

DAN DR
WASHOE CO.

1506-00035

Quantitative analysis
of groundwater flow
in Spanish Springs Valley,
Washoe County, Nevada

University of Nevada
Reno

Quantitative analysis of groundwater flow
in Spanish Springs Valley,
Washoe County, Nevada

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science in
Hydrology/Hydrogeology

by

Amy K. Hadiaris

December, 1988

ACKNOWLEDGMENTS

Funding for this project was provided by the Washoe County Utility Division, and the author would like to express her gratitude to the many people in that office for their assistance during this undertaking. Special thanks are offered to Dan Dragan of the Utility Division and Donald Mahin of the Washoe County Department of Comprehensive Planning for their guidance and support, and also to Moni Fox for applying her drafting skills to this project. Additional advice and editorial assistance was received from the author's thesis committee: Dr. Michael E. Campana of the Desert Research Institute and the University of Nevada, Reno; Dr. James R. Carr of the Department of Geological Sciences; and Dr. F. Donald Tibbitts of the School of Medicine.

Quantitative analysis of groundwater flow
in Spanish Springs Valley,
Washoe County, Nevada

By Amy K. Hadiaris

ABSTRACT

A steady-state groundwater flow model is used to investigate groundwater flow in Spanish Springs Valley. The flow system in the alluvial aquifer is dominated by a groundwater mound created by secondary recharge from the Orr Ditch. The simulated groundwater budget for pre-pumping conditions includes 600 acre-feet per year (acre-ft/yr) recharge from precipitation and 2200 acre-ft/yr recharge from the Orr Ditch. Recharge from precipitation is concentrated in the southeast, where highly transmissive fractured basalts allow rapid infiltration and movement of groundwater. Evapotranspiration of 2400 acre-ft/yr is the major outflow; underflow to the Truckee Meadows and Warm Springs Valley accounts for 100 and 300 acre-ft/yr, respectively. Net basin pumping in 1987 was approximately 700 acre-ft/yr. Forecasted drawdowns for a net pumping rate of 1740 acre-ft/yr ranged from 0 to 42 feet when Orr Ditch recharge was 2200 acre-ft/yr, and from 2 to 48 feet when ditch recharge was reduced by 30 percent.

CONTENTS

	Page
ACKNOWLEDGMENTS	ii
ABSTRACT	iii
LIST OF ILLUSTRATIONS	1
LIST OF TABLES	3
INTRODUCTION	4
Objectives	4
Location and geographic features	6
Previous investigations	10
Numbering system for hydrologic sites	14
HYDROGEOLOGIC SETTING	15
Hydrostratigraphic units	15
Geologic history and structural features	20
Valley-fill thickness	26
HYDROLOGIC SETTING	30
Description of water budget components	30
Groundwater recharge	31
Recharge from precipitation	31
The Orr Ditch	42
Groundwater discharge	49
Evapotranspiration	49
Spanish Spring	51
Subsurface outflow	52
Pumping	54
Groundwater quality	57
SIMULATION ANALYSIS OF GROUNDWATER FLOW	60
Conceptual model of the groundwater flow system	60
Mathematical model development	61
Model structure	61
Model grid	63
Historical water levels and steady-state assumption	65
Steady-state model development and calibration	69
Boundary conditions and control heads	69
Hydraulic conductivity	70
Recharge from precipitation	77
Recharge from the Orr Ditch	79
Evapotranspiration	80
Subsurface outflow	82
Calibrated groundwater budget and potentiometric surface	86

	Page
Sensitivity analysis	90
Aquifer characteristics	94
Evapotranspiration parameters	95
Precipitation recharge	96
Orr Ditch recharge	98
Subsurface outflow	99
Accuracy of model results	100
Model application	102
Pumping scenarios	102
Results	106
 SUMMARY AND CONCLUSIONS	115
 REFERENCES CITED	120
 APPENDIX A: Orr Ditch flow data	123
 APPENDIX B: Selected water quality data	153
 APPENDIX C: Historical water-level data.....	158
 APPENDIX D: TRIAG groundwater flow model	167
 APPENDIX E: Calibrated data input file and results ..	183

ILLUSTRATIONS

	Page
Figure 1. Location of study area, surrounding valleys, and Great Basin	5
2. Geographic features of Spanish Springs Valley	7
3. Orr Ditch/North Truckee Drain system	9
4. Hydrostratigraphic units for Spanish Springs Valley	16
5. Major faults in study area	24
6. Depth-to-bedrock contours from Spanish Springs Valley gravity survey.....	28
7. Isohyetal map for Spanish Springs Valley ...	34
8. Location of precipitation gages used to develop precipitation-altitude relationship.	35
9. Diagram showing relationship between precipitation (p) and water yield (y)	38
10. Contours of equal water yield	40
11. Mean annual water yield of hydrographic sub-areas	41
12. Irrigated cropland and pasture	43
13. Location of stream gages along the Orr Ditch/North Truckee Drain	45
14. Location of subdivisions and major pumping wells	55
15. Finite element grid used in groundwater flow model	64
16. Location of wells which have historical water-level data	67
17. Location and values of control heads	71
18. Location of pumping tests in Spanish Springs Valley	73

	Page
19. Original distribution of hydraulic conductivity	75
20. Calibrated distribution of hydraulic conductivity	76
21. Original and calibrated distribution and rates of recharge from precipitation ...	78
22. Original and calibrated distribution and rates of recharge from the Orr Ditch ...	81
23. Calibrated distribution and simulated rates of evapotranspiration	83
24. Calibrated steady-state potentiometric surface	88
25. Difference between calibrated heads and control heads	89
26. Location of pumping wells in predictive simulations	105
27. Simulated steady-state drawdowns for net basin pumpage of 720 AF/YR and ditch recharge of 2225 AF/YR	108
28. Simulated steady-state drawdowns for net basin pumpage of 1740 AF/YR and ditch recharge of 2225 AF/YR	109
29. Simulated steady-state drawdowns for net basin pumpage of 1740 AF/YR and ditch recharge of 1560 AF/YR	112
30. Potentiometric map for scenario 3	113

TABLES

	Page
1. Average flow data for the Orr Ditch and North Truckee Drain: 1977 through 1987	46
2. Approximate pumpage for selected wells in Spanish Springs Valley in 1987	56
3. Derivation of values for control heads	72
4. Preliminary and calibrated groundwater budgets	87
5. Summary of groundwater flow model sensitivity analysis	91
6. Summary of pumping scenarios	104
7. Summary of simulation results	107

INTRODUCTION

Spanish Springs Valley is an alluvial basin in western Nevada which lies within the Great Basin section of the Basin and Range Province (Figure 1). Increased development in Spanish Springs Valley during recent years has focused attention on the groundwater resources of the area and the potential impacts of future growth on water levels in the valley. This study was launched in an attempt to quantify current groundwater conditions in the alluvial aquifer. Much new data has accumulated since the last basin-wide study of Spanish Springs Valley in 1967, including field data collected by the author during the summer of 1987. This study refines previous estimates of the groundwater budget and provides a planning tool to aid in the optimum development of water resources in Spanish Springs Valley.

Objectives

The objectives of this study are to: 1) refine the conceptual model of the hydrologic system of Spanish Springs Valley; 2) characterize the quality of groundwater in the basin; 3) develop a mathematical model of the groundwater flow system in the alluvial aquifer; 4) quantify recharge to and discharge from the groundwater reservoir, including the effect of the Orr Ditch on water levels in the valley; and 5) use the calibrated model to evaluate different groundwater

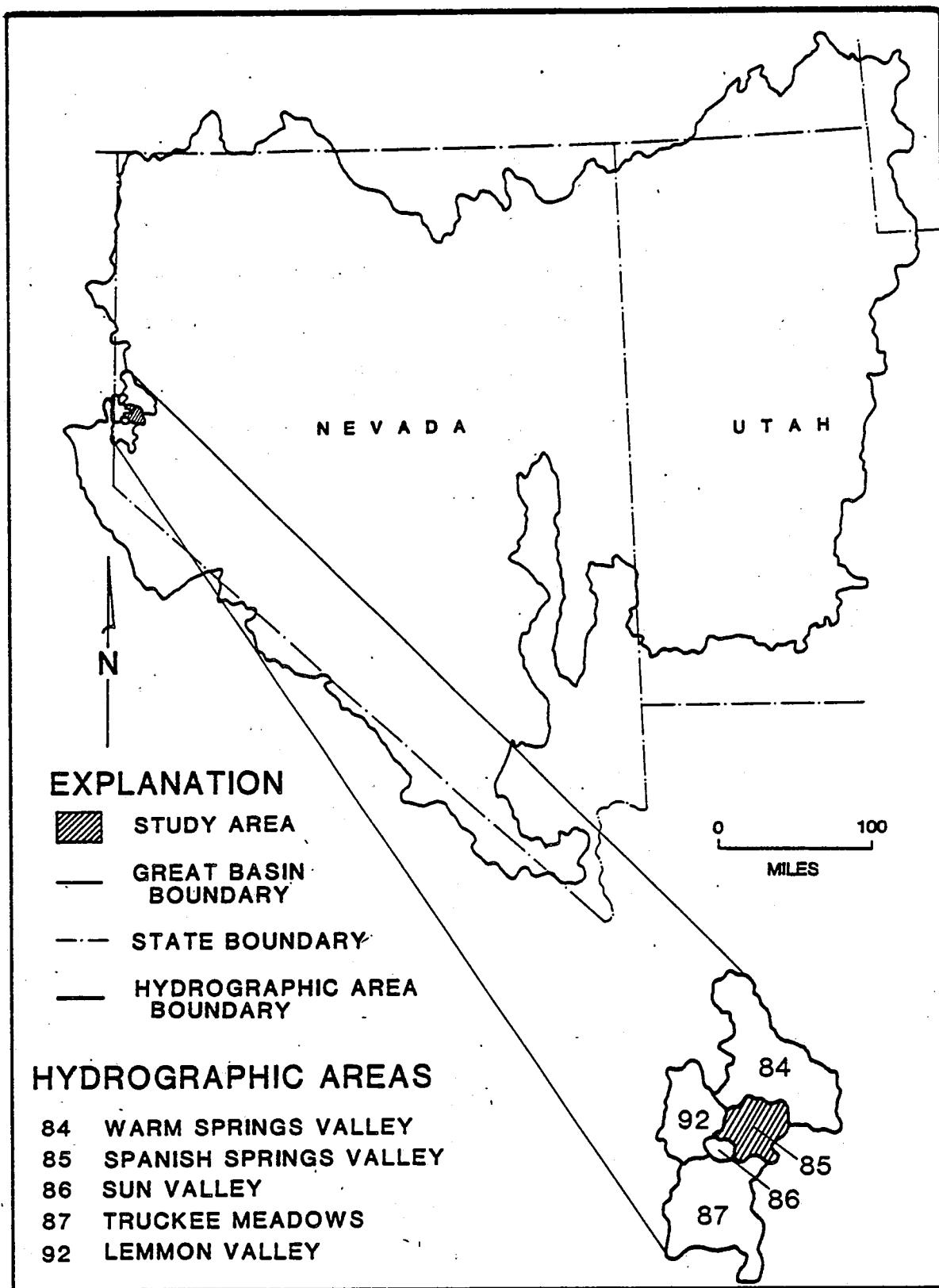


FIGURE 1. Location of study area, surrounding valleys, and Great Basin (modified from Eakin and others, 1976, Figure 1).

management scenarios.

Location and geographic features

Spanish Springs Valley is an alluvial basin located in northwest Nevada, one mile north of the city of Sparks (Figure 2). The watershed encompasses approximately 76 square miles in the southern part of Washoe County. The hydrographic basin is approximately 11 miles long from north to south, and its width ranges from 12 miles at its midpoint to 2 miles near the north end of the valley. Access to Spanish Springs Valley is provided by Nevada State Highway 445 (Pyramid Lake Highway), which runs through the valley from south to north, and Spanish Springs Road, which completes a loop in the southern portion of the valley.

Spanish Springs Valley was named after a spring which discharges from the alluvium in the vicinity of Spanish Springs Ranch. The valley is bounded on the east by mountains of the Pah Rah Range, including Spanish Springs Peak, the highest point in the watershed with an elevation of 7404 feet above sea level. At the southern end of the range lies the Dry Lakes, a closed depression with no surface water drainage to the main valley. Hungry Ridge forms a steep topographic divide in the northwest. The mountain ridges in the northern part of the basin are often greater than 6000 feet above sea level and generally rise 1500 to 3000 feet

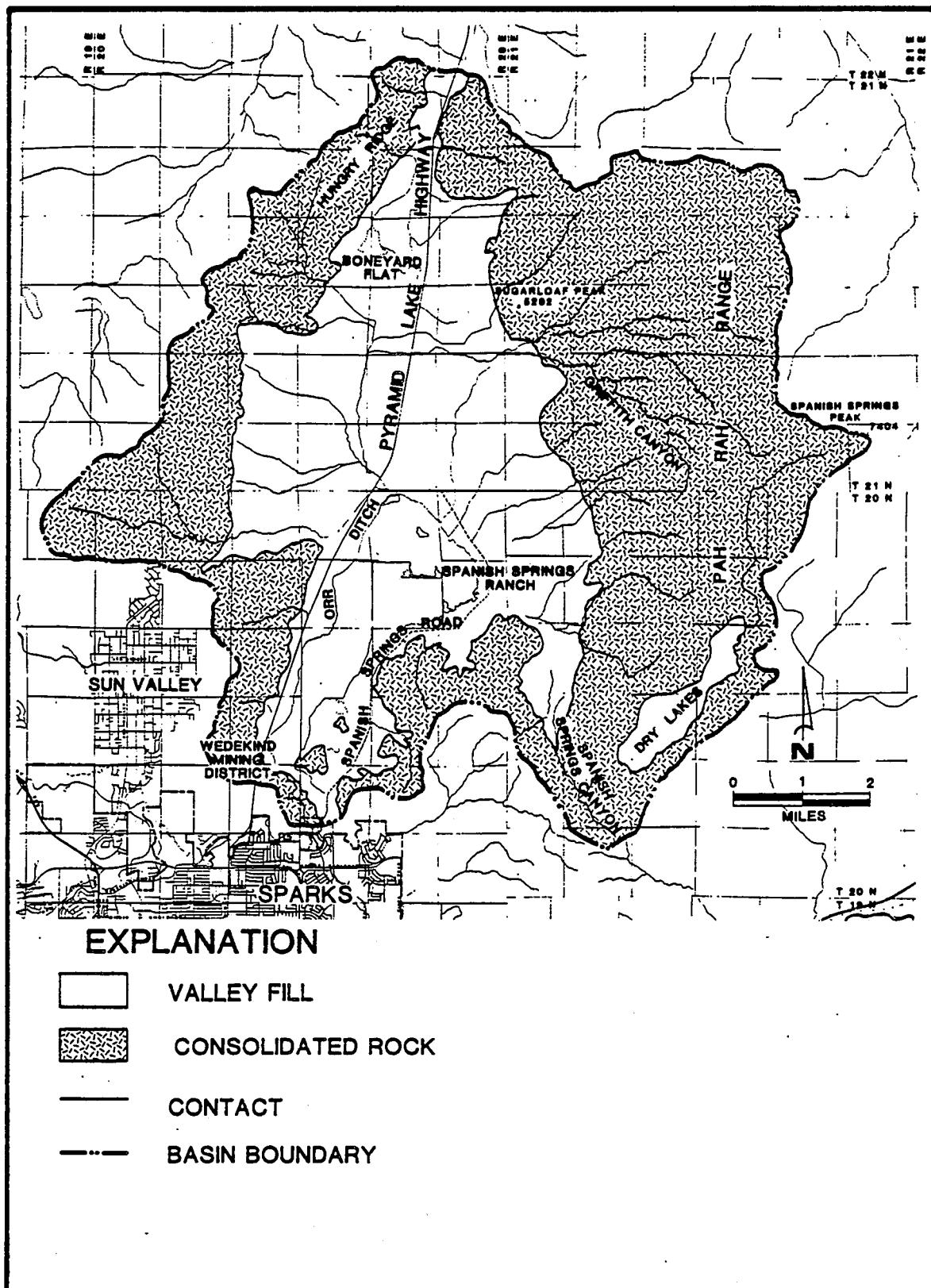


FIGURE 2. Geographic features of Spanish Springs Valley.

above the valley floor. To the southwest the valley is bounded by a group of unnamed hills which comprise the old Wedekind Mining District. Topographic relief in this area is approximately 600 feet. A low pass at the north end of Spanish Springs Valley separates it from Warm Springs Valley, and in the south a narrow outlet leads to the Truckee Meadows.

The area of the valley floor beneath the bedrock-alluvium contact is approximately 26 square miles. In the far north the elevation of the valley floor is 4600 feet. The lowest elevation in the valley, 4420 feet, occurs at the southern outlet. The slope of the valley floor ranges from over 80 feet per mile in the far north to less than 20 feet per mile for most of the valley. A low alluvial ridge in the northern part of the valley has created a small topographically closed segment. The area north of a line extending west from Sugarloaf Peak has internal drainage to a small playa called Boneyard Flat (Rush and Glancy, 1967, p. 8).

There are no natural perennial streams in the watershed, although during intense storms or periods of rapid snowmelt some surface-water runoff may reach the valley floor. The stream which drains from Spanish Springs Valley to the Truckee Meadows consists of excess irrigation water which was brought into the valley by the Orr Ditch (Figure 3).

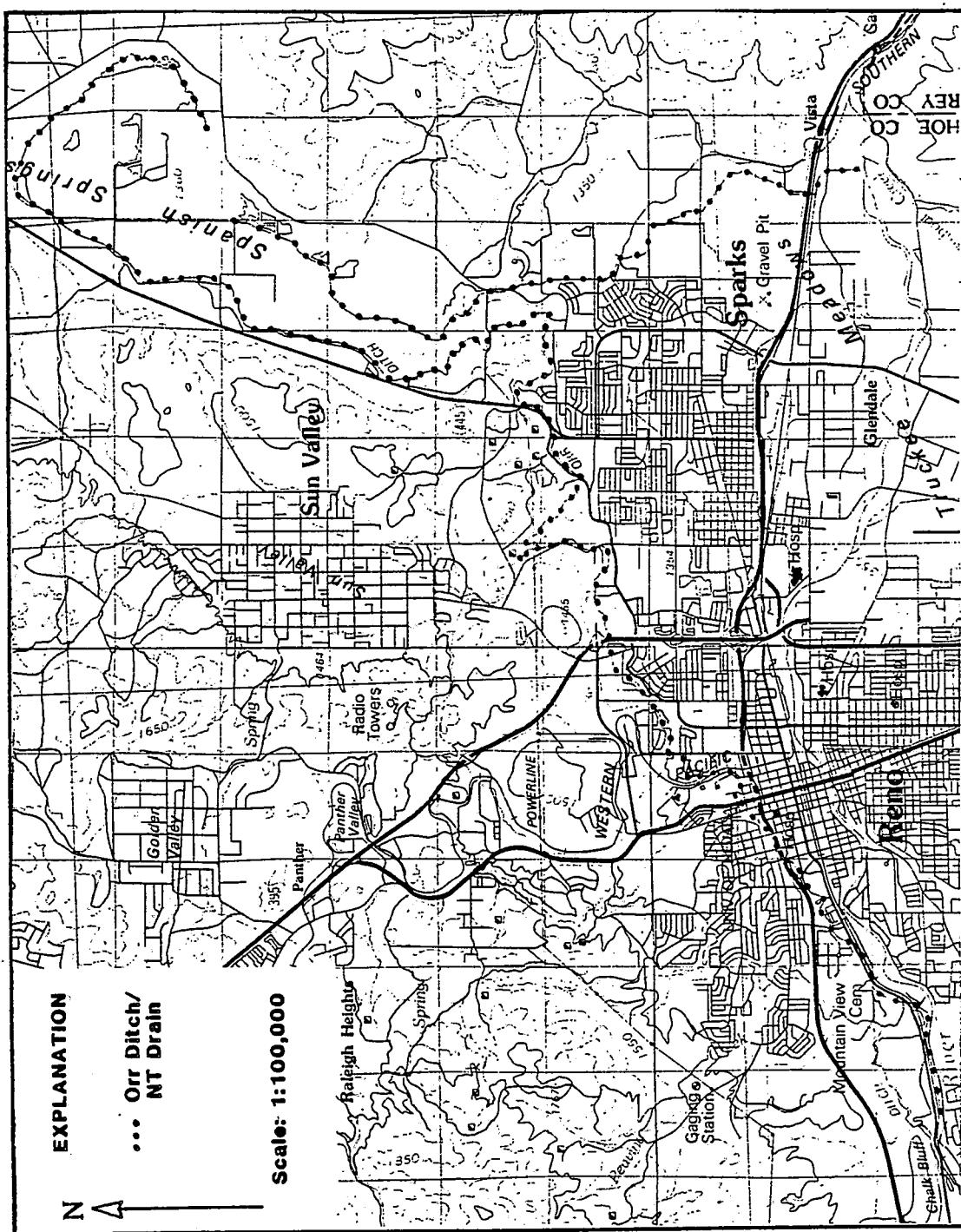


FIGURE 3. Orr Ditch/North Truckee Drain system

Due to the importance of the Orr Ditch on the hydrologic regime of Spanish Springs Valley, a few comments are in order about the history of the ditch. Around 1870 a rancher in the Truckee Meadows by the name of Henry Orr began to divert water from the Truckee River in the vicinity of Chalk Bluff to his ranch approximately three miles away. In 1873 a group of ranchers paid Orr \$500 in gold for the ditch and began the task of lengthening and enlarging the canal to accommodate their own irrigation needs (Nevada State Journal, 1879). By the mid 1870's the ditch was supplying irrigation water to several ranches in the Truckee Meadows. Ranchers who had settled in Spanish Springs Valley began making plans to continue the canal northward, and in 1878 the Orr Ditch Extension had been completed (Nevada State Journal, 1879).

Today, the Orr Ditch continues to supply ranchers in the southern part of Spanish Springs Valley with water imported from the Truckee River. This additional source of groundwater recharge has had a major influence on the groundwater flow pattern and water levels in the valley. Excess irrigation water flows from the valley back to the Truckee River via the North Truckee Drain.

Previous investigations

Four previous studies that describe the hydrology of Spanish Springs Valley are Robinson and Phoenix (1948),

Guyton and Associates (1964), Rush and Glancy (1967), and Cochran (1972). Robinson and Phoenix (1948) discuss the general geology and water-bearing properties of rocks in Spanish Springs Valley and neighboring Sun Valley. Their study included field measurements of depth to water in the few wells existing at that time. From this limited data they concluded that a local groundwater mound had developed in the vicinity of the Orr Ditch and that the water table sloped to the north in the area north of the ditch. They identified the Orr Ditch as the major source of recharge to the basin, and recognized that the amount of groundwater which may be recovered in the future depended upon the quantity of water supplied by the ditch. Several components of the water budget were estimated; those items of particular interest are summarized below:

Evapotranspiration in the area served by the Orr Ditch	3000 acre-feet/yr
Evaporation from ponds	600 acre-feet/yr
Recharge from precipitation	500 acre-feet/yr
Subsurface outflow	negligible

William F. Guyton and Associates (1964) prepared a report for Sierra Pacific Power Company describing groundwater conditions in Spanish Springs Valley. Their study included an inventory of wells in the valley, collection and analysis of nine water quality samples, pumping tests of two existing wells, and drilling of three test holes to depths of 461, 862 and 1141 feet. Based on the estimates of natural discharge and precipitation recharge

made by Robinson and Phoenix (1948), they quantified recharge from the Orr Ditch as approximately 3000 acre-feet per year.

Rush and Glancy (1967) included Spanish Springs Valley in a reconnaissance water-resources study of eleven valleys in northwest Nevada. They describe the overall hydrologic setting of the valley and present a preliminary water budget for natural basin conditions:

Runoff from the mountains	1500 acre-feet/yr
Recharge from precipitation	600 acre-feet/yr
Evapotranspiration of groundwater	900 acre-feet/yr
Subsurface outflow to Truckee Meadows	100 acre-feet/yr

Because they were more confident in their estimate of discharge than recharge, Rush and Glancy chose a value of 1000 acre-feet per year to represent inflow to and outflow from the groundwater reservoir. They also list water level and elevation data for selected wells throughout the valley, but offer a different picture of the groundwater flow system than that provided by Robinson and Phoenix (1948). Rush and Glancy state on page 12 that "...all groundwater in the northern part of the valley, except for a small amount discharged by evapotranspiration, flows southward to the discharge area."

Cochran (1972) prepared a hydrogeologic report on the Spanish Springs Ranch area. He concluded that the flowing wells at the Ranch are due to the presence of a fault in the underlying alluvium which restricts the flow of groundwater

moving from the east to the valley axis. Field data collected during his study indicate that artesian pressure in the wells ranges from about 2 feet to 7 feet above land surface.

Water-resources investigations of valleys adjacent to Spanish Springs Valley include: Warm Springs Valley (Glenn, 1968), Lemmon Valley (Harrill, 1973 and Mahin, 1988), and the Truckee Meadows (Cohen and Loeltz, 1964 and Van Denburgh and others, 1973).

Several regional studies offer information about the geologic setting of Spanish Springs Valley. Stewart (1980) describes the stratigraphy and geologic history of Nevada. More detailed stratigraphic descriptions and a geologic map of Washoe County (scale 1:250,000) are provided by Bonham (1969) in his treatise on the geology and mineral deposits of Washoe County. Hudson (1977) describes the geology and alteration of the Wedekind Mining District which lies in the hills between Spanish Springs Valley and Sun Valley. Trexler and Pease (1980) compiled a geologic map of the Vista quadrangle (scale 1:24,000) which includes the southern portion of Spanish Springs Valley.

Numbering system for hydrologic sites

The numbering system used in this study is based on the Mount Diablo Meridian and Base Line which governs the rectangular subdivision of lands in Nevada. Each location number consists of three units. The first unit is the number of the township north of the Mount Diablo Base Line. The second unit, separated from the first by a slanted line, is the number of the range east of the Mount Diablo Meridian. The third unit, separated from the second by a dash, is the section number followed by four letters identifying the quarter sections. Quarter sections are labelled "A" through "D" in a counterclockwise direction, beginning with "A" for the northeast quarter section. If the third unit ends in a number, then more than one well has the same township, range, and section identification.

HYDROGEOLOGIC SETTING

Hydrostratigraphic units

The identification of hydrostratigraphic units is based not only on specific lithologic characteristics but also on parameters that govern the movement, storage, and release of groundwater. Consolidated rocks in the basin have been divided into four hydrostratigraphic units (Figure 4). These units are: 1) Mesozoic intrusive rocks, composed primarily of granodiorite; 2) Tertiary andesite flows, which have been hydrothermally altered; 3) highly fractured Tertiary basalts; and 4) Pliocene sedimentary rocks. The sedimentary rocks consist of a variety of fluvial and lacustrine deposits containing varying amounts of volcanic debris of contemporaneous origin. Quaternary valley-fill forms a fifth hydrostratigraphic unit.

Hungry Ridge and the hills bordering the northeast side of the valley are composed primarily of Mesozoic intrusive rocks. The most common rock type is a porphyritic granodiorite containing phenocrysts of plagioclase, biotite, and hornblende in a medium to fine-grained matrix of quartz and microcline (Bonham, 1969, p. 8). Given the low porosity and permeability of these rocks, it is likely that this unit acts as a barrier to groundwater flow. Also included in this hydrostratigraphic unit are several erosional remnants of the

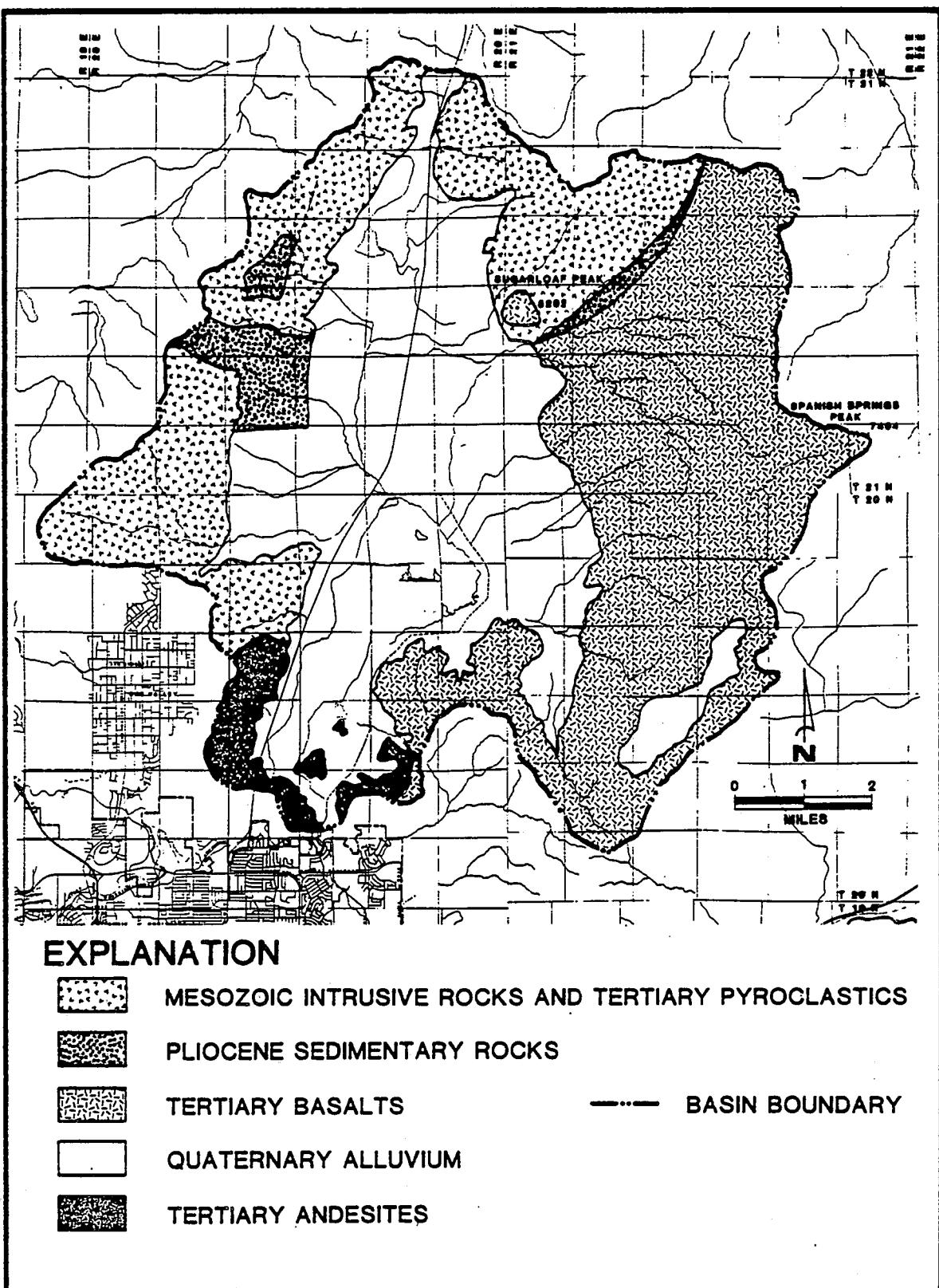


FIGURE 4. Hydrostratigraphic units for Spanish Springs Valley.

Hartford Hill Rhyolite, which unconformably overlie the granodiorite, and a few isolated outcrops of the Peavine Sequence. Welded ash-flow tuffs and other pyroclastic rocks of Miocene age comprise the bulk of the Hartford Hill Rhyolite (Bonham, 1969, p. 23). The Peavine Sequence consists of Triassic and Jurassic metamorphic rocks which occur as small roof pendants in the granitic rocks or in small erosional "windows" surrounded by the Hartford Hill Rhyolite (Bonham, 1969, p. 7).

Tertiary andesite flows in Spanish Springs Valley belong to the Alta Formation and are the host rock for silver and gold orebodies that were mined in the early 1900's (Bonham, 1969, p. 91). Outcrops of these volcanic rocks are confined to the hills in the southwest, but they also underlie the alluvium at shallow depths at the south end of the valley. The Alta Formation reaches its maximum thickness of 2700 feet in the Comstock Lode district and thins markedly in all directions away from Virginia City (Bonham, 1969, p. 25). Hudson (1977, p. 19) believes that the thickness of these flows may be at least 700 feet in the Spanish Springs Valley area. The unaltered flows are composed of phenocrysts of plagioclase and varying proportions of pyroxene and hornblende in a very fine-grained matrix. A zone of hydrothermal alteration, approximately one mile wide from north to south, has created a mineral assemblage which includes a variety of sulfide minerals (Bonham, 1969, p. 92).

The degree of alteration decreases to the north (Bonham, 1969, p. 92). Near the surface, the flows have been extensively bleached due to the development of sulfuric acid from the oxidation of pyrite (Bonham, 1969, p. 25). The resultant rock is a mixture of quartz, iron oxides, and clay minerals (Bonham, 1969, p. 92). Bonham (1969, p. 91) gives a brief history of the Wedekind mine which brings to light certain hydrogeologic properties of this formation. The original mill, east of Pyramid Lake Road, was designed to treat the oxide ores found in the zone of bleached rock. In 1903 the main shaft encountered "hot acid water" at a depth of 213 feet. A 150 gallon per minute pump was able to hold the water level at 100 feet, but the flow of hot water, combined with the sulfide ores encountered at shallow depth, made the operation unprofitable. The hydraulic conductivity of these rocks depends on the density and interconnection of fractures within them and the degree of alteration; this hydrostratigraphic unit has acquired some degree of secondary permeability. Recent water quality analyses from various wells drilled near the south end of the valley indicate that the groundwater associated with this hydrostratigraphic unit is of very poor quality.

Highly fractured olivine basalt flows of middle to upper Pliocene age comprise the third hydrostratigraphic unit. These volcanic rocks form the southern part of the Pah Rah Range which bounds the east side of Spanish Springs Valley.

The total thickness of flows in this area is in excess of 1000 feet, but individual flows are relatively thin, averaging between 15 and 20 feet (Bonham, 1969, p. 39). They dip toward the valley at an angle of 10 to 15 degrees (Robinson and Phoenix, 1948, p. 10). Flow tops are highly vesicular, and some flows have a well-developed platy flow-parting (Bonham, 1969, p. 39) which creates zones of high permeability parallel to the flows. In addition, rapid cooling of the lava created numerous interconnected cooling joints. These characteristics combine to give this hydrostratigraphic unit a very high transmissivity.

Pliocene sedimentary rocks in Spanish Springs Valley crop out in the western hills and east of Sugarloaf Peak. In addition, they are thought to underlie Quaternary alluvium throughout much of the valley. These deposits include a variety of rock types, such as fine-grained sandstone, shale, mudstone, and siltstone. The transmissive properties of this hydrostratigraphic unit are quite low due to the abundance of fine-grained sediments. Robinson and Phoenix (1948, p. 10) describe the outcrop which rests on the basalt slopes east of Sugarloaf Peak as being composed of yellow to white clays and silts with well-defined bedding. Rounded pebbles embedded in clay form a basal conglomerate. Local lenses of diatomite which contain abundant plant remains indicate a depositional environment of a shallow lake or marsh (Bonham, 1969, p. 38). Much of the clastic debris in these sedimentary rocks is

derived from nearby volcanics; in places, the sedimentary deposits are interfingered with basalt flows and beds of basalt tuff (Bonham, 1969, p. 38). Many formation names have been applied locally to similiar outcrops of Pliocene sedimentary rocks throughout northwest Nevada. Although the Pliocene sedimentary rocks in the Spanish Springs Valley area have not been formally named, they have been correlated with the Truckee Formation (Robinson and Phoenix, 1948) and the Coal Valley Formation (Bonham, 1969).

Quaternary alluvium, eroded from the surrounding mountains, partially fills the structural basin created by late Cenozoic faulting. The sorting and grain size of the valley-fill material vary both laterally and vertically. The deposits grade from coarse gravel near the mountains to fine-grained sediments in the center of the valley. Local lenses of gravel and sand in the valley-fill material create zones of greater permeability. Also included in this hydrostratigraphic unit are old alluvial fan deposits on the west side of the valley which Bonham (1969, p. 40) dates as Pre-Lake Lahontan. These deposits are deeply weathered and have been faulted and tilted.

Geologic history and structural features

The Paleozoic history of the Spanish Springs Valley area is virtually unknown because outcrops of these early rocks

are absent in Washoe County. Studies of pre-Mesozoic rocks that crop out in eastern and central Nevada suggest that Washoe County was the site for the deposition of eugeosynclinal facies volcanic and sedimentary rocks throughout the Paleozoic (Bonham, 1969, p. 42).

The geologic history recorded in rocks of Mesozoic age begins with members of the Peavine Sequence, which were deposited during the Triassic and Jurassic. These rocks suggest that the early Mesozoic was characterized by the deposition of sediments in a marine environment, followed by a period of volcanism during which unknown thicknesses of lava flows and pyroclastics were extruded (Cohen and Loeltz, 1964, p. S16). The complex structures preserved in rocks of the Peavine Sequence reveal that these rocks were intensely folded, faulted, and metamorphosed during an episode of late Mesozoic deformation (Bonham, 1969, p. 42). These metamorphosed sedimentary and volcanic rocks were intruded by large granitic plutons during the Cretaceous Period (Bonham, 1969 p. 42). The hills which border Spanish Springs Valley to the west and the north are composed primarily of granodiorite emplaced during the late Mesozoic. A small outcrop of the host metasedimentary and metavolcanic rocks occurs at the northern boundary of the watershed.

Sparse outcrops of Paleocene and Eocene sedimentary rocks throughout the state indicate that Nevada was elevated

and undergoing erosion during the early Tertiary (Stewart, 1980, p. 105). Major igneous activity began in Nevada 43 million years ago, but the oldest volcanic rocks in Washoe County were extruded between 34 and 17 million years ago (Stewart, 1980). The late Oligocene and early Miocene was characterized by voluminous eruptions of rhyolitic ash-flow tuffs and, to a lesser extent, andesitic lava flows (Stewart, 1980, p. 100). Several small outcrops of the Hartford Hill Rhyolite can be found at the north end of Spanish Springs Valley. These erosional remnants rest unconformably on the granitic rocks of the Cretaceous period (Bonham, 1969, p. 52). The Alta Formation, which consists of andesite flows and breccias, forms the low hills in the southwest part of the watershed.

The period from 17 to 6 million years ago brought major changes in the volcanic activity and tectonic setting of Nevada (Stewart, 1980, p. 110). The late Miocene and Pliocene was characterized by the widespread eruption of mafic lava, mostly basalt, and bimodal assemblages of rhyolite and basalt (Stewart, 1980, p. 102). This change in the composition of volcanic rocks is represented in the Spanish Springs Valley area by the basalt flows which form Spanish Springs Peak and the hills in the southeast part of the watershed. Stewart (1980, p. 98) points out that this change in volcanic activity probably reflected a fundamental change in the tectonic setting of Nevada. About this time

extensional block-faulting began which eventually produced the major basins and ranges which characterize the present-day topography (Stewart, 1980, p. 110).

Sedimentary rocks deposited during the Pliocene also reflect this changing tectonic setting. Cohen and Loeltz (1964) describe the depositional history of these rocks. The sediments were deposited in the structural basins created during the early stages of Cenozoic block-faulting. Displacement along normal faults disrupted the regional drainage system, and shallow lakes were formed in these early basins. Intensified movement along these faults at a later date caused drainage of the lakes.

Several of the faults which outlined the present topography of Spanish Springs Valley can be dated as late as Pleistocene. Figure 5 shows the location of major faults in the Spanish Springs Valley hydrographic basin. Bonham (1969, p. 39) states that the present outline of the Pah Rah Range was blocked out during the Pleistocene. Several faults cut these middle to upper Pliocene basalt flows; Bonham (1969, p. 39) estimates at least 1000 feet of vertical movement along these faults. A conspicuous basin and range fault scarp parallels the range bordering the northwest side of the valley. Offset of the Hartford Hill Rhyolite on Hungry Ridge indicates a minimum dip-slip displacement of 1500 feet (Bonham, 1969, p. 52). This fault is believed to continue

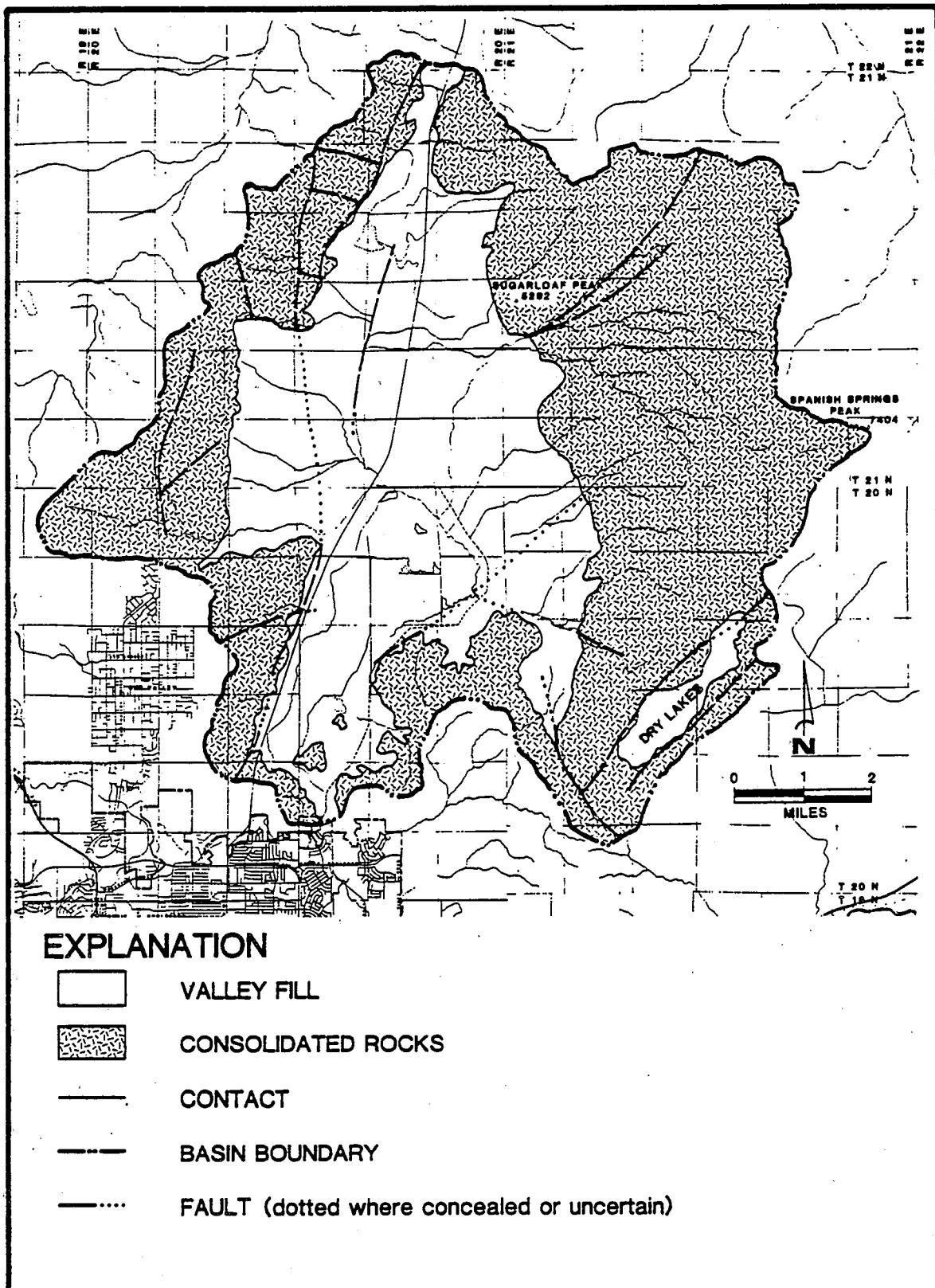


FIGURE 5. Major faults in study area. (modified from Bonham, 1969; Cochran, 1972; and Trexler and Pease, 1980)

southward along the entire west side of the valley (Robinson and Phoenix, 1948, p. 10). Trexler and Pease (1980, p. 21) state that the north-northeast trending faults which bound Spanish Springs Valley on the west exhibit movement as late as mid-Pleistocene. Although it is difficult to place an age on the faults in the northwest, displacement along the major fault does offset old alluvial fan deposits further south which Bonham (1969, p. 40) dates as Quaternary Pre-Lake Lahontan deposits.

One fault of particular interest is the northeast-trending fault which cuts the alluvium in the northwest part of the valley. Although not recorded on existing geologic maps of the area, this fault is apparent on aerial photos and from inspection of stream drainages on the topographic map which covers that part of the valley. If this fault is younger than the lower Pliocene sedimentary rocks, which seems likely, then this could be an area where the low transmissivity deposits have dropped far below land surface. The fact that these sedimentary rocks are exposed in the hills bordering the valley makes it clear that significant tectonic activity has occurred since their deposition.

Snyder and others (1964) show Spanish Springs Valley as having been occupied by a Pleistocene lake, but no evidence exists to support their conclusion. The lack of shoreline features and Pleistocene lake deposits, and the fact that the

basin is not topographically closed, make it unlikely that the basin contained a lake during the Pleistocene. The map of pluvial lakes prepared by Mifflin and Wheat (1979) refutes the existence of a number of lakes shown on this earlier map, including the one shown in Spanish Springs Valley.

Valley-fill thickness

Thickness of the alluvial aquifer was estimated in order to define the lower boundary of the valley-fill groundwater system. Estimates of valley-fill thickness were made by comparing depth-to-bedrock contours derived from a gravity survey with numerous driller's logs throughout the valley.

The Spanish Springs Valley gravity survey was conducted in 1982 by the U.S. Geological Survey Water Resources Division in Carson City, Nevada. The resultant bedrock topography was based on approximately 95 gravity measurements distributed along 7 east-west transects across the valley.

Kearey and Brooks (1984) discuss the application of gravity surveys to the investigation of subsurface geology. Briefly, before the results of a gravity survey can be interpreted it is necessary to correct the data for all variations in the gravitational field which do not result from the differences in density of the underlying rocks. The

gravity measurements are corrected for latitude, elevation, and topographic relief to obtain Bouguer gravity anomalies. The regional gravity gradient is subtracted from the Bouguer anomaly field to isolate the influence of local subsurface features on the gravitational field. These residual gravity anomalies are then interpreted in terms of depth to bedrock. The calculated basement profile is based on a density contrast between the valley fill deposits and the underlying rocks. "Basement" denotes the analytical surface down to which the valley fill sediments would have to extend to produce the observed gravity anomaly (Gimlett, 1967, p. 24). Computed depth to bedrock is sensitive to the choice of density contrast; as assumed density contrast increases, the computed depth to bedrock decreases.

Figure 6 shows the depth-to-bedrock contours derived from the Spanish Springs Valley gravity survey. Computed maximum thickness of the valley fill--approximately 1000 feet--occurs in the northwest part of the basin. The bedrock in this area appears to form a deep trough. Comparison of Figures 5 and 6 show the axis of the trough to be collinear with the previously described fault in the alluvium, which lends further support to the theory that in this area, the low transmissivity lake deposits may have dropped far below land surface. Several test holes have been drilled in the region between the fault and Pyramid Lake Highway; thick clay layers were encountered at a shallow depth. No exploratory

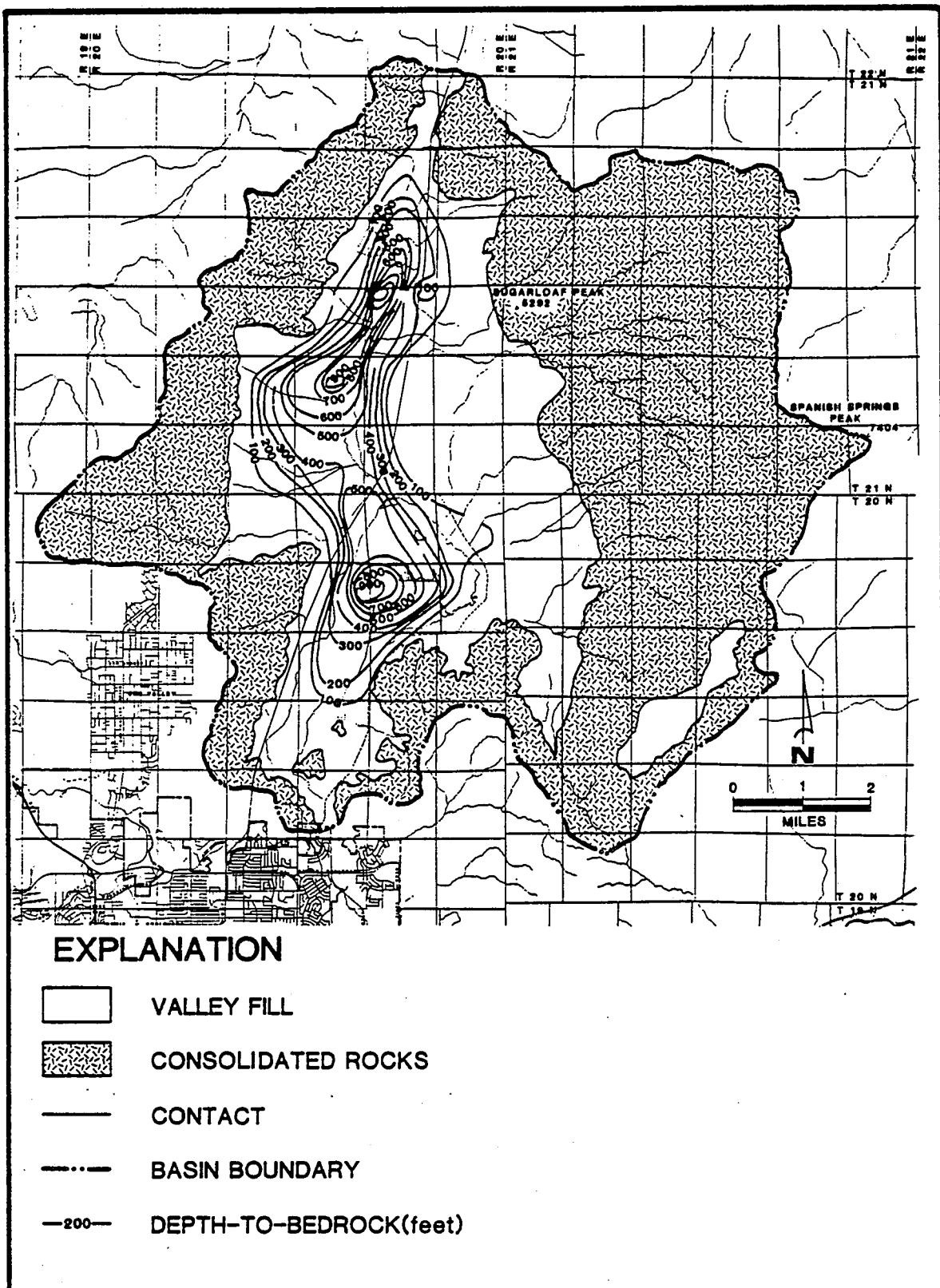


FIGURE 6. Depth-to-bedrock contours from Spanish Springs Valley gravity survey.

drilling has been done in the vicinity of the fault, however. The author believes this area worthy of future exploration. If the trough has accumulated thick sequences of coarse-grained sediments, it could be a potential site for an artificial recharge project in Spanish Springs Valley, should one become necessary in the future.

Comparison of depth-to-bedrock contours and driller's lithologic logs reveal a poor correlation between computed thickness and field data in the eastern portion of the basin. Several test holes drilled east of the 100-foot contour, for example, penetrate up to 500 feet of sediments before reaching bedrock. A possible explanation for this error is the choice of density contrast used in depth-to-bedrock calculations. Although the value is not documented, 0.5 grams per cubic centimeter is often used to represent the density contrast between valley-fill and bedrock (D. Schaefer, U.S. Geological Survey, pers. commm., 1988). It is unlikely that density contrast would be constant throughout the entire valley due to heterogeneities in the valley-fill and differences in the composition of bedrock. Granitic rocks in the west probably have a greater density than the vesicular volcanic rocks in the east. Using too great a density contrast in the east would have underestimated the thickness of the valley-fill.

HYDROLOGIC SETTING

Description of water budget components

Inflow of water to Spanish Springs Valley is from precipitation that falls on the watershed and from imported water brought into the valley by the Orr Ditch. Eakin and others (1976, p. G10) estimate that for many drainage basins in Nevada, approximately 3 to 7 percent of total precipitation becomes groundwater recharge. Infiltration of water applied for irrigation and leakage along the unlined Orr Ditch are secondary sources of recharge to the valley-fill aquifer. No evidence exists for subsurface inflow from adjacent basins.

Evapotranspiration is the major outflow of water from Spanish Springs Valley. Most of the precipitation which falls on the watershed is evapotranspired before it is able to become groundwater recharge. In addition, the high water table in the area served by the Orr Ditch supports a large community of phreatophytes. Groundwater discharge from Spanish Spring mixes with water from the Orr Ditch and is either evapotranspired or carried out of the valley by the North Truckee Drain, which is the only outflow of surface water. The author believes that subsurface flow from Spanish Springs Valley to adjacent basins occurs at both the north and south ends of the valley. Consumptive use of water

pumped from wells is becoming an increasingly important outflow from the groundwater system.

Groundwater recharge

Recharge from precipitation

Many variables influence the amount of groundwater recharge from precipitation, including climate, the spatial and temporal distribution of precipitation, and the geologic and hydrologic characteristics of the consolidated rocks and valley-fill material.

The Spanish Springs Valley watershed lies in a climatic zone known as mid-latitude steppe, which is characterized by cold winters, hot summers, and semi-arid rainfall conditions (Houghton and others, 1975, p. 69). Most of the precipitation falls during the winter and early spring, with an occasional thunderstorm in the summer. The nearest precipitation gage, located at the Reno airport, has an elevation approximately 100 feet below the average altitude of the valley floor in Spanish Springs Valley. Average annual precipitation at this station is 7.33 inches (Klieforth and others, 1983).

The precipitation pattern in Nevada is controlled primarily by topography. Precipitation increases with

altitude due to the effect of decreasing temperature on the percent saturation of a rising air mass. Greater precipitation in the mountains provides most of the recharge; that portion of precipitation and surface water runoff that is not evapotranspired reaches the valley-fill aquifer by infiltration of runoff on permeable alluvial fans, subsurface flow through the alluvium in mountain canyons, and lateral underflow from the consolidated rocks which border the valley. The porosity and permeability of near-surface geologic units therefore play an important role in determining the amount of groundwater recharge. Recharge rates will be significantly higher in areas where rocks with high permeabilities crop out, whereas reduced recharge and increased runoff will occur in areas underlain by low permeability units.

Because there are no precipitation gages within the Spanish Springs Valley watershed, estimates of basin-wide precipitation rely on various methods which take advantage of the relationship between precipitation and altitude. Rush and Glancy (1967, p. 23) estimate an average annual precipitation of 30,000 acre-feet, based on the precipitation-altitude relation shown by Hardman's (1965) precipitation map of Nevada. Their preliminary estimate of 600 acre-feet per year of groundwater recharge is based on a method devised by Eakin and others (1951) which assumes that a certain percentage of precipitation becomes recharge for

each of several elevation zones. This value is in close agreement with the reconnaissance-level estimate of 500 acre-feet per year groundwater recharge made by Robinson and Phoenix (1948).

Klieforth and others (1983) constructed a precipitation map for Spanish Springs Valley using an empirical relationship between precipitation and elevation (Figure 7). Because the drainage pattern of the watershed influences the distribution of groundwater recharge, Figure 7 also shows the hydrographic sub-areas of the basin.

The isohyetal map of Spanish Springs Valley is based on a precipitation-altitude relation that was developed for the Truckee River Basin. Historical rainfall and snowfall measurements from 37 precipitation gages located throughout the Truckee River Basin and adjacent areas of Washoe County were analyzed to determine the areal distribution of precipitation (Klieforth and others, 1983). The locations of these gages are shown in Figure 8; the reader is referred to the original report for a complete listing of the precipitation data used to develop this relationship. Application of this pattern to the Spanish Springs Valley watershed involves the implicit assumption that the same correlation exists between precipitation and altitude. It is possible that the Spanish Springs Valley watershed receives less precipitation at a given elevation than the study area

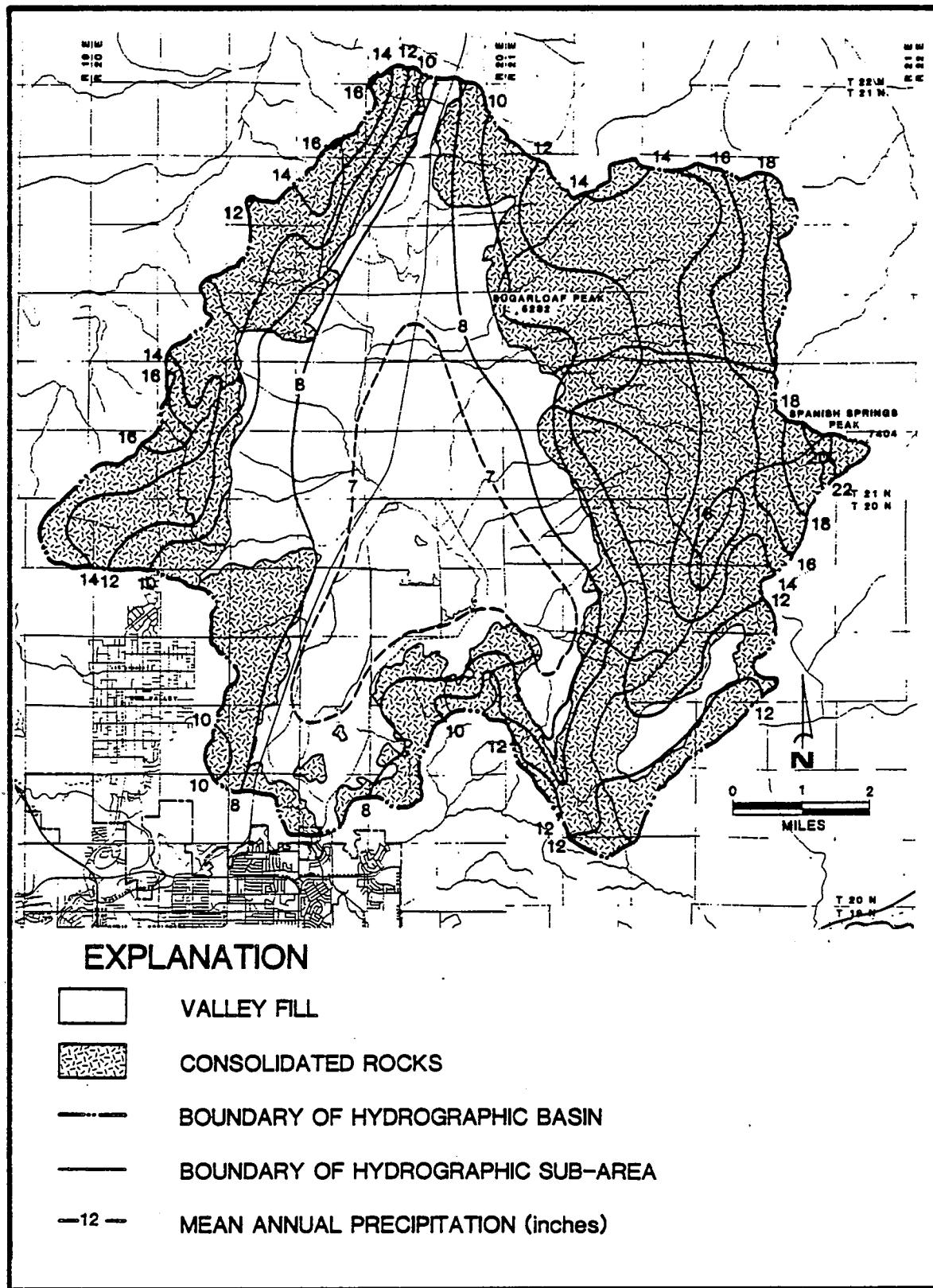


FIGURE 7. Isohyetal map for Spanish Springs Valley.
(modified from Klieforth, et. al., 1983)

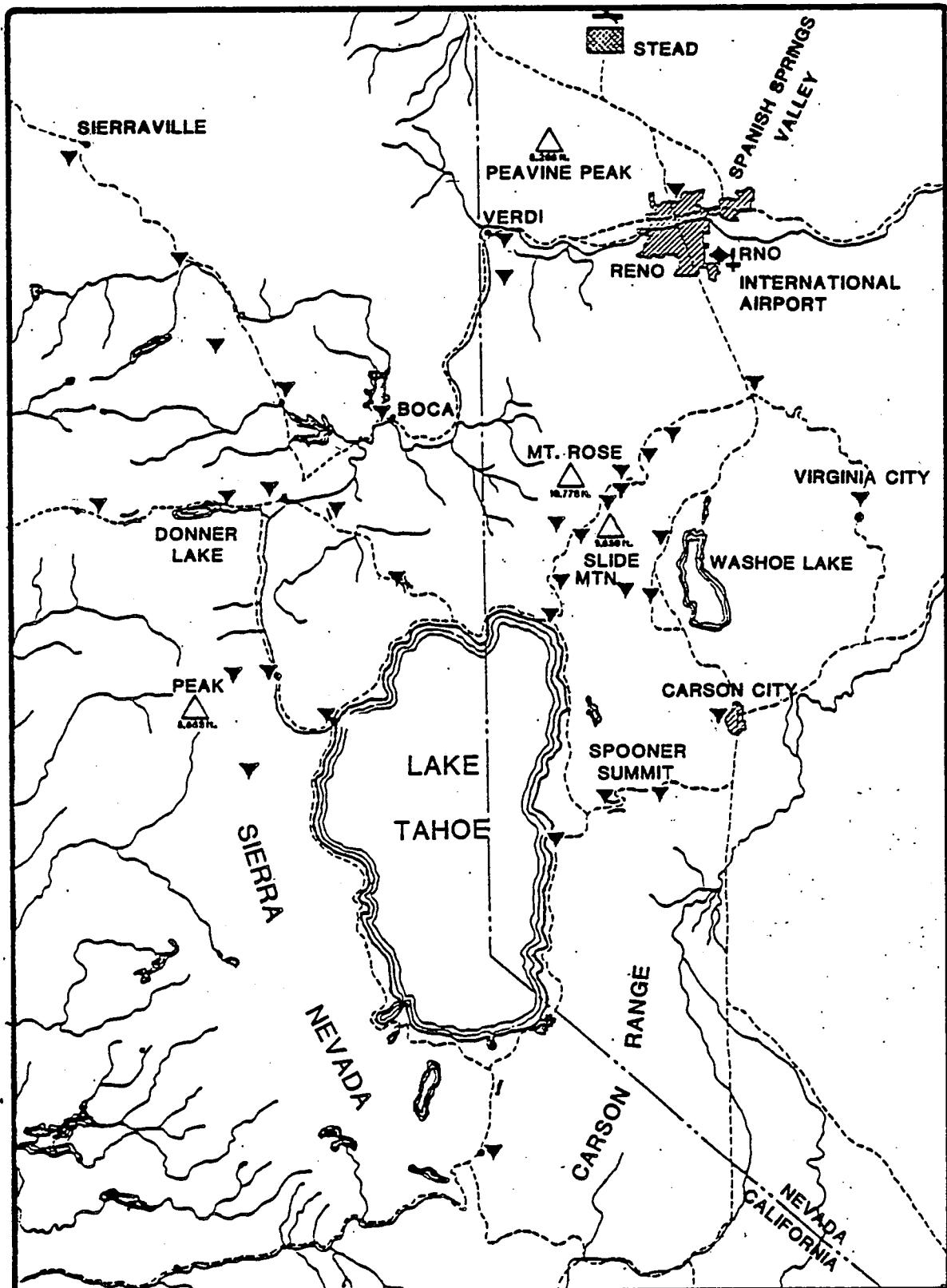


FIGURE 8. Location of precipitation gages used to develop precipitation - altitude relationship. (modified from Klieforth, et. al., 1983, Figure 1)

shown in Figure 8, since much moisture has already been removed from an air mass before it reaches Spanish Springs Valley. However, terrain features, wind directions, and vegetation patterns were also used as guidelines when drawing the isohyetals (Klieforth and others, 1983, p. 27), and this may have reduced any error in the precipitation-altitude relationship as applied to Spanish Springs Valley.

The isohyetal map of the study area showing mean annual precipitation provided a tool by which to estimate the water yield of the basin. Water yield is defined as the volume of water leaving the mountains either as surface-water runoff or subsurface flow. A portion of the water yield will infiltrate to the water table and become groundwater recharge; the remainder will become surface-water runoff. In basins that have only ephemeral streams, such as Spanish Springs Valley, most of the water yield occurs as subsurface flow either through alluvium in mountain canyons or through fractures in bedrock. Such quantities are difficult to measure directly, so an empirical relationship between precipitation and water yield was used to estimate the water yield of the Spanish Springs Valley hydrographic basin. The method was first developed by Rantz (1974) and later applied by Arteaga and Durbin (1978) to the Eagle Valley watershed, which includes a portion of the east slope of the Carson Range.

The precipitation-yield relation applied to Spanish Springs Valley was the one developed for the Eagle Valley watershed (D. Mahin, Washoe County Dept. Comp. Planning, pers. comm., 1988). Arteaga and Durbin (1978) describe how the precipitation-yield relation in Figure 9 was developed. The first step was to collect precipitation and streamflow data for several gaged drainages in the Eagle Valley watershed. Because the stream gages were located at points where bedrock underlies the stream channel at shallow depth, the assumption was made that runoff was equivalent to water yield. Mean annual precipitation for each drainage basin was plotted against mean annual yield. Water yield values associated with the decile values of precipitation for each basin were then used to compute an area-weighted estimate of water yield for that basin. The graph was adjusted by trial and error until it produced an acceptable match between computed and measured water yield.

Several assumptions were made in developing this relationship and applying it to Spanish Springs Valley:

- 1) Streamflow recorded at gaging sites was equal to the entire water yield of that particular drainage basin. Subsurface flow in the Eagle Valley watershed through alluvium and through fractures in bedrock was, therefore, minimal.
- 2) The water yield of a basin is dependent solely on the

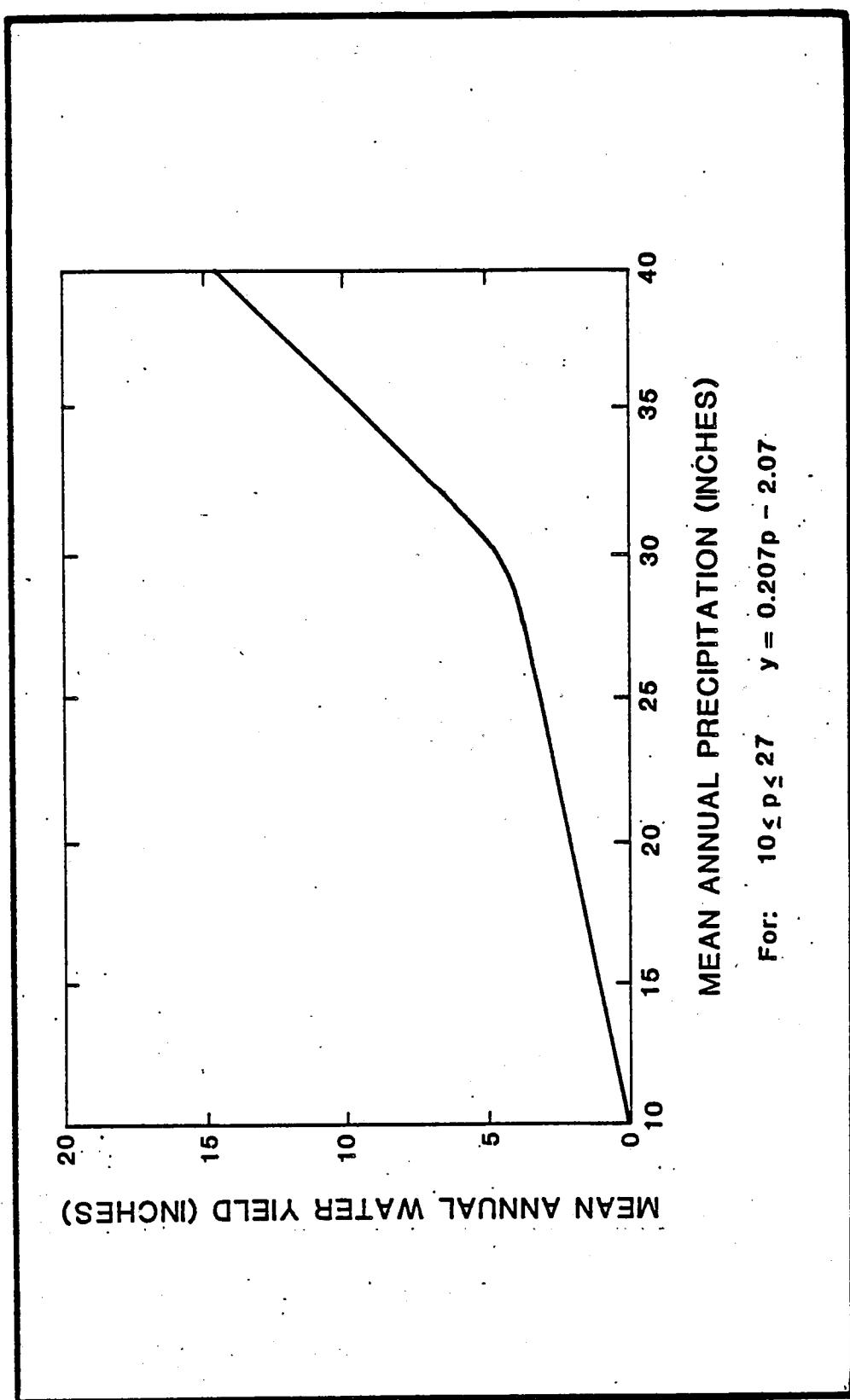


FIGURE 9. Diagram showing relationship between precipitation(p) and water yield(y).
(modified from Arteaga and Durbin, 1978, p.20)

amount of precipitation. Although the geologic, topographic, and vegetative characteristics of a basin will affect the water yield, these factors are not accounted for in the precipitation-yield relationship.

- 3) The same correlation exists between precipitation and yield in Spanish Springs Valley as that seen in the Eagle Valley watershed, despite the different character of the two basins.

The precipitation-yield relation in Figure 9 was used to transform contours of equal precipitation into contours of equal water yield (Figure 10). Total average water yield, as estimated by the Arteaga-Durbin relation, is approximately 1500 acre-feet per year. This is in close agreement with the estimate of surface water runoff contained in Rush and Glancy's (1967) report. The water yield of each hydrographic sub-area is shown in Figure 11. Given the restrictive assumptions discussed above, these values can be interpreted only as very general estimates of water yield; the values proved useful, however, when deciding upon the distribution and magnitude of pre-calibration recharge rates.

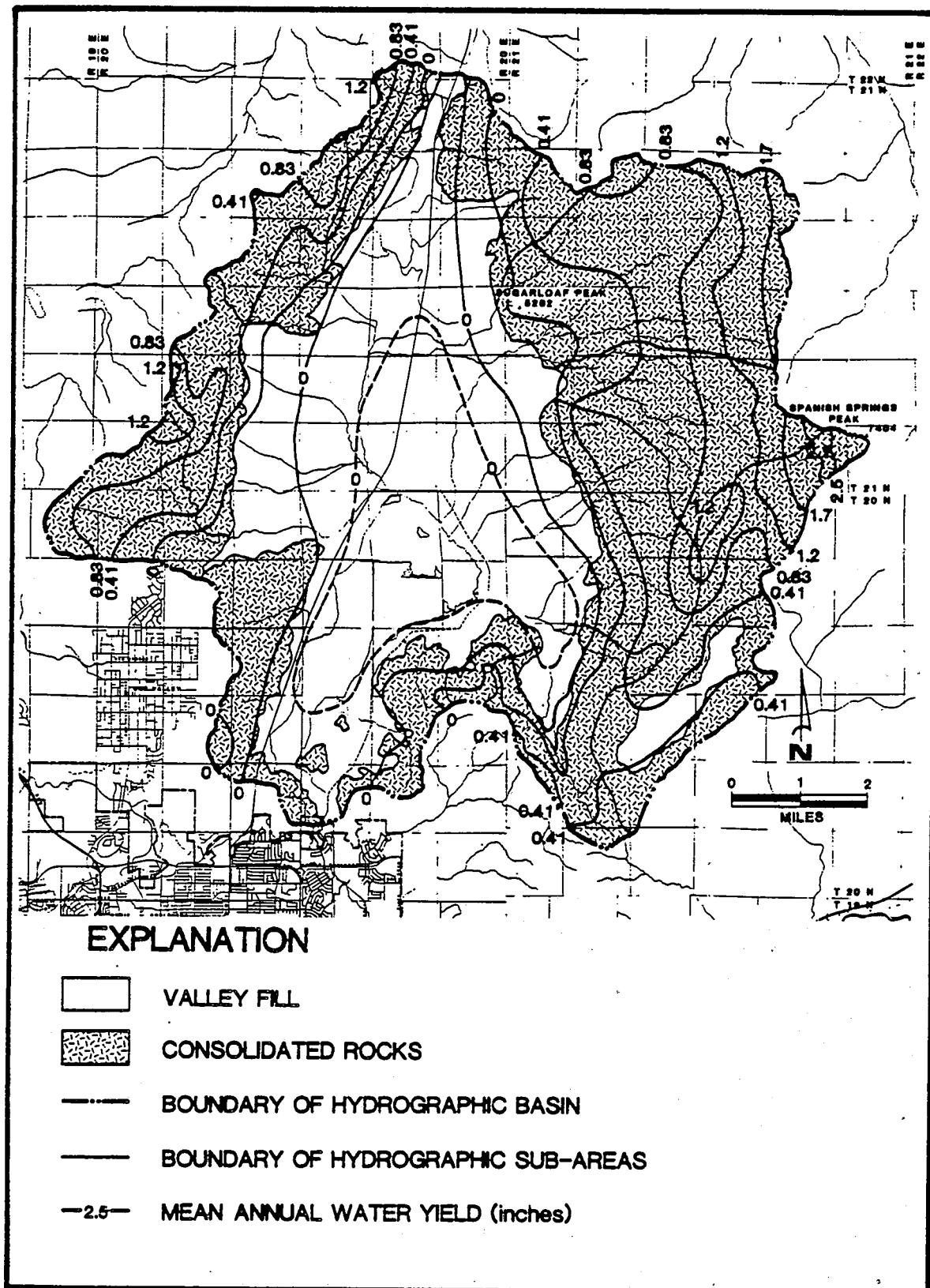


FIGURE 10. Contours of equal water yield.

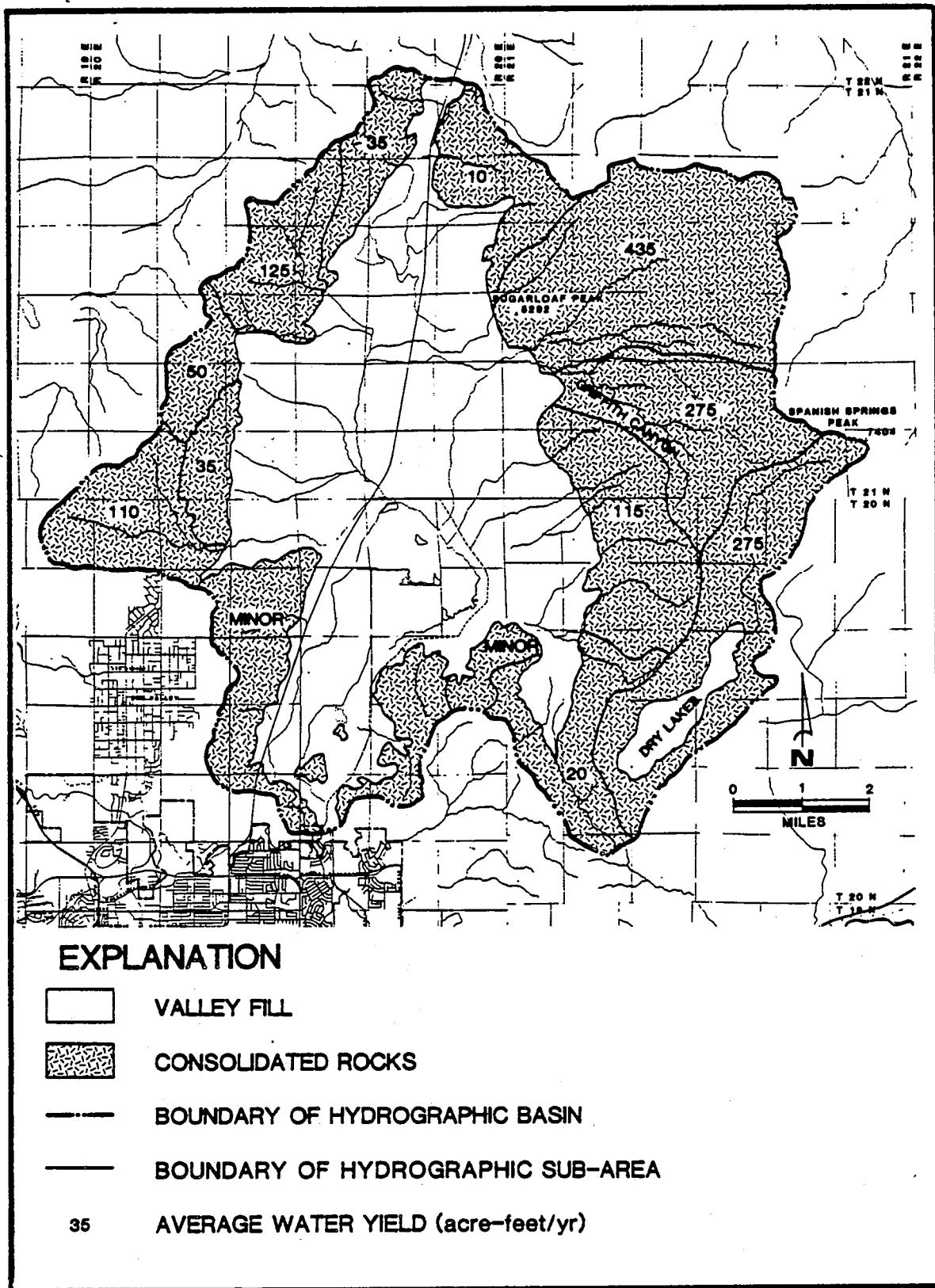


FIGURE 11. Mean annual water yield of hydrographic sub-areas.

The Orr Ditch

The Orr Ditch is an important component of the water budget for Spanish Springs Valley. It enters the hydrographic basin through a narrow outlet in the south and continues across the valley floor for approximately seven miles. Water is diverted for irrigation at several locations; by the time the ditch reaches its terminus in the vicinity of Spanish Springs Ranch, flows have become minimal. Ponding of the imported water in this area has created a wetland community which supports a variety of wildlife.

Water levels throughout the valley have been affected by the presence of the Orr Ditch. Infiltration of irrigation water and leakage along the unlined canal are sources of secondary recharge to the alluvial aquifer. Guyton and Associates (1964) estimated recharge from the Orr Ditch as approximately 3000 acre-feet per year.

All of the land which is irrigated by imported water lies within the perimeter of the Orr Ditch. Native meadowgrass, used to graze cattle, is the primary crop grown in Spanish Springs Valley. The irrigated acreage shown in Figure 12 is based on a series of aerial photos which were taken in September of 1987. Total irrigated land is approximately 1000 acres. Comparison of these recent aerial photos with another set taken during the 1982 irrigation

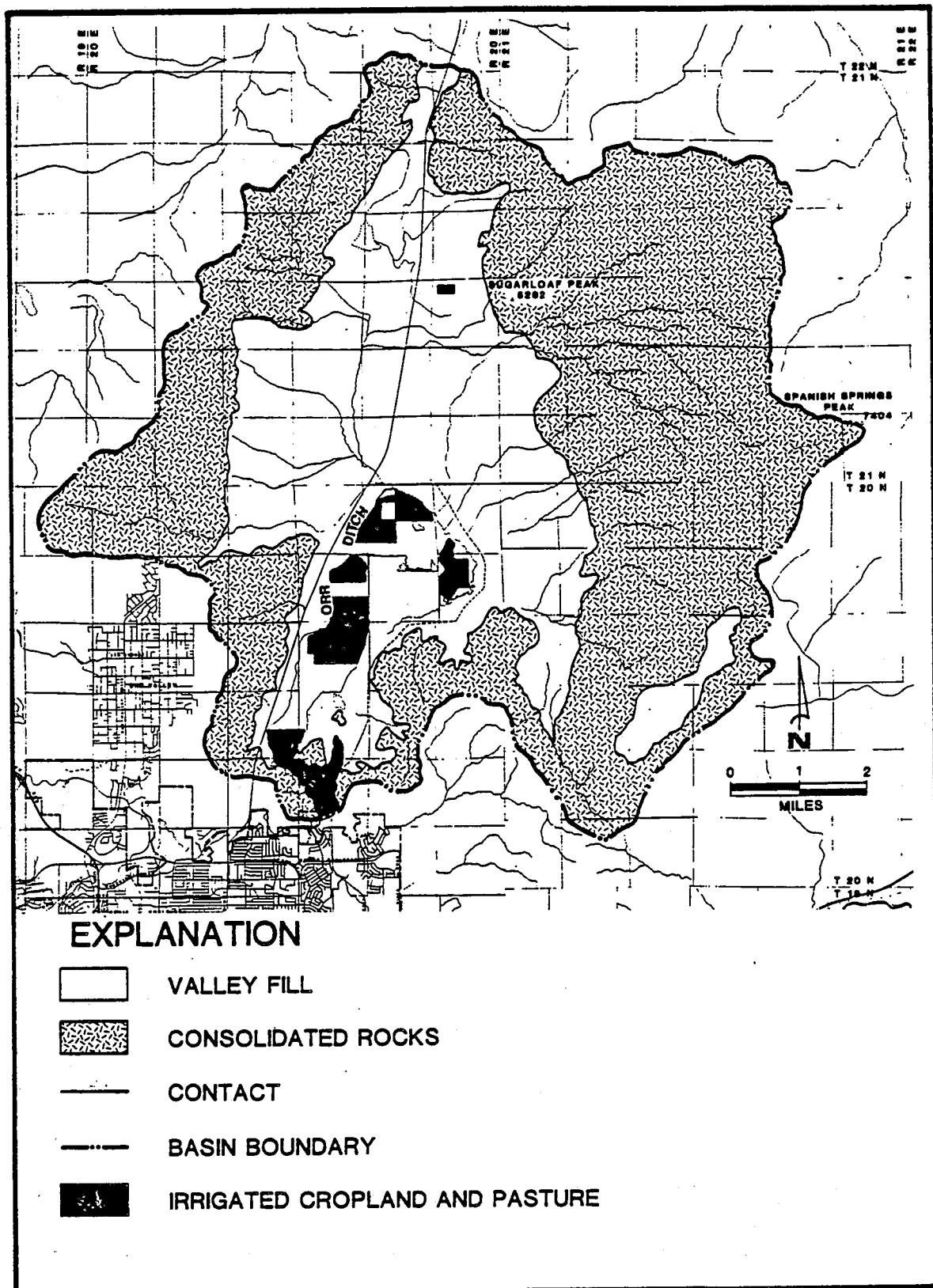


FIGURE 12. Irrigated cropland and pasture.

season shows a decline in irrigated acreage during the past few years. The current figure shows a marked decrease in irrigated acreage when compared to Rush and Glancy's (1967, p. 41) estimate of 1700 acres of irrigated land. This trend is expected to continue in the future as agricultural water rights are gradually converted to municipal use. Reduced secondary recharge associated with declining irrigated acreage will pose a problem in the future if development in the valley proceeds under the assumption that the current amount of groundwater recharge will be available on a permanent basis.

The Office of the Federal Watermaster maintains stream gages at several locations along the Orr Ditch and North Truckee Drain. The gages of interest to this study are shown in Figure 13. Annual flow data for these three gages are summarized in Table 1; daily flow records obtained from the Office of the Federal Watermaster are listed in Appendix A.

The stream gage which records inflow to Spanish Springs Valley is located at the southern boundary of the hydrographic basin. Continuous records for this gage are available from 1977 through 1984; beginning in 1985, however, flow records have been kept only during the irrigation season. In addition, flow in the Orr Ditch was greatly reduced in 1985 due to a legal conflict regarding the diversion of water from the Truckee River (D. Towel, Office

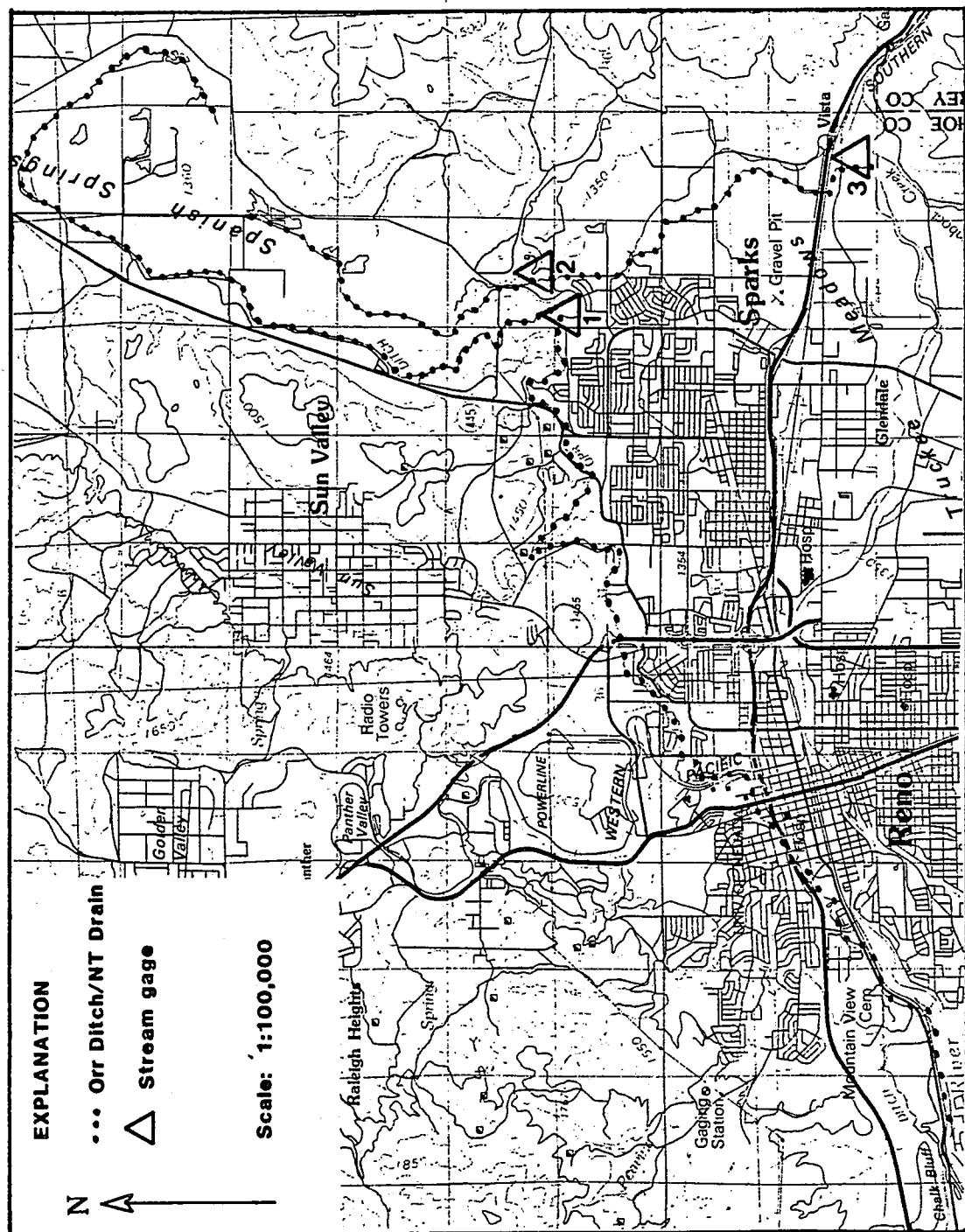


FIGURE 13. Location of stream gages along the Orr Ditch/North Truckee Drain

TABLE 1. Average flow data for the Orr Ditch and
North Truckee Drain: 1977 through 1987 *

YEAR	ACRE-FEET		
	Inflow (Gage #1)	Outflow (Gage #2)	Outflow (Gage #3)
1977	14,141	8,146	19,176
1978	19,978	10,726	25,555
1979	19,581	9,708	23,231
1980	17,692	9,646	25,834
1981	17,934	6,639	20,225
1982	16,437	8,351	----
1983	17,051	11,852	23,566
1984	16,029	10,332	19,567
AVERAGE	17,355	9,425	22,450
1985	13,279	----	20,752
1986	10,831	----	16,606
1987	11,140	----	----
AVERAGE	11,750	(5650)	18,679

* Gage locations are shown in Figure 13.

of the Federal Watermaster, pers. comm., 1987). The Orr Ditch is no longer operated at full capacity year round. During the non-irrigation months, flow in the Orr Ditch is maintained at approximately 5 cubic feet per second (cfs), except during February, March, and part of April when the flow is cut off completely in preparation for the cleaning and dredging of the ditch (D. Towel, Office of the Federal Watermaster, pers. comm., 1987).

Flow records from 1977 through 1984 show an average inflow to Spanish Springs Valley of 17,355 acre-feet per year. The inflow data listed in Table 1 for the years 1985 through 1987 reflect adjustments made by the author to account for unrecorded flow during the winter months. A flow of 5 cfs was assumed to occur during January, October, November, and December, unless the original flow records indicated otherwise. The author assumed no flow from February 1 through mid-April. Average inflow to Spanish Springs Valley from 1985 to 1987, based on the above assumptions, was approximately 11,750 acre feet per year.

From 1977 through 1984 a stream gage was located at the outlet of Spanish Springs Valley to record the flow leaving the basin. Since 1985, however, the only gage monitoring flow in the North Truckee Drain has been the one located near the confluence with the Truckee River. This gage measures not only outflow from Spanish Springs Valley, but also storm

runoff from the city of Sparks and flow from the People's Drain, which consists of water pumped from Helms' Gravel Pit. Although storm runoff is difficult to quantify, flow from the People's Drain is very consistent. The average contribution of Helms' Gravel Pit to the People's Drain is 6.2 million gallons per day (J. Clay, Helms Const. Co., pers. comm., 1987), or approximately 7,000 acre-feet per year.

Analysis of surface water outflow from Spanish Springs Valley is complicated by the fact that flow in the Orr Ditch was greatly reduced in 1985. Data which was collected at the outlet of the basin, therefore, are no longer representative of current flow conditions. The average annual outflow from Spanish Springs Valley during 1985 and 1986 was estimated by subtracting the volume of water contributed by runoff and the People's Drain from the average flow measured at gage #3. The average outflow from Spanish Springs Valley from 1977 to 1984, based on gage #2, was 9425 acre-feet per year. The average flow measured at the gage near the Truckee River for this same time period was 22,450 acre-feet per year. An average of 13,025 acre-feet per year, therefore, was contributed to the North Truckee Drain after leaving Spanish Springs Valley. The author assumed that this same volume of water was added to the North Truckee Drain in 1985 and 1986 after leaving the hydrographic basin. Since the Reno-Sparks flood event which occurred in February of 1986 is not reflected in the outflow measurements of gage #3 (Appendix

A), it was not necessary to account for increased storm flow during this period. Subtracting 13,025 acre-feet from the average total flow recorded at gage #3 during 1985 and 1986 yields an estimate of approximately 5650 acre-feet per year for the average outflow from Spanish Springs Valley.

Comparison of average inflow and outflow estimates indicates that approximately 6100 acre-feet of imported water are consumed annually in Spanish Springs Valley. This water is consumed by evapotranspiration by crops and phreatophytes, evaporation from open bodies of water, and pumping from wells. A portion of this imported water may also leave the basin as subsurface flow.

Groundwater discharge

Evapotranspiration

Evapotranspiration of groundwater is restricted primarily to valley floor areas in the vicinity of the Orr Ditch. Greasewood, rabbitbrush, and desert saltgrass form a typical plant community in the groundwater discharge zone of Spanish Springs Valley. Desert saltgrass, a species with a high salt tolerance, dominates where the capillary fringe reaches the land surface; in these areas, a white alkali crust has formed on the soil due to groundwater evaporation. A variety of sedges and rushes occur in marshy areas where

the water table is at or close to the land surface.

A map prepared by Houghton and others (1975, p. 62) shows that average annual lake evaporation in the vicinity of Spanish Springs Valley ranges from 3.8 to 4.0 feet per year. Evapotranspiration rates are difficult to quantify, however, since the consumptive use of groundwater by a given species depends on many factors, including density of growth, depth to water, water quality, and climate (Robinson, 1958, p. 16). Previous estimates of evapotranspiration rates for desert saltgrass range from 0.5 to approximately 3.0 ft/yr (Rush and Glancy, 1967, p. 34 and Ungar, 1974, p. 270). A wide range of values, from 0.2 to 1.9 ft/yr, have also been attributed to greasewood (Rush and Glancy, 1967, p. 34 and Duell and Nork, 1985, p. 161). Duell and Nork (1985, p. 161) derived an evapotranspiration rate of approximately 2.3 ft/yr for a rabbitbrush site in Owens Valley, California.

The consumptive use of groundwater by phreatophytes is the product of the size of the discharge area and the actual rates of evapotranspiration. Rush and Glancy (1967, p. 34) calculated evapotranspiration of groundwater to be 900 acre-ft/yr from approximately 1900 acres of phreatophytes. Robinson and Phoenix (1948, p. 16) estimated evapotranspiration of groundwater to be 3000 acre-ft/yr from 2500 acres of phreatophytes. Rush and Glancy included in their estimate only those phreatophytes which they

considered to define a natural groundwater discharge zone, whereas Robinson and Phoenix accounted for total evapotranspiration of groundwater in the vicinity of the Orr Ditch.

Spanish Spring

As the above estimates of phreatophyte evapotranspiration illustrate, the natural groundwater discharge zone in Spanish Springs Valley is masked by the artificially high water table created by the Orr Ditch. Similarly, little is known about the natural setting of Spanish Spring, since flow from the spring has been mixing with water from the Orr Ditch for more than a century. A passage in the Reno Evening Gazette (Feb. 15, 1879), which describes the Spanish Spring area before the influx of imported water to the valley, suggests that several small springs and seeps created a groundwater discharge zone of approximately 25 or 30 acres. The discharge zone is believed to be fault controlled; offsetting of hydrostratigraphic units of different hydraulic conductivity probably restricts the flow of groundwater moving west from the Pah Rah Range (Cochran, 1972, p. 3).

Today, Spanish Spring is located under a pond north of Spanish Springs Ranch. Groundwater temperature of several flowing wells on Spanish Springs Ranch is approximately 72 F (Robinson and Phoenix, 1948, Table 2). Groundwater discharge

from Spanish Spring appears to be relatively warm also, because the north end of the pond does not freeze during the winter.

Subsurface outflow

Available data suggest that movement of groundwater from Spanish Springs Valley to adjacent basins may occur at both the north and south ends of the valley. This unusual situation arises from the presence of the Orr Ditch and its effect on water levels throughout the valley. Recharge from the Orr Ditch has created a groundwater mound which exerts a strong influence on the flow system of the alluvial aquifer. The mound serves as a groundwater divide; north of the ditch the water table slopes to the north, indicating groundwater flow towards Warm Springs Valley, while in the south the hydraulic gradient indicates groundwater movement towards the Truckee Meadows.

The hydrogeologic controls on the interbasin movement of groundwater are complex. There must be a favorable hydraulic gradient between two basins, as well as a pathway for subsurface flow, before interbasin movement of groundwater can occur. The amount of subsurface flow leaving Spanish Springs Valley depends, in part, on the cross-sectional area through which groundwater can flow, the hydraulic conductivity of alluvium in that area, and the presence of

fractures which may create secondary permeability in surrounding consolidated rocks.

Rush and Glancy (1967, p. 37) estimated a hydraulic gradient of 30 ft/mile from Spanish Springs Valley to the Truckee Meadows through alluvium in the narrow outlet at the south end of the valley. They calculated an average underflow of 100 acre-feet/yr by assuming an effective flow width of 0.1 miles and an average transmissivity of 30,000 gallons per day/ft. Cohen and Loeltz (1964, p. S23) estimated subsurface flow from Spanish Springs Valley to the Truckee Meadows as approximately 150 acre-feet/yr.

No data are available to define the hydraulic gradient between Spanish Springs Valley and Warm Springs Valley. The steady-state configuration of the water table in Spanish Springs Valley, however, suggests the presence of a groundwater sink at the north end of the basin which the author interprets as subsurface outflow. The cross-sectional area of alluvium at the north end of the valley, although unknown, may be limited by the subsurface extent of consolidated rocks. The fault at the base of Hungry Ridge may act as a conduit through which water may leave the hydrographic basin.

Pumping

Municipal water supply is the primary use of groundwater in Spanish Springs Valley. A few irrigation wells and numerous domestic wells also draw upon the groundwater reservoir.

The greater use of groundwater in Spanish Springs Valley during the last ten years is due to increased housing development. The number of homes in Spanish Springs Valley increased from 90 in 1977 to approximately 900 in 1987. Most of the development has been concentrated in subdivisions near the central and southern portions of the valley, and all rely on local groundwater resources for their water supply.

Figure 14 shows the location of major pumping wells in Spanish Springs Valley; groundwater discharge from each of these wells is summarized in Table 2. Estimated subdivision pumpage is approximately 685 acre-feet/yr. The average pumping rate for these homes, excluding Blue Gem and Oasis mobile home parks, is approximately 0.8 acre-feet/unit. A portion of this returns to the groundwater reservoir as recharge from septic tanks and infiltration of water applied for landscape irrigation; assumed consumptive use averaged 0.63 acre-feet/unit, or approximately 20% secondary recharge.

Total basin-wide pumping in 1987 is estimated at 1405

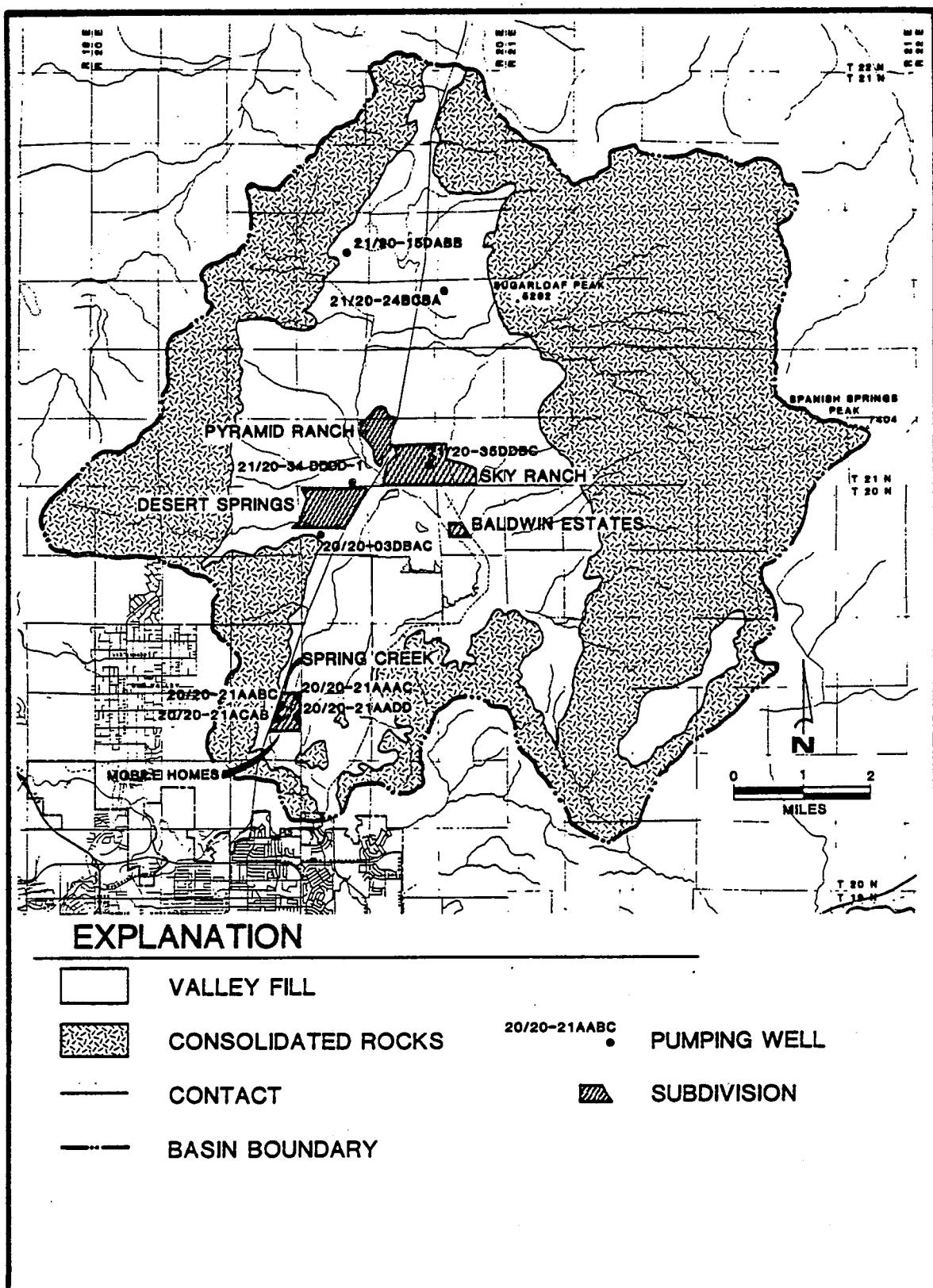


FIGURE 14. Location of subdivisions and major pumping wells.

TABLE 2. Approximate pumpage for selected wells
in Spanish Springs Valley in 1987

LOCATION	WELL	NUMBER UNITS SERVED	TOTAL PUMPAGE *(ACRE-FEET)	APPROX PUMPING (AF/UNIT)	ASSUMED CONSUMPTIVE USE (ACRE-FEET) (AF/UNIT)
20/20-21 AAAC	Spring Creek North Well	10 (1)			
20/20-21 AADD	Spring Creek South Well	124	75 (1)	0.69	75 0.60
20/20-21 AABC	Blue Gem Trailer Park	20 (2)			
20/20-21 ACAB	Oasis Mobile Estates	130	30 (2)	0.38	40 0.31
20/20-03 DBAC	Desert Springs South Well	30 (1)			
21/20-35 CCCC	Desert Springs North Well	465	300 (1)	0.71	250 0.54
21/20-35 DDBC	Sky Ranch SS6	222	220 (3)	0.99	165 0.74
21/20-15 DABB	Gravel pit	---	600 (4)	---	100 ---
21/20-24 BCBA	Donovan irrigation well	---	120 (5)	---	75 ---

ESTIMATED SUBDIVISION PUMPAGE/CONSUMPTIVE USE 685/530 ACRE-FEET

ESTIMATED BASIN-WIDE PUMPAGE/CONSUMPTIVE USE 1405/705 ACRE-FEET

* SOURCE

- (1) Washoe County Utility Division; meter records
- (2) Assumed 0.4 acre-feet per unit
- (3) L. Peterson, SPB Utility Service, pers. comm., 1987
- (4) Proven beneficial use in 1988
- (5) Assumed 30 acres x 4.0 acre-feet/acre

acre-feet. The author assumed, during the course of this study, that most of the groundwater pumped at the gravel pit returned to the alluvial aquifer by infiltration of water in storage ponds.

Groundwater quality

The hydrochemistry of groundwater flow systems evolves over long periods of geologic time through contact with a variety of geologic materials. Different mineral assemblages can cause large variations in the chemistry of groundwater from one region to another; this phenomenon is well-developed in Spanish Springs Valley. Groundwater associated with highly altered and mineralized andesite flows in the southwest portion of the valley is of very poor quality. Groundwater quality improves to the north and east as different hydrostratigraphic units are encountered.

Water quality data for selected wells in Spanish Springs Valley are tabulated in Appendix B. A detailed investigation of groundwater chemistry in Spanish Springs Valley is beyond the scope of this study; the information contained herein is purely descriptive and is based upon water quality data obtained from the Consumer Health Division in Carson City.

High concentrations of sulfate, iron, arsenic, and total dissolved solids are coincident with the zone of hydrothermal

alteration which pervades the Alta Formation. The concentration of these constituents near the southern boundary of the watershed is often more than twice that allowed by state drinking water standards. Total dissolved solids of groundwater from several domestic wells in the area, for example, exceed 2000 milligrams per liter (mg/l). Water quality samples from an abandoned test hole, south of the two Spring Creek wells, had arsenic concentrations greater than 0.2 mg/l, compared to the maximum allowable concentration of 0.05 mg/l. The concentration of iron in groundwater from this hydrostratigraphic unit ranges from less than 0.05 to more than 8.0 mg/l. Sulfate, a product of the weathering and dissolution of sulfide minerals, reaches concentrations approaching 1000 mg/l. Generally, the quality of groundwater in this hydrostratigraphic unit improves to the north as the degree of alteration decreases. The two municipal wells which supply Spring Creek subdivision appear to be on the borderline of this region of poor water quality. The groundwater pumped by these wells does meet state drinking water standards, but by a relatively narrow margin.

The distribution of hydrochemical facies is an important consideration for the development of water resources in Spanish Springs Valley. If the direction of groundwater movement in this hydrostratigraphic unit was reversed because of drawdowns from increased groundwater development farther north, this poor quality water would migrate towards water

supply wells. The groundwater flow model can be used to help circumvent this problem by evaluating the simulated response of the aquifer to different pumping scenarios.

SIMULATION ANALYSIS OF GROUNDWATER FLOW

Conceptual model of the groundwater flow system

The alluvial deposits in Spanish Springs Valley consist of unconsolidated and semi-consolidated sediments which partially fill a structural basin in the surrounding consolidated rocks. These rocks form the lateral and lower boundaries of the valley-fill groundwater system. Hydraulic conductivity of the valley-fill material is generally greater near the mountains and decreases toward the center of the valley. Typical water-bearing zones in the alluvial aquifer are local lenses of sand and gravel which are interbedded with layers of clay and sandy clay.

Natural recharge to the basin is from precipitation in the mountains and is, therefore, concentrated along the perimeter of the valley-fill system. The Orr Ditch is an important source of secondary recharge on the valley floor. Groundwater discharge in the form of evapotranspiration occurs primarily in the vicinity of the Orr Ditch.

The general direction of groundwater flow in the watershed is from recharge areas in the mountains to alluvial deposits in the valley. The flow system of the valley-fill aquifer, however, is dominated by the groundwater mound created by recharge from the Orr Ditch. The water table

slopes to the north in the area north of the Orr Ditch, indicating groundwater flow toward Warm Springs Valley, while in the southern part of the basin the general direction of groundwater flow is toward the Truckee Meadows.

Mathematical model development

Model structure

To quantify groundwater conditions in Spanish Springs Valley, the conceptual model of the flow system must be translated into mathematical terms. A mathematical model is a set of equations which, subject to certain assumptions, describes the physical processes active in the aquifer. It consists of a groundwater flow equation and the appropriate boundary and initial conditions. The partial differential equation for unsteady two-dimensional groundwater flow in an aquifer is:

$$\frac{\partial}{\partial x} \left(T_x \frac{\partial h}{\partial x} \right) + \frac{\partial}{\partial y} \left(T_y \frac{\partial h}{\partial y} \right) + R = S \frac{\partial h}{\partial t}$$

where h is the average hydraulic head along a vertical line [L]

T is transmissivity [L^2/T]

R is a source/sink term [L/T]

S is the storage coefficient [L^3/L^3]

t is time [T]

This equation assumes vertical components of flow in the aquifer are negligible and that the coordinate axes x and y coincide with the principal directions of anisotropy.

Although strictly valid only for confined aquifers, the above equation can also be used for an unconfined flow system if changes in aquifer thickness are small relative to the initial saturated thickness. The groundwater flow model allows transmissivity to vary with time by continually updating aquifer thickness to keep pace with changing water levels. Data input to the model, therefore, requires hydraulic conductivity of each element and the elevation of the base of the flow system at each node. Finally, in steady-state simulations the right hand side of the equation equals zero since there are no changes in groundwater storage with time.

Wang and Anderson (1982) provide an introduction to the finite element method as applied to groundwater problems. Briefly, the numerical method gives an approximation to the solution of the groundwater flow equation. The continuous partial differential equation is replaced by a set of algebraic equations in which the unknowns are the heads at a finite number of nodal points. The TRIAG groundwater flow model solves this set of equations by direct matrix solution techniques.

The model used to simulate groundwater flow in Spanish

Springs Valley was written by Durbin (1985) and modified by Donald A. Mahin of the Washoe County Department of Comprehensive Planning to produce a two-dimensional version capable of running on MS-DOS computers. The model consists of a short main program and a set of independent subroutines written in FORTRAN 77. Computed results consist of the hydraulic head and aquifer thickness at each node, the distribution of evapotranspiration, and a groundwater budget.

Model grid

To simulate groundwater flow in the alluvial aquifer of Spanish Springs Valley, the problem domain was subdivided into a series of elements (Figure 15). The lateral boundaries of the finite element grid are located at or near the alluvium-bedrock contact. Element size varies according to the availability of hydrologic data and the anticipated slope of the water table; small elements can be used where field data points are closely spaced or in regions where a steep gradient is anticipated.

Geometric relations of the alluvial aquifer are specified in the model through the configuration of elements. The location of major pumping wells and control heads, as well as recharge from the Orr Ditch, are represented in the model by the strategic placement of nodes. Physical properties of the alluvial aquifer are represented in the

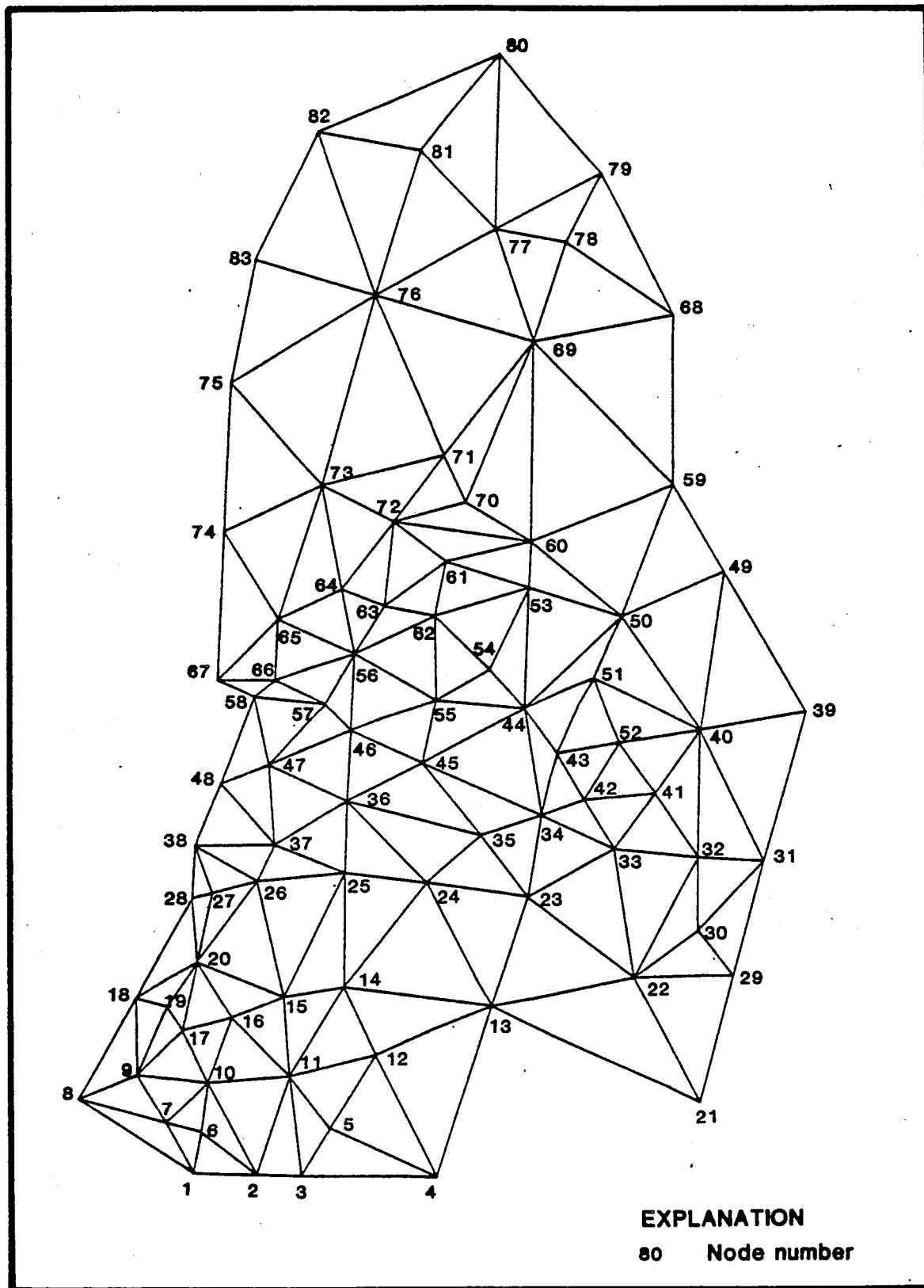


FIGURE 15. Finite element grid used in groundwater flow model.

model by parameter values assigned to each element. Initial average hydrogeologic properties of each element were selected on the basis of known field data. The model assumes each element is isotropic and homogeneous. Interpolation functions which describe the variation of hydraulic head over the area of each element are fundamental to the development of equations in the finite element method; the model assumes that head varies linearly throughout each element. The configuration of the water table in each element, therefore, can be visualized as a planar surface which intersects the computed head values at each node. The interpolating functions will provide an exact representation of the shape of the water table as the element size approaches zero.

Historical water levels and steady-state assumption

Although groundwater systems may require many years to reach a new equilibrium in response to increased pumping, groundwater development in Spanish Springs Valley began fewer than 10 years ago. No basin-wide water level declines have yet been observed; drawdowns have generally been confined to the areas surrounding major pumping wells. Water levels do not appear to have stabilized in either the pumping wells or those monitoring wells which show drawdown; it can be assumed, therefore, that water is being withdrawn from storage and that the system has not yet reached a steady state.

Figure 16 shows the location of wells in Spanish Springs Valley for which time-series water level measurements are available; their historical depths to water are tabulated in Appendix C. The majority of available water level data for the valley has been collected since 1980. Four wells--#6, #7, #8, and #13--have records which include depth to water measurements taken during 1964 and 1965.

Several wells show a seasonal fluctuation in depth to water, with annual water levels peaking in the early spring and dropping to their lowest levels in late summer and early fall. This cycle corresponds with greater evapotranspiration and increased pumping during the summer. A few monitoring wells located near major pumping centers show a steady decline in water levels superimposed on seasonal variations. For example, drawdown in well #1 from 1980 to present is approximately 12 feet. Wells #4 and #5 show water-level declines close to 3 feet during this same time period.

One monitoring well in the valley showed a rise in the static water level from 1979 through 1986. The depth to water in well #7 decreased from 103 feet in July of 1979 to approximately 73 feet in December of 1986. Water levels have since been declining; for example, the depth to water in February of 1988 was approximately 85 feet. Fluctuations in the water level may be due to changing precipitation patterns. The well appears to be drilled in fractured rock

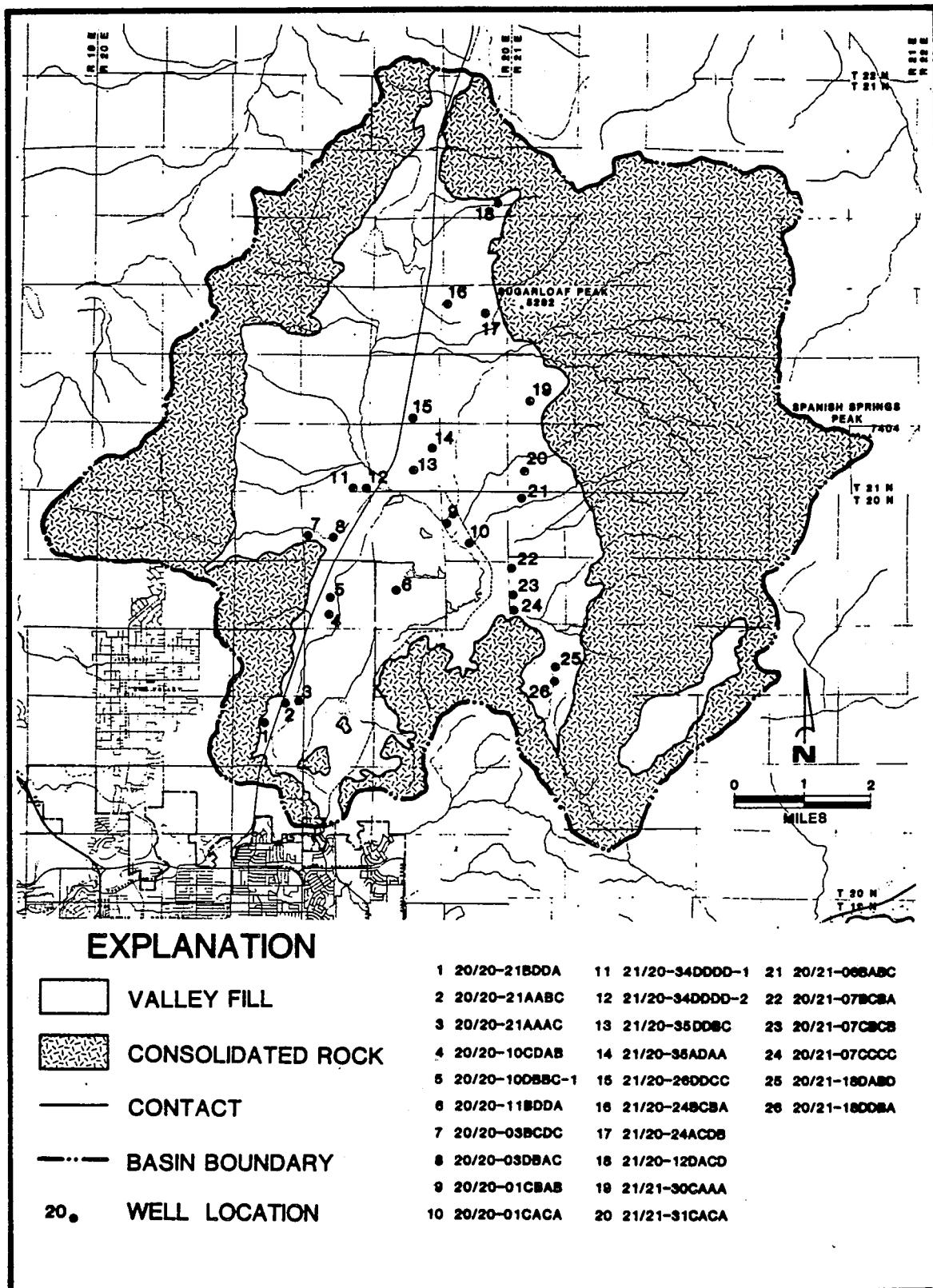


FIGURE 16. Location of wells which have historical water-level data.

and seems to respond relatively quickly to periods of recharge and drought. The initial rise in water levels coincides with several years of above-normal precipitation, whereas the recent decline coincides with the current drought.

Due to the recent onset of groundwater development in Spanish Springs Valley, the groundwater system has not yet re-equilibrated to current pumping levels. Because drawdowns thus far have been limited to areas surrounding major pumping wells, insufficient data are available to calibrate a transient model for the basin. For this reason, a steady-state model was calibrated to pre-pumping conditions using data representative of 1980 water levels. This approach assumes that a steady-state condition existed with respect to recharge from the Orr Ditch. The groundwater system has had longer than 100 years to reach a new equilibrium between increased recharge and groundwater discharge. Prior to the onset of pumping, water levels in the valley had been stable for quite some time. For example, depth to water in well #13 was approximately 63 feet from the earliest measurement in 1964 through 1980. It is apparent that water was no longer being added to storage and that recharge from the Orr Ditch had been balanced by increased groundwater discharge by phreatophytes and, quite possibly, subsurface outflow.

Steady-state model development and calibration

The model was calibrated by the trial-and-error adjustment of input data until simulated groundwater conditions closely matched existing field data. Only minor adjustments were made to evapotranspiration parameters; hydraulic conductivity values and the total amount and distribution of recharge, however, were changed frequently during model calibration. Because the values of several model parameters are unknown, no unique solution of the mathematical model is possible. Many different combinations of recharge and hydraulic conductivity, for example, may generate a similar head distribution in the aquifer. Care was taken, therefore, to ensure that aquifer parameters and values for components of the water budget remained within estimated ranges.

Boundary conditions and control heads

Computed results of a groundwater flow model are sensitive to the choice of boundary conditions. Most lateral boundaries of the problem domain are simulated as constant recharge sources. Areas of subsurface outflow are represented as head-dependent boundaries. Flows are specified as positive when water enters the groundwater system and negative when water leaves the modeled area. The bottom of the simulated groundwater flow system coincides

with estimated depth to bedrock; at the south end of the valley and along the perimeter of the valley-fill system, however, consolidated rocks underlying the thin alluvium were included in the model.

Control heads are estimates of pre-pumping water levels for nodes where field data are available. The degree to which simulated heads reproduce control heads is one indication of how well the model represents groundwater conditions in the valley. Figure 17 shows the location and values of control heads and the difference between observed and simulated heads. Many control heads were calculated using an average annual depth to water prior to the onset of pumping in the basin (Table 3). Single water level measurements made in 1987 were deemed acceptable estimates of steady-state conditions for wells located far from a major pumping center.

Hydraulic conductivity

Hydraulic properties of the valley fill material are not uniquely determined in the calibration process; rather, they are an approximation of actual aquifer characteristics. Initial values of hydraulic conductivity were estimated from drillers' lithologic logs and from several pumping tests conducted in the basin. Figure 18 shows the location of pumping tests in Spanish Springs Valley and the calculated

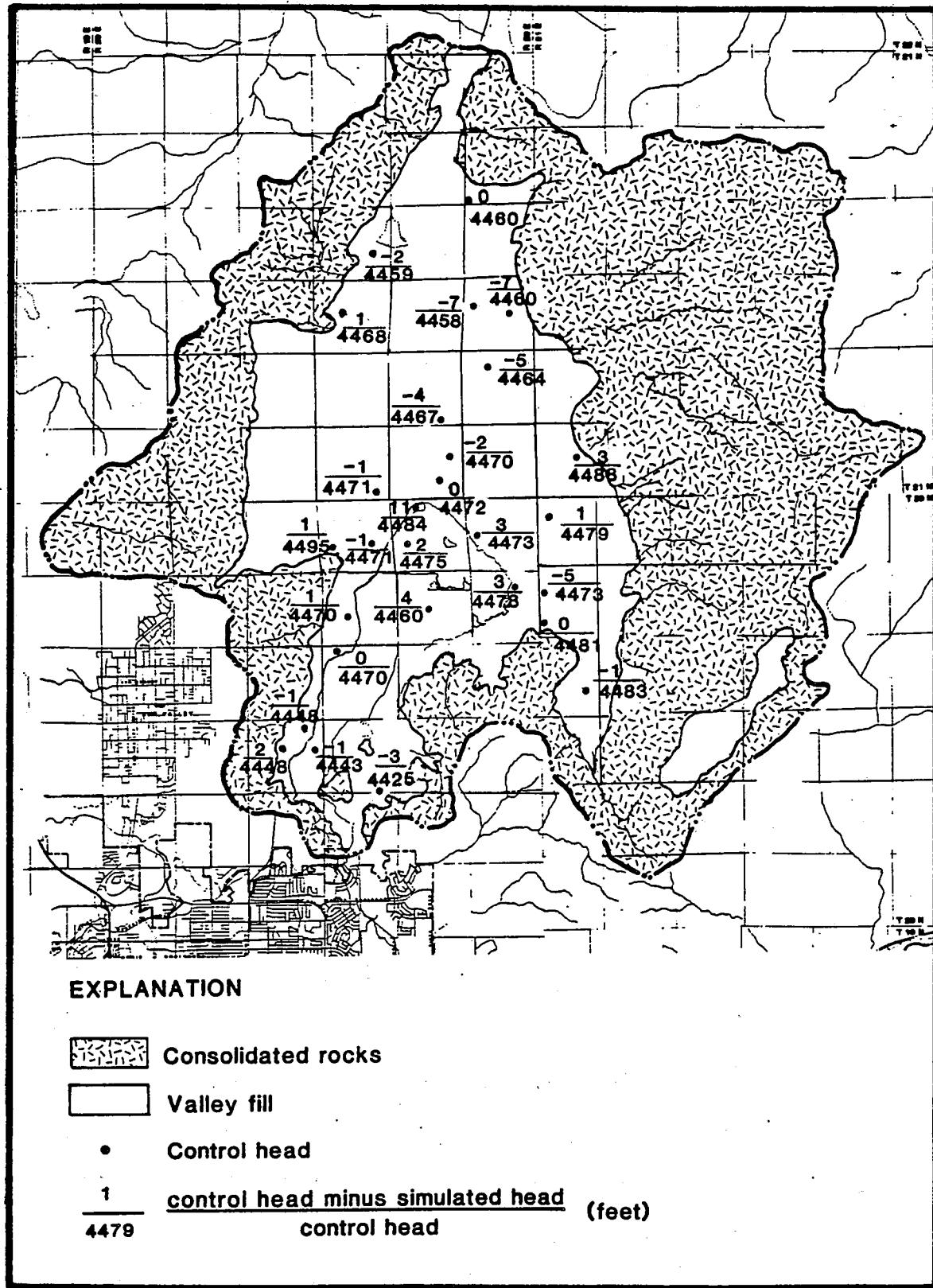


FIGURE 17. Location and values of control heads.

TABLE 3. Derivation of values for control heads

NODE	LOCATION	WELL	SURVEYED ELEVATION (feet)	PRE-PUMPING DEPTH TO WATER (feet)	SOURCE *	CONTROL HEAD (feet)
5	20/20-22 DDDD	Reed/domestic	4481.9	57	3 (1987)	4425
9	20/20-21 BDAA	monitoring well	4538.8	91	2 (1980)	4448
17	20/20-21 ADAB	Spring Creek South Well	4455.7	13	1 (1983)	4443
19	20/20-21 AABC	Blue Gem Trailer Park	4539.9	92	2 (1980)	4448
26	20/20-15 BBAC	Hereford Ranch/domestic	4492.5	23	2 (1980)	4470
30	20/21-18 DABD	Bailey irrigation	4516.1	33	2 (1987)	4483
33	20/21-07 CCCC	"Big Well"	4508.1	27	2 (1980)	4481
37	20/20-10 CDAB	Hereford Ranch/barn	4495.7	26	2 (1980)	4470
43	20/20-12 ACDC	Spanish Springs Ranch	4476.1	+2	3 (1988)	4478
45	20/20-11 BDAA	irrigation/stock	4462.7	3	2 (1964)	4460
49	21/21-31 DDBB	Jacobs/domestic	4759.2	271	3 (1987)	4488
50	20/21-06 BBAC	Countryside North Well	4535.0	56	1 (1980)	4479
52	20/21-07 BCBA	monitoring well	4501.0	28	2 (1980)	4473
54	20/20-01 CBAB	Zundel/domestic	4483.7	11	2 (1980)	4473
56	20/20-02 BCCB	Oppio/domestic	4486.8	12	3 (1948)	4475
61	21/20-35 DDBC	Sky Ranch SS6	4501.1	29	2 (1980)	4472
63	20/20-02 BBCD	Oppio/shed	4486.0	2	3 (1987)	4484
64	21/20-34 DDDD	Desert Springs North Well	4493.1	22	1 (1979)	4471
66	20/20-03 DBAC	Desert Springs South Well	4528.0	57	2 (1964)	4471
67	20/20-03 BCDC	monitoring well	4595.8	101	2 (1964)	4495
69	21/20-25 BAAD	Babel/domestic	4601.4	137	3 (1987)	4464
70	21/20-35 ADAA	Sky Ranch SS3	4522.0	52	2 (1980)	4470
71	21/20-26 DDCC	Sky Ranch SS1	4531.1	64	2 (1964)	4467
77	21/20-24 BCBA	Donovan/irrigation	4554.0	96	2 (1980)	4458
78	21/20-24 ACDB	Donovan/domestic	4655.8	196	2 (1980)	4460
80	21/20-12 CCCC	Wolff/domestic	4598.4	138	3 (1987)	4460
82	21/20-15 DABB	gravel pit	4503.6	45	3 (1985)	4459
83	21/20-22 BDCC	Silver State Soaring	4601.7	134	3 (1987)	4468

* SOURCE

1. Static water level on driller's log
2. Average annual depth-to-water measurement
3. Single depth-to-water measurement

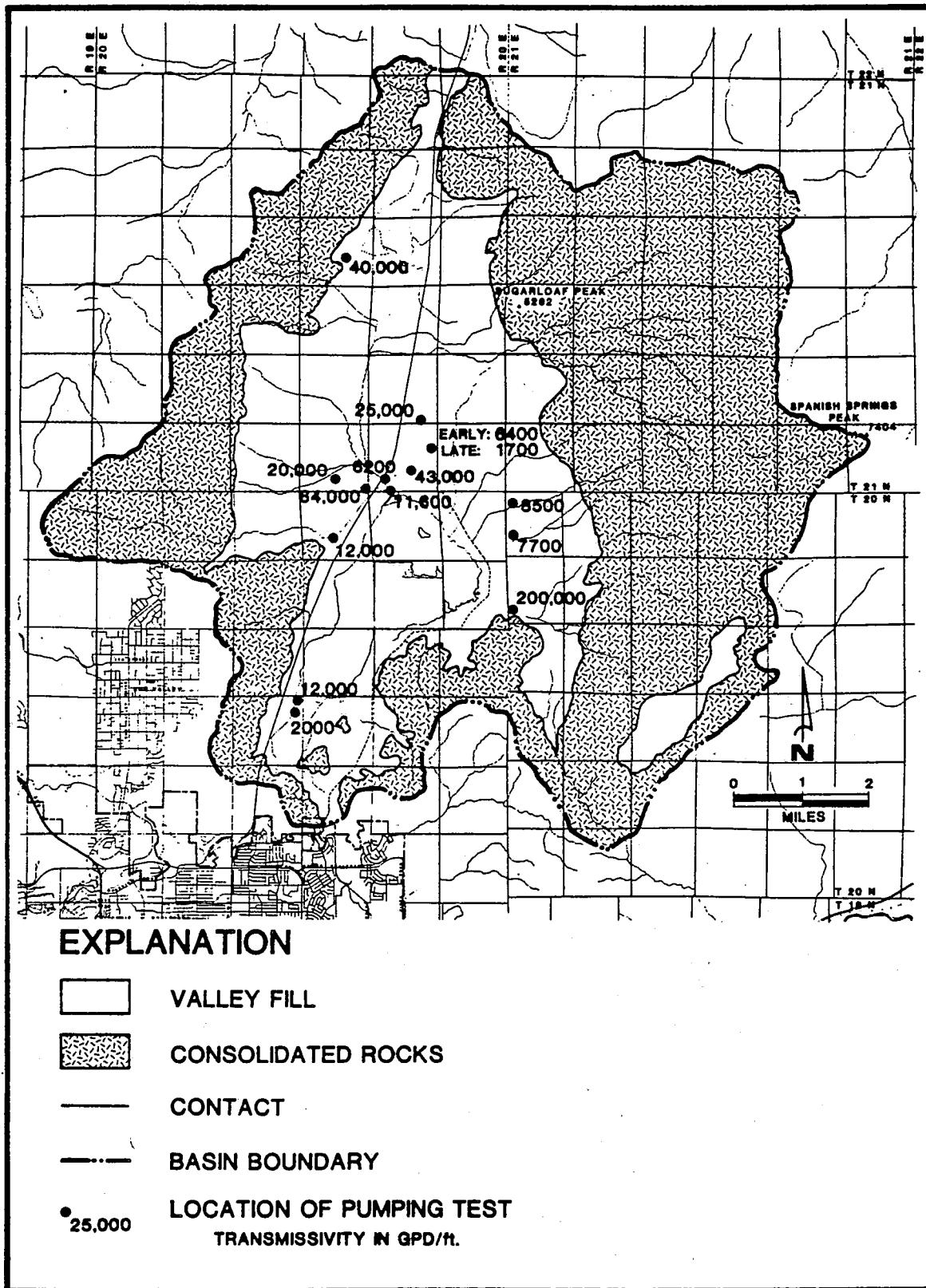


FIGURE 18. Location pumping tests in Spanish Springs Valley.

transmissivities. Average hydraulic conductivity at each site was estimated by dividing transmissivity by the saturated thickness encountered by the well. The grain size and degree of sorting of sedimentary units recorded on drillers' logs allowed a preliminary estimate of hydraulic conductivity in areas where no pumping test data were available. These estimates were based on a weighted average of the hydraulic conductivities of sedimentary units encountered during drilling. The estimated hydraulic conductivity of each type of unconsolidated deposit was based on the range of values given by Freeze and Cherry (1979).

The original and the calibrated distributions of hydraulic conductivity are shown in Figures 19 and 20, respectively. Calibrated values range from 0.01 to 8.0 feet/day. Zones of highest hydraulic conductivity are associated with fractured basalts in the southeast and coarse grained sediments which occur near mountains and in lenses within the valley fill. Low-permeability barriers created by faults are represented by zones of very low hydraulic conductivity. It was necessary to invoke this technique in the vicinity of Spanish Springs Ranch to reproduce the observed head distribution in the southeast part of the valley. Similiarly, a zone of low hydraulic conductivity between wells #7 and #8 was necessary to reproduce the steep gradient between those wells. A brief review of Figure 5 (page 24) shows a major fault in the alluvium which passes

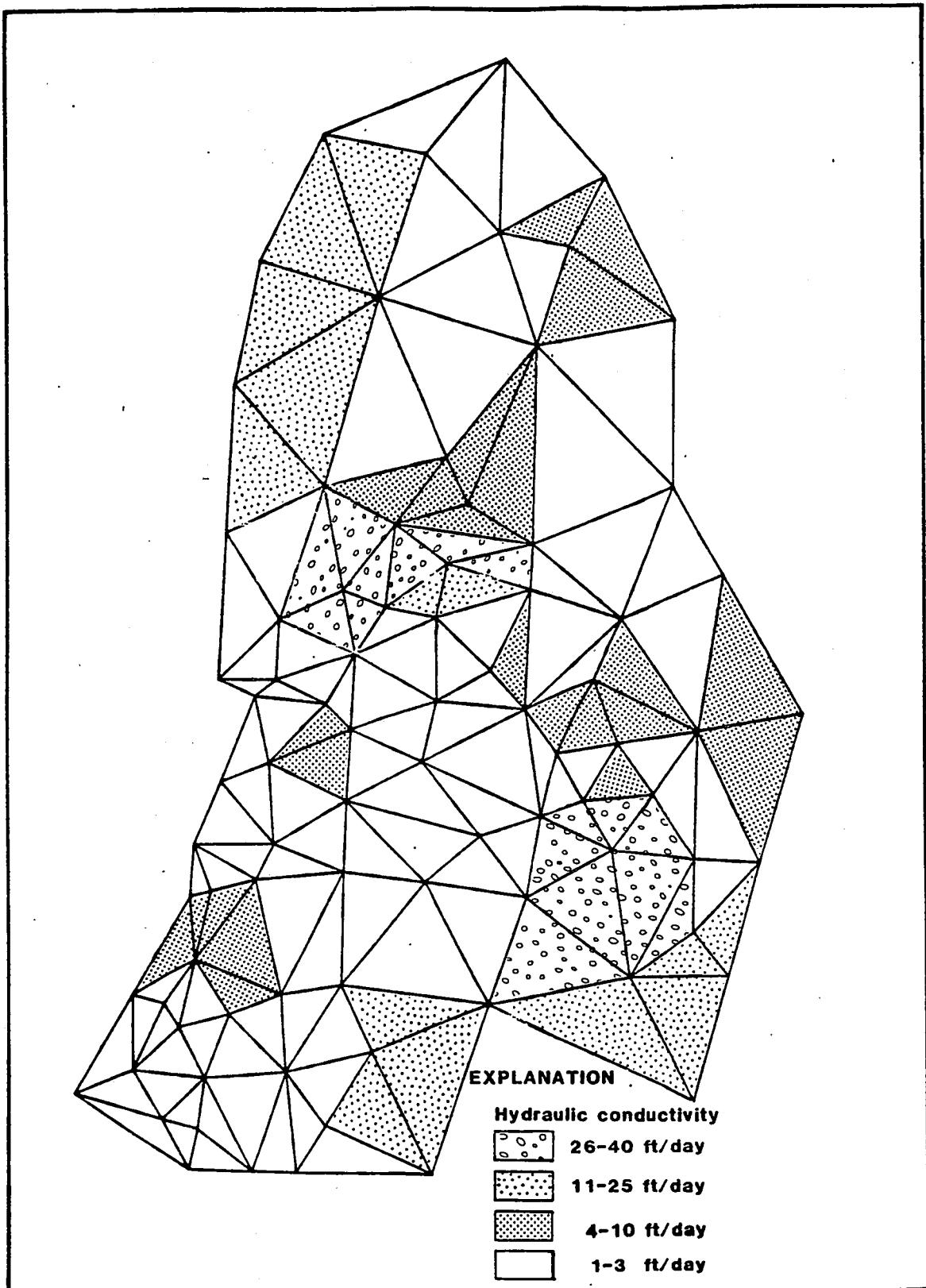


FIGURE 19. Original distribution of hydraulic conductivity.

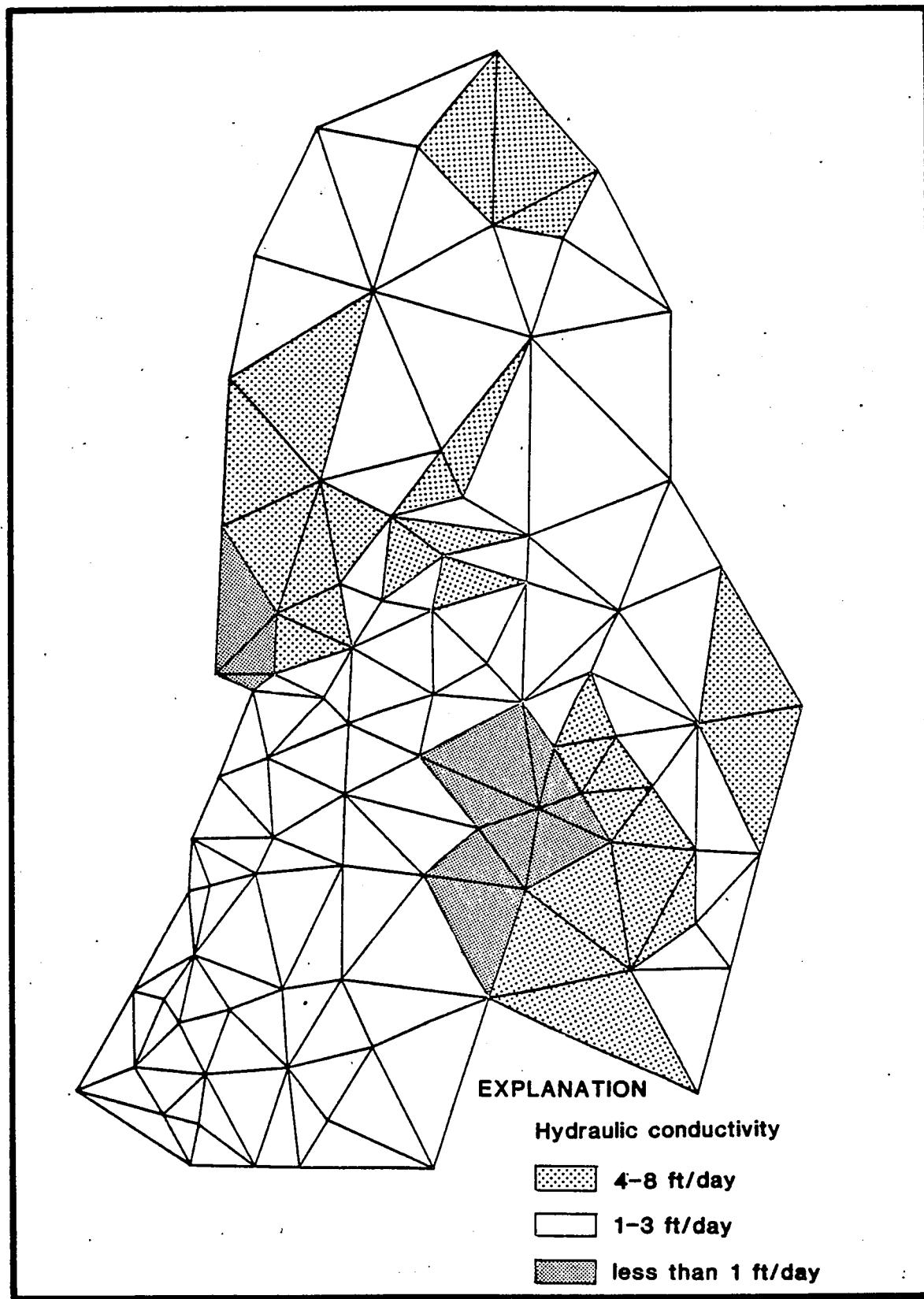


FIGURE 20. Calibrated distribution of hydraulic conductivity.

between well #7 and well #8. The author believes that in this area, the fault may act as a barrier to groundwater flow.

Recharge from precipitation

Estimates of water yield were used to determine the distribution and magnitude of pre-calibration recharge rates. The water yield of each hydrographic sub-area (Figure 11, page 41) was distributed among adjacent boundary nodes, producing a pre-calibration recharge rate of 1200 acre-feet/yr. Water yield of the topographically closed Dry Lakes area was originally excluded from the total estimated recharge. Because estimates of water yield include surface water runoff as well as groundwater recharge, the author assumed pre-calibration recharge rates were maximum estimates of groundwater recharge.

The distribution and amount of recharge were adjusted during calibration of the groundwater flow model. Figure 21 shows the original and the final distribution and rates of recharge from precipitation. Recharge associated with the majority of boundary nodes was decreased, as expected, during successive model runs. Specified flow was increased, however, at the base of the Pah Rah Range in the southeast part of the watershed. Total precipitation recharge for the calibrated model is approximately 600 acre-feet/yr. Most of

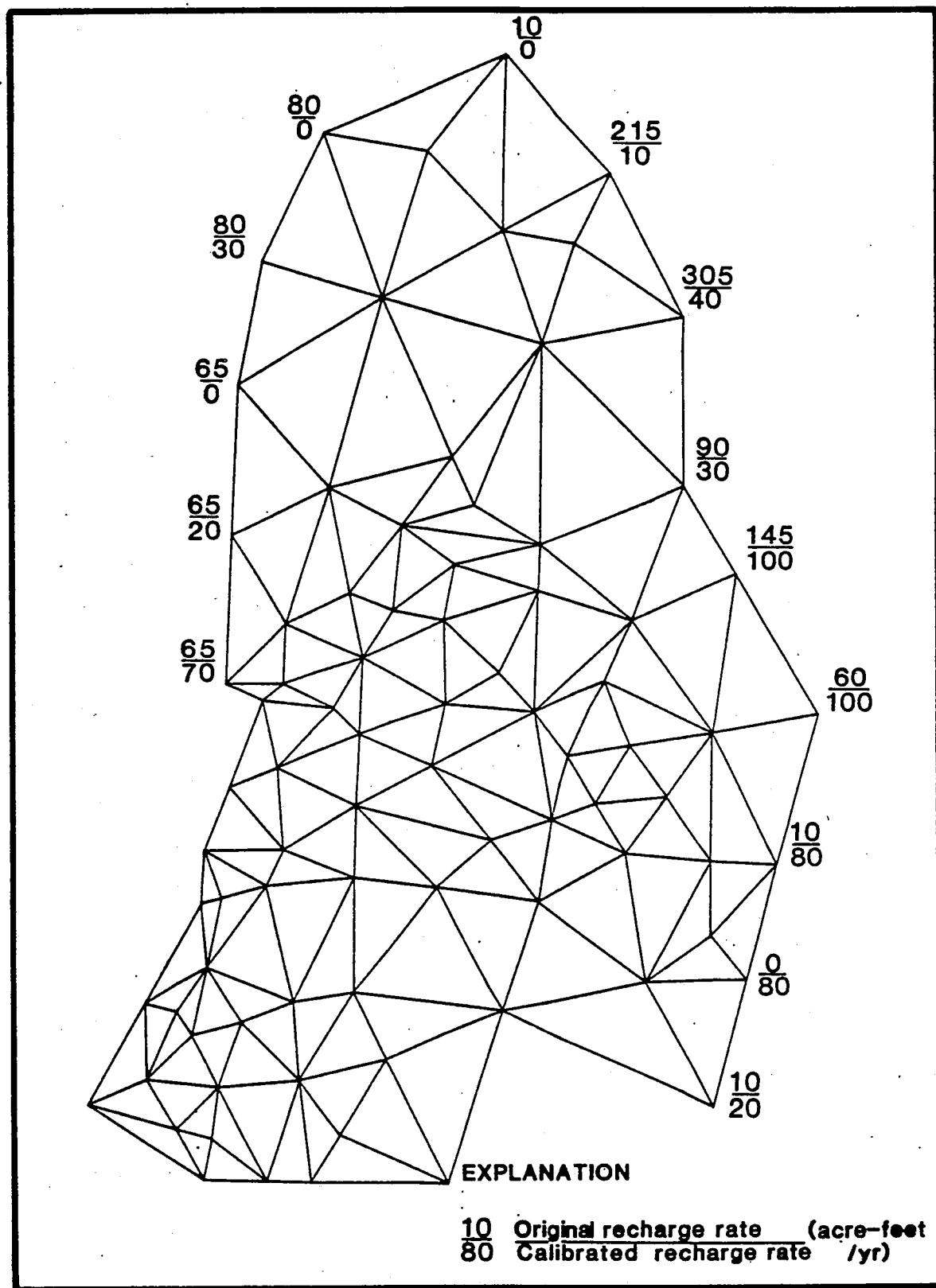


FIGURE 21. Original and calibrated distribution and rates of recharge from precipitation.

the recharge is concentrated in the southeast part of the watershed and reflects the greater precipitation associated with Spanish Springs Peak. Although the Dry Lakes area has no surface-water connection to Spanish Springs Valley, it does appear to contribute a significant amount of groundwater recharge. Estimated water yield of the hydrographic sub-area adjacent to nodes 21, 29, and 31 is only 20 acre-feet/yr. Combined simulated recharge at these nodes, however, is 180 acre-feet/yr. The high transmissivity of fractured basalts in this area would be conducive to subsurface flow from Dry Lakes to the alluvial aquifer of Spanish Springs Valley. The warm temperature (72 F) of flowing wells on Spanish Springs Ranch (Robinson and Phoenix, 1948, Table 2), and possibly of Spanish Spring, suggests relatively deep circulation of groundwater which may be associated with underflow from Dry Lakes.

Recharge from the Orr Ditch

The Orr Ditch was simulated in the model by a series of recharge nodes on the valley floor. Pre-calibration recharge rates were based on a preliminary Orr Ditch water budget. Analysis of streamflow data indicate that approximately 6100 acre-feet of imported water are consumed in the valley each year. Assuming consumptive use of irrigation water to be 2.7 acre-feet/acre/yr, crop evapotranspiration would account for approximately 2700 acre-feet/yr. Evaporation from about 100

acres of free water surface would consume approximately 400 acre-feet/yr. Subtracting the volume of water consumed by crop irrigation and pond evaporation from 6100 acre-feet/yr yields an initial estimate of groundwater recharge of 3000 acre-feet/yr. This amount was distributed among the nodes representing the Orr Ditch and adjacent irrigated acreage.

Figure 22 shows the original and final distribution and rates of recharge from the Orr Ditch. Total secondary recharge for the calibrated model is approximately 2200 acre-feet/yr.

Evapotranspiration

The amount and distribution of evapotranspiration in the groundwater flow model depend on the maximum evapotranspiration rate, a specified extinction depth for evapotranspiration, the local depth to the water table, and the size of the discharge area. Evapotranspiration is simulated as a linear function of depth to the water table. Maximum evapotranspiration occurs when the water table is at land surface; the evapotranspiration rate decreases as depth to water increases. The model assumes no water is evapotranspired when the local depth to water is greater than the specified extinction depth.

Data input to the model include a maximum evapo-

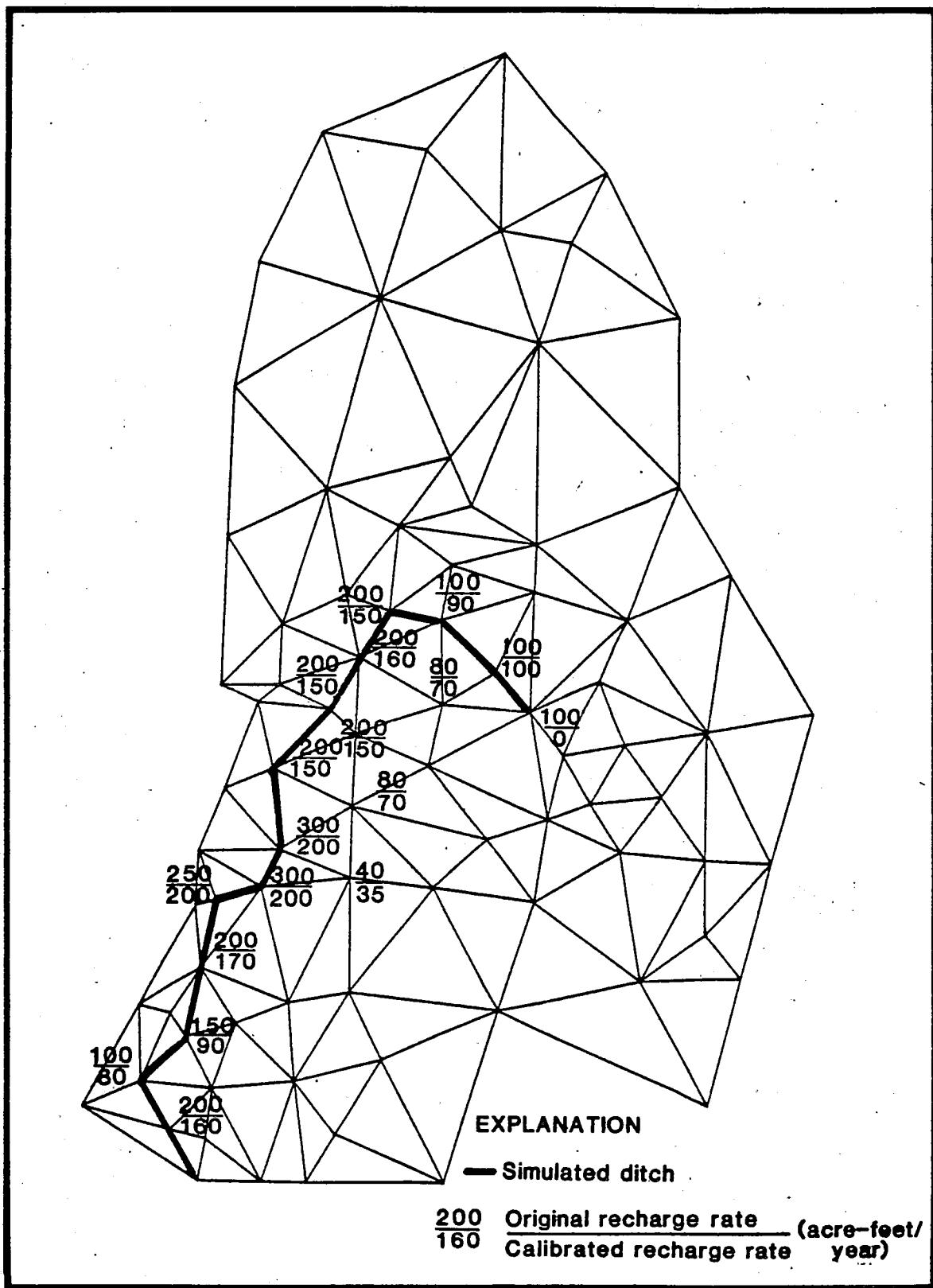


FIGURE 22. Original and calibrated distribution and rates of recharge from the Orr Ditch.

transpiration rate of 4.0 feet/yr and an extinction depth of 15 feet below land surface. Although it is not uncommon for roots of certain species of phreatophytes to reach 40 feet below land surface, phreatophyte roots are likely to be shallower in the vicinity of the Orr Ditch where the water table is near land surface.

The pre-calibration estimate of total evapotranspiration, 4000 acre-ft/yr, was based upon preliminary estimates of groundwater recharge and was, therefore, considered to be a maximum estimate of evapotranspiration. The final distribution and simulated rates of evapotranspiration are shown in Figure 23. A close correspondence exists between the simulated and mapped distribution of phreatophytes in the valley. Evapotranspiration of groundwater is concentrated in the vicinity of Spanish Springs Ranch and along the North Truckee Drain. Total simulated evapotranspiration is approximately 2400 acre-feet/yr from 2500 acres of phreatophytes. Simulated rates of evapotranspiration range from 0.2 to 2.0 feet/yr, which compare favorably to previously discussed phreatophyte evapotranspiration rates.

Subsurface outflow

Three options were available to simulate subsurface outflow. Specified flow boundary conditions could have been used at the north and south ends of the valley; computed

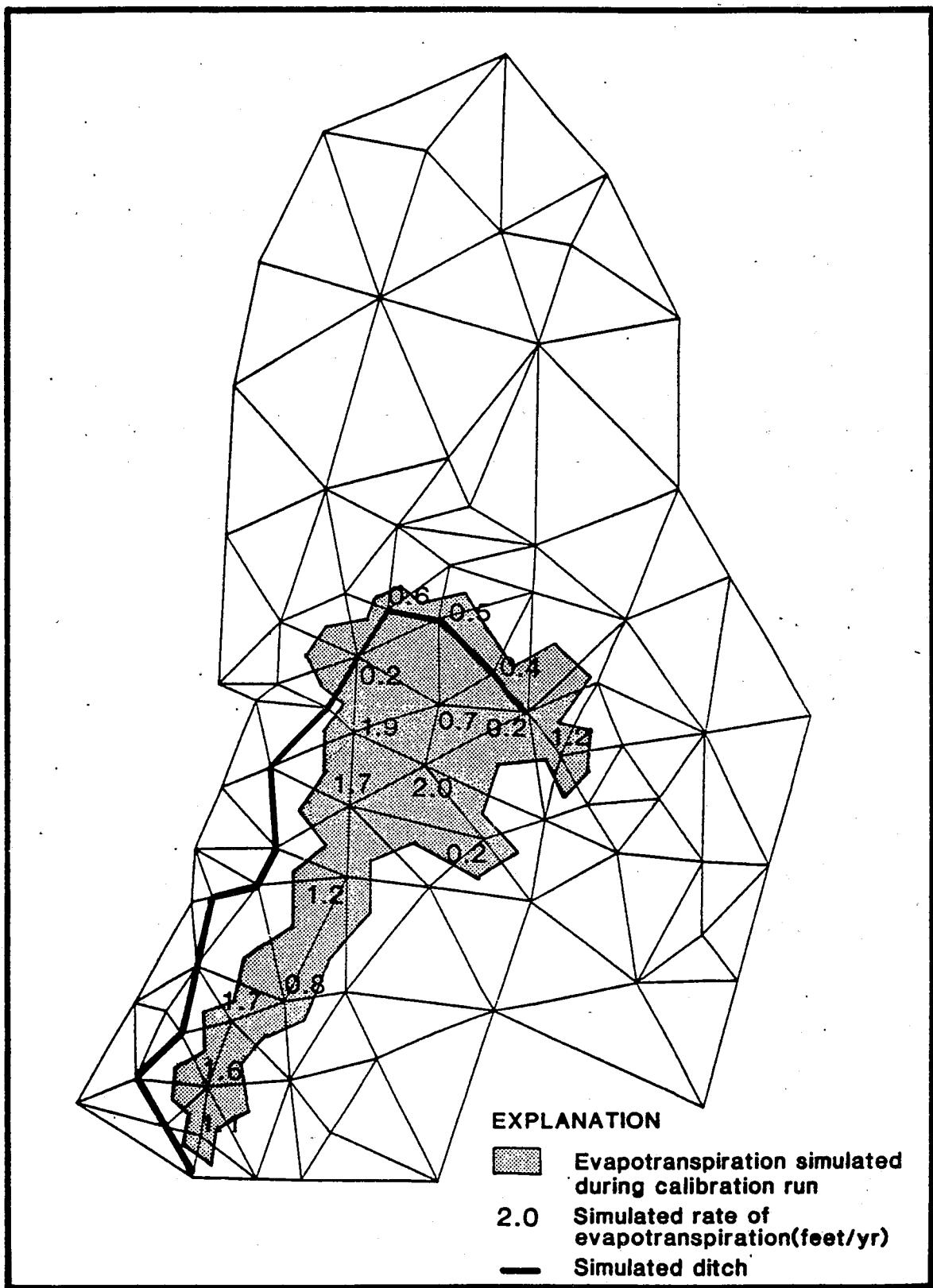


FIGURE 23. Calibrated distribution and simulated rates of evapotranspiration.

results would not have been realistic, however, for model scenarios involving reduced or eliminated ditch recharge. Underflow will decrease as recharge from the Orr Ditch declines. If the groundwater mound was to disappear completely, subsurface outflow would either cease or be restricted to one end of the valley. Maintaining a specified outflow at both locations would generate an inaccurate groundwater flow system.

A second alternative was to designate locations of subsurface outflow as constant head boundaries. This would introduce a head-dependent flux by adding water to the appropriate nodes if computed heads at those nodes declined below calibrated values. By adding water to these nodes to maintain a constant head, the net subsurface outflow would decrease. The problem with this approach lies in the assumption of constant heads at the north and south ends of the valley. The head distribution in these areas will change as ditch recharge decreases and pumping increases. Specifying constant head boundaries in areas of subsurface outflow would impose artificial constraints on the groundwater flow system.

The third option--the one chosen for this model--was to simulate underflow by designating subsurface outflow nodes as "artificial" evapotranspiration nodes. The evapotranspiration function is a head-dependent groundwater discharge

function; whether the discharge arises from phreatophytes or subsurface outflow is irrelevant. Each subsurface outflow node was assigned an artificial elevation equal to its calibrated head. Thus, the water table at these nodes appears to be at land surface in the evapotranspiration subroutine. Maximum subsurface outflow occurs, therefore, under present conditions of maximum ditch recharge.

Groundwater discharge at these nodes will decrease as heads fall below calibrated values. The main drawback to this approach is the restrictions imposed on subsurface outflow due to the reliance upon evapotranspiration parameters. For example, since the chosen extinction depth for evapotranspiration is 15 feet below land surface, the model assumes subsurface outflow will cease when heads at these nodes decrease by more than 15 feet. Although the evapotranspiration function influences the values of computed heads within this range, heads are allowed to fluctuate freely at these boundary nodes in response to stresses imposed on the aquifer.

Given the artificial way in which underflow is simulated, it is impossible to draw quantitative conclusions regarding subsurface outflow under conditions other than which the model was calibrated. The calibrated model--simulating current ditch recharge and no pumping--has approximately 300 acre-feet/yr subsurface outflow to Warm Springs Valley and 100 acre feet/yr underflow to the Truckee

Meadows. Computed subsurface outflow is located in the evapotranspiration section of the output file. Any evapotranspiration associated with nodes 2, 80, 81, and 82 represents simulated subsurface outflow.

Calibrated groundwater budget and potentiometric surface

The original and calibrated groundwater budgets for Spanish Springs Valley are shown in Table 4. For steady-state scenarios, inflow to the groundwater system equals outflow. Total recharge and subsurface outflow are specified as data input, while evapotranspiration is calculated by the model based on related input parameters.

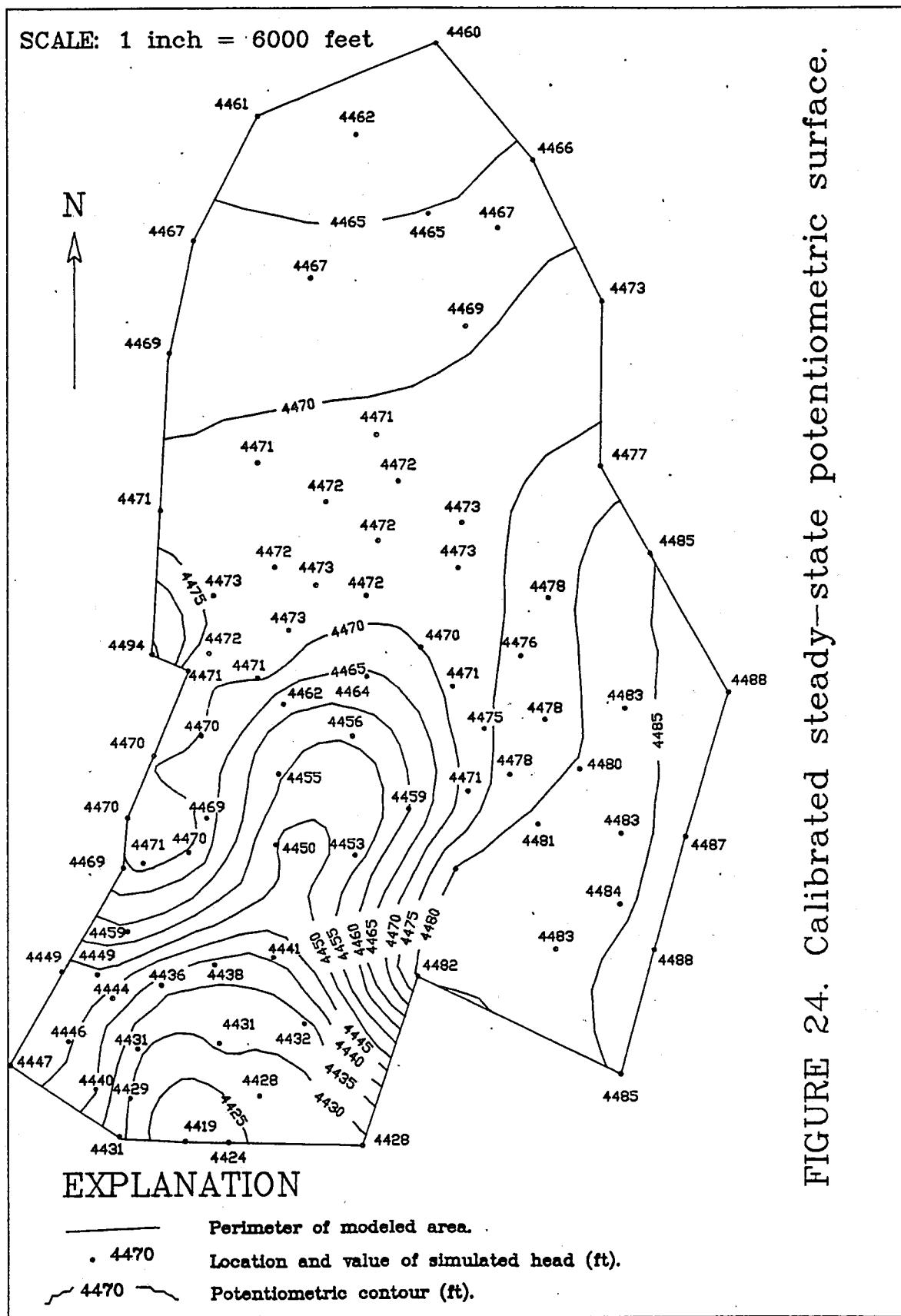
Hydraulic heads computed by the model are contoured in Figure 24. The differences between calibrated heads and control heads are shown in Figure 25. The largest difference between control heads and simulated heads is approximately 11 feet. Eighty-nine percent of simulated heads are within 5 feet of their control values. The statistical match between control heads and their simulated values are summarized below:

	<u>Sample 1 (control)</u>	<u>Sample 2 (model)</u>
Average	4467.75	4467.90
Variance	210.86	187.55
Stnd. Dev.	14.52	13.69
# Observations	28	28

TABLE 4. Preliminary and calibrated groundwater budgets
(Acre-feet/year)*

		PRELIM	CALIB
INFLOW:			
Primary recharge (precipitation)		1200	580
Secondary recharge (Orr Ditch)		3000	2220
Total inflow		4200	2800
OUTFLOW:			
Evapotranspiration		4000	2400
Subsurface outflow to Warm Springs Valley		0	280
Subsurface outflow to Truckee Meadows		200	120
Total outflow		4200	2800

*All figures are rounded to 3 significant digits.



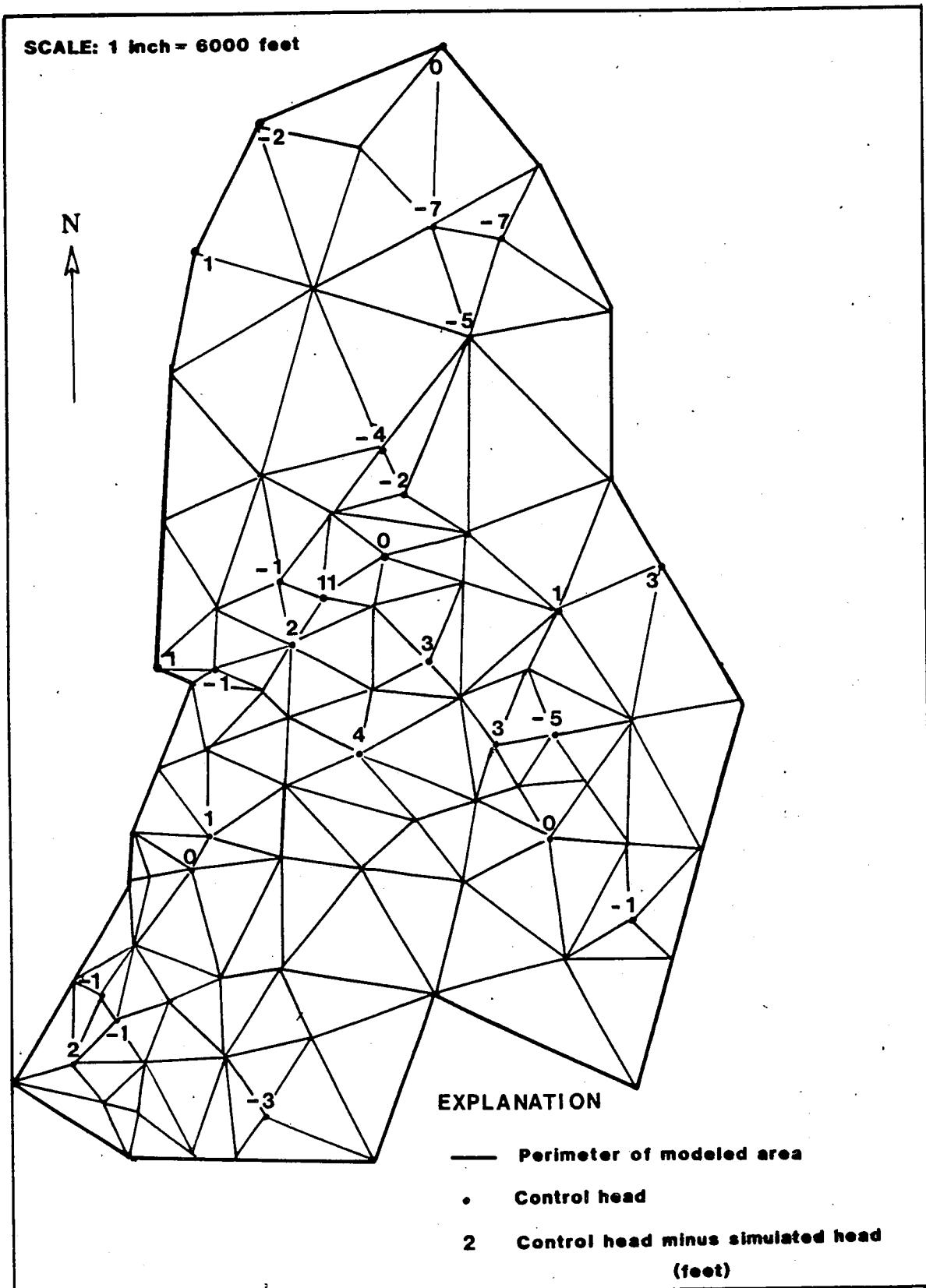


FIGURE 25. Difference between calibrated heads and control heads.

The potentiometric map clearly shows the impact of the Orr Ditch on the groundwater flow pattern in Spanish Springs Valley. Contours in the southern half of the basin are roughly parallel to the irrigation canal; in this area, the calibrated potentiometric surface slopes towards the Truckee Meadows by approximately 12 ft/mile. In the northern part of the basin, the slope of the water table is approximately 3 ft/mile towards Warm Springs Valley.

Sensitivity analysis

Because of uncertainty in much of the data used to develop groundwater flow models, a sensitivity analysis is an important part of such simulations. The goals of sensitivity analysis are to determine the range over which aquifer characteristics may vary without appreciably affecting model results and to identify those parameters to which computed heads are most sensitive. This information allows one to define goals for future data collection.

Results of the sensitivity runs are summarized in Table 5. Adjustments were made to hydraulic conductivity, valley fill thickness, subsurface outflow, groundwater recharge, and evapotranspiration parameters. Model output was analyzed for the degree to which simulated heads reproduced control heads and for changes in simulated heads relative to the final calibration run.

TABLE 5. Summary of groundwater flow model sensitivity analysis

Parameter adjustments	Simulated groundwater budget (acre-ft/yr) (rounded to 3 significant digits)					Control minus simulated heads (feet)		
	Inflows		Outflows			Mean error	Min/Max error	Stnd. Dev.
	Precip- itation recharge	Orr Ditch recharge	Evapo- trans- piration	Under- flow to TM	Under- flow to WSV			
FINAL CALIBRATION RUN	580	2220	2400	120	280	-0.29	0/11	3.65
HYDRAULIC CONDUCTIVITY								
Decrease K's by 1/2 an order of magnitude	580	2220	2500	81	220	-4.54	0/-24	6.65
Increase K's by 1/2 an order of magnitude	580	2220	2320	212	275	8.64	0/29	8.57
VALLEY-FILL THICKNESS								
Decrease VFT by 20%	580	2220	2440	105	258	-2.04	1/10	3.96
Increase VFT by 20%	580	2220	2380	129	295	0.82	0/11	4.04
EVAPOTRANSPIRATION								
Decrease extinction depth by 5 feet	580	2220	2350	135	323	-4.04	0/-9	2.71
Increase extinction depth by 5 feet	580	2220	2450	107	248	3.04	0/14	3.71
Decrease maximum ET rate by 0.5 ft/yr	580	2220	2430	113	265	-1.00	0/10	3.67
Increase maximum ET rate by 0.5 ft/yr	580	2220	2390	123	292	-0.18	0/11	3.44
Decrease land surface elevation by 5 ft	580	2220	2470	98	237	3.96	0/15	4.10
Increase land surface elevation by 5 ft	580	2220	2340	139	322	-4.54	-1/-10	3.38

TABLE 5. Summary of groundwater flow model sensitivity analysis (continued)

Parameter adjustments	Simulated groundwater budget (acre-ft/yr) (rounded to 3 significant digits)					Control minus simulated heads (feet)		
	Inflows		Outflows			Mean error	Min/Max error	Stnd. Dev.
	Precip- itation recharge	Orr Ditch recharge	Evapo- trans- piration	Under- flow to TM	Under- flow to WSV			
Decrease ET area by 20%	580	2220	2400	123	285	-1.14	0/10	3.44
Increase ET area by 20%	580	2220	2410	115	276	-0.14	0/11	3.56
PRECIPITATION RECHARGE								
Decrease recharge by 30%	410	2220	2250	118	262	1.18	0/11	3.97
Increase recharge by 30%	750	2220	2560	118	297	-1.71	0/10	3.97
Transfer 140 AF/YR from SE to NE	580	2220	2380	118	305	-0.32	0/-10	4.44
ORR DITCH RECHARGE								
Decrease recharge by 30%	580	1560	1760	112	266	1.50	0/12	4.13
Increase recharge by 30%	580	2890	3060	125	290	-1.42	0/9	4.82
UNDERFLOW TO TRUCKEE MEADOWS								
Decrease underflow by 100%	580	2220	2530	0	279	-0.68	0/11	4.05
Increase underflow by 100%	580	2220	2290	240	279	0.07	0/11	3.76

TABLE 5. Summary of groundwater flow model sensitivity analysis (continued)

Parameter adjustments	Simulated groundwater budget (acre-ft/yr) (rounded to 3 significant digits)					Control minus simulated heads (feet)		
	Inflows		Outflows			Mean error	Min/Max error	Stnd. Dev.
	Precip- itation recharge	Orr Ditch recharge	Evapo- trans- piration	Under- flow to TM	Under- flow to WSV			
UNDERFLOW TO WARM SPRINGS VALLEY								
Decrease underflow by 100%	580	2220	2690	118	0	-4.36	0/-21	8.20
Increase underflow by 100%	580	2220	2130	118	560	3.82	0/20	5.70

Aquifer characteristics

The sensitivity of computed heads to changes in hydraulic conductivity was tested in the first set of sensitivity runs. In general, decreasing hydraulic conductivity by 1/2 an order of magnitude caused large changes in simulated heads near the perimeter of the modeled area and relatively small or no changes near groundwater discharge zones. Heads at boundary recharge nodes increased, on the average, by 13 feet. Water levels at Orr Ditch recharge nodes rose approximately 8 feet, while heads at evapotranspiration nodes changed from 0 to 2 feet. Heads remained relatively stable at these latter nodes because rising water levels were offset by an increase in the rate of evapotranspiration. The steeper hydraulic gradient between recharge and discharge areas is necessary for groundwater to flow through a medium of lower hydraulic conductivity.

Increasing hydraulic conductivity caused head changes similar in magnitude but opposite in direction. Most of the basin experienced head declines of 1 to 28 feet, with the greatest change occurring in recharge areas. Simulated subsurface outflow to the Truckee Meadows and Warm Springs Valley increased because groundwater was able to move more easily through the system.

Computed transmissivity is also dependent on the

thickness of the valley-fill. To test the sensitivity of the model to errors in estimated depth to bedrock, valley-fill thickness was adjusted by 20%. Simulated heads at boundary recharge nodes rose by an average of 3 feet when thickness of the valley-fill was decreased, whereas interior nodes experienced an average head increase of approximately 1 foot. Increasing valley fill thickness had even less effect on simulated conditions.

Evapotranspiration parameters

Total simulated evapotranspiration is influenced by four input parameters: maximum evapotranspiration rate, extinction depth, land-surface elevation at each evapotranspiration node, and the area associated with each node. The sensitivity of computed heads to each of these parameters was tested in the third set of sensitivity runs.

The head distribution in the aquifer was most sensitive to changes in land-surface elevation and extinction depth. Heads throughout the modeled area decreased 2 to 5 feet in response to a 5-foot decrease in land-surface elevation; increasing the extinction depth by 5 feet caused a similar decline in water levels. The model was not very sensitive to changes in the maximum evapotranspiration rate or to moderate adjustments in the area associated with each evapotranspiration node. Increasing the maximum evapotranspiration

rate by 0.5 ft/yr caused scattered heads throughout the valley to decline by less than 1 foot; increasing the evapotranspiration area of each node by 20% had the same effect. Changing any of the four parameters in the opposite direction produced an equivalent rise in water levels.

Precipitation recharge

The total amount and distribution of recharge from precipitation were adjusted during the fourth set of sensitivity runs. Water levels in the southeast part of the basin showed the greatest fluctuations in response to changes in recharge, because that is where most of the simulated recharge is concentrated. Heads along the perimeter of the modeled area were more sensitive than water levels at interior nodes. In each scenario, adjustments to total recharge were compensated for within the model by an equivalent change in evapotranspiration.

Water levels rose 3 to 6 feet in the southeast in response to a 30% increase in total precipitation recharge. Simulated heads in the northern half of the basin generally rose 1 to 2 feet, whereas heads in or near groundwater discharge zones were unchanged. An equal decrease in precipitation recharge caused a similar pattern of water-level declines throughout the basin.

To test the hypothesis that underflow from Dry Lakes provides recharge to the valley fill aquifer, 140 acre-ft/yr of recharge was moved from the southeast (nodes 29 and 31) to boundary nodes farther north (nodes 49, 59, and 68). Sixty percent of this redistributed recharge was applied to node 68, which is located at the mouth of Griffith Canyon. Although Griffith Canyon is a major drainage in the Spanish Springs Valley watershed, the calibrated model has only 40 acre-ft/yr of groundwater recharge at this location. Thus, this run also tested the sensitivity of computed heads to increased recharge from Griffith Canyon.

The statistical match between simulated and control heads was not seriously affected by redistributing recharge in the above manner; a closer inspection of individual control points, however, showed less correlation between computed and observed heads. Water levels in the southeast declined by 4 to 11 feet, while heads in the north rose by 1 to 9 feet. In each area, computed heads were further from their control values. This sensitivity run suggests the southeast part of the basin receives a greater amount of recharge than can be attributed to precipitation in the low surrounding hills.

The response of heads in the northeast part of the basin warrants further description. Although the head at boundary node 68 increased by 9 feet in response to the additional

applied recharge, heads at adjacent interior nodes rose by only 2 or 3 feet. Another sensitivity run in which recharge at nodes 68 and 79 was eliminated completely caused adjacent interior nodes to decline by only 1 or 2 feet. Despite this unrealistic hydrologic scenario, computed heads at these nodes were still higher than their control values. Thus, the model is relatively insensitive to adjustments in recharge in the vicinity of Griffith Canyon and Sugarloaf Peak. The model's inability to reproduce field data in this area may be linked to a poor understanding of local subsurface geology. Major faults in the adjacent hills probably extend into the valley-fill material and influence the groundwater flow pattern.

Orr Ditch recharge

Recharge from the Orr Ditch was adjusted by 30% to examine the sensitivity of computed heads in the basin to variations in secondary recharge. Increasing recharge by approximately 670 acre-feet/yr produced a similiar increase in evapotranspiration. Computed heads at or near ditch recharge nodes rose 4 to 6 feet, while water levels at evapotranspiration nodes increased by approximately 1 foot. Simulated heads in the north rose 0 to 2 feet in response to increased recharge from the Orr Ditch. Reducing ditch recharge to 1560 acre-feet/yr caused changes similiar in magnitude but opposite in direction.

Subsurface outflow

Underflow from Spanish Springs Valley to adjacent basins was adjusted during the final set of sensitivity runs. Changes in subsurface outflow were compensated for within the model by an equivalent but opposite change in evapotranspiration.

Increasing subsurface outflow to the Truckee Meadows to 240 acre-feet/yr caused computed heads at the extreme south end of the valley to decline by 1 to 16 feet. Heads throughout the rest of the basin were unchanged. Eliminating underflow produced an equivalent rise in water levels. Only one control head was affected during these two sensitivity runs; in both scenarios, the computed head at this node was further from its control value than in the calibrated model.

Adjusting subsurface outflow to Warm Springs Valley produced a greater response in the alluvial aquifer. Increasing underflow to 560 acre-feet/yr caused water levels in the far north to drop 12 to 20 feet. The remaining heads in the northern half of the basin declined, on the average, by approximately 7 feet. Water levels in the vicinity of the Orr Ditch were unchanged, although heads in the southeast declined by 1 to 3 feet. Eliminating underflow to Warm Springs Valley caused head changes similar in magnitude but opposite in direction. The configuration of the water table

was no longer a groundwater mound, but rather a surface sloping from north to south.

Accuracy of model results

The validity of predictions depends on how well the model approximates field conditions. Sources of error in simulation results can be grouped into four categories:

- 1) uncertainty in aquifer parameters and other input data;
- 2) simplifying assumptions made to mathematically describe the groundwater flow system;
- 3) errors made in conceptualization of the flow system; and
- 4) errors associated with the computational scheme.

Using a finite number of nodes causes the numerical solution of the partial differential equation to deviate from the true solution. The greatest source of error in model results, however, is from uncertainties in input data and, in some areas, a lack of data. The validity of forecasted drawdowns depends on the agreement between non-unique, calibrated input parameters and actual values. The sensitivity of computed results to ranges of aquifer parameters and recharge estimates was tested during sensitivity analyses. The natural variation of aquifer parameters within each element, however, introduces a certain degree of error to model results. Generally, the largest deviation between computed heads and control heads occurs in

areas where sparse field data introduce considerable uncertainty in aquifer parameters and subsurface geology.

The assumption of horizontal flow is a source of error for computed heads located near recharge or discharge areas. For example, the largest deviation between a control head and a simulated head is associated with a well located very close to the Orr Ditch, where vertical components of flow are likely to be significant. Similarly, calibrated heads in the vicinity of Spanish Springs Ranch do not reflect the influence of the vertical hydraulic gradient in that area. When the model is used to evaluate drawdowns from different pumping scenarios, the same limitations apply to computed heads in close proximity to pumping wells.

Despite these limitations, the model is still a valuable tool to test groundwater management alternatives and to evaluate the basin-wide response of the alluvial aquifer to different stresses. The overall agreement between simulated groundwater conditions and existing field data lends credibility to model results, although the predictive accuracy of the model can be verified only by long-term monitoring of water levels in the basin.

Model Application

Comparison of different pumping scenarios offers valuable insight regarding the potential effects of future groundwater development in Spanish Springs Valley. Although forecasting of exact drawdowns is not possible, the model may be used to estimate the magnitude and areal extent of drawdowns resulting from different development schemes.

A complete listing of the FORTRAN program used in this study is included in Appendix D; the data input file and model output for the final calibration run are shown in Appendix E. Simulations of groundwater flow were restricted to steady-state conditions and assumptions due to the lack of drawdown data necessary to properly calibrate a transient model. Although the model can be used to forecast time-dependent drawdowns, model results would best be viewed as an indication of the possible range of drawdowns associated with storativities of different orders of magnitude. Continued data collection as water levels decline will permit a calibrated transient model to be developed in the future.

Pumping scenarios

Four alternative pumping scenarios were evaluated with the groundwater flow model. Input data for each scenario are

summarized in Table 6, and the locations of the pumping wells are shown in Figure 26. Scenarios 1 and 4, with approximately 720 acre-ft/year net basin pumpage, represent the estimated groundwater demand in 1987. Simulated pumping of 1740 acre-ft/year in scenarios 2 and 3 is based upon information obtained from Washoe County regarding the number of homes which could potentially be built in Spanish Springs Valley in the future. Final and tentative subdivision maps submitted to the Washoe County Utility Division could allow for a total of approximately 2400 homes in the valley. Assuming a pumping rate of 0.8 acre-ft/yr per unit with 20% secondary recharge from septic tanks and landscape irrigation yields approximately 1550 acre-ft/year net subdivision pumpage. Together with other groundwater demands in the basin, the consumptive use of groundwater could exceed 1700 acre-ft/year. The locations of pumping wells in each scenario correspond to existing wells in the basin, although not all wells are being used at this time. The well field in the west central part of the valley is approximately 1/2 mile north and northwest of the Orr Ditch.

Secondary recharge from the Orr Ditch was reduced by 30% in scenario 3 to gauge the effects of decreasing ditch recharge on drawdowns within the basin. Recharge from the Orr Ditch was removed completely in scenario 4, in combination with 1987 pumping rates, as an example of what might happen to water levels in the basin should no source of

TABLE 6. Summary of pumping scenarios

DISCHARGE (AF/YEAR) ASSIGNED TO NODES

PUMPING NODES *		SCENARIO 1	SCENARIO 2	SCENARIO 3	SCENARIO 4
17	Spring Creek	75	75	75	75
19	Blue Gem and Oasis	40	40	40	40
33	"Big Well"	--	145	145	--
50	Countryside	--	110	110	--
54	Baldwin Estates	7	7	7	7
61	Sky Ranch SS6	165	190	190	165
63	Golden West/Sunset	--	450	450	--
64	Dsrt Sprgs North well	280	325	325	200
65	Hawco Pyramid Ranch	--	300	300	--
66	Dsrt Sprgs South Well	10	50	50	10
69	domestic group	5	5	5	5
77	Donovan irrigation	75	75	75	75
82	gravel pit	100	100	100	100
 SEPTIC/IRRIGATION RECHARGE NODES					
51	Countryside	--	60	60	--
72	Pyramid Ranch	40	75	75	40
 PRECIPITATION RECHARGE					
		580	580	580	580
ORR DITCH RECHARGE					
		2225	2225	1560	0
 TOTAL RECHARGE					
		2805	2805	2140	580
APPROX NET BASIN PUMPAGE					
		720	1740	1740	720

* Secondary recharge from Pyramid Ranch and Countryside subdivisions are accounted for by nodes 72 and 51, respectively. All other pumpage is entered as net discharge. No septic tank recharge was assumed for Spring Creek subdivision, which has a sewer system.

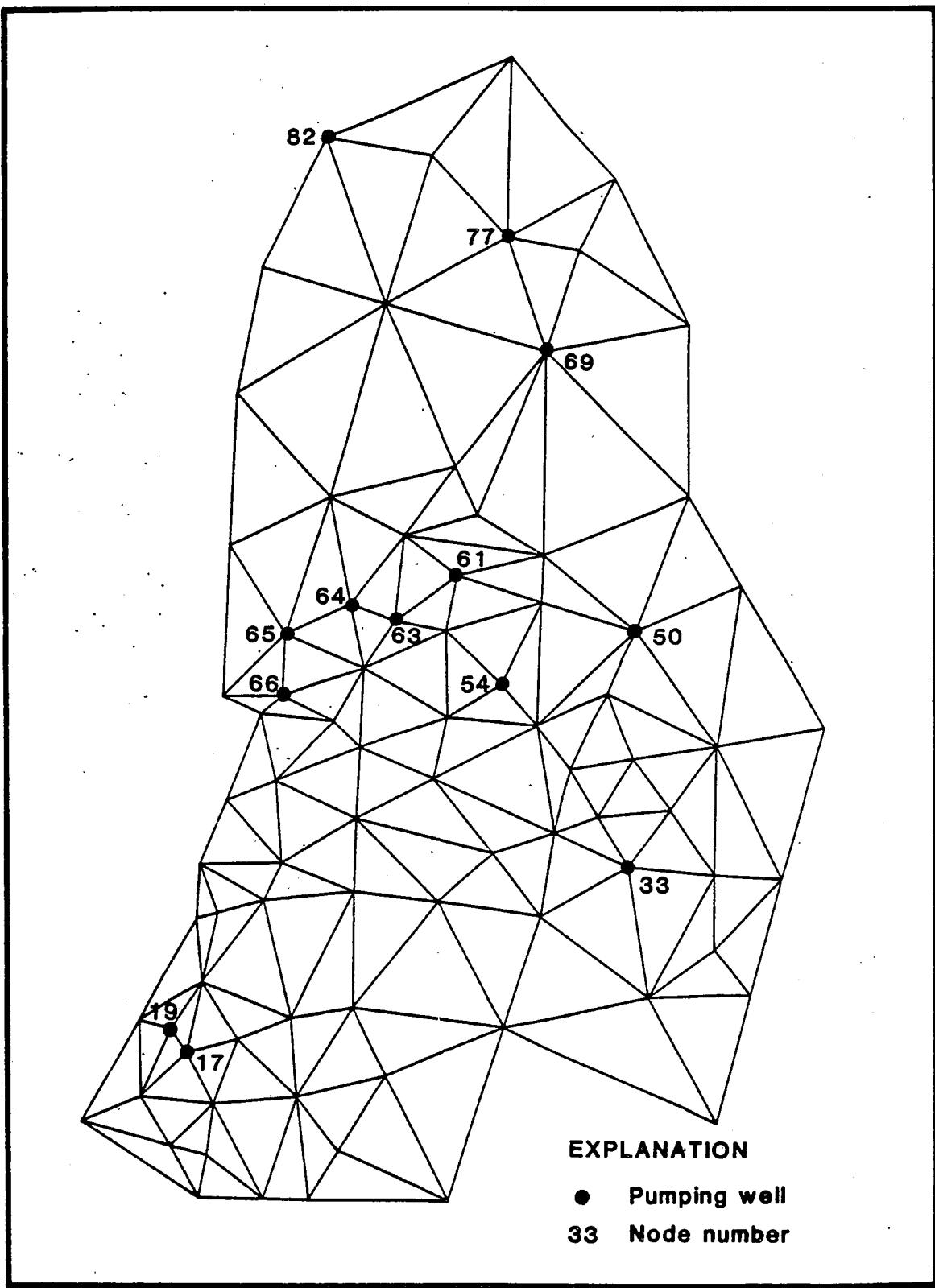


FIGURE 26. Location of pumping wells in predictive simulations.
(Wells identified in Table 6)

secondary recharge be available.

Results

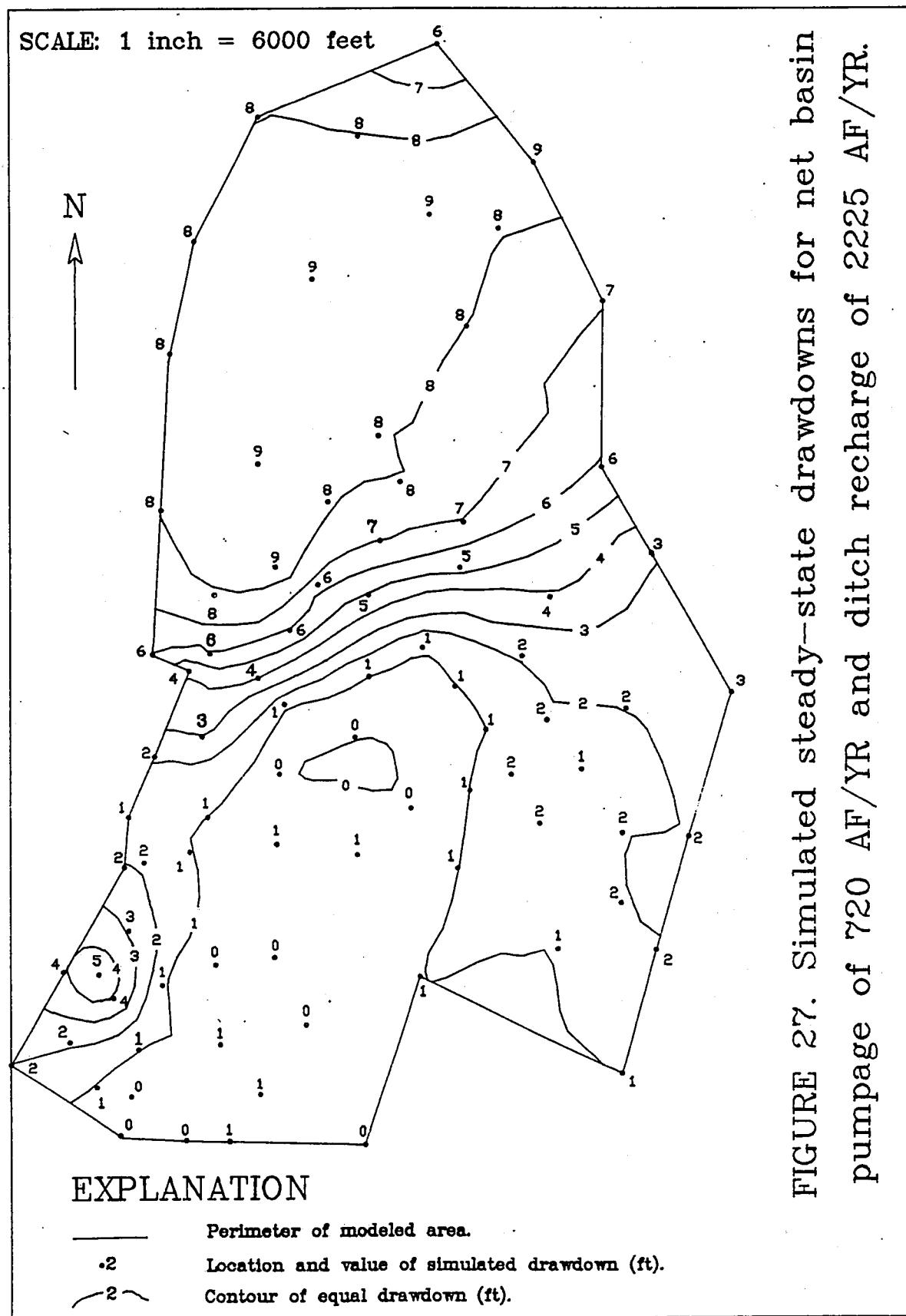
A brief summary of drawdowns simulated in each scenario is shown in Table 7. All reported drawdowns are relative to the values of hydraulic head in the calibrated model. The entire basin experienced drawdowns of fewer than 10 feet in scenario 1, which represents steady-state water-level declines associated with 1987 pumping rates (Figure 27). Average drawdown was 3.5 feet. Evapotranspiration of groundwater decreased from 2400 acre-ft/yr in the calibrated model to 1850 acre-ft/yr.

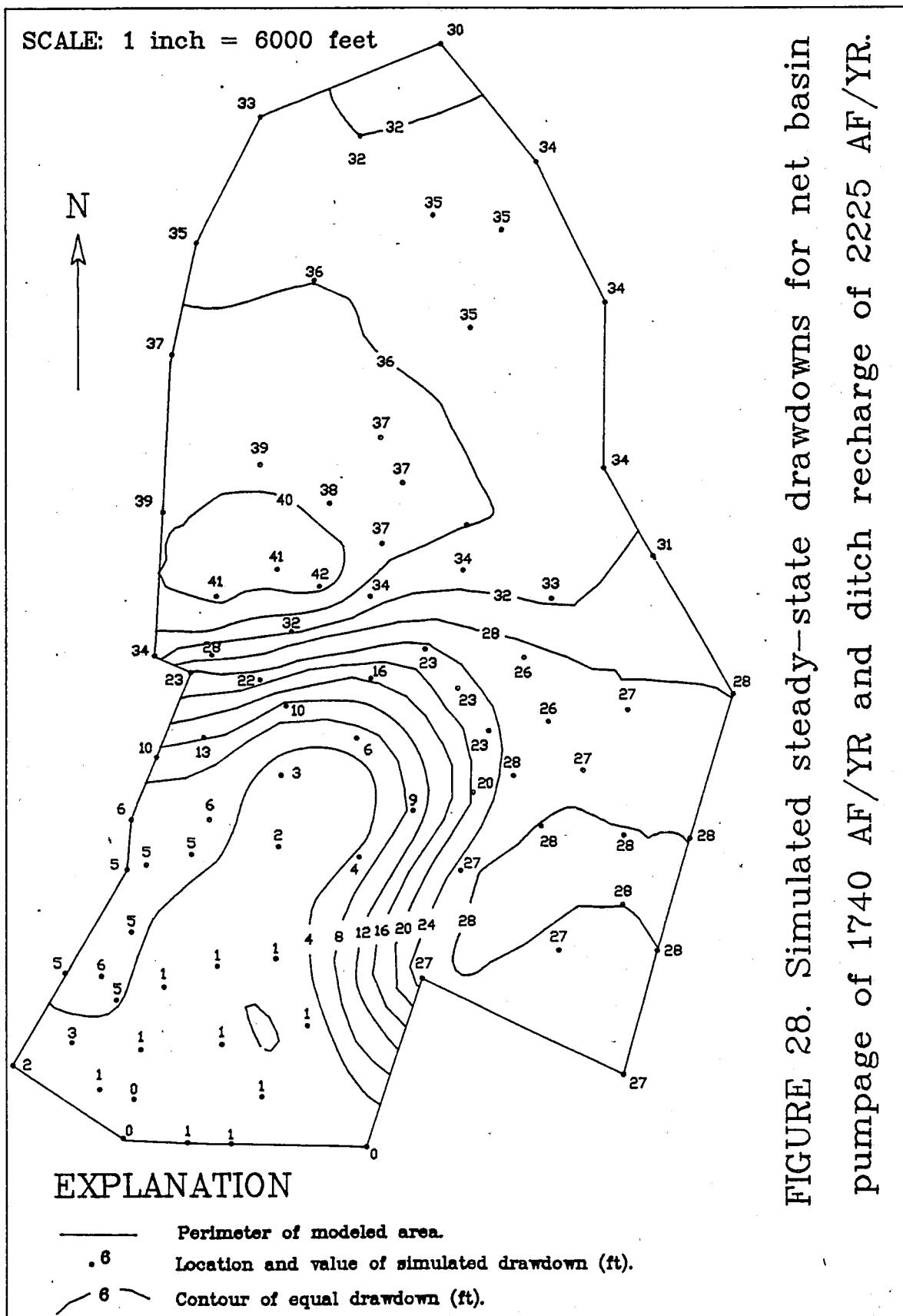
Simulated drawdowns for scenario 2 are shown in Figure 28. Increased pumping created water level declines of up to 42 feet, with an average drawdown of 20.5 feet. The largest impacts from increased pumping occurred near the well field in the west-central part of the valley. To the south, drawdowns are less extensive because of the presence of the Orr Ditch. Drawdowns are greater and more widespread down gradient from the well field.

Another area which experienced notable drawdowns from increased pumping was the southeast part of the valley. Two water-supply wells for the proposed Countryside subdivision, represented by nodes 33 and 50, began production in scenario

TABLE 7. Summary of simulation results

SCENARIO	NET BASIN PUMPAGE (acre-ft/yr)	NET SUBDIVISION PUMPAGE (acre-ft/yr)	RECHARGE PPT/DITCH (acre-ft/yr)	NUMBER OF NODES WITH SIMULATED DRAWDOWN (FT) WITHIN SPECIFIED RANGES				
				0-10 (feet)	11-20	21-30	31-40	41-50
1	720	530	580/2225	0-9	83	0	0	0
2	1740	1550	580/2225	0-42	31	3	22	24
3	1740	1550	580/1560	2-48	17	15	9	13
4	720	530	>580/0	*	*	*	*	*





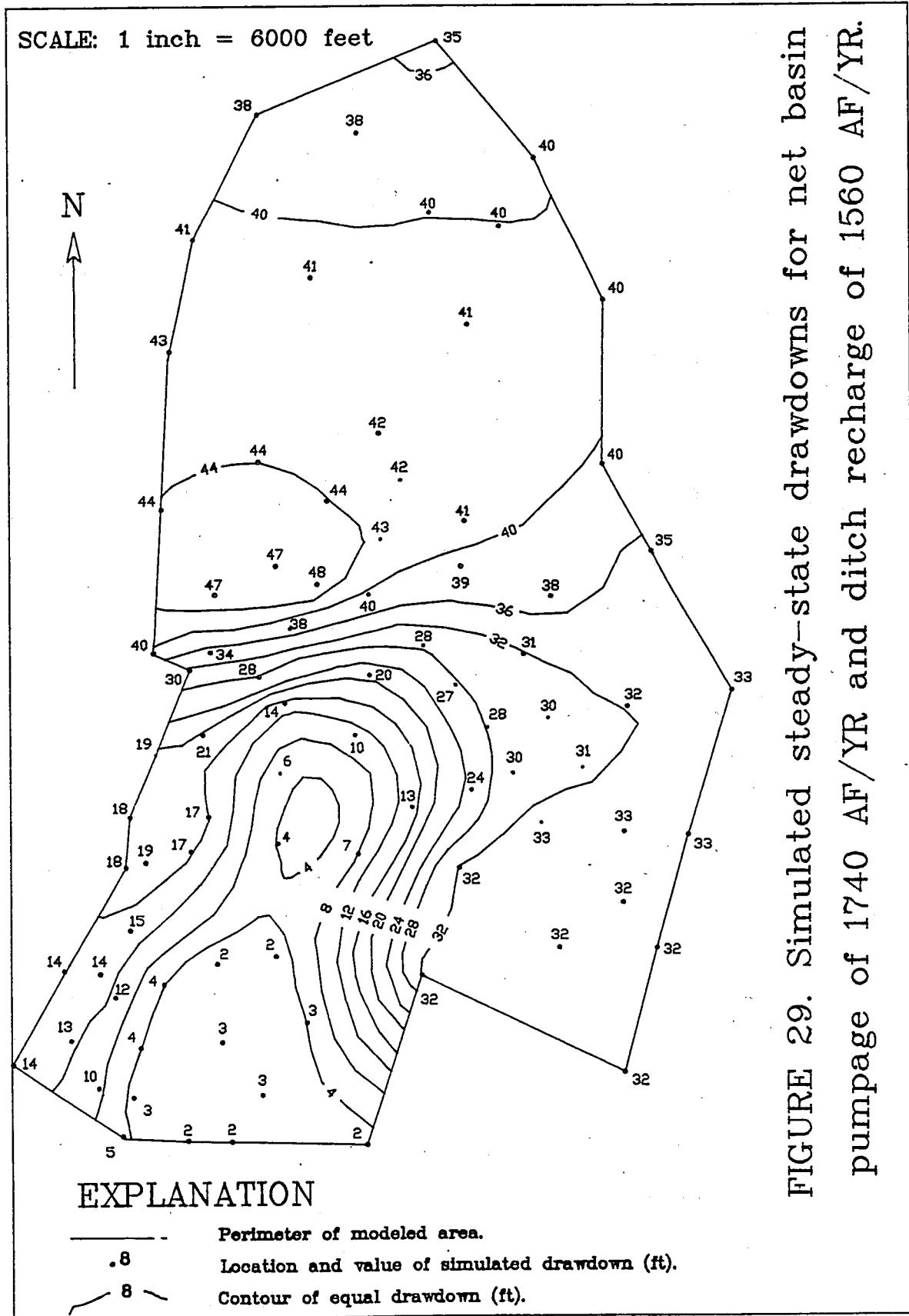
2. Although the simulated net groundwater discharge from these two wells is only 195 acre-ft/yr, drawdowns in the southeast averaged 26 feet. Drawdowns averaged only 6 feet in this area when scenario 2 was run without the Countryside wells. Thus, simulated water levels in the southeast part of the basin are quite sensitive to local pumping. These results are consistent with Cochran's (1972) interpretation and conclusions about the hydrogeology of the Spanish Springs Ranch area. The northeast-trending fault in the vicinity of the ranch most likely creates a groundwater "sub-basin" in the southeast which receives no recharge from the Orr Ditch. Although long-term effects of localized pumping would include the capture of natural groundwater discharge and, possibly, induced recharge from Orr Ditch irrigation, drawdowns in the sub-basin can be expected to be relatively large.

In steady-state simulations, the model compensates for increased pumping by an equivalent reduction in natural groundwater discharge, assuming such discharge is available for capture. In Spanish Springs Valley, the opportunity exists to capture a large quantity of groundwater currently consumed by phreatophytes. Simulated evapotranspiration in scenario 2 decreased to 950 acre-ft/yr, with the area north and west of Spanish Springs Ranch being most affected. Evapotranspiration of groundwater ceased for much of this region, indicating that some of the existing grasslands and marshy areas may dry up if simulated levels of pumping occur.

Simulated drawdowns and computed heads for scenario 3 are contoured in Figures 29 and 30, respectively. Increased pumping levels in combination with reduced ditch recharge produced the same pattern of water level declines as in scenario 2; the average basin-wide drawdown, however, was 26 feet. Simulated drawdowns ranged from 35 to 48 feet in the northern half of the basin, while water level declines averaged 33 feet in the southeast.

Scenario 4 failed to reach a steady-state solution, as one might expect from a review of the data input in Table 6. Estimated net basin pumpage in 1987 exceeded the amount of precipitation recharge in the calibrated model; without Orr Ditch recharge, the model simulated a groundwater mining situation. Water levels in the model continued to decline until the aquifer went dry.

These four simulations make it clear that secondary recharge from the Orr Ditch serves as a buffer against significant water level declines in Spanish Springs Valley. Simulated pumping levels in the basin will be compensated for by capturing natural groundwater discharge and inducing recharge from wetlands and ponds created by the Orr Ditch. If no source of secondary recharge is available, however, a groundwater mining condition may develop, even with 1987 pumping levels. Water imported from the Truckee River may continue to provide this recharge as long as Orr Ditch



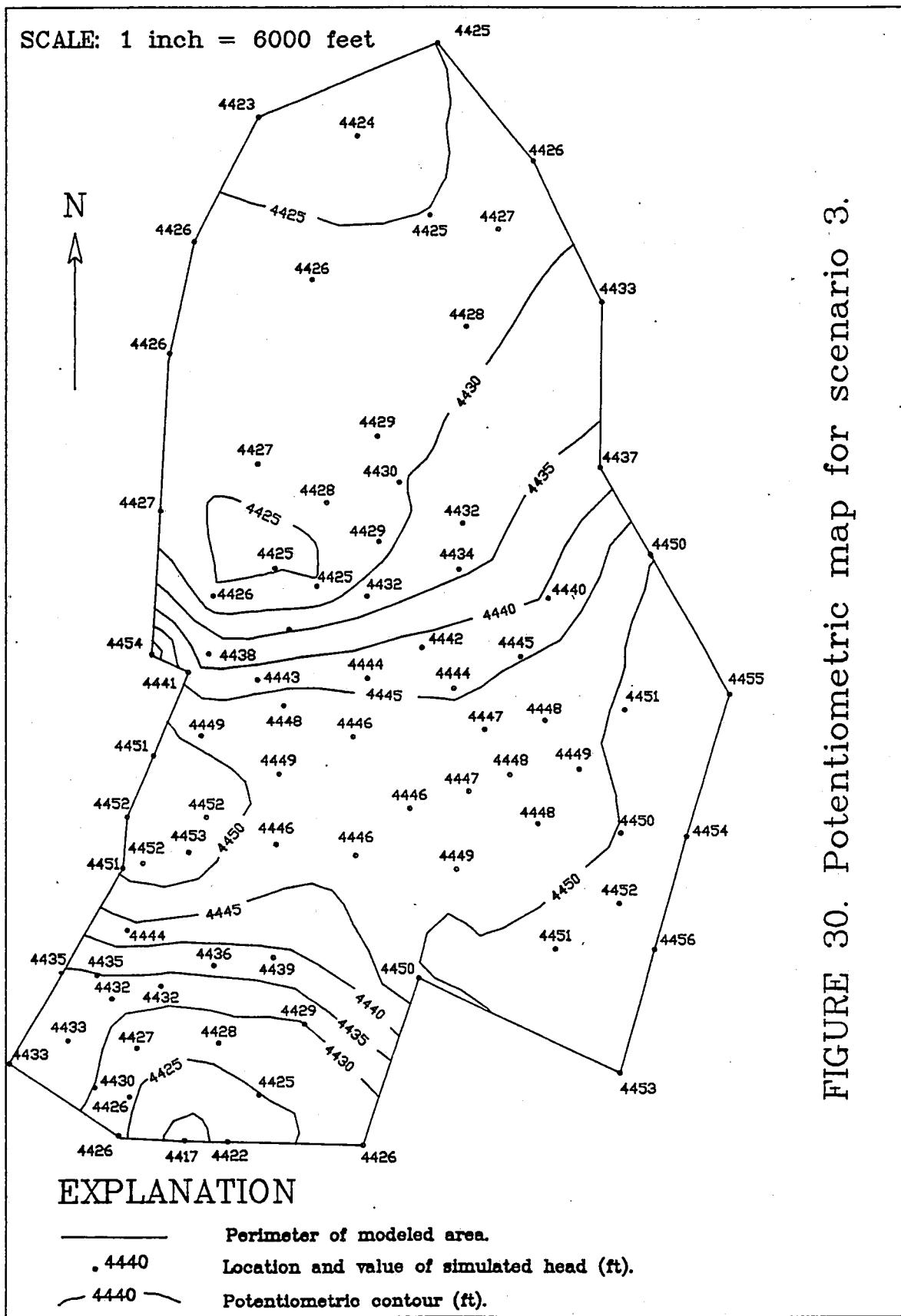


FIGURE 30. Potentiometric map for scenario 3.

surface water rights remain within the basin.

SUMMARY AND CONCLUSIONS

An important refinement to the conceptual model of the hydrologic system of Spanish Springs Valley is the presence of a groundwater mound created by secondary recharge from the Orr Ditch. The water table slopes to the north in the area north of the ditch, indicating groundwater flow toward Warm Springs Valley, while in the southern part of the basin the direction of groundwater flow is toward the Truckee Meadows.

Groundwater associated with highly altered and mineralized andesite flows in the southwest part of the basin is of very poor quality. The concentration of iron, sulfate, arsenic, and total dissolved solids often exceeds state drinking water standards. Groundwater quality improves to the north and east as different hydrostratigraphic units are encountered.

The valley-fill is composed of interbedded, discontinuous layers of clay, sand, and gravel. Maximum estimated thickness of valley-fill is 1000 feet and is located in the northwest part of the valley. A gravity survey indicates that bedrock topography in this area forms a deep trough. The axis of the trough is collinear with a previously unrecorded fault in the alluvium.

Other interpretations about the hydrologic system of Spanish Springs Valley were made during the development and calibration of a steady-state groundwater flow model:

- Underflow from Spanish Springs Valley to adjacent basins may occur at both the north and south ends of the valley. The cross-sectional area of alluvium at the north end of the valley may be limited by the subsurface extent of consolidated rocks; the fault at the base of Hungry Ridge, however, may act as a conduit through which water may leave the basin.
- Although the Dry Lakes area has no surface water connection to Spanish Springs Valley, it does appear to contribute a significant amount of groundwater recharge. The high transmissivity of fractured basalts in this part of the Pah Rah Range would be conducive to subsurface flow from Dry Lakes to the alluvial aquifer in Spanish Springs valley.
- The simulated groundwater budget for pre-pumping conditions includes 600 acre-ft/yr recharge from precipitation and 2200 acre-ft/yr recharge from the Orr Ditch. Recharge from precipitation is concentrated in the southeast part of the watershed. Evapotranspiration of 2400 acre-ft/yr is the major outflow from the groundwater system. Simulated subsurface outflow to the

Truckee Meadows and Warm Springs Valley is 100 and 300 acre-ft/yr, respectively.

- Faults in the vicinity of Spanish Springs Ranch and west of Desert Springs subdivision appear to be low permeability barriers to groundwater flow. The former restricts the flow of groundwater moving west from the Pah Rah Range, creating a groundwater "sub-basin" in the southeast part of the valley.

Water levels in the alluvial aquifer are artificially high due to infiltration of water applied for irrigation and leakage along the unlined Orr Ditch. Although the estimated consumptive use of groundwater in 1987 (720 acre-ft) exceeds the amount of precipitation recharge in the calibrated model, measured drawdowns in the basin are minimal due to the recent onset of groundwater development and the abundant supply of secondary recharge. Reduced Orr Ditch recharge associated with declining irrigated acreage will pose a problem in the future if development in the valley proceeds under the assumption that the current amount of groundwater recharge will be available on a permanent basis.

Simulated steady-state drawdowns resulting from current pumping levels ranged from 0 to 9 feet. A net basin pumpage of 1740 acre-ft/yr produced drawdowns ranging from 0 to 42 feet when Orr Ditch recharge was 2225 acre-ft/yr, and from 2

to 48 feet when ditch recharge was reduced by 30 percent. Drawdowns simulated by the model are representative of the potential drawdowns which may occur after the groundwater system has re-equilibrated to a steady-state condition. Model results give no indication of the length of time necessary to achieve this condition. Forecasted drawdowns, therefore, may be considered conservative estimates of water level declines under a given pumping scenario.

Model simulations make it clear that secondary recharge from the Orr Ditch serves as a buffer against significant water level declines in Spanish Springs Valley. To minimize drawdowns resulting from future groundwater development, wells should be located close to this source of recharge. Placing wells north and northwest of the Orr Ditch would maintain a groundwater divide between the well field and the region of poor water quality, thus limiting the potential for the migration of non-potable groundwater toward pumping wells.

Future work in Spanish Springs Valley should be directed toward developing a transient model for the basin, in order to forecast time-dependent drawdowns and to quantify changes in groundwater storage. In addition, several gaps and uncertainties in available data could be reduced, including:

- amount of precipitation in surrounding hills, particularly

in the Pah Rah Range

- water levels near the perimeter of the valley, to better constrain recharge estimates
- subsurface geology in the northwest and in the vicinity of Griffith Canyon
- hydraulic gradient in the north part of the basin and between Spanish Springs Valley and Warm Springs Valley
- hydraulic characteristics of faults in the alluvium and in surrounding consolidated rocks
- magnitudes and distributions of hydraulic conductivities and storativities.

REFERENCES CITED

- Arteaga, F.E., and T.J. Durbin, 1978, Development of a relation for steady-state pumping rate for Eagle Valley groundwater basin, Nevada, U.S. Geological Survey Open-File Report 79-261, 44 p.
- Bonham, H.F., 1969, Geology and mineral deposits of Washoe and Storey Counties, Nevada, Nevada Bureau of Mines and Geology Bulletin 70, 140 p.
- Cochran, Gilbert F., 1972, Hydrogeologic report on the Spanish Springs Ranch area - Spanish Springs Valley, Nevada, unpublished report, 14 p.
- Cohen, Philip, and O.J. Loeltz, 1964, Evaluation of hydrogeology and hydrogeochemistry of Truckee Meadows area, Washoe County, Nevada, U.S. Geological Survey Water-Supply Paper 1779-S, 63 p.
- Duell, L.F., and D.M. Nork, 1985, Comparison of three micrometeorological methods to calculate evapotranspiration in Owens Valley California, in: Riparian ecosystems and their management: reconciling conflicting uses. U.S.D.A. Forest Service General Technical Report RM-120, 523 p.
- Durbin, Timothy J., 1985, Three-dimensional simulation of free-surface aquifers by finite element method, U.S. Geological Survey Water-Supply Paper 2270, 17 p.
- Eakin, T.E., G.B. Maxey, T.W. Robinson, J.C. Fredericks, and O.J. Loeltz, 1951, Contributions to the hydrology of eastern Nevada, Nevada Department of Conservation and Natural Resources, Water Resource Bulletin 12, 171 p.
- Eakin, T.E., D. Price, and J.R. Harrill, 1976, Summary appraisals of the nation's groundwater resources - Great Basin Region, U.S. Geological Survey Professional Paper 813-G, 37 p.
- Freeze, R.A., and J.A. Cherry, 1979, Groundwater, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 604 p.
- Gimlett, J.I., 1967, Gravity study of Warm Springs Valley, Washoe County, Nevada, Nevada Bureau of Mines Report #15, 31 p.
- Glenn, R.J., 1968, Water resources of Warm Springs Valley, Washoe County, Nevada, Professional Geological Engineer thesis, University of Nevada, Reno, 93 p.

- Guyton, William F. and Associates, 1964, Groundwater conditions in Spanish Springs Valley, Nevada, unpublished report prepared for Sierra Pacific Power Company, 30 p.
- Hardman, G., 1965, Nevada precipitation map, University of Nevada, Agricultural Experimental Station Bulletin 183, 57 p.
- Harrill, James R., 1973, Evaluation of the water resources of Lemmon Valley, Washoe County, Nevada, with emphasis on effects of groundwater development to 1971, Nevada Department of Conservation and Natural Resources, Water Resources Bulletin 42, 130 p.
- Houghton, J.G., C.M. Sakamoto, and R.O. Gifford, 1975, Nevada's weather and climate, Nevada Bureau of Mines and Geology, Special Publication 2, 78 p.
- Hudson, D.M., 1977, Geology and alteration of the Wedekind and part of the Peavine Districts, Washoe County, Nevada, M.S. thesis, University of Nevada, Reno, 97 p.
- Kearey, P., and M. Brooks, 1984, An Introduction to Geophysical Exploration, Blackwell Scientific Publications, Boston, Mass., 296 p.
- Kliefforth, H., W. Albright, and J. Ashby, 1983, Measurement, tabulation, and analysis of rain and snowfall in the Truckee River Basin, unpublished report, Atmospheric Sciences Center, Desert Research Institute, Reno, Nevada.
- Mahin, Donald A., 1988, Recharge estimate and model of the Lemmon Valley hydrographic basin, north of Reno, Nevada. Unpublished report, Washoe County Department of Comprehensive Planning, 38 p.
- Mifflin, M.D., and M.M. Wheat, 1979, Pluvial lakes and estimated climates of Nevada, Nevada Bureau of Mines and Geology Bulletin 94, 51 p.
- Nevada State Journal, January 3, 1879, The Orr Ditch, p. 3
- Rantz, S.E., 1974, Mean annual runoff in the San Francisco Bay region, California, 1931-1970, U.S. Geological Survey Miscellaneous Field Studies Map MF-613.
- Reno Evening Gazette, February 15, 1879, Improving the country, p. 2.

- Robinson, Thomas W., and David A. Phoenix, 1948,
Groundwater in Spanish Spring and Sun Valleys, Washoe
County, Nevada, Nevada State Engineer, unpublished
report, 25 p.
- Robinson, T.W., 1958, Phreatophytes, U.S. Geological Survey
Water-Supply Paper 1423, 84 p.
- Rush, F.E., and P.A. Glancy, 1967, Water resources appraisal
of the Warm Springs-Lemmon Valley area, Washoe County,
Nevada, Nevada Department of Conservation and Natural
Resources, Water Resources-Reconnaissance Series Report
43, 70 p.
- Snyder, C.T., G. Hardman, and F. Zdenek, 1964, Pleistocene
lakes in the Great Basin, U.S. Geological Survey
Miscellaneous Geological Investigations Map I-416.
- Stewart, J.H., 1980, Geology of Nevada, Nevada Bureau of
Mines and Geology Special Publication 4, 136 p.
- Trexler, D.T., and R.C. Pease, 1980, Geologic mapping of the
Vista and Steamboat 7 1/2-minute quadrangles, Nevada,
U.S. Geological Survey Open-File Report 81-832, 32 p.
- Ungar, Irwin A., 1974, Inland halophytes of the United
States, in: Ecology of Halophytes, Reimold, R.J. and
W.H. Queen, Academic Press, Inc., New York, 605 p.
- Van Denburgh, A.S., R.D. Lamke, and J.L. Hughes, 1973, A
brief water resources appraisal of the Truckee River
Basin, Western Nevada, Nevada Department Conservation
and Natural Resources, Water Resources-Reconnaissance
Series Report 57, 122 p.
- Wang, Herbert F., and Mary P. Anderson, 1982, Introduction
to Groundwater Modeling, W.H. Freeman and Co., San
Francisco, California, 237 p.

APPENDIX A
Orr Ditch flow data

OFFICE OF THE WATER MASTER
 TRUCKEE RIVER SYSTEM
 DAILY FLOW RECORD

ORR DITCH INTO SPANISH SPRINGS VALLEY
 @ RECORDER BELOW SIPHON
 1987

Month Date	Apr cfs	May cfs	Jun cfs	Jul cfs	Aug cfs	Sep cfs	Oct cfs
1		30.9	29.8	36.7	34.5	35.3	
2		30.0	28.5	37.5	34.6	33.1	
3		30.6	27.1	36.0	34.7	32.8	
4		28.2	27.1	30.6	36.3	29.6	
5		27.2	29.0	30.6	35.3	29.6	
6		26.4	30.4	30.6	33.2	29.6	
7		27.2	33.4	30.6	30.6	31.5	
8		29.4	33.5	22.4	33.2	32.8	
9		29.0	34.2	21.3	34.6	37.8	
10		29.6	27.8	23.5	33.9	38.4	
11		30.6	27.2	28.9	36.4	35.6	
12		29.3	29.2	29.6	36.4	36.4	
13		28.5	30.5	29.7	34.2	37.6	
14		29.2	32.5	13.3	32.3	38.9	
15		29.7	37.8	22.5	33.1	36.1	
16		30.6	35.0	25.2	33.9	33.5	
17		28.3	32.4	26.4	36.4	32.3	
18		35.3	30.1	29.3	37.0	33.4	
19		37.5	30.9	29.0	36.0	33.1	
20		37.4	29.4	23.8	36.4	28.5	
21	21.0	37.9	31.2	23.5	34.2	30.6	
22	19.0	38.1	31.5	29.3	33.6	30.9	
23	19.5	39.2	32.5	30.8	32.8	31.5	
24	23.4	39.5	29.8	31.5	33.6	30.6	
25	27.7	39.2	29.7	34.5	32.5	30.6	
26	28.4	37.4	6.6	35.8	32.0	28.6	
27	29.3	34.3	5.5	35.3	33.5	25.2	
28	32.0	31.7	32.0	34.5	32.8	11.5	
29	32.8	27.2	29.4	33.6	31.7	11.3	
30	32.1	25.9	30.5	33.1	35.4	5.8	
31		29.3		32.8	35.0		
MAX	32.8	39.5	37.8	37.5	37.0	38.9	
MIN	19.0	25.9	5.5	13.3	30.6	5.8	
AVG	26.5	31.8	29.2	29.4	34.2	30.4	
A-F	525	1950	1732	1807	2099	1806	

Total Acre-Feet: 9,918

OFFICE OF THE WATER MASTER
TRUCKEE RIVER SYSTEM
DAILY FLOW RECORD

ORR DITCH INTO SPANISH SPRINGS VALLEY
@ RECORDER BELOW SIPHON
1986

Month Date	Apr cfs	May cfs	Jun cfs	Jul cfs	Aug cfs	Sep cfs	Oct cfs
1		27.2	32.0	27.4	29.3	31.5	
2		32.8	33.1	29.0	30.9	32.5	
3		32.0	30.1	30.1	31.7	30.1	
4		34.7	29.8	30.1	31.5	28.8	
5		33.1	32.3	29.8	34.2	30.9	
6		32.0	32.5	28.0	33.6	30.1	
7		30.4	32.8	27.7	32.8	29.8	
8		29.3	32.8	27.4	31.7	30.4	
9		29.6	33.1	27.8	30.1	26.1	
10		30.1	33.1	28.8	29.8	0.0	
11		29.0	36.4	28.5	30.1	9.9	
12		29.3	38.9	28.0	30.1	29.6	
13		27.4	44.3	26.4	32.0	29.6	
14		28.2	44.9	27.2	34.7	29.6	
15		32.5	46.6	26.1	33.1	29.6	
16		32.8	33.9	26.1	33.9	29.6	
17		30.9	32.5	27.7	32.5	30.1	
18		31.7	32.0	29.8	31.7	31.2	
19		34.2	29.3	30.1	30.9	31.2	
20		33.4	25.4	30.1	28.8	29.6	
21		33.1	26.9	30.6	33.4	26.9	
22		33.4	27.2	32.5	32.5	29.6	
23		32.8	20.5	37.8	32.3	29.0	
24	18.8	30.9	33.4	40.3	33.1	29.8	
25	17.8	30.1	26.4	40.3	34.2	32.5	
26	18.8	32.8	25.6	23.5	32.8	33.6	
27	18.0	32.5	24.3	38.4	30.6	34.5	
28	18.0	32.3	24.8	36.1	30.4	30.9	
29	21.0	32.0	25.9	34.7	29.0	30.1	
30	26.9	33.6	26.9	33.1	29.6	32.8	
31		33.9		31.7	30.6		
MAX	26.9	34.7	46.6	40.3	34.7	34.5	
MIN	17.8	27.2	20.5	23.5	28.8	0.0	
Avg	19.9	31.6	31.6	30.5	31.7	28.7	
A-F	276	1937	1877	1872	1945	1702	

Total Acre-Feet: 9,609

OFFICE OF THE WATER MASTER
TRUCKEE RIVER SYSTEM
DAILY FLOW RECORD

1985
ORR DITCH ENTERING SPANISH SPRINGS VALLEY,
@ RECORDER BELOW SIPHON

Month Date	Jan cfs	Feb cfs	Mar cfs	Apr cfs	May cfs	Jun cfs	Jul cfs	Aug cfs	Sep cfs	Oct cfs	Nov cfs	Dec cfs
1					37.8	39.5	45.2	42.6	38.4	32.5		
2					35.0	39.2	44.0	43.8	42.9	28.0		
3					36.4	42.3	42.0	41.2	46.9	25.4		
4					37.5	44.9	40.3	44.0	47.8	27.2		
5					35.8	42.3	35.6	46.1	48.1	32.8		
6					35.0	41.2	35.8	46.1	46.9	35.8		
7					33.1	38.1	35.8	41.7	47.5	27.7		
8					36.1	39.2	35.0	40.6	50.2	27.2		
9					35.8	38.9	29.6	39.8	52.8	28.0		
10					35.3	39.2	37.0	38.6	45.8	28.0		
11					34.7	37.0	37.0	37.8	44.0	26.1		
12					35.6	40.9	39.2	40.9	41.2	25.1		
13					33.9	42.3	38.6	38.6	35.6	24.8		
14					31.7	43.5	35.3	38.4	30.1	25.9		
15					34.5	43.8	37.8	38.4	30.6	22.6		
16					35.6	42.0	38.4	39.8	33.1	18.0		
17					36.4	42.3	37.0	40.3	31.2	13.2		
18					37.2	42.0	38.1	40.6	27.9	2.0		
19					35.3	29.3	36.4	40.9	23.3			
20					39.2	44.6	38.9	39.8	22.0			
21					39.8	41.7	42.3	40.9	24.1			
22					35.0	39.2	41.5	42.0	23.8			
23					34.5	41.2	40.6	44.3	23.5			
24					23.8	38.9	42.3	39.5	43.5	21.3		
25					26.9	38.6	45.2	39.2	40.6	22.3		
26					28.8	37.0	44.0	35.6	38.1	13.9		
27					30.6	39.2	43.2	38.0	38.6	0.0		
28					32.5	39.8	17.5	45.2	43.9	0.0		
29					34.5	41.2	46.9	5.0	50.8	0.0		
30					36.7	39.5	46.4	1.3	45.6	13.9		
31						39.8		15.5	38.1			
MAX	0.0	0.0	0.0	36.7	41.2	46.9	45.2	50.8	52.8	35.8		
MIN	0.0	0.0	0.0	23.8	31.7	17.5	1.3	37.8	0.0	2.0		
AVG	0.0	0.0	0.0	30.5	36.6	40.7	35.5	41.5	31.0	25.0		
A-F	0	0	0	423	2247	2416	2179	2547	1840	892		

Total Acre-Feet: 12,544

OFFICE OF THE WATER MASTER
TRUCKEE RIVER SYSTEM
DAILY FLOW RECORD

ORR DITCH ENTERING SPANISH SPRINGS VALLEY, 1984
@ RECORDER BELOW SIPHON

Month Date	Jan cfs	Feb cfs	Mar cfs	Apr cfs	May cfs	Jun cfs	Jul cfs	Aug cfs	Sep cfs	Oct cfs	Nov cfs	Dec cfs
1	7.4			1.3	43.8	45.5	51.7	36.0	38.9	29.3		
2	6.4	No flow during		1.3	46.0	43.8	50.9	34.1	39.2	40.3		
3	6.4	February & March		3.5	45.6	42.6	52.5	30.2	37.8	37.3		
4	6.4			9.1	44.3	44.9	49.1	38.0	36.4	30.0		
5	6.2			10.4	45.6	46.1	54.6	39.2	38.9	28.3		
6	6.2			13.3	46.4	43.8	59.0	38.5	40.9	27.4		
7	6.0			24.8	44.5	47.5	55.4	37.0	40.9	26.0		
8	5.2			29.8	42.4	43.5	53.5	36.0	40.6	25.4		
9	5.2			30.1	43.2	41.5	51.2	36.9	40.0	23.8		
10	5.4			30.1	47.3	43.5	45.8	36.8	37.5	23.0		
11	4.0			30.1	46.0	42.3	46.4	36.6	34.7	27.2		
12	3.9			30.1	45.8	44.0	47.9	37.0	36.1	28.2		
13	4.2			30.4	48.2	47.2	27.6	41.1	36.4	22.0		
14	4.8			30.4	48.0	48.5	47.7	41.2	35.6	22.0		
15	4.8			30.4	48.2	49.5	43.2	41.6	35.8	23.8		
16	4.2			30.6	47.1	47.9	44.2	42.3	33.4	23.5		
17	3.9			30.6	47.5	48.7	47.5	43.5	35.0	23.4		
18	3.9			32.0	50.5	22.3	48.7	42.2	36.4	21.4		
19	3.9			34.4	48.3	27.0	50.5	37.0	37.8	23.8		
20	3.0			37.9	46.3	39.1	50.5	37.7	40.0	27.2		
21	1.2			37.2	47.9	43.5	49.0	36.7	37.8	25.2		
22	1.2			37.4	48.6	46.8	51.9	37.0	36.4	18.7		
23	0.9			38.1	47.8	43.5	55.2	39.5	32.3	18.5		
24	1.0			36.9	48.1	46.2	46.1	39.5	30.9			
25	0.9			39.0	49.6	47.8	35.7	42.6	32.3			
26	0.6			40.0	46.6	46.7	26.4	42.0	40.3			
27	0.9			43.1	46.9	43.9	31.9	41.7	36.4			
28	0.8			42.4	49.0	42.3	32.1	44.0	33.1			
29	0.6			42.5	44.9	47.6	45.4	44.3	32.0			
30	0.6			44.2	45.8	51.0	47.1	43.2	30.6			
31	0.5				46.6		44.6	42.0				
MAX	7.4	0.0	0.0	44.2	50.5	51.0	58.0	44.3	40.9	40.3		
MIN	0.5	0.0	0.0	1.3	42.4	22.3	26.4	30.2	30.6	18.5		
Avg	3.6	0.0	0.0	29.0	46.7	43.9	46.5	39.2	36.5	25.9		
A-F	219	0	0	1725	2865	2610	2856	2406	2167	1160		

Total Acre-Feet: 16,029

Notes: Gage heights were estimated from 4/8 to 4/17.

Daily Inf. v Record
Cubic Feet /r Second

ORR DITCH INTO SP...LISH SPRS.
1983

No.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Mo.
Day	cfs	Day											
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													
22													
23													
24													
25													
26													
27													
28													
29													
30													
31													
MAX:	24.8												
MIN:	3.7												
AVG:	20.4												
A.F.:	364												

TOTAL ESTIMATED FLOW 17,051 ACRE FEET

e=estimated flow

SPRS.

OFFICE OF THE WATER MASTER - TRUCKEE RIVER SYSTEM
 Daily Flow Record
 Cubic : Per Second

ORR DITCH INTO
 SPANISH SPRINGS VALLEY - 1982

Mo.:	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Mo.:	
Day:	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	Day:	
1:	N/R	1.4:	0	0	39.3	41.9	53.3	54.1	54.1	20.4	17.2	10.9	1:	
2:				43.7	40.4	44.3	52.9	54.4	20.0	18.3	9.8	2		
3:				44.9	35.9	41.9	50.2	51.8	19.8	18.3	9.6	3		
4:				42.5	48.3	42.2	49.8	45.5	20.0	18.6	9.8	4		
5:				39.0	48.0	38.4	49.4	40.4	20.0	18.3	10.3	5		
6:				41.3	54.1	28.9	45.5	39.3	20.6	18.0	10.0	6		
7:				41.0	55.0	22.6	51.2	38.4	21.2	15.8	9.8	7		
8:				40.4	49.4	17.4	53.3	42.2	22.1	15.4	9.8	8		
9:				42.2	46.7	40.7	55.3	46.3	22.1	10.0	9.8	9		
10:				45.2	45.9	38.1	50.9	42.5	22.6	10.0	10.0	10		
11:				44.5	43.7	41.3	48.6	41.9	22.6	9.2	9.8	11		
12:				44.6	44.0	43.3	47.7	48.6	22.1	7.8	9.8	12		
13:				43.3	41.0	39.0	48.3	48.0	21.2	7.8	9.8	13		
14:				33.1	41.6	41.9	48.3	47.4	20.9	7.8	9.8	14		
15:				16.0	32.5	38.1	41.0	46.3	44.3	21.8	8.0	9.6	15	
16:				10.9	39.0	37.5	45.9	46.3	47.7	21.8	8.4	9.4E	16	
17:				11.7	47.4	40.4	46.3	42.5	30.1	17.4	8.2	9.2E	17	
18:				12.2	44.6	46.7	48.3	41.6	30.4	15.0	8.8	9.0E	18	
19:				10.5	44.9	49.4	46.7	40.7	30.7	15.0	10.5	8.8E	19	
20:				10.7	38.1	42.2	46.7	32.8	30.7	18.3	8.6	8.6E	20	
21:				14.2	38.7	34.7	46.3	32.3	31.3	17.8	8.8	8.4E	21	
22:				22.6	41.6	43.3	52.5	37.8	31.0	18.3	10.0	8.2E	22	
23:				13.5	44.9	43.7	48.3	46.3	30.1	20.6	10.7	8.0E	23	
24:				16.9	47.4	45.5	49.4	47.4	32.2	20.6	9.2	7.8E	24	
25:				19.2	47.1	42.9	52.5	41.9	30.7	24.0	9.2	7.6E	25	
26:				19.2	47.1	41.6	50.6	40.4	31.0	21.8	8.8	7.4E	26	
27:				24.6	46.3	48.6	49.8	44.3	24.9	15.0	9.0	7.4	27	
28:				30.7	42.2	50.9	49.8	47.4	20.0	15.8	9.2	7.2E	28	
29:				29.5	48.3	53.3	41.9	50.9	24.0	16.9	9.8	7.0E	29	
30:				32.8	50.6	42.5	47.7	50.2	20.6	22.1	15.8	6.8E	30	
31:				49.8		48.0	51.2		17.6		6.6E	31		
MAX:	10.9	17.2		32.8	50.6	55.0	53.3	55.3	54.4	24.0	18.6	10.9	MAX	
MIN:	1.4	1.4		32.5	34.7	22.6	32.2	20.6	15.0	7.8	6.6	MIN		
Avg:	7.0	7.7		10.1	43.1	44.6	43.4	46.6	37.7	19.9	11.5	8.9	AVG.	
A.F:	289.9	39.2		602.3	2644.5	2647.7	2663.1	2882.5	2238.4	1218.5	684.1	546.5	A.F.	

TOTAL ANNUAL FLOW 16,436.6 ACRE FEET

OFFICE OF THE WATER MASTER - TRUCKEE RIVER SYSTEM
 Daily T-flow Record
 Cubic F. ; Per Second.

ORR DITCH INT'L SPANISH SPR
 1981

Mo.:	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Mo.
Day:	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	Day:
1:	8.8	11.5	OFF	26.1E	40.1	46.8	39.8	36.2	43.8	34.8	20.5	10.4	1
2:	8.6	9.0	▲	26.3E	40.7	46.5	40.7	37.4	44.0	35.4	19.8	10.2	2
3:	8.4	8.6		26.6E	40.1	47.4	40.7	37.7	44.0	42.2	18.6	9.8	3
4:	8.4	8.4		26.9E	42.2	44.3	39.5	39.0	43.4	37.7	17.3	9.4	4
5:	8.5	7.8		27.2E	45.7	45.3	40.4	36.8	42.2	5.4	17.5	9.4E	5
6:	7.6	7.0		26.9	43.0	46.8	39.5	37.7	41.3	S/W	17.3	9.4E	6
7:	7.4	6.4		25.3	43.4	45.3	40.3	36.2	41.6	↑	17.8	9.4E	7
8:	7.6	5.9		27.2	43.3	41.9	36.5	36.8	42.2	↓	18.3	9.4	8
9:	7.6	5.7		34.2	40.7	46.3	32.8	37.1	43.7	↓	18.3	9.0	9
10:	7.4	3.6		35.1	41.0	46.8	31.1	38.3	41.9	S/W	18.6	7.8	10
11:	8.8	2.2		31.7	44.3	47.4	33.1	38.5	42.8	14.4	18.3	7.6	11
12:	8.4	2.3		35.4	42.8	49.0	29.1	35.1	43.1	14.9	20.2	7.4	12
13:	5.4	3.1		37.1	44.9	41.3	27.7	36.8	41.0	15.4	20.5	7.2	13
14:	4.1	OFF		35.4	45.9	48.0	27.5	36.8	44.6	15.8	16.3	7.0	14
15:	3.9	OFF	▲	35.1	48.0	42.8	28.9	35.4	44.2	15.3	6.4	6.3	15
16:	3.7			34.8	46.3	39.6	29.4	37.1	40.7	15.1	8.6	6.4	16
17:	3.2			39.2	48.4	36.0	27.7	39.8	41.0	15.1	12.6	7.8	17
18:	2.9			38.3	46.5	35.7	38.0	40.3	41.9	16.1	12.1	6.4	18
19:	2.6			39.8	47.6	35.1	39.5	38.6	41.0	16.1	11.0	12.6	19
20:	4.1			40.1	49.6	38.9	39.5	40.1	42.8	17.3	10.6	27.7	20
21:	4.5E			40.3	49.0	40.1	42.8	38.9	41.6	13.0	11.2	3.7	21
22:	4.6			39.8	44.6	38.6	40.1	37.1	39.2	11.2	16.1	3.7	22
23:	5.2			41.9	43.7	40.2	37.4	37.4	38.6	10.6	15.3	3.2	23
24:	5.2			OFF	40.7	46.2	39.5	36.0	38.9	14.4	18.6	7.4E	24
25:	5.2			22.2	38.9	46.5	29.1	36.5	40.7	41.3	15.8	3.7	25
26:	5.4			56.2	38.0	50.0	16.7	38.3	43.4	16.5	7.6	7.4E	26
27:	7.0			56.8	39.2	50.6	33.1	39.8	41.6	16.7	10.2	7.4E	27
28:	8.2			50.9	40.6	49.6	38.3	38.2	41.0	41.0E	12.3	7.4E	28
29:	8.8			51.6	40.4	48.7	41.6	33.6	38.9	41.1	25.3	11.7	29
30:	8.6			51.6	41.9	47.7	40.3	34.5	40.4	35.7	25.9	10.4	30
31:	8.6			OFF	50.9E	47.1	36.8	44.3	44.6	42.2	20.5	7.4E	31
MAX:	8.8	11.5		56.8	41.9	50.6	48.0	40.7	44.3	35.7	10.6	3.7	MAX
MIN:	2.6	2.2		26.1	22.2	24.3	16.7	27.5	35.1	35.7	10.6	3.2	MIN
AVG:	6.4	6.3		35.0	45.0	41.0	36.0	38.3	41.8	16.5	14.6	8.4	AVG
A.F:	393.4	161.4	673.6	2079.8	2761.5	2432.8	2207.9	2351.1	2481.5	1011.4	866.6	515.6	A.F

*AVERAGE WHEN DITCH ON TOTAL ANNUAL FLOW 17,936.6 ACRE FEET

OFFICE OF THE WATER MASTER - TRUCKEE RIVER SYSTEM
 Daily Infl' Record
 Cubic Feet per Second
 SPRINGS VALLEY BELOW
 SIPHON T980

Mo.: Day:	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Mo.: Day:		
	cfs														
1: 1: 2e	0				46	53	49	44	35	19	9	1:			
2: 2:					50	55	46	43	34	20	12	2:			
3: 3:					51	55	46	42	37	19	16	3:			
4: 4:					51	49	47	41	39	19	13	4:			
5: 5:					51	46	49	44	40	19	9	5:			
6: 6:					52	51	45	50	44	40	18	6:			
7: 7:					47	45	48	47	39	18	12	7:			
8: 8:					44	38	45	47	37	10	15	8:			
9: 9:					46	19	43	48	38	9	12	9:			
10: 10:					45	42	45	47	36	10	11	10:			
11: 11:					43	42	45	45	35	9	11	11:			
12: 12:					42	42	49	46	35	9	11	12:			
13: 13:					47	42	46	46	39	37	11	13:			
14: 14:					16	52	41	49	47	34	36	10			
15: 15:					16	52	43	47	49	31	28	9			
16: 16:					52	45	44	47	33	28	9	8			
17: 17:					55	46	44	49	31	29	10	6	17:		
18: 18:					0	54	46	45	45	29	25	10	6	18:	
19: 19:					53	44	45	45	29	18	11	7	19:		
20: 20:					50	44	48	46	28	17	11	7	20:		
21: 21:					51	42	46	46	29	17	11	8	21:		
22: 22:					55	40	47	53	29	15	11	9	22:		
23: 23:					55	45	46	52	31	15	11	9	23:		
24: 24:					54	45	37	44	34	17	12	9	24:		
25: 25:					0	54	43	47	41	34	17	7	10	25:	
26: 26:					0	54	45	46	40	33	17	7	10	26:	
27: 27:					52	47	45	40	34	18	5	11	27:		
28: 28:					49	44	50	42	34	19	3	11	28:		
29: 29:					47	47	45	47	43	33	19	4	10	29:	
30: 30:					46	50	43	44	37	19	7	10	30:		
31: 31:					48	48	47	45	45	18	10	31:			
MAX:					47	55	51	55	48	40	20	16	MAX:		
MIN:					16	46	40	19	40	28	15	3	6	MIN:	
AVG:					47	47	45	46	37	28	11	10	AVG:		
A.F:					0	956	3192	2701	2772	2218	1691	671	606	A.F:	

TOTAL ANNUAL FLOW 17,692 ACRE FEET

OFFICE OF THE WATERMASTER - TRUCKEE RIVER SYSTEM
 Daily Inflow Record
 Cubic Feet Per Second

ORR DITCH TO SPANISH SPRINGS
 below siphon 1979

Mo.: Day:	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	No.:	
	cfs	Day:												
1: 1	3	13	0	0	4.5	5.8	5.6	4.1	4.9	4.6	0	12	1:	
2: 2	3	14	0	0	5.0	6.1	6.2	4.1	4.6	4.4	5	12	2:	
3: 3	5	14	0	0	4.8	5.7	5.2	3.9	4.6	4.5	17	12	3:	
4: 4	23	17	0	0	5.5	5.8	5.2	4.2	4.8	4.8	17	12	4:	
5: 5	27	15	0	0	5.7	5.8	5.4	4.2	4.5	4.5	17	8	5:	
6: 6	24	15	0	0	5.4	5.6	5.8	4.0	4.2	4.4	17	8	6:	
7: 7	24	16	0	0	5.2	5.6	5.2	4.1	3.9	4.2	17	8	7:	
8: 8	24	14	0	0	4.5	5.4	4.8	4.4	3.6	4.0	16	8	8:	
9: 9	25	14	0	0	4.1	5.8	4.6	4.4	4.0	3.1	12	8	9:	
10: 10	25	12	0	0	5.5	5.7	4.9	4.4	4.3	2.4	12	8	10:	
11: 11	34	11	0	0	5.3	5.4	4.3	4.5	4.0	2.1	10	7	11:	
12: 12	18	12	0	0	5.3	5.3	5.2	4.4	4.0	1.9	10	8	12:	
13: 13	16	13	0	3	5.5	5.2	5.4	4.4	3.8	1.9	10	13	13:	
14: 14	14	3	0	21	6.0	5.4	5.7	4.7	3.7	1.8	10	14	14:	
15: 15	14	0	0	23	6.1	5.4	5.8	4.6	3.8	1.9	10	12	15:	
16: 16	13	0	0	28	5.9	5.3	4.8	4.4	3.7	2.0	9	10	16:	
17: 17	12	0	0	26	5.4	5.6	2.4	4.1	3.8	1.9	9	4	17:	
18: 18	12	0	0	36	5.5	6.1	4.6	4.5	3.9	1.9	10	0	18:	
19: 19	10	0	0	43	5.2	5.2	4.7	4.4	3.7	1.9	9	0	19:	
20: 20	6	0	0	38	5.0	5.3	4.8	4.6	3.3	2.1	9	0	20:	
21: 21	9	0	0	36	5.3	6.6	4.6	4.8	3.1	2.0	10	0	21:	
22: 22	10	0	0	34	5.2	3.9	4.4	4.8	3.2	2.3	9	0	22:	
23: 23	13	0	0	37	5.3	5.1	4.5	4.5	4.0	2.1	9	0	23:	
24: 24	13	0	0	42	5.0	4.8	4.9	4.5	4.0	1.6	9	0	24:	
25: 25	13	0	0	43	4.7	4.6	4.6	4.2	3.8	1.7	10	0	25:	
26: 26	13	0	0	43	5.1	4.5	4.4	3.8	4.0	1.8	12	0	26:	
27: 27	19	0	0	45	5.2	5.2	4.1	3.8	4.2	1.9	12	1	27:	
28: 28	16	0	0	45	5.4	5.0	4.3	3.9	4.2	1.8	12	1	28:	
29: 29	10	--	0	50	5.8	5.2	4.6	4.9	4.5	1.9	12	1	29:	
30: 30	4	--	0	44	5.2	5.4	4.6	5.3	5.3	1.6	12	1	30:	
31: 31	7	--	0	43	4.9	4.9	4.6	5.0	5.0	1.6	12	1	31:	
MAX:	34	17	0	50	6.1	6.6	6.2	5.3	5.3	17	14	MAX:		
MIN:	3	0	0	41	3.9	2.4	3.8	3.1	0	0	0	0	MIN:	
Avg:	15	7	0	21	5.2	5.4	4.8	4.4	4.0	2.5	11	5	Avg:	
A.F:	909	362	0	1261	3218	3204	2974	2691	2404	1564	659	335	A.F:	

TOTAL ANNUAL FLOW 19,581 ACRE FEET

OFFICE OF THE WATER MASTER - TRUCKEE RIVER SYSTEM ORR DITCH TO SPA SH
Daily Lin. "w Record
Cubic Feet Per Second

1978

Mo.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Mo.
Day	cfs	Day											
1	8	4	6	6	41	57	52	54	39	21	7	1	1
2	8	4	6	6	40	58	60	51	36	14	7	2	2
3	8	5	6	6	40	61	62	54	31	9	7	3	3
4	8	6	6	6	41	61	63	61	46	31	9	7	4
5	8	7	6	6	50	55	36	60	53	38	9	6	5
6	12	7	1	1	51	56	26	58	58	40	10	6	6
7	8	7	1	1	55	58	51	55	54	38	8	7	7
8	8	9	1	1	55	52	48	61	50	36	7	5	8
9	11	7	1	1	58	61	43	60	48	36	9	1	9
10	10	6	1	1	58	64	45	53	44	35	8	0	10
11	8	6	1	1	53	65	46	56	43	34	11	2	11
12	6	5	1	1	47	63	53	52	39	35	9	5	12
13	5	5	1	1	46	66	57	53	39	36	9	3	13
14	6	4	1	1	48	67	60	50	41	36	9	5	14
15	9	4	0	23	44	59	58	58	42	26	11	3	15
16	16	4	0	27	44	44	46	58	44	12	9	3	16
17	11	4	0	27	52	58	44	59	41	15	8	4	17
18	7	4	1	25	59	63	42	62	41	21	8	3	18
19	7	4	1	35	57	61	44	62	45	21	8	3	19
20	7	4	1	25	57	56	46	57	42	21	9	3	20
21	6	4	1	27	60	60	43	54	37	21	12	4	21
22	6	3	1	29	60	58	44	46	39	20	13	3	22
23	6	1	1	34	60	57	48	48	41	20	12	3	23
24	11	1	1	35	61	61	48	48	40	21	12	3	24
25	13	0	1	34	54	61	52	56	39	21	12	3	25
26	5	0	1	29	57	61	51	48	39	21	12	3	26
27	5	1	1	30	57	61	55	52	38	21	12	3	27
28	5	1	1	38	53	55	52	48	35	21	7	3	28
29	4	1	1	38	47	52	53	55	36	21	7	3	29
30	4	1	1	43	43	57	54	54	39	22	7	3	30
31	4	1	1	53	53	56	54	54	24	24	3	3	31
MAX:	16	9	1	43	61	67	63	62	58	40	28	7	MAX:
MIN:	4	0	0	0	40	44	26	46	35	12	7	0	MIN:
Avg:	8	4	1	29	52	59	50	55	44	27	10	4	Avg:
A.F:	477	228	46	1020	3180	3501	3055	3356	2604	1683	596	232	A.F:

TOTAL ANNUAL FLOW 19,978 ACRE FEET

OFFICE OF THE WATERMASTER - TRUCKEE RIVER SYSTEM

Daily Inflow Record	ORR DITCH to SPANISH SPRINGS VLY
Cubic Feet Per Second	

CUBIC LATTICE

OFFICE OF THE WATER MASTER
TRUCKEE RIVER SYSTEM
DAILY FLOW RECORD

N. TRUCKEE DRAIN LEAVING SPANISH SPRINGS
e RECORDER BELOW SIPHON (1/1-4/9)
e RECORDER ABOVE SHADOW LANE (4/10-12/7)

1984

Month Date	Jan cfs	Feb cfs	Mar cfs	Apr cfs	May cfs	Jun cfs	Jul cfs	Aug cfs	Sep cfs	Oct cfs	Nov cfs	Dec cfs
1	12.7	2.4	1.6	15.8	20.2	26.4	19.6	23.5	21.5	25.1	10.6	9.6
2	11.4	2.3	1.6	15.8	20.9	24.0	20.3	23.5	20.0	27.0	8.6	9.6
3	10.5	2.0	1.3	23.5	21.7	24.8	18.9	21.0	19.8	28.9	8.0	9.8
4	10.5	1.8	1.2	18.3	19.5	19.0	16.0	22.4	18.6	27.6	7.5	8.9
5	10.1	1.7	1.1	7.9	21.0	17.9	15.2	24.3	18.0	26.6	8.4	7.1
6	10.1	1.5	1.0	4.5	19.9	18.4	14.8	26.7	19.1	26.7	10.5	7.1
7	10.1	1.3	0.9	6.9	19.8	21.0	12.0	27.0	17.7	25.2	12.9	7.1
8	9.3	1.3	0.8	17.5	20.5	21.2	12.3	27.0	19.4	22.0	10.2	6.7
9	9.7	1.3	0.8	25.7	22.9	22.0	13.6	28.7	20.6	21.3	7.4	7.6
10	10.1	1.3	0.7	9.5	24.1	24.5	16.5	28.4	22.6	22.4	8.1	7.5
11	10.1	1.3	0.7	12.0	23.5	23.3	17.9	29.9	22.2	25.0	7.9	7.1
12	10.1	1.4	0.7	10.8	24.4	24.7	23.4	32.1	23.1	25.0	7.5	7.1
13	10.1	1.4	0.6	6.2	24.1	22.8	16.7	30.5	23.3	20.1	11.2	7.1
14	10.1	1.4	0.7	11.0	21.4	23.5	17.9	22.1	22.6	19.3	14.1	7.1
15	10.1	1.2	0.7	11.1	19.8	23.1	19.1	20.3	20.0	19.6	12.0	7.1
16	10.1	1.3	0.7	10.0	19.8	24.8	17.9	17.7	20.9	22.9	11.8	7.1
17	10.1	1.4	0.7	12.4	20.1	35.1	15.1	17.0	21.3	28.6	11.7	7.1
18	12.9	1.3	0.7	17.4	24.2	28.8	18.2	17.3	23.9	29.9	11.3	7.1
19	10.9	1.7	0.7	14.8	26.6	21.9	21.0	17.6	27.5	34.7	6.8	7.1
20	10.9	1.7	0.7	15.2	28.1	19.7	23.6	19.2	27.4	39.8	6.4	
21	6.0	2.0	0.7	13.1	26.9	21.5	23.7	20.6	24.9	38.2	6.3	
22	4.7	2.1	0.6	14.4	26.9	21.7	27.3	19.9	24.4	31.7	6.1	
23	3.6	1.9	0.5	16.3	24.1	20.2	34.8	19.9	19.9	29.3	6.1	
24	2.7	1.7	0.5	17.2	24.0	20.7	24.1	17.6	20.6	26.2	6.1	
25	2.3	1.7	0.6	16.9	20.6	20.3	21.4	19.5	21.2	24.0	5.7	
26	2.3	1.4	0.6	18.1	17.9	22.2	17.6	19.6	22.4	13.5	5.9	
27	2.5	1.4	0.6	17.6	14.4	20.4	15.2	18.1	22.6	12.2	10.8	
28	2.5	1.4	0.6	18.8	21.0	19.6	15.3	16.8	23.5	11.1	25.1	
29	2.6	1.5	0.5	18.0	22.0	18.7	17.9	18.5	22.8	11.2	14.4	
30	2.5		1.2	17.1	21.4	19.9	17.7	19.4	23.8	11.3	9.9	
31	2.3		9.7		26.2		21.6	20.3		11.6		
MAX	12.9	2.4	9.7	25.7	28.1	35.1	34.8	32.1	27.5	39.8	25.1	9.8
MIN	2.3	1.2	0.5	4.5	14.4	17.9	12.0	16.8	17.7	11.1	5.7	6.7
AVG	7.9	1.6	1.1	14.5	22.2	22.4	18.9	22.1	21.9	23.8	9.6	7.6
A-F	483	91.5	67.1	859	1362	1330	1161	1359	1298	1461	573	286

Total Acre-Feet: 10,332

Note: Feb 1-8 and Dec 12-19 are estimated values.

OFFICE OF THE WATER MASTER - TRUCKEE RIVER SYSTEM
 Daily Inflow Record
 Cubic Feet Per Second

N. TRUCKEE DRAIN @ SSV

-1983

Mo.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Mo.	
Day	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	Day	
1:	6.9e				11.8	28.3	19.8	23.8	36.6	19.8	15.9	17.7	1:	
2:					9.4	32.6	18.5	25.4	35.0	19.4	15.2	16.4	2:	
3:					11.8	27.7	19.8	25.1	33.7	20.3	14.4	17.7	3:	
4:					17.7	32.6	18.5	24.6	34.4	18.5	13.3	19.1	4:	
5:					11.5	32.0	17.4	23.0	33.4	17.4	12.6	16.0	5:	
6:					12.7	30.8	17.4	19.6	34.4	18.3	12.8	15.7	6:	
7:					13.4	33.3	15.4	18.5	32.5	18.9	12.6	13.8	7:	
8:					12.4	38.8	15.9	20.1	30.7	17.4	12.6	12.4	8:	
9:					12.1	31.4	16.5	22.8	27.0	16.1	12.6	11.1	9:	
10:					11.8	28.9	18.5	22.6	25.4	15.0	12.4	11.0	10:	
11:					10.2	30.2	22.5	26.2	24.1	14.4	13.1	10.2	11:	
12:					9.4	31.4	26.8	25.4	23.8	14.3	10.7	9.6	12:	
13:					9.6	32.0	24.1	24.6	27.3	14.8	11.7	9.1	13:	
14:					3.69	2.42	18.6	30.2	26.0	25.7	27.9	15.0	12.0	14:
15:					19.1	27.6	27.0	26.8	26.2	14.3	12.8	12.4	15:	
16:					18.2	26.2	26.5	25.4	23.6	13.7	12.6	12.6	16:	
17:					16.4	24.3	25.1	24.9	21.5	15.4	16.1	8.3	17:	
18:					19.5	24.9	25.1	26.0	19.6	14.3	34.0	7.3	18:	
19:					18.6	22.8	24.9	29.0	17.6	12.6	32.0	6.9	19:	
20:					17.7	20.3	25.1	29.3	17.6	10.1	26.0	6.7	20:	
21:					2.5e	16.4	19.4	25.4	30.1	19.8	10.1	28.9	6.6	21:
22:					9.9	20.0	21.0	25.4	31.0	19.4	10.6	23.4	8.3	22:
23:					8.3	15.3	17.2	25.7	35.3	20.8	11.7	23.4	5.3	23:
24:					8.3	13.8	18.1	25.7	36.0	23.6	12.0	35.4	5.4	24:
25:					7.8	18.2	20.1	26.0	36.0	24.6	12.6	27.1	5.0	25:
26:					8.9	24.4	22.3	23.8	37.8	22.8	13.7	24.9	7.6	26:
27:					8.6	22.3	22.3	23.3	38.3	22.3	13.7	22.9	9.4	27:
28:					5.0e	2.0e	11.5	21.8	31.4	20.8	13.5	20.9	9.4	28:
29:					16.8	18.2	19.6	19.4	29.8	19.4	13.3	19.5	8.1	29:
30:					12.4	18.2	19.2	19.2	35.3	20.3	13.7	18.6	9.4	30:
31:					14.21	-	20.0	-	20.8	40.2	-	15.0	-	31:
MAX:	63.6	5.0e	2.5e	16.8	24.4	38.8	27.0	40.2	36.6	20.3	34.0	19.1	MAX:	
MIN:	3.2	3.7	2.0e	7.8	9.4	17.2	15.4	18.5	17.6	10.1	10.7	5.0	MIN:	
AVG:	18.6	4.2	2.2	10.3	15.8	26.3	22.0	28.2	25.5	14.8	18.7	10.1	AVG:	
A.F:	1185	288	157	450	971	1560	1348	1733	1517	911	1110	622	A.F:	

TOTAL ESTIMATED FLOW 11852 ACRE FEET

e=estimated flow

OFFICE OF THE WATER MASTER - TRUCKEE RIVER SYSTEM
 Daily Infl Record
 Cubic Feet Per Second

N. TRUCKEE DRAIN @ SPANISH SPF
 1982

Mo.	JAN. Day	FEB. cfs	MAR. cfs	APR. cfs	MAY. cfs	JUN. cfs	AUG. cfs	SEP. cfs	OCT. cfs	NOV. cfs	DEC. cfs	Mo. Day	
1					25.6	23.4	18.6	21.1	12.4	24.1	11.3	1	
2					25.1	17.4	21.1	26.2	17.8	25.6	11.3	2	
3					22.7	16.3	18.6	17.4	18.9	24.9	13.4	3	
4					8.9	23.2	15.9	16.7	14.5	18.9	23.7	4	
5					7.8	23.7	20.3	16.7	14.8	18.9	23.2	5	
6					9.7	16.8	17.0	13.2	14.5	18.4	22.7	6	
7					12.2	17.8	17.0	14.8	16.7	17.8	20.4	7	
8					14.2	16.3	13.2	19.8	15.6	17.8	19.5	8	
9					16.8	16.0	14.1	19.0	12.8	17.8	14.7	9	
10					16.4	16.3	13.2	15.2	11.0	17.8	13.8	10	
11					15.5	18.1	17.0	14.2	11.3	17.6	13.8	11	
12					13.8	18.1	18.2	18.6	11.9	17.6	12.2	12	
13					16.0	18.6	18.6	22.0	13.5	17.6	11.7	13	
14					16.8	16.5	16.7	24.8	17.0	17.6	9.7	14	
15					20.4	18.9	15.6	22.0	20.3	17.6	8.2	15	
16					23.7	19.4	16.7	17.8	27.2	17.3	8.5	16	
17					26.0	21.3E	15.9	13.5	29.2	17.3	9.3	17	
18					28.4	21.8E	15.2E	14.5	27.0	12.0	8.9	18	
19					26.0	22.4E	14.8E	17.4	28.1	7.5	6.6	19	
20					13.4	22.6E	13.8	17.4	28.1	20.2	0.4	20	
21					12.8	23.4E	17.8	15.2	26.7	25.6	8.9	21	
22					16.0	24.0	20.7	19.0	26.2	26.5	13.0	22	
23					14.2	24.0	21.1	16.7	25.6	27.5	14.2	23	
24					14.7	22.1	22.4	14.2	27.3	27.5	13.8	24	
25					15.1	24.5	23.8	16.7	27.8	30.9	13.4	25	
26					13.8	25.1	23.4	15.2	28.1	26.5	13.4	26	
27					19.5	13.5	23.8	15.6	24.8	20.9	11.3	27	
28					16.8	21.6	25.7	19.4	21.6	22.3	12.2	28	
29					16.8	32.6	20.3	19.4	24.0	23.2	13.8	29	
30					16.8	20.7	15.9	17.4	20.8	31.4	18.2	30	
31						12.2	17.8			26.0		6.9E	31
MAX:					28.4	32.6	25.7	24.8	29.2	31.4	16.8	MAX	
MIN:					7.8	13.4	12.2	13.2	11.0	7.5	5.9	MIN	
Avg:					16.4	21.1	18.0	17.5	21.0	20.5	14.6	10.7 AVG	
A.F.:					879.5	1254.6	1105.3	1075.8	1251.5	869.5	656.2	A.F.	

TOTAL ANNUAL FLOW 8351.2 ACRE FEET

OFFICE OF THE WATER MASTER - TRUCKEE RIVER SYSTEM
 Daily Infl Record
 Cubic Feet , or Second

Daily Infl Rec
Cubic Feet or Se

NORTH TRUCKEE DRAIL @ ORR
SYPHON 1981

Mo.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Mo:
Day:	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	Day:
1	14.8	27.2	8.6	13.3	18.1	24.9	10.4	5.2	1	5.2	5.2	1	
2	15.3	27.0	9.3	10.8	11.5	23.6	12.9	5.7	2	5.7	5.7	2	
3	16.6	27.2	10.0	12.2	12.5	26.2	12.1	5.5	3	5.5	5.5	3	
4	17.4	26.8	10.4	15.6	13.3	29.3	11.4	5.5	4	5.5	5.5	4	
5	19.3	27.2	12.4	9.2	13.3	17.0	11.4	5.2	5	5.2	5	5	
6	22.2	16.2	10.0	8.3	18.1	12.0	7.4	4.4	6	4.4	4.4	6	
7	20.7	17.8	9.9	9.2	16.8	9.6	8.5	2.7	7	2.7	2.7	7	
8	18.1E	16.2	7.9	8.6	19.8	7.7	11.7	4	8	4	4	8	
9	17.9E	19.3	5.1	10.5	8.0	6.7	11.4	3.2	9	3.2	3.2	9	
10	17.6E	17.3	5.6	11.8	9.5	3.4	11.0	1.8	10	1.8	1.8	10	
11	17.4E	17.8	9.8	14.6	11.1	4.6	11.7	2.2	11	2.2	2.2	11	
12	21.1	23.9	8.9	15.2	18.1	4.4	10.7	2.5	12	2.5	2.5	12	
13	18.3	20.1	8.3	13.6	17.3	3.0	14.9	2.4	13	2.4	2.4	13	
14	12.7	17.1	20.7	11.3	12.5	14.8	2.9E	12.9	14	2.2	2.2	14	
15	15.5	18.8	17.8	6.5	10.5	17.0	5.9E	4.4	15	1.9	1.9	15	
16	14.5	18.6	19.9	6.0	14.4	16.8	5.9E	3.0	16	1.5	1.5	16	
17	18.2	20.0	13.7	6.7	16.8	17.3	5.7E	3.2	17	1.9	1.9	17	
18	20.9	21.6	10.0	7.8	16.5	16.8	5.7E	6.4	18	5.5	5.5	18	
19	19.3	20.2	18.4	10.5	12.9	18.1	5.5E	6.2	19	6.7	6.7	19	
20	13.4	18.1	17.8	9.8	9.8	18.6	9.5	3.6	20	15.3	15.3	20	
21	14.3	18.3	21.9	14.0	9.5	17.3	8.2	5.2	21	2.7	2.7	21	
22	15.0	18.8	19.5	14.0	13.6	19.0	7.4	7.9	22	2.5	2.5	22	
23	18.2	17.6	17.6	11.1	13.6	15.6	8.5	8.2	23	2.4	2.4	23	
24	16.0	19.5	16.7	8.0	14.0	16.4	13.6	10.4	24	2.2	2.2	24	
25	17.6	19.7	12.4	9.5	13.2	19.0	13.9	3.2	25	2.7	2.7	25	
26	16.0	28.0	7.9	11.1	12.2	21.7	11.7	4.0	26	3.6	3.6	26	
27	17.6	29.0	10.0	11.1	11.8	23.4	12.3	5.0	27	2.7	2.7	27	
28	20.0	29.0	8.6	10.9	14.8	23.4	11.7	5.5	28	1.6	1.6	28	
29	19.3	29.0	11.6	8.3	15.6	24.8	22.0	4.6	29	.9	.9	29	
30	16.6	25.6	12.0	8.3	10.8	20.0	18.9	5.2	30	.8	.8	30	
31	26.6	11.1	16.0	14.2	14.2	14.2	1.2	31		1.2	1.2	31	

TOTAL ANNUAL FLOW 6,638.8 ACRE FEET

OFFICE OF THE WATER MASTER - TRUCKEE RIVER SYSTEM
 Daily Inflow Record
 Cubic Feet Per Second

NORTH TRUCKEE DRAIN
 At Off Siphon - 1980

Mo.: Day:	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Mo.: Day:	
	cfs													
1:	22	1	1	1	1	19	28	24	16	20	14	18	3	
2:	21	22	28	33	33	16	16	19	14	14	18	18	2	
3:	21	26	37	37	17	17	17	17	14	19	19	7	3	
4:	16	28	33	19	19	18	18	18	16	16	17	17	4	
5:	18	39	28	20	20	15	15	19	19	19	19	18	5	
6:	22	45	28	18	18	20	20	19	19	19	21	21	6	
7:	20	41	28	19	19	26	26	18	18	13	13	12	7	
8:	16	32	28	19	19	29	29	10	10	12	12	10	8	
9:	12	29	15	19	19	26	26	21	21	16	16	13	9	
10:	6	26	13	18	18	26	26	22	22	16	16	14	10	
11:	13	23	43	21	21	26	26	18	18	15	15	10	11	
12:	25	24	41	24	24	20	20	19	19	14	14	10	12	
13:	N/R	N/R	N/R	N/R	N/R	35	36	22	40	16	15	15	3	13
14:	40	24	24	28	28	20	20	30	30	16	17	17	2	14
15:	↑	36	24	14	20	20	21	21	21	13	11	11	7	15
16:	34	24	16	18	18	12	12	14	14	10	10	N/R	16	
17:	31	16	18	18	18	15	15	15	15	10	10	10	17	
18:	30	18	17	18	17	25	25	15	15	16	16	16	18	
19:	30	18	18	18	16	16	16	40	40	15	15	15	19	
20:	33	23	15	15	17	15	17	15	35	14	14	14	20	
21:	30	19	12	19	19	19	19	33	33	12	12	12	21	
22:	23	16	13	22	22	21	21	32	32	12	12	8	22	
23:	19	18	19	23	23	20	20	28	28	13	13	N/R	23	
24:	15	18	27	20	20	21	21	28	28	15	15	15	24	
25:	20	21	43	19	19	20	20	25	25	16	16	16	25	
26:	28	27	14	16	18	18	18	21	21	8	8	8	26	
27:	31	35	15	15	15	19	19	20	20	6	6	6	27	
28:	30	40	15	16	16	19	19	16	16	5	5	5	28	
29:	14	30	45	17	17	19	19	18	18	4	4	4	29	
30:	16	30	16	26	26	21	21	15	15	17	2	2	N/R	
31:	31	31	14	20	20	17	17	17	17	N/R	31	N/R	31	
MAX:	40	45	43	43	43	40	40	40	40	21	21	18	MAX	
MIN:	6	16	12	15	12	12	12	13	13	2	2	2	MIN	
AVG:	15	24.7	26.5	23.5	18.9	21.7	20.4	12.6	12.6	9.3	9.3	9.3	AVG	
A.F.:	59	1517	1574	1441	1158	1287	1249	790	790	371	371	371	A.F.	

TOTAL ANNUAL FLOW 9646 ACRE FEET

OFFICE OF THE WATER MASTER - TRUCKEE RIVER SYSTEM
 Daily Inflow Record
 Cubic Feet Per Second

NORTH TRUCKEE DRAIN
 (At Orr Extension Siphon) 1979

Mo.: Day	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Mo.: Day	
	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs		
1	4.0	4.0	1.8	3	20.8	27.6	21.2	12.0	29.4	26.0	7.6	10.8	1	
2	0.6	3.6	1.7	3	20.8	26.0	25.5	12.4	22.0	24.0	9.4	10.0	2	
3	0	7.0	1.4	.3	20.0	24.5	17.6	10.4	19.6	26.0	14.0	9.7	3	
4	12.4	7.0	1.4	.3	17.6	24.0	21.2	15.2	19.6	30.6	14.8	9.1	4	
5	31.8	7.0	1.3	3	16.4	25.0	21.6	15.2	13.2	29.4	14.4	6.1	5	
6	19.6	5.5	1.4	.3	15.6	22.0	21.2	13.2	11.6	27.0	12.4	6.1	6	
7	16.4	5.5	1.4	.3	18.8	21.6	17.6	15.2	10.8	28.2	12.8	6.1	7	
8	11.6	7.3	1.4	.3	16.0	22.0	20.8	16.8	16.0	30.0	12.4	7.6	8	
9	8.8	8.5	1.6	.3	12.0	25.0	23.5	16.8	20.8	23.5	10.8	8.8	9	
10	8.8	4.3	1.6	1	23.5	23.0	25.5	12.8	22.5	20.8	11.6	8.8	10	
11	39.0	3.0	1.6	.1	28.2	22.0	19.2	14.4	20.0	19.2	11.6	10.0	11	
12	27.0	3.8	1.3	.1	31.8	22.0	16.0	17.2	21.6	17.2	10.4	14.0	12	
13	18.0	6.1	1.1	.1	28.8	21.6	18.4	17.6	22.0	15.6	9.4	13.6	13	
14	10.0	18.4	.9	.7	28.8	21.2	18.4	14.8	21.6	15.6	8.2	12.8	14	
15	9.4	7.3	.9	8.2	25.5	24.0	18.0	16.0	21.2	14.4	8.2	9.7	15	
16	8.8	2.6	6.1	27.0	23.5	16.4	16.4	21.6	13.6	10.8	11.2	16		
17	8.2	3.8	4.9	30.6	25.0	8.8	12.4	19.2	12.8	9.7	9.7	17		
18	7.6	3.8	11.6	32.4	25.0	14.8	12.4	20.8	12.0	10.4	4.3	18		
19	7.0	3.4	12.4	36.0	25.0	15.2	15.6	19.2	12.0	11.2	1.8	19		
20	6.4	2.6	.6	11.2	34.8	22.0	13.6	16.0	14.4	14.8	9.7	2.2	20	
21	5.8	2.6	11.6	27.6	27.0	22.5	15.2	14.4	19.6	9.1	3.8	21		
22	5.2	2.2	6.4	27.6	27.6	14.8	14.0	16.4	15.2	6.4	5.5	22		
23	4.6	2.2	5.5	30.6	19.6	12.4	14.0	15.2	14.8	6.4	7.3	23		
24	4.0	2.2	8.2	32.4	15.6	15.6	18.4	14.4	15.2	8.2	15.2	24		
25	3.6	2.0	10.4	30.6	16.4	12.0	17.2	14.4	17.6	8.8	17.6	25		
26	3.2	1.8	12.8	31.8	14.8	12.8	21.6	16.8	20.0	10.0	11.2	26		
27	2.8	2.2	.1	9.4	30.6	18.0	12.4	17.2	19.2	18.8	10.8	10.4	27	
28	2.4	1.8	7.9	27.6	16.0	12.0	20.0	20.4	18.4	11.6	10.4	28		
29	2.0	1.2	26.5	17.2	12.8	28.2	20.4	18.8	11.6	10.4	12.8	29		
30	1.2	1.2	12.4	17.6	13.2	26.5	26.5	16.4	12.0	12.8	30			
31	1.7	1.7	23.5	13.2	28.2	8.5					18.4	31		
MAX:	39.0	18.4	1.8	12.8	27.6	25.5	28.2	29.4	27.0	14.8	14.0	MAX:		
MIN:	1.2	1.8	.1	12.0	14.8	8.8	10.4	10.8	8.5	6.4	1.8	MIN:		
AVG:	9.4	4.7	1.0	5.3	26.4	22.1	17.0	16.5	18.8	19.2	10.5	9.5	AVG:	
A.F:	578	260	61	318	1,619	1,310	1,042	1,012	1,120	1,180	623	585	A.F:	

TOTAL ANNUAL FLOW 9,708 ACRE FEET

OFFICE OF THE WATER MASTER - TRUCKEE RIVER SYSTEM
 Daily Inflow Record
 NORTH TRUCKEE DRAIN AT
 Orr Ditch Extension Siphon
 1978

Mo.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Mo.
Day	cfs	Day											
1	7	7	2	1	26	28	16	23	26	22	20	11	1
2	7	6	2	1	20	30	32	21	21	22	19	9	2
3	7	6	2	1	19	30	31	21	21	22	12	6	3
4	7	6	2	1	20	29	28	19	19	26	9	4	4
5	7	6	2	1	18	26	24	20	23	31	9	4	5
6	9	8	1	1	18	24	18	20	29	32	8	4	6
7	6	10	2	1	20	26	19	18	27	28	9	2	7
8	6	12	2	1	18	26	19	19	24	34	8	1	8
9	9	7	2	1	20	28	18	18	24	35	9	1	9
10	8	8	2	1	20	29	15	20	23	31	8	1	10
11	7	8	2	1	20	32	16	18	24	29	8	6	11
12	6	8	2	1	22	33	18	17	26	29	5	4	12
13	6	8	2	1	19	33	23	18	24	26	8	5	13
14	6	7	2	1	19	31	23	15	26	26	9	4	14
15	7	7	2	2	19	33	26	18	22	24	11	4	15
16	11	5	2	6	20	30	25	18	19	13	9	4	16
17	11	5	2	12	22	24	26	17	18	12	9	4	17
18	10	5	2	9	18	26	18	18	18	18	9	4	18
19	10	5	2	9	18	26	18	17	24	10	9	4	19
20	10	5	1	12	20	26	33	19	27	10	10	5	20
21	10	4	1	10	28	26	32	18	32	12	14	7	21
22	10	4	1	14	23	26	26	18	32	14	14	1	22
23	9	4	1	13	23	28	24	20	33	13	15	8	23
24	11	3	1	13	32	29	24	24	31	10	15	7	24
25	12	3	1	15	31	30	29	28	30	6	12	5	25
26	11	3	1	10	30	27	29	26	28	11	10	7	26
27	8	3	1	10	28	26	28	24	25	12	9	8	27
28	6	3	1	16	28	25	20	25	22	12	9	7	28
29	5	1	20	27	23	20	26	22	18	9	4	29	
30	7	1	25	29	21	26	29	20	20	9	8	30	
31	7	1	32	32	20	26	26	28	22	11	10	5	31
MAX:	12	12	2	25	32	33	29	33	32	20	11	MAX:	
MIN:	5	3	1	1	18	21	15	15	18	6	5	1	MIN:
AVG:	8	6	2	7	23	28	23	21	25	20	10	5	AVG:
A.F:	501	329	99	416	1400	1645	1434	1263	1465	1247	622	305	A.F:

TOTAL ANNUAL FLOW 10,726 ACRE FEET

OFFICE OF THE WATER MASTER - TRUCKEE RIVER SYSTEM
 Daily Inflow Record
 NORTH TRUCKEE DRAIN at ORR
 DITCH SIPHON
 Cubic Feet Per Second
 1977

Mo.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Mo.
Day:	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	Day:
1						30.1	11.2	14.4	13.6	.62	.63	.62	1
2						30.1	20.4	15.2	16.8	.83	.63	.83	2
3						22.0	30.1	23.5	16.0	.17.2	.62	.51	3
4						28.8	30.1	21.2	14.4	17.2	.62	.51	4
5													5
6													6
7													7
8													8
9													9
10													10
11													11
12													12
13													13
14													14
15													15
16													16
17													17
18													18
19													19
20													20
21													21
22													22
23													23
24													24
25													25
26													26
27													27
28													28
29													29
30													30
31													31
MAX:	10.7	6.4	7.0	23.8	36.0	35.0	24.5	20.4	17.2	.94	1.70	.970	MAX
MIN:													MIN
AVG:	10.7	6.4	4.0	18.8	27.5	26.3	9.1	9.7	10	.10	.10	.40	AVG
A.F:	656.8	354.8	245.5	1116.7	1638.0	1562.2	920.7	975.9	381.4	27.0	.62	.93	A.F
										36.8	179.8		

TOTAL ANNUAL FLOW 8,146 ACRE FEET

*Jan 1 thru. June 10 - Twice weekly spot flow measurements at Baring Ave.

OFFICE OF THE WATER MASTER
TRUCKEE RIVER SYSTEM
DAILY FLOW RECORD

N. TRUCKEE DRAIN NEAR CONFLUENCE WITH RIVER
@ RECORDER SOUTH OF I-BO NEAR BUSYARD
1986

Month Date	Jan cfs	Feb cfs	Mar cfs	Apr cfs	May cfs	Jun cfs	Jul cfs	Aug cfs	Sep cfs	Oct cfs	Nov cfs	Dec cfs
1 21.9	15.6	11.6	18.6	18.2	38.5	26.2	27.6	26.2	30.6	20.4	19.6	
2 22.3	17.6	12.8	21.1	16.6	32.7	24.0	26.7	25.7	30.0	20.8	18.9	
3 21.5	14.5	17.6	24.9	16.6	28.6	23.6	27.1	26.2	29.0	22.3	17.9	
4 24.9	13.1	22.7	19.3	18.2	23.6	22.7	26.7	24.4	29.0	21.1	17.6	
5 26.2	13.1	20.4	24.9	19.6	26.2	24.0	24.4	22.7	28.1	21.1	18.2	
6 23.1	13.4	13.4	19.6	20.0	25.7	24.0	25.7	23.2	24.9	21.1	19.6	
7 21.5	12.6	17.2	25.7	21.1	28.6	25.7	27.6	23.6	27.1	22.7	19.6	
8 20.4	12.8	156.5	21.9	19.6	29.5	28.1	27.6	21.1	24.9	23.1	19.3	
9 20.8	12.1	37.3	28.1	19.6	30.6	30.0	26.7	21.5	25.3	21.9	18.6	
10 20.4	11.8	22.3	34.9	18.6	34.3	28.1	26.2	16.3	24.4	21.9	22.3	
11 19.6	12.1	17.6	31.6	19.6	32.1	25.7	25.3	18.9	26.7	22.3	23.4	
12 19.3	10.6	14.2	22.3	20.0	34.3	26.2	25.7	16.6	25.3	21.5	19.3	
13 19.3	18.9	12.1	22.7	23.1	37.9	25.7	26.7	24.9	22.3	21.1	18.6	
14 18.6	24.4	15.1	19.6	22.3	34.9	27.1	27.6	26.2	21.5	22.3	16.3	
15 18.2	109.0	17.6	18.2	21.5	33.2	27.6	26.2	25.3	24.0	21.5	16.0	
16 17.9	N/R	20.4	16.0	23.6	30.6	27.1	25.7	24.9	24.0	22.3	14.8	
17 18.6	N/R	21.5	18.9	24.0	30.0	29.5	26.2	25.7	24.9	20.8	16.0	
18 19.6	N/R	27.6	18.9	23.1	29.5	27.6	25.3	27.6	26.7	20.4	17.6	
19 18.6	N/R	18.2	19.3	23.6	29.0	25.3	26.7	27.6	25.7	21.1	17.9	
20 18.2	N/R	18.2	18.2	27.6	28.6	26.7	27.6	29.5	25.3	21.1	20.0	
21 18.2	N/R	17.9	16.9	27.6	28.1	26.7	28.1	28.1	21.1	21.5	18.9	
22 16.9	N/R	17.9	18.2	31.6	27.6	76.7	27.1	27.6	23.1	20.8	18.2	
23 16.9	N/R	16.6	18.9	28.1	27.1	45.1	28.1	27.1	21.1	20.4	19.3	
24 16.3	N/R	17.6	20.4	30.6	26.7	32.7	27.1	30.6	19.3	20.0	18.6	
25 16.6	N/R	17.6	19.3	26.7	26.2	36.1	25.7	30.0	21.1	17.9	18.9	
26 16.3	N/R	16.6	19.6	25.3	25.7	34.3	24.4	30.6	20.0	15.6	19.6	
27 15.6	12.1	17.2	19.6	26.7	24.0	26.2	22.7	34.9	20.0	23.6	20.4	
28 15.6	10.4	17.2	18.9	33.2	26.7	25.7	23.6	33.2	19.3	22.7	19.6	
29 15.3		18.6	17.9	28.6	28.6	27.6	21.9	32.7	20.0	21.5	20.0	
30 15.6		19.3	18.6	27.6	28.1	27.6	23.1	29.0	20.4	20.0	19.6	
31 14.2		18.6		32.1		27.6	23.1		20.4		20.0	
MAX	26.2	109.0	156.5	34.9	33.2	38.5	76.7	28.1	34.9	30.6	23.6	23.4
MIN	14.2	10.4	11.6	16.0	16.6	23.6	22.7	21.9	16.3	19.3	15.6	14.8
AVG	19.0	13.2	22.9	21.1	23.7	29.6	29.4	25.9	26.1	24.1	21.2	18.9
A-F	1166	734	1404	1254	1455	1756	1804	1592	1548	1476	1258	1158

Total Acre-Feet: 16,606

OFFICE OF THE WATER MASTER
TRUCKEE RIVER SYSTEM
DAILY FLOW RECORD

N. TRUCKEE DRAIN NEAR CONFLUENCE WITH RIVER
@ RECORDER SOUTH OF I-80 NEAR BUSYARD
1965

Month Date	Jan cfs	Feb cfs	Mar cfs	Apr. cfs	May cfs	Jun cfs	Jul cfs	Aug cfs	Sep cfs	Oct cfs	Nov cfs	Dec cfs
1	26.7	17.9	18.6	18.9	23.6	33.7	33.8	27.6	37.9	34.3	20.8	29.5
2	26.7	17.6	18.2	19.6	25.3	40.4	34.3	34.3	37.9	36.7	21.9	42.3
3	26.7	17.2	14.2	18.2	27.6	40.4	37.3	35.5	38.5	34.3	23.1	32.7
4	26.7	17.2	20.8	18.6	29.0	40.4	34.9	34.9	45.1	34.3	23.1	28.1
5	26.7	17.6	20.8	17.9	31.1	33.8	33.8	32.1	43.0	36.7	22.7	30.6
6	26.7	17.2	20.0	16.6	32.1	35.1	31.6	34.9	46.5	43.0	21.9	30.0
7	26.2	18.9	20.0	17.6	33.8	37.9	26.7	32.7	49.4	39.1	21.1	30.6
8	26.2	41.0	19.3	18.2	37.3	38.5	26.7	31.1	46.5	47.2	21.9	23.5
9	25.3	23.1	19.6	17.2	36.1	37.3	26.7	31.6	57.4	45.8	22.7	29.0
10	25.3	18.6	20.0	17.6	34.9	37.3	26.2	32.7	48.7	43.0	23.1	25.7
11	25.3	16.9	22.7	16.3	36.7	36.1	30.6	30.6	45.8	41.0	24.4	24.0
12	25.3	16.9	20.4	17.6	35.5	35.7	33.2	33.8	46.5	39.1	25.3	23.1
13	25.3	18.9	20.0	23.6	34.3	37.3	30.8	37.3	44.4	35.5	25.7	21.5
14	25.3	18.6	19.6	28.1	33.8	37.9	32.7	34.9	43.7	33.2	24.9	21.9
15	25.3	19.6	19.6	27.1	33.2	38.5	31.1	37.3	41.8	33.2	24.0	23.1
16	20.4	19.3	20.8	25.3	34.3	35.5	29.5	34.9	42.3	32.7	27.6	21.5
17	20.4	17.9	19.6	21.9	34.3	31.6	30.0	35.5	40.4	32.1	34.3	25.7
18	23.1	18.2	25.3	18.2	34.9	33.8	30.8	36.1	57.4	28.6	34.3	23.1
19	24.4	18.6	19.6	17.9	34.3	29.8	29.5	36.7	43.7	28.1	33.2	21.1
20	23.1	19.3	19.6	22.3	33.2	34.3	33.8	34.9	40.4	26.7	32.1	18.9
21	24.4	18.6	19.3	21.5	32.1	37.9	37.9	32.1	39.7	24.0	32.1	19.3
22	23.6	19.6	19.6	27.6	34.3	38.5	35.1	32.7	39.1	22.3	31.1	19.3
23	22.3	19.3	19.6	22.3	31.6	35.1	33.8	30.0	38.5	21.9	30.0	18.6
24	24.4	17.2	18.6	22.7	30.0	36.1	34.9	30.0	35.5	21.1	31.1	18.9
25	22.7	18.2	19.6	22.7	33.2	45.8	35.5	31.6	34.3	20.4	31.6	18.9
26	25.3	18.6	20.0	23.6	34.3	40.4	36.7	34.3	33.8	20.8	31.1	18.9
27	22.3	18.2	26.7	22.7	35.7	35.5	34.9	35.5	26.2	20.0	32.7	18.6
28	21.5	18.6	23.1	29.0	36.1	30.0	37.9	33.2	24.0	19.6	35.5	18.9
29	21.5		20.0	27.1	34.9	35.5	30.6	38.5	22.7	19.6	35.5	18.9
30	28.0		19.6	24.9	35.5	33.8	26.7	41.0	22.7	19.6	30.0	24.0
31	18.2		19.6		37.9		25.3	37.9		20.0		21.9
MAX	26.7	41.0	26.7	29.0	37.9	45.8	37.9	41.0	57.4	47.2	35.5	42.3
MIN	18.2	16.9	14.2	16.3	23.6	29.0	25.3	27.6	22.7	19.6	20.0	18.6
AVG	24.1	19.2	20.2	21.4	33.3	36.7	32.0	34.1	40.4	30.8	27.6	24.2
A-F	1480	1067	1237	1273	2043	2181	1965	2091	2401	1889	1642	1482

Total Acre-Feet: 20,752

OFFICE OF THE WATER MASTER
TRUCKEE RIVER SYSTEM
DAILY FLOW RECORD

N. TRUCKEE DRAIN NEAR CONFLUENCE WITH RIVER
@ RECORDER NORTH OF I-80 (1/1-4/3)
@ RECORDER SOUTH OF I-80 NEAR BUSYARD (4/12-12/31)

1984

Month Date	Jan cfs	Feb cfs	Mar cfs	Apr cfs	May cfs	Jun cfs	Jul cfs	Aug cfs	Sep cfs	Oct cfs	Nov cfs	Dec cfs
1	19.6	3.8	1.6	2.4	42.2	43.8	45.4	40.6	45.3	44.8	21.8	30.5
2	17.7	3.7	1.6	2.7	44.9	42.1	46.4	40.8	44.0	45.0	23.4	30.2
3	17.0	3.4	1.4	2.9	46.0	43.8	43.3	38.2	42.8	48.7	29.5	30.3
4	12.0	3.3	1.4	0.0	42.9	45.0	40.1	36.9	38.2	46.1	30.9	30.4
5	8.9	3.2	1.1	0.0	43.9	46.9	43.2	37.1	35.1	45.4	25.5	27.0
6	9.1	3.0	1.0	0.0	41.4	37.2	40.6	35.2	37.7	47.8	23.0	27.0
7	9.3	3.1	1.0	0.0	40.7	37.7	32.6	36.4	34.2	50.2	23.4	26.9
8	8.4	2.8	0.9	0.0	41.1	37.2	32.3	36.6	35.1	46.9	24.2	26.9
9	7.1	2.9	0.9	0.0	43.3	37.2	33.0	35.7	38.2	45.6	25.1	26.9
10	7.3	2.9	1.0	0.0	44.9	48.1	35.1	34.9	39.9	46.1	26.0	26.9
11	6.9	2.7	0.5	0.0	44.7	43.8	35.9	39.3	44.4	52.3	26.9	26.9
12	6.5	2.7	0.5	24.6	49.5	44.4	42.0	41.7	42.9	49.2	27.8	26.9
13	6.8	3.0	0.7	23.8	46.8	44.4	34.3	41.9	43.1	40.3	31.4	26.9
14	7.4	3.7	1.1	28.6	42.4	50.0	36.5	42.1	41.5	40.2	30.6	26.8
15	7.6	4.6	0.8	27.7	40.6	53.4	39.9	42.0	38.9	42.3	28.9	26.8
16	8.0	4.3	0.7	26.0	39.9	51.4	38.5	39.2	38.6	50.7	28.6	26.8
17	6.9	3.3	0.3	28.5	38.1	104.2	33.7	39.1	38.8	66.9	28.7	26.8
18	9.5	3.0	0.6	31.1	44.1	76.1	38.1	39.0	41.1	55.7	29.2	26.8
19	10.0	2.7	0.9	34.8	46.9	51.4	46.5	40.0	47.9	55.8	22.2	26.8
20	8.3	2.6	0.8	36.8	48.7	46.9	48.2	39.4	48.1	55.9	21.6	26.7
21	5.8	2.6	0.7	35.3	49.1	49.8	45.5	42.7	44.6	56.0	22.4	26.7
22	5.4	2.7	0.5	36.2	47.0	51.6	51.1	44.3	43.6	56.1	22.5	26.7
23	5.2	2.4	0.4	37.7	49.4	48.8	84.8	41.9	37.7	47.5	22.2	26.7
24	5.7	2.2	1.5	41.0	62.8	49.2	57.6	40.7	37.4	47.3	23.0	26.7
25	5.9	2.0	1.8	41.9	45.0	47.8	43.9	44.1	38.6	43.5	22.0	26.7
26	5.5	1.9	2.0	43.5	39.9	45.7	38.4	45.8	41.5	30.9	22.5	26.7
27	5.1	1.7	2.2	41.1	36.7	44.9	35.9	43.9	42.3	26.9	32.9	26.6
28	5.0	1.6	1.3	41.5	39.9	44.8	39.1	39.3	43.6	23.7	69.8	26.6
29	5.0	1.7	1.6	39.7	42.7	46.4	39.7	38.7	43.8	22.5	40.3	26.6
30	4.3		2.4	39.0	45.0	48.1	37.6	41.9	41.7	22.0	31.6	26.6
31	4.1		2.3		47.5		41.5	41.9		22.8		26.6
MAX	19.6	4.6	2.4	43.5	62.8	104.2	84.8	45.8	48.1	66.9	69.8	30.5
MIN	4.1	1.6	0.3	2.4	36.7	37.2	32.3	34.9	34.2	22.0	21.6	26.6
AVG	8.1	2.9	1.1	30.3	44.4	48.7	42.0	40.0	41.1	44.3	27.9	27.2
A-F	498	165	71	1320	2728	2895	2575	2454	2439	2720	1660	1672
Helm's *	580	543	580									

Total Acre-Feet: 19,567

* Water pumped from Helm's gravel pit which bypassed USHM station during Jan-Mar.

Daily Inf., Record
Cubic Feet per Second
NORTH TRUCKEE DRAIN @ KLEPPE
& I=80 1983

Mo. : Day	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Mo. : Day	
	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs		
1: 20.60	19.60	75.30			15.95	31.60	19.74	18.36e	36.30	33.06	31.98	18.87	1:	
2: 22.30	23.50	37.60			12.40e	29.10	20.66e	32.52	27.96	31.94	15.72	2:		
3: 21.70	21.10	25.90			10.54e	31.00	20.66	31.98e	31.44	27.47	30.41	27.47	3:	
4: 18.10	18.10	22.30			24.09	33.50	20.20	32.52e	32.52	27.47	29.92	20.82	4:	
5: 18.60e	17.10	22.90			13.36	24.10	18.82	32.52e	31.98	21.60	27.96	15.06	5:	
6: 19.10e	17.60	20.60			13.36	23.60	16.73	32.52e	33.60	22.92	26.49	13.80	6:	
7: 16.60e	34.40	22.90			14.39	32.80	14.39	32.52e	31.98	23.36	25.56	11.40	7:	
8: 17.60e	72.50	9.90			13.04	26.20	12.72	33.06e	30.41	21.21	24.68	9.40	8:	
9: 17.60e	42.10	33.60			12.08	22.50	13.68	29.43	29.92	19.26	24.68e	7.64	9:	
10: 18.60	25.30	20.60			21.58	26.20	16.34	43.06	26.00	18.09	24.68e	6.61	10:	
11: 17.10	27.10	21.70			13.36	32.80	19.28	35.76	24.24	18.48	50.46	5.70	11:	
12: 16.60	43.00	26.50			9.76	23.60	29.69	32.52	24.68	17.70	29.92	5.36	12:	
13: 18.80	31.30				8.46	23.60	24.09	37.47	26.49	18.48	46.36	4.28	13:	
14: 9.60	24.70				18.36	27.80	25.15	30.41	33.06	20.04	46.36	2.77	14:	
15: 21.10	22.30	△O RECORD			22.04	16.70	29.06	31.44	33.60	18.87	46.36	2.30	15:	
16: 17.10	20.10				24.09e	17.90	29.06	27.47	30.41	19.26	48.34	2.88	16:	
17: 15.09	20.10				19.60	21.10	28.43	27.47	29.92	21.21	100.00e	3.35	17:	
18: 17.10e	39.40				17.12	14.40	30.32	23.80	27.47	19.26	41.18	2.67	18:	
19: 18.10e	25.30				17.51	13.00	30.32	33.06	26.49	18.48	41.18	2.08	19:	
20: 15.80e	21.10				12.08	14.80	26.70e	28.45	26.49	13.50	34.68	1.91	20:	
21: 16.20e	17.60				7.57	23.56	26.70e	29.92	28.94	13.20	32.52	1.66	21:	
22: 27.10e	17.10				13.40	10.80	15.56	27.30e	31.44	30.41	13.50	29.92	1.53	22:
23: 21.70e	17.60				13.00	14.39	9.76	27.80e	31.44	30.90	16.71	30.90	1.06	23:
24: 100.00e	17.10				12.70	14.00	12.08	27.80e	30.41	35.22	18.87	100.00e	.84	24:
25: 100.00e	23.50				12.40	46.30	15.56	28.40e	30.90	39.96	18.48	93.95	1.91	25:
26: 58.50	24.70				12.10	35.50	17.90	28.40e	30.41	34.14	22.04	34.14	30.90	26:
27: 51.80	29.90				9.20	27.27e	21.58	22.00e	34.14	34.14	22.92	30.41	31.44	27:
28: 34.40	35.20				22.00	20.66e	20.66	21.12e	27.96	29.43	22.92	28.94	15.72	28:
29: 34.40					47.80	15.17	19.28	20.66e	23.80	28.94	23.36	28.45	4.14	29:
30: 33.60					25.60	10.54	21.12	19.74e	31.44	34.68	23.36	26.49	20.43	30:
31: 29.90					14.80		18.82e	36.91		28.94		36.91	31:	
MAX: 100.00e	72.50	75.30	47.80	46.30	33.50	30.41	40.00	40.00	33.10	100.00e	36.90	MAX:		
MIN: 9.60	17.10	9.90	9.20	8.46	9.76	12.72	18.36	24.24	13.20	24.68	.84	MIN:		
Avg: 27.70	26.70	28.30	18.70	17.10	22.10	23.00	30.40	30.90	21.00	40.00	10.50	Avg:		
A.F: 1698	1482	1738e	1110e	1050	1313	1414	1868	1834	1291	2374	647	A.F:		

+ A.F. FROM HELM'S PIT TOTAL ESTIMATED FLOW 580 599 675 654 656 672 656

e=estimated flow * PRIOR TO 3/12, HELM'S PIT CONTRIBUTION WAS INCLUDED IN RECORDED FLOWS.

WATER INFORMATION SYSTEM
Daily Int. Record
Cubic Feet per Second

NORTH TRUCKEE DRAIN
@ KLEPPE LANE 1982

Mo. : JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Mo.:
Day:	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	Day:
1:					14.6e	29	45	39	36	36	36	1
2:					50.7e	42	53	42	54	25	25	2
3:					50.7e	45	49	44	53	26	26	3
4:					50.7e	38	42	41	52	28	28	4
5:					50.7e	46	40	42	22	28	28	5
6:												
7:												
8:												
9:												
10:												
11:												
12:												
13:												
14:												
15:												
16:												
17:												
18:												
19:												
20:												
21:												
22:												
23:												
24:												
25:												
26:												
27:												
28:												
29:												
30:												
31:												
MAX:					46.7	50.7	63	106	93	82	174	MAX:
MIN:					8.2	14.6	29	31	21	15	25	MIN:
AVG:					24.9	41.4	43	54	39	34	42	AVG:
A.F:					789	2542	2635	3204	2384	2037	2580	A.F:

TOTAL ESTIMATED FLOW 16,171 ACRE FEET

e=estimated flow

Daily Runoff Record
Cubic Feet per Second

N. TRUCKEE DRAINAGE KLEPPE
1981

Mo.: Day:	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Mo.: Day:	
	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs		
1: 1	27.6	20.1	18.6	30.6	36.8	53.6	30.0	28.8	34.0	38.3	26.4	1		
2: 2	27.6	20.1	18.6	34.0	39.9	40.1	28.8	28.2	31.2	38.3	27.6	2		
3: 3	27.0	19.1	17.0	38.3	40.7	47.3	31.2	30.6	28.8	40.7	30.0	3		
4: 4	27.0	19.6	19.1	38.3	39.1	44.7	31.9	30.6	35.4	47.3	34.0	4		
5: 5	26.4	20.6	18.6	36.1	37.5	45.5	31.2	29.4	28.2	40.7	34.7	5		
6: 6	23.1	20.6	17.8	30.9	41.5	43.9	30.0	31.9	35.4	28.2	30.0	6		
7: 7	23.1	20.1	18.2	21.1	42.3	46.4	29.4	34.7	38.3	25.2	30.0	7		
8: 8	23.1	20.6	17.8	18.6	33.3	43.9	22.6	34.0	28.8	22.6	31.2	8		
9: 9	23.1	21.1	17.6	21.6	36.1	42.3	23.6	35.4	24.6	22.6	31.9	9		
10: 10	22.6	22.6	15.8	22.6	38.3	41.5	27.6	30.6	23.6	21.1	30.0	10		
11: 11	22.6	19.1	17.4	27.0	41.5	40.7	26.4	37.5	27.6	23.6	31.9	11		
12: 12	22.6	18.2	16.6	25.8	43.9	42.3	25.8	39.1	34.0	23.1	30.6	12		
13: 13	24.6	17.0	20.1	26.4	41.5	42.3	25.2	45.5	36.1	22.1	30.2	13		
14: 14	24.1	17.4	16.6	28.2	36.1	43.9	25.2	42.3	32.6	25.2	100.0	14		
15: 15	23.6	15.8	15.0	31.2	41.5	41.5	25.2	34.7	36.1	30.0	34.0	15		
16: 16	23.1	13.8	14.2	27.6	73.0	44.7	22.6	38.3	36.3	31.2	27.6	16		
17: 17	22.6	12.5	14.6	28.8	73.0	39.1	23.1	39.9	38.3	31.2	21.1	17		
18: 18	22.1	13.8	15.4	31.9	96.6	36.1	25.2	30.0	38.3	30.6	18			
19: 19	21.6	15.8	18.6	34.0	44.7	39.9	25.8	32.6	36.1	30.0	19			
20: 20	16.6	15.8	16.2	28.8	74.2	39.1	27.0	28.8	41.5	27.6	20			
21: 21	16.6	15.0	17.4	31.7	75.4	37.5	36.8	29.4	39.9	28.2	21			
22: 22	16.6	14.6	17.4	39.9	76.6	36.1	34.7	34.0	42.3	27.6	22			
23: 23	17.0	16.6	16.6	39.1	75.4	33.3	37.5	34.7	36.1	27.6	23			
24: 24	17.0	17.0	17.4	38.3	70.6	31.2	36.8	31.9	40.7	30.0	24			
25: 25	17.4	16.6	19.6	39.9	45.5	28.2	35.4	29.4	40.7	32.6	25			
26: 26	16.6	17.8	39.1	39.1	66.4	26.4	37.5	33.3	43.9	30.0	26			
27: 27	17.8E	17.8	38.3	36.1	65.1	27.6	40.7	31.9	44.7	38.3	27			
28: 28	18.6E	18.2	33.3	38.3	56.6	28.8	32.6	34.7	44.7	50.9	28			
29: 29	20.1E	20.1	29.4	37.5	53.6	28.2	31.9	34.7	42.3	22.6	29			
30: 30	21.1	31.2	36.1	54.6	30.0	27.0	34.7	39.1	36.1	30				
31: 31	21.1	35.4	53.6	53.6	26.4	30.6	31.9	31.9	31.9	31				
	MAX:	27.6	22.6	39.1	96.6	53.6	40.7	45.5	44.7	50.9	100.0		MAX:	
	MIN:	16.6	12.5	14.2	18.6	33.3	26.4	22.6	28.2	23.6	21.1		MIN:	
	AVG:	21.7	17.8	20.6	32.0	53.1	39.2	29.5	33.6	36.0	37.1		AVG:	
	A.F:	1334.5	984.7	1263.8	1900.6	3260.0	2326.7	1811.9	2063.6	2137.2	1891.7	1249.8		A.F:

TOTAL ANNUAL FLOW 20,225.4 ACRE FEET

Daily Infil Record
Cubic Feet per Second

NORTH TRUCKEE D' IN
KLEPPE LANE
1980

Mo.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Mo.
Day:	cfs	Day:											
1:	31	38	32	48	45	36	42	37	31	22	1		
2:	31e	30	42	44	34	46	40	-	39	32	20	2	
3:	29	43	41	36	40	73	39	33	32	30	24	3	
4:	26	36	36	35	42	56	42	38	37	34	41	4	
5:	25	35	45	36	49	50	40	40	40	32	38	5	
6:	20	38	40	34	43	49	38	47	39	29	23	6	
7:	19	36	35	40	47	50	38	46	37	25	19	7	
8:	22e	20	35	32	39	46	72	36	53	38	29	17	8
9:	19	32	31	30	51	39	36	48	42	27	21	9	
10:	15	30	31	35	47	37	36	47	46	28	21	10	
11:	19	29	29	44	44	39	39	43	50	42	36	22	11
12:	21	29	59	44	47	38	31	37	30	22	22	12	
13:	21	24	70	48	41	38	31	38	32	22	22	13	
14:	21	24	62	44	39	35	34	37	27	22	22	14	
15:	21	40	62	41	41	38	33	37	37	27	22	15	
16:	23	24	55	41	41	38	33	37	37	27	24	16	
17:	26	26	48	39	47	40	33	39	39	27	24	17	
18:	124	26	46	46	49	40	35	41	20	24	24	18	
19:	52	35	41	45	46	39	41	34	33	28	24	19	
20:		43	45	43	43	43	39	41	33	32	24	20	
21:		36	60	43	39	41	44	33	33	27	24	25	
22:		40	76	40	37	54	46	33	28	24	24	22	
23:		32	66	38	36	58	46	32	28	24	24	23	
24:		35	43	36	33	47	47	33	28	24	24	24	
25:	18	36	50	37	37	43	43	29	27	24	25		
26:	36	41	44	37	38	42	40	16	23	24	24	26	
27:	34	38	52	39	28	43	35	17	24	24	24	27	
28:	16	34	46	40	38	43	39	17	24	24	24	28	
29:	26	41	33	45	41	41	42	34	18	24	24	29	
30:	27	30	46	44	50	45	40	32	19	25	30		
31:	35		54	35	42	42	32			25	31		
MAX:		45	66	53	75	58	53	46	36	41	41	MAX:	
MIN:		24	30	36	33	35	31	16	17	17	17	MIN:	
AVG:		33	46	43	45	40	41	36	27	24	24	AVG:	
A.F.:	1731	1669	2032	1980	2847	2576	2768	2481	2453	2202	1626	1469	A.F.:

TOTAL ANNUAL FLOW 25834 ACRE FEET

OFFICE OF THE WATER MASTER - TRUCKEE RIVER SYSTEM
 Daily Inflow Record
 Cubic Feet Per Second

NORTH TRUCKEE DRAIN
 (at Kleppe Lane) 1979

Mo.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Mo.
Day	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs	Day
1	19	27	21	17	42	34	36	35	35	43	30	29	1
2	20	27	20	15	45	36	37	38	35	42	32	29	2
3	26	25	21	15	47	38	37	36	33	43	36	28	3
4	26	25	21	15	44	36	45	34	33	46	35	26	4
5	25	29	19	17	57	35	42	37	34	47	33	23	5
6	27	32	18	18	57	37	39	34	35	49	33	22	6
7	26	25	17	18	50	35	38	34	37	50	33	23	7
8	27	36	17	18	41	36	42	34	39	50	33	26	8
9	26	35	18	18	36	39	40	37	36	42	29	27	9
10	28	34	23	20	48	40	40	36	39	40	42	29	10
11	32	30	24	18	40	39	45	35	37	39	39	28	11
12	26	30	22	18	40	40	42	35	41	35	35	28	12
13	26	28	18	19	40	39	36	35	35	43	36	25	13
14	26	47	20	37	40	37	39	36	35	45	37	26	14
15	26	30	27	31	40	39	38	36	36	41	36	26	15
16	26	26	22	27	40	40	40	37	35	45	35	28	16
17	26	26	21	24	40	41	41	33	35	44	34	29	17
18	26	24	22	32	41	42	42	33	35	42	33	27	18
19	26	24	21	32	40	46	37	35	39	33	27	23	19
20	26	26	15	32	39	45	37	36	36	36	25	23	20
21	26	26	14	32	35	43	47	34	35	40	35	26	21
22	26	24	16	29	35	45	46	34	37	34	23	26	22
23	26	24	22	29	34	45	36	34	36	31	25	32	23
24	26	24	24	30	33	37	37	35	32	30	26	64	24
25	26	23	24	31	34	35	35	35	38	32	27	47	25
26	26	24	23	35	37	35	36	37	37	35	26	33	26
27	26	22	21	35	37	34	36	37	37	34	25	34	27
28	26	21	19	33	34	34	37	35	36	33	28	33	28
29	26	17	33	33	36	38	35	38	38	33	26	33	29
30	27	16	38	36	34	36	34	36	38	30	26	47	30
31	25	17	34	34	35	35	35	35	35	30	49	31	
MAX:	32	47	27	38	57	46	47	38	45	50	36	64	MAX:
MIN:	19	21	14	15	33	34	33	34	32	30	23	22	MIN:
AVG:	26	28	20	26	40	38	38	35	38	38	33	30	AVG:
A.F.:	1588:	1552:	1228	1517	2471	2281	2360	2166	2251	2307	1677	1833	A.F.

TOTAL ANNUAL FLOW 23,231 ACRE FEET

OFFICE OF THE WATER MASTER TRUCKEE RIVER SYSTEM
 Daily Inflow Record
 Cubic Feet Per Second

NORTH TRUCKEE DRAIN AT
 Kleppe Lane
 1978

Mo.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Mo.
Day	cfs	Day											
1:	25	23	17	17	17	17	44	42	39	49	58	37	1:
2:	23	23	19	14	47	45	39	49	45	47	66	36	2:
3:	24	23	15	15	47	52	37	45	45	47	38	34	3:
4:	23	23	30	15	19	47	52	37	42	47	34	34	4:
5:	30	24	19	16	42	44	40	47	47	49	33	34	5:
6:	30	24	13	17	43	36	42	50	51	51	32	30	6:
7:	30	36	13	17	40	37	37	62	49	31	26	7:	7:
8:	23	33	17	17	45	40	39	52	52	35	24	8:	8:
9:	38	29	15	17	43	39	37	56	55	32	26	9:	9:
10:	28	23	13	16	49	34	40	53	52	31	29	10:	10:
11:	23	21	18	15	17	49	35	42	50	52	34	30	11:
12:	22	19	17	15	43	36	42	54	52	33	31	12:	12:
13:	25	19	13	17	43	40	42	50	50	33	30	13:	13:
14:	28	18	15	21	45	40	39	64	50	35	31	14:	14:
15:	28	17	15	17	45	41	39	53	51	34	31	15:	15:
16:	38	17	17	26	45	42	39	48	42	34	31	16:	16:
17:	33	17	15	30	44	40	40	42	42	35	34	32	17:
18:	25	16	16	30	42	44	37	39	48	38	34	33	18:
19:	27	15	11	29	40	32	40	48	37	34	32	19:	19:
20:	27	15	13	32	42	42	40	49	36	34	28	20:	20:
21:	28	14	19	32	40	42	39	53	36	46	27	21:	21:
22:	28	13	11	37	40	41	39	54	40	45	24	22:	22:
23:	27	14	15	37	49	39	37	40	59	39	38	26	23:
24:	25	15	10	37	43	46	37	44	60	57	31	37	24:
25:	26	15	17	37	43	46	41	48	56	36	35	27	25:
26:	30	15	13	34	40	45	41	49	56	36	35	28	26:
27:	25	15	12	32	40	45	41	48	54	38	34	28	27:
28:	24	15	12	37	39	46	38	42	50	40	34	29	28:
29:	21	11	38	38	47	43	48	48	43	35	26	29:	29:
30:	22	15	33	38	42	40	49	48	47	35	24	30:	30:
31:	23	25	40	40	40	47	47	50	50	50	21	31:	31:
MAX:	38	36	30	49	49	52	49	64	64	52	66	37	MAX:
MIN:	21	13	10	14	17	39	34	42	37	31	31	21	MIN:
Avg:	27	20	16	25	49	44	40	41	52	44	37	29	Avg:
A.F.	1630	1091	952	1489	2988	2622	2465	2538	3069	2721	2192	1798	A.F.:

TOTAL ANNUAL FLOW 25,555 ACRE FEET

OFFICE OF THE WATER MASTER - TRUCKEE RIVER SYSTEM
 Daily Low Record
 NORTH TRUCKEE DR/ at KLEPPE
 LANE
 1977

Mo.: Day	JAN. cfs	FEB. cfs	MAR. cfs	APR. cfs	MAY. cfs	JUN. cfs	JUL. cfs	AUG. cfs	SEP. cfs	OCT. cfs	NOV. cfs	DEC. cfs	Mo.: Day
1:					44:	42:	28:	30:	11:	10:	10:	10:	1:
2:					40:	53:	32:	33:	11:	10:	10:	10:	2:
3:					46.8:	41:	53:	36:	10:	9:	12:	12:	3:
4:					39:	52:	33:	38:	10:	9:	12:	12:	4:
5:					47.0:	45:	31:	36:	10:	10:	10:	10:	5:
6:					35:	40:	29:	34:	10:	10:	10:	10:	6:
7:					37:	24:	27:	33:	10:	9:	12:	12:	7:
8:					39:	24:	30:	31:	11:	10:	10:	10:	8:
9:					72:	27:	30:	30:	10:	10:	10:	10:	9:
10:					34.0:	63:	25:	30:	31:	10:	14:	13:	10:
11:					56:	25:	30:	32:	11:	11:	17:	17:	11:
12:					22.6:	52:	26:	24:	32:	11:	15:	19:	12:
13:					49.0:	52:	29:	28:	31:	11:	12:	13:	13:
14:					49:	49:	24:	29:	24:	10:	11:	13:	14:
15:					49:	26:	27:	12:	13:	13:	13:	13:	15:
16:					45:	26:	26:	9:	11:	13:	13:	13:	16:
17:					46.2:	40:	26:	23:	12:	10:	12:	12:	17:
18:					42:	24:	28:	9:	10:	13:	13:	13:	18:
19:					36.0:	59:	24:	28:	13:	13:	15:	17:	19:
20:					57:	23:	28:	10:	11:	12:	15:	15:	20:
21:					53:	21:	29:	11:	11:	13:	13:	13:	16:
22:					45:	26:	31:	11:	13:	15:	15:	16:	21:
23:					39:	25:	29:	11:	11:	13:	13:	13:	22:
24:					46.9:	39:	23:	28:	11:	11:	11:	11:	24:
25:					25.2:	39:	24:	28:	11:	10:	11:	16:	25:
26:					36.4:	38:	26:	28:	7:	11:	12:	17:	26:
27:					45.0:	38:	24:	33:	9:	13:	12:	12:	27:
28:					52.0:	35:	25:	31:	8:	10:	11:	11:	28:
29:					45.0:	37:	28:	30:	9:	12:	10:	10:	29:
30:					45.0:	45:	28:	32:	9:	12:	10:	10:	30:
31:					29.3:	45.0:	28:	35:	10:	10:	10:	10:	31:
MAX:					36.4:	52.0:	72:	53:	36:	38:	13:	15:	38:
MIN:					22.6:	34.0:	35:	21:	23:	7:	10:	9:	13:
AVG:					25.2:	29.3:	31.7:	45.3:	30:	29:	20:	11:	18:
A.F:					1362.6:	1397.1:	1798.3:	1883.0:	2780.5:	1841:	1780:	1188:	685:

TOTAL ANNUAL FLOW 19,176 ACRE FEET

APPENDIX B
Selected water quality data

T/R-sec	LOCATION	DATE	CONCENTRATION (mg/l)													
			TDS	SO4	NO3	As	Fe	Mn	Ca	Mg	Na	K	C1	HCO3	F	pH
20/20-01	7450 Baldwin	Apr 1986	253	22	4.8	0.012	0.18	0.02	9	3	69	2	15	171	0.22	8.21
20/20-01	7434 Baldwin	Feb 1983	341	56	2.8	0.000	0.27	0.05	25	8	79	4	45	188	0.19	8.04
20/20-01	7475 Baldwin	Sep 1979	352	47	9.8	0.000	0.69	0.04	34	11	60	5	41	176	0.14	7.88
20/20-01	7445 Baldwin	May 1985	378	56	9.9	0.008	0.00	0.00	42	16	51	4	60	161	0.16	7.94
20/20-01	7438 Baldwin	Aug 1981	263	29	14.9	0.010	0.08	0.01	12	4	63	3	19	127	0.30	8.22
20/20-01	7430 Baldwin	Sep 1979	273	40	15.0	0.010	0.53	0.02	11	2	80	3	37	102	0.22	8.24
20/20-01	7495 SS Road	Oct 1978	258	26	10.6	0.005	0.05	0.03	24	9	37	3	21	134	0.22	7.95
20/20-02	7700 PL Road	Oct 1942	955	281	=	=	=	=	152	46	66	=	57	395	=	=
20/20-02	7900 PL Road	Feb 1971	904	276	20.0	=	0.14	=	155	47	69	=	145	270	0.32	7.79
20/20-03	Dsrt Sogs south well	Jun 1963	258	72	=	=	0.10	=	10	5	84	=	17	142	=	7.40
20/20-03	Dsrt Sogs south well	Feb 1964	195	34	=	=	0.18	=	9	3	65	=	14	148	=	7.50
20/20-03	Dsrt Sogs south well	Mar 1979	347	27	6.7	0.005	0.32	0.03	10	2	62	3	10	134	0.70	7.85
20/20-03	Dsrt Sogs south well	Oct 1974	240	16	14.7	0.005	0.04	0.01	31	11	26	4	9	168	0.12	7.81
20/20-03	8000 PL Road	Jul 1976	278	29	18.5	0.000	0.01	0.00	33	8	43	3	20	171	0.20	7.89
20/20-10	7000 PL Road	Sep 1986	145	13	5.5	0.003	1.22	0.01	8	3	34	5	7	85	0.19	8.72
20/20-12	6360 SS Road	Jul 1982	371	54	5.1	0.005	0.05	0.00	27	8	81	4	45	166	0.18	8.20
20/20-12	7755 SS Road	May 1983	2132	990	0.1	0.180	0.40	0.10	14	3	780	2	11	503	0.60	8.50
20/20-21	Sprrg Ck test hole	May 1983	2418	1200	0.7	0.220	=	=	=	=	=	=	=	=	=	8.58
20/20-21	Sprrg Ck test hole	Jun 1983	2100	1130	=	0.270	=	=	=	=	=	=	=	=	=	=
20/20-21	Sprrg Ck test hole	Oct 1983	842	330	0.1	0.005	0.07	0.02	17	4	290	2	67	230	0.40	7.90
20/20-21	Sprrg Ck south well	Feb 1986	841	324	0.0	0.003	0.04	0.01	21	4	264	1	70	276	0.44	8.24
20/20-21	Sprrg Ck south well	Feb 1987	857	334	0.0	0.005	0.09	0.02	23	5	281	1	75	276	0.38	8.15
20/20-21	Sprrg Ck south well	Sep 1987	894	334	0.0	0.006	0.04	0.02	25	5	269	1	83	278	0.38	7.93
20/20-21	Sprrg Ck north well	Oct 1984	824	288	7.0	0.010	0.22	0.05	73	12	105	5	84	378	0.38	8.31
20/20-21	Oasis Mobile	Jul 1964	717	144	15.0	=	0.03	=	16	1	277	=	32	537	0.55	8.60
20/20-21	Oasis Mobile	Feb 1965	740	336	7.5	=	0.23	=	78	15	133	=	50	146	0.30	7.00
20/20-21	Oasis Mobile	Feb 1965	870	480	7.3	=	0.64	=	96	20	172	=	49	151	0.20	7.40
20/20-21	Oasis Mobile	Feb 1971	873	398	7.6	=	0.19	=	99	21	141	=	58	173	0.28	7.71
20/20-21	Oasis Mobile	May 1971	857	370	10.4	=	0.09	=	99	17	129	=	46	167	0.35	7.57
20/20-21	Oasis Mobile	May 1971	845	378	11.2	=	0.06	=	96	18	139	=	49	173	0.33	7.56
20/20-21	Oasis Mobile	Jun 1980	924	392	9.4	0.000	0.01	0.01	100	19	150	2	77	163	0.15	7.79

T/R-sec	LOCATION	DATE	CONCENTRATION (mg/l)													
			TDS	SO4	N03	As	Fe	Mn	Ca	Mg	Na	K	C1	HCO3	F	pH
20/20-21	Oasis Mobile	Sep 1984	912	372	15.3	0.000	0.00	0.01	108	21	153	2	82	183	0.22	8.03
20/20-21	Blue Gem Tp	Aug 1977	788	412	7.8	0.000	0.18	0.00	108	16	98	2	45	61	0.18	7.79
20/20-21	Blue Gem Tp	Jan 1979	807	426	5.8	0.005	0.11	0.01	108	14	110	2	39	63	0.23	7.97
20/20-21	Briar Hollow	Oct 1979	2054	1306	2.0	0.015	0.19	0.02	288	73	175	5	23	105	0.20	7.31
20/20-22	2770 SS Road	Jul 1970	516	92	26.0	=	=	=	72	21	41	=	50	207	0.22	7.90
20/20-23	2780 SS Road	Aug 1960	364	110	42.5	=	=	=	55	13	77	=	27	205	=	7.72
20/20-23	5020 SS Road	Aug 1972	515	71	73.0	0.035	0.04	=	72	14	66	=	90	146	0.11	7.89
20/20-27	1905 SS Road	Jul 1977	1161	635	3.0	0.000	0.06	0.00	132	43	145	3	13	129	0.56	7.12
20/20-27	1975 SS Road	Apr 1967	688	360	6.0	=	0.52	=	67	29	95	=	18	110	=	6.82
20/20-27	2011 SS Road	Nov 1977	470	254	5.8	0.000	2.12	0.13	20	9	82	6	15	10	0.16	5.64
20/20-27	2120 SS Road	Mar 1967	775	312	2.0	=	20.00	=	58	38	56	=	2	142	=	6.78
20/20-27	2371 SS Road	Oct 1982	445	226	0.2	0.000	41.63	0.77	30	15	63	6	7	68	0.10	6.36
20/20-27	2550 SS Road	Dec 1976	1953	750	72.2	0.000	0.02	0.00	190	74	319	2	275	354	0.47	8.22
20/20-27	2710 SS Road	Apr 1975	1145	422	52.0	0.000	0.06	0.02	120	50	174	4	76	334	0.41	7.61
20/20-27	3140 SS Road	Nov 1960	1237	936	=	=	=	=	259	10	176	=	14	93	=	6.60
20/20-27	7355 Shadow Ln	Oct 1981	793	356	11.7	0.000	0.12	0.01	61	31	136	3	16	198	0.44	7.18
20/20-27	7450 Shadow Ln	Dec 1978	1212	647	4.1	0.000	1.05	0.02	91	54	220	6	47	207	0.75	7.61
20/20-27	7600 Shadow Ln	Mar 1982	1201	616	1.8	0.002	0.04	0.00	1	1	392	3	25	183	2.86	7.77
20/20-27	7645 Shadow Ln	Oct 1985	2468	1513	7.7	=	63.45	3.72	226	64	189	10	32	0	0.54	3.75
20/20-27	7385 Shadow Ln	Apr 1982	919	436	11.5	0.000	1.34	0.03	71	29	130	6	36	139	0.33	7.44
20/20-27	7427 Shadow Ln	Nov 1976	1856	1013	2.0	0.000	0.75	0.04	142	68	320	7	41	198	1.70	7.88
20/20-27	7495 Shadow Ln	Jul 1978	2232	1385	4.9	0.000	0.92	0.00	7	9	717	3	36	195	2.67	7.70
20/20-27	7560 Shadow Ln	Aug 1972	2029	1020	2.4	0.010	0.67	=	183	86	245	=	50	258	1.90	7.89
20/20-27	7405 Shadow Ln	Apr 1977	726	412	5.2	0.000	4.49	0.37	74	19	68	9	23	0	0.25	4.46
20/20-27	2115 Shadow Ln	Dec 1979	1193	678	4.1	0.000	2.65	0.56	119	58	159	9	40	156	0.61	7.01
20/21-06	Ontryside south well	Apr 1986	906	424	11.9	0.000	0.99	0.24	82	29	135	7	44	161	0.48	6.67
20/21-06	Ontryside north well	Nov 1983	178	14	8.5	0.005	0.11	0.02	10	5	36	2	10	126	0.20	8.00
20/21-07	=====	May 1978	135	16	6.6	0.000	0.40	0.02	5	2	43	4	9	78	0.31	8.35

T/R-sec	LOCATION	DATE	CONCENTRATION (mg/l)										pH			
			TDS	SO4	NO3	As	Fe	Mn	Ca	Mg	Na	K	Cl			
20/21-07	=====	Aug 1981	137	13	8.1	0.000	0.05	0.00	7	3	35	6	4	71	0.21	8.40
20/21-07	*Big Well*	May 1984	164	14	7.7	0.005	0.01	0.00	8	4	35	6	8	95	0.20	8.35
20/21-18	6300 SS Rd	Aug 1979	403	41	15.6	0.000	0.00	0.00	57	38	21	2	28	281	0.22	7.77
21/20-24	430 Calle/Plata	Apr 1984	229	26	8.7	0.005	0.00	0.01	37	11	24	3	15	161	0.28	7.74
21/20-24	440 Calle/Plata	Dec 1978	258	20	12.4	0.005	0.79	0.26	25	9	20	3	19	110	0.18	8.08
21/20-25	399 Calle Limpio	Aug 1985	243	16	14.6	0.008	0.16	0.02	33	11	26	3	12	171	0.10	8.05
21/20-26	Sky Ranch SS1	Apr 1964	229	30	=	=	=	=	39	16	10	=	24	146	0.15	7.62
21/20-26	Sky Ranch SS1	Oct 1976	298	32	24.1	0.005	0.09	0.01	41	16	18	4	26	137	0.04	7.82
21/20-34	Desrt Spgs north well	Nov 1979	410	76	16.8	0.010	0.05	0.00	29	7	83	5	42	159	0.62	7.81
21/20-34	Desrt Spgs north well	Dec 1979	413	75	16.7	0.015	0.00	0.02	30	7	84	5	45	159	0.64	7.95
21/20-34	Desrt Spgs north well	Oct 1981	430	73	22.2	0.010	0.01	0.00	36	8	83	4	58	154	0.62	8.02
21/20-34	Desrt Spgs north well	May 1982	437	71	28.0	0.010	0.00	0.00	38	8	83	4	67	163	0.59	8.01
21/20-35	Sky Ranch SS3	Nov 1978	285	32	35.0	0.000	0.05	0.00	42	0	25	4	23	159	0.40	7.70
21/20-35	Sky Ranch SS3	Jul 1986	305	52	26.0	0.008	0.08	0.02	38	13	23	4	25	129	0.10	7.60
21/20-35	Sky Ranch SS6	Dec 1977	371	57	8.9	0.005	0.06	0.00	49	19	41	5	20	212	0.14	8.29
21/20-35	Sky Ranch SS6	Nov 1978	409	63	4.0	0.005	0.10	0.00	58	21	38	5	24	246	0.12	7.55
21/20-35	Sky Ranch SS6	Nov 1981	372	56	8.5	0.005	0.16	0.01	53	18	37	5	18	244	0.12	8.19
21/20-35	Sky Ranch SS6	May 1983	389	52	8.2	0.005	0.01	0.00	51	18	37	5	19	254	0.10	7.91
21/20-35	Sky Ranch SS6	Aug 1986	402	58	10.1	0.007	0.02	0.02	55	19	41	6	31	=	0.10	=
21/20-35	SPPCo. hole #18	Mar 1979	440	87	17.1	0.005	0.00	0.01	53	14	60	5	55	159	0.38	7.88
21/20-35	SPPCo. hole #19	Apr 1964	660	255	=	=	1.00	0.01	6	1	218	=	112	83	2.80	7.73
21/21-01	400 Descanso	Nov 1982	395	161	0.7	0.055	0.19	0.01	51	19	27	7	17	112	0.22	7.57
21/21-07	3090 Barranca	May 1985	279	11	0.0	0.006	0.08	0.01	2	0	111	1	3	224	0.28	8.72
21/21-09	724 Encanto	Feb 1979	289	38	0.2	0.005	1.09	0.04	4	0	110	2	22	171	0.26	8.66
21/21-17	2955 Los Arboles	Jan 1980	295	88	3.1	0.000	2.44	0.06	9	5	101	3	42	115	0.22	8.47
21/21-19	545 Capistrano	Jul 1980	188	27	9.7	0.000	0.05	0.03	29	6	12	3	11	105	0.16	7.88
21/21-19	535 Calle Bonito	Mar 1986	448	160	4.0	0.008	0.07	0.02	89	13	27	5	30	151	0.15	7.75
21/21-19	565 Calle Bonito	Mar 1986	515	201	2.3	0.006	0.52	0.15	103	14	30	5	35	156	0.15	7.68
21/21-19	585 Calle/Plata	Jan 1985	452	173	0.2	0.005	1.45	0.07	75	3	60	2	25	139	0.23	7.80
21/21-19	585 Que Pasa Ct	Feb 1985	1014	500	0.1	0.027	4.50	1.19	146	63	47	10	12	254	0.19	7.51
21/21-19	580 Que Pasa Ct	Feb 1985	463	150	0.1	0.009	0.59	0.14	91	16	37	6	25	229	0.25	7.66

T/R-sec	LOCATION	DATE	CONCENTRATION (mg/l)													
			TDS	SO4	NO3	As	Fe	Mn	Ca	Mg	Na	K	Cl	HCO3	F	pH
21/21-19	601 Calle/Plata	Oct 1984	959	473	0.1	0.005	0.49	0.08	184	28	52	8	40	183	0.16	7.57
21/21-20	605 Calle/Plata	Oct 1979	659	240	1.5	0.010	3.16	0.13	123	16	59	8	54	234	0.21	7.34
21/21-20	645 Valley Verdi	Nov 1979	182	21	0.4	0.005	0.16	0.00	3	1	60	0	16	83	0.14	8.73

APPENDIX C

**Historical water-level data
(feet below land surface)**

1	2	3	4
20/20 21 BDDA	20/20 21 AABC	20/20 21 AAAC	20/20 10 CDAB
field across trailer park	Blue Gem Trailer Park	Spring Creek North Well	Hereford Ranch
LS Elev: 4538.8	LS Elev: 4539.9.	LS Elev: -----	LS Elev: 4495.7
07/24/79 -92.74	07/24/79 -92.03	09/10/86 -27.08	06/12/80 -26.54
04/16/80 -89.98	04/16/80 -90.86	10/03/86 -25.19	07/17/80 -25.86
06/12/80 -91.38	06/12/80 -93.02	11/17/86 -24.34	08/12/80 -25.66
07/17/80 -92.41	07/17/80 -93.47	12/19/86 -23.44	09/20/80 -25.19
08/11/80 -93.14	08/12/80 -94.43	01/28/87 -24.84	10/17/80 -25.47
09/20/80 -91.68	09/23/80 -93.21	03/11/87 -25.28	11/18/80 -26.18
10/17/80 -92.47	10/21/80 -92.77	04/22/87 -28.20	12/16/80 -26.84
11/18/80 -90.05	11/18/80 -91.98	07/10/87 -32.10	01/19/81 -27.40
12/16/80 -89.64	12/16/80 -91.66	08/14/87 -31.94	02/19/81 -28.04
01/19/81 -89.54	01/19/81 -90.80	09/20/87 -32.42	03/18/81 -28.49
02/19/81 -89.62	02/19/81 -91.47	10/19/87 -31.18	04/21/81 -28.97
03/18/81 -89.94	03/18/81 -92.83	11/19/87 -29.22	05/20/81 -28.49
04/21/81 -91.33	04/21/81 -93.45	12/21/87 -28.72	06/23/81 -27.50
05/20/81 -92.59	05/20/81 -94.35	02/09/88 -28.64	04/13/82 -29.58
06/23/81 -94.90	06/23/81 -97.09		04/25/83 -28.97
04/13/82 -92.10	04/13/82 -94.10		05/02/84 -30.08
04/20/83 -92.80	06/18/84 -97.74		06/18/84 -28.84
05/02/84 -91.70	02/22/85 -95.39		02/22/85 -29.60
06/18/84 -95.87	03/13/86 -97.83		04/04/85 -30.10
02/22/85 -93.43	07/02/86 -104.21		03/12/86 -29.45
04/04/85 -93.60	03/03/87 -99.39		07/02/86 -29.55
03/12/86 -95.79	10/19/87 -105.53		03/03/87 -29.88
07/02/86 -101.26			10/19/87 -29.09
08/04/86 -102.42			
09/10/86 -103.31			
10/03/86 -101.54			
11/17/86 -103.98			
12/19/86 -98.44			
01/28/87 -101.83			
03/03/87 -97.68			
03/11/87 -97.53			
04/22/87 -99.73			
06/06/87 -101.45			
07/10/87 -103.74			
08/14/87 -107.33			
09/20/87 -106.43			
10/19/87 -107.65			
11/19/87 -104.82			
12/21/87 -103.88			
02/09/88 -104.72			

5

6

7

20/20 10 DBBC-1

20/20 11 BDDA

20/20 03 BCDC

Hereford Ranch

Gaspari

=====

LS Elev: -----

LS Elev: 4462.7

LS Elev: 4595.8

06/12/80	-20.53	04/02/64	-2.20	02/24/64	-100.60	10/03/86
07/17/80	-20.24	04/08/64	-2.30	02/28/64	-100.70	11/17/86
08/12/80	-19.61	04/10/64	-2.49	03/18/64	-101.10	12/19/86
09/20/80	-19.01	04/13/64	-2.64	03/31/64	-101.40	01/28/87
10/17/80	-19.76	04/16/64	-2.70	04/30/64	-101.50	03/03/87
11/18/80	-20.31	04/30/64	-2.57	05/29/64	-101.70	03/11/87
12/16/80	-20.78	05/29/64	-1.58	07/01/64	-100.80	04/22/87
01/19/81	-21.29	07/01/64	-3.16	07/31/64	-100.90	06/06/87
02/19/81	-21.62	07/31/64	-4.73	08/31/64	-101.10	07/10/87
03/18/81	-21.99	08/31/64	-5.27	09/29/64	-101.50	08/14/87
04/21/81	-22.13	09/29/64	-3.12	10/30/64	-101.60	09/20/87
05/20/81	-21.47	10/31/64	-2.06	11/28/64	-101.70	10/19/87
06/23/81	-20.82	11/28/64	-2.05	01/05/65	-101.70	11/19/87
04/13/82	-22.85	01/05/65	-1.25	01/29/65	-101.70	12/21/87
04/20/83	-32.70	01/29/65	-1.40	02/26/65	-101.90	02/09/88
05/02/84	-22.90	02/26/65	-2.10	03/30/65	-102.10	
06/18/84	-21.70	03/30/65	-2.33	04/28/65	-102.30	
02/18/85	-22.35	04/28/65	-2.03	05/28/65	-102.30	
04/04/85	-23.01	06/30/65	-2.55	06/30/65	-102.30	
03/12/86	-21.92	07/30/65	-4.18	07/30/65	-102.30	
07/02/86	-22.64	07/12/79	-3.23	07/11/79	-103.06	
09/10/86	-25.44	04/16/80	-2.07	04/11/80	-101.45	
10/03/86	-21.54	06/12/80	-1.72	06/12/80	-100.85	
11/17/86	-21.54	07/17/80	-2.73	07/17/80	-100.14	
12/19/86	-22.04	08/11/80	-3.63	08/12/80	-99.58	
01/28/87	-22.48	09/20/80	-2.74	09/23/80	-98.84	
03/03/87	-22.79	10/17/80	-1.86	10/21/80	-98.18	
03/11/87	-22.80	11/18/80	-1.80	11/18/80	-97.91	
04/22/87	-23.21	12/16/80	-1.60	12/16/80	-97.20	
06/06/87	-22.74	01/19/81	-1.60	01/19/81	-96.53	
07/10/87	-22.84	02/19/81	-0.96	02/19/81	-95.89	
08/14/87	-23.18	03/18/81	-1.43	03/18/81	-95.74	
09/20/87	-22.72	04/21/81	-1.30	04/21/81	-95.64	
10/19/87	-22.70	05/20/81	-1.47	05/20/81	-95.44	
11/19/87	-23.16	06/23/81	-2.24	06/23/81	-95.54	
12/21/87	-23.47	04/13/82	-1.36	04/13/82	-89.62	
02/09/88	-27.01	04/20/83	-1.80	04/20/83	-67.67	
		05/02/84	-1.08	05/02/84	-75.70	
		06/15/84	-1.23	06/18/84	-76.22	
		04/04/85	-1.03	04/04/85	-79.20	
		03/13/86	-0.64	03/13/86	-83.82	
		07/02/86	-2.35	07/02/86	-73.74	
		03/03/87	-1.21	08/04/86	-73.52	
		10/20/87	-3.30	09/10/86	-72.60	

8

9

10

20/20 03 DBAC

20/20 01 CBAB

20/20 01 CACA

Dsrt Sprgs
South well

7475 Baldwin

7430 Baldwin

LS Elev: 4528.0

LS Elev: 4483.7

LS Elev: -----

02/24/64	-57.20	01/28/87	-56.06	07/18/79	-12.07	07/18/79	-13.72
03/19/64	-57.50	03/03/87	-55.92	04/10/80	-10.46	04/10/80	-12.74
03/31/64	-58.50	07/10/87	-56.14	06/11/80	-9.78	06/11/80	-12.71
05/29/64	-57.10	10/20/87	-61.32	07/18/80	-10.87	07/18/80	-22.84
07/01/64	-56.80	11/19/87	-64.28	08/11/80	-10.87	08/11/80	-16.89
07/31/64	-56.70	12/21/87	-61.08	09/23/80	-10.51	08/12/80	-13.08
08/31/64	-56.50	02/09/88	-58.95	10/17/80	-10.31	09/23/80	-13.25
09/29/64	-56.50			11/20/80	-10.78	10/17/80	-13.39
10/30/64	-56.40			12/17/80	-11.08	11/20/80	-13.42
11/28/64	-56.60			01/20/81	-11.35	12/17/80	-13.41
01/05/65	-56.70			02/21/81	-11.61	01/20/81	-13.50
01/29/65	-56.80			03/18/81	-11.74	02/21/81	-13.66
02/26/65	-57.10			04/21/81	-12.10	03/18/81	-13.49
03/30/65	-57.20			05/20/81	-11.99	04/21/81	-13.59
04/28/65	-57.20			06/23/81	-11.88	05/20/81	-13.60
05/28/65	-56.90			04/13/82	-11.94	06/23/81	-15.59
06/30/65	-56.60			04/20/83	-11.27	04/13/82	-13.30
07/30/65	-56.40			05/02/84	-9.55	04/20/83	-12.48
07/12/79	-59.25			06/15/84	-10.17	05/02/84	-12.72
04/16/80	-58.69			04/04/85	-11.34	06/15/84	-14.68
06/12/80	-55.89			03/13/86	-7.99	04/04/85	-13.07
07/17/80	-56.20			07/02/86	-9.97	03/13/86	-11.74
08/12/80	-57.38			03/03/87	-11.33	07/02/86	-12.11
09/23/80	-55.32					03/03/87	-12.78
10/21/80	-57.04						
11/18/80	-54.90						
12/16/80	-54.95						
01/19/81	-55.13						
02/19/81	-55.29						
03/18/81	-55.49						
04/21/81	-55.63						
05/20/81	-55.56						
06/23/81	-61.58						
06/18/84	-55.80						
03/26/86	-55.24						
07/02/86	-55.37						
08/04/86	-55.57						
09/10/86	-55.58						
10/03/86	-55.35						
11/17/86	-55.34						
12/19/86	-56.79						

11	12	13	14
21/20 34 0000-1	21/20 34 0000-2	21/20 35 00BC	21/20 35 ADAA
Dsrt Sprgs North Well	SPPCo. test hole #18	Sky Ranch SS6	Sky Ranch SS3
LS Elev: 4493.1	LS Elev: -----	LS Elev: 4501.1	LS Elev: 4522.0
06/11/80 -23.30	09/10/86 -29.02	07/16/79 -29.91	07/17/79 -52.39
07/17/80 -23.30	10/03/86 -26.90	04/10/80 -29.11	04/10/80 -51.80
08/18/80 -24.15	11/17/86 -24.51	06/11/80 -28.96	06/12/80 -56.21
10/21/80 -24.14	12/19/86 -27.16	07/18/80 -28.88	07/18/80 -52.14
11/20/80 -24.35	01/28/87 -24.57	08/12/80 -28.69	08/12/80 -51.95
12/16/80 -24.21	03/11/87 -24.85	09/23/80 -28.52	09/23/80 -52.60
01/19/81 -24.33	04/22/87 -26.78	10/17/80 -28.56	10/17/80 -51.93
02/19/81 -24.44	08/14/87 -31.30	11/18/80 -28.29	11/18/80 -51.75
03/19/81 -24.56	10/19/87 -25.75	12/17/80 -28.69	12/17/80 -51.60
04/21/81 -25.87	11/19/87 -24.93	01/19/81 -28.89	01/19/81 -51.50
05/20/81 -26.44	12/21/87 -25.05	02/19/81 -28.95	02/19/81 -56.29
06/23/81 -25.50	02/09/88 -25.37	03/19/81 -29.21	03/18/81 -59.47
03/26/86 -26.11		04/21/81 -29.46	04/21/81 -51.70
07/02/86 -32.31		05/20/81 -29.51	05/20/81 -52.32
		06/23/81 -29.90	06/23/81 -54.50
		04/14/82 -29.95	04/14/82 -50.89
		11/17/86 -31.89	03/26/86 -52.55
		12/19/86 -31.41	08/04/86 -53.70
		01/28/87 -30.86	10/03/86 -53.16
		03/11/87 -31.17	11/17/86 -52.62
		04/22/87 -34.20	12/19/86 -52.45
		06/06/87 -36.45	01/28/87 -52.27
		07/10/87 -37.35	03/03/87 -52.07
		08/14/87 -39.51	03/11/87 -52.06
			04/22/87 -52.07
			06/06/87 -52.36
			07/10/87 -52.56
			08/14/87 -52.75
			10/19/87 -54.61

15

16

17

21/20 26 DDCC

21/20 24 BCBA

21/20 24 ACDB

Sky Ranch SS1

Donovan
irrigationDonovan
domestic

LS Elev: 4531.1

LS Elev: 4554.0

LS Elev: 4655.8

04/02/64	-63.30	08/04/86	-64.18	07/25/79	-99.70	07/25/79	-196.8
04/08/64	-63.20	09/10/86	-64.39	01/31/80	-95.98	06/02/80	-195.4
04/13/64	-63.30	10/03/86	-64.43	04/16/80	-95.62	07/17/80	-196.7
04/14/64	-63.20	11/17/86	-64.31	06/02/80	-95.51	08/12/80	-195.8
04/16/64	-63.30	12/19/86	-64.43	07/17/80	-95.81	09/23/80	-195.9
04/30/64	-63.50	01/28/87	-64.36	08/11/80	-96.21	10/21/80	-195.7
05/29/64	-63.40	03/03/87	-64.32	09/20/80	-95.78	11/20/80	-196.9
07/01/64	-63.40	03/11/87	-64.27	10/21/80	-95.64	12/16/80	-195.6
07/31/64	-63.30	04/22/87	-64.17	11/20/80	-95.59	01/19/81	-194.6
08/31/64	-63.20	06/06/87	-64.11	12/16/80	-95.43	02/19/81	-194.5
09/29/64	-63.80	07/10/87	-64.13	01/19/81	-95.39	03/18/81	-193.7
10/30/64	-63.50	08/14/87	-64.05	02/19/81	-95.20	04/21/81	-198.6
11/28/64	-63.50	10/19/87	-65.01	03/18/81	-95.23	05/20/81	-197.2
01/05/65	-63.20	11/19/87	-64.95	04/21/81	-95.38	06/23/81	-196.1
01/29/65	-63.30	12/21/87	-65.36	05/20/81	-95.67	04/14/82	-195.5
02/26/65	-63.20	02/09/88	-64.61	06/23/81	-96.29	04/20/83	-170.0
03/30/65	-63.20			04/13/82	-95.40	05/02/84	-168.9
04/28/65	-63.20			04/20/83	-95.18	03/14/86	-197.0
05/28/65	-63.30			05/02/84	-96.79	07/02/86	-190.0
06/30/65	-63.20			04/04/85	-100.17	03/17/87	-198.3
07/30/65	-63.20			03/13/86	-95.20	11/19/87	-198.3
07/13/79	-63.83			07/02/86	-97.36		
04/10/80	-64.08			08/04/86	-97.86		
06/11/80	-63.57			09/10/86	-97.23		
07/17/80	-63.37			10/03/86	-96.69		
08/11/80	-63.35			11/17/86	-100.30		
09/23/80	-64.45			12/19/86	-103.01		
10/17/80	-63.86			01/28/87	-95.79		
11/18/80	-63.46			03/03/87	-95.66		
12/16/80	-63.29			03/11/87	-95.64		
01/19/81	-63.26			04/22/87	-102.77		
02/19/81	-63.10			06/06/87	-97.84		
03/18/81	-63.09			07/10/87	-97.52		
04/21/81	-69.06			08/14/87	-101.88		
05/20/81	-63.10			10/19/87	-97.36		
06/23/81	-64.95			11/19/87	-96.96		
04/13/82	-63.11			12/21/87	-96.51		
04/20/83	-63.17			02/09/88	-96.30		
05/02/84	-64.70						
04/04/85	-64.70						
03/13/86	-64.15						
07/02/86	-64.19						

18

19

20

21

21/20 12 DACD

21/21 30 CAAA

21/21 31 CACA

20/21 06 BABC

440 Alamosa

2440 Los Pinos

2245 Cielo Vista

Countryside

LS Elev: -----

LS Elev: -----

LS Elev: -----

LS Elev: -----

07/03/79 -340.36

07/16/79 -210.24

07/17/79 -132.80

06/06/87 -69.52

01/31/80 -340.72

01/31/80 -212.88

04/10/80 -133.75

07/10/87 -69.22

03/19/80 -340.63

03/19/80 -210.46

06/11/80 -133.67

08/14/87 -69.03

06/11/80 -340.58

06/12/80 -211.30

07/16/80 -135.57

10/19/87 -69.67

07/17/80 -340.58

07/17/80 -211.20

08/12/80 -135.13

11/19/87 -69.58

08/11/80 -340.50

08/12/80 -210.10

09/23/80 -135.55

12/21/87 -69.50

09/20/80 -340.53

09/23/80 -210.30

10/17/80 -135.94

02/09/88 -69.51

10/21/80 -340.58

10/21/80 -210.30

11/20/80 -134.81

11/20/80 -340.75

04/13/82 -211.16

12/17/80 -134.22

12/16/80 -340.49

03/03/87 -210.62

01/19/81 -133.55

01/19/81 -340.62

02/19/81 -133.74

02/19/81 -340.44

03/18/81 -133.63

03/18/81 -340.53

04/21/81 -133.72

04/21/81 -340.68

05/20/81 -133.56

05/20/81 -340.56

06/23/81 -133.59

06/23/81 -341.25

04/13/82 -133.22

04/13/82 -340.82

04/20/83 -132.64

11/11/82 -340.50

05/02/84 -133.61

04/20/83 -340.86

04/03/85 -132.49

05/02/84 -342.85

03/14/86 -132.27

04/04/85 -341.12

07/02/86 -132.67

03/13/86 -344.72

03/03/87 -135.64

07/02/86 -341.29

10/19/87 -135.30

08/04/86 -341.24

09/10/86 -341.13

10/03/86 -341.40

11/17/86 -341.17

12/19/86 -341.16

01/28/87 -341.15

03/03/87 -341.48

03/11/87 -341.17

04/22/87 -341.22

06/06/87 -341.18

07/10/87 -341.23

08/14/87 -341.09

10/19/87 -341.65

11/19/87 -341.75

12/21/87 -341.80

02/09/88 -341.85

22	23	24	25
20/21 07 BCBA	20/21 07 CBCB	20/21 07 CCCC	20/21 18 DABD
=====	=====	"Big Well"	Bailey north well
LS Elev: 4501.0	LS Elev: -----	LS Elev: 4508.1	LS Elev: 4516.1
07/24/79 -28.82	07/23/79 -5.62	07/18/79 -26.42	07/23/79 -36.99
04/11/80 -28.71	06/11/80 -5.75	04/11/80 -26.85	04/11/80 -35.45
06/11/80 -28.33	07/18/80 -5.91	06/11/80 -26.95	06/11/80 -35.31
07/18/80 -28.20	08/11/80 -5.71	07/18/80 -27.08	07/18/80 -35.28
08/11/80 -28.17	09/20/80 -5.67	08/11/80 -26.93	08/11/80 -35.25
09/20/80 -28.04	10/17/80 -5.67	09/20/80 -26.87	09/20/80 -35.17
10/17/80 -28.20	11/20/80 -5.57	10/17/80 -25.89	10/17/80 -35.27
11/20/80 -28.08	12/17/80 -5.46	11/20/80 -26.79	11/20/80 -35.14
12/17/80 -27.96	01/20/81 -5.46	12/17/80 -26.68	12/17/80 -35.02
01/20/81 -28.01	02/21/81 -5.57	01/20/81 -26.61	01/20/81 -35.02
02/21/81 -28.22	03/19/81 -5.29	02/21/81 -26.70	02/21/81 -35.06
03/19/81 -27.86	04/22/81 -5.42	03/19/81 -26.42	03/19/81 -34.88
04/22/81 -28.13	05/20/81 -5.29	04/22/81 -26.62	04/22/81 -34.96
05/20/81 -28.03	06/23/81 -5.28	05/20/81 -26.45	05/20/81 -34.93
06/23/81 -28.01	04/13/82 -5.24	06/23/81 -28.51	06/23/81 -35.04
04/13/82 -28.05	05/04/83 -4.99	04/13/82 -26.45	05/04/83 -34.01
05/04/83 -27.62	05/02/84 -5.80	06/15/84 -25.93	05/02/84 -33.71
05/02/84 -27.69	06/15/84 -4.99	04/04/85 -25.74	06/15/84 -34.46
06/15/84 -27.29	04/04/85 -4.70	03/14/86 -25.78	04/04/85 -34.44
04/04/85 -27.25	03/26/86 -5.06	07/03/86 -26.20	03/14/86 -35.01
03/26/86 -27.26	07/03/86 -5.34	08/04/86 -26.19	07/03/86 -32.18
07/03/86 -26.49	08/04/86 -5.30	09/10/86 -26.20	08/04/86 -31.96
08/04/86 -27.16	09/10/86 -5.28	10/03/86 -26.13	09/10/86 -32.08
09/10/86 -26.69	10/03/86 -5.17	11/17/86 -25.83	10/03/86 -32.13
10/03/86 -26.82	11/17/86 -4.96	12/19/86 -25.81	11/17/86 -32.10
11/17/86 -26.65	12/19/86 -5.82	01/28/87 -25.70	12/19/86 -32.07
12/19/86 -26.55	01/28/87 -4.86	03/04/87 -26.13	03/04/87 -32.87
01/28/87 -27.34	03/04/87 -4.06	03/11/87 -25.78	10/20/87 -32.91
03/04/87 -26.67	03/11/87 -4.91	04/22/87 -25.99	
03/11/87 -28.20	04/22/87 -5.07	06/06/87 -26.12	
04/22/87 -27.68	06/06/87 -5.20	07/10/87 -26.03	
06/06/87 -26.70	07/10/87 -5.16	08/14/87 -25.92	
07/10/87 ===	08/14/87 -5.08	10/19/87 -25.92	
08/14/87 -26.60	10/19/87 -5.05	11/19/87 -25.93	
10/19/87 -26.76	11/19/87 -5.11	12/21/87 -25.98	
11/19/87 -26.90	12/21/87 -5.04	02/09/88 -25.85	
12/21/87 -26.91	02/09/88 -5.07		
02/09/88 -26.82			

20/21 18 DDBA

Bailey
south well

LS Elev: -----

07/23/79	-44.73
04/11/80	-42.49
06/11/80	-42.49
07/18/80	-42.92
08/11/80	-42.63
09/20/80	-42.46
10/17/80	-42.69
11/20/80	-42.23
12/17/80	-42.08
01/20/81	-42.30
02/21/81	-42.37
03/19/81	-42.01
04/22/81	-42.18
05/20/81	-42.24
06/23/81	-42.50
05/04/83	-41.55
05/02/84	-41.60
05/15/84	-40.03
06/15/84	-41.04
04/04/85	-41.47
03/14/86	-44.59
07/03/86	-43.82
08/04/86	-43.49
09/10/86	-43.39
10/03/86	-43.13
11/17/86	-42.52
12/19/86	-43.39
01/28/87	-41.97
03/04/87	-41.67
03/11/87	-42.97
04/22/87	-42.58
08/14/87	-41.98
10/20/87	-42.11
11/19/87	-42.39
12/21/87	-42.22
02/09/88	-42.44

APPENDIX D
TRIAG groundwater flow model

PROGRAM TRIAG

```

C
C   FINITE ELEMENT MODEL TO SIMULATE SURFACE AND
C   GROUNDWATER HYDROLOGY MODIFIED FROM THE USGS 3D MODEL
C   WRITTEN BY: Timothy J. Durbin (1985)
C   MODIFIED FOR MS-DOS COMPUTERS UNDER FORTRAN 77
C   VERSION 1.1 (7/16/86) -- 80 COLUMN PRINTERS
C   Copyright By : Donald A. Mahin      NOVEMBER 6, 1985
C

COMMON /BIG3/WLC,H,HL,K,S,C,Q,CCHRH,CETLH,F,RHSV,THK,
1 HLIT,XE,YE,AE,BE,D,E,NTS,NND
REAL PARAMX(50),WLC(325),H(250),HL(250),
1 XE(3),YE(3),AE(3,3),BE(3,3),D(3),E(3),K(325),S(325),
2 C(250),Q(250),CCHRH(250),CCHLH(250),
3 CETRH(250),CETLH(250),F(250),RHSV(250),THK(250),HLIT(250)
INTEGER NTS(325),NND(325),OUT
CHARACTER*64 DATAIN, RESULTS, PLOT
DATA PARAMX /50*1.0/
NWLM=0
INN=5
OUT=6
WRITE(*,89)
89 FORMAT(' TRIAG    2-D FINITE ELEMENT MODEL',//)
C
WRITE(*,99)
99 FORMAT(' What is the name of the DATA file? ',\)
READ(*,100) DATAIN
100 FORMAT(A)
WRITE(*,199)
199 FORMAT(' What is the name of the LONG OUTPUT file? ',\)
READ(*,100) RESULTS
WRITE(*,399)
399 FORMAT(' What is the name of the PLOT file? ',\)
READ(*,100) PLOT
OPEN(INN,FILE=DATAIN,ACCESS='SEQUENTIAL')
OPEN(OUT,FILE=RESULTS,STATUS='NEW',ACCESS='SEQUENTIAL')
OPEN(7,FILE=PLOT,STATUS='NEW',ACCESS='SEQUENTIAL')
REWIND (INN)
WRITE(*,299)
299 FORMAT(/' PROGRAM RUNNING ....',//,
1      ' The program may run for several hours . . . . .',//,
2      ' Wait for the System Prompt: A> B> or C> . . . . .',//)
C
CALL MODELL(PARAMX,INN,OUT)
IOUT=1
CALL MODEL2(PARAMX,INN,OUT,NWLM,IOUT)
CLOSE(INN)
CLOSE(OUT)
CLOSE(7)
STOP
END

```

```

SUBROUTINE MODELL(PARAMX,INN,OUT)
C   SOLUTION OF TWO-DIMENSIONAL GROUND-WATER-FLOW
C       EQUATIONS BY FINITE-ELEMENT METHOD USING
C           LINEAR TRIANGULAR ELEMENTS
C   INPUT VARIABLES
COMMON /MODEL/ IN,X,Y,K0,S0,BASE,H0,
1  DELT,MAXNS,NITER,NN,NE,NB,CLOSE,NPLT,IPLT
INTEGER IN(325,3),NPLT(10)
CHARACTER TITLE(80)
REAL X(250),Y(250),K0(325),S0(325),BASE(250),H0(250)
COMMON /BIG/A
COMMON /BIG1/B
COMMON /BIG2/LHSM
COMMON /BIG3/WLC,H,HL,K,S,C,Q,CCHRH,CETLH,F,RHSV,THK,
1 HLIT,XE,YE,AE,BE,D,E,NTS,NND
C   INTERNAL VARIABLES AND VARIABLES PASSED FROM OTHER SUBROUTINES
REAL PARAMX(50),WLC(325),H(250),HL(250),
1 XE(3),YE(3),AE(3,3),BE(3,3),D(3),E(3),A(250,20),B(250,20),
2 K(325),S(325),C(250),Q(250),CCHRH(250),CCHLH(250),
3 CETRH(250),CETLH(250),LHSM(250,20),
4 F(250),RHSV(250),THK(250),HLIT(250)
REAL NDXDX,NDYDY
INTEGER NTS(325),NND(325),OUT
C   DIMENSIONED FOR MAXIMUM
C       NODES=250
C       ELEMENTS=325
C       HALF-BAND WIDTH=20
C       MEASURED WATER LEVELS=325
C   BEGIN DATA INPUT
C   BASIN NAME
READ(INN,900) (TITLE(I),I=1,80)
WRITE(OUT,901) (TITLE(I),I=1,80)
900 FORMAT(80A1)
901 FORMAT(80A1/80(' -')/)
C   TIME STEP (DAYS),NUMBER OF TIME STEPS,NUMBER OF ET ITERATIONS
READ(INN,902) DELT,MAXNS,NITER,CLOSE
WRITE(OUT,903) DELT,MAXNS,NITER,CLOSE
DELT=DELT*3600.0*24.0
902 FORMAT(F12.0,216,F12.0)
903 FORMAT(//11X,'TIME PARAMETERS'/1H ,10X,15(' -')/1H ,10X,
1   'TIME STEP',21X,F8.1/1H ,10X,'NUMBER OF TIME STEPS',14X,I4/
2   1H ,10X,'NUMBER OF ET ITERATIONS' ,15/
3   1H ,10X,'CLOSURE CRITERION FOR ITERATIONS',F6.3)
C   NUMBER OF NODES AND ELEMENTS
READ(INN,*) IPLT,(NPLT(I),I=1,IPLT)
READ(INN,904) NN,NE
WRITE(OUT,905) NN,NE
904 FORMAT (216)
905 FORMAT(/11X,'FINITE-ELEMENT DATA'/1H ,10X,19(' -')/1H ,10X,
1   'NUMBER OF NODES ',I10/1H ,10X,'NUMBER OF ELEMENTS',I10)
C   NODE COORDINATES (FEET)
READ(INN,906) FACX,FACY
READ(INN,907) (I,X(I),Y(I),N=1,NN)

```

```

DO 100 I=1,NN
X(I)=X(I)*FACX
Y(I)=Y(I)*FACY
100 CONTINUE
WRITE(OUT,908) FACX,FACY
WRITE(OUT,909) (I,X(I),Y(I),I=1,NN)
906 FORMAT(2F12.0)
907 FORMAT(3(I6,2F6.0,6X))
908 FORMAT(//11X,'NODE COORDINATES'/1H ,10X,16('-')/1H ,10X,
1  'FACTOR FOR X',1PE11.3/1H ,10X,'FACTOR FOR Y',1PE11.3/
2  1H ,10X,2('NODE',11X,'X',11X,'Y',5X)/)
909 FORMAT((1H ,10X,2(I4,F12.1,F12.1,5X)))
C ELEMENT INCIDENCES (COUNTER CLOCKWISE)
READ(INN,910) (I,(IN(I,J),J=1,3),N=1,NE)
WRITE(OUT,911)
WRITE(OUT,912) (I,(IN(I,J),J=1,3),I=1,NE)
910 FORMAT(2(4I6,6X))
911 FORMAT(//11X,'ELEMENT INCIDENCES'/1H ,10X,18('-')/1H ,10X,
1  2('ELEM',13X,'CORNERS',9X)/)
912 FORMAT((1H ,10X,2(I4,2X,3I6,9X)))
C FIND HALF-BAND WIDTH
INBMAX=0
DO 102 L=1,NE
IMAX=0
IMIN=325
DO 101 I=1,3
II=IN(L,I)
IMAX=MAX0(IMAX,II)
IMIN=MIN0(IMIN,II)
101 CONTINUE
INB=IMAX-IMIN+1
INBMAX=MAX0(INB,INBMAX)
102 CONTINUE
NB=INBMAX
WRITE(OUT,913) NB
913 FORMAT(/11X,'HALF-BAND WIDTH',I13)
C HYDRAULIC CONDUCTIVITY (FEET PER DAY)
READ(INN,914) FACK
READ(INN,915) (K0(I),I=1,NE)
DO 103 I=1,NE
K0(I)=K0(I)*FACK
103 CONTINUE
WRITE(OUT,917) FACK
WRITE(OUT,918) (I,K0(I),I=1,NE)
DO 104 I=1,NE
K0(I)=K0(I)/(3600.0*24.0)
104 CONTINUE
914 FORMAT(E12.0)
915 FORMAT(10F6.0)
917 FORMAT(//11X,'HYDRAULIC CONDUCTIVITY'/1H ,10X,22('-')/1H ,10X,
1  'FACTOR FOR K',1PE11.3/1H ,10X,
2  2('ELEM',13X,'VALUE',4X)/)
918 FORMAT((1H ,10X,2(I4,9X,F9.1,4X)))

```

```

C      SPECIFIC YIELD DIMENSIONLESS)
READ(INN,919) FACS
READ(INN,920) (S0(I),I=1,NE)
DO 105 I=1,NE
S0(I)=S0(I)*FACS
105 CONTINUE
WRITE(OUT,922) FACS
WRITE(OUT,923) (I,S0(I),I=1,NE)
919 FORMAT(E12.0)
920 FORMAT(10F6.0)
922 FORMAT(//1X,'SPECIFIC YIELD'/1H ,10X,16('-')/1H ,10X,
1   'FACTOR FOR S',1PE11.3/1H ,10X,
2   2('ELEM',13X,'VALUE',4X)/)
923 FORMAT((1H ,10X,2(I4,9X,F9.4,4X)))
C      ALTITUDE FOR BASE OF AQUIFER (FEET)
READ(INN,925) (BASE(I),I=1,NN)
WRITE(OUT,926)
WRITE(OUT,927) (I,BASE(I),I=1,NN)
925 FORMAT(10F6.0)
926 FORMAT(//1X,'BASE OF AQUIFER'/1H ,10X,15('-')/1H ,10X,
1   3('NODE',7X,'VALUE',4X)/)
927 FORMAT((11X,3(I4,3X,F9.1,4X)))
C      INITIAL WATER LEVELS (FEET)
READ(INN,928) (HO(I),I=1,NN)
WRITE(OUT,929)
WRITE(OUT,930) (I,HO(I),I=1,NN)
928 FORMAT(10F6.0)
929 FORMAT(//1X,'INITIAL WATER LEVELS'/1H ,10X,20('-')/1H ,10X,
1   3('NODE',7X,'VALUE',4X)/)
930 FORMAT((11X,3(I4,3X,F9.1,4X)))
C
599  FORMAT(1H ,10I10)
699  FORMAT(1H ,10F10.3)
IF(IPLT.LT.1) GO TO 737
WRITE(7,599) (NPLT(I),I=1,IPLT)
WRITE(7,699) (X(NPLT(I)),I=1,IPLT)
WRITE(7,699) (Y(NPLT(I)),I=1,IPLT)
C      CONSTANT-HEAD NODES, PUMPAGE AND RECHARGE,
C      AND EVAPOTRANSPIRATION
C
737  CALL CHEAD1(INN,OUT,NN)
CALL PUMP1(INN,OUT,NN)
CALL EVAP1(INN,OUT,NN)
C      END OF DATA INPUT
RETURN
END

```

```

SUBROUTINE MODEL2(PARAMX,INN,OUT,NWLM,IOUT)
COMMON /MODEL/ IN,X,Y,K0,S0,BASE,H0,
1   DELT,MAXNS,NITER,NN,NE,NB,CLOSE,NPLT,IPLT
    INTEGER IN(325,3),TITLE(80),NPLT(10)
    REAL X(250),Y(250),K0(325),S0(325),BASE(250),H0(250)
    COMMON /BIG/A
    COMMON /BIG1/B
    COMMON /BIG2/LHSM
    COMMON /BIG3/WLC,H,HL,K,S,C,Q,CCHRH,CETLH,F,RHSV,THK,
1   HLIT,XE,YE,AE,BE,D,E,NTS,NND
C   INTERNAL VARIABLES AND VARIABLES PASSED FROM OTHER SUBROUTINES
    REAL PARAMX(50),WLC(325),H(250),HL(250),
1   XE(3),YE(3),AE(3,3),BE(3,3),D(3),E(3),A(250,20),B(250,20),
2   K(325),S(325),C(250),Q(250),CCHRH(250),CCHLH(250),
3   CETRH(250),CETLH(250),LHSM(250,20),
4   F(250),RHSV(250),THK(250),HLIT(250)
    REAL NDXDX,NDYDY
    INTEGER NTS(325),NND(325),OUT
C   CURRENT VALUES FOR HYDRAULIC CONDUCTIVITY AND SPECIFIC STORAGE
    DO 350
    L=1,NE
    K(L)=K0(L)
    S(L)=S0(L)
350  CONTINUE
C   INITIAL WATER LEVELS
    DO 400 I=1,NN
    HL(I)=H0(I)
    H(I)=H0(I)
400  CONTINUE
C   BEGIN TIME-STEP LOOP
    KNS=0
401  KNS=KNS+1
    IF(KNS.GT.MAXNS) RETURN
C   INTERCHANGE WATER LEVELS
    DO 402 I=1,NN
    HL(I)=H(I)
402  CONTINUE
C   COMPUTE VALUES FOR SOURCE/SINK VECTOR (Q) AND
C   COMPUTE CONSTANT-HEAD COEFFICIENTS (CCHRH) AND (CCHLH)
    CALL PUMP2(INN,OUT,PARAMX,Q,SUMP,KNS)
    IOUTX=0
    CALL CHEAD2(INN,OUT,PARAMX,CCHRH,CCHLH,H,SUMCH,IOUTX)
C   BEGIN THICKNESS, EVAPOTRANSPIRATION, AND RIVER
C   ITERATIONS
    DO 4171 I=1,NN
    HLIT(I)=HL(I)
4171 CONTINUE
    DO 421 ITER=1,NITER
C   UPDATE AQUIFER-THICKNESS VALUES
    DO 404 I=1,NN
    THK(I)=H(I)-BASE(I)
    IF(THK(I).LE.10.0) THK(I)=10.0
404  CONTINUE
C   INITIALIZE MATRICIES (A) AND (B)

```

```

DO 406 I=1,NN
DO 405 J=1,NB
A(I,J)=0.0
B(I,J)=0.0
405 CONTINUE
406 CONTINUE
C BEGIN LOOP OVER ELEMENTS
DO 412 L=1,NE
C ELEMENT STIFFNESS MATRIX (AE) AND DYNAMIC MATRIX (BE)
DO 407 I=1,3
II=IN(L,I)
XE(I)=X(II)
YE(I)=Y(II)
407 CONTINUE
D(1)=YE(2)-YE(3)
D(2)=YE(3)-YE(1)
D(3)=YE(1)-YE(2)
E(1)=XE(3)-XE(2)
E(2)=XE(1)-XE(3)
E(3)=XE(2)-XE(1)
AREA=(D(1)*XE(1)+D(2)*XE(2)+D(3)*XE(3))/2.0
DO 409 I=1,3
DO 408 J=1,3
NDXDX=D(I)*D(J)/(12.0*AREA)
NDYDY=E(I)*E(J)/(12.0*AREA)
AE(I,J)=0.0
DO 4071 N=1,3
II=IN(L,N)
AE(I,J)=AE(I,J)+K(L)*THK(II)*NDXDX
1 +K(L)*THK(II)*NDYDY
4071 CONTINUE
BE(I,J)=S(L)*AREA/12.0
IF(I.EQ.J) BE(I,J)=BE(I,J)*2.0
408 CONTINUE
409 CONTINUE
C GLOBAL STIFFNESS MATRIX (A) AND DYNAMIC MATRIX (B)
DO 411 I=1,3
II=IN(L,I)
DO 410 J=1,3
JJ=IN(L,J)-II+1
IF(JJ.LT.1) GO TO 410
A(II,JJ)=A(II,JJ)+AE(I,J)
B(II,JJ)=B(II,JJ)+BE(I,J)
410 CONTINUE
411 CONTINUE
412 CONTINUE
DO 414 I=1,NN
DO 413 J=1,NB
B(I,J)=B(I,J)/DELT
413 CONTINUE
414 CONTINUE
C END LOOP OVER ELEMENTS

```

```

C MULTIPLICATION OF GLOBAL DYNAMIC MATRIX (B) AND
LAST-WATER LEVEL VECTOR (HL) TO PRODUCE VECTOR (C)
DO 417 I=1,NN
C(I)=B(I,1)*HL(I)
DO 416 J=2,NB
II=I+J-1
IF (II.GT.NN) GO TO 415
C(I)=C(I)+B(I,J)*HL(II)
415 II=I-J+1
IF (II.LT.1) GO TO 416
C(I)=C(I)+B(II,J)*HL(II)
416 CONTINUE
417 CONTINUE
C COMPUTE RIVER AND EVAPOTRANSPIRATION COEFFICIENTS
IOUTX=0
SUMR=0.0
CALL EVAP2(INN,OUT,PARAMX,CETRH,CETLH,H,SUMET,KNS,IOUTX)
C CONSTRUCT LEFT-HAND-SIDE MATRIX (G)
DO 419 I=1,NN
DO 418 J=1,NB
LHSM(I,J)=A(I,J)+B(I,J)
418 CONTINUE
LHSM(I,1)=LHSM(I,1)+CETLH(I)+CCHLH(I)
419 CONTINUE
C CONSTRUCT RIGHT-HAND-SIDE VECTOR (F)
DO 420 I=1,NN
F(I)=-Q(I)-CETRH(I)-CCHRH(I)
RHSV(I)=C(I)-F(I)
420 CONTINUE
C COMPUTE NEW WATER-LEVEL VECTOR (H)
CALL BAND(INN,OUT,LHSM,RHSV,H,NN,NB)
C CHECK FOR CLOSURE
DELMAX=0.0
DO 4201 I=1,NN
DELH=ABS(H(I)-HLIT(I))
IF (DELH.GT.DELMAX) DELMAX=DELH
HLIT(I)=H(I)
4201 CONTINUE
IF (DELMAX.LE.CLOSE) GO TO 4211
421 CONTINUE
IF (ITER.GT.NITER) ITER=ITER-1
C END THICKNESS, RIVER, AND EVAPOTRANSPIRATION ITERATIONS
C UPDATE COMPUTE-WATER-LEVEL VECTOR (WLC)
4211 IF (NWLM.EQ.0) GO TO 423
DO 422 I=1,NWLM
IF (NTS(I).EQ.KNS) WLC(I)=H(NND(I))
422 CONTINUE
C DISPLAY WATER LEVELS AND AQUIFER THICKNESS
423 CONTINUE
IF (IOUT.EQ.0) GO TO 401
TIME=KNS*DELT/(3600.0*24.0)
WRITE(OUT,980) KNS, TIME, ITER, DELMAX
WRITE(OUT,981) (I,H(I),I=1,NN)

```

```
      IF(IPLT.GT.0)WRITE(7,555) (H(NPLT(I)),I=1,IPLT)
555  FORMAT(1H ,10F10.3)
      WRITE(OUT,982)
      WRITE(OUT,981) (I,THK(I),I=1,NN)
982  FORMAT(//1X,'AQUIFER THICKNESS'/1H ,10X,17(''')/
1   1H ,10X,3('NODE',7X,'VALUE',4X)/)
980  FORMAT(///1X,'TIME STEP',I4/1H ,10X,13(''')/1H ,10X,
1   'ELAPSED TIME',F10.1,1X,'DAYS'/
2   1H ,10X,'NUMBER OF ITERATIONS',I4/
3   1H ,10X,'WATER-LEVEL CHANGE ON LAST ITERATION',F10.4/
4   1H ,10X,'COMPUTED WATER LEVELS'/
5   1H ,10X,21(''')/1H ,10X,3('NODE',7X,'VALUE',4X)/)
981  FORMAT((1H ,10X,3(I4,3X,F9.1,4X)))
C   ASSEMBLE WATER BUDGET AND DISPLAY
      CALL EVAP2(INN,OUT,PARAMX,CETRH,CETLH,H,SUMET,KNS,IOUT)
      CALL CHEAD2(INN,OUT,PARAMX,CCHRH,CCHLH,H,SUMCH,IOUT)
      CALL BUDGET(INN,OUT,X,Y,IN,H,HL,S,DELT,NE,SUMP,SUMR,SUMET,
1 SUMCH,IOUT)
C   END TIME-STEP LOOP
      GO TO 401
      END
```

```

SUBROUTINE EVAP1(INN,OUT,NN)
COMMON /EVAP/ ETAREA,LAND,HOET,FACSET,
1 ETNODE,NETN,DELHO,ETMAX,NNX
REAL ETAREA(200),LAND(200),HOET(200),QET(200),
1 CETRH(250),CETLH(250),H(250),FACSET(100),PARAMX(50)
INTEGER ETNODE(200),OUT
C NUMBER OF ET NODES, DEPTH TO ZERO ET (FEET),
C AND MAXIMUM ET RATE (FEET PER YEAR)
NNX=NN
READ(INN,900) NETN,DELHO,ETMAX,MAXNS
IF(NETN.EQ.0) RETURN
WRITE(OUT,901) DELHO,ETMAX
ETMAX=ETMAX/(3600.0*24.0*365.0)
900 FORMAT(16,2F6.0,16)
901 FORMAT(//11X,'EVAPOTRANSPIRATION'/1H ,10X,18('-')/1H ,10X,
1 'DEPTH TO ZERO ET',F9.1/1H ,10X,
2 'MAXIMUM ET RATE',F10.1)
C ET NODES, AREA (ACRES), LAND-SURFACE ALTITUDE (FEET)
READ(INN,902) (ETNODE(I),ETAREA(I),LAND(I),I=1,NETN)
WRITE(OUT,903)
WRITE(OUT,904) (ETNODE(I),ETAREA(I),LAND(I),I=1,NETN)
902 FORMAT(16,2F6.0)
903 FORMAT(//11X,'NODE',5X,'AREA',5X,'LAND'|)
904 FORMAT(1H ,10X,I4,2F9.1)
C TIME-SET MULTIPLIERS
READ(INN,910)
(FACSET(I),I=1,MAXNS)
WRITE(OUT,911)
WRITE(OUT,912) (I,FACSET(I),I=1,MAXNS)
910 FORMAT(6X,F6.0)
911 FORMAT(//11X,'TIME-STEP MULTIPLIERS'/1H ,10X,21(' ')
1 1H ,10X,'STEP',4X,'FACTOR'|)
912 FORMAT((1H ,10X,I4,4X,F6.3))
C ADJUST LAND ALTITUDES TO REPRESENT ZERO-ET ALTITUDE
DO 101 I=1,NETN
ETAREA (I) = ETAREA (I)*43560.0
HOET(I)=LAND(I)-DELHO
101 CONTINUE
C END OF DATA INPUT
RETURN
END
C
SUBROUTINE EVAP2(INN,OUT,PARAMX,CETRH,CETLH,H,SUMET,KNS,IOUT)
COMMON /EVAP/ ETAREA,LAND,HOET,FACSET,
1 ETNODE,NETN,DELHO,ETMAX,NNX
REAL ETAREA(200),LAND(200),HOET(200),QET(200),
1 CETRH(250),CETLH(250),H(250),FACSET(100),PARAMX(50)
INTEGER ETNODE(200),OUT
C INITIALIZE VECTORS (CETRH) AND (CETLH)
DO 100 I=1,NNX
CETRH(I)=0.0
CETLH(I)=0.0

```

```
100 CONTINUE
SUMET=0.0
IF(NETN.EQ.0) RETURN
C COMPUTE LEFT-HAND AND RIGHT-HAND COEFFICIENTS
DO 110 I=1,NETN
J=ETNODE(I)
COEF=ETAREA(I)*ETMAX*FACSET(KNS)/DELHO
CETRH(J)=0.0
CETLH(J)=0.0
IF(H(J).LE.HOET(I)) GO TO 110
CETRH(J)=COEF*HOET(I)
CETLH(J)=COEF
110 CONTINUE
C PRINT RESULTS
IF(IOUT.EQ.0) RETURN
C COMPUTE ET FLUXES
SUMET=0.0
DO 120 I=1,NETN
J=ETNODE(I)
QET(I)=CETRH(J)-CETLH(J)*H(J)
SUMET=SUMET+QET(I)
120 CONTINUE
WRITE(OUT,950) SUMET
WRITE(OUT,951) (ETNODE(I),QET(I),I=1,NETN)
950 FORMAT(///1X,'EVAPOTRANSPIRATION'/1H ,10X,18('-')/1H ,10X,
1 'CUMULATIVE RATE',F9.4/1H ,10X,
2 'NODE',5X,'RATE'/)
951 FORMAT(1H ,10X,I4,F12.4)
RETURN
END
```

```

SUBROUTINE CHEAD1(INN,OUT,NN)
COMMON /CHEAD/ NCHN,CHNODE,CHEAD,FACTOR,NNX
REAL CHEAD(50),PARAMX(50),CCHRH(250),CCHLH(250),H(250),QCH(50)
INTEGER CHNODE(50),OUT
C CONSTANT-HEAD NODES AND WATER-LEVEL VALUES
NNX=NN
READ(INN,900),NCHN,FACTOR
IF(NCHN.EQ.0) RETURN
READ(INN,901)(CHNODE(I),CHEAD(I),I=1,NCHN)
WRITE(OUT,902) FACTOR
WRITE(OUT,903)(CHNODE(I),CHEAD(I),I=1,NCHN)
900 FORMAT(I6,E12.0)
901 FORMAT(I6,F6.0)
902 FORMAT(//10X,'CONSTANT-HEAD NODES'/1H ,10X,19('')/1H ,10X,
1  'LEAKANCE FACTOR',1PE12.3/1H ,10X,
2  'NODE',8X,'HEAD')
903 FORMAT(1H ,10X,I4,F12.4)
C END OF DATA INPUT
RETURN
END
C
SUBROUTINE CHEAD2(INN,OUT,PARAMX,CCHRH,CCHLH,H,SUMCH,IOUT)
COMMON /CHEAD/ NCHN,CHNODE,CHEAD,FACTOR,NNX
REAL CHEAD(50),PARAMX(50),CCHRH(250),CCHLH(250),H(250),QCH(50)
INTEGER CHNODE(50),OUT
C INITIALIZE VECTORS (CCHRH) AND (CCHLH)
DO 100 I=1,NNX
CCHRH(I)=0.0
CCHLH(I)=0.0
100 CONTINUE
SUMCH=0.0
IF (NCHN.EQ.0) RETURN
C COMPUTE LEFT-HAND AND RIGHT-HAND COEFFICIENTS
DO 101 I=1,NCHN
J=CHNODE(I)
CCHLH(J)=FACTOR
CCHRH(J)=FACTOR*CHEAD(I)
101 CONTINUE
C
C PRINT RESULTS
IF(IOUT.EQ.0) RETURN
C COMPUTE CONSTANT-HEAD FLUXES
SUMCH=0.0
DO 150 I=1,NCHN
J=CHNODE(I)
QCH(I)=CCHRH(J)-CCHLH(J)*H(J)
SUMCH=SUMCH+QCH(I)
150 CONTINUE
WRITE(OUT,950) SUMCH
WRITE(OUT,951)(CHNODE(I),QCH(I),I=1,NCHN)
950 FORMAT(//10X,'CONSTANT-HEAD NODES'/1H ,10X,19('')/1H ,10X,
1  'CUMULATIVE RATE',F9.4/1H ,10X,

```

```

      2  'NODE',8X,'RATE')
951 FORMAT(1H ,10X,I4,F12.4)
      RETURN
      END
C
      SUBROUTINE PUMP1(INN,OUT,NN)
COMMON /PUMP/ QSET,FACSET,NPUMP,NSET,NNX,QRECH,NRECH
REAL Q(250),QSET(250,10),FACSET(100),PARAMX(50),QRECH(250)
INTEGER NSET(100),OUT
C      READ # OF PUMPING DATA SETS, FACTOR FOR PUMPING, # OF TIME
C      CONSTANT RECHARGE NODES, AND NUMBER OF TIME STEPS
      NNX=NN
      READ(INN,900) NPUMP,FACQ,NRECH,MAXNS
      IF(NPUMP.EQ.0) RETURN
      WRITE(OUT,901) NPUMP,FACQ
C      INITIALIZE VECTOR (QRECH)
      DO 155 I=1,NNX
      QRECH(I)=0.0
155  CONTINUE
900  FORMAT(16,E12.0,2I6)
901  FORMAT(//11X,'RECHARGE AND DISCHARGE'/1H ,10X,22('')/1H ,10X,
1      'NUMBER OF PUMPAGE DATA SETS',I5/1H ,10X,
2      'FACTOR FOR Q',10X,1PE10.3)
C      READ TIME CONSTANT RECHARGE+ & DISCHARGE- DATA (ACRE FEET PER YEAR)
      IF(NRECH.EQ.0) GO TO 77
      READ(INN,903)(I,QRECH(I)),KK=1,NRECH)
C      CONVERT ACRE FEET PER YEAR TO CFS
      DO 177 I=1,NNX
      QRECH(I)=QRECH(I)*(1.3812785E-3)
      WRITE(OUT,955)
      WRITE(OUT,905) (I,QRECH(I)),I=1,NN)
955  FORMAT(//11X,'CONSTANT FLUX RATE (CFS), RECHARGE IS POSITIVE',
1 /1H ,10X,46('')/1H ,10X,3('NODE',7X,'VALUE',4X)/)
C      PUMPAGE DATA SETS (CUBIC FEET PER SECOND) WITH IN (+) AND OUT (-)
77   DO 101 J=1,10
      DO 100 I=1,250
      QSET(I,J)=0.0
100  CONTINUE
101  CONTINUE
      DO 103 J=1,NPUMP
      READ(INN,902) NQ
      READ(INN,903) (I,QSET(I,J)),K=1,NQ)
      DO 102 I=1,NN
      QSET(I,J)=QSET(I,J)*FACQ
102  CONTINUE
      WRITE(OUT,904) J
      WRITE(OUT,905) (I,QSET(I,J)),I=1,NN)
103  CONTINUE
902  FORMAT(16)
903  FORMAT(5(16,F6.0))
904  FORMAT(//11X,'PUMPAGE SET',I5/1H ,10X,16('')/1H ,10X,
1      3('NODE',7X,'VALUE',4X)/)

```

```

905 FORMAT((1H ,10X,3(I4,3X,F9.4,4X)))
C   TIME-STEP INDICATORS AND MULTIPLIERS
    READ(INN,906) (I,NSET(I),FACSET(I),J=1,MAXNS)
    WRITE(OUT,907)
    WRITE(OUT,908) (I,NSET(I),FACSET(I),I=1,MAXNS)
906 FORMAT(I6,I6,F6.0)
907 FORMAT(///11X,'TIME-STEP INDICATORS AND MULTIPLIERS'/1H ,10X,
1 37('')/1H ,10X,'STEP',7X,'SET',4X,'FACTOR')
908 FORMAT((1H ,10X,14,7X,13,4X,F6.3))
C   END DATA INPUT
    RETURN
    END
    SUBROUTINE PUMP2(INN,OUT,PARAMX,Q,SUMP,KNS)
    COMMON /PUMP/ QSET,FACSET,npump,nset,nnx,qrech,nrech
    REAL Q(250),QSET(250,10),FACSET(100),PARAMX(50),QRECH(250)
    INTEGER NSET(100),OUT
C   INITIALIZE VECTOR (Q)
    DO 105 I=1,NNX
    Q(I)=0.0
105  CONTINUE
    SUMP=0.0
    IF((NPUMP+NRECH).LT.1) RETURN
C   COMPUTE PUMPAGE FOR TIME STEP
    J=NSET(KNS)
    DO 104 I=1,NNX
    Q(I)=(QSET(I,J)*FACSET(KNS))+QRECH(I)
104  CONTINUE
    SUMP=0.0
    DO 106 I=1,NNX
    SUMP=SUMP+Q(I)
106  CONTINUE
    RETURN
    END
    SUBROUTINE BAND(INN,OUT,G,F,H,NN,NB)
    REAL G(250,20),F(250),H(250)
    INTEGER INN,OUT
C   UPPER TRINGULARIZE MATRIX OF COEFFICIENTS (G)
    DO 221 I=1,NN
    IP=NN-I+1
    IF(NB.LT.IP) IP=NB
    DO 220 J=1,IP
    IQ=NB-J
    IF((I-1).LT.IQ) IQ=I-1
    SUM=G(I,J)
    IF(IQ.LT.1) GO TO 450
    DO 440 K=1,IQ
    II=I-K
    JZ=J+K
    SUM=SUM-G(II,K+1)*G(II,JZ)
440  CONTINUE
450  IF(J.NE.1) GO TO 230
    IF(SUM.LE.0.0) GO TO 260

```

```

        TEMP=1.0/SQRT(SUM)
        G(I,J)=TEMP
        GO TO 220
230    G(I,J)=SUM*TEMP
220    CONTINUE
221    CONTINUE
        GO TO 261
260    WRITE(OUT,910) I
        STOP
910    FORMAT(//10X,'UPPER TRIANGULARIZATION FAILS AT ROW',I4)
C      BACK SUBSTITUTION OF VECTOR (F) INTO UPPER TRIANGULARIZED MATRIX
261    CONTINUE
        DO 320 I=1,NN
        J=I-NB+1
        IF((I+1).LE.NB) J=1
        SUM=F(I)
        K1=I-1
        IF(J.GT.K1) GO TO 340
        DO 330 K=J,K1
        II=I-K+1
        SUM=SUM-G(K,II)*H(K)
330    CONTINUE
340    H(I)=SUM*G(I,1)
320    CONTINUE
        DO 540 I1=1,NN
        I=NN-I1+1
        J=I+NB-1
        IF(J.GT.NN) J=NN
        SUM=H(I)
        K2=I+1
        IF(K2.GT.J) GO TO 250
        DO 550 K=K2,J
        KK=K-I+1
        SUM=SUM-G(I,KK)*H(K)
550    CONTINUE
250    H(I)=SUM*G(I,1)
540    CONTINUE
        RETURN
        END
C
        SUBROUTINE BUDGET(INN,OUT,X,Y,IN,H,HL,S,DELT,NE,
1      SUMP,SUMR,SUMET,SUMCH,IOUT)
        REAL X(250),Y(250),S(325),H(250),HL(250)
        REAL XE(3),YE(3),D(3)
        INTEGER IN(325,3),OUT
C      COMPUTE STORAGE CHANGE (INCREASE POSITIVE)
        IF(IOUT.EQ.0) RETURN
        DELS=0.0
        DO 102 L=1,NE
        DO 100 I=1,3
        II=IN(L,I)

```

```
XE(I)=X(II)
YE(I)=Y(II)
100 CONTINUE
D(1)=YE(2)-YE(3)
D(2)=YE(3)-YE(1)
D(3)=YE(1)-YE(2)
AREA=(D(1)*XE(1)+D(2)*XE(2)+D(3)*XE(3))/2.0
SDELH=0.0
DO 101 I=1,3
II=IN(L,I)
SDELH=SDELH+H(II)-HL(II)
101 CONTINUE
DELS=DELS+SDELH*S(L)*AREA/3.0
102 CONTINUE
DELS=DELS/DELT
C WATER-BUDGET RESIDUAL (RESIDUAL-OUT POSITIVE)
RESID=SUMP+SUMR+SUMET+SUMCH-DELS
C DISPLAY WATER BUDGET
WRITE(OUT,900) SUMP,SUMCH,SUMET,SUMR,DELS,RESID
900 FORMAT(//11X,'GROUND-WATER BUDGET'/1H ,10X,19(''')/
1 1H ,10X,'SOURCE-SINK NODES',9X,F12.5/
2 1H ,10X,'CONSTANT-HEAD NODES',7X,F12.5/
3 1H ,10X,'EVAPOTRANSPIRATION',8X,F12.5/
4 1H ,10X,'STREAM-AQUIFER INTERACTION',F12.5/
5 1H ,10X,'STORAGE CHANGE',12X,F12.5/
6 1H ,10X,'RESIDUAL',18X,F12.5)
RETURN
END
```

APPENDIX E
Calibrated data input file and results

Spanish Springs Valley

365.000 4 5 .05

0

83 139
1.0 1.0

number of nodes and elements

1	4457	311	2	6931	209	3	8698	158
4	14049	26	5	9874	2024	6	4801	1935
7	3431	2319	8	90	3319	9	2340	4216
10	5094	3912	11	8287	4112	12	11689	4878
13	16294	6729	14	10474	7521	15	8122	7193
16	6040	6399	17	4083	5914	18	2313	7184
19	3512	6841	20	4706	8586	21	24394	2908
22	21841	7820	23	17801	11005	24	13790	11587
25	10573	12033	26	7108	11724	27	5322	11274
28	4542	11067	29	25755	7814	30	24402	9608
31	27023	12289	32	24465	12459	33	21138	12819
34	18325	14182	35	15948	13427	36	10693	14856
37	7839	13103	38	4710	13132	39	28730	18112
40	24591	17468	41	22780	15024	42	20006	14768
43	18977	16636	44	17721	18354	45	13664	16314
46	10874	17607	47	7637	16332	48	5754	15604
49	25596	23694	50	21542	21931	51	20438	19546
52	21397	17016	53	17950	23090	54	16406	19913
55	14244	18725	56	11085	20610	57	9895	18640
58	7112	18968	59	23646	27142	60	18060	24924
61	14707	24175	62	14249	22026	63	12255	22447
64	10582	23129	65	8100	22013	66	7935	19620
67	5676	19648	68	23745	33778	69	18251	32800
70	15552	26528	71	14698	28380	72	12660	25741
73	9886	27259	74	6026	25463	75	6340	31342
76	12061	34704	77	16812	37263	78	19567	36702
79	20981	39433	80	17073	44160	81	13918	40396
82	9915	41181	83	7367	36167			

1 1 7 8 2 7 9 8

3 7 10 9 4 6 10 7

5 1 6 7 6 1 2 6

7 2 10 6 8 2 11 10

9 10 11 16 10 10 16 17

11 9 10 17 . 12 9 17 19

13 9 19 18 14 8 9 18

15 18 19 20 16 19 17 20

17 17 16 20 18 16 15 20

19 11 15 16 20 11 14 15

21 11 12 14 22 11 5 12

23 3 5 11 24 2 3 11

25 3 4 5 26 5 4 12

27 4 13 12 28 12 13 14

29 14 13 24 30 13 23 24

31 13 22 23 32 13 21 22
32 21 22 23 31 22 23 22

33 21 29 22 34 22 29 30
25 22 21 20 21 20 21 20

35 29 31 30 36 30 31 32

element, bounding nodes

(counterclockwise)

37	22	30	32	38	22	32	33
39	22	33	23	40	23	33	34
41	23	34	35	42	23	35	24
43	24	35	36	44	25	24	36
45	14	24	25	46	15	14	25
47	15	25	26	48	15	26	20
49	20	26	27	50	20	27	28
51	18	20	28	52	28	27	38
53	27	26	38	54	26	37	38
55	26	25	37	56	37	25	36
57	47	37	36	58	37	47	48
59	37	48	38	60	48	47	58
61	47	57	58	62	47	46	57
63	36	46	47	64	36	45	46
65	36	35	45	66	35	34	45
67	34	44	45	68	34	43	44
69	34	42	43	70	34	33	42
71	33	41	42	72	33	32	41
73	32	40	41	74	32	31	40
75	31	39	40	76	40	39	49
77	40	49	50	78	40	50	51
79	40	51	52	80	41	40	52
81	52	42	41	82	42	52	43
83	52	51	43	84	43	51	44
85	44	51	50	86	44	50	53
87	44	53	54	88	44	54	55
89	44	55	45	90	46	45	55
91	46	55	56	92	46	56	57
93	57	56	66	94	57	66	58
95	58	66	67	96	67	66	65
97	56	65	66	98	56	64	65
99	56	63	64	100	56	62	63
101	55	62	56	102	55	54	62
103	54	53	62	104	62	53	61
105	61	53	60	106	53	50	60
107	50	59	60	108	50	49	59
109	59	68	69	110	60	59	69
111	60	69	70	112	60	70	72
113	61	60	72	114	62	61	63
115	63	61	72	116	63	72	64
117	64	72	73	118	65	64	73
119	65	73	74	120	67	65	74
121	74	73	75	122	73	76	75
123	73	71	76	124	73	72	71
125	72	70	71	126	70	69	71
127	71	69	76	128	69	77	76
129	69	78	77	130	69	68	78
131	68	79	78	132	77	78	79
133	77	79	80	134	77	80	81
135	76	77	81	136	75	76	83
137	76	82	83	138	76	81	82

139	80	82	81	factor for hydraulic conductivity							
1.00											
1.5	1.5	1.5	1.5	1.5	1.5	1.0	1.0	1.5	2.5		
2.0	1.9	2.0	1.4	3.0	3.0	2.5	1.5	1.0	1.0		
1.0	1.0	1.5	1.5	1.0	1.0	0.0	0.0	0.0	0.0		
6.0	6.0	2.0	2.0	2.5	2.0	8.0	8.0	8.0	8.0	0.8	
0.3	0.3	1.0	1.5	2.0	2.0	1.5	1.5	3.0	2.5		
2.5	3.0	3.0	3.0	1.5	1.5	2.5	3.0	3.0	3.5		
3.0	2.5	2.5	2.0	1.0	0.8	0.8	0.1	0.8	0.8		
8.0	8.0	2.0	2.5	5.0	5.0	2.7	2.5	2.0	2.5		
8.0	8.0	4.0	1.5	1.0	2.0	3.0	3.0	2.0	2.0		
1.5	1.0	3.5	3.5	0.2	0.2	4.5	5.0	3.0	1.0		
1.5	2.0	2.0	5.0	3.0	3.0	2.5	2.5	2.5	2.5		
3.5	3.0	6.0	3.0	4.0	2.0	4.0	4.0	5.0	0.7		
4.0	4.0	1.5	3.0	5.0	4.0	2.5	3.0	2.5	2.5		
1.0	4.0	4.0	4.0	3.5	3.0	3.0	3.0	2.5			
0.0000000001				factor for specific yield							
0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05		
0.05	0.05	0.01	0.01	0.01	0.50	0.50	0.50	0.50	0.50		
0.50	0.05	0.05	0.05	0.05	0.05	.000	.000	.000	.000		
.004	.004	4.00	5.00	5.00	7.00	5.00	.004	.004	0.50		
0.50	0.50	0.80	0.80	0.50	0.50	0.80	0.50	0.50	0.05		
0.05	0.05	1.00	1.00	0.80	0.80	1.00	1.00	1.00	0.50		
1.00	1.00	1.00	0.80	0.80	0.80	0.80	0.80	1.00	0.50		
0.80	0.80	0.50	4.00	5.00	5.00	4.00	2.60	1.50	1.50		
0.80	0.80	0.80	1.00	2.00	2.00	1.50	1.50	0.80	0.80		
0.80	0.50	1.00	1.00	4.00	4.00	1.00	5.00	4.00	1.00		
1.00	1.00	1.00	1.00	0.80	2.00	6.00	6.00	8.00	8.00		
10.0	5.00	1.00	5.00	5.00	5.00	6.00	7.00	8.00	7.00		
8.00	8.00	5.00	8.00	10.0	10.0	5.00	5.00	8.00	7.00		
0.05	8.00	10.0	5.00	5.00	10.0	17.0	17.0	2.00			
3900.	3830.	3900.	3850.	3980.	3740.	3770.	3880.	3800.	3740.		
3940.	3970.	4000.	3980.	3850.	3840.	3890.	3840.	3940.	3900.		
4100.	4000.	4030.	3840.	3650.	3880.	3890.	3930.	3990.	3920.		
3960.	3910.	4010.	3880.	3880.	3260.	3690.	3800.	4140.	4000.		
3910.	3890.	3680.	3790.	3570.	3570.	3790.	4100.	4160.	3990.		
3710.	3800.	3700.	3980.	3780.	3590.	3690.	3760.	4160.	3730.		
3530.	3500.	3480.	3490.	3660.	3530.	4200.	3960.	3800.	3520.		
3530.	3330.	3510.	3750.	2800.	3030.	3950.	4150.	4290.	4000.		
2710.	3500.	3600.									
4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.		
4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.		
4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.		
4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.		
4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.		
4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.		
4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.		
4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.		
4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.		
4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.		
4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.	4465.		
0		1.0									
4		1.0	11	4							

21 20.0 29 80.0 31 80.0 39 100.0 49 100.0 recharge from precipitation (AF/yr)
 59 30.0 67 70.0 68 40.0 74 20.0 79 10.0
 83 30.0
 17
 7 .2208 9 .1104 17 .1242 20 .2346 25 .0483 pumpage data set #1 (cfs)
 26 .2760 27 .2760 36 .0966 37 .2760 46 .2070 - calibrated recharge from Orr Ditch
 47 .2070 54 .1380 55 .0966 56 .2208 57 .2070
 62 .1242 63 .2070
 25
 7 .2208 9 .1104 17 .0207 19-.0552 20 .2346 pumpage data set #2 (cfs)
 25 .0483 26 .2760 27 .2760 36 .0966 37 .2760 - current ditch (2225 AF/yr)
 46 .2070 47 .2070 54 .1283 55 .0966 56 .2208 - current pumping (760 AF/yr)
 57 .2070 61-.2277 62 .1242 63 .2070 64-.3864
 66-.0138 69-.0069 72 .0552 77-.1035 82-.1380
 29
 7 .2208 9 .1104 17 .0207 19-.0552 20 .2346 pumpage data set #3 (cfs)
 25 .0483 26 .2760 27 .2760 33-.2000 36 .0966 - current ditch (2225 AF/yr)
 37 .2760 46 .2070 47 .2070 50-.1518 51 .0828 - increased pumping (1750 AF/yr)
 54 .1283 55 .0966 56 .2208 57 .2070 61-.2622
 62 .1242 63-.4140 64-.4485 65-.4140 66-.0690
 69-.0069 72 .1035 77-.1035 82-.1380
 29
 7 .0552 9 .0552 17-.0483 19-.0552 20 .1656 pumpage data set #4 (cfs)
 25 .0000 26 .1380 27 .1380 33-.2000 36 .0966 - reduced ditch (1560 AF/yr)
 37 .1380 46 .2070 47 .1380 50-.1518 51 .0828 - increased pumping (1750 AF/yr)
 54 .1283 55 .0966 56 .2070 57 .1932 61-.2622
 62 .1242 63-.4140 64-.4485 65-.4140 66-.0690
 69-.0069 72 .1035 77-.1035 82-.1380
 1 4 1.0 time step, pumpage data set, factor
 2 4 1.0
 3 4 1.0
 4 4 1.0
 30 15.0 4.0 4 #ET nodes, depth to zero ET (ft), max ET rate (ft/yr), #time steps
 2 30.0 4419.
 6 98.0 4440.
 7 163.0 4495.
 9 149.0 4494.
 10 136.0 4440.
 15 205.0 4450.
 16 132.0 4445.
 17 82.0 4492.
 20 175.0 4491.
 25 259.0 4460.
 26 171.0 4490.
 27 82.0 4490.
 34 150.0 4487.
 35 218.0 4473.
 36 214.0 4464.
 37 156.0 4489.
 43 100.0 4485.
 44 150.0 4485.
 ET node, area (acres), land surface elevation (ft)

45 100.0 4464.
46 151.0 4470.
47 169.0 4488.
54 175.0 4484.
55 196.0 4476.
56 163.0 4487.
57 110.0 4488.
62 159.0 4485.
63 90.0 4486.
80 20.0 4460.
81 15.0 4462.
82 35.0 4461.

1.0
1.0
1.0
1.0

Spanish Springs Valley

TIME PARAMETERS

TIME STEP 365.0
 NUMBER OF TIME STEPS 4
 NUMBER OF ET ITERATIONS 5
 CLOSURE CRITERION FOR ITERATIONS .050

FINITE-ELEMENT DATA

NUMBER OF NODES 83
 NUMBER OF ELEMENTS 139

NODE COORDINATES

FACTOR FOR X 1.000E+00
 FACTOR FOR Y 1.000E+00

NODE	X	Y	NODE	X	Y
1	4457.0	311.0	2	6931.0	209.0
3	8698.0	158.0	4	14049.0	26.0
5	9874.0	2024.0	6	4801.0	1935.0
7	3431.0	2319.0	8	90.0	3319.0
9	2340.0	4216.0	10	5094.0	3912.0
11	8287.0	4112.0	12	11689.0	4878.0
13	16294.0	6729.0	14	10474.0	7521.0
15	8122.0	7193.0	16	6040.0	6399.0
17	4083.0	5914.0	18	2313.0	7184.0
19	3512.0	6841.0	20	4706.0	8586.0
21	24394.0	2908.0	22	21841.0	7820.0
23	17801.0	11005.0	24	13790.0	11587.0
25	10573.0	12033.0	26	7108.0	11724.0
27	5322.0	11274.0	28	4542.0	11067.0
29	25755.0	7814.0	30	24402.0	9608.0
31	27023.0	12289.0	32	24465.0	12459.0
33	21138.0	12819.0	34	18325.0	14182.0
35	15948.0	13427.0	36	10693.0	14856.0
37	7839.0	13103.0	38	4710.0	13132.0
39	28730.0	18112.0	40	24591.0	17468.0
41	22780.0	15024.0	42	20006.0	14768.0
43	18977.0	16636.0	44	17721.0	18354.0
45	13664.0	16314.0	46	10874.0	17607.0
47	7637.0	16332.0	48	5754.0	15604.0
49	25596.0	23694.0	50	21542.0	21931.0
51	20438.0	19546.0	52	21397.0	17016.0
53	17950.0	23090.0	54	16406.0	19913.0

55	14244.0	18725.0	56	11085.0	20610.0
57	9895.0	18640.0	58	7112.0	18968.0
59	23646.0	27142.0	60	18060.0	24924.0
61	14707.0	24175.0	62	14249.0	22026.0
63	12255.0	22447.0	64	10582.0	23129.0
65	8100.0	22013.0	66	7935.0	19620.0
67	5676.0	19648.0	68	23745.0	33778.0
69	18251.0	32800.0	70	15552.0	26528.0
71	14698.0	28380.0	72	12660.0	25741.0
73	9886.0	27259.0	74	6026.0	25463.0
75	6340.0	31342.0	76	12061.0	34704.0
77	16812.0	37263.0	78	19567.0	36702.0
79	20981.0	39433.0	80	17073.0	44160.0
81	13918.0	40396.0	82	9915.0	41181.0
83	7367.0	36167.0			

ELEMENT INCIDENCES

ELEM	CORNERS				ELEM	CORNERS			
1	1	7	8		2	7	9	8	
3	7	10	9		4	6	10	7	
5	1	6	7		6	1	2	6	
7	2	10	6		8	2	11	10	
9	10	11	16		10	10	16	17	
11	9	10	17		12	9	17	19	
13	9	19	18		14	8	9	18	
15	18	19	20		16	19	17	20	
17	17	16	20		18	16	15	20	
19	11	15	16		20	11	14	15	
21	11	12	14		22	11	5	12	
23	3	5	11		24	2	3	11	
25	3	4	5		26	5	4	12	
27	4	13	12		28	12	13	14	
29	14	13	24		30	13	23	24	
31	13	22	23		32	13	21	22	
33	21	29	22		34	22	29	30	
35	29	31	30		36	30	31	32	
37	22	30	32		38	22	32	33	
39	22	33	23		40	23	33	34	
41	23	34	35		42	23	35	24	
43	24	35	36		44	25	24	36	
45	14	24	25		46	15	14	25	
47	15	25	26		48	15	26	20	
49	20	26	27		50	20	27	28	
51	18	20	28		52	28	27	38	
53	27	26	38		54	26	37	38	
55	26	25	37		56	37	25	36	
57	47	37	36		58	37	47	48	
59	37	48	38		60	48	47	58	

61	47	57	58	62	47	46	57
63	36	46	47	64	36	45	46
65	36	35	45	66	35	34	45
67	34	44	45	68	34	43	44
69	34	42	43	70	34	33	42
71	33	41	42	72	33	32	41
73	32	40	41	74	32	31	40
75	31	39	40	76	40	39	49
77	40	49	50	78	40	50	51
79	40	51	52	80	41	40	52
81	52	42	41	82	42	52	43
83	52	51	43	84	43	51	44
85	44	51	50	86	44	50	53
87	44	53	54	88	44	54	55
89	44	55	45	90	46	45	55
91	46	55	56	92	46	56	57
93	57	56	66	94	57	66	58
95	58	66	67	96	67	66	65
97	56	65	66	98	56	64	65
99	56	63	64	100	56	62	63
101	55	62	56	102	55	54	62
103	54	53	62	104	62	53	61
105	61	53	60	106	53	50	60
107	50	59	60	108	50	49	59
109	59	68	69	110	60	59	69
111	60	69	70	112	60	70	72
113	61	60	72	114	62	61	63
115	63	61	72	116	63	72	64
117	64	72	73	118	65	64	73
119	65	73	74	120	67	65	74
121	74	73	75	122	73	76	75
123	73	71	76	124	73	72	71
125	72	70	71	126	70	69	71
127	71	69	76	128	69	77	76
129	69	78	77	130	69	68	78
131	68	79	78	132	77	78	79
133	77	79	80	134	77	80	81
135	76	77	81	136	75	76	83
137	76	82	83	138	76	81	82
139	80	82	81				

HALF-BAND WIDTH

13

HYDRAULIC CONDUCTIVITY

FACTOR FOR K 1.000E+00

ELEM	VALUE	ELEM	VALUE
1	1.5	2	1.5
3	1.5	4	1.5

5	1.5	6	1.5
7	1.0	8	1.0
9	1.5	10	2.5
11	2.0	12	1.9
13	2.0	14	1.4
15	3.0	16	3.0
17	2.5	18	1.5
19	1.0	20	1.0
21	1.0	22	1.0
23	1.5	24	1.5
25	1.0	26	1.0
27	.0	28	.0
29	.0	30	.0
31	6.0	32	6.0
33	2.0	34	2.0
35	2.5	36	2.0
37	8.0	38	8.0
39	8.0	40	.8
41	.3	42	.3
43	1.0	44	1.5
45	2.0	46	2.0
47	1.5	48	1.5
49	3.0	50	2.5
51	2.5	52	3.0
53	3.0	54	3.0
55	1.5	56	1.5
57	2.5	58	3.0
59	3.0	60	3.5
61	3.0	62	2.5
63	2.5	64	2.0
65	1.0	66	.8
67	.8	68	.1
69	.8	70	.8
71	8.0	72	8.0
73	2.0	74	2.5
75	5.0	76	5.0
77	2.7	78	2.5
79	2.0	80	2.5
81	8.0	82	8.0
83	4.0	84	1.5
85	1.0	86	2.0
87	3.0	88	3.0
89	2.0	90	2.0
91	1.5	92	1.0
93	3.5	94	3.5
95	.2	96	.2
97	4.5	98	5.0
99	3.0	100	1.0
101	1.5	102	2.0
103	2.0	104	5.0
105	3.0	106	3.0

107	2.5	108	2.5
109	2.5	110	2.5
111	3.5	112	3.0
113	6.0	114	3.0
115	4.0	116	2.0
117	4.0	118	4.0
119	5.0	120	.7
121	4.0	122	4.0
123	1.5	124	3.0
125	5.0	126	4.0
127	2.5	128	3.0
129	2.5	130	2.5
131	1.0	132	4.0
133	4.0	134	4.0
135	3.5	136	3.0
137	3.0	138	3.0
139	2.5		

SPECIFIC YIELD

FACTOR FOR S 1.000E-10			
ELEM	VALUE	ELEM	VALUE
1	.0000	2	.0000
3	.0000	4	.0000
5	.0000	6	.0000
7	.0000	8	.0000
9	.0000	10	.0000
11	.0000	12	.0000
13	.0000	14	.0000
15	.0000	16	.0000
17	.0000	18	.0000
19	.0000	20	.0000
21	.0000	22	.0000
23	.0000	24	.0000
25	.0000	26	.0000
27	.0000	28	.0000
29	.0000	30	.0000
31	.0000	32	.0000
33	.0000	34	.0000
35	.0000	36	.0000
37	.0000	38	.0000
39	.0000	40	.0000
41	.0000	42	.0000
43	.0000	44	.0000
45	.0000	46	.0000
47	.0000	48	.0000
49	.0000	50	.0000
51	.0000	52	.0000
53	.0000	54	.0000

55	.0000	56	.0000
57	.0000	58	.0000
59	.0000	60	.0000
61	.0000	62	.0000
63	.0000	64	.0000
65	.0000	66	.0000
67	.0000	68	.0000
69	.0000	70	.0000
71	.0000	72	.0000
73	.0000	74	.0000
75	.0000	76	.0000
77	.0000	78	.0000
79	.0000	80	.0000
81	.0000	82	.0000
83	.0000	84	.0000
85	.0000	86	.0000
87	.0000	88	.0000
89	.0000	90	.0000
91	.0000	92	.0000
93	.0000	94	.0000
95	.0000	96	.0000
97	.0000	98	.0000
99	.0000	100	.0000
101	.0000	102	.0000
103	.0000	104	.0000
105	.0000	106	.0000
107	.0000	108	.0000
109	.0000	110	.0000
111	.0000	112	.0000
113	.0000	114	.0000
115	.0000	116	.0000
117	.0000	118	.0000
119	.0000	120	.0000
121	.0000	122	.0000
123	.0000	124	.0000
125	.0000	126	.0000
127	.0000	128	.0000
129	.0000	130	.0000
131	.0000	132	.0000
133	.0000	134	.0000
135	.0000	136	.0000
137	.0000	138	.0000
139	.0000		

BASE OF AQUIFER

NODE	VALUE	NODE	VALUE	NODE	VALUE
1	3900.0	2	3830.0	3	3900.0
4	3850.0	5	3980.0	6	3740.0

7	3770.0	8	3880.0	9	3800.0
10	3740.0	11	3940.0	12	3970.0
13	4000.0	14	3980.0	15	3850.0
16	3840.0	17	3890.0	18	3840.0
19	3940.0	20	3900.0	21	4100.0
22	4000.0	23	4030.0	24	3840.0
25	3650.0	26	3880.0	27	3890.0
28	3930.0	29	3990.0	30	3920.0
31	3960.0	32	3910.0	33	4010.0
34	3880.0	35	3880.0	36	3260.0
37	3690.0	38	3800.0	39	4140.0
40	4000.0	41	3910.0	42	3890.0
43	3680.0	44	3790.0	45	3570.0
46	3570.0	47	3790.0	48	4100.0
49	4160.0	50	3990.0	51	3710.0
52	3800.0	53	3700.0	54	3980.0
55	3780.0	56	3590.0	57	3690.0
58	3760.0	59	4160.0	60	3730.0
61	3530.0	62	3500.0	63	3480.0
64	3490.0	65	3660.0	66	3530.0
67	4200.0	68	3960.0	69	3800.0
70	3520.0	71	3530.0	72	3330.0
73	3510.0	74	3750.0	75	2800.0
76	3030.0	77	3950.0	78	4150.0
79	4290.0	80	4000.0	81	2710.0
82	3500.0	83	3600.0		

INITIAL WATER LEVELS

NODE	VALUE	NODE	VALUE	NODE	VALUE
1	4465.0	2	4465.0	3	4465.0
4	4465.0	5	4465.0	6	4465.0
7	4465.0	8	4465.0	9	4465.0
10	4465.0	11	4465.0	12	4465.0
13	4465.0	14	4465.0	15	4465.0
16	4465.0	17	4465.0	18	4465.0
19	4465.0	20	4465.0	21	4465.0
22	4465.0	23	4465.0	24	4465.0
25	4465.0	26	4465.0	27	4465.0
28	4465.0	29	4465.0	30	4465.0
31	4465.0	32	4465.0	33	4465.0
34	4465.0	35	4465.0	36	4465.0
37	4465.0	38	4465.0	39	4465.0
40	4465.0	41	4465.0	42	4465.0
43	4465.0	44	4465.0	45	4465.0
46	4465.0	47	4465.0	48	4465.0
49	4465.0	50	4465.0	51	4465.0
52	4465.0	53	4465.0	54	4465.0
55	4465.0	56	4465.0	57	4465.0

58	4465.0	59	4465.0	60	4465.0
61	4465.0	62	4465.0	63	4465.0
64	4465.0	65	4465.0	66	4465.0
67	4465.0	68	4465.0	69	4465.0
70	4465.0	71	4465.0	72	4465.0
73	4465.0	74	4465.0	75	4465.0
76	4465.0	77	4465.0	78	4465.0
79	4465.0	80	4465.0	81	4465.0
82	4465.0	83	4465.0		

RECHARGE AND DISCHARGE

NUMBER OF PUMPAGE DATA SETS 4
 FACTOR FOR Q 1.000E+00

CONSTANT FLUX RATE (CFS), RECHARGE IS POSITIVE

NODE	VALUE	NODE	VALUE	NODE	VALUE
1	.0000	2	.0000	3	.0000
4	.0000	5	.0000	6	.0000
7	.0000	8	.0000	9	.0000
10	.0000	11	.0000	12	.0000
13	.0000	14	.0000	15	.0000
16	.0000	17	.0000	18	.0000
19	.0000	20	.0000	21	.0276
22	.0000	23	.0000	24	.0000
25	.0000	26	.0000	27	.0000
28	.0000	29	.1105	30	.0000
31	.1105	32	.0000	33	.0000
34	.0000	35	.0000	36	.0000
37	.0000	38	.0000	39	.1381
40	.0000	41	.0000	42	.0000
43	.0000	44	.0000	45	.0000
46	.0000	47	.0000	48	.0000
49	.1381	50	.0000	51	.0000
52	.0000	53	.0000	54	.0000
55	.0000	56	.0000	57	.0000
58	.0000	59	.0414	60	.0000
61	.0000	62	.0000	63	.0000
64	.0000	65	.0000	66	.0000
67	.0967	68	.0553	69	.0000
70	.0000	71	.0000	72	.0000
73	.0000	74	.0276	75	.0000
76	.0000	77	.0000	78	.0000
79	.0138	80	.0000	81	.0000
82	.0000	83	.0414		

PUMPAGE SET 1

NODE	VALUE	NODE	VALUE	NODE	VALUE
1	.0000	2	.0000	3	.0000
4	.0000	5	.0000	6	.0000
7	.2208	8	.0000	9	.1104
10	.0000	11	.0000	12	.0000
13	.0000	14	.0000	15	.0000
16	.0000	17	.1242	18	.0000
19	.0000	20	.2346	21	.0000
22	.0000	23	.0000	24	.0000
25	.0483	26	.2760	27	.2760
28	.0000	29	.0000	30	.0000
31	.0000	32	.0000	33	.0000
34	.0000	35	.0000	36	.0966
37	.2760	38	.0000	39	.0000
40	.0000	41	.0000	42	.0000
43	.0000	44	.0000	45	.0000
46	.2070	47	.2070	48	.0000
49	.0000	50	.0000	51	.0000
52	.0000	53	.0000	54	.1380
55	.0966	56	.2208	57	.2070
58	.0000	59	.0000	60	.0000
61	.0000	62	.1242	63	.2070
64	.0000	65	.0000	66	.0000
67	.0000	68	.0000	69	.0000
70	.0000	71	.0000	72	.0000
73	.0000	74	.0000	75	.0000
76	.0000	77	.0000	78	.0000
79	.0000	80	.0000	81	.0000
82	.0000	83	.0000		

PUMPAGE SET 2

NODE	VALUE	NODE	VALUE	NODE	VALUE
1	.0000	2	.0000	3	.0000
4	.0000	5	.0000	6	.0000
7	.2208	8	.0000	9	.1104
10	.0000	11	.0000	12	.0000
13	.0000	14	.0000	15	.0000
16	.0000	17	.0207	18	.0000
19	-.0552	20	.2346	21	.0000
22	.0000	23	.0000	24	.0000
25	.0483	26	.2760	27	.2760
28	.0000	29	.0000	30	.0000
31	.0000	32	.0000	33	.0000
34	.0000	35	.0000	36	.0966

37	.2760	38.	.0000	39	.0000
40	.0000	41	.0000	42	.0000
43	.0000	44	.0000	45	.0000
46	.2070	47	.2070	48	.0000
49	.0000	50	.0000	51	.0000
52	.0000	53	.0000	54	.1283
55	.0966	56	.2208	57	.2070
58	.0000	59	.0000	60	.0000
61	-.2277	62	.1242	63	.2070
64	-.3864	65	.0000	66	-.0138
67	.0000	68	.0000	69	-.0069
70	.0000	71	.0000	72	.0552
73	.0000	74	.0000	75	.0000
76	.0000	77	-.1035	78	.0000
79	.0000	80	.0000	81	.0000
82	-.1380	83	.0000		

PUMPAGE SET 3

NODE	VALUE	NODE	VALUE	NODE	VALUE
1	.0000	2	.0000	3	.0000
4	.0000	5	.0000	6	.0000
7	.2208	8	.0000	9	.1104
10	.0000	11	.0000	12	.0000
13	.0000	14	.0000	15	.0000
16	.0000	17	.0207	18	.0000
19	-.0552	20	.2346	21	.0000
22	.0000	23	.0000	24	.0000
25	.0483	26	.2760	27	.2760
28	.0000	29	.0000	30	.0000
31	.0000	32	.0000	33	-.2000
34	.0000	35	.0000	36	.0966
37	.2760	38	.0000	39	.0000
40	.0000	41	.0000	42	.0000
43	.0000	44	.0000	45	.0000
46	.2070	47	.2070	48	.0000
49	.0000	50	-.1518	51	.0828
52	.0000	53	.0000	54	.1283
55	.0966	56	.2208	57	.2070
58	.0000	59	.0000	60	.0000
61	-.2622	62	.1242	63	-.4140
64	-.4485	65	-.4140	66	-.0690
67	.0000	68	.0000	69	-.0069
70	.0000	71	.0000	72	.1035
73	.0000	74	.0000	75	.0000
76	.0000	77	-.1035	78	.0000
79	.0000	80	.0000	81	.0000
82	-.1380	83	.0000		

PUMPAGE SET 4

NODE	VALUE	NODE	VALUE	NODE	VALUE
1	.0000	2	.0000	3	.0000
4	.0000	5	.0000	6	.0000
7	.0552	8	.0000	9	.0552
10	.0000	11	.0000	12	.0000
13	.0000	14	.0000	15	.0000
16	.0000	17	-.0483	18	.0000
19	-.0552	20	.1656	21	.0000
22	.0000	23	.0000	24	.0000
25	.0000	26	.1380	27	.1380
28	.0000	29	.0000	30	.0000
31	.0000	32	.0000	33	-.2000
34	.0000	35	.0000	36	.0966
37	.1380	38	.0000	39	.0000
40	.0000	41	.0000	42	.0000
43	.0000	44	.0000	45	.0000
46	.2070	47	.1380	48	.0000
49	.0000	50	-.1518	51	.0828
52	.0000	53	.0000	54	.1283
55	.0966	56	.2070	57	.1932
58	.0000	59	.0000	60	.0000
61	-.2622	62	.1242	63	-.4140
64	-.4485	65	-.4140	66	-.0690
67	.0000	68	.0000	69	-.0069
70	.0000	71	.0000	72	.1035
73	.0000	74	.0000	75	.0000
76	.0000	77	-.1035	78	.0000
79	.0000	80	.0000	81	.0000
82	-.1380	83	.0000		

TIME-STEP INDICATORS AND MULTIPLIERS

STEP	SET	FACTOR
1	1	1.000
2	1	1.000
3	1	1.000
4	1	1.000

EVAPOTRANSPIRATION

DEPTH TO ZERO ET 15.0
 MAXIMUM ET RATE 4.0

NODE	AREA	LAND
2	32.0	4420.0
6	98.0	4440.0
7	163.0	4495.0
9	149.0	4494.0
10	136.0	4440.0
15	205.0	4450.0
16	132.0	4445.0
17	82.0	4492.0
20	175.0	4491.0
25	259.0	4460.0
26	171.0	4490.0
27	82.0	4490.0
34	150.0	4487.0
35	218.0	4473.0
36	214.0	4464.0
37	156.0	4489.0
43	100.0	4485.0
44	150.0	4485.0
45	100.0	4464.0
46	151.0	4470.0
47	169.0	4488.0
54	175.0	4484.0
55	196.0	4476.0
56	163.0	4487.0
57	110.0	4488.0
62	159.0	4485.0
63	90.0	4486.0
80	21.0	4461.0
81	16.0	4463.0
82	38.0	4462.0

TIME-STEP MULTIPLIERS

STEP	FACTOR
1	1.000
2	1.000
3	1.000
4	1.000

TIME STEP 4

ELAPSED TIME 1460.0 DAYS
 NUMBER OF ITERATIONS 1
 WATER-LEVEL CHANGE ON LAST ITERATION .0068
 COMPUTED WATER LEVELS

NODE	VALUE	NODE	VALUE	NODE	VALUE
1	4431.4	2	4418.8	3	4423.8
4	4428.4	5	4427.6	6	4429.1
7	4440.4	8	4447.4	9	4446.3
10	4430.9	11	4431.0	12	4432.0
13	4482.1	14	4441.2	15	4438.1
16	4436.4	17	4444.4	18	4448.8
19	4448.9	20	4458.8	21	4485.4
22	4483.2	23	4481.1	24	4452.5
25	4449.5	26	4470.2	27	4471.0
28	4468.9	29	4487.6	30	4483.9
31	4486.5	32	4482.9	33	4481.0
34	4470.8	35	4458.6	36	4455.2
37	4469.2	38	4470.2	39	4487.7
40	4483.4	41	4480.2	42	4477.7
43	4474.5	44	4470.6	45	4456.3
46	4462.0	47	4469.8	48	4469.7
49	4485.2	50	4477.5	51	4476.4
52	4477.7	53	4472.9	54	4470.3
55	4463.7	56	4472.8	57	4470.5
58	4471.4	59	4476.5	60	4472.7
61	4472.1	62	4471.8	63	4473.4
64	4472.4	65	4472.7	66	4471.6
67	4494.4	68	4473.3	69	4469.3
70	4471.6	71	4470.8	72	4471.5
73	4470.6	74	4471.3	75	4468.9
76	4466.6	77	4465.0	78	4467.0
79	4465.5	80	4460.0	81	4462.1
82	4460.9	83	4466.8		

AQUIFER THICKNESS

NODE	VALUE	NODE	VALUE	NODE	VALUE
1	531.4	2	588.8	3	523.8
4	578.4	5	447.6	6	689.1
7	670.4	8	567.4	9	646.4
10	690.9	11	491.0	12	462.0
13	482.1	14	461.2	15	588.1
16	596.4	17	554.4	18	608.8
19	508.9	20	558.8	21	385.4
22	483.2	23	451.0	24	612.5

25	799.5	26	590.2	27	581.0
28	538.9	29	497.6	30	563.9
31	526.5	32	572.9	33	471.0
34	590.8	35	578.6	36	1195.2
37	779.2	38	670.2	39	347.7
40	483.4	41	570.2	42	587.7
43	794.5	44	680.6	45	886.3
46	892.0	47	679.8	48	369.7
49	325.2	50	487.5	51	766.4
52	677.7	53	772.9	54	490.3
55	683.7	56	882.8	57	780.5
58	711.4	59	316.6	60	742.7
61	942.1	62	971.8	63	993.4
64	982.4	65	812.7	66	941.6
67	294.4	68	513.3	69	669.3
70	951.6	71	940.8	72	1141.5
73	960.6	74	721.3	75	1668.9
76	1436.6	77	515.0	78	317.0
79	175.5	80	460.0	81	1752.1
82	960.9	83	866.8		

EVAPOTRANSPIRATION

CUMULATIVE RATE -3.8714
NODE RATE

2	-.1631
6	-.1475
7	.0000
9	.0000
10	-.2952
15	-.2345
16	-.3116
17	.0000
20	.0000
25	-.4291
26	.0000
27	.0000
34	.0000
35	-.0476
36	-.4878
37	.0000
43	-.1675
44	-.0307
45	-.2684
46	-.3899
47	.0000
54	-.0839

55	-.1946
56	-.0484
57	.0000
62	-.1066
63	-.0794
80	-.1081
81	-.0829
82	-.1946

GROUND-WATER BUDGET

SOURCE-SINK NODES	3.87164
CONSTANT-HEAD NODES	.00000
EVAPOTRANSPIRATION	-3.87138
STREAM-AQUIFER INTERACTION	.00000
STORAGE CHANGE	.00000
RESIDUAL	.00027