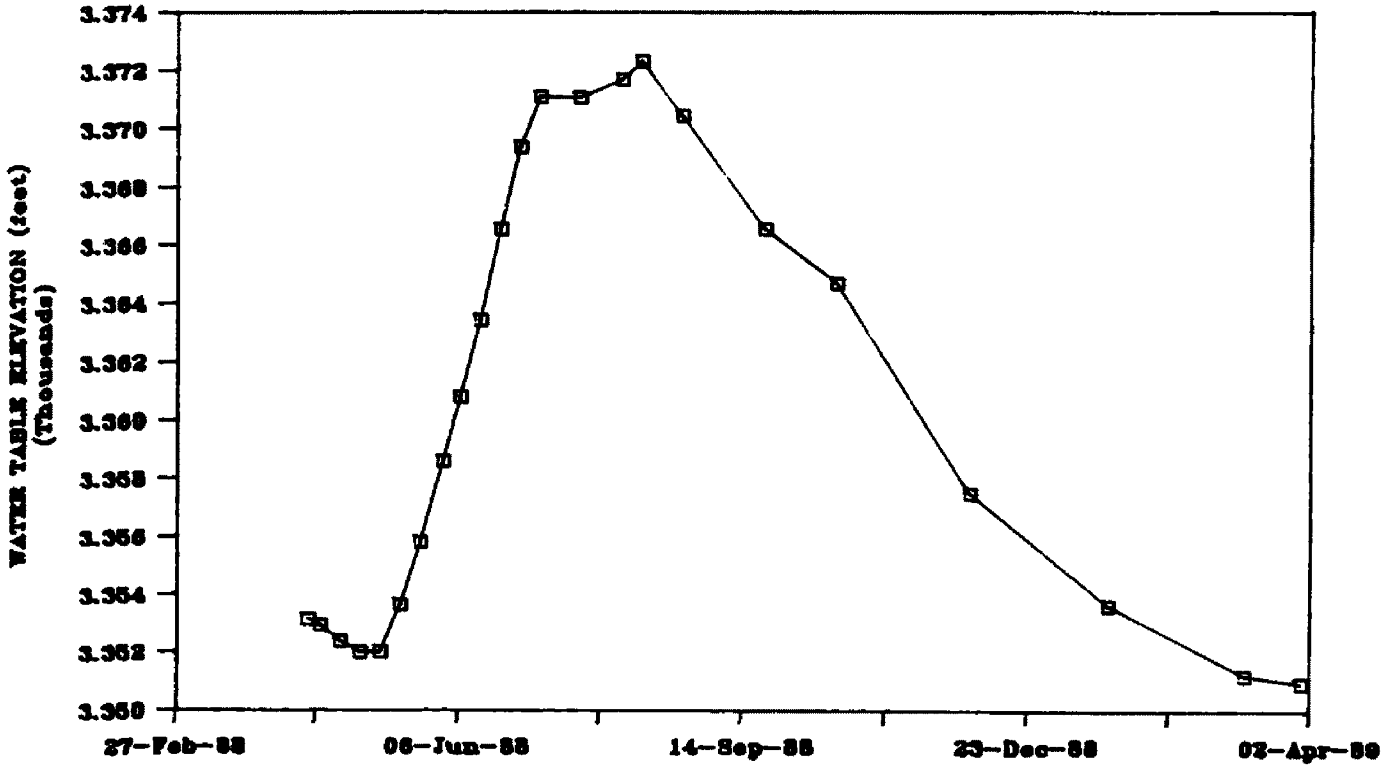


FIGURE 20: Hydrograph for well 20.

## WELL 6 (16N19W17CCA)

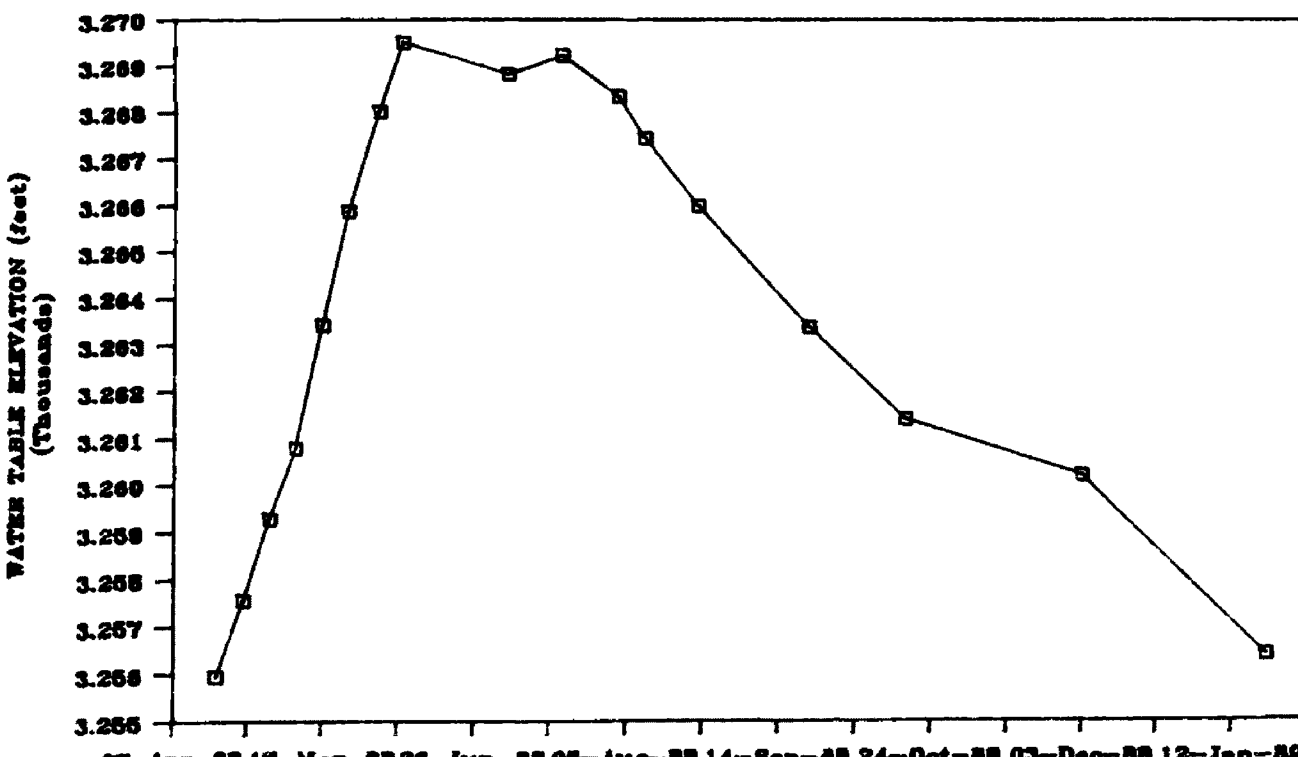


FIGURE 21: Hydrograph for well 6.

the surrounding mountains (Figure 1) and subsequent recharge is supported by seepage out of upgradient ditchs (S and E canals; Figures 7 and 11).

Hydrographs throughout the valley drop sharply in late September - early October when flows in irrigation ditches are either cutoff or decreased.

Leakage from the Jocko River is lowest during summer months (Figure 24), the gaining reach of the river is expanded. However, wells maintain their highest elevations during summer months. Alternative sources of recharge must maintain summer increases in aquifer storage. Figures 20 and 21 indicate the water table rises on the Agency Fan boundary during summer; this suggests lateral inflow on Agency Fan boundary is elevated through much of the summer. Seepage data collected during this study show that ditches continue to leak through the summer. The river appears to be a secondary source of recharge during the summer.

Figure 22 shows the migration of selected water table contours from May, 1988 to March, 1989. Contours on Agency Fan boundary and within Finley Creek display little seasonal variation. I suggest that on Agency and Finley Creek Fans, lateral ground water flow maintains water levels at a fairly constant elevation throughout much of the year. Recharge across these two fans supports the base recharge flow into the Jocko Fan aquifer. Because ditches only flow seasonally, this further suggests that recharge from

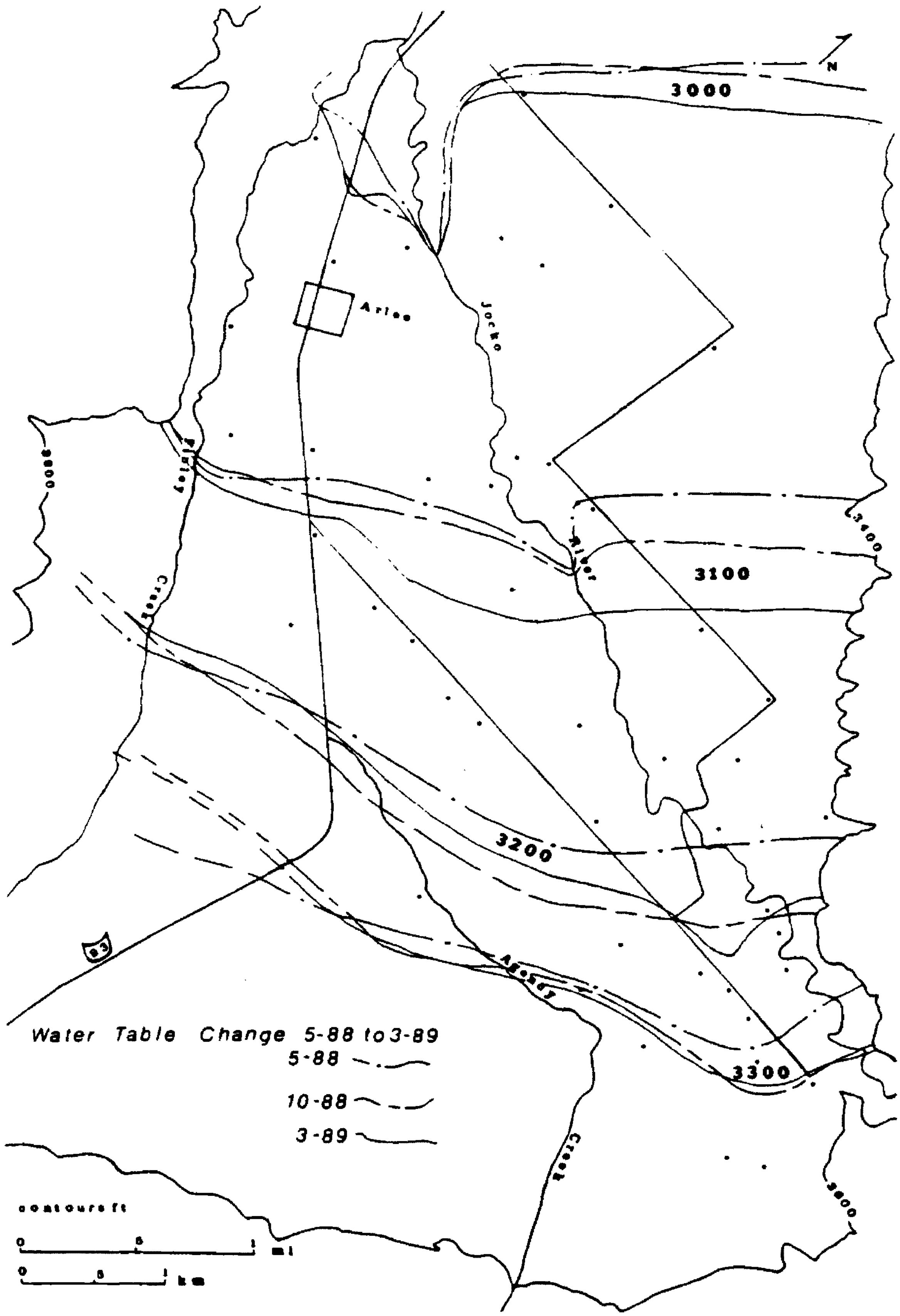


FIGURE 22: Migration of selected water table contours.

surrounding mountains dominates recharge across the fan boundaries.

On the northeast margin of the Jocko Valley, seasonal variation between water level contours increase down-fan to 3,100 feet (945 m) (Figure 22). Seasonal variations in leakage from surface water channels cause the elevation of the water table to rise above base levels on the northeast margin of the valley.

Analysis of hydrographs and Figure 22 suggest; 1) water table elevations in the Jocko Fan aquifer respond rapidly to seasonal recharge and subside equally rapidly when recharge is decreased, 2) the Jocko River leaks water to the aquifer throughout the year, but only at elevated rates during spring, 3) irrigation ditches appear to be the principal surface water channels recharging the aquifer during the summer, 4) lateral inflow from Agency Fan is an important source of year-round recharge, and 5) the majority of spring -early summer recharge leaves Jocko Fan aquifer by December.

Two results of seasonal variations in recharge are manifested in water table contour maps (Figures 16 and 17):

1) Early summer increases in water table elevations push the gaining reach of the Jocko River 1.5 miles (2.4 km) upstream in less than two months. The gaining reach does not return to March levels until December or January.

2) Decrease in water table slope in the upper fan from March to July is caused by seasonal increases in lateral inflow

along Agency Fan and development of a mound in the water table.

## GROUND WATER BALANCE:

The water balance is directed at determining inflows to, and outflows from, the Jocko Fan aquifer; therefore, flow within the surface water system is considered as it interacts with the ground water system. The specific equation which applies to the Jocko Valley is:

(leakage from the Jocko River + leakage from the irrigation ditches + lateral flow from Agency Fan, Jocko Canyon, and fractured bedrock + infiltration from precipitation and irrigation) = ( ground water discharge into the Jocko River + lateral flow out of the aquifer + pumping + evapotranspiration ) ± changes in storage.

In this section, each component is evaluated. Figure 23 is a schematic of the major inflows to, and outflows from, the Jocko Fan aquifer. Below, I round numbers to the nearest one hundred to avoid implying false accuracy.

### Inflows:

In the final balance, leakage from Finley Creek is ignored. Little data are available on Finley Creek, however estimated average flow is 15 cfs (0.42 cms), leakage would be a minor component of the total budget. Inflow from Precambrian bedrock is ignored in calculations and numerical modeling. Well yields and specific capacities indicate that hydraulic conductivities for bedrock aquifers are low (Thompson, 1988; Slagle, 1988). Although some bedrock recharge may occur, without alternative data it is considered a minor component of the budget.

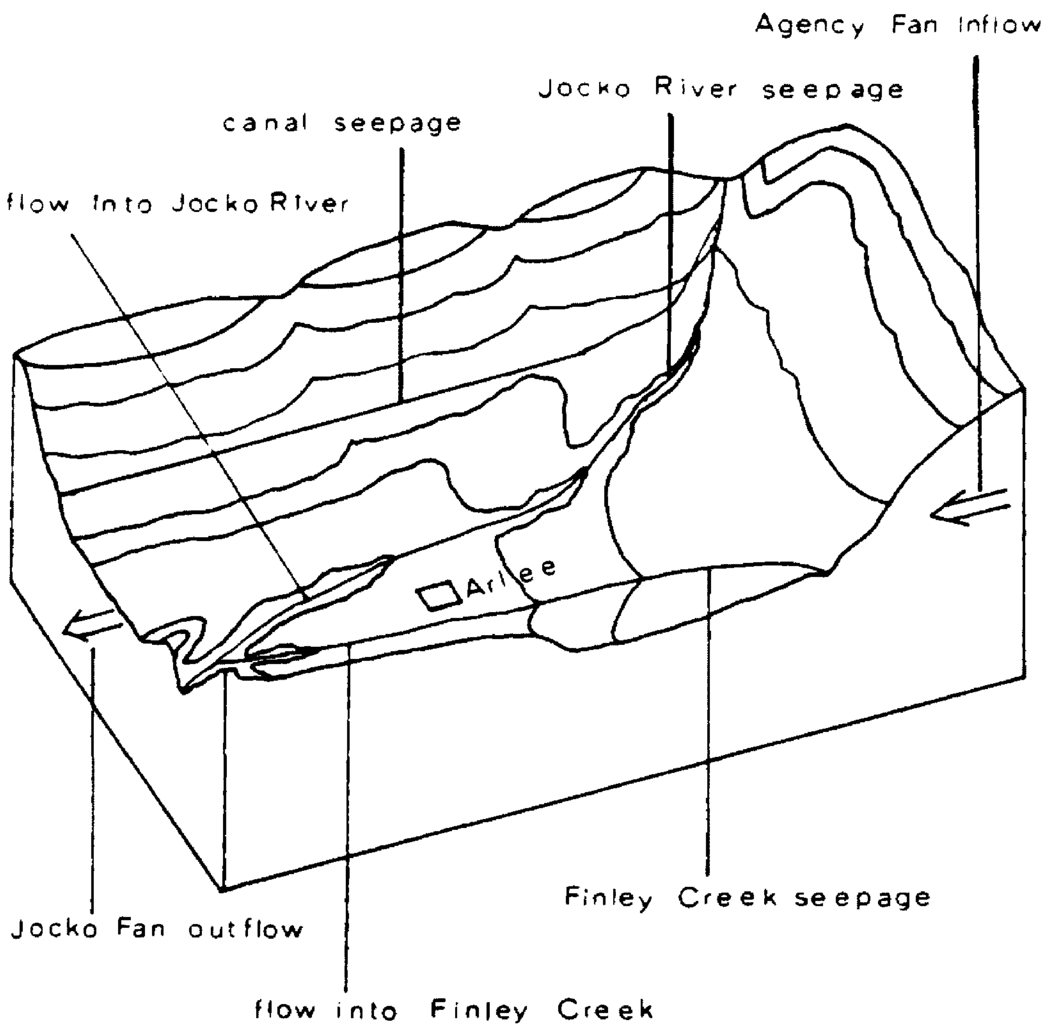


FIGURE 23: Schematic diagram of aquifer water balance.

<u>Leakage from the Jocko River:</u>

In the upper Jocko Fan area, the Jocko River loses water to the aquifer throughout the year. I calculated monthly leakage values for the Jocko River (Figure 24) using discharge data and provisional CSKT gauge data. During peak spring runoff, the volume of river leakage is greatest. Before peak spring runoff has ceased river leakage decreases. Rapid rises in the water table cause the gaining reach of the Jocko River to migrate upstream, decreasing the area over which leakage occurs.

Averaged over the 1987-1988 water year, the Jocko River lost 13,400 acre-feet of water to the Jocko Fan aquifer. During late May there was a dramatic increase in the leakage rate; this is reflected in the average May leakage rate (Figure 24).

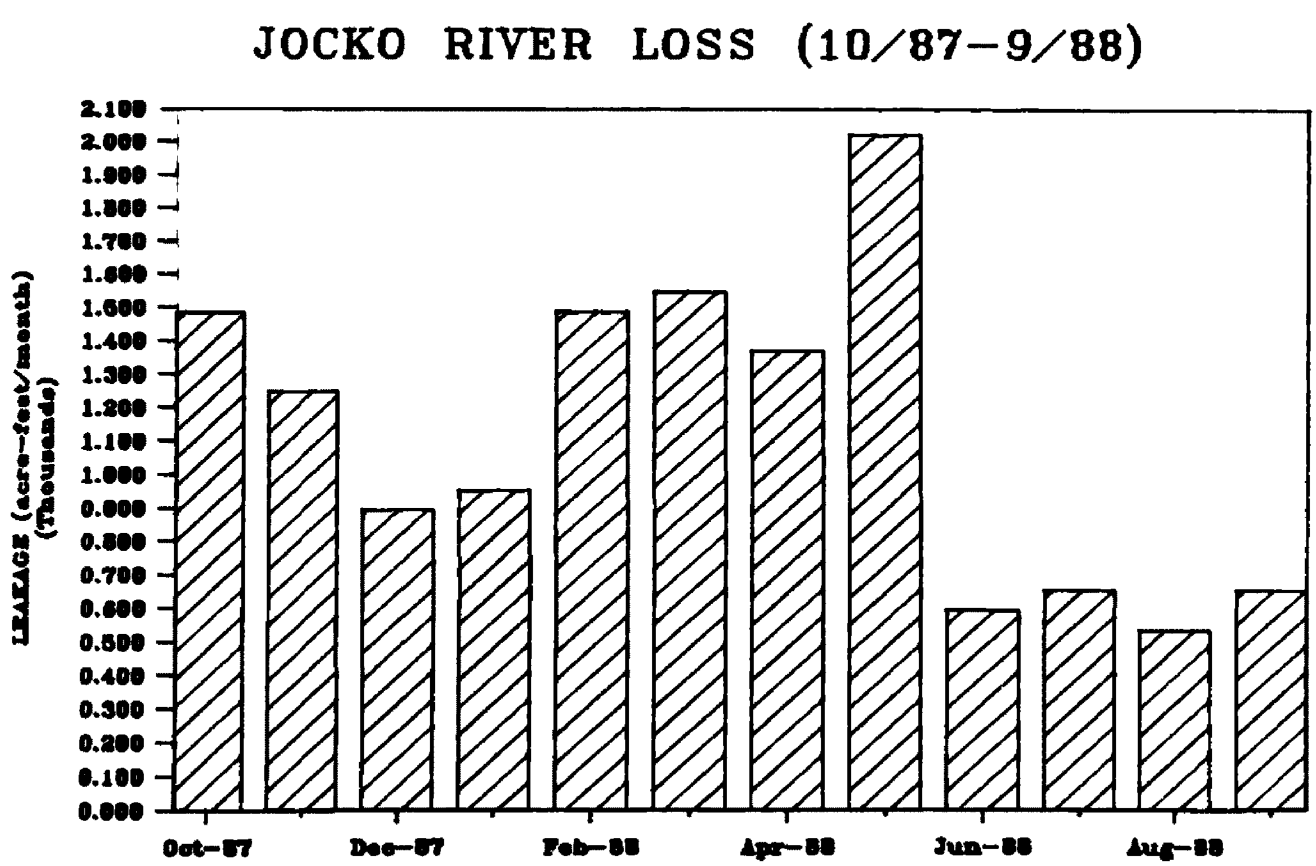


FIGURE 24: Leakage through the streambed of the Jocko River.

Leakage from Irrigation Diversions:

The irrigation ditches are all above the water table, they are all potential losing reaches. In 1988, ditches were turned on in mid-April and turned off by December. In between, there was a period during late summer when ditch flow was severely reduced to maintain instream flow within the Jocko River. Specific irrigation seepage data collected during this study are presented in Appendix C.

There is wide variation in seepage results; part due to variability between ditches and part to monthly variation in ditch flow. Using 1.2 cfs/1000 ft (.03 cms/305 m) the average of all ditch loss data as a leakage rate, multiplying it by 5 months to represent the approximate time when ditch flow is high, estimated leakage from 105,600 feet (32,186 m) of irrigation diversions is 37,700 acre-feet for the period April, 1988 to December, 1988.

Ground Water Inflow:

Two sources of ground water inflow are major recharge components in the water budget; 1) lateral flow from Jocko Canyon, and 2) lateral flow across Agency Fan boundary. For water budget calculations, the Finley Creek Fan-Jocko Fan boundary is incorporated into the Agency Fan boundary. All recharge and discharge flow is estimated using Darcy's law expressed as:

$$Q = -(K*I*A)$$

Q equals discharge, K the hydraulic conductivity, I the hydraulic gradient, and A the cross-sectional area through which flow occurs. I checked hydraulic conductivity values used to determine lateral inflow against calibrated values in the numerical model.

Lateral flow from Jocko Canyon is calculated using a hydraulic gradient of 0.01, hydraulic conductivity of 1,500 ft/d (457 m), and cross-sectional area of 90,000 square feet (8,361 sq m). With these values, lateral flow from Jocko Canyon into the Jocko Fan aquifer is 11,100 acre-feet/yr.

Lateral flow from Agency Fan is calculated using a hydraulic gradient of 0.04, hydraulic conductivity of 150 ft/d (46 m/d) (Thompson, 1988), and cross-sectional area of 1,108,800 square feet (103,008 sq m). With these values, lateral flow into the Jocko Fan aquifer is 55,000 acre-feet/yr. This is the main component of recharge to the Jocko Fan aquifer. The headwater supporting this flow includes the Finley Creek drainage, and the north flowing drainages of the Rattlesnake Mountains. Also S and E canals (Figures 7 and 11) seasonally leak water into Agency Fan.

<u>Precipitation and Sprinkler Infiltration:</u>

Precipitation and sprinkler infiltration are not considered in water budget calculations. Sprinklers are operated during maximum plant growth and evapotranspiration months, precipitation on the valley floor averages only 15 inches (33 cm) per year. Precipitation and sprinkler infiltration may be partially offset by evapotranspiration prior to infiltration. Thompson (1988) monitored wells after a major precipitation event but was unable to detect infiltration recharge from hydrographs.

Outflows:

Return Flow Into the Jocko River:

The lower reach of the Jocko River gains water from the Jocko Fan aquifer throughout the year (Figure 25); values

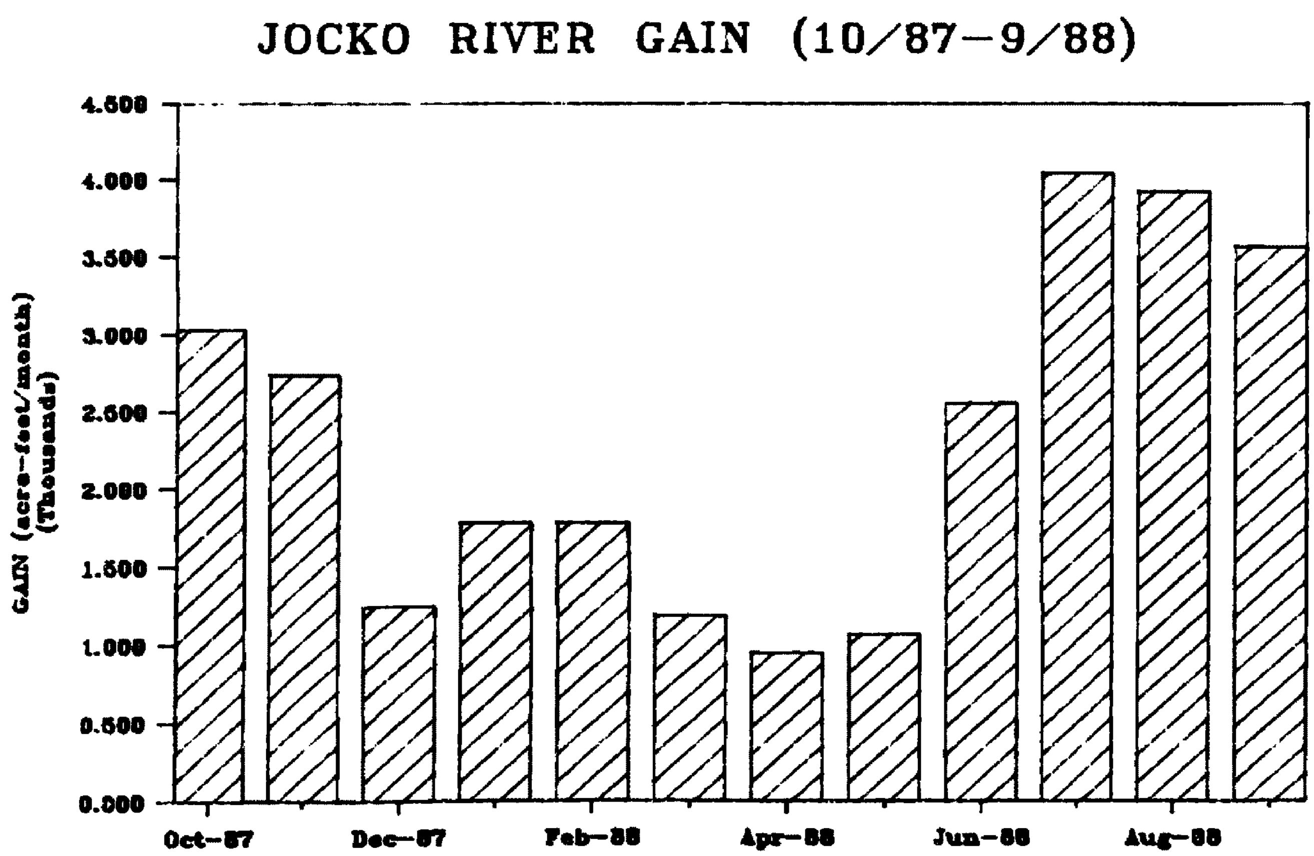


FIGURE 25: Gain across the streambed of the Jocko River.

are determined from discharge data and provisional CSKT gauge data.

Averaged through the year, the Jocko River gained 27,900 acre-feet of ground water from the Jocko Fan aquifer. Maximum ground water discharge into the river occurs after spring runoff and upstream migration of the gaining reach.

Lateral Flow Out Of the Jocko Fan Aquifer:

Lateral flow out of the aquifer occurs between the bedrock high north of Arlee and the northeast valley margin. The base of the aquifer is constrained by seismic refraction data. Using a cross-sectional area of 985,596 square feet (91,562 sq m), hydraulic conductivity of 500 ft/d (152 m/d), and hydraulic gradient of 0.02 the amount of water flowing across this boundary is 81,500 acre-feet/yr.

Pumping:

Ver Hey (1987), working in the Missoula Valley, found that households consumed on average 170 g/d (.18 acre-ft/yr) of water. Estimating 800 households in the Jocko Valley, 140 acre-ft/yr of ground water are used for domestic purposes.

Evapotranspiration:

Throughout the study area, the elevation of the water table is over 25 feet (7.6 m) below land surface. Twenty five feet (7.6 m) is below the generally accepted depth (6 feet (1.6 m); Brown and Eychaner, 1988) where evapotranspiration ceases to be important. Evapotranspiration is ignored as a mechanism to discharge water from the aquifer, rates are difficult to quantify, but are believed small.

## Changes In Storage:

Seasonal variation in the amount of water stored in the Jocko Fan aquifer is dramatic; variations of fifteen percent of total saturated aquifer thickness are evident on upper Jocko Fan (Figure 26, well 45) in high hydraulic conductivity sediments. Well 33 (Figure 19), approximately 4 miles (6.4 km) from Jocko Canyon, is in lower hydraulic conductivity material. Although the magnitude of the seasonal fluctuation is less than well 45, it is still five percent of the saturated aquifer thickness.

Figure 27 (well S; provisional CSKT data) is a longer term hydrograph for a Jocko valley well located near the head of the fan. The hydrograph illustrates large seasonal variation in head. The hydrograph also shows water levels for 1986-1988 have not returned to the same elevation they reached in 1984 and 1985.

I attempted to calculate changes in storage occurring in the Jocko Fan aquifer between April, 6 1988 to March, 30 1989. Water level elevations for March, 1989 recovered to

## WELL 45 (16N19W8DAB)

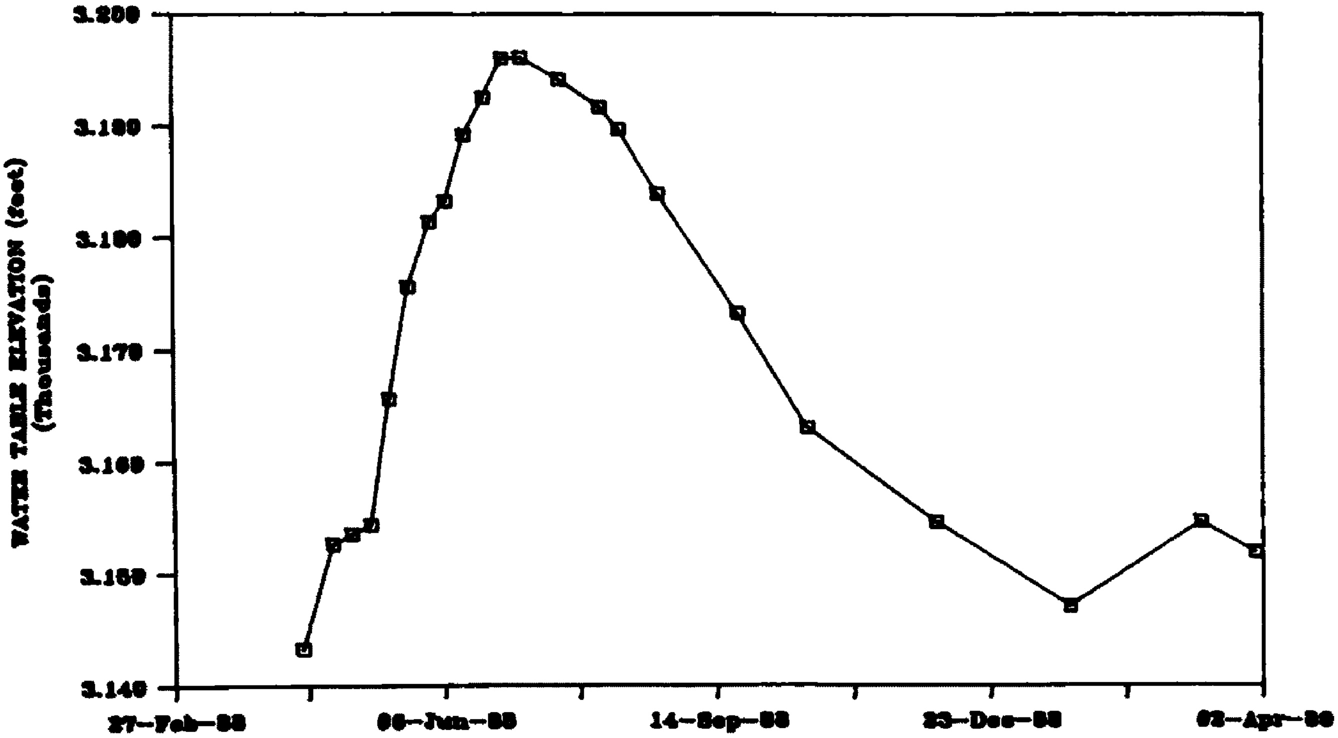


FIGURE 26: Hydrograph for well 45.

## WELL S (SINCLAIR WELL)

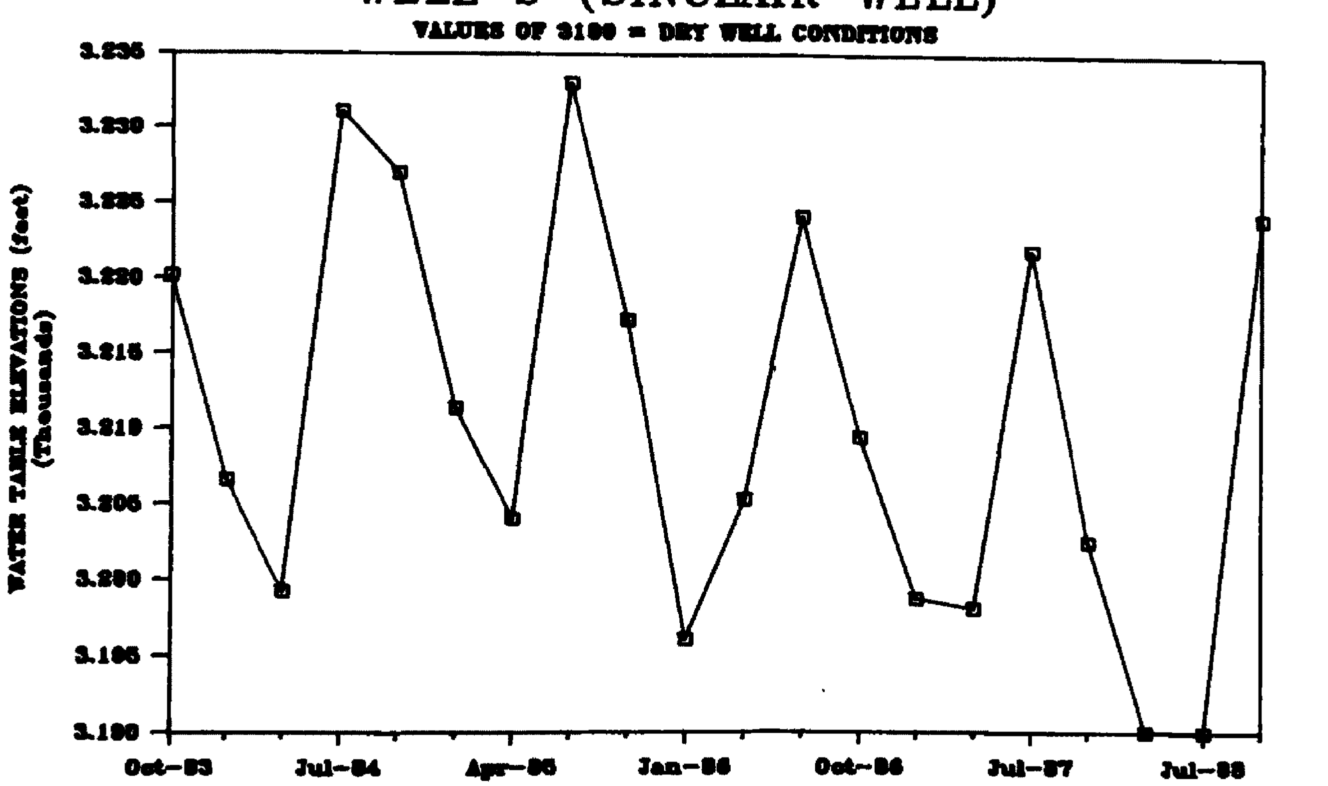


FIGURE 27: Hydrograph for well S.

plus or minus five feet (1.5 m) of levels for April, 1988, average variation was three feet (.9 m). I could not determine if there was an increase or decrease in the change in storage, March, 1989 heads did not vary consistently either above or below the April, 1988 heads. Using a specific yield of 0.1, and head change of three feet (.9 m), the average change in the water table, the magnitude of the change in storage is estimated to be 2,500 acre-feet/year.

Summary of Inflows and Outflows:

Discharge data (CSKT gauge site after the confluence of the Jocko River with Spring Creek, but prior to the river confluence with Valley Creek, Figure 7) provide a control on the total amount of water leaving the Jocko Valley. The gauge site is located where the valley is constricted and most available water is in the river. Discharge data for the site (Thompson, 1988; provisional CSKT data) are found in Table 1. Results of the water balance for the Jocko Fan aquifer are within 10 percent of each other (Table 2). Surface water fluxes are most accurately defined, error may be introduced estimating the amount of lateral ground water flow. Flow in the Jocko River below Valley Creek (Table 1) is less than the inflows to, and outflows from, the Jocko Fan aquifer. This discrepancy may be caused by water stored within the aquifer in the north end of the Jocko Valley.

TABLE 1: DISCHARGE DATA: JOCKO RIVER ABOVE VALLEY CREEK.

| DATE | 1/87 | 2/87 | 6/87 | 9/87 | 4/88 | 7/88 |
|---|---|---|---|---|---|---|
| Q (CFS) | 115 | 107 | 200 | 145 | 95 | 178 |
| AVERAGE Q (CFS) | | 140 | 99,900 acre-feet/year | | | |

TABLE 2: AVERAGE ANNUAL GROUND WATER BALANCE 1987-1988.

| SOURCE | AVERAGE ANNUAL RATE (acre-feet per year) |
|---|---|
| FLOWS: | |
| RIVER LEAKAGE | 13,000 |
| DITCH LEAKAGE | 37,700 |
| INFLOW FROM JOCKO CANYON | 11,200 |
| INFLOW FROM AGENCY FAN | 55,500 |
| TOTAL INFLOWS | 116,700 |
| OUTFLOWS: | |
| RIVER LEAKAGE | 27,900 |
| OUTFLOW FROM AQUIFER | 81,500 |
| PUMPING | 140 |
| TOTAL OUTFLOWS | 109,500 |
| AVERAGE OUTFLOW OF JOCKO RIVER- ABOVE VALLEY CREEK | 99,900 |

## GROUND WATER SIMULATION:

The USGS three-dimensional model (MODFLOW) is a finite-difference model designed to solve a general three-dimensional governing equation for ground water flow (McDonald and Harbaugh, 1984). A brief algorithm for

MODFLOW is presented in Appendix E.

## Model Configuration:

Where possible, boundaries for the Jocko Valley ground water flow model conform to natural physical boundaries. The aquifer is discretized into square grids 1,000 ft by 1,000 ft (305 by 305 m) oriented parallel to the northwest-southeast trend of the valley (Figure 28). The model grid size is 21 by 35 cells.

Bedrock highs on the east and west margin of the valley are modeled as no-flow boundaries. The north boundary of the flow model does not conform to a natural physical boundary. The location of this boundary is set three to four cells from areas of interest to minimize boundary effects on the solution. Specified-head cells are used on this boundary. Where possible, the south boundary of the model conforms to surface expression of the contact between Agency Fan and Jocko Fan. On the Agency Fan and Jocko Canyon boundaries, specified-head cells are used. Along Finley Creek, specified-head and no-flow cells are used.

## Simulation of Aquifer Recharge And Discharge:

Lateral flow into the Jocko Fan aquifer is simulated using the general-head boundary package. Input includes; 1) specification of head on the boundary, and 2) input of a

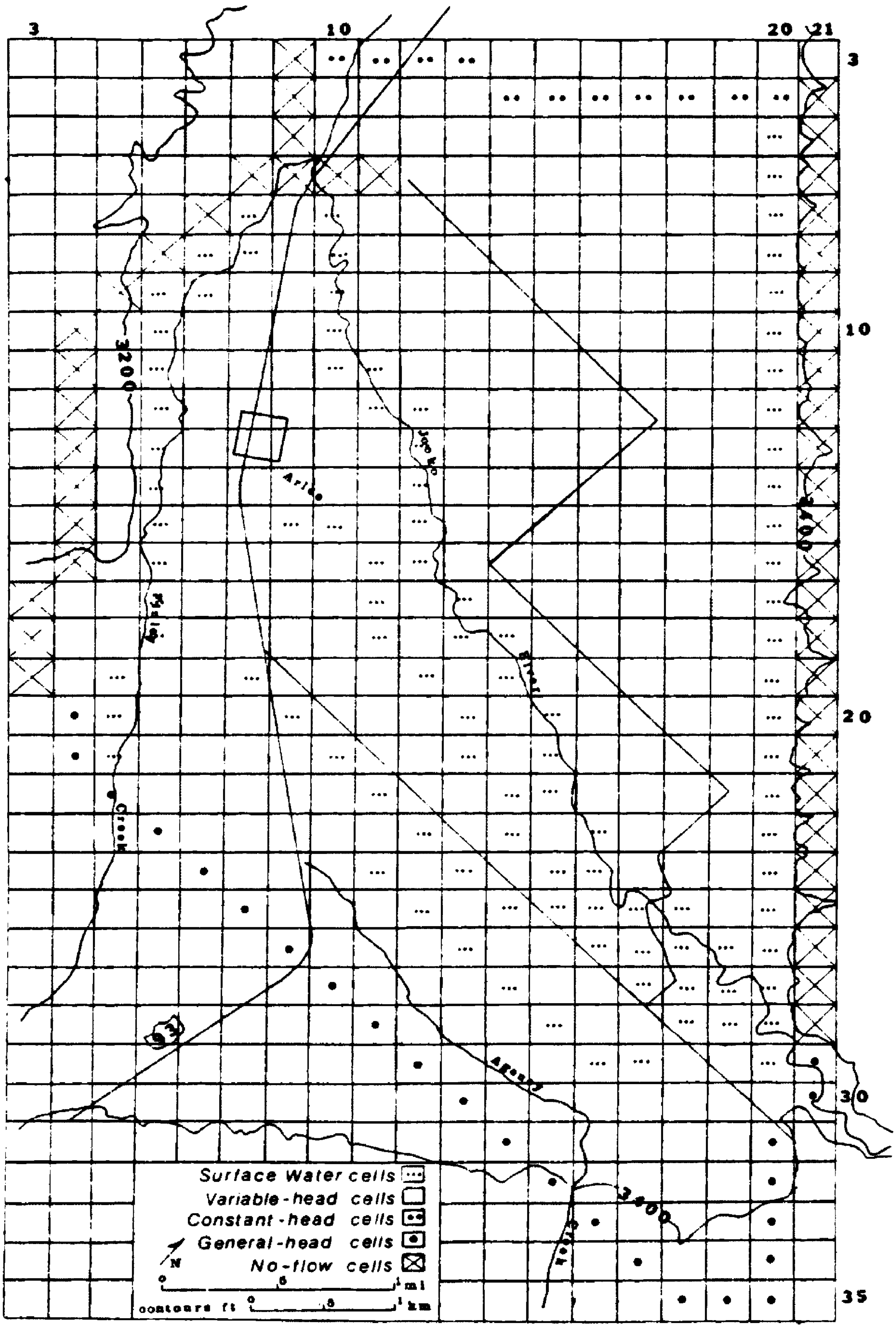


FIGURE 28: Model configuration and boundaries.

conductance term between the source, or boundary cell, and the adjacent interior cell. Conductance is set at a high value, 999,999 ft*ft/D, to simulate a constant-head cell. For transient simulations values of head were changed for each month, as warranted by changes visible on monthly water table maps.

Lateral flow out of the aquifer is modeled using the specified-head package. Values of head are held constant over the year because seasonal shifts in the water table are small (Figure 22).

River and irrigation canal recharge and discharge are modeled using the river package without modification (McDonald and Harbaugh, 1984). I determined river stage by interpolating elevations between survey points, and by use of topographic maps. Hydraulic conductance is an equivalent conductance term input into the river package. It groups length and width of a reach within a node, thickness of the river bed, and hydraulic conductivity of the river bed into a single term. I determined conductance values initially input into the model by solving:

$$Criv = Qriv / (Hriv - H \text{ or } Rbot)$$

Criv = hydraulic conductance
Qriv = discharge across stream bed
Hriv = river stage
H = aquifer water level
Rbot = river bottom

With this equation, stream bed thickness and hydraulic conductivity are not explicitly input.

During transient simulations only river stage was adjusted. There is no evidence suggesting seasonal inputs of fine material alter the hydraulic conductivity of the stream bed. The area of the stream bed does not change dramatically over the year, the river channel is laterally constrained due to an incised channel.

Calibration of the Steady State Model:

Early April head data are used for steady state calibration. As hydrographs indicate, there may be no time when the Jocko Fan aquifer is in true steady state condition. However, in early April the system has minimal external stresses and qausi-steady state conditions, evident for winter months, prevail.

The steady state model is calibrated to four criteria: water table elevations; water balance calculations; fluxes in and out of the river; and the position of the gaining and losing reach of the river. In both steady state and transient simulations, calibration points not centered in cells are linearly interpolated to the center of cells.

Model parameters adjusted during calibration included; 1) hydraulic conductivity, 2) methods of simulating boundaries, 3) aquifer base, and 4) river bed conductance. Calibration continued until minimal improvement occurred in the mean absolute error between simulations.

Hydraulic Conductivity:

Hydraulic conductivity proved to be a difficult model variable to evaluate. The range of values reported in previous work is large, there are few data to constrain values. In all simulations, hydraulic conductivity was zoned to match a fining down-fan geologic configuration. Initially, I used values as high as 8,000 ft/d (2438 m/d) in the proximal fan zone. Although model input reproduced the approximate water table configuration, water balance results were unacceptable. Flow out of the aquifer exceeded water balance estimates by 300 percent, primarily because fluxes across recharging boundaries increased. Principally through a trial and error approach, best fitting heads and water balance numbers, I arrived at the final hydraulic conductivity configuration (Figure 29).

Aquifer Base:

In the main part of the model, I adjusted the elevation of the aquifer base minimally because seismic data are available. Initially, on Agency Fan I used the same slope to the aquifer base as in the rest of the aquifer. After examination of cross-sections, seismic data, and the steep upper fan water table gradient, I increased the slope of the

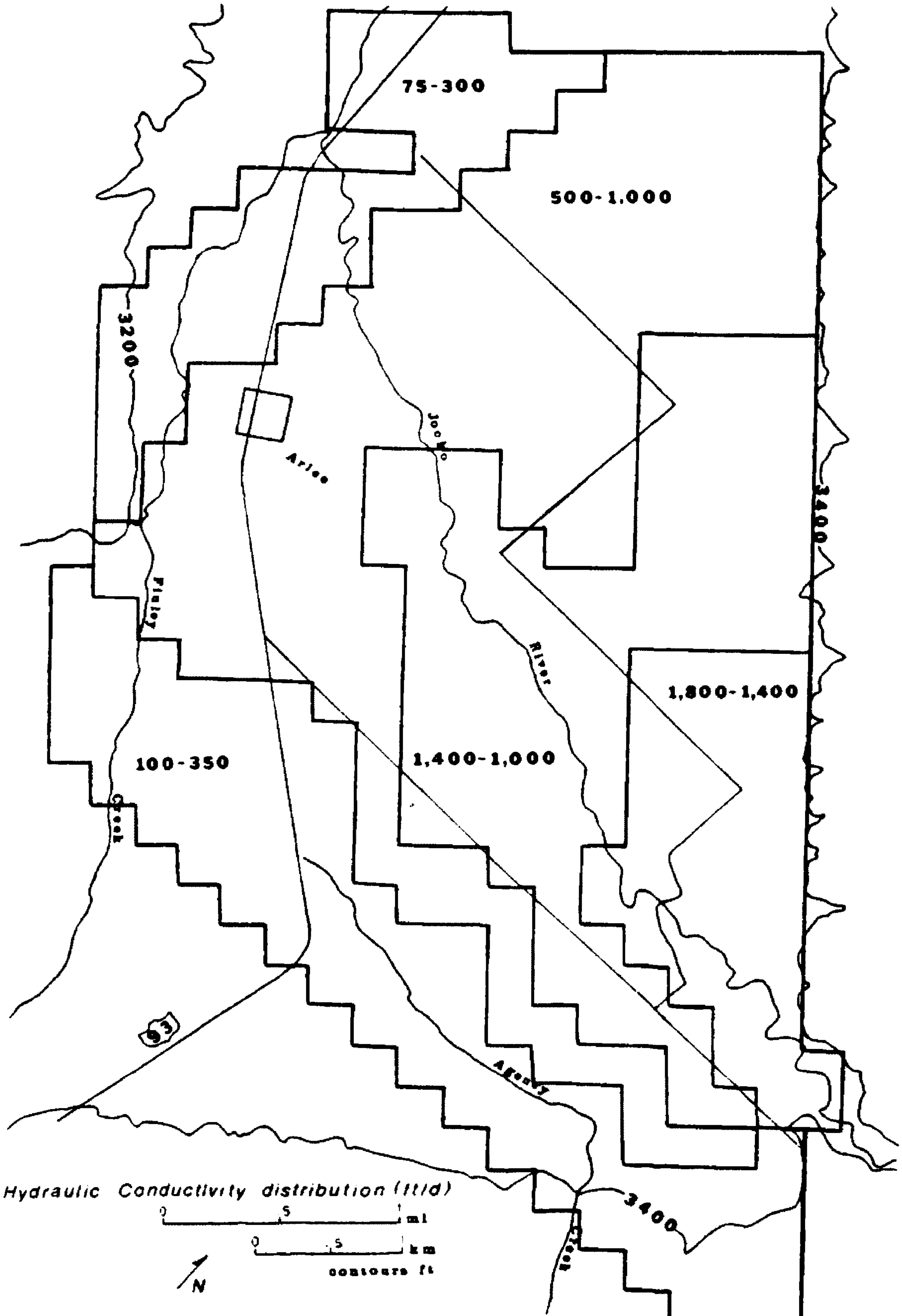


FIGURE 29: Calibrated hydraulic conductivity distribution.

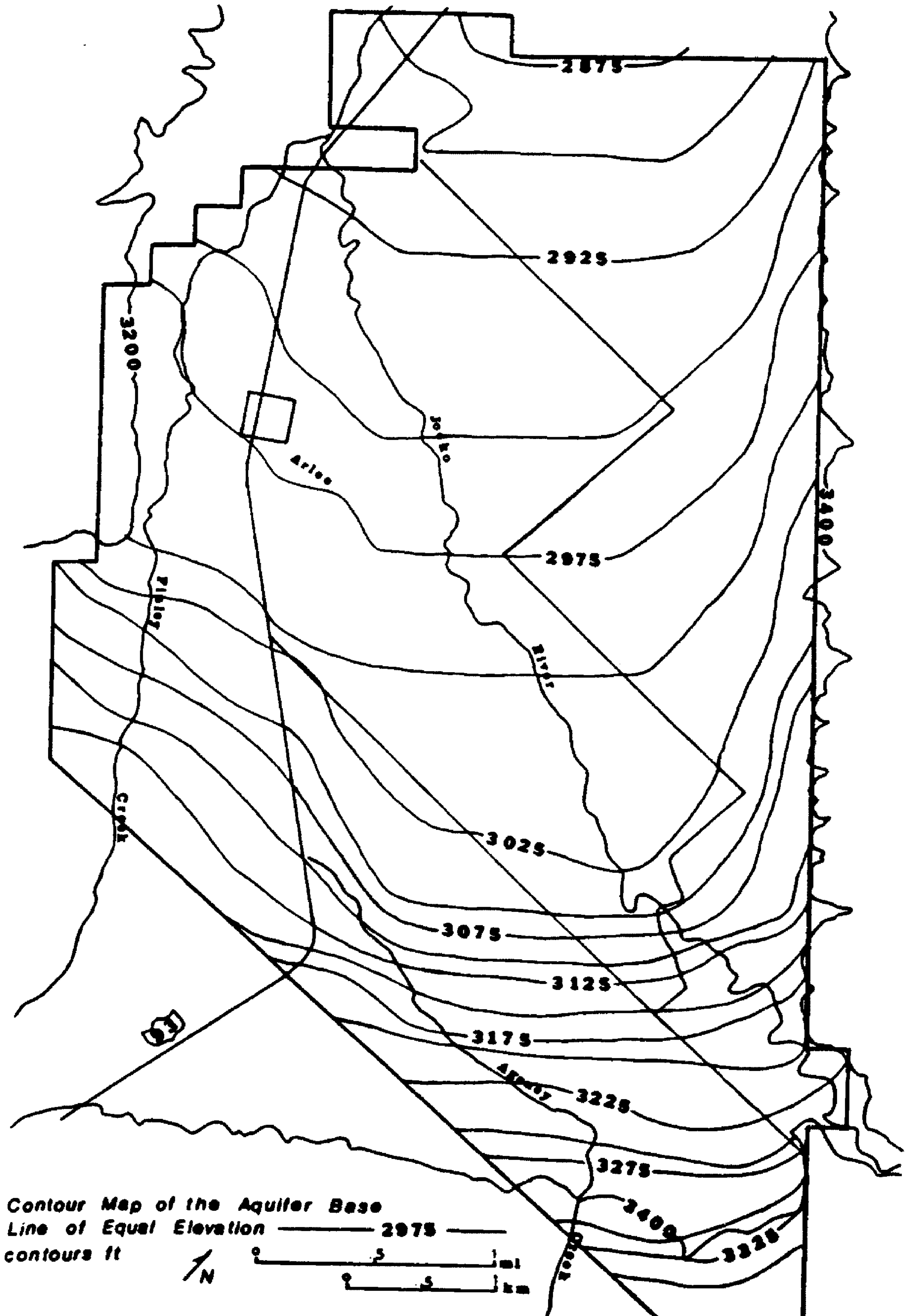


FIGURE 30: Calibrated aquifer base.

aquifer base from the river to Agency Fan (Figure 30).

Model Boundaries:

Initially, I treated Agency Fan boundary as a variable-head, specified-flux boundary. This configuration proved inadequate, I changed the boundary to a specified-head boundary. Head is the best known quantity along Agency Fan and the general-head boundary uses head values to determine rates of lateral flow. At first, cells along the west margin of Finley Creek were all designated specified-head cells. During calibration, some of the cells were changed to no-flow cells to cut off lateral recharge which occurs when specified-head cells are used.

River Bed Conductance:

Using initially calculated values of river bed conductance, known leakage rates out of the Jocko River could not be reproduced. I calculated final river conductance values by printing out cell by cell river leakage values calculated by the model and adjusting river bed conductance until model values matched known values. The calibrated river bed conductance values are consistently 30 to 50 percent greater than initially calculated values.

Model Results For Steady State Simulation:

Three checks on the amount of error in the steady state simulation are presented; 1) comparison of the measured and modeled water table surface, 2) water balance comparisons, and 3) statistical measures of error. Another check, developed in subsequent sections, is the ability of input to the steady state model to reproduce transient data.

Measured and modeled water table contours for early April, 1988 are plotted in Figure 31. Overall water table trends match well and the position of measured and modeled contours agree. In the immediate vicinity of Arlee, I was unable to model some of the variations in water table contours. This area has different water chemistry than the rest of the aquifer (Thompson, 1988) and recharge from bedrock may influence ground water flow.

Table 3 contains a simplified water balance comparing flows into the model with calculated flow into the Jocko Fan aquifer for April 6, 1988. During this time, irrigation ditches were not running.

TABLE 3: MODELED VERSUS MEASURED INFLOWS; STEADY STATE.

| SOURCE | MODELED (ACRE-FT/DAY) | CALCULATED (ACRE-FT/DAY) |
|---|---|---|
| AGENCY FAN | 140. | 150. |
| JOCKO CANYON | 25. | 30. |
| RIVER LEAKAGE | 45. | 48. |
| TOTAL | 210. | 228. |

The difference between the two mass balances is eight percent.

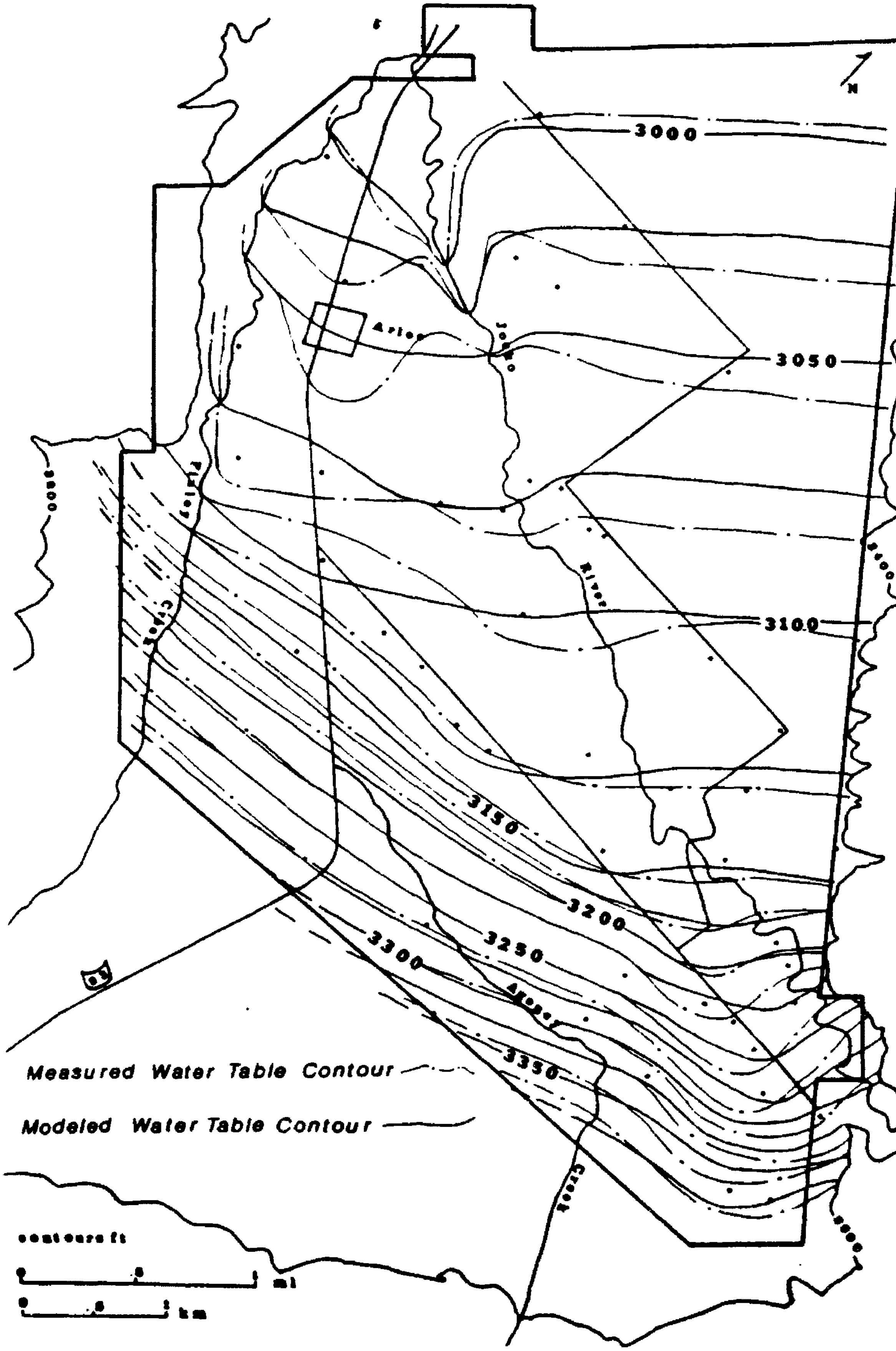


FIGURE 31: Measured versus modeled water table contours, steady state model.

Commonly, mean error and mean absolute error are used as statistical measures of the closeness of fit between real and modeled data (Brown and Eychaner, 1988; Buckles and Watts, 1988). Because model calculated values vary both positively and negatively about calibration points, the mean absolute error (MAE) is a better measure of the data fit than mean error. Mean absolute error, $\Sigma |Yi| / N$ , where $|Yi|$ equals the sum of the data points, N is number of data points, is applied to both steady state and transient simulations. For the steady state model, the mean absolute error is 5.0 feet (1.5 m); this indicates that the average variation of each modeled point is plus or minus 5.0 feet (1.5 m) about the corresponding calibration point.

I attempted to develop an acceptable error range based on the total possible error. The total possible error is the saturated aquifer thickness which is between 150 to 200 feet (46-61 m). Using 175 feet (53 m), a mean absolute error of 5 feet (1.5 m) is 3 percent of the total possible error. Further, I consider 5.0 feet (1.5 m) an acceptable error because; 1) measured head changes 25 to 30 feet (7.6 to 9 m) within each model grid in the upper fan area, and 2) the head change across the model is 375 feet (114 m).

## Transient Calibration:

Since calibration of the steady state model is within an acceptable error range, I used input for the steady state model in the transient model. Head values calculated with the steady state model are used as initial heads for the transient model.

I ran the transient model for the period April, 1988 through March, 1989. Changes in aquifer storage are modeled during transient simulations, therefore a specific yield value is input. Transient simulations are calibrated to four aquifer variables: water table elevations; mass balance calculations; fluxes in and out of the river; and the seasonal migration of the gaining and losing reach of the Jocko River.

The principal stress on the aquifer I modeled is spring runoff and filling of irrigation diversions. Variables adjusted during calibration center around the quantity and timing of recharge and include; 1) specified heads in the general-head package, 2) river stage, and 3) irrigation canal stage. Specific yield values were adjusted over the range 0.1 to 0.25.

Four canals were turned on during the simulation: K canal; R canal; Jocko Road canal; and D canal (Figure 28). These canals carry the greatest flow of ditches overlying the Jocko Fan aquifer. I determined values for river stage by examining hydrographs of the Jocko River (CSKT provisional data). I determined ditch stage from hydrograph data for K canal (CSKT provisional data) and ditch gauging results.

## Results of Transient Simulation:

Four independent measures are used to check the error of the transient simulation; 1) measured versus modeled seasonal migration of the gaining and losing reach of the Jocko River, 2) measured versus modeled hydrographs, 3) water balance calculations, and 4) statistical measures of model accuracy.

Figure 32 is a plot of the measured migration of the gaining and losing reach of the Jocko River compared to model derived values. Reaches 1 through 7 correspond to grids (19,14) through (24,16) in Figure 28. Aside from June and October, the model exactly matched measured data.

Measured head data are compared to modeled head data for selected wells (Figures 33-38) across the model. The hydrographs show the model is able to follow the pulse of spring recharge and subsequent water level declines.

Total calculated inflows to, and outflows from, the Jocko Fan aquifer are compared with modeled calculated inflows and outflows in Table 4.

TABLE 4: MODELED VERSUS MEASURED BALANCE; TRANSIENT MODEL.

| (UNITS ACRE-FEET/YEAR) | | | |
|---|---|---|---|
| CALCULATED INFLOWS | 116,700 | MODELED INFLOWS | 122,750 |
| CALCULATED OUTFLOWS | 109,500 | MODELED OUTFLOWS | 122,750 |

Calculated and modeled inflows and outflows are within nine percent of each other. Modeled inflows equal modeled

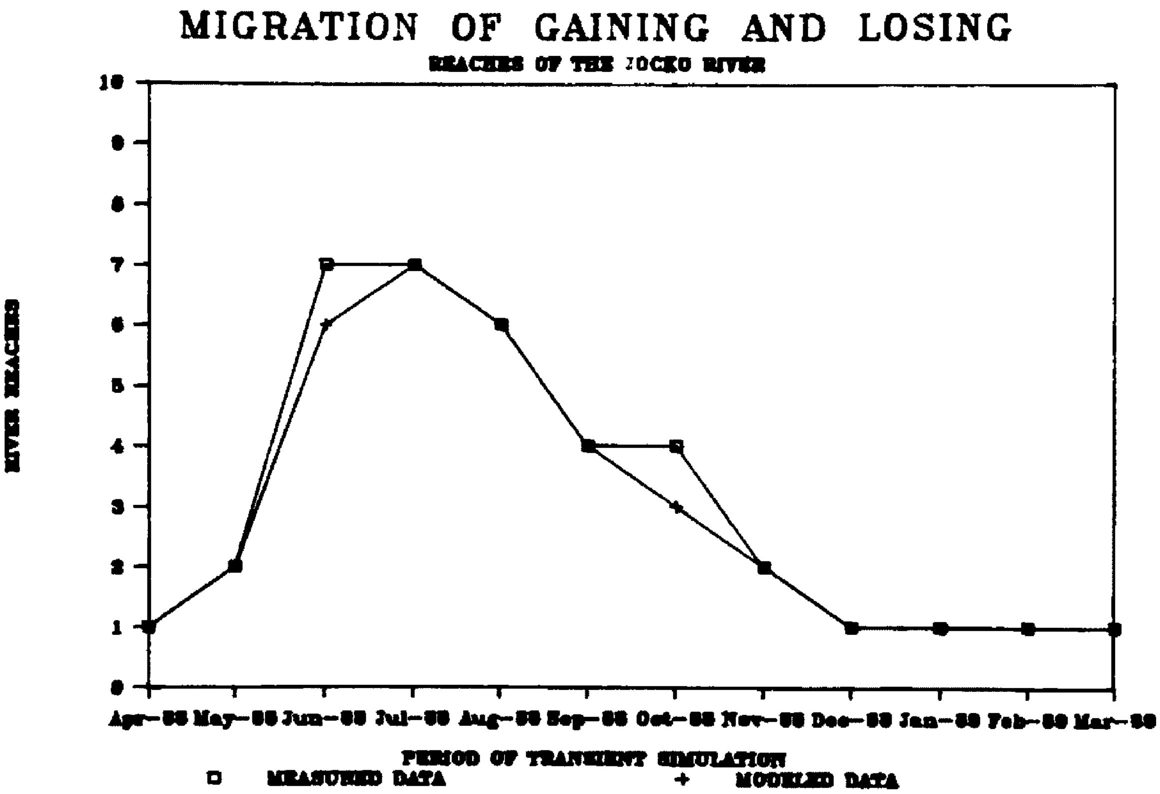


FIGURE 32: Modeled versus measured migration of the gaining reach of the Jocko River.

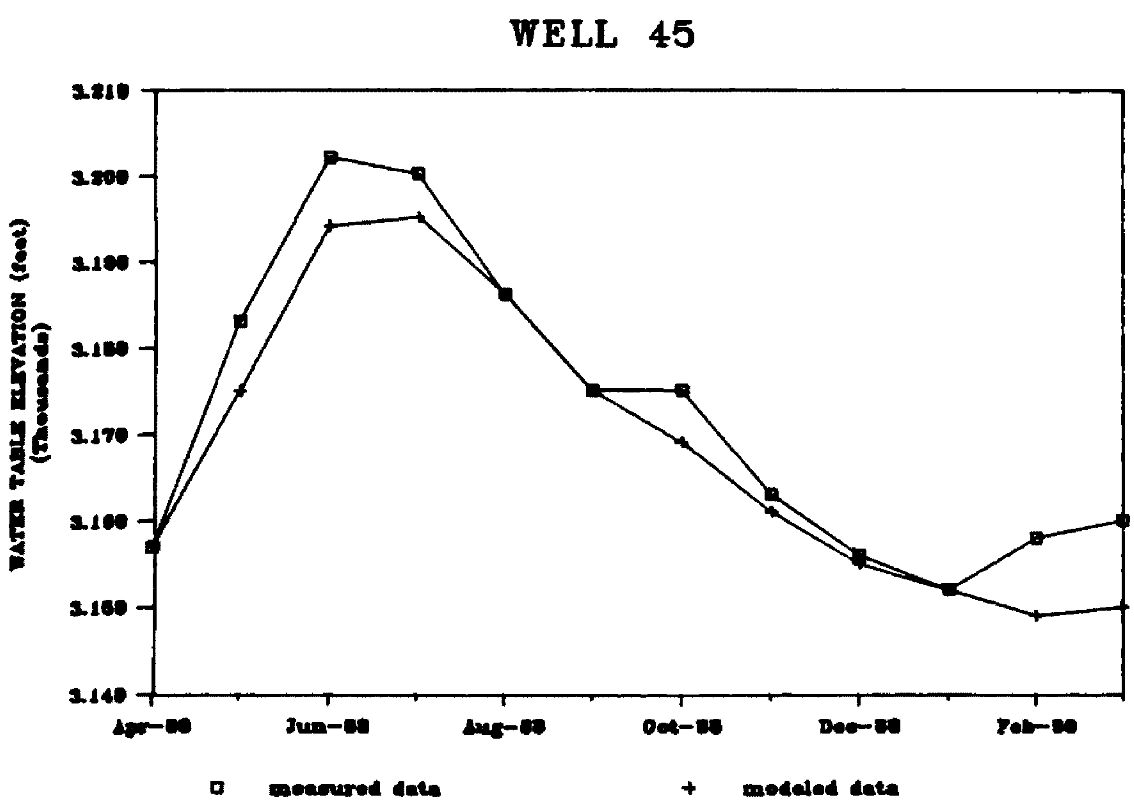


FIGURE 33: Hydrograph comparing measured and modeled data, well 45.

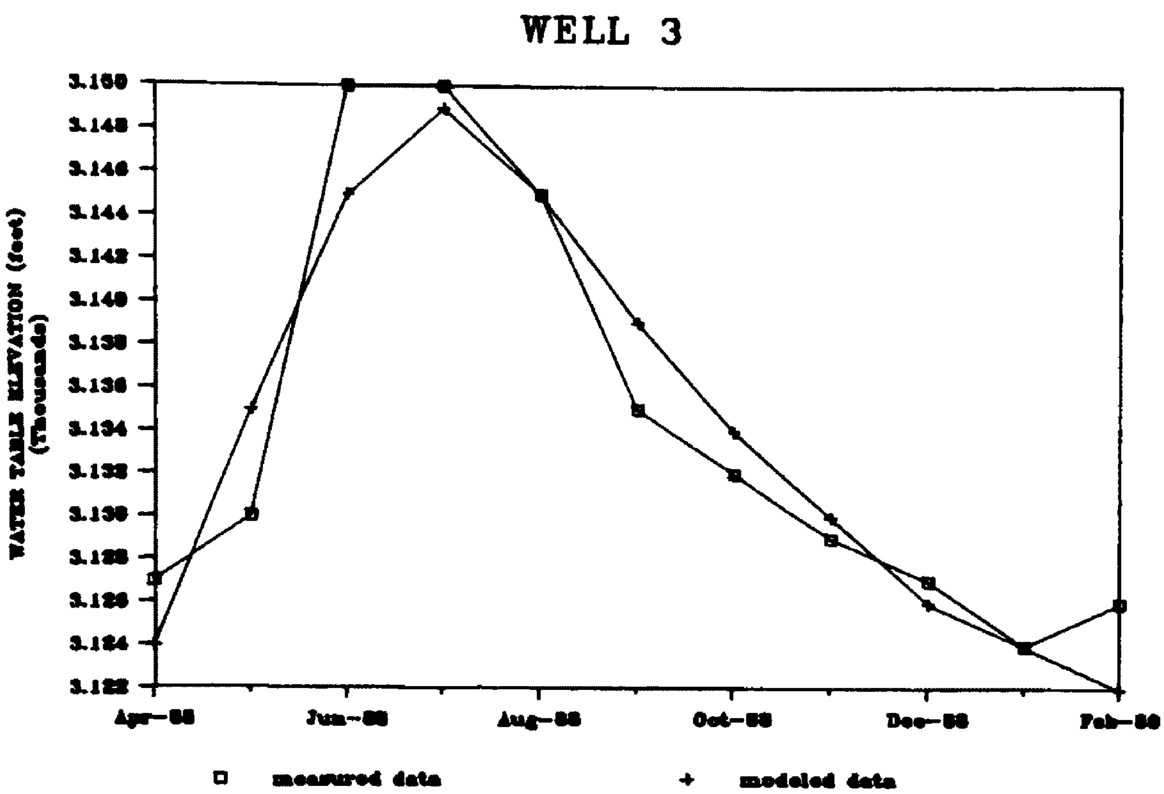


FIGURE 34: Hydrograph comparing measured and modeled data, well 3.

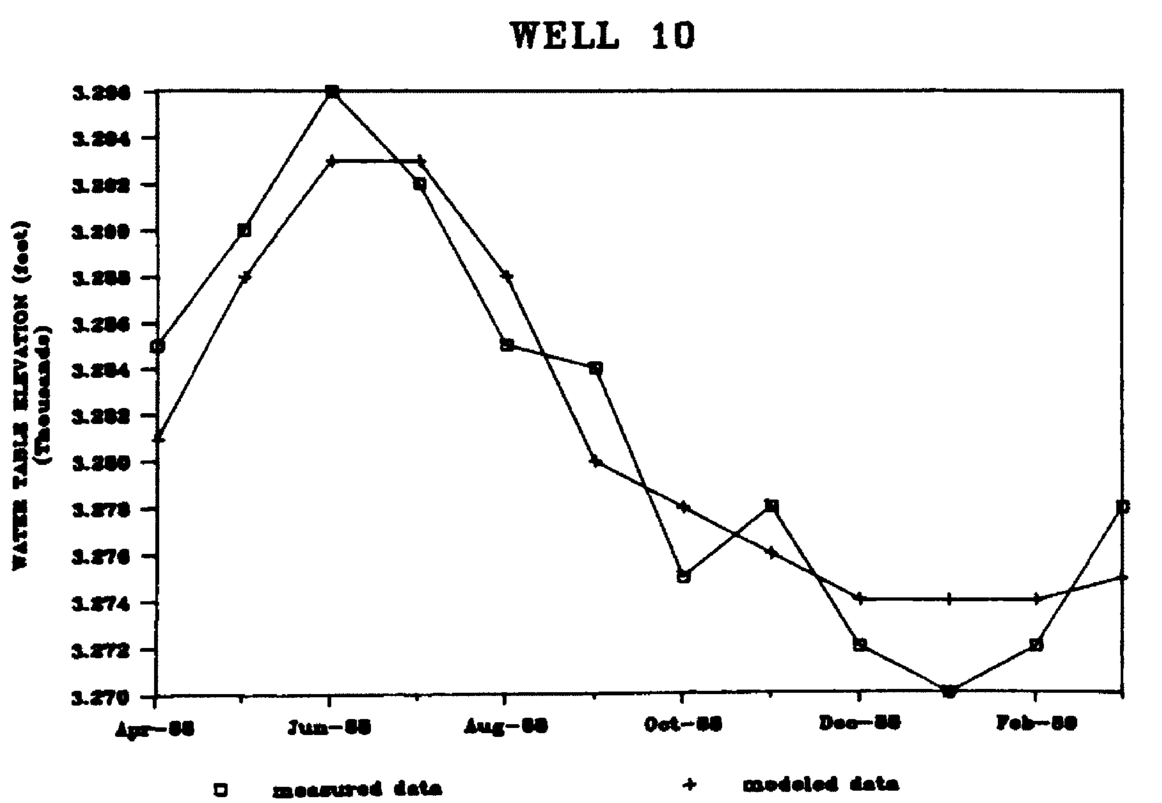


FIGURE 35: Hydrograph comparing measured and modeled data, well 10.

## WELL 17

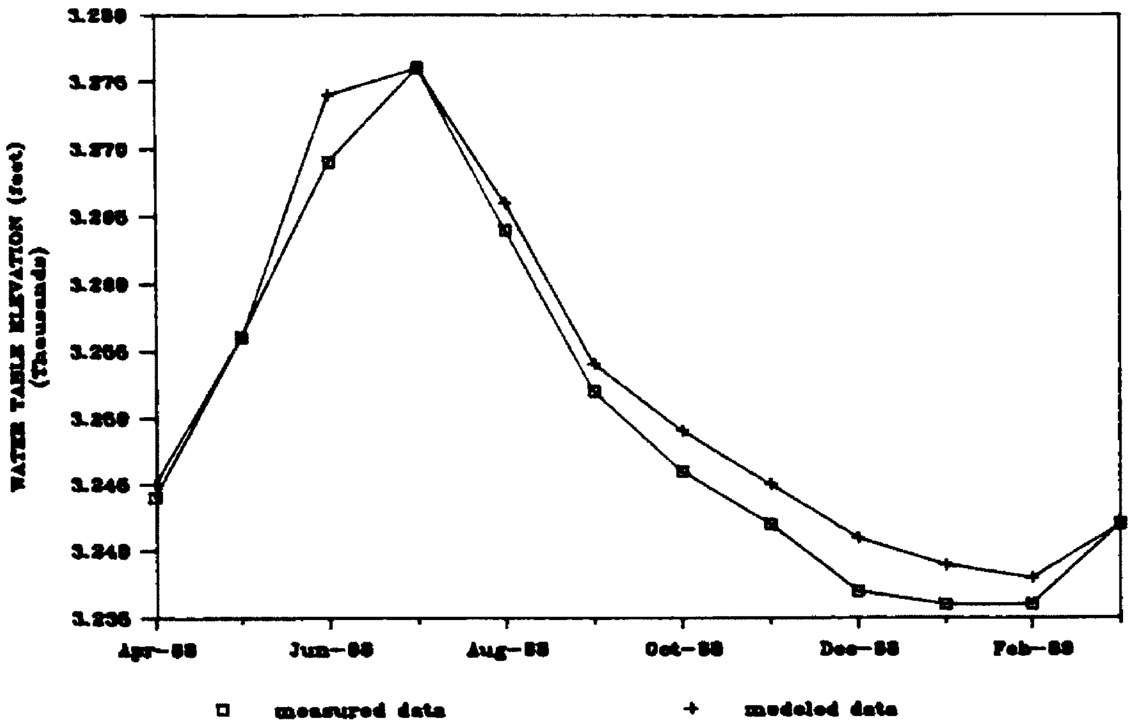


FIGURE 36: Hydrograph comparing measured and modeled data, well 17.

## WELL 26

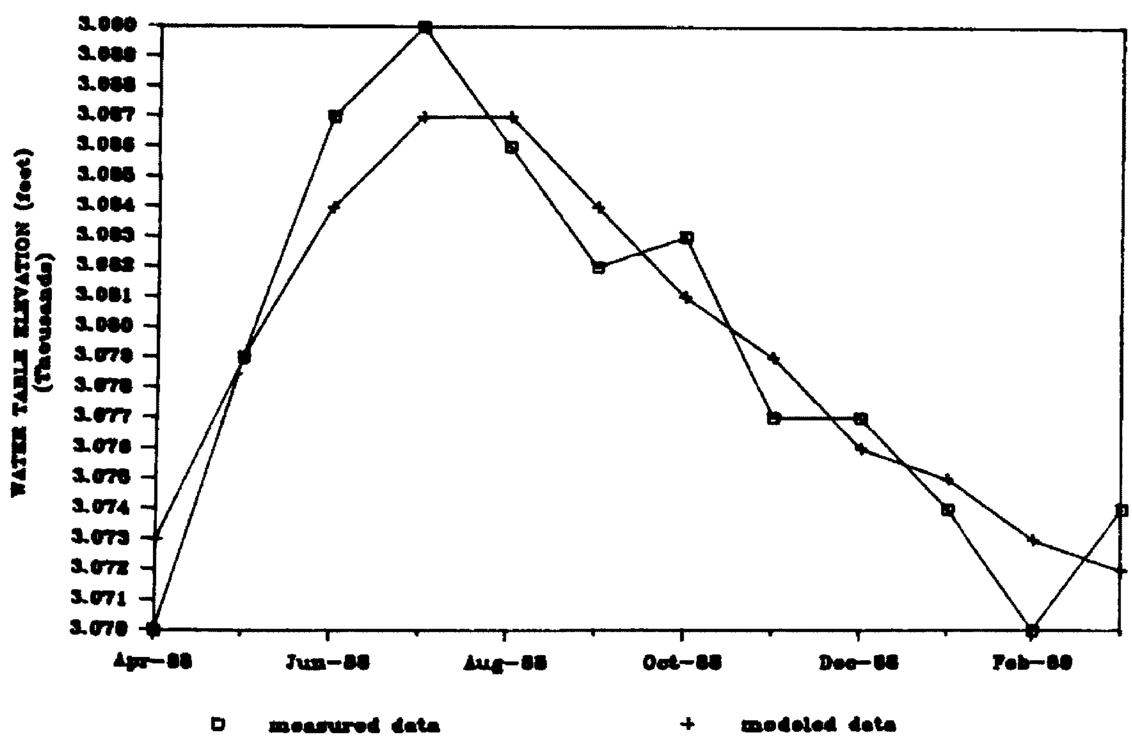


FIGURE 37: Hydrograph comparing measured and modeled data. well 26.

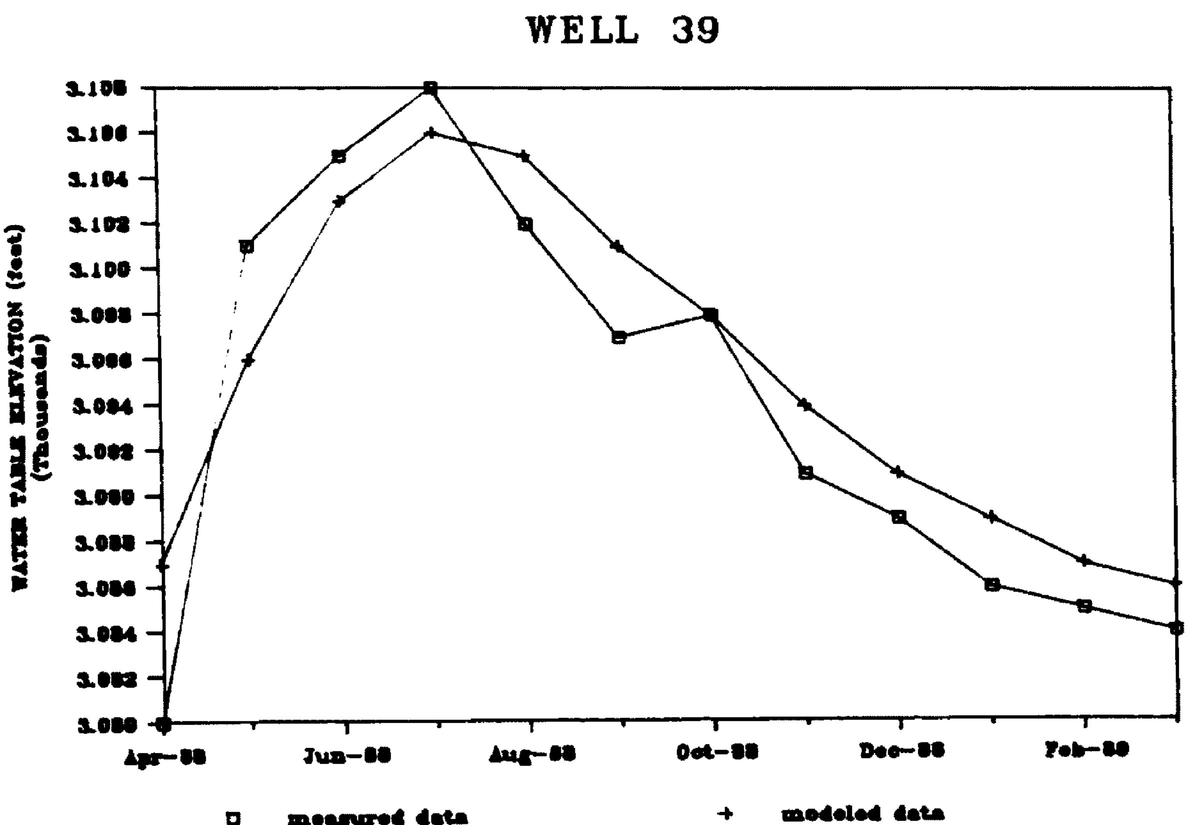


FIGURE 38: Hydrograph comparing measured and modeled data well 39.

outflows, model calculated discrepancy between inflows and outflows was always less than 2 percent.

As a final check, Table 5 contains the mean absolute error for each stress period of the transient simulation.

TABLE 5: MEAN ABSOLUTE ERROR (Ft), TRANSIENT SIMULATIONS.

| | | | | | |
|---|---|---|---|---|---|
| APRIL | 5.2 (MAE) | AUGUST | 4.5 (MAE) | DECEMBER | 4.8 (MAE) |
| MAY | 4.3 | SEPTEMBER | 5.4 | JANUARY | 4.3 |
| JUNE | 4.9 | OCTOBER | 4.3 | FEBRUARY | 5.0 |
| JULY | 4.2 | NOVEMBER | 4.9 | MARCH | 4.8 |

The mean absolute error averaged over 12 months is 4.7 feet (1.4 m), less than the mean absolute error for the steady state model.

## Sensitivity Analysis:

Sensitivity analysis is performed by isolating one model parameter, holding other parameters fixed, and adjusting the value of the isolated variable. The additive or subtractive effects grouped variables may have on head distribution cannot be examined through sensitivity analysis. A potentially more valuable approach to sensitivity analysis is subjectively analyzing model response to variables during calibration (Danskin, 1988).

I adjusted three model parameters during sensitivity analysis; 1) specific yield, 2) hydraulic conductivity, and 3) surface water stage. Values were adjusted both 50 percent below and 50 percent above values used during modeling. The runs are compared using the mean absolute error averaged over the year (Table 6).

TABLE 6: RESULTS OF SENSITIVITY ANALYSIS; MAE (Ft):

| PARAMETER VALUE | 50 % | 100 % | 150 % |
|---|---|---|---|
| SPECIFIC YIELD | 5.1 (MAE) | 4.7 (MAE) | 5.4 (MAE) |
| HYDRAULIC CONDUCTIVITY | 6.0 | 4.7 | 5.2 |
| SURFACE WATER STAGE | 5.9 | 4.7 | 5.0 |

The transient model remained stable for each parameter adjusted. Increases in hydraulic conductivity had the greatest effect, changes in hydraulic conductivity and surface water leakage caused major changes in water balance results. I suggest that the model remained stable during sensitivity analysis because parameters were uniformly varied across the model and the difference between adjacent values remained the same.

## Model Discussion:

Transient simulation of the unconfined Jocko Fan aquifer matched measured data for the period April, 1988 through March, 1989 within an acceptable error. The poorest calibration occurred southwest of Arlee; as previously stated this part of the aquifer may receive recharge from fractured bedrock. The best calibration occurred in the upper fan area, the zone of maximum interest.

Numerical models do not provide unique solutions to problems they are designed to address, different combinations of model input can produce the same results. There are, however, several components of the transient simulation of Jocko Fan aquifer found necessary to reproduce yearly changes in water levels:

1) Measured early summer increases in water table elevations could not be simulated without turning on irrigation diversions throughout the model.

2) Higher or lower hydraulic conductivity values produced water balance results that did not equate with calculated water balance results.

3) Water table elevations along the Agency Fan-Jocko Fan boundary could only be supported with lateral flow from Agency Fan.

4) The steep water table slope on upper Jocko Fan could only be reproduced with an equally steep aquifer base.

The initial postulate of this study stated that leakage through the streambed of the Jocko river and irrigation canals is the principal source of recharge to the Jocko Fan aquifer. Water balance calculations and calibration of the numerical model, indicate that lateral inflow on Agency Fan boundary may be a more critical source of recharge. This was not anticipated by Thompson (1988), nor initially during this study. Recharge on Agency Fan boundary does increase and decrease seasonally, however, as Figure 22 suggests, along most of the Agency Fan boundary recharge is fairly constant throughout the year. The southeast corner of Agency Fan is exceptional; perennial springs emanate from this area and, as Figure 22 indicates, there is a slug of spring recharge.

All data I have presented indicate that the Jocko Fan aquifer is extremely dynamic. The aquifer rises rapidly in response to recharge and subsides equally rapidly when recharge is diminished. Although I calibrated a transient model for a one year period, extrapolations of this model must be viewed cautiously, primarily because the aquifer is so dynamic. Impacts to the aquifer, resultant from model operations uses to evaluate adjusted surface water flows, should be examined for trends, not absolute values.

## Model Predictions:

I performed four transient model operations for predictive purposes; 1) I lowered ditch stage and increased river stage, 2) spring runoff was diverted from the Jocko River into irrigation ditches, 3) ditches were never turned on, and 4) I kept water diverted into the Mission Valley in the Jocko drainage.

In the first model operation (P1), I lowered ditch stage uniformly 50 percent, and increased river stage. I increased river stage 0.4 feet (.12 m) for April and July, 0.5 feet (.15 m) for May and June, and 0.1 (.03) feet for August, September, and October. I increased river stage during April, before stage was increased in the calibrated transient model, because much of early spring runoff is normally diverted into irrigation canals. For this and the following model operation (P2), the water balances are within 10 percent of the calibrated model water balance.

Drawdown occurred across the model (Figure 39; July water levels) into late summer. There is no detectable effect on water levels during winter months. The greatest decreases in head correspond to high hydraulic conductivity areas and areas adjacent to major canals. Drawdown occurred because water was taken from losing channels (irrigation ditches) and put into the river which loses water only in its upper reach. Hydrographs for prediction 1 and 2 are compared to measured and modeled data for well 8 in Figure 40.

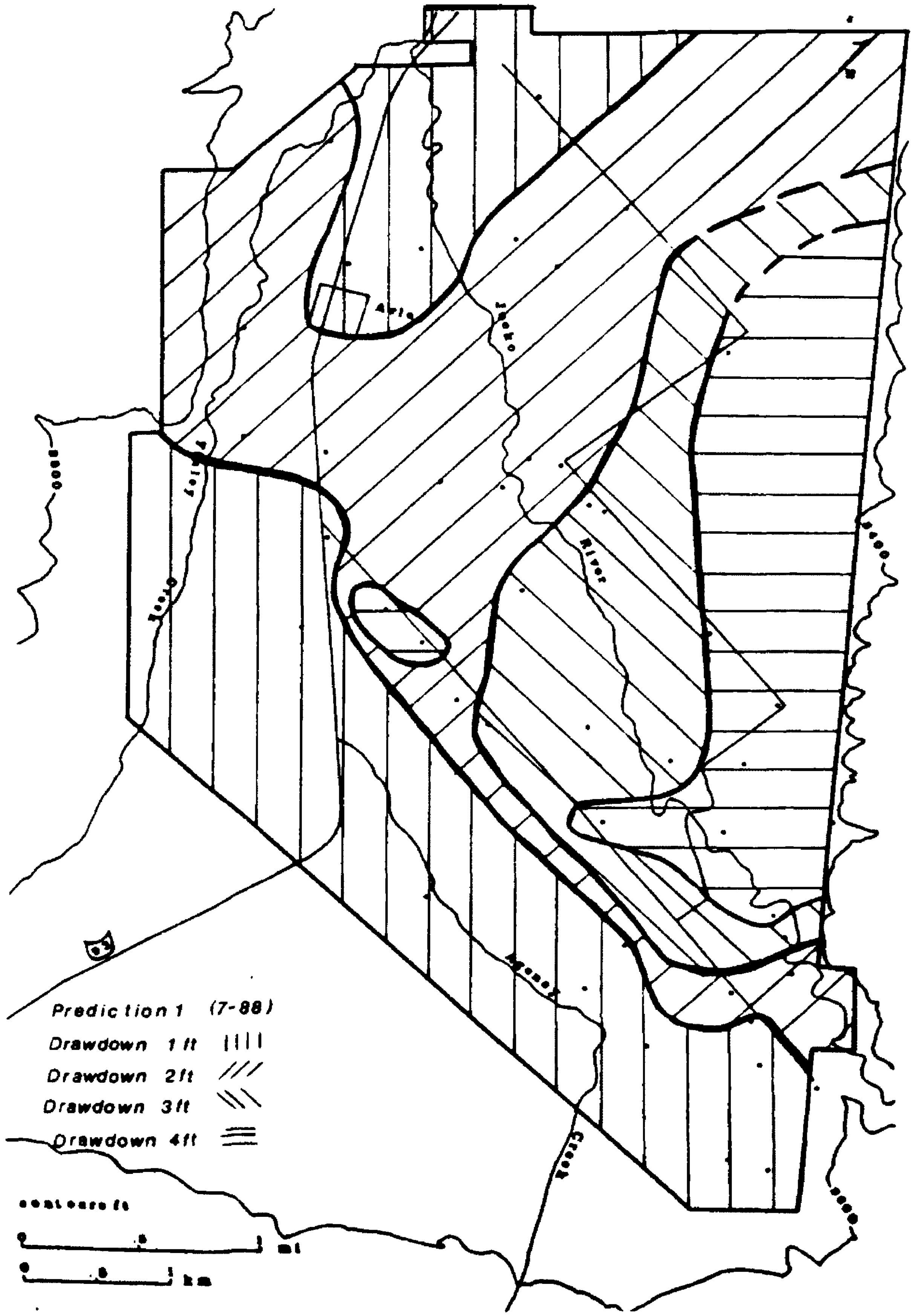


FIGURE 39: Drawdown contour map of prediction one (7-88).

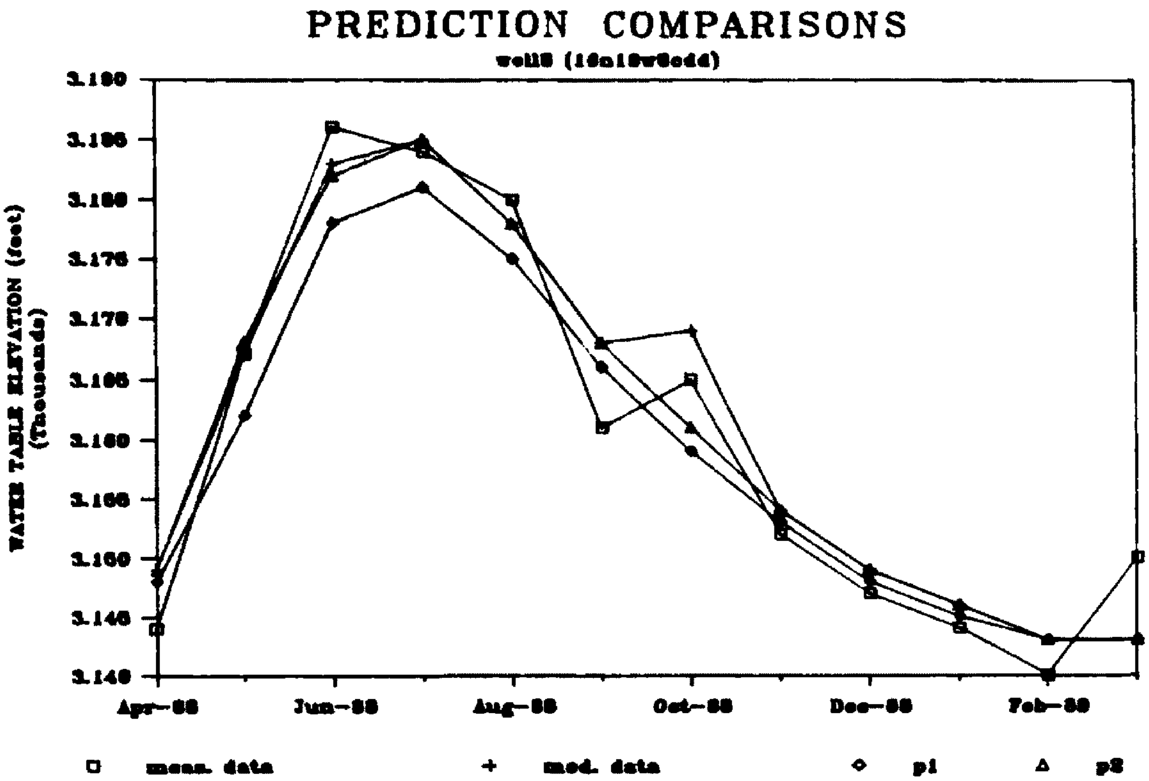


FIGURE 40: Hydrograph comparing predictions one and two to measured and modeled data, well 8.

For the next model operation (P2), I kept river stage at early April values and put water normally contributing to spring runoff in irrigation ditches. During May, I increased stage in K canal 1.5 feet (.46 m) and 1.0 feet (.3 m) in the other canals. In June, I increased stage in K canal 1.1 feet (.34 m) and 0.6 feet (.18 m) in the other canals, and for July and August I increased stage in K canal stage 0.2 feet (.06 m) and 0.1 feet (.03 m) in the other canals.

The effect of this adjustment is minimal and a contour plot is not presented. Water levels increased one to two feet (.3-.6 m) in the upper fan for May through July, but there was no change during winter months.

Because the above two simulations had minimal effect on water table elevations, I performed a simulation turning off all ditches (P3). Ditches were never activated, river stage was increased 0.5 feet (.15 m) in April, 1.0 feet (.3 m) for May through July, 0.1 feet (.03 m) in August, and 0.2 feet (.06 m) in September and October.

Drawdown occurred across the model (Figure 41, July water levels) into late summer. Again there is no detectable effect in winter months. Areas of maximum drawdown occurred in the upper fan and along irrigation ditches. Hydrographs for predictions 3 and 4 are compared with measured and modeled data in Figure 42 for well 8.

In the final model operation (P4), I took water normally diverted into the Mission Valley, and added it to spring runoff in the Jocko River. I added 15,000 acre-ft of water to the Jocko River for May and June; this equals an increase in stage of 1.4 feet (.43 m).

This contribution of water caused heads values to increase 1 feet (.61 m) in the mid-fan (Figure 43; July water levels). The impact to the aquifer of prediction four is not detectable for winter months. Possibly, water levels did not increase more because additional water was not diverted into irrigation ditches.

In all four model operations, I adjusted surface water flows during spring and summer months, but I did not adjust

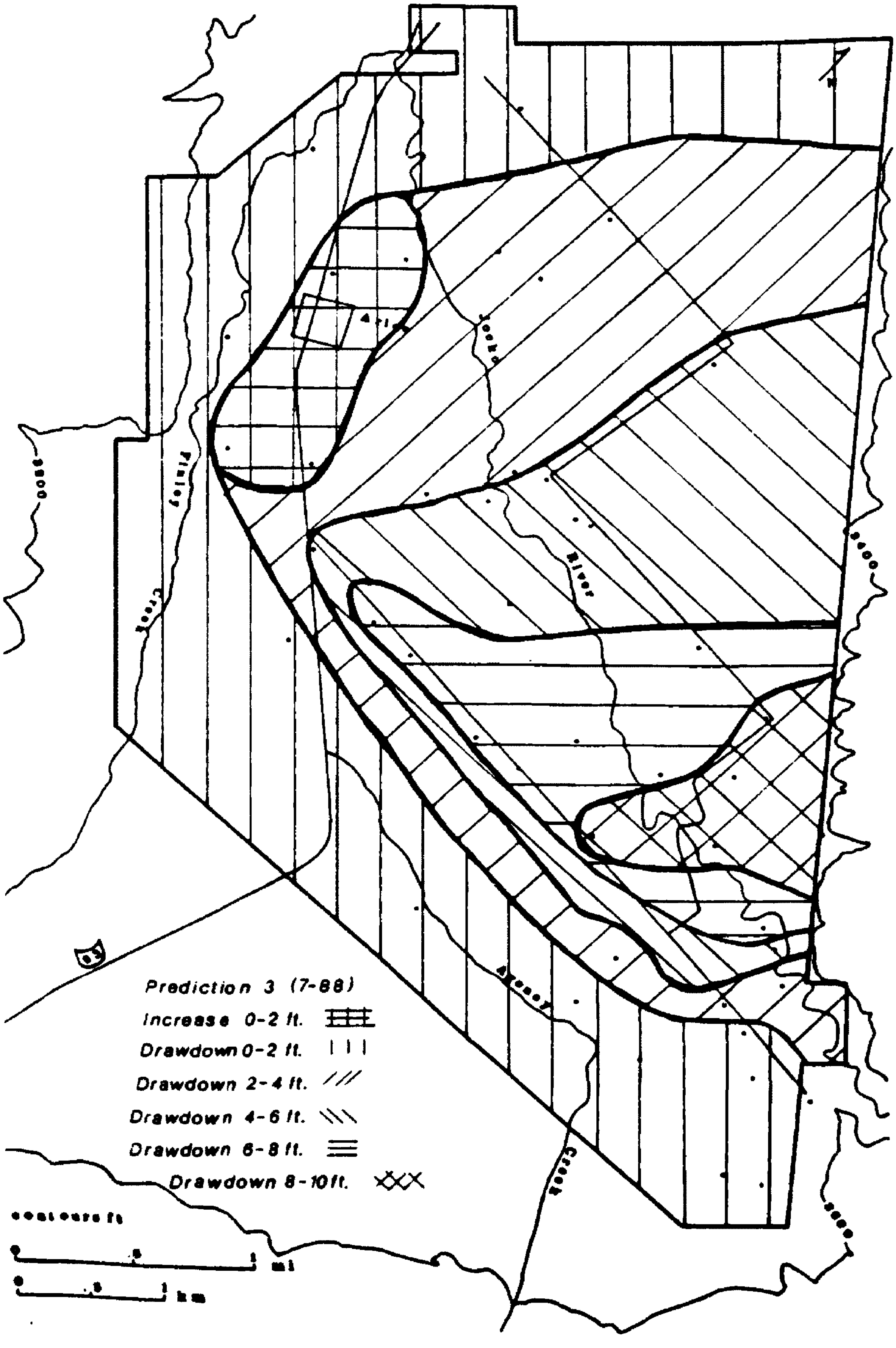


FIGURE 41: Drawdown contour map of prediction three (7-88).

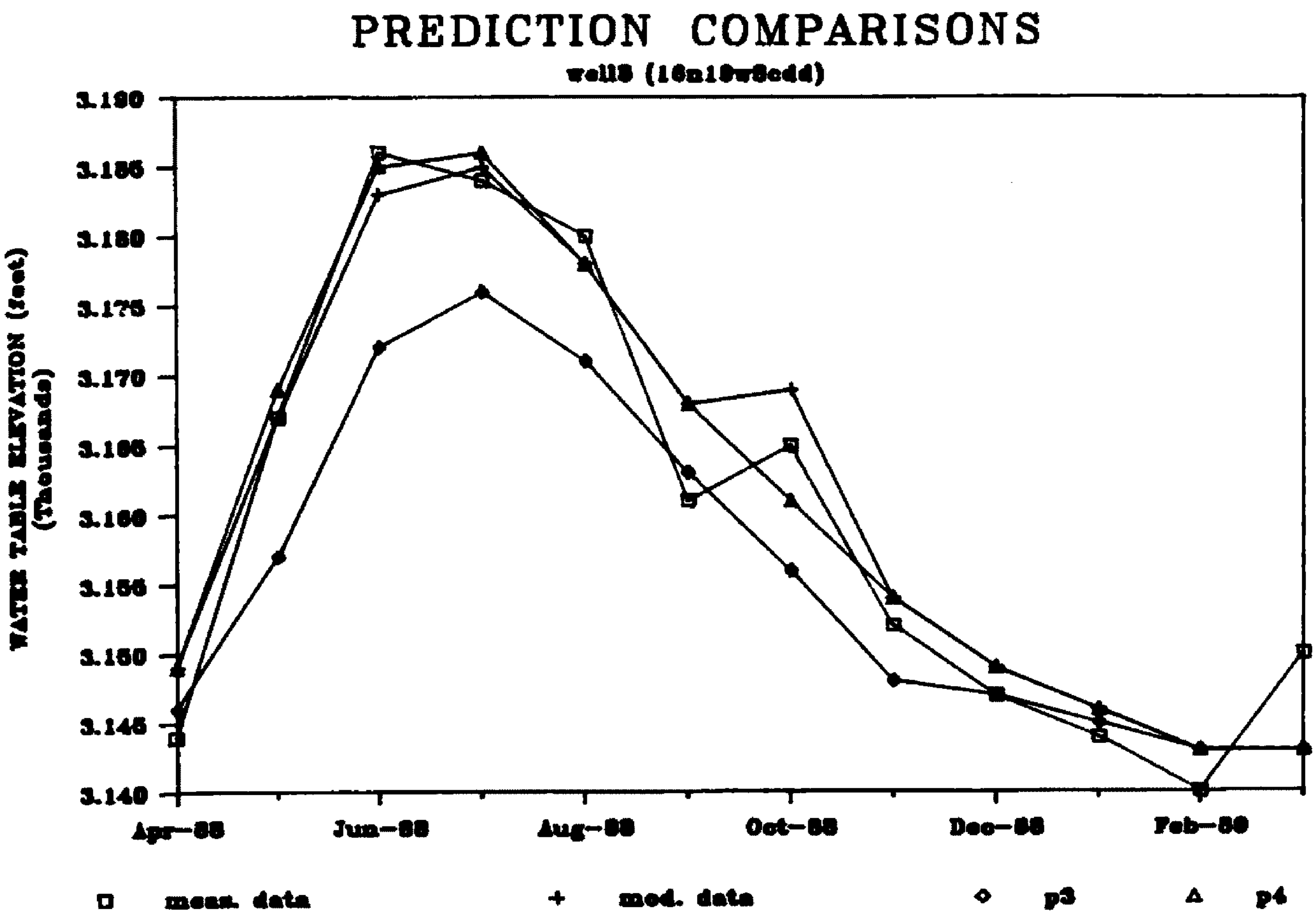


FIGURE 42: Hydrograph comparing predictions three and four to measured and modeled data, well 8.

the "base flow", or winter recharge rate. Water levels were affected during summer months. None of the operations had an effect on water levels during winter months. This suggests the aquifer responds and recovers dynamically to external stresses. The influence of adjustments made to spring - early summer recharge had diminished by winter months.

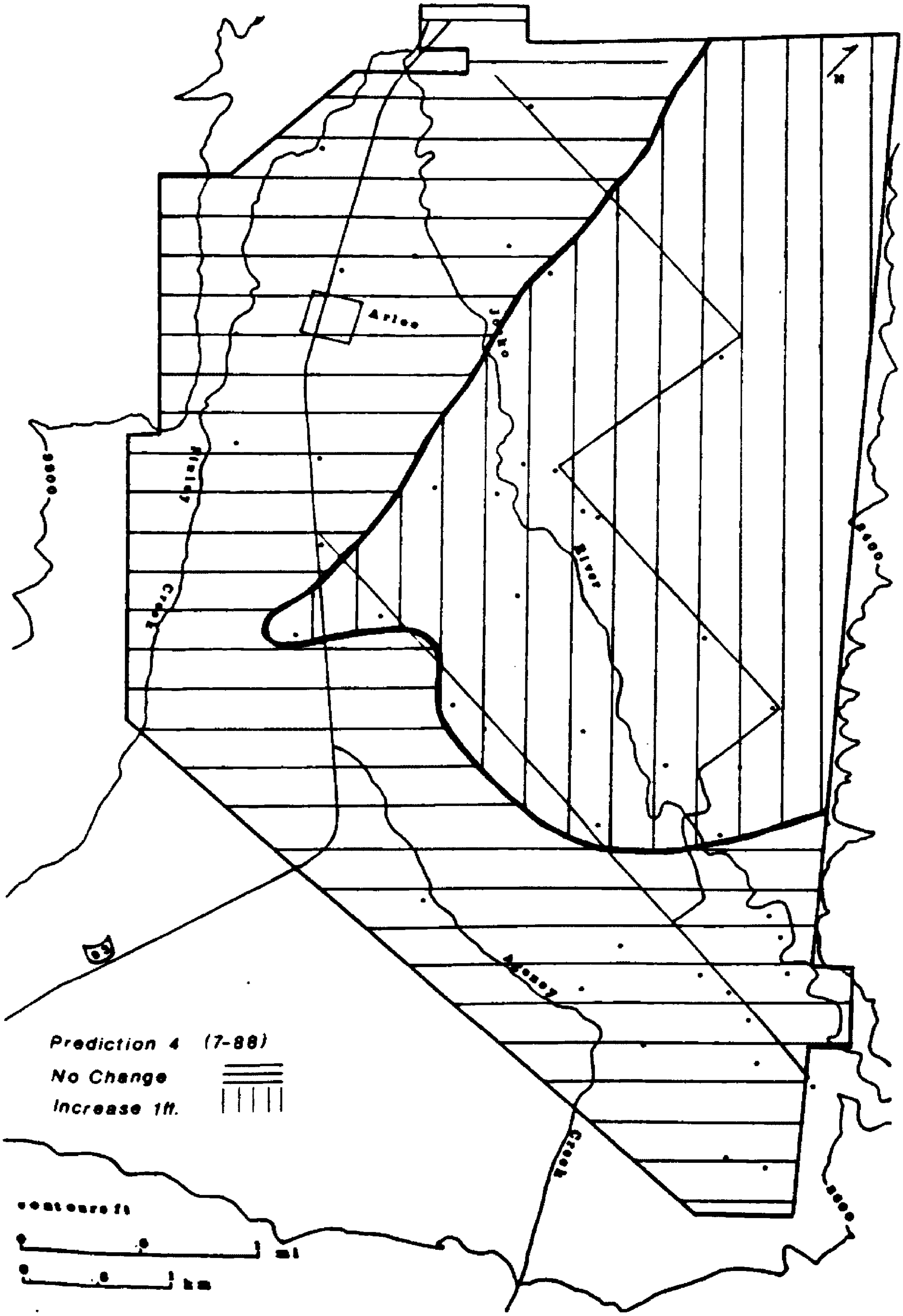


FIGURE 43: Drawdown contour map of prediction four (7-88).

## CAUSE OF WATER TABLE FLUCTUATIONS:

Water table fluctuations are a function of annual and seasonal changes in recharge to the aquifer. During spring - early summer recharge, the aquifer is overwhelmed with water, increasing aquifer storage, thus causing water table elevations to rise. In the spring, the hydraulic gradient of the Jocko Fan aquifer is steep across the entire aquifer. When recharge events decrease, the highly conductive aquifer rapidly responds and returns to lower water table elevations but maintains a steep gradient. Rapid changes in aquifer storage are visible on hydrographs, in Figure 22, and are suggested by results of model predictions.

Model predictions indicate that decreasing irrigation flow in the summer and fall results in a reduction in water table elevations during this period. However during the following winter months when ditches are not running, the effects of decreasing summer and fall irrigation recharge are not detectable on the winter water table position. This suggests the cause of winter water table declines is directly tied to variability in Jocko Fan recharge rates during winter months.

Apparently, recharge to the Jocko Fan aquifer during winter is sustained by river leakage and lateral inflow from Agency Fan. Rates of river leakage during winter months are dependant upon stage levels, and ultimately yearly basin-wide recharge from precipitation. The rate of lateral inflow across Agency Fan appears to be relatively consistent throughout the year (Figure 22). The water table drops more dramatically on Jocko Fan than on Agency Fan during the winter. This increases the hydraulic gradient between the two fans during winter and probably sustains rates of recharge across Agency Fan during the winter.

Recharge to the Agency Fan aquifer during winter months is minimal, and lateral flow to the Jocko Fan aquifer is being derived from a reduction in Agency Fan storage. Below average precipitation since 1983 has caused a general lowering of the water table in Agency Fan, decreasing aquifer storage, and decreasing the winter flux across the Agency Fan - Jocko Fan interface.

It appears water table elevation declines during winter months are more directly due to below average precipitation than seasonal variations in surface water management.

# CHAPTER FOUR: CONCLUSIONS.

1) Throughout the Jocko Valley, sections of the late Quaternary depositional history of the valley are preserved; the Jocko Fan is the most recent and complete piece in the sequence of Quaternary deposition. The most appropriate modern analogue for the Jocko Fan is a braided outwash fan; a depositional feature forming today in proglacial environmental settings.

2) The unconfined Jocko Fan aquifer, comprised of sediments of the Jocko Fan, is a hydraulically interconnected system which thins from 310 feet (95 m) in the Jocko Canyon area to less than 200 feet (61 m) north and east of Arlee. The aquifer is coarse grained along its entire length, and consequently, it exhibits high transmissivities.

3) Leakage from the Jocko River is greatest in May, during spring runoff, prior to up-fan migration of the gaining reach of the river. During June the volume of water lost from the Jocko River is lower; this trend continues through September when the gaining reach of the river migrates down-fan. The timing and rates of ground water inflow to the Jocko River is also of hydrologic significance. Maximum inflow rates to the river mirror the period of minimum loss from the river, and correspond to the period when the gaining reach of the river is expanded.

4) As anticipated, irrigation diversions leak water to the underlying aquifer. The water which the ditches leak forms an important seasonal contribution the aquifer mass balance. Consistent drops in water levels across the aquifer in October when ditch flow is reduced or cutoff indicate ditch flows sustain the water table into the fall.

5) The importance of lateral inflow from Agency Fan is indicated by water balance and model results. Water level contours on Jocko Fan aquifer follow the surface trend of Agency Fan. The slope of the aquifer base of the Jocko Fan aquifer follows the slope of Agency Fan.

6) Because the Jocko Fan aquifer is relatively small and has a large volume of spring - early summer recharge it responds very rapidly to recharge events. Hydrographs indicate that there is only a one to two week lag time between surface water leakage events and a corresponding rise in the water table. Because the aquifer has a steep hydraulic gradient and high transmissivities when recharge events cease the water table declines rapidly. Seasonal trends in the water table indicate that the majority of spring-early summer recharge leaves the Jocko Fan aquifer by December.

7) High hydraulic conductivities, steep gradients in the base of the aquifer, and rapid responses to recharge events were difficult to match with the ground water flow model; however, the final model calibration is well within

acceptable error limits.

## Recommendations for Further Study:

Results of this study indicate that Agency Fan is an important source of recharge. Further hydrogeologic study in the Jocko Valley should include measurement of aquifer properties on Agency Fan and also interactions between Agency Fan and Jocko Fan.

Determining hydraulic conductivity in coarse grained alluvial aquifers is extremely difficult. Pumping tests do not stress the aquifer sufficiently, the sediments are too coarse grained for effective permeameter testing. In this study, the final hydraulic conductivity distribution was determined through model calibration. Little field data exists to support final results. Further hydrogeologic study in the Jocko Valley would be benefited if an approach for determining hydraulic conductivity could be developed. Specifically, this would increase the confidence in the model, but it would also have application to coarse valley-fill aquifers throughout the intermontane west.

A final recommendation for continued study is long-term maintenance of an observation well network to monitor changes in aquifer storage. With longer water level records, verification of the numerical model would have more significance and changes in aquifer storage could be evaluated.

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# APPENDIX A: GEOLOGY

GLACIATION

Alpine Glaciation

Continental Glaciation

MONITORING WELL CONSTRUCTION

Well Log

## APPENDIX A: GEOLOGY.

### GLACIATION:

#### Alpine glaciation:

Major alpine and continental glacial events which affected northwest Montana are discussed below; this section is included to support introductory geologic material and discussion of the depositional setting of the Jocko Fan.

Pre-Bull Lake morainal material points to three major glaciations separated by extensive interglacial periods. Bull Lake glacial maxima occurred approximately 150,000 yrs b.p., and between 90,000 and 60,000 yrs b.p. (Porter et al., 1983). Pinedale glacial maxima occurred 40,000, 25,000, and 15,000 yrs b.p. (Pierce, 1976; Porter et al.,1983). Alpine deglaciation began by 14,000 yrs b.p., it was complete by 9,500 yrs b.p..

The early to mid-Holocene climate in the northwest Rocky Mountain region was warmer than the present climate (Clague et al., 1989). This period, the Altithermal, climaxed between 8,000 and 6,000 yrs b.p.. Following the Altithermal, glaciers reoccupied the Rocky Mountains. Nomenclature for this time, the Neoglacial period, varies from range to range based on local correlations (Burke et al., 1983).

#### Continental Glaciation:

The chronology of the Cordilleran ice sheet is best preserved in the Puget and Fraser lowlands of western Washington and British Columbia. Several authors (Waitt and Thorson, 1983; Atwater, 1986; Booth, 1987) suggest close synchronicity of continental glaciation sequences east and west of the Cascade Range, particularly for the Fraser glaciation.

Pre-Fraser age ice-sheet glaciations did influence the northwest Rocky Mountain region (Waitt and Thorson, 1983), however, their extent and timing is poorly documented. Fraser-age Cordilleran ice initially grew out of British Columbia source areas around 25,000 yrs b.p.. Piedmont glaciers climaxed around 15,000 yrs b.p.. Timing of the final Fraser continental deglaciation differed east and west of the Cascades (Booth, 1987). By 13,000 yrs b.p., the Puget lobe was well north of the Canadian border, but the more easterly Purcell Trench lobe lingered near its Fraser-age maximum, 150 km inside the United States border. The Fraser-age maximum of the Flathead lobe is marked by the Mission moraine (Curry, 1977; Stoffel, 1980). The margin of the Flathead lobe was north of Kalispell by 13,000 to 12,500 yrs b.p. (Waitt and Thorson, 1983; date on Mt St Helens ash).

At least one pre-Fraser age ice sheet dammed the Clark Fork River (Waitt and Thorson, 1983), however, the best record of lake filling and draining corresponds to Fraser glaciation. Data documenting repeated catastrophic floods of Glacial Lake Missoula are prevalent in eastern and southcentral Washington (Baker, 1983; Waitt, 1980; Atwater,1986). In northwest Montana, multiple lake strands and repeated sequences of varved silts (Chambers, 1971) point to renewed filling of Glacial Lake Missoula.

Evidence illustrating that each episode of lake filling lasted only a short time includes; 1) moderately developed lake strand lines (Alden, 1953), 2) presence, on average, of only 25 varved couplets within each measured sequence of lake silts (Chambers, 1971), 3) absence of a spillway around the Purcell Trench lobe terminal zone (Bretz, 1956), and 4) the scarcity of ice-rafted dropstones in Glacial Lake Missoula silts (Alden, 1953). Data also suggest that final lake fillings had less volume, and therefore lower elevations, than earlier lake stages. This is documented by thinning of topmost sets of varved lake silts (Chambers, 1971), and also thinning of topmost sets of flood generated beds in southwestern and northeastern Washington (Waitt, 1980; Atwater, 1986). No absolute dates mark final glacial Lake Missoula flooding events, although Atwater (1986) and Waitt (1980, 1985) present strong evidence that final flooding events occurred before 13,000 yrs b.p..

## MONITORING WELL CONSTRUCTION:

Drilling was performed with a forward-air rotary cyclone

T-60 drill. Six inch casing was driven contemporaneously with drilling. An eccentric bit (Driscoll, 1986), attached to a down-the-hole hammer, was used to make hole. The eccentric bit (Odex bit) cut a wider hole than the casing diameter, allowing the casing to drop under its own weight. Some hammering was necessary to drive the casing; this was done using the down-the-hole hammer and a special drive shoe.

The base of the aquifer was reached at 307 feet (94 m), and the well was cased to 322 feet (98 m). After pulling out the Odex bit and drill steel, the casing was hammered down one foot (.3 m) with a conventional casing driver; this closed off the open hole and occluded any down hole wash. The well was then drilled open hole through clay to 398 feet (121 m) with a five inch roller bit.

To complete the well, a double ended packer was placed at 310 feet (94 m), sealing off the sand and gravel aquifer from underlying clays. Then, using a down hole perforator, four rows of perforations were cut from 298 to 198 feet (91-60 m). The well was developed for 1.5 hours using compressed air, and finally, the well perimeter was grouted to a depth of three feet. Figure 44 is a log for well MW. Geology is not detailed because the sedimentary sequence had few variations.

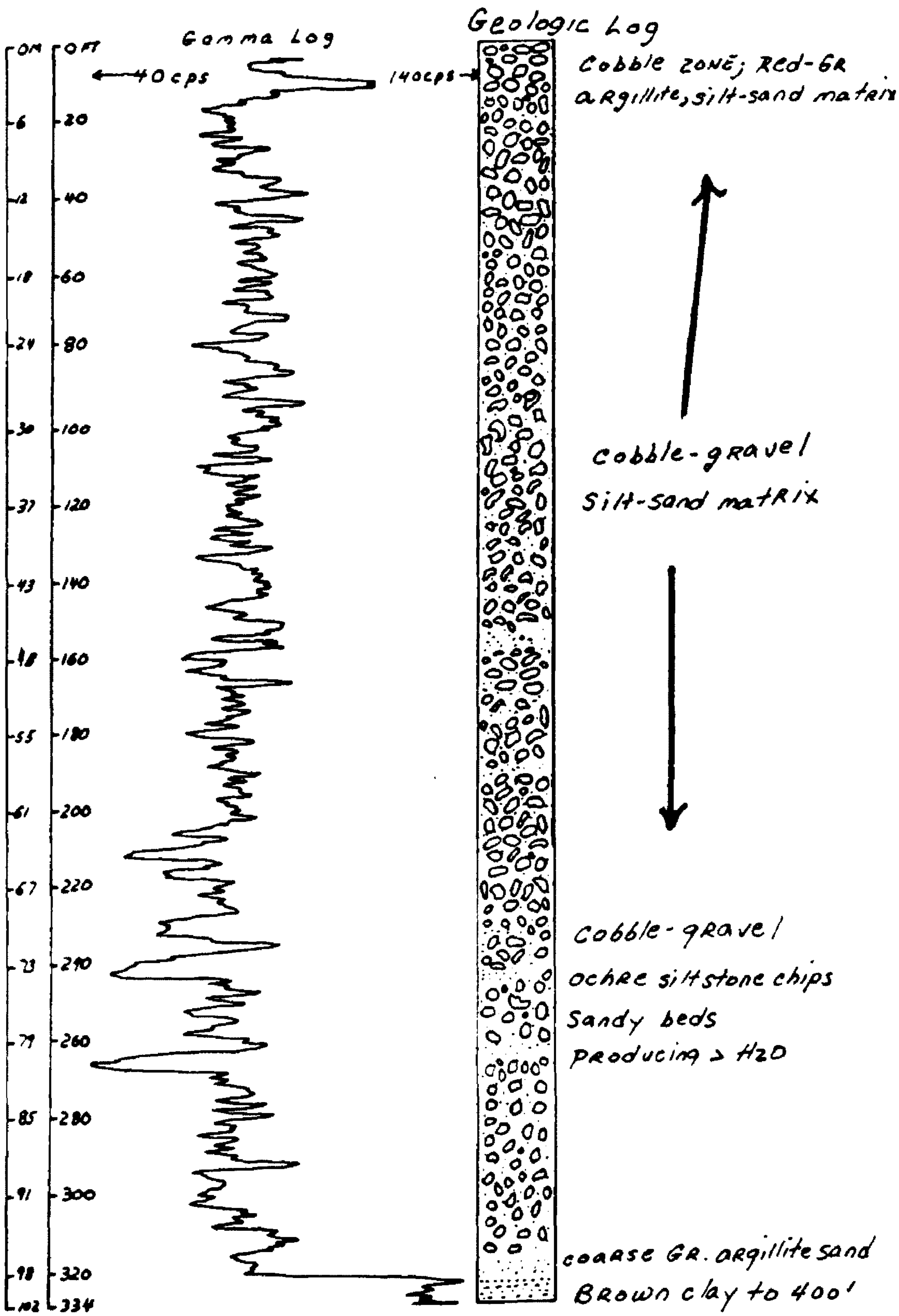


FIGURE 44: Well log, well MW.

## APPENDIX B: SEISMIC REFRACTION

## APPENDIX B: SEISMIC REFRACTION.

Equipment used during seismic refraction work in the Jocko Valley included a 24 channel EG&G GEOMETRICS signal enhancement seismogram and 10-hertz geophones. Each spread used 24 geophones, spaced 100 feet (30 m) apart. The energy source was kinepack-two component explosive, with charge size ranging from one half to three pounds. Charges were set, on average, five feet (1.5 m) below land surface. Seven shotholes were drilled per spread, two off each end of the spread, and five within the spread. Shooting onto a spread from both directions (reverse shooting) is needed to adequately delineate dipping refractors.

Refraction data were modeled using SIPT1. SIPT1 uses a combination delay-time ray tracing procedure (Pakisar and Black, 1957) to calculate depth to refractors beneath each geophone. If refractions from a layer are intercepted by several geophones, a modified delay-time procedure (Hobson-Overton method) is used. The Hobson-Overton method (Scott et al.,1972) minimizes the variation in delay-time between refractors to determine depth to refractors. Ray paths, adjusted for refractor dip, are traced upward to the surface for each refractor for final model refinement. Traveltimes are calculated from the length of raypaths, they are compared to field determined traveltimes. Up to three raypath iterations can be performed to minimize the variation between calculated versus observed raypath travel times. Two main limitations of SIPT1 are (Haeni et al., 1987); 1) each layer is modeled as extending across the whole cross-section, and 2) each layer is modeled as having constant horizontal and vertical velocities.

Input to the model includes: 1) arrival time picks for the first p-wave reaching a geophone for each shotpoint, 2) X,Y, and Z coordinates for each geophone and shotpoint, and 3) initial layer assignments for each arrival event. In addition, velocity cards which override model calculated velocity can be used. SIPT1 is designed with six exit points which control the degree to which the program runs and subsequent output. The output includes: 1) a summary of input data, 2) calculated velocities for each geophone for each shotpoint, 3) arrival times corrected to a datum, 4) depth to refractors beneath each geophone, 5) traveltime plots, and 6) cross-sectional plots. The best fit to the data is made by minimizing the deviation of plotted refractor depth beneath each geophone with the fitted refractor line on the cross-section plot. This is done by adjusting initial layer assignments, and by use of input velocity overrides.

Problems encountered using seismic refraction in the Jocko Valley include: 1) high frequency noise from irrigation pumps made first picks difficult for some geophones, and 2) source energy was rapidly attenuated because of the thick unsaturated zone. Also, first arrivals from the water table were intermittent; this may be due either to rapid energy attenuation or blind layer problems.

During initial interpretation, depth to refractors was shallow. A velocity (3,500 ft/s, 1067 m/s) was input for layer one to match the known water table elevation. This increased depth to refractors, rays traveled a greater distance through layer one in a given time. The input velocity (3,500 ft/s, 1067 m/s) is high for unsaturated material; the model calculated that the layer one velocity was between 1,500 and 2,500 ft/s (457-762 m/s). However, the input velocity may be justified in the Jocko Valley. The unsaturated zone can be up to 175 ft (53 m) thick; material under this load may undergo compression and increase in velocity above anticipated values.

Only one control point is available to check the final accuracy of refraction interpretation; this was the project drilled well (well MW, Figure 8). At this point the seismic interpretation estimated the base of the aquifer at 330 feet (101 m). Subsequent drilling showed that the base of the aquifer was at 307 feet (94 m). This is an error of 7 percent, within the error range of ten percent cited by Haeni (1986). Although there are no control points for the other profiles, interpretation produced geologically consistent results which matched predicted aquifer geometry.

## APPENDIX C: SURFACE WATER RESULTS

PROVISIONAL CSKT SURFACE WATER DATA

## APPENDIX C: SURFACE WATER RESULTS.

Seepage data for irrigation diversions collected during this study are presented in Table 7. Approximately the first 1.5 miles (2.4 km) of K canal are cement lined; in the following discussion, and in numerical modeling efforts, this section was considered non-leaky. K-canal lateral is representative of the smaller ditches flowing over the Jocko Fan. Flow for sites K3-K4 and sites K5-K6 was measured twice in one day; the maximum discharge variation between measurements was 2.7 % of total flow.

TABLE 7: SEEPAGE LOSS RESULTS FOR IRRIGATION DITCHES.

| REACH | DISTANCE | DATE | Q1(CFS) | Q2(CFS) | CHANGE |
|---|---|---|---|---|---|
| K CANAL | | | | | |
| K1/K2 | 2100 ft | 6/4/88 | 100.87 | 97.28 | 3.59 |
| | | 8/5/88 | 66.68 | 66.16 | 0.52 |
| K3/K4 | 3170 ft | 6/4/88 | 78.9 | 75.96 | 2.94 |
| | | 6/23/88 | 113.04 | 103.08 | 9.16 |
| | | 8/5/88 | 66.6 | 60.92 | 5.68 |
| | | 8/5/88 | 66.51 | 59.22 | 7.29 |
| K5/K6 | 4930 ft | 7/8/88 | 34.91 | 31.9 | 3.01 |
| | | 7/8/88 | 35.16 | 32.57 | 2.59 |
| K-CANAL LATERAL | | | | | |
| K10-1/K10-2 | 1200 ft | 6/23/88 | 19.1 | 17.2 | 1.9 |
| K10-3/K10-4 | 1100 ft | 6/23/88 | 9.91 | 9.16 | 0.7 |
| R-CANAL | | | | | |
| R1/R2 | 2000 ft | 4/22/88 | 39.36 | 36.62 | 2.74 |
| | | 5/26/88 | 61.01 | 59.54 | 1.47 |
| | | 10/7/88 | 16.21 | 14.73 | 1.48 |
| R3/R4 | 2800 ft | 5/26/88 | 26.28 | 22.36 | 3.92 |
| | | 10/7/88 | 6.69 | 4.47 | 2.22 |
| R5/R6 | 3550 ft | 5/26/88 | 8.17 | 6.32 | 1.85 |
| | | 6/23/88 | 7.88 | 6.75 | 1.13 |

Jocko River sites were all gauged in one day, starting at the valley head and moving downstream. Sites were usually gauged within 1.5 hours of each other. Criteria for choosing sites included channel stability and access to the site. Table 8 shows the distance between gauge sites, the calculated mean flow rate for each reach on 7/10/88, and the travel time of a slug of water between sites.

TABLE 8: MEAN TRAVEL TIME BETWEEN GAUGED REACHES (7/10/88).

| Distance between sites. | | Mean flow rate. | Water travel time. |
|---|---|---|---|
| J1-J3 | 10700 ft. | 0.84 cfs | 3.5 hr. |
| J3-J5 | 6400 ft. | 0.85 cfs | 2.1 hr. |
| J5-J6 | 5400 ft. | 1.03 cfs | 1.46 hr. |
| J6-J7 | 4600 ft | 2.10 cfs | 0.60 hr. |
| J7-J8 | 7450 ft. | 1.50 cfs | 1.40 hr. |

In principle, one person should be able to gauge a slug of water as it moves down the river.

Discharge measurements taken on the Jocko River are presented in Table 9. Selected provisional data collected by the CSKT are also presented in Table 9.

TABLE 9: JOCKO RIVER DISCHARGE MEASUREMENTS.

SITES WITH DISTANCE BETWEEN THEM

J1 -10700'- J3 -6400'- J5 -5400'- J6 -4600' -J7 -7450'-J8

| DATES | J1 | J3 | J5 | J6 | J7 | J8 |
|---|---|---|---|---|---|---|
| 7/10/88 | 45.21 | 54.39 | 52.0 | 61.0 | 89.75 | 153.3 |
| 8/15/88 | 42.67 | 42.3 | 36.89 | 40.39 | 71.07 | 135.49 |
| 10/7/88 | 38.29 | 39.92 | 35.84 | 24.05 | 40.82 | 79.06 |
| 11/3/88 | 47.3 | 49.97 | 47.7 | - | 41.69 | 80.1 |

SELECTED CSKT GAUGING RESULTS

| SITES | 4/20/88 | 7/10/88 |
|---|---|---|
| JOCKO BELOW K CANAL | 61.4 | 46.8 |
| JOCKO BELOW BIG KNIFE | 43.4 | 42.5 |
| JOCKO ABOVE FISH HATCHERY | 38.9 | 53.7 |
| JOCKO BELOW FINLEY CREEK | 46.7 | 134.0 |
| JOCKO ABOVE VALLEY CREEK | 94.1 | 178.0 |
| FINLEY CREEK,COUTURE LOOP | 6.2 | - |
| FINLEY CREEK AT MOUTH | 7.6 | 2. |

**PROVISIONAL CSKT DISCHARGE DATA**

SITE C1: JOCKO RIVER BELOW K CANAL

| DATES | DISCHARGE (CFS) |
|---|---|
| 10/01/87 | 45 |
| 10/14/87 | 45 |
| 11/02/87 | 41 |
| 11/05/87 | 40 |
| 12/14/87 | 40 |
| 12/28/87 | 40 |
| 12/31/87 | 35 |
| 01/14/88 | 40 |
| 02/01/88 | 40 |
| 02/08/88 | 42 |
| 02/12/88 | 44 |
| 02/15/88 | 44 |
| 02/18/88 | 44 |
| 02/22/88 | 44 |
| 03/03/88 | 44 |
| 03/07/88 | 45 |
| 03/14/88 | 44 |
| 03/21/88 | 50 |
| 03/25/88 | 50 |
| 04/04/88 | 50 |
| 04/06/88 | 50 |
| 04/08/88 | 58 |
| 04/11/88 | 56 |
| 04/12/88 | 44 |
| 04/13/88 | 52 |
| 04/14/88 | 64 |
| 04/15/88 | 71 |
| 04/16/88 | 98 |
| 04/18/88 | 105 |
| 04/19/88 | 102 |
| 04/20/88 | 79 |
| 04/21/88 | 61 |
| 04/22/88 | 47 |
| 04/23/88 | 41 |
| 04/26/88 | 44 |
| 04/27/88 | 47 |
| 04/28/88 | 42 |
| 04/29/88 | 75 |
| 04/30/88 | 102 |
| 05/02/88 | 52 |
| 05/03/88 | 39 |
| 05/04/88 | 42 |
| 05/05/88 | 71 |
| 05/06/88 | 79 |
| 05/07/88 | 126 |
| 05/09/88 | 156 |
| 05/11/88 | 102 |
| 05/12/88 | 156 |
| 05/13/88 | 253 |
| 05/14/88 | 222 |
| 05/16/88 | 156 |
| 05/17/88 | 258 |
| 05/18/88 | 187 |
| 05/19/88 | 137 |
| 05/20/88 | 120 |
| 05/21/88 | 103 |
| 05/23/88 | 125 |
| 05/24/88 | 194 |
| 05/25/88 | 262 |
| 05/26/88 | 163 |
| 05/27/88 | 175 |
| 05/28/88 | 148 |
| 05/31/88 | 167 |
| 06/01/88 | 130 |
| 06/02/88 | 126 |
| 06/03/88 | 130 |
| 06/06/88 | 156 |
| 06/07/88 | 120 |
| 06/08/88 | 97 |
| 06/09/88 | 94 |
| 06/10/88 | 76 |
| 06/11/88 | 60 |
| 06/13/88 | 58 |
| 06/14/88 | 52 |
| 06/15/88 | 65 |
| 06/16/88 | 56 |
| 06/17/88 | 59 |
| 06/18/88 | 53 |
| 06/20/88 | 50 |
| 06/21/88 | 50 |
| 06/22/88 | 48 |
| 06/23/88 | 50 |
| 06/24/88 | 48 |
| 06/25/88 | 49 |
| 06/27/88 | 43 |
| 06/28/88 | 47 |
| 06/29/88 | 50 |
| 06/30/88 | 55 |
| 07/01/88 | 52 |
| 07/02/88 | 48 |
| 07/06/88 | 49 |
| 07/07/88 | 47 |
| 07/08/88 | 52 |
| 07/09/88 | 53 |
| 07/11/88 | 47 |
| 07/12/88 | 52 |
| 07/13/88 | 53 |
| 07/14/88 | 52 |
| 07/15/88 | 50 |
| 07/16/88 | 47 |
| 07/18/88 | 48 |
| 07/19/88 | 53 |
| 07/20/88 | 48 |
| 07/21/88 | 50 |
| 07/22/88 | 48 |
| 07/23/88 | 49 |
| 07/25/88 | 44 |
| 07/26/88 | 47 |
| 07/27/88 | 44 |
| 07/28/88 | 47 |
| 07/29/88 | 47 |
| 07/30/88 | 44 |
| 08/01/88 | 41 |
| 08/02/88 | 44 |
| 08/03/88 | 40 |
| 08/04/88 | 41 |
| 08/05/88 | 38 |
| 08/06/88 | 41 |
| 08/08/88 | 34 |
| 08/09/88 | 37 |
| 08/10/88 | 37 |
| 08/11/88 | 39 |
| 08/12/88 | 36 |
| 08/13/88 | 38 |
| 08/15/88 | 37 |
| 08/16/88 | 37 |
| 08/17/88 | 37 |
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| 08/24/88 | 37 |
| 08/25/88 | 37 |
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| 08/29/88 | 38 |
| 08/30/88 | 37 |
| 09/01/88 | 37 |
| 09/02/88 | 37 |
| 09/03/88 | 36 |
| 09/06/88 | 35 |
| 09/07/88 | 35 |
| 09/08/88 | 37 |
| 09/09/88 | 37 |
| 09/10/88 | 36 |
| 09/12/88 | 39 |
| 09/13/88 | 37 |
| 09/14/88 | 35 |
| 09/15/88 | 38 |
| 09/17/88 | 38 |
| 09/19/88 | 41 |
| 09/20/88 | 40 |
| 09/21/88 | 37 |
| 09/22/88 | 37 |
| 09/23/88 | 36 |
| 09/26/88 | 37 |
| 09/27/88 | 40 |
| 09/28/88 | 40 |
| 09/29/88 | 36 |
| 09/30/88 | 36 |

SITE C2: JOCKO RIVER BELOW BIG KNIFE CREEK

| DATE | DISCHARGE (CFS) |
|---|---|
| 02/01/88 | 30 |
| 02/08/88 | 34 |
| 02/09/88 | 36 |
| 02/12/88 | 36 |
| 02/15/88 | 35 |
| 02/18/88 | 36 |
| 02/22/88 | 36 |
| 03/03/88 | 36 |
| 03/07/88 | 37 |
| 03/14/88 | 36 |
| 03/15/88 | 39 |
| 03/21/88 | 38 |
| 03/25/88 | 37 |
| 03/28/88 | 41 |
| 04/04/88 | 43 |
| 04/06/88 | 42 |
| 04/08/88 | 50 |
| 04/11/88 | 50 |
| 04/12/88 | 51 |
| 04/13/88 | 43 |
| 04/14/88 | 54 |
| 04/15/88 | 64 |
| 04/16/88 | 100 |
| 04/18/88 | 119 |
| 04/19/88 | 84 |
| 04/20/88 | 84 |
| 04/21/88 | 55 |
| 04/22/88 | 42 |
| 04/23/88 | 40 |
| 04/26/88 | 43 |
| 04/27/88 | 45 |
| 04/28/88 | 42 |
| 04/30/88 | 109 |
| 05/02/88 | 52 |
| 05/03/88 | 36 |
| 05/04/88 | 43 |
| 05/05/88 | 76 |
| 05/06/88 | 86 |
| 05/07/88 | 142 |
| 05/09/88 | 74 |
| 05/11/88 | 102 |
| 05/12/88 | 163 |
| 05/13/88 | 275 |
| 05/14/88 | 210 |
| 05/16/88 | 134 |
| 05/17/88 | 183 |
| 05/18/88 | 177 |
| 05/19/88 | 146 |
| 05/20/88 | 115 |
| 05/21/88 | 102 |
| 05/23/88 | 124 |
| 05/24/88 | 215 |
| 05/25/88 | 290 |
| 05/26/88 | 170 |
| 05/27/88 | 146 |
| 05/28/88 | 132 |
| 05/31/88 | 170 |
| 06/01/88 | 103 |
| 06/02/88 | 107 |
| 06/03/88 | 103 |
| 06/04/88 | 103 |
| 06/06/88 | 134 |
| 06/07/88 | 112 |
| 06/08/86 | 86 |
| 06/09/88 | 85 |
| 06/10/88 | 72 |
| 06/11/88 | 61 |
| 06/13/88 | 61 |
| 06/14/88 | 53 |
| 06/15/88 | 68 |
| 06/16/88 | 58 |
| 06/17/88 | 49 |
| 06/18/88 | 48 |
| 06/20/88 | 46 |
| 06/21/88 | 44 |
| 06/22/88 | 43 |
| 06/23/88 | 43 |
| 06/24/88 | 42 |
| 06/25/88 | 40 |
| 06/27/88 | 36 |
| 06/28/88 | 36 |
| 06/29/88 | 37 |
| 06/30/88 | 41 |
| 07/01/88 | 38 |
| 07/02/88 | 37 |
| 07/07/88 | 37 |
| 07/08/88 | 35 |
| 07/09/88 | 37 |
| 07/11/88 | 36 |
| 07/12/88 | 45 |
| 07/13/88 | 37 |
| 07/14/88 | 38 |
| 07/15/88 | 32 |
| 07/16/88 | 32 |
| 07/18/88 | 42 |
| 07/19/88 | 44 |
| 07/20/88 | 39 |
| 07/21/88 | 42 |
| 07/22/88 | 31 |
| 07/23/88 | 35 |
| 07/25/88 | 33 |
| 07/26/88 | 41 |
| 07/27/88 | 42 |
| 07/28/88 | 42 |
| 07/29/88 | 35 |
| 07/30/88 | 30 |
| 08/01/88 | 35 |
| 08/03/88 | 30 |
| 08/04/88 | 34 |
| 08/05/88 | 30 |
| 08/06/88 | 36 |
| 08/08/88 | 28 |
| 08/09/88 | 30 |
| 08/10/88 | 26 |
| 08/11/88 | 27 |
| 08/12/88 | 33 |
| 08/15/88 | 31 |
| 08/16/88 | 32 |
| 08/17/88 | 32 |
| 08/18/88 | 31 |
| 08/19/88 | 26 |
| 08/20/88 | 26 |
| 08/22/88 | 31 |
| 08/23/88 | 28 |
| 08/24/88 | 28 |
| 08/26/88 | 27 |
| 08/27/88 | 27 |
| 08/29/88 | 25 |
| 08/30/88 | 28 |
| 08/31/88 | 26 |
| 09/01/88 | 25 |
| 09/02/88 | 23 |
| 09/03/88 | 28 |
| 09/06/88 | 27 |
| 09/07/88 | 28 |
| 09/08/88 | 31 |
| 09/09/88 | 32 |
| 09/10/88 | 31 |
| 09/12/88 | 34 |
| 09/13/88 | 28 |
| 09/15/88 | 28 |
| 09/16/88 | 34 |
| 09/17/88 | 34 |
| 09/19/88 | 37 |
| 09/20/88 | 32 |
| 09/21/88 | 34 |
| 09/22/88 | 34 |
| 09/23/88 | 30 |
| 09/24/88 | 36 |
| 09/26/88 | 31 |
| 09/27/88 | 34 |
| 09/28/88 | 34 |
| 09/29/88 | 33 |
| 09/30/88 | 34 |

SITE C3: JOCKO RIVER ABOVE FISH HATCHERY

| DATE | DISCHARGE (CFS) |
|---|---|
| 02/01/88 | 17 |
| 02/08/88 | 18 |
| 02/09/88 | 18 |
| 02/12/88 | 18 |
| 02/15/88 | 17 |
| 02/22/88 | 18 |
| 03/03/88 | 18 |
| 03/07/88 | 19 |
| 03/14/88 | 19 |
| 03/21/88 | 20 |
| 03/25/88 | 21 |
| 03/28/88 | 24 |
| 04/04/88 | 25 |
| 04/06/88 | 25 |
| 04/08/88 | 33 |
| 04/11/88 | 33 |
| 04/12/88 | 33 |
| 04/13/88 | 27 |
| 04/14/88 | 36 |
| 04/15/88 | 44 |
| 04/16/88 | 64 |
| 04/18/88 | 82 |
| 04/19/88 | 82 |
| 04/20/88 | 61 |
| 04/21/88 | 43 |
| 04/22/88 | 29 |
| 04/23/88 | 25 |
| 04/26/88 | 30 |
| 04/27/88 | 31 |
| 04/28/88 | 33 |
| 04/30/88 | 87 |
| 05/02/88 | 38 |
| 05/03/88 | 24 |
| 05/04/88 | 28 |
| 05/05/88 | 54 |
| 05/06/88 | 54 |
| 05/07/88 | 97 |
| 05/09/88 | 65 |
| 05/11/88 | 85 |
| 05/12/88 | 127 |
| 05/13/88 | 187 |
| 05/14/88 | 171 |
| 05/16/88 | 131 |
| 05/17/88 | 200 |
| 05/18/88 | 152 |
| 05/19/88 | 123 |
| 05/20/88 | 104 |
| 05/21/88 | 97 |
| 05/23/88 | 108 |
| 05/24/88 | 161 |
| 05/25/88 | 210 |
| 05/26/88 | 148 |
| 05/28/88 | 129 |
| 05/31/88 | 146 |
| 06/01/88 | 129 |
| 06/02/88 | 117 |
| 06/03/88 | 112 |
| 06/04/88 | 115 |
| 06/06/88 | 135 |
| 06/07/88 | 115 |
| 06/08/88 | 100 |
| 06/09/88 | 97 |
| 06/10/88 | 77 |
| 06/11/88 | 79 |
| 06/13/88 | 61 |
| 06/14/88 | 54 |
| 06/15/88 | 68 |
| 06/16/88 | 64 |
| 06/17/88 | 62 |
| 06/18/88 | 58 |
| 06/20/88 | 57 |
| 06/21/88 | 55 |
| 06/22/88 | 54 |
| 06/23/88 | 55 |
| 06/24/88 | 58 |
| 06/25/88 | 55 |
| 06/27/88 | 55 |
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| 06/29/88 | 61 |
| 06/30/88 | 68 |
| 07/01/88 | 66 |
| 07/02/88 | 65 |
| 07/07/88 | 61 |
| 07/08/88 | 59 |
| 07/09/88 | 68 |
| 07/11/88 | 61 |
| 07/12/88 | 71 |
| 07/13/88 | 64 |
| 07/14/88 | 64 |
| 07/15/88 | 64 |
| 07/16/88 | 62 |
| 07/18/88 | 65 |
| 07/19/88 | 65 |
| 07/20/88 | 62 |
| 07/21/88 | 64 |
| 07/22/88 | 62 |
| 07/23/88 | 62 |
| 07/25/88 | 57 |
| 07/26/88 | 59 |
| 07/27/88 | 59 |
| 07/28/88 | 59 |
| 07/29/88 | 57 |
| 07/30/88 | 49 |
| 08/01/88 | 58 |
| 08/03/88 | 53 |
| 08/04/88 | 45 |
| 08/05/88 | 46 |
| 08/06/88 | 48 |
| 08/08/88 | 39 |
| 08/09/88 | 39 |
| 08/10/88 | 40 |
| 08/11/88 | 37 |
| 08/12/88 | 37 |
| 08/15/88 | 38 |
| 08/16/88 | 37 |
| 08/17/88 | 37 |
| 08/18/88 | 37 |
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| 08/22/88 | 36 |
| 08/23/88 | 36 |
| 08/24/88 | 35 |
| 08/26/88 | 38 |
| 08/27/88 | 38 |
| 08/29/88 | 35 |
| 08/30/88 | 33 |
| 08/31/88 | 34 |
| 09/01/88 | 34 |
| 09/02/88 | 33 |
| 09/03/88 | 31 |
| 09/06/88 | 27 |
| 09/07/88 | 27 |
| 09/08/88 | 29 |
| 09/09/88 | 29 |
| 09/10/88 | 29 |
| 09/12/88 | 31 |
| 09/13/88 | 28 |
| 09/15/88 | 27 |
| 09/16/88 | 28 |
| 09/17/88 | 27 |
| 09/19/88 | 31 |
| 09/20/88 | 31 |
| 09/21/88 | 25 |
| 09/22/88 | 25 |
| 09/23/88 | 25 |
| 09/24/88 | 26 |
| 09/26/88 | 24 |
| 09/27/88 | 26 |
| 09/28/88 | 26 |
| 09/29/88 | 24 |
| 09/30/88 | 24 |

SITE C4: JOCKO RIVER BELOW FINLEY CREEK

| DATE | DISCHARGE (CFS) |
|---|---|
| 10/01/87 | 68 |
| 10/14/87 | 80 |
| 11/02/87 | 68 |
| 11/05/87 | 69 |
| 12/14/87 | 59 |
| 12/28/87 | 30 |
| 12/31/87 | 35 |
| 01/14/88 | 49 |
| 02/08/88 | 45 |
| 02/09/88 | 68 |
| 02/12/88 | 50 |
| 02/15/88 | 50 |
| 02/22/88 | 46 |
| 03/03/88 | 45 |
| 03/07/88 | 44 |
| 03/14/88 | 40 |
| 03/21/88 | 41 |
| 03/28/88 | 46 |
| 04/04/88 | 50 |
| 04/06/88 | 48 |
| 04/08/88 | 56 |
| 04/11/88 | 55 |
| 04/12/88 | 53 |
| 04/13/88 | 49 |
| 04/14/88 | 52 |
| 04/15/88 | 68 |
| 04/16/88 | 87 |
| 04/18/88 | 136 |
| 04/19/88 | 113 |
| 04/20/88 | 104 |
| 04/21/88 | 82 |
| 04/22/88 | 71 |
| 04/23/88 | 60 |
| 04/26/88 | 62 |
| 04/27/88 | 62 |
| 04/28/88 | 56 |
| 04/30/88 | 108 |
| 05/02/88 | 63 |
| 05/03/88 | 48 |
| 05/04/88 | 55 |
| 05/05/88 | 76 |
| 05/06/88 | 96 |
| 05/07/88 | 125 |
| 05/09/88 | 125 |
| 05/11/88 | 140 |
| 05/12/88 | 177 |
| 05/13/88 | 263 |
| 05/14/88 | 248 |
| 05/16/88 | 198 |
| 05/17/88 | 278 |
| 05/18/88 | 225 |
| 05/19/88 | 184 |
| 05/20/88 | 160 |
| 05/21/88 | 152 |
| 06/02/88 | 228 |
| 06/03/88 | 225 |
| 06/04/88 | 257 |
| 06/06/88 | 275 |
| 06/07/88 | 263 |
| 06/08/88 | 245 |
| 06/09/88 | 234 |
| 06/10/88 | 184 |
| 06/11/88 | 175 |
| 06/13/88 | 162 |
| 06/14/88 | 154 |
| 06/15/88 | 160 |
| 06/16/88 | 150 |
| 06/17/88 | 150 |
| 06/18/88 | 142 |
| 06/20/88 | 138 |
| 06/21/88 | 130 |
| 06/22/88 | 128 |
| 06/23/88 | 130 |
| 06/24/88 | 128 |
| 06/25/88 | 130 |
| 06/27/88 | 128 |
| 06/28/88 | 128 |
| 06/29/88 | 142 |
| 06/30/88 | 146 |
| 07/01/88 | 144 |
| 07/02/88 | 144 |
| 07/07/88 | 148 |
| 07/08/88 | 148 |
| 07/09/88 | 146 |
| 07/11/88 | 142 |
| 07/12/88 | 150 |
| 07/13/88 | 148 |
| 07/14/88 | 148 |
| 07/15/88 | 144 |
| 07/16/88 | 146 |
| 07/18/88 | 142 |
| 07/19/88 | 146 |
| 07/20/88 | 140 |
| 07/21/88 | 136 |
| 07/22/88 | 130 |
| 07/23/88 | 140 |
| 07/25/88 | 126 |
| 07/26/88 | 132 |
| 07/27/88 | 130 |
| 07/28/88 | 126 |
| 07/29/88 | 125 |
| 07/30/88 | 125 |
| 08/01/88 | 117 |
| 08/03/88 | 126 |
| 05/23/88 | 175 |
| 05/24/88 | 239 |
| 05/25/88 | 290 |
| 05/26/88 | 217 |
| 05/28/88 | 206 |
| 06/01/88 | 230 |
| 08/11/88 | 113 |
| 08/12/88 | 110 |
| 08/15/88 | 110 |
| 08/16/88 | 108 |
| 08/17/88 | 106 |
| 08/18/88 | 106 |
| 08/19/88 | 103 |
| 08/22/88 | 104 |
| 08/23/88 | 103 |
| 08/24/88 | 101 |
| 08/26/88 | 103 |
| 08/27/88 | 103 |
| 08/29/88 | 96 |
| 08/30/88 | 94 |
| 08/31/88 | 92 |
| 09/01/88 | 99 |
| 09/02/88 | 96 |
| 09/03/88 | 92 |
| 09/06/88 | 90 |
| 09/07/88 | 87 |
| 09/08/88 | 89 |
| 09/09/88 | 89 |
| 09/10/88 | 90 |
| 09/12/88 | 92 |
| 09/15/88 | 90 |
| 09/16/88 | 89 |
| 09/17/88 | 87 |
| 09/19/88 | 92 |
| 09/20/88 | 92 |
| 09/21/88 | 92 |
| 09/22/88 | 92 |
| 09/23/88 | 90 |
| 09/24/88 | 82 |
| 09/26/88 | 82 |
| 09/27/88 | 86 |
| 09/28/88 | 86 |
| 09/29/88 | 80 |
| 09/30/88 | 79 |
| 08/04/88 | 119 |
| 08/05/88 | 119 |
| 08/06/88 | 119 |
| 08/08/88 | 113 |
| 08/09/88 | 112 |
| 08/10/88 | 113 |

**APPENDIX D: CHANNEL ADJUSTMENTS**

HOLOCENE CHANNEL ADJUSTMENTS

PRESENT CHANNEL

**APPENDIX D: CHANNEL ADJUSTMENTS.**

HOLOCENE CHANNEL ADJUSTMENTS:

Although not referenced in the text, the following section is included because the Jocko River is a major hydrologic feature in the Jocko Valley. Possibly this introduction will spur someones interest to examine channel adjustments in the Jocko River in detail.

In the interval from latest Pleistocene to the present, the Jocko River has transformed from a braided stream channel network to a single channel, meandering network. Concurrent with changes in channel morphology, river entrenchment has created a narrow canyon down the fan axis. This sequence of river metamorphosis has been widely observed in deglaciated, semi-arid terrains of the western United States (Mackin, 1948; Knox, 1983; Schumm and Brackenridge, 1987).

Water and sediment discharge are the two independent (exogenic) variables controlling channel morphology in a catchment (Schumm, 1968; Schumm and Brackenridge, 1987). Schumm (1969) presents the following relation for bedload discharge:

$$Qs \approx (W,L,S,F) \;/\; (H,P)$$

At a constant water discharge, if bedload discharge (Qs) increases, channel width (W), meander wavelength (L), channel gradient (S), and width/depth ratio (F) increase and depth (H) and sinuosity (P) decrease. Mobilization of drift after deglaciation caused increased bedload discharge rates in the Jocko Valley. One way the river adjusted was to increase channel slope. Ancestral braided channels preserved on the present surface of the Jocko Fan (slope, 1.64 %) suggest that the surface of the fan approximates paleochannel slope. The network of braided channels preserved on Jocko Fan lasted only as long as bedload flux rates were high.

At the valley head, the Jocko River has cut down over 100 feet (30 m). Erosional (cut) terraces dipping down-fan are exposed from inside Jocko Canyon to north of Arlee. Entrainment of channel material, and consequent river entrenchment, cannot occur without an increase in the basal shear stress of the moving river. The relation for basal shear stress is:

$$Tb = (\rho*G*H)*\sin \phi$$

This states that basal shear stress (Tb) equals the product of fluid density ($\rho$), gravitational acceleration (G), fluid depth (H), and the sin of the surface slope ($\phi$). Solving the bedload discharge and shear stress equations for depth (H), and relating basal shear stress solely to the causative (exogenic) parameter Qs:

$$Tb \approx (1 / Qs)$$

This inverse relation states that decrease in bedload discharge will cause increase in basal shear stress of a river, at a constant water discharge. Essentially, this is an expression of the concept of river grade (Mackin, 1948). If, at a constant water discharge, sediment yield is decreased, the river will respond by mobilizing its bed to maintain competence. In the Jocko Valley, downcutting began shortly after sediment yields decreased, and continued through the Holocene.

Throughout the above discussion, constant water discharge has been assumed. Although variations in water discharge must have occurred during the Holocene, particularly during the Altithermal maximum, remnants of alpine glaciers probably existed in the Jocko watershed during the early Holocene, glaciers reoccupied the watershed during the Neoglacial.

## PRESENT CHANNEL:

Data for the present course of the Jocko River are plotted onto Figure 44 (Schumm and Khan, 1972; Schumm and Brackenridge, 1987). Although data do not match experimental results, the figure provides a framework for comparison of reaches.

Reach 1 (confluence of Jocko River-Cold Creek to 400 feet (122 m) above K canal diversion) of the Jocko River is a single channel flowing through Jocko Canyon. The river is entrenched, the canyon walls narrow, and consequently the river channel is constrained to flow within a single channel. Reach 2 (400 feet (122 m) above K canal diversion to 600 feet (183 m) below Theresa Adams bridge) shows a sharp increase in slope and sinuosity relative to reach 1; this is because the river leaves the confines of Jocko Canyon and flows on the upper Jocko Fan surface. The channel is deeply entrenched and braiding cannot occur. Numerous nickpoints, abrupt breaks in channel gradient (Heede, 1975), exist along reach 2 of the Jocko River. Nickpoints are areas of active headward channel erosion and lowering of channel gradient (Heede, 1975, 1976; Beschta and Platts, 1986). In the Jocko River, nickpoints are expressed as pool and riffle sequences. Both channel nickpoints, and

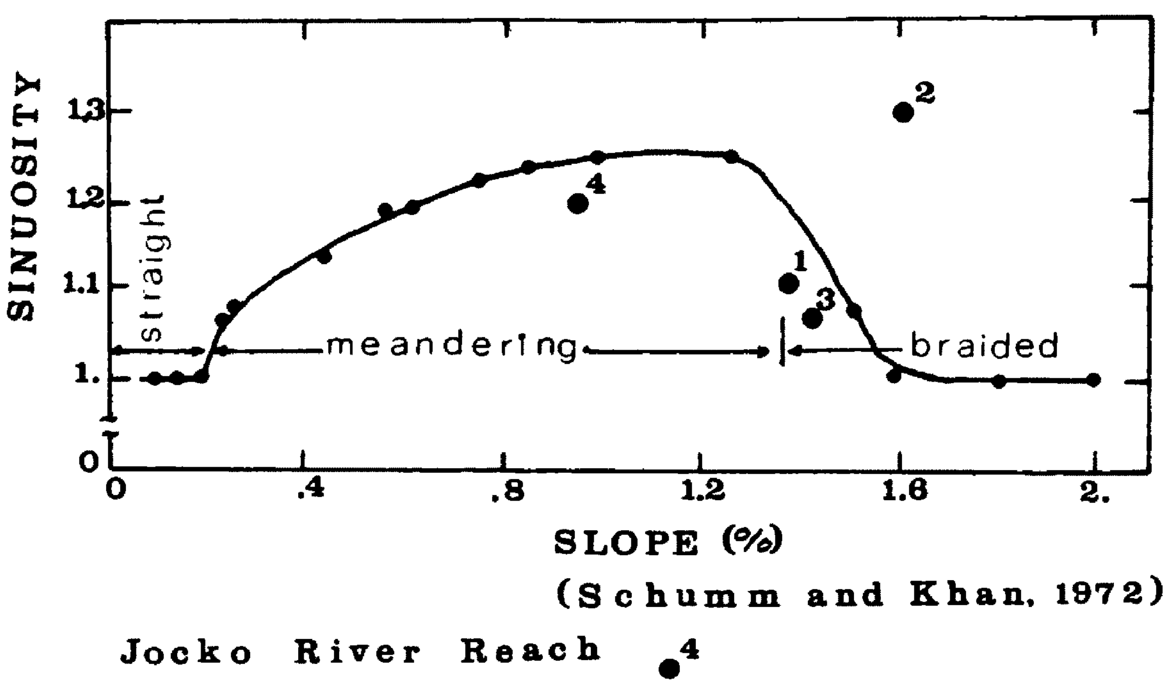


FIGURE 45: Slope versus sinuosity for river channels.

high sinuosity in the channel, dissipate stream energy in reach 2. This is necessary because the slope of the channel is oversteep, but nevertheless constrained to flow within a single channel.

The present day floodplain of reach 3 of the Jocko River (600 feet (183 m) below Theresa Adams bridge to confluence of Jocko River-Finley Creek) is much wider than the upper reaches of the Jocko River. Older terraces flank the river, but are well back from the present course. Examination of Figure 45 reveals that reach 3 has a low sinuosity to slope ratio. Recalling the bedload discharge relation, decreased sinuosity coupled with increased slope indicates higher sediment yields. Most of this reach has recently abandoned unvegetated gravel bars on the channel margins. Reach 4 of the Jocko River (confluence Jocko River-Finley Creek to confluence Jocko River-Valley Creek) also has a low sinuosity to slope ratio. This area was not examined in detail, however much of the valley floor appears to be reworked fan sediments.

Several authors (Heede, 1975; Mackin, 1948; Schumm, 1968) have noted that rivers try to approach a constant gradient along their entire length. Data presented above, and figure 20 (Thompson, 1988, p.57), show the Jocko River has a variable gradient along its length. To move toward a more constant channel gradient, the Jocko River is actively downcutting in its upper reaches and aggrading in its mid and possibly lower reach.

It is possible that the lowered channel gradient in the mid and lower reach of the Jocko River is not due to aggredation, but instead increased water discharge. This section of the river is principally within the year-round gaining reach of the Jocko River, it carries more water than the upper reaches of the river. Using a relation, similar to the sediment discharge relation, (Schumm, 1968; Schumm and Brackenridge, 1987) for water discharge:

$$Qw \approx (W,D,L) / S$$

With increase in water discharge (Qw), channel width (W), channel depth (D), and meander wavelenth (L) increase, and channel gradient (S) decreases. In terms of this relationship, it is possible to attribute lowered channel slope in the mid and lower reach of the river to increased water discharge. However, this does not explain abandoned bars along the mid and lower reaches of the Jocko River.

## APPENDIX E: COMPUTER MODEL

INPUT FILES

## APPENDIX E: COMPUTER MODEL.

MODFLOW is a solution routine designed to solve the partial-differential equation for transient groundwater flow through porous media, assuming constant water density and viscosity. Several references, for example (Freeze and Cherry, 1982; Remson et al., 1971) present derivations of the transient groundwater flow equation. Fundamentally, the equation couples Darcy's Law with a water conservation expression and a source/sink term to account for external stresses. The solution is dependant upon both boundary and initial conditions for the system in question.

In MODFLOW, partial-differential equations are expressed in finite-difference form. Implicit in this, is the spatial breakdown of a continuous aquifer system into a network of grids. In this way, values for parameters in the equations of groundwater flow (hydraulic conductivity, storage, and source/sink terms) are distributed between grids; this is referred to as a distributed-parameter approach (Domenico, 1972). To a degree, depending upon the spatial discretization of the aquifer system, distributing parameters can account for macroscopic heterogeneities found in aquifer systems. MODFLOW uses a block-centered grid system, nodes defining each grid are centered within that grid.

After finite-difference equations have been formulated for each node within the model, the strongly implicit procedure (SIP) solution routine is implemented (Mcdonald and Harbaugh, 1984; Remson et al., 1971). SIP ia matrix algebra routine which, in simplest form, operates by writing the finite-difference equation for each node as an equivalent matrix equation. The matrices are then transformed and solved by matrix decompositions. In this manner, finite-difference equations for each cell are solved for each iteration within each time step. The solution for each iteration is compared to a user input error tolerance; when the solution is within the error tolerance, the partial-differential equation for the groundwater system, with given boundary and initial conditions, has been solved.

**COMPUTER INPUT FILES**

```
USGS 3-D MODEL - BASIC INPUT FILE
JOCKO VALLEY MODEL -STEADY STATE
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  3  0  0  5  0 00  9  0 12 00  0 14
        0        1
        1        1              (2313)        -1
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0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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0 0 0 0 0 0 0 0 0 1 1 1 1 -1 -1 -1 -1 -1 -1 -1 0 0 0
0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0
0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 0 0 0
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0
0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0
0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0
0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0
0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0
0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0
0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0
0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0
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0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0
0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0
0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0
0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0
0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0
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0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0
0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 0
0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 0 0 0
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0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
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```
USGS 3-D MODEL - SIP INPUT FILE
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        1.     .001          1          0          0
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USGS 3-D MODEL - OUTPUT CONTROL FILE
STEADY STATE
########################################
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        0         0         0         0
        0         0         0         0
        0         0         0         0
        0         0         0         0
        0         0         0         0
        0         0         0         0
        0         0         0         0
        0         0         0         0
        0         1         1         1
        1         1         1         0
```

USGS 3-D MODEL - BLOCK CENTERED FLOW INPUT PACKAGE
**************************************************

```
1 -25
1
0 1.
0 1000.
0 1000.
3 1. (23F10.0) -1
```

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 300. | 300. | 300. |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 300. | 300. | 300. |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 300. | 300. | 300. |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 300. |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 200. | 200. | 300. | 300. | 300. |
| 0 | 0 | 0 | 0 | 0 | 0 | 200. | 200. | 200. | 300. | 300. | 600. |
| 0 | 0 | 0 | 0 | 0 | 100. | 200. | 200. | 200. | 300. | 300. | 600. |
| 0 | 0 | 0 | 0 | 75. | 100. | 200. | 200. | 200. | 300. | 600. | 600. |
| 0 | 0 | 0 | 0 | 75. | 100. | 200. | 200. | 200. | 600. | 600. | 600. |
| 0 | 0 | 0 | 0 | 75. | 200. | 200. | 600. | 600. | 600. | 600. | 600. |
| 0 | 0 | 0 | 0 | 75. | 200. | 600. | 600. | 600. | 600. | 600. | 600. |
| 0 | 0 | 0 | 0 | 75. | 600. | 600. | 600. | 600. | 600. | 1000. | 1000. |
| 0 | 0 | 0 | 0 | 100. | 600. | 600. | 600. | 600. | 600. | 1000. | 1000. |
| 0 | 0 | 0 | 0 | 600. | 600. | 600. | 600. | 600. | 600. | 1000. | 1000. |
| 0 | 0 | 0 | 225. | 600. | 600. | 600. | 600. | 600. | 600. | 600. | 1200. |
| 0 | 0 | 0 | 225. | 600. | 225. | 600. | 250. | 250. | 600. | 600. | 1200. |
| 0 | 0 | 0 | 225. | 225. | 225. | 250. | 100. | 250. | 250. | 600. | 1000. |
| 0 | 0 | 0 | 225. | 225. | 225. | 100. | 100. | 100. | 250. | 600. | 1000. |
| 0 | 0 | 0 | 225. | 225. | 225. | 100. | 100. | 100. | 150. | 600. | 1000. |
| 0 | 0 | 0 | 0 | 225. | 225. | 100. | 100. | 100. | 150. | 500. | 1000. |
| 0 | 0 | 0 | 0 | 0 | 225. | 100. | 100. | 100. | 150. | 250. | 1000. |
| 0 | 0 | 0 | 0 | 0 | 0 | 100. | 100. | 100. | 150. | 250. | 600. |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100. | 100. | 150. | 150. | 250. |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100. | 150. | 150. | 150. |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 150. | 150. | 150. |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 150. | 150. |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 150. |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

USGS 3-D MODEL - BLOCK CENTERED FLOW INPUT PACKAGE

##################################################

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 300. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 300. | 300. | 300. | 300. | 800. | 800. | 800. | 800. | 0 | 0 | 0 |
| 300. | 300. | 300. | 500. | 800. | 800. | 800. | 800. | 0 | 0 | 0 |
| 300. | 300. | 500. | 500. | 800. | 800. | 800. | 800. | 0 | 0 | 0 |
| 300. | 500. | 500. | 500. | 800. | 800. | 800. | 800. | 0 | 0 | 0 |
| 500. | 500. | 500. | 500. | 800. | 800. | 800. | 800. | 0 | 0 | 0 |
| 600. | 500. | 500. | 500. | 800. | 800. | 800. | 800. | 0 | 0 | 0 |
| 600. | 600. | 500. | 500. | 800. | 800. | 800. | 800. | 0 | 0 | 0 |
| 600. | 800. | 800. | 800. | 1200. | 1200. | 1200. | 1200. | 0 | 0 | 0 |
| 600. | 800. | 800. | 800. | 1200. | 1200. | 1200. | 1200. | 0 | 0 | 0 |
| 600. | 800. | 800. | 800. | 1200. | 1200. | 1200. | 1200. | 0 | 0 | 0 |
| 1000. | 800. | 800. | 800. | 1200 | 1200. | 1200. | 1200. | 0 | 0 | 0 |
| 1000. | 800. | 800. | 800. | 1200. | 1200. | 1200. | 1200. | 0 | 0 | 0 |
| 1000. | 1000. | 800. | 800. | 1200. | 1200. | 1200. | 1200. | 0 | 0 | 0 |
| 1200. | 1000. | 1000. | 800. | 1200. | 1200. | 1200. | 1200. | 0 | 0 | 0 |
| 1200. | 1200. | 1200. | 1200. | 1400. | 1400. | 1400. | 1400. | 0 | 0 | 0 |
| 1200. | 1200. | 1200. | 1200. | 1400. | 1400. | 1400. | 1400. | 0 | 0 | 0 |
| 1200. | 1200. | 1200. | 1200. | 1400. | 1400. | 1400. | 1400. | 0 | 0 | 0 |
| 1000. | 1200. | 1200. | 1200. | 1400. | 1400. | 1400. | 1400. | 0 | 0 | 0 |
| 1000. | 1200. | 1200. | 1200. | 1400. | 1400. | 1400. | 1400. | 0 | 0 | 0 |
| 1000. | 1200. | 1200. | 1400. | 1400. | 1400. | 1400. | 1400. | 0 | 0 | 0 |
| 600. | 1200. | 1200. | 1400. | 1400. | 1400. | 1400. | 1400. | 0 | 0 | 0 |
| 250. | 600. | 1200. | 1200. | 1400. | 1400. | 1400. | 1400. | 0 | 0 | 0 |
| 250. | 600. | 1200. | 1200. | 1200. | 1400. | 1400. | 1400. | 0 | 0 | 0 |
| 150. | 250. | 1000. | 1000. | 1000. | 1000. | 1400. | 1400. | 0 | 0 | 0 |
| 150. | 100. | 600. | 1000. | 1000. | 1000. | 1400. | 1400. | 0 | 0 | 0 |
| 150. | 150. | 250. | 600. | 600. | 1000. | 1400. | 1400. | 1800. | 0 | 0 |
| 150. | 150. | 250. | 250. | 600. | 800. | 1200. | 1400. | 1800. | 0 | 0 |
| 0 | 150. | 250. | 250. | 250. | 250. | 600. | 350. | 0 | 0 | 0 |
| 0 | 0 | 250. | 250. | 250. | 250. | 250. | 350. | 0 | 0 | 0 |
| 0 | 0 | 0 | 250. | 250. | 250. | 250. | 350. | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 250. | 250. | 250. | 150. | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 250. | 150. | 150. | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | . | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

USGS 3-D MODEL - BLOCK CENTERED FLOW INPUT PACKAGE
******************************************************

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 1. | (23F10.0) | | -1 | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2910. | 2910. | 2900. | 2880. |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2920. | 2910. | 2900. |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2940. | 2935. | 2925. |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2900. |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2930. | 2925. | 2920. | 2910. | 2910. |
| 0 | 0 | 0 | 0 | 0 | 0 | 2945. | 2940. | 2935. | 2930. | 2920. | 2920. |
| 0 | 0 | 0 | 0 | 0 | 2970. | 2960. | 2950. | 2940. | 2935. | 2930. | 2930. |
| 0 | 0 | 0 | 0 | 0 | 2985. | 2965. | 2955. | 2945. | 2940. | 2940. | 2935. |
| 0 | 0 | 0 | 0 | 2985. | 2980. | 2960. | 2955. | 2945. | 2940. | 2940. | 2940. |
| 0 | 0 | 0 | 0 | 2990. | 2985. | 2960. | 2960. | 2955. | 2945. | 2940. | 2940. |
| 0 | 0 | 0 | 0 | 2995. | 2990. | 2980. | 2970. | 2965. | 2955. | 2950. | 2950. |
| 0 | 0 | 0 | 0 | 2995. | 3000. | 2985. | 2980. | 2970. | 2960. | 2960. | 2960. |
| 0 | 0 | 0 | 0 | 3000. | 3005. | 2990. | 2985. | 2980. | 2980. | 2970. | 2970. |
| 0 | 0 | 0 | 0 | 3000. | 3010. | 3000. | 2990. | 2985. | 2985. | 2975. | 2975. |
| 0 | 0 | 0 | 3060. | 3010. | 3010. | 3005. | 3000. | 2990. | 2990. | 2980. | 2980. |
| 0 | 0 | 0 | 3075. | 3035. | 3035. | 3035. | 3035. | 3005. | 2990. | 2990. | 2990. |
| 0 | 0 | 0 | 3100. | 3065. | 3065. | 3045. | 3035. | 3035. | 3010. | 3000. | 3000. |
| 0 | 0 | 0 | 3115. | 3095. | 3085. | 3070. | 3050. | 3040. | 3020. | 3010. | 3010. |
| 0 | 0 | 0 | 3130. | 3120. | 3110. | 3090. | 3085. | 3055. | 3030. | 3015. | 3010. |
| 0 | 0 | 0 | 0 | 3130. | 3125. | 3110. | 3100. | 3060. | 3040. | 3030. | 3020. |
| 0 | 0 | 0 | 0 | 0 | 3135. | 3120. | 3120. | 3090. | 3070. | 3025. | 3025. |
| 0 | 0 | 0 | 0 | 0 | 0 | 3135. | 3120. | 3110. | 3095. | 3040. | 3035. |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3145. | 3120. | 3115. | 3075. | 3050. |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3150. | 3140. | 3110. | 3085. |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3195. | 3155. | 3130. |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3200. | 3170. |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3205. |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

USGS 3-D MODEL - BLOCK CENTERED FLOW INPUT PACKAGE

\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$\$

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2870. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2880. | 2880. | 2880. | 2880. | 2880. | 2895. | 2900. | 2925. | 0 | 0 | 0 |
| 2890. | 2890. | 2870. | 2890. | 2890. | 2900. | 2905. | 2935. | 0 | 0 | 0 |
| 2900. | 2900. | 2900. | 2900. | 2900. | 2905. | 2915. | 2945. | 0 | 0 | 0 |
| 2910. | 2910. | 2910. | 2910. | 2910. | 2915. | 2925. | 2955. | 0 | 0 | 0 |
| 2920. | 2920. | 2920. | 2920. | 2920. | 2925. | 2935. | 2965. | 0 | 0 | 0 |
| 2930. | 2930. | 2930. | 2930. | 2930. | 2935. | 2945. | 2975. | 0 | 0 | 0 |
| 2935. | 2935. | 2935. | 2935. | 2935. | 2940. | 2950. | 2980. | 0 | 0 | 0 |
| 2940. | 2940. | 2940. | 2940. | 2945. | 2950. | 2960. | 2990. | 0 | 0 | 0 |
| 2940. | 2940. | 2940. | 2940. | 2950. | 2955. | 2965. | 2995. | 0 | 0 | 0 |
| 2950. | 2950. | 2950. | 2950. | 2960. | 2965. | 2975. | 3010. | 0 | 0 | 0 |
| 2960. | 2960. | 2960. | 2960. | 2960. | 2970. | 2980. | 3010. | 0 | 0 | 0 |
| 2970. | 2970. | 2970. | 2970. | 2970. | 2980. | 2990. | 3025. | 0 | 0 | 0 |
| 2975. | 2975. | 2975. | 2975. | 2980. | 2990. | 3000. | 3030. | 0 | 0 | 0 |
| 2980. | 2980. | 2980. | 2980. | 2985. | 2995. | 3005. | 3035. | 0 | 0 | 0 |
| 2990. | 2990. | 2990. | 2990. | 2995. | 3005. | 3010. | 3045. | 0 | 0 | 0 |
| 3000. | 3000. | 3000. | 3000. | 3000. | 3005. | 3020. | 3055. | 0 | 0 | 0 |
| 3010. | 3010. | 3010. | 3010. | 3005. | 3010. | 3030. | 3075. | 0 | 0 | 0 |
| 3010. | 3010. | 3010. | 3010. | 3010. | 3015. | 3035. | 3075. | 0 | 0 | 0 |
| 3015. | 3015. | 3015. | 3015. | 3015. | 3020. | 3040. | 3080. | 0 | 0 | 0 |
| 3025. | 3020. | 3020. | 3020. | 3020. | 3030. | 3050. | 3085. | 0 | 0 | 0 |
| 3035. | 3030. | 3030. | 3025. | 3025. | 3030. | 3070. | 3090. | 0 | 0 | 0 |
| 3050. | 3050. | 3050. | 3050. | 3050. | 3065. | 3095. | 3095. | 0 | 0 | 0 |
| 3085. | 3085. | 3085. | 3085. | 3085. | 3110. | 3135. | 3135. | 0 | 0 | 0 |
| 3130. | 3130. | 3130. | 3130. | 3130. | 3145. | 3145. | 3165. | 0 | 0 | 0 |
| 3168. | 3168. | 3168. | 3160. | 3160. | 3160. | 3180. | 3160. | 0 | 0 | 0 |
| 3200. | 3205. | 3205. | 3205. | 3205. | 3205. | 3200. | 3200. | 3220. | 0 | 0 |
| 3235. | 3235. | 3230. | 3230. | 3230. | 3220. | 3210. | 3210. | 3240. | 0 | 0 |
| 0 | 3255. | 3255. | 3250. | 3250. | 3250. | 3245. | 3250. | 0 | 0 | 0 |
| 0 | 0 | 3285. | 3280. | 3280. | 3280. | 3280. | 3295. | 0 | 0 | 0 |
| 0 | 0 | 0 | 3300. | 3295. | 3295. | 3315. | 3335. | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 3330. | 3335. | 3320. | 3365. | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 3360. | 3365. | 3370. | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

USGS 3-D MODEL - RIVER INPUT PACKAGE
STEADY STATE
########################################

47 -55
47

| | | | | | |
|---|---|---|---|---|---|
| 1 | 7 | 9 | 2975. | 55976. | 2973. |
| 1 | 8 | 9 | 2985. | 55434. | 2982. |
| 1 | 8 | 10 | 2985. | 55473. | 2982. |
| 1 | 9 | 9 | 2990. | 55000. | 2987. |
| 1 | 9 | 10 | 2990. | 55000. | 2987. |
| 1 | 10 | 10 | 2995. | 55000. | 2992. |
| 1 | 11 | 10 | 2998. | 25000. | 2995. |
| 1 | 12 | 10 | 3005. | 25000. | 3002. |
| 1 | 13 | 11 | 3030. | 25959. | 3027. |
| 1 | 14 | 11 | 3035. | 25539. | 3032. |
| 1 | 15 | 12 | 3035. | 25000. | 3033. |
| 1 | 16 | 12 | 3055. | 25000. | 3053. |
| 1 | 17 | 12 | 3065. | 25000. | 3063. |
| 1 | 18 | 12 | 3078. | 25000. | 3075. |
| 1 | 18 | 13 | 3085. | 25000. | 3083. |
| 1 | 19 | 13 | 3090. | 25000. | 3088. |
| 1 | 19 | 14 | 3100. | 25000. | 3098. |
| 1 | 20 | 14 | 3115. | 25000. | 3113. |
| 1 | 21 | 15 | 3125. | 55000. | 3123. |
| 1 | 22 | 15 | 3140. | 55000. | 3138. |
| 1 | 23 | 15 | 3150. | 55000. | 3148. |
| 1 | 24 | 15 | 3160. | 55000. | 3158. |
| 1 | 24 | 16 | 3175. | 55000. | 3173. |
| 1 | 25 | 16 | 3190. | 55000. | 3188. |
| 1 | 25 | 17 | 3216. | 55000. | 3214. |
| 1 | 26 | 17 | 3230. | 55000. | 3228. |
| 1 | 26 | 18 | 3240. | 55000. | 3238. |
| 1 | 27 | 18 | 3255. | 55000. | 3253. |
| 1 | 27 | 19 | 3270. | 60000. | 3268. |
| 1 | 28 | 19 | 3280. | 60000. | 3278. |
| 1 | 29 | 20 | 3300. | 60000. | 3298. |
| 1 | 20 | 5 | 3175. | 30867. | 3173. |
| 1 | 19 | 5 | 3135. | 30867. | 3133. |
| 1 | 18 | 5 | 3120. | 30867. | 3118. |
| 1 | 17 | 5 | 3110. | 30996. | 3108. |
| 1 | 16 | 5 | 3095. | 30025. | 3093. |
| 1 | 15 | 5 | 3075. | 30177. | 3073. |
| 1 | 14 | 5 | 3065. | 15715. | 3063. |
| 1 | 13 | 6 | 3040. | 15253. | 3038. |
| 1 | 12 | 6 | 3030. | 12164. | 3027. |
| 1 | 12 | 5 | 3030. | 11544. | 3027. |
| 1 | 11 | 6 | 3020. | 14633. | 3018. |
| 1 | 10 | 6 | 3010. | 15867. | 3008. |
| 1 | 9 | 6 | 3005. | 14633. | 3003. |
| 1 | 9 | 7 | 3002. | 14633. | 3000. |
| 1 | 8 | 7 | 2995. | 16177. | 2993. |
| 1 | 7 | 8 | 2985. | 16947. | 2983. |

USGS 3-D MODEL - GENERAL HEAD INPUT PACKAGE
STEADY STATE
################################################

23 -1
23

| | | | | |
|---|---|---|---|---|
| 1 | 20 | 4 | 3162. | 999999. |
| 1 | 21 | 4 | 3176. | 999999. |
| 1 | 22 | 5 | 3195. | 999999. |
| 1 | 23 | 6 | 3190. | 999999. |
| 1 | 24 | 7 | 3195. | 999999. |
| 1 | 25 | 8 | 3210. | 999999. |
| 1 | 26 | 9 | 3225. | 999999. |
| 1 | 27 | 10 | 3235. | 999999. |
| 1 | 28 | 11 | 3258. | 999999. |
| 1 | 29 | 12 | 3268. | 999999. |
| 1 | 30 | 13 | 3280. | 999999. |
| 1 | 31 | 14 | 3310. | 999999. |
| 1 | 32 | 15 | 3350. | 999999. |
| 1 | 33 | 16 | 3370. | 999999. |
| 1 | 34 | 17 | 3380. | 999999. |
| 1 | 35 | 18 | 3380. | 999999. |
| 1 | 35 | 19 | 3380. | 999999. |
| 1 | 35 | 20 | 3380. | 999999. |
| 1 | 34 | 20 | 3370. | 999999. |
| 1 | 33 | 20 | 3345. | 999999. |
| 1 | 32 | 20 | 3312. | 999999. |
| 1 | 29 | 21 | 3250. | 999999. |
| 1 | 30 | 21 | 3250. | 999999. |

```
JSGS 3-D MODEL - GENERAL HEAD INPUT PACKAGE
TRANSIENT MODEL
**********************************************
APRIL. 1988
************
       23       -55
       23
        1        20         4     3154.    999999.
        1        21         4     3172.    999999.
        1        22         5     3218.    999999.
        1        23         6     3228.    999999.
        1        24         7     3230.    999999.
        1        25         8     3230.    999999.
        1        26         9     3234.    999999.
        1        27        10     3250.    999999.
        1        28        11     3260.    999999.
        1        29        12     3270.    999999.
        1        30        13     3288.    999999.
        1        31        14     3322.    999999.
        1        32        15     3358.    999999.
        1        33        16     3362.    999999.
        1        34        17     3370.    999999.
        1        35        18     3386.    999999.
        1        35        19     3392.    999999.
        1        35        20     3392.    999999.
        1        34        20     3380.    999999.
        1        33        20     3348.    999999.
        1        32        20     3312.    999999.
        1        29        21     3256.    999999.
        1        30        21     3260.    999999.
MAY. 1988
**********
       23
        1        20         4     3162.    999999.
        1        21         4     3182.    999999.
        1        22         5     3230.    999999.
        1        23         6     3236.    999999.
        1        24         7     3236.    999999.
        1        25         8     3236.    999999.
        1        26         9     3238.    999999.
        1        27        10     3257.    999999.
        1        28        11     3267.    999999.
        1        29        12     3280.    999999.
        1        30        13     3298.    999999.
        1        31        14     3332.    999999.
        1        32        15     3368.    999999.
        1        33        16     3370.    999999.
        1        34        17     3380.    999999.
        1        35        18     3386.    999999.
        1        35        19     3392.    999999.
        1        35        20     3392.    999999.
        1        34        20     3360.    999999.
        1        33        20     3350.    999999.
        1        32        20     3315.    999999.
        1        29        21     3272.    999999.
        1        30        21     3276.    999999.
JUNE. 1988
***********
       23
        1        20         4     3164.    999999.
        1        21         4     3186.    999999.
        1        22         5     3226.    999999.
        1        23         6     3236.    999999.
        1        24         7     3236.    999999.
        1        25         8     3236.    999999.
        1        26         9     3245.    999999.
        1        27        10     3264.    999999.
        1        28        11     3274.    999999.
        1        29        12     3286.    999999.
        1        30        13     3306.    999999.
        1        31        14     3336.    999999.
        1        32        15     3372.    999999.
        1        33        16     3374.    999999.
        1        34        17     3384.    999999.
        1        35        18     3394.    999999.
        1        35        19     3398.    999999.
        1        35        20     3390.    999999.
        1        34        20     3388.    999999.
        1        33        20     3362.    999999.
        1        32        20     3334.    999999.
        1        29        21     3290.    999999.
        1        30        21     3298.    999999.
JULY.1988
**********
       23
        1        20         4     3164.    999999.
        1        21         4     3184.    999999.
        1        22         5     3220.    999999.
        1        23         6     3230.    999999.
        1        24         7     3232.    999999.
        1        25         8     3234.    999999.
        1        26         9     3242.    999999.
        1        27        10     3264.    999999.
        1        28        11     3274.    999999.
        1        29        12     3286.    999999.
        1        30        13     3304.    999999.
        1        31        14     3334.    999999.
        1        32        15     3370.    999999.
        1        33        16     3380.    999999.
        1        34        17     3388.    999999.
        1        35        18     3396.    999999.
        1        35        19     3400.    999999.
        1        35        20     3400.    999999.
        1        34        20     3390.    999999.
        1        33        20     3362.    999999.
        1        32        20     3334.    999999.
        1        29        21     3292.    999999.
        1        30        21     3304.    999999.
```

AUGUST, 1988
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23 -55
23

| | | | | |
|---|---|---|---|---|
| 1 | 20 | 4 | 3152. | 999999. |
| 1 | 21 | 4 | 3168. | 999999. |
| 1 | 22 | 5 | 3203. | 999999. |
| 1 | 23 | 6 | 3214. | 999999. |
| 1 | 24 | 7 | 3214. | 999999. |
| 1 | 25 | 8 | 3220. | 999999. |
| 1 | 26 | 9 | 3230. | 999999. |
| 1 | 27 | 10 | 3250. | 999999. |
| 1 | 28 | 11 | 3268. | 999999. |
| 1 | 29 | 12 | 3278. | 999999. |
| 1 | 30 | 13 | 3296. | 999999. |
| 1 | 31 | 14 | 3328. | 999999. |
| 1 | 32 | 15 | 3366. | 999999. |
| 1 | 33 | 16 | 3376. | 999999. |
| 1 | 34 | 17 | 3380. | 999999. |
| 1 | 35 | 18 | 3396. | 999999. |
| 1 | 35 | 19 | 3402. | 999999. |
| 1 | 35 | 20 | 3402. | 999999. |
| 1 | 34 | 20 | 3388. | 999999. |
| 1 | 33 | 20 | 3362. | 999999. |
| 1 | 32 | 20 | 3334. | 999999. |
| 1 | 29 | 21 | 3278. | 999999. |
| 1 | 30 | 21 | 3288. | 999999. |

SEPTEMBER, 1988
#################

23

| | | | | |
|---|---|---|---|---|
| 1 | 20 | 4 | 3145. | 999999. |
| 1 | 21 | 4 | 3160. | 999999. |
| 1 | 22 | 5 | 3196. | 999999. |
| 1 | 23 | 6 | 3200. | 999999. |
| 1 | 24 | 7 | 3200. | 999999. |
| 1 | 25 | 8 | 3210. | 999999. |
| 1 | 26 | 9 | 3220. | 999999. |
| 1 | 27 | 10 | 3240. | 999999. |
| 1 | 28 | 11 | 3252. | 999999. |
| 1 | 29 | 12 | 3264. | 999999. |
| 1 | 30 | 13 | 3284. | 999999. |
| 1 | 31 | 14 | 3320. | 999999. |
| 1 | 32 | 15 | 3354. | 999999. |
| 1 | 33 | 16 | 3354. | 999999. |
| 1 | 34 | 17 | 3376. | 999999. |
| 1 | 35 | 18 | 3398. | 999999. |
| 1 | 35 | 19 | 3402. | 999999. |
| 1 | 35 | 20 | 3402. | 999999. |
| 1 | 34 | 20 | 3388. | 999999. |
| 1 | 33 | 20 | 3354. | 999999. |
| 1 | 32 | 20 | 3330. | 999999. |
| 1 | 29 | 21 | 3264. | 999999. |
| 1 | 30 | 21 | 3266. | 999999. |

OCTOBER, 1988
##############

23

| | | | | |
|---|---|---|---|---|
| 1 | 20 | 4 | 3145. | 999999. |
| 1 | 21 | 4 | 3162. | 999999. |
| 1 | 22 | 5 | 3198. | 999999. |
| 1 | 23 | 6 | 3200. | 999999. |
| 1 | 24 | 7 | 3200. | 999999. |
| 1 | 25 | 8 | 3210. | 999999. |
| 1 | 26 | 9 | 3220. | 999999. |
| 1 | 27 | 10 | 3240. | 999999. |
| 1 | 28 | 11 | 3252. | 999999. |
| 1 | 29 | 12 | 3262. | 999999. |
| 1 | 30 | 13 | 3282. | 999999. |
| 1 | 31 | 14 | 3318. | 999999. |
| 1 | 32 | 15 | 3352. | 999999. |
| 1 | 33 | 16 | 3352. | 999999. |
| 1 | 34 | 17 | 3374. | 999999. |
| 1 | 35 | 18 | 3400. | 999999. |
| 1 | 35 | 19 | 3402. | 999999. |
| 1 | 35 | 20 | 3402. | 999999. |
| 1 | 34 | 20 | 3388. | 999999. |
| 1 | 33 | 20 | 3352. | 999999. |
| 1 | 32 | 20 | 3328. | 999999. |
| 1 | 29 | 21 | 3260. | 999999. |
| 1 | 30 | 21 | 3260. | 999999. |

NOVEMBER, 1988
###############

23

| | | | | |
|---|---|---|---|---|
| 1 | 20 | 4 | 3145. | 999999. |
| 1 | 21 | 4 | 3162. | 999999. |
| 1 | 22 | 5 | 3196. | 999999. |
| 1 | 23 | 6 | 3200. | 999999. |
| 1 | 24 | 7 | 3200. | 999999. |
| 1 | 25 | 8 | 3210. | 999999. |
| 1 | 26 | 9 | 3220. | 999999. |
| 1 | 27 | 10 | 3240. | 999999. |
| 1 | 28 | 11 | 3250. | 999999. |
| 1 | 29 | 12 | 3262. | 999999. |
| 1 | 30 | 13 | 3280. | 999999. |
| 1 | 31 | 14 | 3314. | 999999. |
| 1 | 32 | 15 | 3350. | 999999. |
| 1 | 33 | 16 | 3350. | 999999. |
| 1 | 34 | 17 | 3360. | 999999. |
| 1 | 35 | 18 | 3394. | 999999. |
| 1 | 35 | 19 | 3396. | 999999. |
| 1 | 35 | 20 | 3398. | 999999. |
| 1 | 34 | 20 | 3386. | 999999. |
| 1 | 33 | 20 | 3350. | 999999. |
| 1 | 32 | 20 | 3324. | 999999. |
| 1 | 29 | 21 | 3255. | 999999. |
| 1 | 30 | 21 | 3256. | 999999. |

DECEMBER, 1988

$$$$$$$$$$$$$$$$

| | | | | |
|---|---|---|---|---|
| 23 | -55 | | | |
| 23 | | | | |
| 1 | 20 | 4 | 3145. | 999999. |
| 1 | 21 | 4 | 3160. | 999999. |
| 1 | 22 | 5 | 3195. | 999999. |
| 1 | 23 | 6 | 3200. | 999999. |
| 1 | 24 | 7 | 3200. | 999999. |
| 1 | 25 | 8 | 3210. | 999999. |
| 1 | 26 | 9 | 3220. | 999999. |
| 1 | 27 | 10 | 3240. | 999999. |
| 1 | 28 | 11 | 3250. | 999999. |
| 1 | 29 | 12 | 3262. | 999999. |
| 1 | 30 | 13 | 3280. | 999999. |
| 1 | 31 | 14 | 3312. | 999999. |
| 1 | 32 | 15 | 3346. | 999999. |
| 1 | 33 | 16 | 3350. | 999999. |
| 1 | 34 | 17 | 3360. | 999999. |
| 1 | 35 | 18 | 3392. | 999999. |
| 1 | 35 | 19 | 3394. | 999999. |
| 1 | 35 | 20 | 3394. | 999999. |
| 1 | 34 | 20 | 3386. | 999999. |
| 1 | 33 | 20 | 3348. | 999999. |
| 1 | 32 | 20 | 3314. | 999999. |
| 1 | 29 | 21 | 3252. | 999999. |
| 1 | 30 | 21 | 3254. | 999999. |

JANUARY. 1988

$$$$$$$$$$$$$$$

| | | | | |
|---|---|---|---|---|
| 23 | | | | |
| 1 | 20 | 4 | 3145. | 999999. |
| 1 | 21 | 4 | 3160. | 999999. |
| 1 | 22 | 5 | 3195. | 999999. |
| 1 | 23 | 6 | 3200. | 999999. |
| 1 | 24 | 7 | 3200. | 999999. |
| 1 | 25 | 8 | 3210. | 999999. |
| 1 | 26 | 9 | 3220. | 999999. |
| 1 | 27 | 10 | 3240. | 999999. |
| 1 | 28 | 11 | 3250. | 999999. |
| 1 | 29 | 12 | 3262. | 999999. |
| 1 | 30 | 13 | 3280. | 999999. |
| 1 | 31 | 14 | 3312. | 999999. |
| 1 | 32 | 15 | 3346. | 999999. |
| 1 | 33 | 16 | 3350. | 999999. |
| 1 | 34 | 17 | 3360. | 999999. |
| 1 | 35 | 18 | 3392. | 999999. |
| 1 | 35 | 19 | 3392. | 999999. |
| 1 | 35 | 20 | 3394. | 999999. |
| 1 | 34 | 20 | 3380. | 999999. |
| 1 | 33 | 20 | 3344. | 999999. |
| 1 | 32 | 20 | 3310. | 999999. |
| 1 | 29 | 21 | 3252. | 999999. |
| 1 | 30 | 21 | 3252. | 999999. |

FEBRUARY. 1988

$$$$$$$$$$$$$$$$

| | | | | |
|---|---|---|---|---|
| 23 | | | | |
| 1 | 20 | 4 | 3145. | 999999. |
| 1 | 21 | 4 | 3164. | 999999. |
| 1 | 22 | 5 | 3198. | 999999. |
| 1 | 23 | 6 | 3200. | 999999. |
| 1 | 24 | 7 | 3200. | 999999. |
| 1 | 25 | 8 | 3210. | 999999. |
| 1 | 26 | 9 | 3220. | 999999. |
| 1 | 27 | 10 | 3240. | 999999. |
| 1 | 28 | 11 | 3250. | 999999. |
| 1 | 29 | 12 | 3262. | 999999. |
| 1 | 30 | 13 | 3280. | 999999. |
| 1 | 31 | 14 | 3312. | 999999. |
| 1 | 32 | 15 | 3346. | 999999. |
| 1 | 33 | 16 | 3350. | 999999. |
| 1 | 34 | 17 | 3360. | 999999. |
| 1 | 35 | 18 | 3387. | 999999. |
| 1 | 35 | 19 | 3387. | 999999. |
| 1 | 35 | 20 | 3387. | 999999. |
| 1 | 34 | 20 | 3375. | 999999. |
| 1 | 33 | 20 | 3344. | 999999. |
| 1 | 32 | 20 | 3310. | 999999. |
| 1 | 29 | 21 | 3248. | 999999. |
| 1 | 30 | 21 | 3252. | 999999. |

MARCH. 1988

$$$$$$$$$$$$$

| | | | | |
|---|---|---|---|---|
| 23 | | | | |
| 1 | 20 | 4 | 3145. | 999999. |
| 1 | 21 | 4 | 3164. | 999999. |
| 1 | 22 | 5 | 3198. | 999999. |
| 1 | 23 | 6 | 3210. | 999999. |
| 1 | 24 | 7 | 3210. | 999999. |
| 1 | 25 | 8 | 3215. | 999999. |
| 1 | 26 | 9 | 3222. | 999999. |
| 1 | 27 | 10 | 3242. | 999999. |
| 1 | 28 | 11 | 3252. | 999999. |
| 1 | 29 | 12 | 3264. | 999999. |
| 1 | 30 | 13 | 3282. | 999999. |
| 1 | 31 | 14 | 3312. | 999999. |
| 1 | 32 | 15 | 3348. | 999999. |
| 1 | 33 | 16 | 3356. | 999999. |
| 1 | 34 | 17 | 3360. | 999999. |
| 1 | 35 | 18 | 3387. | 999999. |
| 1 | 35 | 19 | 3387. | 999999. |
| 1 | 35 | 20 | 3387. | 999999. |
| 1 | 34 | 20 | 3380. | 999999. |
| 1 | 33 | 20 | 3348. | 999999. |
| 1 | 32 | 20 | 3314. | 999999. |
| 1 | 29 | 21 | 3254. | 999999. |
| 1 | 30 | 21 | 3258. | 999999. |

USGS 3 D MODEL   RIVER INPUT PACKAGE
TRANSIENT MODEL
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
APRIL, 1988
$$$$$$$$$$$$

105   -55

105

| | | | | | |
|---|---|---|---|---|---|
| 1 | 7 | 9 | 2975. | 55976. | 2973. |
| 1 | 8 | 9 | 2985. | 55434. | 2982. |
| 1 | 8 | 10 | 2985. | 55473. | 2982. |
| 1 | 9 | 9 | 2990. | 55000. | 2987. |
| 1 | 9 | 10 | 2990. | 55000. | 2987. |
| 1 | 10 | 10 | 2995. | 55000. | 2992. |
| 1 | 11 | 10 | 2998. | 25000. | 2995. |
| 1 | 12 | 10 | 3005. | 25000. | 3002. |
| 1 | 13 | 11 | 3030. | 25959. | 3027. |
| 1 | 14 | 11 | 3035. | 25539. | 3032. |
| 1 | 15 | 12 | 3035. | 25000. | 3033. |
| 1 | 16 | 12 | 3055. | 25000. | 3053. |
| 1 | 17 | 12 | 3065. | 25000. | 3063. |
| 1 | 18 | 12 | 3078. | 25000. | 3075. |
| 1 | 18 | 13 | 3085. | 25000. | 3083. |
| 1 | 19 | 13 | 3090. | 25000. | 3088. |
| 1 | 19 | 14 | 3100. | 25000. | 3098. |
| 1 | 20 | 14 | 3115. | 25000. | 3113. |
| 1 | 21 | 15 | 3125. | 25767. | 3123. |
| 1 | 22 | 15 | 3140. | 25919. | 3138. |
| 1 | 23 | 15 | 3150. | 55000. | 3148. |
| 1 | 24 | 15 | 3160. | 55000. | 3158. |
| 1 | 24 | 16 | 3175. | 55000. | 3173. |
| 1 | 25 | 16 | 3190. | 55000. | 3188. |
| 1 | 25 | 17 | 3216. | 55000. | 3214. |
| 1 | 26 | 17 | 3230. | 55000. | 3228. |
| 1 | 26 | 18 | 3240. | 55000. | 3238. |
| 1 | 27 | 18 | 3255. | 55000. | 3253. |
| 1 | 27 | 19 | 3270. | 60000. | 3268. |
| 1 | 28 | 19 | 3280. | 60000. | 3278. |
| 1 | 29 | 20 | 3300. | 60000. | 3298. |
| 1 | 20 | 5 | 3175. | 30867. | 3173. |
| 1 | 19 | 5 | 3135. | 30867. | 3133. |
| 1 | 18 | 5 | 3120. | 30867. | 3118. |
| 1 | 17 | 5 | 3110. | 30996. | 3108. |
| 1 | 16 | 5 | 3095. | 30025. | 3093. |
| 1 | 15 | 5 | 3075. | 30177. | 3073. |
| 1 | 14 | 5 | 3065. | 15715. | 3063. |
| 1 | 13 | 6 | 3040. | 15253. | 3038. |
| 1 | 12 | 6 | 3030. | 12164. | 3027. |
| 1 | 12 | 5 | 3030. | 11544. | 3027. |
| 1 | 11 | 6 | 3020. | 14633. | 3018. |
| 1 | 10 | 6 | 3010. | 15867. | 3008. |
| 1 | 9 | 6 | 3005. | 14633. | 3003. |
| 1 | 9 | 7 | 3002. | 14633. | 3000. |
| 1 | 8 | 7 | 2995. | 16177. | 2993. |
| 1 | 7 | 8 | 2985. | 16947. | 2983. |
| 1 | 6 | 20 | 3239. | 20000. | 3238. |
| 1 | 7 | 20 | 3241. | 20000. | 3240. |
| 1 | 8 | 20 | 3244. | 20000. | 3243. |
| 1 | 9 | 20 | 3245. | 20000. | 3244. |
| 1 | 10 | 20 | 3248. | 20000. | 3247. |
| 1 | 11 | 20 | 3249. | 20000. | 3248. |
| 1 | 12 | 20 | 3250. | 20000. | 3249. |
| 1 | 13 | 20 | 3251. | 20000. | 3250. |
| 1 | 14 | 20 | 3252. | 20000. | 3251. |
| 1 | 15 | 20 | 3253. | 20000. | 3252. |
| 1 | 16 | 20 | 3254. | 20000. | 3253. |
| 1 | 17 | 20 | 3255. | 20000. | 3254. |
| 1 | 18 | 20 | 3295. | 20000. | 3294. |
| 1 | 19 | 20 | 3296. | 20000. | 3294.5 |
| 1 | 20 | 20 | 3297. | 40000. | 3295.5 |
| 1 | 21 | 20 | 3298. | 40000. | 3296.5 |
| 1 | 22 | 20 | 3299. | 60000. | 3297.5 |
| 1 | 23 | 20 | 3344. | 60000. | 3342.5 |
| 1 | 24 | 20 | 3347. | 60000. | 3345.5 |
| 1 | 25 | 20 | 3375. | 60000. | 3373.5 |
| 1 | 26 | 20 | 3376. | 60000. | 3374.5 |
| 1 | 27 | 20 | 3385. | 60000. | 3383.5 |
| 1 | 28 | 20 | 3400. | 60000. | 3398.5 |
| 1 | 15 | 9 | 3113. | 20000. | 3112. |
| 1 | 15 | 10 | 3124. | 20000. | 3123. |
| 1 | 16 | 11 | 3139. | 20000. | 3137. |
| 1 | 17 | 11 | 3161. | 20000. | 3160. |
| 1 | 18 | 11 | 3169. | 20000. | 3168. |
| 1 | 19 | 12 | 3194. | 20000. | 3193. |
| 1 | 20 | 13 | 3209. | 20000. | 3208. |
| 1 | 21 | 13 | 3214. | 20000. | 3213. |
| 1 | 22 | 14 | 3242. | 40000. | 3241. |
| 1 | 23 | 14 | 3244. | 40000. | 3243. |
| 1 | 24 | 15 | 3279. | 40000. | 3278. |
| 1 | 25 | 15 | 3284. | 40000. | 3283. |
| 1 | 26 | 16 | 3314. | 40000. | 3313. |
| 1 | 27 | 17 | 3337. | 40000. | 3336. |
| 1 | 28 | 18 | 3362. | 40000. | 3361. |
| 1 | 29 | 18 | 3372. | 40000. | 3371. |
| 1 | 29 | 19 | 3377. | 40000. | 3376. |
| 1 | 19 | 8 | 3163.6 | 30000. | 3163. |
| 1 | 20 | 9 | 3183.6 | 30000. | 3183. |
| 1 | 21 | 10 | 3198.6 | 30000. | 3198. |
| 1 | 22 | 11 | 3223.6 | 30000. | 3223. |
| 1 | 23 | 12 | 3248.6 | 30000. | 3248. |
| 1 | 24 | 13 | 3268.6 | 30000. | 3268. |
| 1 | 25 | 14 | 3288.6 | 30000. | 3288. |
| 1 | 26 | 15 | 3313.6 | 30000. | 3313. |
| 1 | 27 | 16 | 3318.6 | 30000. | 3318. |
| 1 | 28 | 17 | 3353.6 | 30000. | 3353. |
| 1 | 29 | 18 | 3378.6 | 30000. | 3378. |
| 1 | 24 | 11 | 3233.6 | 30000. | 3233. |
| 1 | 25 | 12 | 3258.6 | 30000. | 3258. |
| 1 | 26 | 13 | 3288.6 | 30000. | 3268. |

| | | | | | |
|---|---|---|---|---|---|
| 1 | 27 | 14 | 3308.6 | 30000. | 3306. |
| 1 | 28 | 15 | 3328.6 | 30000. | 3326. |
| 1 | 29 | 16 | 3348.6 | 30000. | 3346. |
| 1 | 29 | 17 | 3363.6 | 30000. | 3363. |

MAY. 1988
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105

| | | | | | |
|---|---|---|---|---|---|
| 1 | 7 | 9 | 2976. | 55975. | 2973. |
| 1 | 8 | 9 | 2986. | 55425. | 2982. |
| 1 | 8 | 10 | 2986. | 55475. | 2982. |
| 1 | 9 | 9 | 2991. | 55000. | 2987. |
| 1 | 9 | 10 | 2991. | 55000. | 2987. |
| 1 | 10 | 10 | 2996. | 55000. | 2992. |
| 1 | 11 | 10 | 2999. | 25000. | 2995. |
| 1 | 12 | 10 | 3006. | 25000. | 3002. |
| 1 | 13 | 11 | 3031. | 25950. | 3027. |
| 1 | 14 | 11 | 3036. | 25540. | 3032. |
| 1 | 15 | 12 | 3036. | 25000. | 3033. |
| 1 | 16 | 12 | 3056. | 25000. | 3053. |
| 1 | 17 | 12 | 3066. | 25000. | 3063. |
| 1 | 18 | 12 | 3079. | 25000. | 3075. |
| 1 | 18 | 13 | 3086.2 | 25000. | 3083. |
| 1 | 19 | 13 | 3091.2 | 25000. | 3088. |
| 1 | 19 | 14 | 3101.2 | 25000. | 3098. |
| 1 | 20 | 14 | 3116.2 | 25000. | 3115. |
| 1 | 21 | 15 | 3126.2 | 55000. | 3123. |
| 1 | 22 | 15 | 3141.2 | 55000. | 3138. |
| 1 | 23 | 15 | 3151.2 | 55000. | 3148. |
| 1 | 24 | 15 | 3161.2 | 55000. | 3158. |
| 1 | 24 | 16 | 3176.2 | 55000. | 3173. |
| 1 | 25 | 16 | 3191.2 | 55000. | 3188. |
| 1 | 25 | 17 | 3217.2 | 55000. | 3214. |
| 1 | 26 | 17 | 3231.2 | 55000. | 3228. |
| 1 | 26 | 18 | 3241.2 | 55000. | 3238. |
| 1 | 27 | 18 | 3256.2 | 55000. | 3253. |
| 1 | 27 | 19 | 3271.2 | 60000. | 3268. |
| 1 | 28 | 19 | 3281.2 | 60000. | 3278. |
| 1 | 29 | 20 | 3301.2 | 60000. | 3298. |
| 1 | 20 | 5 | 3176. | 30865. | 3173. |
| 1 | 19 | 5 | 3136. | 30865. | 3133. |
| 1 | 18 | 5 | 3121. | 30865. | 3118. |
| 1 | 17 | 5 | 3111. | 30995. | 3108. |
| 1 | 16 | 5 | 3096. | 30025. | 3093. |
| 1 | 15 | 5 | 3076. | 30175. | 3073. |
| 1 | 14 | 5 | 3065.6 | 15725. | 3063. |
| 1 | 13 | 6 | 3040.6 | 15250. | 3038. |
| 1 | 12 | 6 | 3030.6 | 12165. | 3027. |
| 1 | 12 | 5 | 3030.6 | 11545. | 3027. |
| 1 | 11 | 6 | 3020.6 | 14635. | 3018. |
| 1 | 10 | 6 | 3010.6 | 15865. | 3008. |
| 1 | 9 | 6 | 3005.6 | 14635. | 3003. |
| 1 | 9 | 7 | 3002.6 | 14635. | 3000. |
| 1 | 8 | 7 | 2995.6 | 16175. | 2993. |
| 1 | 7 | 8 | 2985.6 | 16950. | 2983. |
| 1 | 6 | 20 | 3240.5 | 20000. | 3238. |
| 1 | 7 | 20 | 3242.5 | 20000. | 3240. |
| 1 | 8 | 20 | 3245.5 | 20000. | 3243. |
| 1 | 9 | 20 | 3246.5 | 20000. | 3244. |
| 1 | 10 | 20 | 3249.5 | 20000. | 3247. |
| 1 | 11 | 20 | 3250.5 | 20000. | 3248. |
| 1 | 12 | 20 | 3251.5 | 20000. | 3249. |
| 1 | 13 | 20 | 3252.5 | 20000. | 3250. |
| 1 | 14 | 20 | 3253.5 | 20000. | 3251. |
| 1 | 15 | 20 | 3254.5 | 20000. | 3252. |
| 1 | 16 | 20 | 3255.5 | 20000. | 3253. |
| 1 | 17 | 20 | 3256.5 | 20000. | 3254. |
| 1 | 18 | 20 | 3296.5 | 40000. | 3294. |
| 1 | 19 | 20 | 3297.5 | 40000. | 3294.5 |
| 1 | 20 | 20 | 3298.5 | 40000. | 3295.5 |
| 1 | 21 | 20 | 3299.5 | 40000. | 3296.5 |
| 1 | 22 | 20 | 3300.5 | 40000. | 3297.5 |
| 1 | 23 | 20 | 3345.5 | 60000. | 3342.5 |
| 1 | 24 | 20 | 3348.5 | 60000. | 3345.5 |
| 1 | 25 | 20 | 3376.5 | 60000. | 3373.5 |
| 1 | 26 | 20 | 3377.5 | 60000. | 3374.5 |
| 1 | 27 | 20 | 3386.5 | 60000. | 3383.5 |
| 1 | 28 | 20 | 3401.5 | 60000. | 3398.5 |
| 1 | 15 | 9 | 3114.6 | 20000. | 3112. |
| 1 | 15 | 10 | 3125.6 | 20000. | 3123. |
| 1 | 16 | 11 | 3140.6 | 20000. | 3138. |
| 1 | 17 | 11 | 3162.6 | 20000. | 3160. |
| 1 | 18 | 11 | 3170.6 | 20000. | 3168. |
| 1 | 19 | 12 | 3195.6 | 20000. | 3193. |
| 1 | 20 | 13 | 3210.6 | 20000. | 3208. |
| 1 | 21 | 13 | 3215.6 | 20000. | 3213. |
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| 1 | 27 | 17 | 3338.6 | 40000. | 3336. |
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| 1 | 29 | 19 | 3378.6 | 40000. | 3376. |
| 1 | 19 | 8 | 3165.6 | 30000. | 3163. |
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| 1 | 27 | 16 | 3320.6 | 30000. | 3318. |
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| 1 | 29 | 17 | 3365.6 | 30000. | 3363 |

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| 1 | 18 | 5 | 3120.5 | 30867. | 3118. |
| 1 | 17 | 5 | 3110.5 | 30996. | 3108. |
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| 1 | 15 | 5 | 3075.5 | 30177. | 3073. |
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| 1 | 13 | 6 | 3040. | 15253. | 3038. |
| 1 | 12 | 6 | 3030. | 12164. | 3027. |
| 1 | 12 | 5 | 3030. | 11544. | 3027. |
| 1 | 11 | 6 | 3020. | 14633. | 3018. |
| 1 | 10 | 6 | 3010. | 15867. | 3008. |
| 1 | 9 | 6 | 3005. | 14633. | 3003. |
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| 1 | 8 | 7 | 2995. | 16177. | 2993. |
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| 1 | 8 | 20 | 3246. | 20000. | 3243. |
| 1 | 9 | 20 | 3247. | 20000. | 3244. |
| 1 | 10 | 20 | 3250. | 20000. | 3247. |
| 1 | 11 | 20 | 3251. | 20000. | 3248. |
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| 1 | 18 | 11 | 3170.7 | 20000. | 3168. |
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| 1 | 23 | 12 | 3250.7 | 30000. | 3248. |
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| 1 | 25 | 14 | 3290.7 | 30000. | 3288. |
| 1 | 26 | 15 | 3315.7 | 30000. | 3313. |
| 1 | 27 | 16 | 3320.7 | 30000. | 3318. |
| 1 | 28 | 17 | 3355.7 | 30000. | 3353. |
| 1 | 29 | 18 | 3380.7 | 30000. | 3378. |
| 1 | 24 | 11 | 3235.7 | 30000. | 3233. |
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| 1 | 26 | 13 | 3290.7 | 30000. | 3268. |

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| 1 | 28 | 15 | 3330.7 | 30000. | 3328. |
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| 1 | 29 | 17 | 3365.7 | 30000. | 3363. |
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| 1 | 11 | 10 | 2998.5 | 25000. | 2995. |
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| 1 | 13 | 11 | 3030.5 | 25959. | 3027. |
| 1 | 14 | 11 | 3035.5 | 25539. | 3032. |
| 1 | 15 | 12 | 3035.5 | 25000. | 3033. |
| 1 | 16 | 12 | 3055.5 | 25000. | 3053. |
| 1 | 17 | 12 | 3065.5 | 25000. | 3063. |
| 1 | 18 | 12 | 3078.5 | 25000. | 3075. |
| 1 | 18 | 13 | 3085.5 | 25000. | 3083. |
| 1 | 19 | 13 | 3090.5 | 25000. | 3088. |
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| 1 | 20 | 14 | 3115.2 | 25000. | 3113. |
| 1 | 21 | 15 | 3125.2 | 55000. | 3123. |
| 1 | 22 | 15 | 3140.2 | 55000. | 3138. |
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| 1 | 25 | 16 | 3190.2 | 55000. | 3188. |
| 1 | 25 | 17 | 3216.2 | 55000. | 3214. |
| 1 | 26 | 17 | 3230.2 | 55000. | 3228. |
| 1 | 26 | 18 | 3240.2 | 55000. | 3238. |
| 1 | 27 | 18 | 3255.2 | 55000. | 3253. |
| 1 | 27 | 19 | 3270.2 | 60000. | 3268. |
| 1 | 28 | 19 | 3280.2 | 60000. | 3278. |
| 1 | 29 | 20 | 3300.2 | 60000. | 3298. |
| 1 | 20 | 5 | 3175. | 30867. | 3173. |
| 1 | 19 | 5 | 3135. | 30867. | 3133. |
| 1 | 18 | 5 | 3120. | 30867. | 3118. |
| 1 | 17 | 5 | 3110. | 30996. | 3108. |
| 1 | 16 | 5 | 3095. | 30025. | 3093. |
| 1 | 15 | 5 | 3075. | 30177. | 3073. |
| 1 | 14 | 5 | 3065. | 15715. | 3063. |
| 1 | 13 | 6 | 3040. | 15253. | 3038. |
| 1 | 12 | 6 | 3030. | 12164. | 3027. |
| 1 | 12 | 5 | 3030. | 11544. | 3027. |
| 1 | 11 | 6 | 3020. | 14633. | 3018. |
| 1 | 10 | 6 | 3010. | 15867. | 3008. |
| 1 | 9 | 6 | 3005. | 14633. | 3003. |
| 1 | 9 | 7 | 3002. | 14633. | 3000. |
| 1 | 8 | 7 | 2995. | 16177. | 2993. |
| 1 | 7 | 8 | 2985. | 16947. | 2983. |

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| 1 | 6 | 20 | 3241. | 20000. | 3238. |
| 1 | 7 | 20 | 3243. | 20000. | 3240. |
| 1 | 8 | 20 | 3246. | 20000. | 3243. |
| 1 | 9 | 20 | 3247. | 20000. | 3244. |
| 1 | 10 | 20 | 3250. | 20000. | 3247. |
| 1 | 11 | 20 | 3251. | 20000. | 3248. |
| 1 | 12 | 20 | 3252. | 20000. | 3249. |
| 1 | 13 | 20 | 3253. | 20000. | 3250. |
| 1 | 14 | 20 | 3254. | 20000. | 3251. |
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| 1 | 17 | 20 | 3257. | 20000. | 3254. |
| 1 | 18 | 20 | 3297. | 40000. | 3294. |
| 1 | 19 | 20 | 3298. | 40000. | 3294.5 |
| 1 | 20 | 20 | 3298. | 40000. | 3295.5 |
| 1 | 21 | 20 | 3300. | 40000. | 3296.5 |
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| 1 | 18 | 11 | 3170.5 | 20000. | 3168. |
| 1 | 19 | 12 | 3195.5 | 20000. | 3193. |
| 1 | 20 | 13 | 3210.5 | 20000. | 3208. |
| 1 | 21 | 13 | 3215.5 | 20000. | 3213. |
| 1 | 22 | 14 | 3243.5 | 40000. | 3241. |
| 1 | 23 | 14 | 3245.5 | 40000. | 3243. |
| 1 | 24 | 15 | 3280.5 | 40000. | 3278. |
| 1 | 25 | 15 | 3285.5 | 40000. | 3283. |
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| 1 | 29 | 18 | 3373.5 | 40000. | 3371. |
| 1 | 29 | 19 | 3378.5 | 40000. | 3376. |
| 1 | 19 | 8 | 3165.5 | 30000. | 3163. |
| 1 | 20 | 9 | 3185.5 | 30000. | 3183. |
| 1 | 21 | 10 | 3200.5 | 30000. | 3198. |
| 1 | 22 | 11 | 3225.5 | 30000. | 3223. |
| 1 | 23 | 12 | 3250.5 | 30000. | 3248. |
| 1 | 24 | 13 | 3270.5 | 30000. | 3268. |
| 1 | 25 | 14 | 3290.5 | 30000. | 3288. |
| 1 | 26 | 15 | 3315.5 | 30000. | 3313. |
| 1 | 27 | 16 | 3320.5 | 30000. | 3318. |
| 1 | 28 | 17 | 3355.5 | 30000. | 3353. |
| 1 | 29 | 18 | 3380.5 | 30000. | 3378. |
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| 1 | 26 | 13 | 3290.5 | 30000. | 3288. |

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| 1 | 29 | 16 | 3350.5 | 30000. | 3348. |
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| 1 | 14 | 11 | 3035.5 | 25539. | 3032. |
| 1 | 15 | 12 | 3035.5 | 25000. | 3033. |
| 1 | 16 | 12 | 3055.5 | 25000. | 3053. |
| 1 | 17 | 12 | 3065.5 | 25000. | 3063. |
| 1 | 18 | 12 | 3078.5 | 25000. | 3075. |
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| 1 | 19 | 13 | 3090.5 | 25000. | 3088. |
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| 1 | 20 | 14 | 3114.8 | 25000. | 3113. |
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| 1 | 26 | 17 | 3229.8 | 55000. | 3228. |
| 1 | 26 | 18 | 3239.8 | 55000. | 3238. |
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| 1 | 27 | 19 | 3269.8 | 60000. | 3268. |
| 1 | 28 | 19 | 3279.8 | 60000. | 3278. |
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| 1 | 20 | 5 | 3174.8 | 30867. | 3173. |
| 1 | 19 | 5 | 3134.8 | 30867. | 3133. |
| 1 | 18 | 5 | 3119.8 | 30867. | 3118. |
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| 1 | 16 | 5 | 3094.8 | 30025. | 3093. |
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| 1 | 13 | 6 | 3040. | 15253. | 3038. |
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| 1 | 10 | 6 | 3010. | 15867. | 3008. |
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| 1 | 9 | 7 | 3002. | 14633. | 3000. |
| 1 | 8 | 7 | 2995. | 16177. | 2993. |

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| 1 | 7 | 8 | 2985. | 16947. | 2983. |
| 1 | 6 | 20 | 3239. | 20000. | 3238. |
| 1 | 7 | 20 | 3241. | 20000. | 3240. |
| 1 | 8 | 20 | 3244. | 20000. | 3243. |
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| 1 | 10 | 20 | 3248. | 20000. | 3247. |
| 1 | 11 | 20 | 3249. | 20000. | 3248. |
| 1 | 12 | 20 | 3250. | 20000. | 3249. |
| 1 | 13 | 20 | 3251. | 20000. | 3250. |
| 1 | 14 | 20 | 3252. | 20000. | 3251. |
| 1 | 15 | 20 | 3253. | 20000. | 3252. |
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| 1 | 17 | 20 | 3255. | 20000. | 3254. |
| 1 | 18 | 20 | 3295. | 20000. | 3294. |
| 1 | 19 | 20 | 3296. | 20000. | 3294.5 |
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| 1 | 29 | 18 | 3372. | 40000. | 3371. |
| 1 | 29 | 19 | 3377. | 40000. | 3376. |
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| 1 | 20 | 9 | 3184. | 30000. | 3183. |
| 1 | 21 | 10 | 3199. | 30000. | 3198. |
| 1 | 22 | 11 | 3224. | 30000. | 3223. |
| 1 | 23 | 12 | 3249. | 30000. | 3248. |
| 1 | 24 | 13 | 3269. | 30000. | 3268. |
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| 1 | 26 | 13 | 3289. | 30000. | 3288. |
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| 1 | 17 | 12 | 3065.5 | 25000. | 3063. |
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| 1 | 20 | 14 | 3114.6 | 25000. | 3115. |
| 1 | 21 | 15 | 3124.6 | 55000. | 3123. |
| 1 | 22 | 15 | 3139.6 | 55000. | 3138. |
| 1 | 23 | 15 | 3149.6 | 55000. | 3148. |
| 1 | 24 | 15 | 3159.6 | 55000. | 3158. |
| 1 | 24 | 16 | 3174.6 | 55000. | 3173. |
| 1 | 25 | 16 | 3189.6 | 55000. | 3188. |
| 1 | 25 | 17 | 3215.6 | 55000. | 3214. |
| 1 | 26 | 17 | 3229.6 | 55000. | 3228. |
| 1 | 26 | 18 | 3239.6 | 55000. | 3238. |
| 1 | 27 | 18 | 3254.6 | 55000. | 3253. |
| 1 | 27 | 19 | 3269.6 | 60000. | 3268. |
| 1 | 28 | 19 | 3279.6 | 60000. | 3278. |
| 1 | 29 | 20 | 3299.6 | 60000. | 3298. |
| 1 | 20 | 5 | 3174.6 | 30865. | 3173. |
| 1 | 19 | 5 | 3134.6 | 30865. | 3133. |
| 1 | 18 | 5 | 3119.6 | 30865. | 3118. |
| 1 | 17 | 5 | 3109.6 | 30995. | 3108. |
| 1 | 16 | 5 | 3094.6 | 30025. | 3093. |
| 1 | 15 | 5 | 3074.6 | 30175. | 3073. |
| 1 | 14 | 5 | 3065. | 15725. | 3063. |
| 1 | 13 | 6 | 3040. | 15250. | 3038. |
| 1 | 12 | 6 | 3030. | 12165. | 3027. |
| 1 | 12 | 5 | 3030. | 11545. | 3027. |
| 1 | 11 | 6 | 3020. | 14635. | 3018. |
| 1 | 10 | 6 | 3010. | 15865. | 3008. |
| 1 | 9 | 6 | 3005. | 14635. | 3003. |
| 1 | 9 | 7 | 3002. | 14635. | 3000. |
| 1 | 8 | 7 | 2995. | 16175. | 2993. |
| 1 | 7 | 8 | 2985. | 16950. | 2983. |
| 1 | 6 | 20 | 3239. | 20000. | 3238. |
| 1 | 7 | 20 | 3241. | 20000. | 3240. |
| 1 | 8 | 20 | 3244. | 20000. | 3243. |
| 1 | 9 | 20 | 3245. | 20000. | 3244. |
| 1 | 10 | 20 | 3248. | 20000. | 3247. |
| 1 | 11 | 20 | 3249. | 20000. | 3248. |
| 1 | 12 | 20 | 3250. | 20000. | 3249. |
| 1 | 13 | 20 | 3251. | 20000. | 3250. |
| 1 | 14 | 20 | 3252. | 20000. | 3251. |
| 1 | 15 | 20 | 3253. | 20000. | 3252. |
| 1 | 16 | 20 | 3254. | 20000. | 3253. |
| 1 | 17 | 20 | 3255. | 20000. | 3254. |
| 1 | 18 | 20 | 3295. | 40000. | 3294. |
| 1 | 19 | 20 | 3296. | 40000. | 3294.5 |
| 1 | 20 | 20 | 3297. | 40000. | 3295.5 |
| 1 | 21 | 20 | 3298. | 40000. | 3296.5 |
| 1 | 22 | 20 | 3299. | 40000. | 3297.5 |
| 1 | 23 | 20 | 3344. | 60000. | 3342.5 |
| 1 | 24 | 20 | 3347. | 60000. | 3345.5 |
| 1 | 25 | 20 | 3375. | 60000. | 3373.5 |
| 1 | 26 | 20 | 3376. | 60000. | 3374.5 |
| 1 | 27 | 20 | 3385. | 60000. | 3383.5 |
| 1 | 28 | 20 | 3400. | 60000. | 3398.5 |
| 1 | 15 | 9 | 3113. | 20000. | 3112. |
| 1 | 15 | 10 | 3124. | 20000. | 3123. |
| 1 | 16 | 11 | 3139. | 20000. | 3138. |
| 1 | 17 | 11 | 3161. | 20000. | 3160. |
| 1 | 18 | 11 | 3169. | 20000. | 3168. |
| 1 | 19 | 12 | 3194. | 20000. | 3193. |
| 1 | 20 | 13 | 3209. | 20000. | 3208. |
| 1 | 21 | 13 | 3214. | 20000. | 3213. |
| 1 | 22 | 14 | 3242. | 40000. | 3241. |
| 1 | 23 | 14 | 3244. | 40000. | 3243. |
| 1 | 24 | 15 | 3279. | 40000. | 3278. |
| 1 | 25 | 15 | 3285. | 40000. | 3283. |
| 1 | 26 | 16 | 3314. | 40000. | 3313. |
| 1 | 27 | 17 | 3337. | 40000. | 3336. |
| 1 | 28 | 18 | 3362. | 40000. | 3361. |
| 1 | 29 | 18 | 3370. | 40000. | 3369. |
| 1 | 29 | 19 | 3377. | 40000. | 3376. |

OCTOBER. 1986
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87

| | | | | | |
|---|---|---|---|---|---|
| 1 | 7 | 9 | 2975.3 | 55975. | 2973. |
| 1 | 8 | 9 | 2985.3 | 55434. | 2982. |
| 1 | 8 | 10 | 2985.3 | 55473. | 2982. |
| 1 | 9 | 9 | 2990.3 | 55000. | 2987. |
| 1 | 9 | 10 | 2990.3 | 55000. | 2987. |
| 1 | 10 | 10 | 2995.3 | 55000. | 2992. |
| 1 | 11 | 10 | 2998.3 | 25000. | 2995. |
| 1 | 12 | 10 | 3005.3 | 25000. | 3002. |
| 1 | 13 | 11 | 3030.3 | 25959. | 3027. |
| 1 | 14 | 11 | 3035.3 | 25539. | 3032. |

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|---|---|---|---|---|---|
| 1 | 15 | 12 | 3035.3 | 25000. | 3033. |
| 1 | 16 | 12 | 3055.3 | 25000. | 3053. |
| 1 | 17 | 12 | 3065.3 | 25000. | 3063. |
| 1 | 18 | 12 | 3078.3 | 25000. | 3075. |
| 1 | 18 | 13 | 3085.3 | 25000. | 3083. |
| 1 | 19 | 13 | 3090.3 | 25000. | 3088. |
| 1 | 19 | 14 | 3099.6 | 25000. | 3098. |
| 1 | 20 | 14 | 3114.6 | 25000. | 3113. |
| 1 | 21 | 15 | 3124.6 | 55000. | 3123. |
| 1 | 22 | 15 | 3139.6 | 55000. | 3138. |
| 1 | 23 | 15 | 3149.6 | 55000. | 3148. |
| 1 | 24 | 15 | 3159.6 | 55000. | 3158. |
| 1 | 24 | 16 | 3174.6 | 55000. | 3173. |
| 1 | 25 | 16 | 3189.6 | 55000. | 3188. |
| 1 | 25 | 17 | 3215.6 | 55000. | 3214. |
| 1 | 26 | 17 | 3229.6 | 55000. | 3228. |
| 1 | 26 | 18 | 3239.6 | 55000. | 3238. |
| 1 | 27 | 18 | 3254.6 | 55000. | 3253. |
| 1 | 27 | 19 | 3269.6 | 60000. | 3268. |
| 1 | 28 | 19 | 3279.6 | 60000. | 3278. |
| 1 | 29 | 20 | 3299.6 | 60000. | 3298. |
| 1 | 20 | 5 | 3174.6 | 30867. | 3173. |
| 1 | 19 | 5 | 3134.6 | 30867. | 3133. |
| 1 | 18 | 5 | 3119.6 | 30867. | 3118. |
| 1 | 17 | 5 | 3109.6 | 30996. | 3108. |
| 1 | 16 | 5 | 3094.6 | 30025. | 3093. |
| 1 | 15 | 5 | 3074.6 | 30177. | 3073. |
| 1 | 14 | 5 | 3065. | 15715. | 3063. |
| 1 | 13 | 6 | 3040. | 15253. | 3038. |
| 1 | 12 | 6 | 3030. | 12164. | 3027. |
| 1 | 12 | 5 | 3030. | 11544. | 3027. |
| 1 | 11 | 6 | 3020. | 14633. | 3018. |
| 1 | 10 | 6 | 3010. | 15867. | 3008. |
| 1 | 9 | 6 | 3005. | 14633. | 3003. |
| 1 | 9 | 7 | 3002. | 14633. | 3000. |
| 1 | 8 | 7 | 2995. | 16177. | 2993. |
| 1 | 7 | 8 | 2985. | 16947. | 2983. |
| 1 | 6 | 20 | 3239. | 20000. | 3238. |
| 1 | 7 | 20 | 3241. | 20000. | 3240. |
| 1 | 8 | 20 | 3244. | 20000. | 3243. |
| 1 | 9 | 20 | 3245. | 20000. | 3244. |
| 1 | 10 | 20 | 3248. | 20000. | 3247. |
| 1 | 11 | 20 | 3249. | 20000. | 3248. |
| 1 | 12 | 20 | 3250. | 20000. | 3249. |
| 1 | 13 | 20 | 3251. | 20000. | 3250. |
| 1 | 14 | 20 | 3252. | 20000. | 3251. |
| 1 | 15 | 20 | 3253. | 20000. | 3252. |
| 1 | 16 | 20 | 3254. | 20000. | 3253. |
| 1 | 17 | 20 | 3255. | 20000. | 3254. |
| 1 | 18 | 20 | 3295. | 40000. | 3294. |
| 1 | 19 | 20 | 3296. | 40000. | 3294.5 |
| 1 | 20 | 20 | 3297. | 40000. | 3295.5 |
| 1 | 21 | 20 | 3298. | 40000. | 3296.5 |
| 1 | 22 | 20 | 3299. | 60000. | 3297.5 |
| 1 | 23 | 20 | 3344. | 60000. | 3342.5 |
| 1 | 24 | 20 | 3347. | 60000. | 3345.5 |
| 1 | 25 | 20 | 3375. | 60000. | 3373.5 |
| 1 | 26 | 20 | 3376. | 60000. | 3374.5 |
| 1 | 27 | 20 | 3385. | 60000. | 3383.5 |
| 1 | 28 | 20 | 3400. | 60000. | 3398.5 |
| 1 | 15 | 9 | 3113. | 20000. | 3112. |
| 1 | 15 | 10 | 3124. | 20000. | 3123. |
| 1 | 16 | 11 | 3139. | 20000. | 3138. |
| 1 | 17 | 11 | 3161. | 20000. | 3160. |
| 1 | 18 | 11 | 3169. | 20000. | 3168. |
| 1 | 19 | 12 | 3194. | 20000. | 3193. |
| 1 | 20 | 13 | 3209. | 20000. | 3208. |
| 1 | 21 | 13 | 3214. | 20000. | 3213. |
| 1 | 22 | 14 | 3242. | 40000. | 3241. |
| 1 | 23 | 14 | 3244. | 40000. | 3243. |
| 1 | 24 | 15 | 3279. | 40000. | 3278. |
| 1 | 25 | 15 | 3284. | 40000. | 3283. |
| 1 | 26 | 16 | 3314. | 40000. | 3313. |
| 1 | 27 | 17 | 3337. | 40000. | 3336. |
| 1 | 28 | 18 | 3362. | 40000. | 3361. |
| 1 | 29 | 18 | 3372. | 40000. | 3371. |
| 1 | 29 | 19 | 3377. | 40000. | 3376. |

NOVEMBER, 1988
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47

| | | | | | |
|---|---|---|---|---|---|
| 1 | 7 | 9 | 2975.2 | 55976. | 2973 |
| 1 | 8 | 9 | 2985.2 | 55434. | 2982. |
| 1 | 8 | 10 | 2985.2 | 55473. | 2982. |
| 1 | 9 | 9 | 2990.2 | 55000. | 2987. |
| 1 | 9 | 10 | 2990.2 | 55000. | 2987. |
| 1 | 10 | 10 | 2995.2 | 55000. | 2992. |
| 1 | 11 | 10 | 2998.2 | 25000. | 2995. |
| 1 | 12 | 10 | 3005.2 | 25000. | 3002. |
| 1 | 13 | 11 | 3030.2 | 25959. | 3027. |
| 1 | 14 | 11 | 3035.2 | 25539. | 3032. |
| 1 | 15 | 12 | 3035.2 | 25000. | 3033. |
| 1 | 16 | 12 | 3055.2 | 25000. | 3053. |
| 1 | 17 | 12 | 3065.2 | 25000. | 3063. |
| 1 | 18 | 12 | 3078.2 | 25000. | 3075. |
| 1 | 18 | 13 | 3085.2 | 25000. | 3083. |
| 1 | 19 | 13 | 3090.2 | 25000. | 3088. |
| 1 | 19 | 14 | 3099.8 | 25000. | 3098. |
| 1 | 20 | 14 | 3114.8 | 25000. | 3113. |
| 1 | 21 | 15 | 3124.8 | 55000. | 3123. |
| 1 | 22 | 15 | 3139.8 | 55000. | 3138. |
| 1 | 23 | 15 | 3149.8 | 55000. | 3148. |
| 1 | 24 | 15 | 3159.8 | 55000. | 3158. |
| 1 | 24 | 16 | 3174.8 | 55000. | 3173. |
| 1 | 25 | 16 | 3189.8 | 55000. | 3188. |
| 1 | 25 | 17 | 3215.8 | 55000. | 3214. |
| 1 | 26 | 17 | 3229.8 | 55000. | 3228. |
| 1 | 26 | 18 | 3239.8 | 55000. | 3238. |
| 1 | 27 | 18 | 3254.8 | 55000. | 3253. |

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|---|---|---|---|---|---|
| 1 | 27 | 19 | 3269.8 | 60000. | 3268. |
| 1 | 28 | 19 | 3279.8 | 60000. | 3278. |
| 1 | 29 | 20 | 3299.8 | 60000. | 3298. |
| 1 | 20 | 5 | 3174.8 | 30867. | 3173. |
| 1 | 19 | 5 | 3134.8 | 30867. | 3133. |
| 1 | 18 | 5 | 3119.8 | 30867. | 3118. |
| 1 | 17 | 5 | 3109.8 | 30996. | 3108. |
| 1 | 16 | 5 | 3094.8 | 30025. | 3093. |
| 1 | 15 | 5 | 3074.8 | 30177. | 3073. |
| 1 | 14 | 5 | 3065. | 15715. | 3063. |
| 1 | 13 | 6 | 3040. | 15253. | 3038. |
| 1 | 12 | 6 | 3030. | 12164. | 3027. |
| 1 | 12 | 5 | 3030. | 11544. | 3027. |
| 1 | 11 | 6 | 3020. | 14633. | 3018. |
| 1 | 10 | 6 | 3010. | 15867. | 3008. |
| 1 | 9 | 6 | 3005. | 14633. | 3003. |
| 1 | 9 | 7 | 3002. | 14633. | 3000. |
| 1 | 8 | 7 | 2995. | 16177. | 2993. |
| 1 | 7 | 8 | 2985. | 16947. | 2983. |

DECEMBER. 1988
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| | | | | | |
|---|---|---|---|---|---|
| 47 | -55 | | | | |
| 47 | | | | | |
| 1 | 7 | 9 | 2975.2 | 55976. | 2973. |
| 1 | 8 | 9 | 2985.2 | 55434. | 2982. |
| 1 | 8 | 10 | 2985.2 | 55473. | 2982. |
| 1 | 9 | 9 | 2990.2 | 55000. | 2987. |
| 1 | 9 | 10 | 2990.2 | 55000. | 2987. |
| 1 | 10 | 10 | 2995.2 | 55000. | 2992. |
| 1 | 11 | 10 | 2998.2 | 25000. | 2995. |
| 1 | 12 | 10 | 3005.2 | 25000. | 3002. |
| 1 | 13 | 11 | 3030.2 | 25959. | 3027. |
| 1 | 14 | 11 | 3035.2 | 25539. | 3032. |
| 1 | 15 | 12 | 3035.2 | 25000. | 3033. |
| 1 | 16 | 12 | 3055.2 | 25000. | 3053. |
| 1 | 17 | 12 | 3065.2 | 25000. | 3063. |
| 1 | 18 | 12 | 3078.2 | 25000. | 3075. |
| 1 | 18 | 13 | 3085.2 | 25000. | 3083. |
| 1 | 19 | 13 | 3090.2 | 25000. | 3088. |
| 1 | 19 | 14 | 3100. | 25000. | 3098. |
| 1 | 20 | 14 | 3115. | 25000. | 3113. |
| 1 | 21 | 15 | 3125. | 25767. | 3123. |
| 1 | 22 | 15 | 3140. | 25919. | 3138. |
| 1 | 23 | 15 | 3150. | 55000. | 3148. |
| 1 | 24 | 15 | 3160. | 55000. | 3158. |
| 1 | 24 | 16 | 3175. | 55000. | 3173. |
| 1 | 25 | 16 | 3190. | 55000. | 3188. |
| 1 | 25 | 17 | 3216. | 55000. | 3214. |
| 1 | 26 | 17 | 3230. | 55000. | 3228. |
| 1 | 26 | 18 | 3240. | 55000. | 3238. |
| 1 | 27 | 18 | 3255. | 55000. | 3253. |
| 1 | 27 | 19 | 3270. | 60000. | 3268. |
| 1 | 28 | 19 | 3280. | 60000. | 3278. |
| 1 | 29 | 20 | 3300. | 60000. | 3298. |
| 1 | 20 | 5 | 3175. | 30867. | 3173. |
| 1 | 19 | 5 | 3135. | 30867. | 3133. |
| 1 | 18 | 5 | 3120. | 30867. | 3118. |
| 1 | 17 | 5 | 3110. | 30996. | 3108. |
| 1 | 16 | 5 | 3095. | 30025. | 3093. |
| 1 | 15 | 5 | 3075. | 30177. | 3073. |
| 1 | 14 | 5 | 3065. | 15715. | 3063. |
| 1 | 13 | 6 | 3040. | 15253. | 3038. |
| 1 | 12 | 6 | 3030. | 12164. | 3027. |
| 1 | 12 | 5 | 3030. | 11544. | 3027. |
| 1 | 11 | 6 | 3020. | 14633. | 3018. |
| 1 | 10 | 6 | 3010. | 15867. | 3008. |
| 1 | 9 | 6 | 3005. | 14633. | 3003. |
| 1 | 9 | 7 | 3002. | 14633. | 3000. |
| 1 | 8 | 7 | 2995. | 16177. | 2993. |
| 1 | 7 | 8 | 2985. | 16947. | 2983. |

JANUARY. 1989
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|---|---|---|---|---|---|
| 47 | | | | | |
| 1 | 7 | 9 | 2975.2 | 55975. | 2973. |
| 1 | 8 | 9 | 2985.2 | 55425. | 2982. |
| 1 | 8 | 10 | 2985.2 | 55475. | 2982. |
| 1 | 9 | 9 | 2990.2 | 55000. | 2987. |
| 1 | 9 | 10 | 2990.2 | 55000. | 2987. |
| 1 | 10 | 10 | 2995.2 | 55000. | 2992. |
| 1 | 11 | 10 | 2998.2 | 25000. | 2995. |
| 1 | 12 | 10 | 3005.2 | 25000. | 3002. |
| 1 | 13 | 11 | 3030.2 | 25950. | 3027. |
| 1 | 14 | 11 | 3035.2 | 25540. | 3032. |
| 1 | 15 | 12 | 3035.2 | 25000. | 3033. |
| 1 | 16 | 12 | 3055.2 | 25000. | 3053. |
| 1 | 17 | 12 | 3065.2 | 25000. | 3063. |
| 1 | 18 | 12 | 3078.2 | 25000. | 3075. |
| 1 | 18 | 13 | 3085.2 | 25000. | 3083. |
| 1 | 19 | 13 | 3090.2 | 25000. | 3088. |
| 1 | 19 | 14 | 3100. | 25000. | 3098. |
| 1 | 20 | 14 | 3115. | 25000. | 3113. |
| 1 | 21 | 15 | 3125. | 55000. | 3123. |
| 1 | 22 | 15 | 3140. | 55000. | 3138. |
| 1 | 23 | 15 | 3150. | 55000. | 3148. |
| 1 | 24 | 15 | 3160. | 55000. | 3158. |
| 1 | 24 | 16 | 3175. | 55000. | 3173. |
| 1 | 25 | 16 | 3190. | 55000. | 3188. |
| 1 | 25 | 17 | 3216. | 55000. | 3214. |
| 1 | 26 | 17 | 3230. | 55000. | 3228. |
| 1 | 26 | 18 | 3240. | 55000. | 3238. |
| 1 | 27 | 18 | 3255. | 55000. | 3253. |
| 1 | 27 | 19 | 3270. | 60000. | 3268. |
| 1 | 28 | 19 | 3280. | 60000. | 3278. |
| 1 | 29 | 20 | 3300. | 60000. | 3298. |
| 1 | 20 | 5 | 3175. | 30865. | 3173. |
| 1 | 19 | 5 | 3135. | 30865. | 3133. |
| 1 | 18 | 5 | 3120. | 30865. | 3118. |
| 1 | 17 | 5 | 3110. | 30995. | 3108. |

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| 1 | 16 | 5 | 3095. | 30025. | 3093. |
| 1 | 15 | 5 | 3075. | 30175. | 3073. |
| 1 | 14 | 5 | 3065. | 15725. | 3063. |
| 1 | 13 | 6 | 3040. | 15250. | 3038. |
| 1 | 12 | 6 | 3030. | 12165. | 3027. |
| 1 | 12 | 5 | 3030. | 11545. | 3027. |
| 1 | 11 | 6 | 3020. | 14635. | 3018. |
| 1 | 10 | 6 | 3010. | 15865. | 3008. |
| 1 | 9 | 6 | 3005. | 14635. | 3003. |
| 1 | 9 | 7 | 3002. | 14635. | 3000. |
| 1 | 8 | 7 | 2995. | 16175. | 2993. |
| 1 | 7 | 8 | 2985. | 16950. | 2983. |

FEBRUARY. 1989

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47

| | | | | | |
|---|---|---|---|---|---|
| 1 | 7 | 9 | 2975. | 55975. | 2973. |
| 1 | 8 | 9 | 2985. | 55434. | 2982. |
| 1 | 8 | 10 | 2985. | 55473. | 2982. |
| 1 | 9 | 9 | 2990. | 55000. | 2987. |
| 1 | 9 | 10 | 2990. | 55000. | 2987. |
| 1 | 10 | 10 | 2995. | 55000. | 2992. |
| 1 | 11 | 10 | 2998. | 25000. | 2995. |
| 1 | 12 | 10 | 3005. | 25000. | 3002. |
| 1 | 13 | 11 | 3030. | 25959. | 3027. |
| 1 | 14 | 11 | 3035. | 25539. | 3032. |
| 1 | 15 | 12 | 3035. | 25000. | 3033. |
| 1 | 16 | 12 | 3055. | 25000. | 3053. |
| 1 | 17 | 12 | 3065. | 25000. | 3063. |
| 1 | 18 | 12 | 3078. | 25000. | 3075. |
| 1 | 18 | 13 | 3085. | 25000. | 3083. |
| 1 | 19 | 13 | 3090. | 25000. | 3088. |
| 1 | 19 | 14 | 3100. | 25000. | 3098. |
| 1 | 20 | 14 | 3115. | 25000. | 3113. |
| 1 | 21 | 15 | 3125. | 55000. | 3123. |
| 1 | 22 | 15 | 3140. | 55000. | 3138. |
| 1 | 23 | 15 | 3150. | 55000. | 3148. |
| 1 | 24 | 15 | 3160. | 55000. | 3158. |
| 1 | 24 | 16 | 3175. | 55000. | 3173. |
| 1 | 25 | 16 | 3190. | 55000. | 3188. |
| 1 | 25 | 17 | 3216. | 55000. | 3214. |
| 1 | 26 | 17 | 3230. | 55000. | 3228. |
| 1 | 26 | 18 | 3240. | 55000. | 3238. |
| 1 | 27 | 18 | 3255. | 55000. | 3253. |
| 1 | 27 | 19 | 3270. | 60000. | 3268. |
| 1 | 28 | 19 | 3280. | 60000. | 3278. |
| 1 | 29 | 20 | 3300. | 60000. | 3298. |
| 1 | 20 | 5 | 3175. | 30867. | 3173. |
| 1 | 19 | 5 | 3135. | 30867. | 3133. |
| 1 | 18 | 5 | 3120. | 30867. | 3118. |
| 1 | 17 | 5 | 3110. | 30996. | 3108. |
| 1 | 16 | 5 | 3095. | 30025. | 3093. |
| 1 | 15 | 5 | 3075. | 30177. | 3073. |
| 1 | 14 | 5 | 3065. | 15715. | 3063. |
| 1 | 13 | 6 | 3040. | 15253. | 3038. |
| 1 | 12 | 6 | 3030. | 12164. | 3027. |
| 1 | 12 | 5 | 3030. | 11544. | 3027. |
| 1 | 11 | 6 | 3020. | 14633. | 3018. |
| 1 | 10 | 6 | 3010. | 15867. | 3008. |
| 1 | 9 | 6 | 3005. | 14633. | 3003. |
| 1 | 9 | 7 | 3002. | 14633. | 3000. |
| 1 | 8 | 7 | 2995. | 16177. | 2993. |
| 1 | 7 | 8 | 2985. | 16947. | 2983. |

MARCH. 1989

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47

| | | | | | |
|---|---|---|---|---|---|
| 1 | 7 | 9 | 2975. | 55976. | 2973 |
| 1 | 8 | 9 | 2985. | 55434. | 2982. |
| 1 | 8 | 10 | 2985. | 55473. | 2982. |
| 1 | 9 | 9 | 2990. | 55000. | 2987. |
| 1 | 9 | 10 | 2990. | 55000. | 2987. |
| 1 | 10 | 10 | 2995. | 55000. | 2992. |
| 1 | 11 | 10 | 2998. | 25000. | 2995. |
| 1 | 12 | 10 | 3005. | 25000. | 3002. |
| 1 | 13 | 11 | 3030. | 25959. | 3027. |
| 1 | 14 | 11 | 3035. | 25539. | 3032. |
| 1 | 15 | 12 | 3035. | 25000. | 3033. |
| 1 | 16 | 12 | 3055. | 25000. | 3053. |
| 1 | 17 | 12 | 3065. | 25000. | 3063. |
| 1 | 18 | 12 | 3078. | 25000. | 3075. |
| 1 | 18 | 13 | 3085. | 25000. | 3083. |
| 1 | 19 | 13 | 3090. | 25000. | 3088. |
| 1 | 19 | 14 | 3100. | 25000. | 3098. |
| 1 | 20 | 14 | 3115. | 25000. | 3113. |
| 1 | 21 | 15 | 3125. | 55000. | 3123. |
| 1 | 22 | 15 | 3140. | 55000. | 3138. |
| 1 | 23 | 15 | 3150. | 55000. | 3148. |
| 1 | 24 | 15 | 3160. | 55000. | 3158. |
| 1 | 24 | 16 | 3175. | 55000. | 3173. |
| 1 | 25 | 16 | 3190. | 55000. | 3188. |
| 1 | 25 | 17 | 3216. | 55000. | 3214. |
| 1 | 26 | 17 | 3230. | 55000. | 3228. |
| 1 | 26 | 18 | 3240. | 55000. | 3238. |
| 1 | 27 | 18 | 3255. | 55000. | 3253. |
| 1 | 27 | 19 | 3270. | 60000. | 3268. |
| 1 | 28 | 19 | 3280. | 60000. | 3278. |
| 1 | 29 | 20 | 3300. | 60000. | 3298. |
| 1 | 20 | 5 | 3175. | 30867. | 3173. |
| 1 | 19 | 5 | 3135. | 30867. | 3133. |
| 1 | 18 | 5 | 3120. | 30867. | 3118. |
| 1 | 17 | 5 | 3110. | 30996. | 3108. |
| 1 | 16 | 5 | 3095. | 30025. | 3093. |
| 1 | 15 | 5 | 3075. | 30177. | 3073. |
| 1 | 14 | 5 | 3065. | 15715. | 3063. |
| 1 | 13 | 6 | 3040. | 15253. | 3038. |
| 1 | 12 | 6 | 3030. | 12164. | 3027. |
| 1 | 12 | 5 | 3030. | 11544. | 3027. |
| 1 | 11 | 6 | 3020. | 14633. | 3018. |
| 1 | 10 | 6 | 3010. | 15867. | 3008. |
| 1 | 9 | 6 | 3005. | 14633. | 3003. |
| 1 | 9 | 7 | 3002. | 14633. | 3000. |
| 1 | 8 | 7 | 2995. | 16177. | 2993. |
| 1 | 7 | 8 | 2985. | 16947. | 2983. |

## APPENDIX F: WATER LEVEL DATA

KEY FOR WATER LEVEL DATA

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| | |
|---|---|
| WELL NUMBER REFERENCED TO FIG. 10 | COORDINATE LOCATION |
| | ELEVATION TO TOP OF CASING (FEET) |
| | CASING HEIGHT (FEET) |

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| DATE | DEPTH BELOW CASING (FEET) | DEPTH BELOW LAND SURFACE REFERENCED TO SEA LEVEL (FEET) |
|---|---|---|

************************************************************

| WELL #33 | 16N20W18CC | | WELL #5 | 16N19W18AAB | | WELL #15 | 16N19W16BAB | |
|---|---|---|---|---|---|---|---|---|
| | | 3095.17 | | | 3256.15 | | | 3379.44 |
| | | -4.10 | | | 1.75 | | | 1.92 |
| | | | 06-Apr-88 | 132.50 | 3123.65 | 06-Apr-88 | 167.40 | 3210.12 |
| 15-Apr-88 | 67.91 | 3031.36 | 19-Apr-88 | 130.56 | 3125.59 | 19-Apr-88 | 157.17 | 3220.35 |
| 19-Apr-88 | 68.31 | 3030.96 | 26-Apr-88 | 128.52 | 3127.63 | 26-Apr-88 | 155.91 | 3221.61 |
| 26-Apr-88 | 67.84 | 3031.43 | 03-May-88 | 125.48 | 3130.67 | 03-May-88 | 155.52 | 3222.00 |
| 03-May-88 | 67.27 | 3032.00 | 10-May-88 | 121.23 | 3134.92 | 10-May-88 | 155.13 | 3222.39 |
| 10-May-88 | 66.69 | 3032.58 | 17-May-88 | 117.17 | 3138.98 | 17-May-88 | 146.29 | 3231.23 |
| 17-May-88 | 65.80 | 3033.47 | 24-May-88 | 113.43 | 3142.72 | 24-May-88 | 144.57 | 3232.95 |
| 24-May-88 | 65.05 | 3034.22 | 01-Jun-88 | 106.02 | 3150.13 | 01-Jun-88 | 137.26 | 3240.26 |
| 01-Jun-88 | 63.11 | 3036.16 | 07-Jun-88 | 104.48 | 3151.67 | 07-Jun-88 | 133.86 | 3243.66 |
| 07-Jun-88 | 62.42 | 3036.85 | 14-Jun-88 | 100.37 | 3155.78 | 14-Jun-88 | 129.80 | 3247.72 |
| 14-Jun-88 | 61.71 | 3037.56 | 21-Jun-88 | 97.11 | 3159.04 | 21-Jun-88 | 130.29 | 3247.23 |
| 21-Jun-88 | 61.98 | 3037.29 | 28-Jun-88 | 95.16 | 3160.99 | 28-Jun-88 | 122.07 | 3255.45 |
| 28-Jun-88 | 60.24 | 3039.03 | 05-Jul-88 | 94.29 | 3161.86 | 05-Jul-88 | 119.62 | 3257.90 |
| 05-Jul-88 | 59.60 | 3039.67 | 19-Jul-88 | 95.20 | 3160.95 | 19-Jul-88 | 119.35 | 3258.17 |
| 19-Jul-88 | 58.44 | 3040.83 | 03-Aug-88 | 96.71 | 3159.44 | 03-Aug-88 | 122.23 | 3255.29 |
| 03-Aug-88 | 58.12 | 3041.15 | 10-Aug-88 | 98.33 | 3157.82 | 10-Aug-88 | 125.57 | 3251.95 |
| 10-Aug-88 | 58.17 | 3041.10 | 24-Aug-88 | 100.77 | 3155.38 | 24-Aug-88 | 133.27 | 3244.25 |
| 24-Aug-88 | 58.99 | 3040.28 | 22-Sep-88 | 110.59 | 3145.56 | 22-Sep-88 | 145.77 | 3231.75 |
| 22-Sep-88 | 60.47 | 3038.80 | 17-Oct-88 | 115.90 | 3140.25 | 17-Oct-88 | 151.44 | 3226.08 |
| 17-Oct-88 | 60.86 | 3038.41 | 03-Dec-88 | 123.35 | 3132.80 | 03-Dec-88 | 168.08 | 3209.44 |
| 03-Dec-88 | 63.90 | 3035.37 | 21-Jan-89 | 130.09 | 3126.06 | 21-Jan-89 | 161.57 | 3215.95 |
| 21-Jan-89 | 68.02 | 3031.25 | | | | 10-Mar-89 | 165.48 | 3212.04 |
| 10-Mar-89 | 69.47 | 3029.80 | | | | 30-Mar-89 | 155.66 | 3221.86 |

| WELL #36 | 16N19W6BBB | | WELL #28 | 16N20W11DBC | | WELL #2 | 16N19W18BBB | |
|---|---|---|---|---|---|---|---|---|
| | | 3149.05 | | | 3104.52 | | | 3194.76 |
| | | 1.75 | | | 1.79 | | | 1.83 |
| 06-Apr-88 | 102.93 | 3044.37 | | | | 06-Apr-88 | 77.76 | 3115.17 |
| 15-Apr-88 | 101.32 | 3045.98 | | | | 19-Apr-88 | 78.44 | 3114.49 |
| 19-Apr-88 | 103.19 | 3044.11 | 19-Apr-88 | 32.17 | 3070.56 | 26-Apr-88 | 75.70 | 3117.23 |
| 26-Apr-88 | 102.26 | 3045.04 | 26-Apr-88 | 32.02 | 3070.71 | 03-May-88 | 73.70 | 3119.23 |
| 03-May-88 | 100.70 | 3046.60 | 03-May-88 | 32.90 | 3069.83 | 10-May-88 | 71.18 | 3121.75 |
| 10-May-88 | 98.92 | 3048.38 | 10-May-88 | 32.33 | 3070.40 | 17-May-88 | 68.32 | 3124.61 |
| 17-May-88 | 96.80 | 3050.50 | 17-May-88 | 32.22 | 3070.51 | 24-May-88 | 64.88 | 3128.05 |
| 24-May-88 | 94.04 | 3053.26 | 24-May-88 | 32.24 | 3070.49 | 01-Jun-88 | 60.97 | 3131.96 |
| 01-Jun-88 | 90.43 | 3056.87 | 01-Jun-88 | 32.09 | 3070.64 | 07-Jun-88 | 58.19 | 3134.74 |
| 07-Jun-88 | 87.42 | 3059.88 | 21-Jun-88 | 30.72 | 3072.01 | 14-Jun-88 | 56.02 | 3136.91 |
| 14-Jun-88 | 85.78 | 3061.52 | 05-Jul-88 | 30.98 | 3071.75 | 21-Jun-88 | 54.24 | 3138.69 |
| 21-Jun-88 | 83.38 | 3063.92 | 03-Aug-88 | 28.09 | 3074.64 | 28-Jun-88 | 53.73 | 3139.20 |
| 28-Jun-88 | 81.49 | 3065.81 | 10-Aug-88 | 27.72 | 3075.01 | 05-Jul-88 | 54.04 | 3138.89 |
| 05-Jul-88 | 79.77 | 3067.53 | 24-Aug-88 | 27.84 | 3074.89 | 19-Jul-88 | 55.79 | 3137.14 |
| 19-Jul-88 | 78.50 | 3068.80 | 22-Sep-88 | 28.94 | 3073.79 | 03-Aug-88 | 57.46 | 3135.47 |
| 03-Aug-88 | 79.08 | 3068.22 | 17-Oct-88 | 30.25 | 3072.48 | 10-Aug-88 | 59.35 | 3133.58 |
| 10-Aug-88 | 80.99 | 3066.31 | 03-Dec-88 | 30.80 | 3071.93 | 24-Aug-88 | 61.62 | 3131.31 |
| 24-Aug-88 | 81.87 | 3065.43 | 21-Jan-89 | 31.60 | 3071.13 | 22-Sep-88 | 66.32 | 3126.61 |
| 22-Sep-88 | 86.02 | 3061.28 | 30-Mar-89 | 28.96 | 3073.77 | 17-Oct-88 | 69.98 | 3122.95 |
| 17-Oct-88 | 89.39 | 3057.91 | | | | 03-Dec-88 | 71.92 | 3121.01 |
| 03-Dec-88 | 94.73 | 3052.57 | | | | 21-Jan-89 | 77.49 | 3115.44 |
| 21-Jan-89 | 99.22 | 3048.08 | | | | 30-Mar-89 | 76.08 | 3116.85 |
| 10-Mar-89 | 101.47 | 3045.83 | | | | | | |

| WELL #14 | 16N19W9DBC | | WELL #45 | 16N19W8DAB | | WELL #1 | 16N20W13ABA | |
|---|---|---|---|---|---|---|---|---|
| | | 3382.95 | | | 3284.49 | | | 3165.95 |
| | | 1.44 | | | 1.75 | | | -5.80 |
| 06-Apr-88 | 145.10 | 3236.41 | | | | | | |
| 15-Apr-88 | 147.32 | 3234.19 | 15-Apr-88 | 139.50 | 3143.24 | | | |
| 19-Apr-88 | 141.84 | 3239.67 | 26-Apr-88 | 130.16 | 3152.58 | 19-Apr-88 | 57.45 | 3114.30 |
| 26-Apr-88 | 142.38 | 3239.13 | 03-May-88 | 129.25 | 3153.49 | 26-Apr-88 | 54.37 | 3117.38 |
| 03-May-88 | 140.60 | 3240.91 | 10-May-88 | 128.41 | 3154.33 | 03-May-88 | 51.96 | 3119.79 |
| 10-May-88 | 136.06 | 3245.45 | 17-May-88 | 117.18 | 3165.56 | 10-May-88 | 48.51 | 3123.24 |
| 17-May-88 | 129.70 | 3251.81 | 24-May-88 | 107.24 | 3175.50 | 17-May-88 | 45.48 | 3126.27 |
| 24-May-88 | 126.63 | 3254.88 | 01-Jun-88 | 101.42 | 3181.32 | 24-May-88 | 41.27 | 3130.48 |
| 01-Jun-88 | 122.04 | 3259.47 | 07-Jun-88 | 99.56 | 3183.18 | 01-Jun-88 | 37.23 | 3134.52 |
| 07-Jun-88 | 119.80 | 3261.71 | 14-Jun-88 | 93.61 | 3189.13 | 21-Jun-88 | 33.09 | 3138.66 |
| 14-Jun-88 | 117.90 | 3263.61 | 21-Jun-88 | 90.24 | 3192.50 | 17-Oct-88 | 49.87 | 3121.88 |
| 21-Jun-88 | 116.54 | 3264.97 | 28-Jun-88 | 86.75 | 3195.99 | 03-Dec-88 | 50.95 | 3120.80 |
| 28-Jun-88 | 111.74 | 3269.77 | 05-Jul-88 | 86.69 | 3196.05 | 21-Jan-89 | 56.65 | 3115.10 |
| 05-Jul-88 | 111.12 | 3270.39 | 19-Jul-88 | 88.59 | 3194.15 | 30-Mar-89 | 57.22 | 3114.53 |
| 19-Jul-88 | 111.42 | 3270.09 | 03-Aug-88 | 91.09 | 3191.65 | 19-Jul-88 | 78.50 | 3093.25 |
| 03-Aug-88 | 115.04 | 3266.47 | 10-Aug-88 | 93.06 | 3189.68 | 03-Aug-88 | 79.08 | 3092.67 |
| 10-Aug-88 | 118.40 | 3263.11 | 24-Aug-88 | 98.78 | 3183.96 | 10-Aug-88 | 80.99 | 3090.76 |
| 24-Aug-88 | 126.03 | 3255.48 | 22-Sep-88 | 109.52 | 3173.22 | 24-Aug-88 | 81.87 | 3089.88 |
| 22-Sep-88 | 136.33 | 3245.18 | 17-Oct-88 | 119.64 | 3163.10 | 22-Sep-88 | 86.02 | 3085.73 |
| 17-Oct-88 | 140.10 | 3241.41 | 03-Dec-88 | 128.12 | 3154.62 | 17-Oct-88 | 89.39 | 3082.36 |
| 03-Dec-88 | 147.45 | 3234.06 | 21-Jan-89 | 135.70 | 3147.04 | 03-Dec-88 | 94.73 | 3077.02 |
| 21-Jan-89 | 153.40 | 3228.11 | 10-Mar-89 | 128.08 | 3154.66 | 21-Jan-89 | 99.22 | 3072.53 |
| 10-Mar-89 | 147.78 | 3233.73 | 30-Mar-89 | 130.85 | 3151.89 | 10-Mar-89 | 101.47 | 3070.28 |

| WELL #3 | 16N19W18BBA | | WELL #22 | 16N20W13CDD | | WELL #12 | 16N19W16BDD | |
|---|---|---|---|---|---|---|---|---|
| | | 3213.58 | | | 3189.73 | | | 3307.20 |
| | | 1.75 | | | -3.85 | | | 1.92 |
| | | | | | | 06-Apr-88 | 118.10 | 3187.10 |
| | | | | | | 19-Apr-88 | 112.57 | 3192.71 |
| 19-Apr-88 | 89.71 | 3122.12 | 19-Apr-88 | 30.48 | 3163.10 | 26-Apr-88 | 114.39 | 3190.89 |
| 26-Apr-88 | 87.59 | 3124.24 | 26-Apr-88 | 24.26 | 3169.32 | 03-May-88 | 112.32 | 3192.96 |
| 03-May-88 | 85.13 | 3126.70 | 03-May-88 | 20.83 | 3172.75 | 10-May-88 | 110.75 | 3194.53 |
| 10-May-88 | 83.62 | 3128.21 | 10-May-88 | 17.63 | 3175.95 | 17-May-88 | 105.13 | 3200.15 |
| 17-May-88 | 83.50 | 3128.33 | 17-May-88 | 12.40 | 3181.18 | 24-May-88 | 101.48 | 3203.80 |
| 24-May-88 | 79.19 | 3132.64 | 24-May-88 | 12.00 | 3181.58 | 01-Jun-88 | 96.28 | 3209.00 |
| 01-Jun-88 | 76.68 | 3135.15 | 01-Jun-88 | 10.22 | 3183.36 | 07-Jun-88 | 92.85 | 3212.43 |
| 07-Jun-88 | 71.30 | 3140.53 | 21-Jun-88 | 11.60 | 3181.98 | 14-Jun-88 | 90.47 | 3214.81 |
| 14-Jun-88 | 68.60 | 3143.23 | 03-Aug-88 | 17.79 | 3175.79 | 21-Jun-88 | 87.79 | 3217.49 |
| 21-Jun-88 | 76.90 | 3134.93 | 10-Aug-88 | 20.17 | 3173.41 | 28-Jun-88 | 84.34 | 3220.94 |
| 28-Jun-88 | 66.04 | 3145.79 | 24-Aug-88 | 23.48 | 3170.10 | 05-Jul-88 | 84.08 | 3221.20 |
| 05-Jul-88 | 66.47 | 3145.36 | 22-Sep-88 | 26.34 | 3167.24 | 19-Jul-88 | 85.40 | 3219.88 |
| 19-Jul-88 | 67.94 | 3143.89 | 17-Oct-88 | 26.52 | 3167.06 | 03-Aug-88 | 88.40 | 3216.88 |
| 03-Aug-88 | 70.50 | 3141.33 | 03-Dec-88 | 27.01 | 3166.57 | 10-Aug-88 | 90.38 | 3214.90 |
| 10-Aug-88 | 71.16 | 3140.67 | 21-Jan-89 | 30.93 | 3162.65 | 24-Aug-88 | 97.74 | 3207.54 |
| 24-Aug-88 | 73.70 | 3138.13 | 30-Mar-89 | 30.50 | 3163.08 | 22-Sep-88 | 107.76 | 3197.52 |
| 22-Sep-88 | 83.77 | 3128.06 | | | | 17-Oct-88 | 113.97 | 3191.31 |
| 17-Oct-88 | 86.57 | 3125.26 | | | | 03-Dec-88 | 125.74 | 3179.54 |
| 03-Dec-88 | 85.34 | 3126.49 | | | | 21-Jan-89 | 115.25 | 3190.03 |
| 21-Jan-89 | 91.69 | 3120.14 | | | | 30-Mar-89 | 113.82 | 3191.46 |
| 10-Mar-89 | 78.58 | 3133.25 | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| WELL #46 | SCHLIMMER | | WELL #31 | 16N20W2CDC | | WELL #37 | 16N19W7BBB | |
| | | 2948.58 | | | 3040.71 | | | 3190.64 |
| | | 1.50 | | | 0.92 | | | 1.92 |
| 15-Apr-88 | 13.92 | 2933.16 | | | | 15-Apr-88 | 119.17 | 3069.55 |
| 26-Apr-88 | 13.92 | 2933.16 | 19-Apr-88 | 32.92 | 3006.87 | 19-Apr-88 | 117.63 | 3071.09 |
| 03-May-88 | 13.66 | 2933.42 | 26-Apr-88 | 35.07 | 3004.72 | 26-Apr-88 | 119.45 | 3069.27 |
| 10-May-88 | 13.17 | 2933.91 | 03-May-88 | 32.15 | 3007.64 | 03-May-88 | 118.27 | 3070.45 |
| 17-May-88 | 13.10 | 2933.98 | 10-May-88 | 32.09 | 3007.70 | 10-May-88 | 115.54 | 3073.18 |
| 24-May-88 | 12.37 | 2934.71 | 17-May-88 | 31.88 | 3007.91 | 17-May-88 | 111.15 | 3077.57 |
| 01-Jun-88 | 11.88 | 2935.20 | 24-May-88 | 31.75 | 3008.04 | 24-May-88 | 108.96 | 3079.76 |
| 21-Jun-88 | 11.79 | 2935.29 | 01-Jun-88 | 31.31 | 3008.48 | 01-Jun-88 | 106.28 | 3082.44 |
| 05-Jul-88 | 11.61 | 2935.47 | 21-Jun-88 | 30.09 | 3009.70 | 07-Jun-88 | 103.95 | 3084.77 |
| 03-Aug-88 | 12.00 | 2935.08 | 05-Jul-88 | 27.76 | 3012.03 | 14-Jun-88 | 104.00 | 3084.72 |
| 10-Aug-88 | 11.40 | 2935.68 | 03-Aug-88 | 23.25 | 3016.54 | 21-Jun-88 | 102.84 | 3085.88 |
| 24-Aug-88 | 11.57 | 2935.51 | 10-Aug-88 | 22.82 | 3016.97 | 28-Jun-88 | 101.83 | 3086.89 |
| 22-Sep-88 | 12.11 | 2934.97 | 24-Aug-88 | 22.80 | 3016.99 | 05-Jul-88 | 101.34 | 3087.38 |
| 17-Oct-88 | 12.55 | 2934.53 | 22-Sep-88 | 23.59 | 3016.20 | 19-Jul-88 | 100.86 | 3087.86 |
| 03-Dec-88 | 12.97 | 2934.11 | 17-Oct-88 | 24.85 | 3014.94 | 03-Aug-88 | 101.52 | 3087.20 |
| 21-Jan-89 | 13.42 | 2933.66 | 03-Dec-88 | 26.79 | 3013.00 | 10-Aug-88 | 101.93 | 3086.79 |
| 10-Mar-89 | 12.34 | 2934.74 | 21-Jan-89 | 28.35 | 3011.44 | 24-Aug-88 | 103.19 | 3085.53 |
| 30-Mar-89 | 13.55 | 2933.53 | 30-Mar-89 | 32.52 | 3007.27 | 22-Sep-88 | 105.15 | 3083.57 |
| | | | | | | 17-Oct-88 | 106.79 | 3081.93 |
| | | | | | | 03-Dec-88 | 111.67 | 3077.05 |
| | | | | | | 21-Jan-89 | 102.70 | 3086.02 |
| | | | | | | 10-Mar-89 | 115.88 | 3072.84 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| WELL #40 | 16N19W7BAB | | WELL #10 | 16N19W16CBB | | WELL #41 | 16N19W8BAA | |
| | | 3211.23 | | | 3337.65 | | | 3267.89 |
| | | 1.04 | | | 1.71 | | | 0.92 |
| | | | 06-Apr-88 | 42.55 | 3293.39 | | | |
| 15-Apr-88 | 131.21 | 3078.98 | 19-Apr-88 | 40.57 | 3295.37 | 15-Apr-88 | 166.67 | 3100.30 |
| 19-Apr-88 | 129.74 | 3080.45 | 26-Apr-88 | 35.63 | 3300.31 | 19-Apr-88 | 163.03 | 3103.94 |
| 26-Apr-88 | 130.84 | 3079.35 | 03-May-88 | 35.59 | 3300.35 | 26-Apr-88 | 162.70 | 3104.27 |
| 03-May-88 | 129.17 | 3081.02 | 10-May-88 | 32.24 | 3303.70 | 03-May-88 | 159.54 | 3107.43 |
| 10-May-88 | 125.67 | 3084.52 | 17-May-88 | 29.06 | 3306.88 | 17-May-88 | 146.70 | 3120.27 |
| 17-May-88 | 122.30 | 3087.89 | 24-May-88 | 28.96 | 3306.98 | 24-May-88 | 141.86 | 3125.11 |
| 24-May-88 | 117.36 | 3092.83 | 01-Jun-88 | 27.98 | 3307.96 | 01-Jun-88 | 136.86 | 3130.11 |
| 01-Jun-88 | 112.06 | 3098.13 | 07-Jun-88 | 26.85 | 3309.09 | 07-Jun-88 | 39.12 | 3227.85 |
| 07-Jun-88 | 111.57 | 3098.62 | 14-Jun-88 | 27.72 | 3308.22 | 14-Jun-88 | 39.18 | 3227.79 |
| 14-Jun-88 | 109.98 | 3100.21 | 21-Jun-88 | 29.28 | 3306.66 | 21-Jun-88 | 53.85 | 3213.12 |
| 28-Jun-88 | 106.69 | 3103.50 | 28-Jun-88 | 31.70 | 3304.24 | 05-Jul-88 | 123.78 | 3143.19 |
| 05-Jul-88 | 105.78 | 3104.41 | 05-Jul-88 | 30.79 | 3305.15 | 03-Aug-88 | 128.65 | 3138.32 |
| 19-Jul-88 | 105.98 | 3104.21 | 19-Jul-88 | 30.70 | 3305.24 | 10-Aug-88 | 130.33 | 3136.64 |
| 03-Aug-88 | 107.04 | 3103.15 | 03-Aug-88 | 35.29 | 3300.65 | 24-Aug-88 | 133.89 | 3133.08 |
| 10-Aug-88 | 107.62 | 3102.57 | 10-Aug-88 | 37.16 | 3298.78 | 22-Sep-88 | 139.87 | 3127.10 |
| 24-Aug-88 | 109.45 | 3100.74 | 24-Aug-88 | 37.56 | 3298.38 | 17-Oct-88 | 145.21 | 3121.76 |
| 22-Sep-88 | 112.52 | 3097.67 | 22-Sep-88 | 39.03 | 3296.91 | 03-Dec-88 | 152.31 | 3114.66 |
| 17-Oct-88 | 115.94 | 3094.25 | 17-Oct-88 | 40.08 | 3295.86 | 10-Mar-89 | 158.90 | 0.00 |
| 03-Dec-88 | 122.22 | 3087.97 | 03-Dec-88 | 43.61 | 3292.33 | 30-Mar-89 | 160.12 | 3106.85 |
| 21-Jan-89 | 126.50 | 3083.69 | 21-Jan-89 | 46.22 | 3289.72 | | | |
| 10-Mar-89 | 127.34 | 3082.85 | 10-Mar-89 | 41.17 | 3294.77 | | | |
| 30-Mar-89 | 129.51 | 3080.68 | 30-Mar-89 | 34.74 | 3301.20 | | | |

WELL #8 16N19W8CDD 3316.25 2.04

| | | |
|---|---|---|
| 06-Apr-88 | 175.13 | 3139.08 |
| 19-Apr-88 | 174.35 | 3139.86 |
| 26-Apr-88 | 173.25 | 3140.96 |
| 03-May-88 | 169.45 | 3144.76 |
| 10-May-88 | 164.14 | 3150.07 |
| 17-May-88 | 159.02 | 3155.19 |
| 24-May-88 | 150.20 | 3164.01 |
| 01-Jun-88 | 145.95 | 3168.26 |
| 07-Jun-88 | 143.40 | 3170.81 |
| 14-Jun-88 | 138.34 | 3175.87 |
| 21-Jun-88 | 134.52 | 3179.69 |
| 28-Jun-88 | 131.94 | 3182.27 |
| 05-Jul-88 | 130.30 | 3183.91 |
| 19-Jul-88 | 131.82 | 3182.39 |
| 03-Aug-88 | 132.61 | 3181.60 |
| 10-Aug-88 | 134.34 | 3179.87 |
| 24-Aug-88 | 138.15 | 3176.06 |
| 22-Sep-88 | 149.21 | 3165.00 |
| 17-Oct-88 | 154.93 | 3159.28 |
| 03-Dec-88 | 164.44 | 3149.77 |
| 21-Jan-89 | 171.68 | 3142.53 |
| 10-Mar-89 | 175.72 | 3138.49 |
| 30-Mar-89 | 172.45 | 3141.76 |

WELL #27 16N20W12AAC 3096.88 1.83

| | | |
|---|---|---|
| 15-Apr-88 | 20.41 | 3074.64 |
| 19-Apr-88 | 21.90 | 3073.15 |
| 26-Apr-88 | 21.84 | 3073.21 |
| 03-May-88 | 20.49 | 3074.56 |
| 10-May-88 | 14.97 | 3080.08 |
| 17-May-88 | 11.30 | 3083.75 |
| 24-May-88 | 10.22 | 3084.83 |
| 01-Jun-88 | 8.10 | 3086.95 |
| 07-Jun-88 | 8.02 | 3087.03 |
| 14-Jun-88 | 7.74 | 3087.31 |
| 21-Jun-88 | 7.26 | 3087.79 |
| 28-Jun-88 | 7.64 | 3087.41 |
| 05-Jul-88 | 6.95 | 3088.10 |
| 19-Jul-88 | 8.05 | 3087.00 |
| 24-Aug-88 | 7.56 | 3087.49 |
| 22-Sep-88 | 8.95 | 3086.10 |
| 17-Oct-88 | 9.30 | 3085.75 |
| 21-Jan-89 | 16.15 | 3078.90 |
| 30-Mar-89 | 18.70 | 3076.35 |

WELL #4 16N19W18ABB 3243.51 2.20

| | | |
|---|---|---|
| 19-Apr-88 | 108.91 | 3132.40 |
| 26-Apr-88 | 108.92 | 3132.39 |
| 03-May-88 | 106.12 | 3135.19 |
| 10-May-88 | 104.50 | 3136.81 |
| 17-May-88 | 105.95 | 3135.36 |
| 24-May-88 | 103.79 | 3137.52 |
| 01-Jun-88 | 100.18 | 3141.13 |
| 21-Jun-88 | 87.64 | 3153.67 |
| 05-Jul-88 | 86.43 | 3154.88 |
| 03-Aug-88 | 88.88 | 3152.43 |
| 10-Aug-88 | 90.20 | 3151.11 |
| 24-Aug-88 | 92.47 | 3148.84 |
| 22-Sep-88 | 103.42 | 3137.89 |
| 17-Oct-88 | 103.85 | 3137.46 |
| 03-Dec-88 | 114.80 | 3126.51 |
| 21-Jan-89 | 110.70 | 3130.61 |
| 30-Mar-89 | 108.44 | 3132.87 |

WELL #16 16N19W16BAA 3385.48 1.33

| | | |
|---|---|---|
| 06-Apr-88 | 158.45 | 3225.70 |
| 19-Apr-88 | 162.04 | 3222.11 |
| 26-Apr-88 | 155.33 | 3228.82 |
| 03-May-88 | 152.84 | 3231.31 |
| 10-May-88 | 152.28 | 3231.87 |
| 17-May-88 | 146.81 | 3237.34 |
| 24-May-88 | 142.66 | 3241.49 |
| 01-Jun-88 | 138.05 | 3246.10 |
| 07-Jun-88 | 137.27 | 3246.88 |
| 14-Jun-88 | 130.38 | 3253.77 |
| 21-Jun-88 | 126.39 | 3257.76 |
| 28-Jun-88 | 121.90 | 3262.25 |
| 05-Jul-88 | 119.38 | 3264.77 |
| 19-Jul-88 | 118.63 | 3265.52 |
| 03-Aug-88 | 121.51 | 3262.64 |
| 10-Aug-88 | 124.53 | 3259.62 |
| 24-Aug-88 | 132.95 | 3251.20 |
| 22-Sep-88 | 144.96 | 3239.19 |
| 17-Oct-88 | 153.98 | 3230.17 |
| 03-Dec-88 | 162.02 | 3222.13 |
| 21-Jan-89 | 166.24 | 3217.91 |
| 30-Mar-89 | 162.39 | 3221.76 |

WELL #35 16N20W1BDC 3116.49 0.67

| | | |
|---|---|---|
| 15-Apr-88 | 83.65 | 3032.17 |
| 19-Apr-88 | 83.61 | 3032.21 |
| 26-Apr-88 | 84.81 | 3031.01 |
| 03-May-88 | 82.57 | 3033.25 |
| 10-May-88 | 81.84 | 3033.98 |
| 17-May-88 | 80.82 | 3035.00 |
| 24-May-88 | 79.56 | 3036.26 |
| 01-Jun-88 | 78.19 | 3037.63 |
| 07-Jun-88 | 76.72 | 3039.10 |
| 14-Jun-88 | 75.54 | 3040.28 |
| 21-Jun-88 | 75.10 | 3040.72 |
| 28-Jun-88 | 74.22 | 3041.60 |
| 05-Jul-88 | 72.59 | 3043.23 |
| 19-Jul-88 | 72.30 | 3043.52 |
| 03-Aug-88 | 71.66 | 3044.16 |
| 10-Aug-88 | 71.90 | 3043.92 |
| 24-Aug-88 | 73.01 | 3042.81 |
| 22-Sep-88 | 75.03 | 3040.79 |
| 17-Oct-88 | 76.17 | 3039.65 |
| 03-Dec-88 | 79.40 | 3036.42 |
| 21-Jan-89 | 71.58 | 3044.24 |
| 10-Mar-89 | 82.90 | 3032.92 |

WELL #24 16N20W13BBB 3123.81 1.17

| | | |
|---|---|---|
| 19-Apr-88 | 50.32 | 3072.32 |
| 26-Apr-88 | 54.24 | 3068.40 |
| 03-May-88 | 54.38 | 3068.26 |
| 10-May-88 | 53.60 | 3069.04 |
| 17-May-88 | 53.26 | 3069.38 |
| 24-May-88 | 48.93 | 3073.71 |
| 01-Jun-88 | 54.60 | 3068.04 |
| 21-Jun-88 | 51.87 | 3070.77 |
| 05-Jul-88 | 47.37 | 3075.27 |
| 03-Aug-88 | 49.59 | 3073.05 |
| 10-Aug-88 | 52.42 | 3070.22 |
| 24-Aug-88 | 50.44 | 3072.20 |
| 22-Sep-88 | 55.46 | 3067.18 |
| 17-Oct-88 | 53.27 | 3069.37 |
| 03-Dec-88 | 53.48 | 3069.16 |
| 21-Jan-89 | 57.48 | 3065.16 |
| 30-Mar-89 | 53.27 | 3069.37 |

| WELL #42 | 16N19W8BAA | 3301.19<br>1.92 | WELL #19 | 16N19W16AAA | 3407.20<br>1.67 | WELL #18 | 16N19W16ABD | 3393.45<br>1.25 |
|---|---|---|---|---|---|---|---|---|
| | | | 06-Apr-88 | 107.38 | 3298.15 | 06-Apr-88 | 123.40 | 3268.80 |
| 15-Apr-88 | 188.73 | 3110.54 | 19-Apr-88 | 107.83 | 3297.70 | 19-Apr-88 | 123.40 | 3268.80 |
| 19-Apr-88 | 187.37 | 3111.90 | 26-Apr-88 | 107.70 | 3297.83 | 26-Apr-88 | 121.25 | 3270.95 |
| 26-Apr-88 | 184.34 | 3114.93 | 03-May-88 | 103.80 | 3301.73 | 03-May-88 | 121.41 | 3270.79 |
| 03-May-88 | 179.54 | 3119.73 | 10-May-88 | 61.49 | 3344.04 | 10-May-88 | 120.59 | 3271.61 |
| 10-May-88 | 173.06 | 3126.21 | 17-May-88 | 60.11 | 3345.42 | 17-May-88 | 120.38 | 3271.82 |
| 17-May-88 | 165.16 | 3134.11 | 24-May-88 | 59.66 | 3345.87 | 24-May-88 | 115.26 | 3276.94 |
| 24-May-88 | 158.80 | 3140.47 | 01-Jun-88 | 61.42 | 3344.11 | 01-Jun-88 | 106.68 | 3285.52 |
| 01-Jun-88 | 152.66 | 3146.61 | 07-Jun-88 | 60.98 | 3344.55 | 07-Jun-88 | 100.78 | 3291.42 |
| 07-Jun-88 | 151.22 | 3148.05 | 14-Jun-88 | 55.48 | 3350.05 | 14-Jun-88 | 96.84 | 3295.36 |
| 14-Jun-88 | 141.03 | 3158.24 | 21-Jun-88 | 57.20 | 3348.33 | 21-Jun-88 | 90.26 | 3301.94 |
| 21-Jun-88 | 137.33 | 3161.94 | 28-Jun-88 | 58.39 | 3347.14 | 28-Jun-88 | 88.58 | 3303.62 |
| 28-Jun-88 | 133.68 | 3165.59 | 05-Jul-88 | 59.45 | 3346.08 | 05-Jul-88 | 86.58 | 3305.62 |
| 05-Jul-88 | 136.03 | 3163.24 | 19-Jul-88 | 59.70 | 3345.83 | 19-Jul-88 | 86.98 | 3305.22 |
| 19-Jul-88 | 140.60 | 3158.67 | 03-Aug-88 | 67.50 | 3338.03 | 03-Aug-88 | 88.45 | 3303.75 |
| 03-Aug-88 | 144.78 | 3154.49 | 10-Aug-88 | 67.66 | 3337.87 | 24-Aug-88 | 99.03 | 3293.17 |
| 10-Aug-88 | 147.20 | 3152.07 | 24-Aug-88 | 79.69 | 3325.84 | 22-Sep-88 | 107.48 | 3284.72 |
| 24-Aug-88 | 151.99 | 3147.28 | 22-Sep-88 | 98.78 | 3306.75 | 17-Oct-88 | 113.02 | 3279.18 |
| 22-Sep-88 | 159.55 | 3139.72 | 17-Oct-88 | 102.02 | 3303.51 | 03-Dec-88 | 120.08 | 3272.12 |
| 17-Oct-88 | 165.73 | 3133.54 | 03-Dec-88 | 106.25 | 3299.28 | 21-Jan-89 | 123.84 | 3268.36 |
| | | | 30-Mar-89 | 99.78 | 3305.75 | 10-Mar-89 | 124.02 | 3268.18 |
| | | | | | | 30-Mar-89 | 118.51 | 3273.69 |

| WELL #26 | 16N20W12ACD | 3170.03<br>1.21 | WELL #38 | 16N20W12AAC | 3099.94<br>2.58 | WELL #43 | 16N19W9BBC | 3367.82<br>1.75 |
|---|---|---|---|---|---|---|---|---|
| | | | 15-Apr-88 | 30.55 | 3066.81 | 15-Apr-88 | 86.88 | 3279.19 |
| 19-Apr-88 | 94.87 | 3073.95 | 19-Apr-88 | 28.02 | 3069.34 | 19-Apr-88 | 84.41 | 3281.66 |
| 26-Apr-88 | 94.87 | 3073.95 | 26-Apr-88 | 31.62 | 3065.74 | 26-Apr-88 | 81.57 | 3284.50 |
| 03-May-88 | 94.27 | 3074.55 | 03-May-88 | 30.70 | 3066.66 | 03-May-88 | 80.52 | 3285.55 |
| 10-May-88 | 91.59 | 3077.23 | 10-May-88 | 28.02 | 3069.34 | 10-May-88 | 80.49 | 3285.58 |
| 17-May-88 | 88.49 | 3080.33 | 17-May-88 | 24.13 | 3073.23 | 17-May-88 | 80.54 | 3285.53 |
| 24-May-88 | 87.81 | 3081.01 | 24-May-88 | 22.76 | 3074.60 | 24-May-88 | 80.67 | 3285.40 |
| 01-Jun-88 | 83.36 | 3085.46 | 01-Jun-88 | 17.24 | 3080.12 | 01-Jun-88 | 80.65 | 3285.42 |
| 07-Jun-88 | 81.75 | 3087.07 | 07-Jun-88 | 22.59 | 3074.77 | 07-Jun-88 | 81.00 | 3285.07 |
| 14-Jun-88 | 79.64 | 3089.18 | 14-Jun-88 | 19.69 | 3077.67 | 14-Jun-88 | 81.30 | 3284.77 |
| 21-Jun-88 | 77.61 | 3091.21 | 21-Jun-88 | 18.97 | 3078.39 | 21-Jun-88 | 81.05 | 3285.02 |
| 28-Jun-88 | 76.48 | 3092.34 | 28-Jun-88 | 18.28 | 3079.08 | 28-Jun-88 | 81.40 | 3284.67 |
| 19-Jul-88 | 75.26 | 3093.56 | 05-Jul-88 | 17.85 | 3079.51 | 05-Jul-88 | 82.01 | 3284.06 |
| 03-Aug-88 | 76.85 | 3091.97 | 19-Jul-88 | 17.56 | 3079.80 | 19-Jul-88 | 82.72 | 3283.35 |
| 10-Aug-88 | 76.83 | 3091.99 | 03-Aug-88 | 18.30 | 3079.06 | 03-Aug-88 | 85.79 | 3280.28 |
| 24-Aug-88 | 78.26 | 3090.56 | 10-Aug-88 | 18.19 | 3079.17 | 10-Aug-88 | 83.54 | 3282.53 |
| 22-Sep-88 | 81.56 | 3087.26 | 24-Aug-88 | 18.97 | 3078.39 | 24-Aug-88 | 85.50 | 3280.57 |
| 17-Oct-88 | 83.16 | 3085.66 | 22-Sep-88 | 20.27 | 3077.09 | 22-Sep-88 | 84.29 | 3281.78 |
| 03-Dec-88 | 86.20 | 3082.62 | 17-Oct-88 | 21.30 | 3076.06 | 17-Oct-88 | 83.81 | 3282.26 |
| 21-Jan-89 | 91.40 | 3077.42 | 03-Dec-88 | 25.47 | 3071.89 | 03-Dec-88 | 87.46 | 3278.61 |
| 10-Mar-89 | 94.90 | 3073.92 | 21-Jan-89 | 27.60 | 3069.76 | 21-Jan-89 | 85.36 | 3280.71 |
| 30-Mar-89 | 93.03 | 3075.79 | 30-Mar-89 | 28.80 | 3068.56 | 10-Mar-89 | 89.67 | 3276.40 |

| WELL #11 | 16N19W16BDD | | WELL #32 | 17N20W36DCC | | WELL #44 | 16N19W8CAA | |
|---|---|---|---|---|---|---|---|---|
| | | 3357.64 | | | 3046.88 | | | 3211.53 |
| | | 1.92 | | | 1.22 | | | 1.15 |
| | | | 15-Apr-88 | 45.14 | 3000.52 | 15-Apr-88 | 84.47 | 3125.91 |
| 19-Apr-88 | 32.76 | 3322.96 | 19-Apr-88 | 45.25 | 3000.41 | 19-Apr-88 | 83.00 | 3127.38 |
| 26-Apr-88 | 29.95 | 3325.77 | 26-Apr-88 | 45.42 | 3000.24 | 26-Apr-88 | 82.45 | 3127.93 |
| 03-May-88 | 31.60 | 3324.12 | 03-May-88 | 45.22 | 3000.44 | 03-May-88 | 79.42 | 3130.96 |
| 10-May-88 | 28.94 | 3326.78 | 10-May-88 | 44.62 | 3001.04 | 10-May-88 | 73.69 | 3136.69 |
| 17-May-88 | 26.94 | 3328.78 | 17-May-88 | 43.63 | 3002.03 | 17-May-88 | 64.98 | 3145.40 |
| 24-May-88 | 26.88 | 3328.84 | 01-Jun-88 | 40.06 | 3005.60 | 24-May-88 | 59.32 | 3151.06 |
| 01-Jun-88 | 24.70 | 3331.02 | 07-Jun-88 | 39.14 | 3006.52 | 01-Jun-88 | 53.99 | 3156.39 |
| 14-Jun-88 | 20.75 | 3334.97 | 14-Jun-88 | 38.30 | 3007.36 | 07-Jun-88 | 54.62 | 3155.76 |
| 21-Jun-88 | 22.90 | 3332.82 | 21-Jun-88 | 36.98 | 3008.68 | 14-Jun-88 | 49.05 | 3161.33 |
| 28-Jun-88 | 25.62 | 3330.10 | 28-Jun-88 | 35.58 | 3010.08 | 21-Jun-88 | 46.32 | 3164.06 |
| 05-Jul-88 | 25.40 | 3330.32 | 05-Jul-88 | 34.50 | 3011.16 | 28-Jun-88 | 40.44 | 3169.94 |
| 19-Jul-88 | 25.95 | 3329.77 | 19-Jul-88 | 32.43 | 3013.23 | 05-Jul-88 | 43.04 | 3167.34 |
| 03-Aug-88 | 27.82 | 3327.90 | 03-Aug-88 | 31.29 | 3014.37 | 19-Jul-88 | 41.29 | 3169.09 |
| 10-Aug-88 | 28.06 | 3327.66 | 10-Aug-88 | 30.94 | 3014.72 | | | |
| 24-Aug-88 | 29.80 | 3325.92 | 24-Aug-88 | 36.57 | 3009.09 | | | |
| 22-Sep-88 | 33.60 | 3322.12 | 22-Sep-88 | 33.29 | 3012.37 | | | |
| 17-Oct-88 | 35.32 | 3320.40 | 17-Oct-88 | 35.35 | 3010.31 | | | |
| 03-Dec-88 | 39.79 | 3315.93 | 03-Dec-88 | 36.29 | 3009.37 | | | |
| 21-Jan-89 | 37.99 | 3317.73 | 21-Jan-89 | 41.42 | 3004.24 | | | |
| 30-Mar-89 | 29.20 | 3326.52 | 10-Mar-89 | 44.91 | 3000.75 | | | |
| | | | 30-Mar-89 | 46.02 | 2999.64 | | | |

| WELL #13 | 16N19W9CAD | | WELL#17 | 16N19W16ABB | | WELL #29 | 16N20W11ADB | |
|---|---|---|---|---|---|---|---|---|
| | | 3295.24 | | | 3394.62 | | | 3088.27 |
| | | 2.42 | | | 0.75 | | | 2.50 |
| 06-Apr-88 | 69.10 | 3223.72 | 06-Apr-88 | 162.15 | 3231.72 | | | |
| 19-Apr-88 | 63.06 | 3229.76 | 19-Apr-88 | 157.58 | 3236.29 | | | |
| 26-Apr-88 | 62.91 | 3229.91 | 26-Apr-88 | 154.50 | 3239.37 | 19-Apr-88 | 62.17 | 3023.60 |
| 03-May-88 | 61.14 | 3231.68 | 03-May-88 | 153.03 | 3240.84 | 26-Apr-88 | 62.82 | 3022.95 |
| 10-May-88 | 59.72 | 3233.10 | 10-May-88 | 151.24 | 3242.63 | 03-May-88 | 62.32 | 3023.45 |
| 17-May-88 | 54.26 | 3238.56 | 17-May-88 | 147.65 | 3246.22 | 10-May-88 | 62.07 | 3023.70 |
| 24-May-88 | 52.05 | 3240.77 | 24-May-88 | 143.36 | 3250.51 | 17-May-88 | 61.44 | 3024.33 |
| 01-Jun-88 | 47.28 | 3245.54 | 01-Jun-88 | 138.38 | 3255.49 | 24-May-88 | 60.00 | 3025.77 |
| 07-Jun-88 | 45.04 | 3247.78 | 07-Jun-88 | 136.53 | 3257.34 | 01-Jun-88 | 57.57 | 3028.20 |
| 14-Jun-88 | 43.37 | 3249.45 | 14-Jun-88 | 130.89 | 3262.98 | 07-Jun-88 | 55.21 | 3030.56 |
| 21-Jun-88 | 40.64 | 3252.18 | 21-Jun-88 | 125.63 | 3268.24 | 14-Jun-88 | 52.40 | 3033.37 |
| 28-Jun-88 | 37.82 | 3255.00 | 28-Jun-88 | 121.02 | 3272.85 | 21-Jun-88 | 51.98 | 3033.79 |
| 05-Jul-88 | 37.68 | 3255.14 | 05-Jul-88 | 118.48 | 3275.39 | 28-Jun-88 | 48.28 | 3037.49 |
| 19-Jul-88 | 38.88 | 3253.94 | 19-Jul-88 | 118.60 | 3275.27 | 05-Jul-88 | 45.06 | 3040.71 |
| 03-Aug-88 | 41.70 | 3251.12 | 03-Aug-88 | 120.80 | 3273.07 | 19-Jul-88 | 45.43 | 3040.34 |
| 10-Aug-88 | 44.79 | 3248.03 | 10-Aug-88 | 123.89 | 3269.98 | 03-Aug-88 | 44.13 | 3041.64 |
| 24-Aug-88 | 52.43 | 3240.39 | 24-Aug-88 | 131.87 | 3262.00 | 10-Aug-88 | 46.06 | 3039.71 |
| 22-Sep-88 | 61.15 | 3231.67 | 22-Sep-88 | 143.75 | 3250.12 | 24-Aug-88 | 46.74 | 3039.03 |
| 17-Oct-88 | 63.99 | 3228.83 | 17-Oct-88 | 149.32 | 3244.55 | 22-Sep-88 | 51.99 | 3033.78 |
| 03-Dec-88 | 66.55 | 3226.27 | 03-Dec-88 | 153.88 | 3239.99 | 03-Dec-88 | 61.67 | 3024.10 |
| 21-Jan-89 | 67.55 | 3225.27 | 21-Jan-89 | 157.39 | 3236.48 | 21-Jan-89 | 65.80 | 3019.97 |
| 30-Mar-89 | 64.93 | 3227.89 | 10-Mar-89 | 157.48 | 3236.39 | 10-Mar-89 | 68.28 | 3017.49 |
| | | | 30-Mar-89 | 157.10 | 3236.77 | 30-Mar-89 | 70.40 | 3015.37 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| WELL #39 | 16N19W7BBA | | WELL #6 | 16N19W17CCA | | WELL #30 | 16N20W2DDB | |
| | | 3207.90 | | | 3289.42 | | | 3082.56 |
| | | 1.42 | | | -0.50 | | | -5.70 |
| 06-Apr-88 | 129.25 | 3077.23 | | | | | | |
| 15-Apr-88 | 120.90 | 3085.58 | | | | | | |
| 19-Apr-88 | 127.49 | 3078.99 | 19-Apr-88 | 33.46 | 3255.96 | 19-Apr-88 | 56.36 | 3031.92 |
| 26-Apr-88 | 129.32 | 3077.16 | 26-Apr-88 | 31.87 | 3257.55 | 26-Apr-88 | 56.60 | 3031.68 |
| 03-May-88 | 127.59 | 3078.89 | 03-May-88 | 30.13 | 3259.29 | 03-May-88 | 56.32 | 3031.96 |
| 10-May-88 | 123.99 | 3082.49 | 10-May-88 | 28.62 | 3260.80 | 10-May-88 | 56.32 | 3031.96 |
| 17-May-88 | 118.11 | 3088.37 | 17-May-88 | 26.00 | 3263.42 | 17-May-88 | 55.92 | 3032.36 |
| 24-May-88 | 115.93 | 3090.55 | 24-May-88 | 23.56 | 3265.86 | 24-May-88 | 55.60 | 3032.68 |
| 01-Jun-88 | 112.22 | 3094.26 | 01-Jun-88 | 21.41 | 3268.01 | 01-Jun-88 | 54.90 | 3033.38 |
| 07-Jun-88 | 110.60 | 3095.88 | 07-Jun-88 | 19.92 | 3269.50 | 05-Jul-88 | 53.30 | 3034.98 |
| 14-Jun-88 | 109.38 | 3097.10 | 05-Jul-88 | 20.60 | 3268.82 | 19-Jul-88 | 52.73 | 3035.55 |
| 21-Jun-88 | 108.82 | 3097.66 | 19-Jul-88 | 20.19 | 3269.23 | 03-Aug-88 | 51.95 | 3036.33 |
| 28-Jun-88 | 106.79 | 3099.69 | 03-Aug-88 | 21.09 | 3268.33 | 10-Aug-88 | 51.95 | 3036.33 |
| 05-Jul-88 | 106.06 | 3100.42 | 10-Aug-88 | 21.98 | 3267.44 | 24-Aug-88 | 52.26 | 3036.02 |
| 19-Jul-88 | 106.24 | 3100.24 | 24-Aug-88 | 23.44 | 3265.98 | 22-Sep-88 | 52.82 | 3035.46 |
| 03-Aug-88 | 106.99 | 3099.49 | 22-Sep-88 | 26.04 | 3263.38 | 17-Oct-88 | 53.32 | 3034.96 |
| 10-Aug-88 | 107.55 | 3098.93 | 17-Oct-88 | 27.99 | 3261.43 | 03-Dec-88 | 54.07 | 3034.21 |
| 24-Aug-88 | 108.99 | 3097.49 | 03-Dec-88 | 29.20 | 3260.22 | 21-Jan-89 | 55.12 | 3033.16 |
| 22-Sep-88 | 111.58 | 3094.90 | 21-Jan-89 | 33.04 | 3256.38 | 30-Mar-89 | 58.03 | 3030.25 |
| 17-Oct-88 | 114.55 | 3091.93 | | | | | | |
| 03-Dec-88 | 120.49 | 3085.99 | | | | | | |
| 21-Jan-89 | 125.50 | 3080.98 | | | | | | |
| 30-Mar-89 | 126.92 | 3079.56 | | | | | | |

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|---|---|---|---|---|---|---|---|---|
| WELL #21 | 16N19W15BDB | | WELL #9 | 16N19W17ADA | | WELL #20 | 16N19W15CBA | |
| | | 3496.59 | | | 3343.06 | | | 3431.91 |
| | | 1.73 | | | 1.00 | | | 1.92 |
| | | | 06-Apr-88 | 104.70 | 3237.36 | | | |
| 15-Apr-88 | 123.68 | 3371.18 | 19-Apr-88 | 105.71 | 3236.35 | 15-Apr-88 | 76.87 | 3353.12 |
| 19-Apr-88 | 124.13 | 3370.73 | 26-Apr-88 | 101.91 | 3240.15 | 19-Apr-88 | 77.07 | 3352.92 |
| 26-Apr-88 | 123.76 | 3371.10 | 03-May-88 | 95.37 | 3246.69 | 26-Apr-88 | 77.62 | 3352.37 |
| 03-May-88 | 123.97 | 3370.89 | 10-May-88 | 91.15 | 3250.91 | 03-May-88 | 78.00 | 3351.99 |
| 10-May-88 | 124.19 | 3370.67 | 17-May-88 | 88.40 | 3253.66 | 10-May-88 | 77.99 | 3352.00 |
| 17-May-88 | 124.21 | 3370.65 | 24-May-88 | 85.32 | 3256.74 | 17-May-88 | 76.35 | 3353.64 |
| 24-May-88 | 122.54 | 3372.32 | 01-Jun-88 | 82.05 | 3260.01 | 24-May-88 | 74.18 | 3355.81 |
| 01-Jun-88 | 119.68 | 3375.18 | 07-Jun-88 | 81.70 | 3260.36 | 01-Jun-88 | 71.40 | 3358.59 |
| 07-Jun-88 | 117.23 | 3377.63 | 14-Jun-88 | 81.91 | 3260.15 | 07-Jun-88 | 69.19 | 3360.80 |
| 14-Jun-88 | 117.80 | 3377.06 | 21-Jun-88 | 83.21 | 3258.85 | 14-Jun-88 | 66.58 | 3363.41 |
| 21-Jun-88 | 112.33 | 3382.53 | 28-Jun-88 | 77.65 | 3264.41 | 21-Jun-88 | 63.44 | 3366.55 |
| 28-Jun-88 | 111.75 | 3383.11 | 05-Jul-88 | 78.31 | 3263.75 | 28-Jun-88 | 60.62 | 3369.37 |
| 05-Jul-88 | 109.13 | 3385.73 | 19-Jul-88 | 79.26 | 3262.80 | 05-Jul-88 | 58.88 | 3371.11 |
| 19-Jul-88 | 109.70 | 3385.16 | 03-Aug-88 | 82.54 | 3259.52 | 19-Jul-88 | 58.90 | 3371.09 |
| 03-Aug-88 | 107.80 | 3387.06 | 10-Aug-88 | 84.60 | 3257.46 | 03-Aug-88 | 58.28 | 3371.71 |
| 10-Aug-88 | 107.14 | 3387.72 | 24-Aug-88 | 87.90 | 3254.16 | 10-Aug-88 | 57.68 | 3372.31 |
| 24-Aug-88 | 108.68 | 3386.18 | 22-Sep-88 | 95.42 | 3246.64 | 24-Aug-88 | 59.54 | 3370.45 |
| 22-Sep-88 | 108.69 | 3386.17 | 17-Oct-88 | 97.74 | 3244.32 | 22-Sep-88 | 63.43 | 3366.56 |
| 17-Oct-88 | 108.69 | 3386.17 | 03-Dec-88 | 102.05 | 3240.01 | 17-Oct-88 | 65.30 | 3364.69 |
| 03-Dec-88 | 119.12 | 3375.74 | 21-Jan-89 | 108.80 | 3233.26 | 03-Dec-88 | 72.48 | 3357.51 |
| 21-Jan-89 | 121.25 | 3373.61 | 10-Mar-89 | 111.06 | 3231.00 | 21-Jan-89 | 76.35 | 3353.64 |
| 10-Mar-89 | 126.08 | 3368.78 | 30-Mar-89 | 99.75 | 3242.31 | 10-Mar-89 | 78.77 | 3351.22 |

| WELL #34 | 16N20W18CC | 3087.22 | WELL #23 | 16N20W128AC | 3132.71 | WELL #25 | 16N19W7CAB | 3220.79 |
|---|---|---|---|---|---|---|---|---|
| | | 0.50 | | | 1.92 | | | 1.88 |
| 19-Apr-88 | 70.58 | 3016.14 | 19-Apr-88 | 67.51 | 3063.28 | 19-Apr-88 | 126.81 | 3092.11 |
| 26-Apr-88 | 70.56 | 3016.16 | 26-Apr-88 | 66.87 | 3063.92 | 26-Apr-88 | 128.63 | 3090.29 |
| 03-May-88 | 69.74 | 3016.98 | 03-May-88 | 66.83 | 3063.96 | 03-May-88 | 124.13 | 3094.79 |
| 10-May-88 | 68.73 | 3017.99 | 10-May-88 | 61.84 | 3068.95 | 10-May-88 | 119.64 | 3099.28 |
| 17-May-88 | 67.54 | 3019.18 | 17-May-88 | 58.92 | 3071.87 | 17-May-88 | 113.93 | 3104.99 |
| 24-May-88 | 66.05 | 3020.67 | 24-May-88 | 54.85 | 3075.94 | 24-May-88 | 110.20 | 3108.72 |
| 01-Jun-88 | 64.93 | 3021.79 | 01-Jun-88 | 48.79 | 3082.00 | 01-Jun-88 | 106.29 | 3112.63 |
| 07-Jun-88 | 62.44 | 3024.28 | 07-Jun-88 | 45.56 | 3085.23 | 07-Jun-88 | 103.50 | 3115.42 |
| 14-Jun-88 | 61.89 | 3024.83 | 14-Jun-88 | 41.96 | 3088.83 | 14-Jun-88 | 100.75 | 3118.17 |
| 21-Jun-88 | 58.72 | 3028.00 | 21-Jun-88 | 40.27 | 3090.52 | 21-Jun-88 | 98.49 | 3120.43 |
| 28-Jun-88 | 57.19 | 3029.53 | 28-Jun-88 | 39.09 | 3091.70 | 28-Jun-88 | 99.22 | 3119.70 |
| 05-Jul-88 | 55.70 | 3031.02 | 05-Jul-88 | 38.85 | 3091.94 | 05-Jul-88 | 96.60 | 3122.32 |
| 19-Jul-88 | 53.28 | 3033.44 | 19-Jul-88 | 38.90 | 3091.89 | 19-Jul-88 | 96.95 | 3121.97 |
| 03-Aug-88 | 53.51 | 3033.21 | 03-Aug-88 | 40.41 | 3090.38 | 03-Aug-88 | 97.66 | 3121.26 |
| 10-Aug-88 | 52.17 | 3034.55 | 10-Aug-88 | 42.24 | 3088.55 | 10-Aug-88 | 98.37 | 3120.55 |
| 24-Aug-88 | 53.15 | 3033.57 | 24-Aug-88 | 45.68 | 3085.11 | 24-Aug-88 | 99.30 | 3119.62 |
| 17-Oct-88 | 58.82 | 3027.90 | 22-Sep-88 | 51.74 | 3079.05 | 22-Sep-88 | 103.08 | 3115.84 |
| 03-Dec-88 | 62.80 | 3023.92 | 17-Oct-88 | 55.37 | 3075.42 | 17-Oct-88 | 108.82 | 3110.10 |
| 21-Jan-89 | 66.55 | 3020.17 | 03-Dec-88 | 58.80 | 3071.99 | 03-Dec-88 | 115.60 | 3103.32 |
| 10-Mar-89 | 70.40 | 3016.32 | 21-Jan-89 | 63.92 | 3066.87 | 21-Jan-89 | 123.07 | 3095.85 |
| 30-Mar-89 | 69.35 | 3017.37 | 30-Mar-89 | 65.79 | 3065.00 | 30-Mar-89 | 125.38 | 3093.54 |

| WELL #7 | 16N19W8CBC | 3282.19 |
|---|---|---|
| | | 1.71 |
| 19-Apr-88 | 164.55 | 3115.93 |
| 26-Apr-88 | 161.87 | 3118.61 |
| 03-May-88 | 158.68 | 3121.80 |
| 10-May-88 | 151.84 | 3128.64 |
| 17-May-88 | 144.75 | 3135.73 |
| 24-May-88 | 139.85 | 3140.63 |
| 01-Jun-88 | 134.49 | 3145.99 |
| 07-Jun-88 | 130.32 | 3150.16 |
| 14-Jun-88 | 126.40 | 3154.08 |
| 21-Jun-88 | 123.18 | 3157.30 |
| 28-Jun-88 | 120.71 | 3159.77 |
| 05-Jul-88 | 119.47 | 3161.01 |
| 19-Jul-88 | 120.08 | 3160.40 |
| 03-Aug-88 | 121.35 | 3159.13 |
| 10-Aug-88 | 122.90 | 3157.58 |
| 24-Aug-88 | 124.02 | 3156.46 |
| 22-Sep-88 | 125.77 | 3154.71 |
| 17-Oct-88 | 145.45 | 3135.03 |
| 03-Dec-88 | 154.08 | 3126.40 |
| 21-Jan-89 | 118.12 | 3162.36 |

# APPENDIX G: AQUIFER TEST DATA

AQUIFER TEST DATA - WELL MW

| TIME | DRAWDOWN |
|---|---|
| .38 | 3.02 |
| .72 | 3.21 |
| .88 | 2.94 |
| 1.12 | 2.98 |
| 1.38 | 2.99 |
| 1.68 | 2.97 |
| 2.00 | 3.02 |
| 2.33 | 3.02 |
| 2.75 | 3.03 |
| 2.92 | 3.12 |
| 3.28 | 3.08 |
| 3.62 | 3.02 |
| 4.12 | 3.07 |
| 4.67 | 3.12 |
| 5.22 | 3.09 |
| 6.02 | 3.08 |
| 6.57 | 3.10 |
| 7.22 | 3.07 |
| 7.82 | 3.09 |
| 8.50 | 3.10 |
| 9.23 | 3.09 |
| 10.00 | 3.11 |
| 12.00 | 3.15 |
| 14.00 | 3.10 |
| 16.15 | 3.14 |
| 18.23 | 3.17 |
| 20.10 | 3.17 |
| 25.70 | 3.16 |
| 30.00 | 3.11 |
| 35.00 | 3.11 |
| 40.00 | 3.11 |
| 45.00 | 3.11 |
| 50.00 | 3.11 |
| 60.00 | 3.11 |
| 70.00 | 3.11 |
| 80.00 | 3.11 |
| 90.00 | 3.11 |
| 95.00 | 3.11 |
| 100.00 | 3.11 |
| 110.00 | 3.11 |