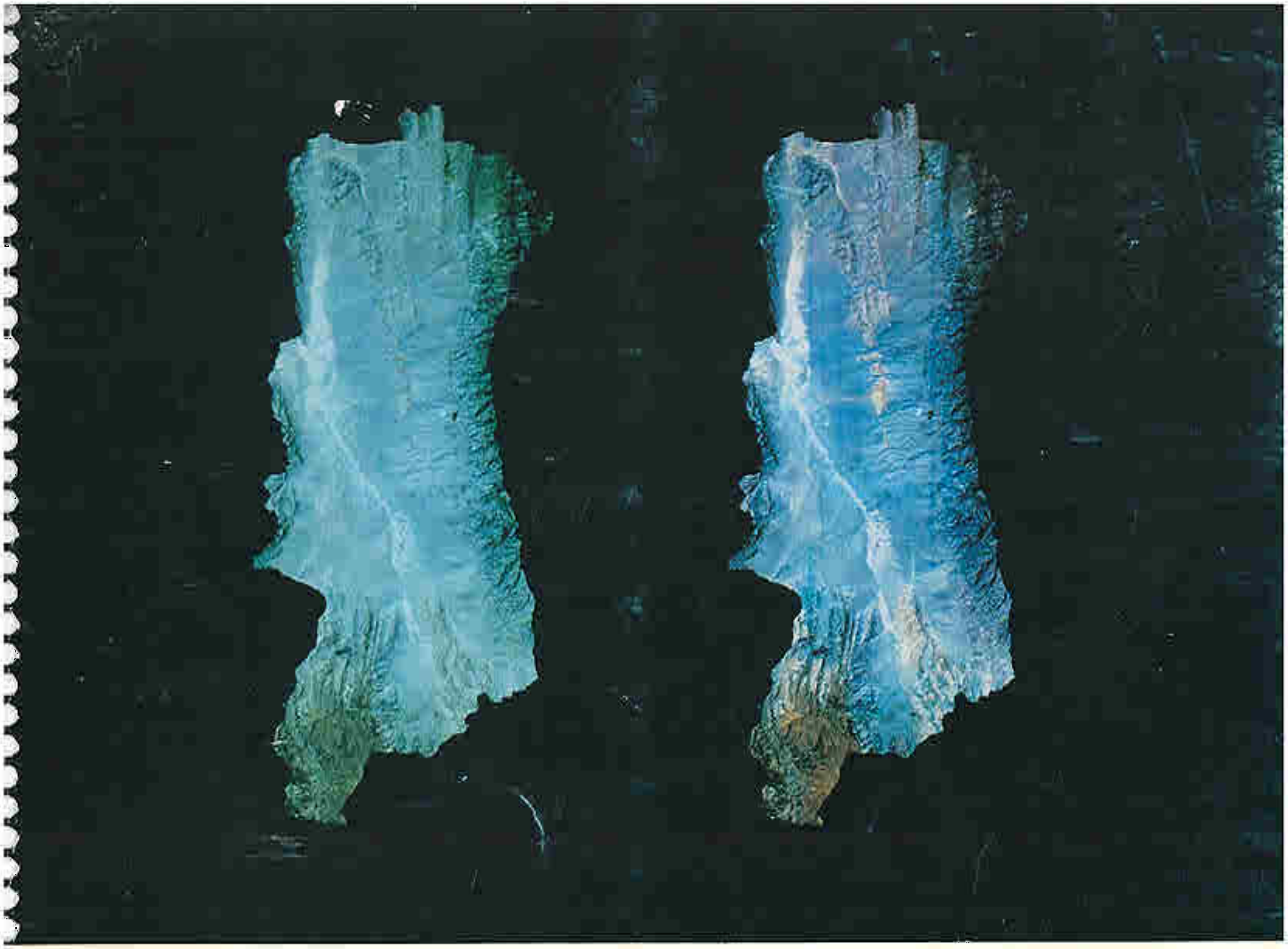

HYDROLOGY AND STEADY STATE GROUND-WATER MODEL OF COYOTE SPRING VALLEY, CLARK AND LINCOLN COUNTIES, NEVADA

DO NOT REMOVE

1992

Las Vegas Valley Water District

COOPERATIVE WATER PROJECT
Water for Nevada's Future
Report No. 3
Hydrographic Basin 210

HYDROLOGY AND STEADY STATE GROUND-WATER MODEL OF COYOTE SPRING VALLEY, CLARK AND LINCOLN COUNTIES, NEVADA

1992

By

Thomas S. Buqo, Quarda Drici, and David B. Goings

The Earth Technology Corporation

PREFACE

This report on the water resources and development potential of Coyote Spring Valley is one of three reports on three basins in southern and eastern Nevada prepared by The Earth Technology Corporation for the Las Vegas Valley Water District as part of the District's Cooperative Water Resources Program. The work was conducted between April and August 1990. Mr. Thomas Buqo, Managing Senior Hydrogeologist, was the project manager and principal author of this report. Ms. Ouarda Drici, Senior Project Hydrogeologist, developed the ground–water flow model and assisted in preparing the report. Mr. David Goings, Senior Staff Hydrogeologist, performed detailed evaluations of the available data and prepared selected sections of the report. Additional assistance was provided by Mr. Christopher Garey, Staff Geologist. Quality assurance reviews and technical assistance were provided by Dr. Richard Bateman, Principal Hydrogeologist and Dr. James Tracy a consultant to the Las Vegas Valley Water District. Information used in performing this work was provided by the Nevada State Engineer Office, the U.S. Geological Survey, Summit Engineering, Inc., and the U.S. Air Force. Additional information and technical assistance was provided by the staff of the Research Department of the Las Vegas Valley Water District, under the direction of Mr. Terry Katzer.

T. S Buqo

Thomas S Buqo

Project Manager

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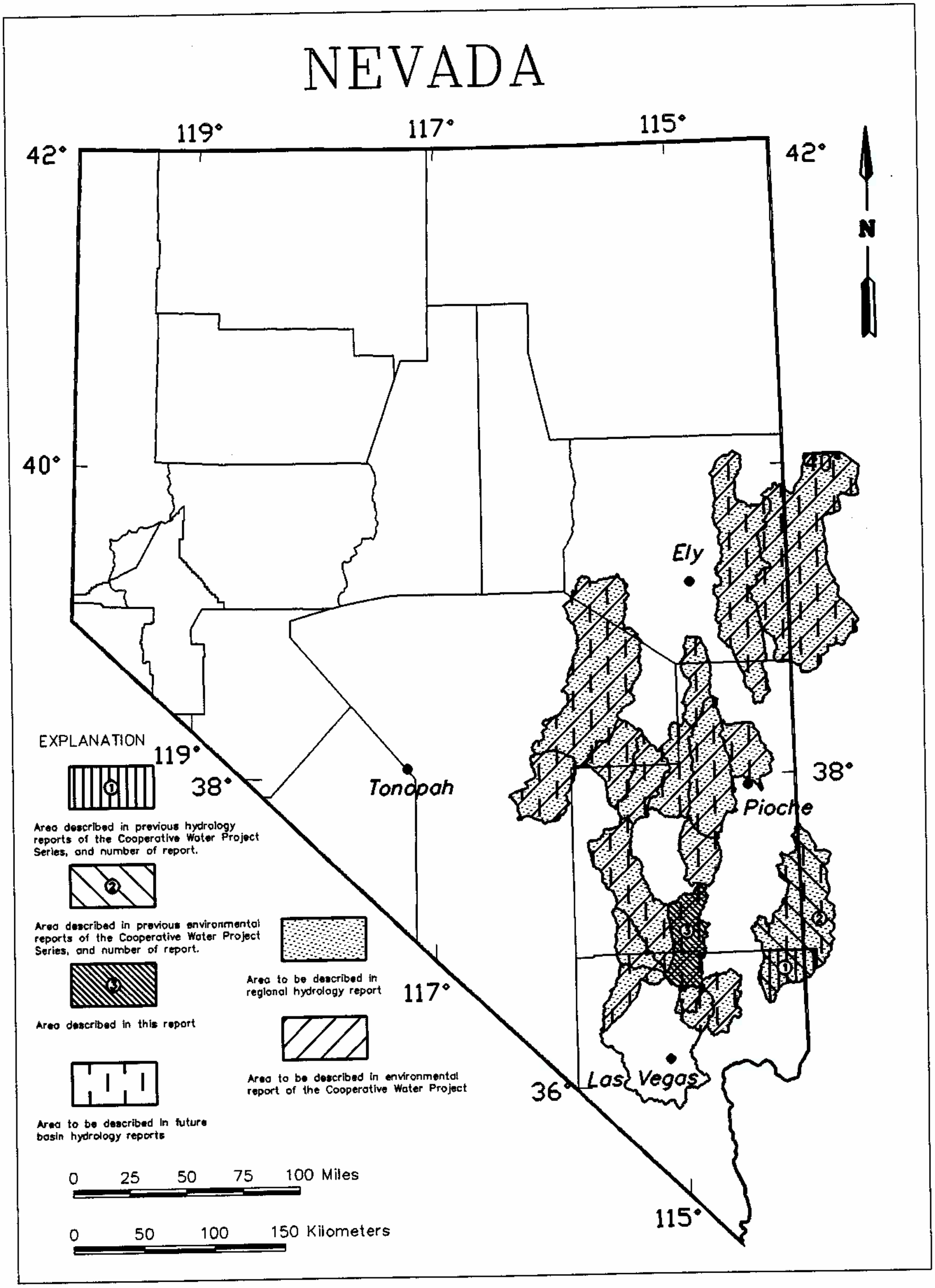

Areas described in previous reports of this series, the area described in this report and the areas to be described in future reports.

COOPERATIVE WATER PROJECT SERIES

REFERENCES

Report No.

1. Brothers, K., Tracy, J., Katzer, T., Stock, M. Bentley, C., Zdon, A., and Kepper, J., 1992, Hydrology and interactive computer modeling of ground and surface-water in the Lower Virgin River Valley, primarily in Clark County, Nevada, 1992: Las Vegas Valley Water District, Cooperative Water Project, Series Report No. 1, 90 p.

2. Woodward-Clyde Consultants, Dames and Moore, and the Las Vegas Valley Water District, 1992, Environmental report of the Virgin River water resource development project, Clark County, Nevada, 130 p.

3. Buqo, T.S., Drici, Q., and Goings, D.B., 1992, Hydrology and steady state ground-water model of Coyote Spring Valley, Clark and Lincoln Counties, Nevada, 83 p.

INTRODUCTION

In October 1989, the Las Vegas Valley Water District (District) filed five applications to appropriate ground water in Coyote Spring Valley in Clark and Lincoln Counties, Nevada. In March 1990, The Earth Technology Corporation entered into an agreement with the District to provide hydrologic and geologic services in support of these water right filings. This report details the hydrologic assessment of Coyote Spring Valley that was conducted, and the steady-state ground-water flow model developed to represent the Coyote Spring Valley's aquifer system.

BACKGROUND

Coyote Spring Valley is an arid basin located about 25 miles north of Las Vegas, Nevada (Figure 1). Although the valley is undeveloped, exploratory drilling conducted by the U.S. Air Force in the early 1980s found that the regional carbonate aquifer underlying the valley is capable of yielding large quantities of ground water.

In 1981, a well drilled into the carbonate aquifer in the east-central part of Coyote Spring Valley produced a yield of 3,400 gallons per minute, at that time the largest producing water well from the carbonate aquifer in Nevada. This discovery led to further study of the resource potential of the regional carbonate aquifer by the District, the state of Nevada, the U.S. Geological Survey, and the U.S. Bureau of Reclamation, the Desert Research Institute (DRI), and others. Although other areas have been investigated, none have shown the potential of Coyote Spring Valley for development of this regional aquifer.

The District plans to develop the water resources of Coyote Spring Valley through the development of a well field and distribution system that will convey the water to users in metropolitan areas of Clark County. Potentially, some water may be applied to industrial use in Coyote Spring Valley. Preliminary plans call for the drilling of water wells at five locations; final optimized wellfield designs will be developed in subsequent phases of the development program and will be based upon detailed planning and environmental studies.

To assist its efforts in formulating final plans for developing the water resources of Coyote Spring Valley, the District initiated a program to develop a numerical model of the ground-water flow regime of the valley. A numerical model is a computer code which translates the mechanics of ground-water flow through the earth through a series of mathematical equations. By coupling the available information on Coyote Spring Valley (and similar valleys in Nevada) with the predictive capabilities of the model, it is possible to predict the response of the ground water to the proposed water withdrawals by the District.

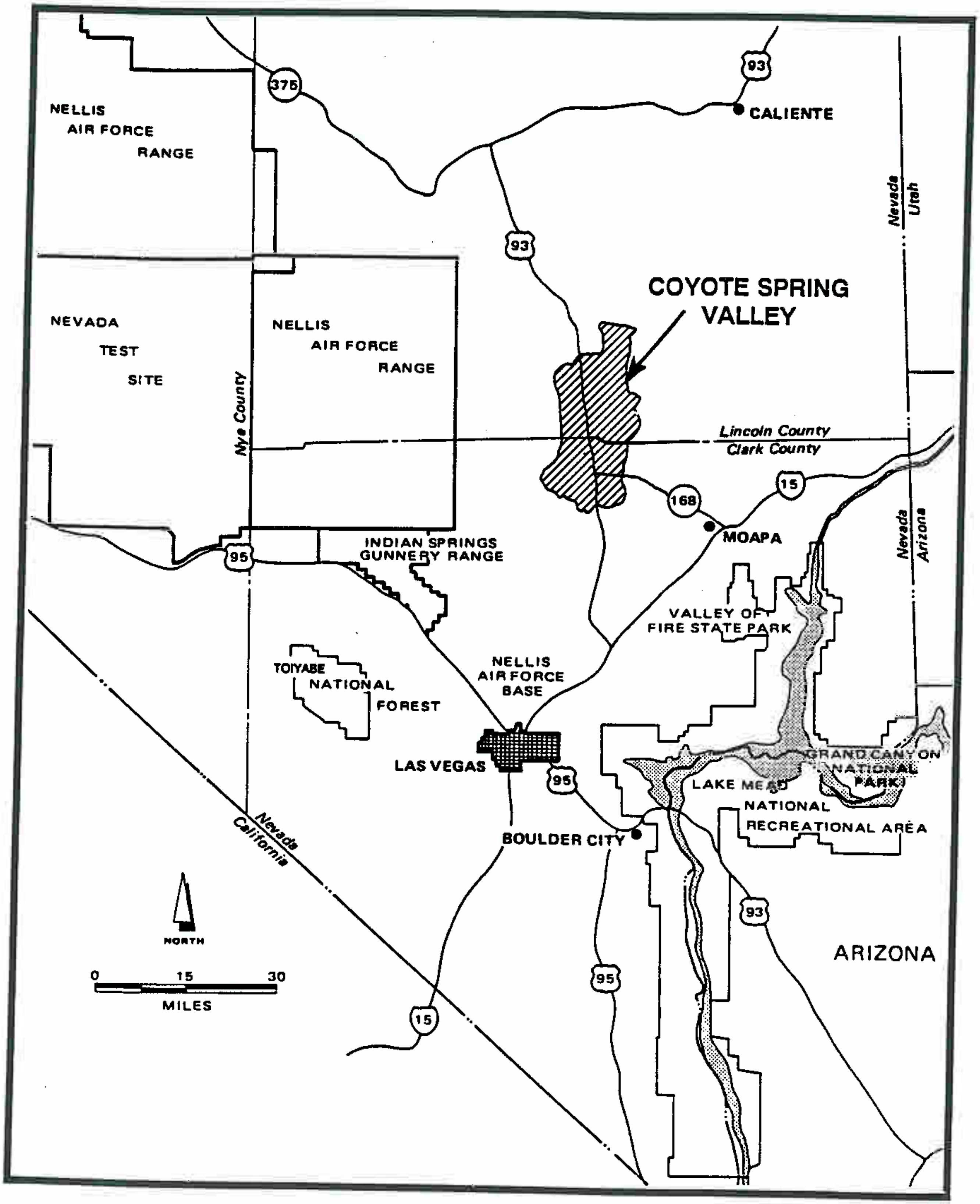

Figure 1. Coyote Spring regional map (adapted from ERTEC Western (1981)).

The development of a model of ground-water flow for Coyote Spring Valley serves two important purposes; first, it is a useful planning tool in developing well field designs by allowing water supply design experts to simulate the efficiency of different design alternatives; secondly, it allows planners to simulate the potential effects of the water withdrawals, if any, on neighboring water users, or the environment.

Both beneficial and negative impacts may result from ground-water withdrawals from the valley-fill deposits and/or the regional carbonate aquifer in the arid basins of Nevada. The benefits derived from the application of currently unused groundwater to beneficial use is, of course, the primary positive impact. The economic impact of large-scale ground-water development programs, such as that proposed by the District, is likely to be appreciable and the project is likely to result in significant short-term and long-term economic benefits. The proposed program will require the cooperative efforts of large teams of scientists, engineers, and water planners, and the services of the water well and construction industries.

Beside the favorable economic impacts expected to result from the proposed development of ground water in Coyote Spring Valley, negative impacts can occur. The primary negative impact of ground-water withdrawals is the lowering of ground-water levels in the vicinity of the production wells; this lowering of water levels is commonly referred to as drawdown. In general, if the drawdown near a pumping well, or a wellfield, is significant, then the direction and rate of ground-water flow can be altered and may result in:

- Increased pumping lifts and costs for existing water users;
- Reductions in spring-flow rates;
- Reductions in surface-water flows; and
- Degradation of water quality.

The magnitude and significance of these impacts depends largely upon the overall hydrologic setting of the basin where the withdrawals occur. In remote, undeveloped or underdeveloped basins with no surface water or large springs (such as Coyote Spring Valley), the drawdown that will result from ground-water development may not result in significant adverse impacts. In other instances, the presence of sensitive environments in a valley may be adversely impacted as a result of the same amount of drawdown. Examples of sensitive environments in Nevada include: 1) wetland areas that provide valuable habitat for many types of wildlife; 2) surface water flows and their associated riparian habitats; 3) springs that either support wildlife or have been developed for ranching, mining, quasi-municipal, or domestic uses; and 4) areas where ground water provides the sole source of drinking water for a community.

Because many of the basins in eastern and southern Nevada are hydraulically linked, via the regional carbonate aquifer, into vast flow systems, the drawdown that results from the development of ground water in one valley can ultimately impact the environment of another valley. Thus, the development of a numerical model of ground-water flow to simulate the impacts of pumping must take into account the environment in peripheral valleys as well as the valley actually being modelled.

For example, although there are no large springs or developed areas in Coyote Spring Valley, the valley is in direct hydraulic communication with other valleys. At the Muddy River Springs area in Moapa Valley, a series of large springs that discharge ground water from the regional carbonate aquifer are the dominant hydrologic feature of the region. According to scientific studies, the water discharged from these springs is derived almost exclusively from the large carbonate reservoir under Coyote Spring Valley. These springs, collectively discharging about 36,000 acre-ft per year at a rate of more than 50 cfs, have provided an important source of water for man since prehistoric time. Today, these springs continue to provide an important source of water for the Moapa Band of the Paiute Indians and other users. The discharge at the springs also provides water for wildlife and sustains a habitat that supports a variety of aquatic species.

The presence of the sensitive environment at the Muddy River Springs Area is an important factor that must be taken into account if the vast, proven water resources of Coyote Spring Valley are to be developed. Extensive testing of the regional carbonate aquifer in Coyote Spring Valley was conducted by the Air Force in the early 1980s at the request of the Nevada State Engineer to determine the potential impacts of ground-water development in the valley on this sensitive environment. This testing, and subsequent work reported by the U.S. Geological Survey, suggest that development of the water resources in Coyote Spring Valley, if carefully planned and implemented, can be done in a manner that minimizes undesirable impacts on this sensitive environment.

The use of numerical methods to simulate the hydrologic conditions in Coyote Spring Valley can provide a tool that may be used for predicting the effects that would be expected to result from the proposed District development plan. Recently, the U.S. Geological Survey has reported the findings of a cooperative study of the water resources potential of the carbonate aquifer conducted in cooperation with the U.S. Bureau of Reclamation, state and local agencies, including the District (Dettinger, 1989). This report recommends the effective use of computer models for predicting the site-specific effects of water withdrawals from the carbonate aquifer. The report concluded that increased confidence in such predictions can be achieved through a staged approach to development coupled with adequate monitoring and interpretation. The development of a computer model of the steady-state ground-water regime in Coyote Spring Valley performed as part of this investigation represents one of the first steps in implementing such a staged approach. Subsequent steps, such as the development of the transient flow model, will be performed by the District.

The steady-state model, described in detail in this report, provides a preliminary representation of the aquifer system based upon the information available at this time. As additional data becomes available through District efforts, the model of the ground-water regime in Coyote Spring Valley can be updated accordingly to provide even more refined simulations.

PURPOSE AND SCOPE

The purpose of this investigation was twofold: 1) to define the hydrologic conditions of Coyote Spring Valley, and 2) to develop a calibrated ground-water flow model of the valley. The District will use the numerical model to simulate the potential impacts of the proposed water development. The specific objectives of these investigations were to:

- Collect land use data in the valley;
- Compile and review published reports and unpublished data on the basin;
- Interpret the available data and determine the characteristics of the basin; and
- Prepare a computer model to simulate the steady-state ground-water flow in the basin.

To achieve these objectives, a detailed investigation of the hydrologic conditions of Coyote Spring Valley was conducted. The scope of work included a review of all available published and unpublished data, the evaluation of the occurrence and movement of ground water and water chemistry, and the development of conceptual and steady-state numerical models of the hydrogeologic regime of the valley. The basin characterization information and steady-state flow model discussed in this report will be used by the District to develop a transient model of the valley's ground-water regime.

LOCATION AND PHYSIOGRAPHIC SETTING

Coyote Spring Valley is within the Great Basin Physiographic Region as defined by Fenneman (1931). Figure 2 shows the topographic expression of the valley and the basin boundaries as defined by the Nevada State Engineer. The valley is located between the Kane Spring Valley to the east; the Sheep Range to the west; the Arrow Canyon Range to the southeast; the Las Vegas Range to the southwest; the Delamar Valley to the northeast, and the Pahranagat Valley to the northwest.

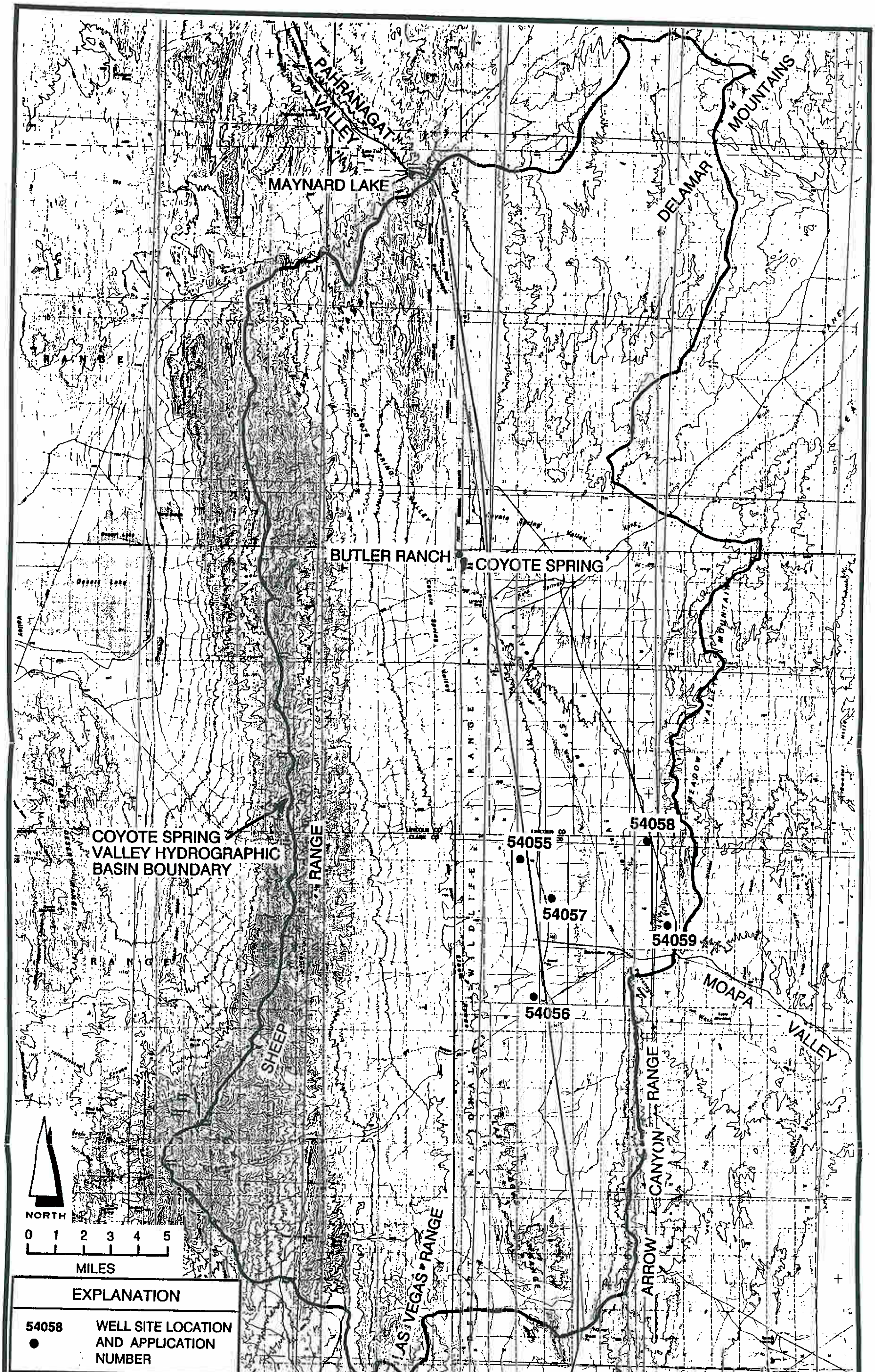

Figure 2. Physiography and location of Coyote Spring Valley. Base maps are 1:100,000 scale maps for the Indian Springs, Pahranagat Range, Clover Mountains, and Overton 30'x60' Quadrangles.

Coyote Spring Valley is approximately 41 miles along its central axis, approximately 17 miles wide and covers 657 square miles (Scott, et al., 1971). The valley floor is a segment of a large topographic trough that includes, from north to south, White River Valley, Pahroc Valley, Pahranagat Valley, Coyote Spring Valley, and Moapa Valley. The present day lowland of Coyote Spring Valley is the former flood plain of the White River, which forms the topographic axis of the valley. This presently dry streambed is now called Pahranagat Wash on topographic maps of the area. Pahranagat Wash slopes southward through Coyote Spring Valley from the gap at Maynard Lake, at an altitude of about 3,120 feet. Approximately 30 miles south of the gap the channel is about 1,000 feet lower.

The valley floor ranges in elevation from approximately 3,810 feet on the alluvial fans to less than 2,134 feet near the outlet for the valley. On the west, Coyote Spring Valley is bounded by the Sheep Range which rises to an elevation of 9,911 feet above mean sea level at Hayford Peak. On the southeast, the valley is bounded by the Arrow Canyon Range with a maximum elevation of 5,203 feet above mean sea level at its highest point. The southwestern part of the basin is bounded by the Las Vegas Range with a maximum elevation of approximately 4,931 feet.

The physiography of Coyote Spring Valley is similar to that of adjacent areas in southern Nevada; mountains rise on the east, west and north. Alluvial fans radiate from the major mountain watersheds, forming a somewhat continuous bajada. On the valley floor, the major feature is Pahranagat Wash, a partially incised ephemeral stream. In areas where the brown claystones of the Muddy Creek Formation crop out, the topography is characterized by badlands erosion that is almost devoid of vegetation.

AVAILABILITY OF DATA

Coyote Spring Valley is located in a remote and unpopulated portion of Clark and Lincoln Counties, however, a number of evaluations of the water resources of the area have been performed. As a result of these evaluations, and the limited development that occurred historically in the valley, conditions in the valley have been relatively well defined. A total of 13 wells exist in Coyote Spring Valley, for which some level of data either exists, or existed at one time. The locations of these wells are shown in Figure 3. As shown, the distribution of data points in the valley, although not ideal, does provide for coverage of a large area.

Perhaps more important is the level of data that is available. Previous investigations of Coyote Spring, Nevada, and adjacent areas, have generated an extensive data base on some parts of the valley. These data provide specific measures or estimates of the

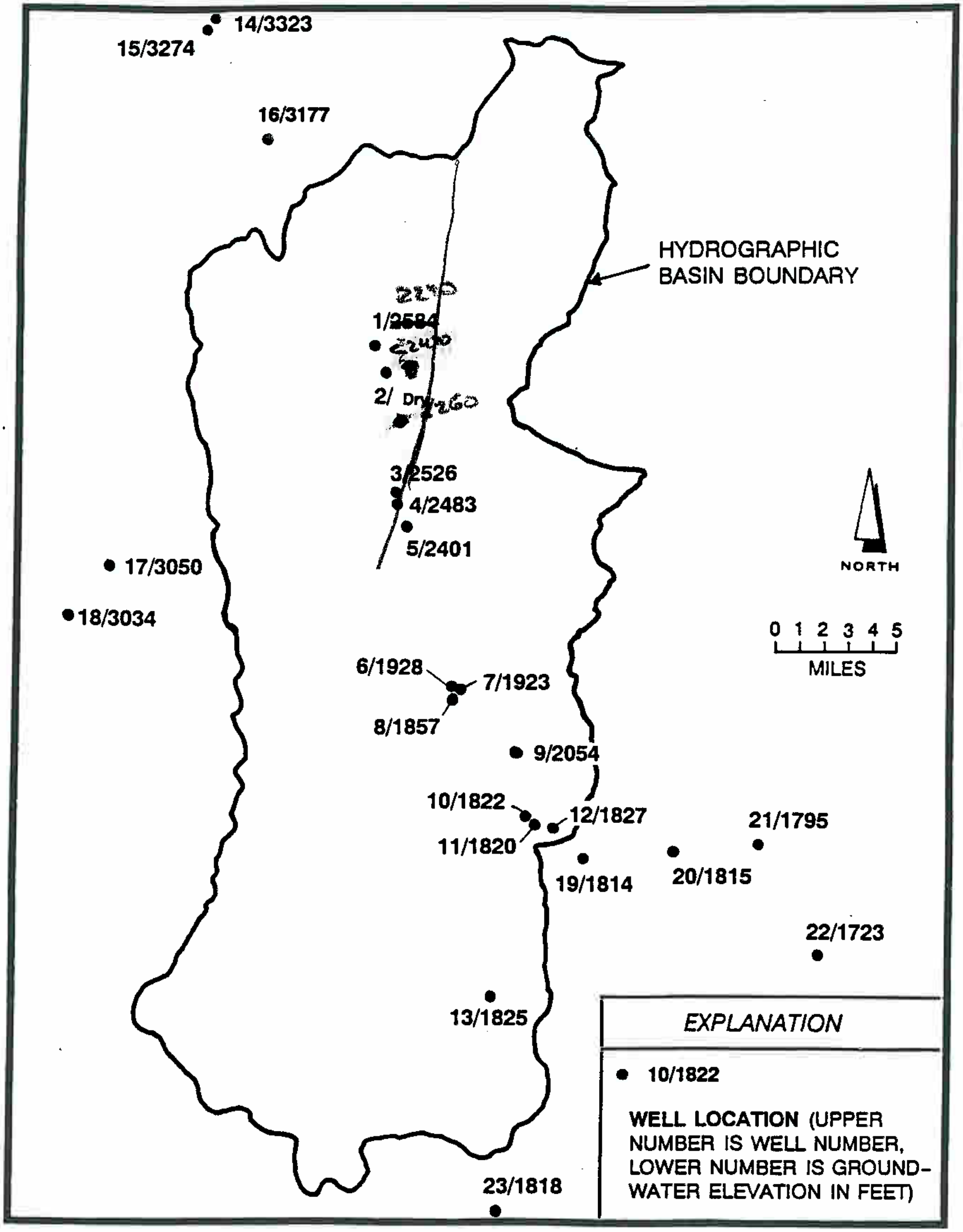

Figure 3. Existing wells in Coyote Spring Valley.

ground-water conditions at selected points in time and values for key hydrologic parameters.

Several of the wells that were drilled as part of the Air Force's MX investigations extend through the valley-fill into the underlying carbonate rocks. Summary information of each of the wells for which data was available is listed in Table 1, with individual well numbers keyed into Figure 3. It was from the data collected at these locations, the observations made during reconnaissance trips to the valley, and the knowledge of the overall regional ground-water setting, that both the conceptual and numerical models of Coyote Spring Valley, discussed later in the report, were based. Appendix A provides an explanation of the well location designations used in this report.

Although not extensively developed, there have been a number of studies of the valley that provide both data and interpretations useful in understanding and modelling the water resources potential. Previous investigators have included Eakin (1964); Winograd and Thordarson (1975); Guth (1980); Ertec Western (1981); Thomas et al. (1986); Thomas (1988), Kirk and Campana (1988), and Dettinger (1989). The sources of recent data available for Coyote Spring Valley include: 1) details on water well construction from Well Drillers Reports filed with the Nevada State Engineer Office; 2) water level, spring discharge, and water chemistry data and the results of aquifer tests from the U.S. Geological Survey databases; and 3) the results of aquifer tests and exploratory drilling into the carbonate aquifer by the Air Force during 1980 and 1981.

Other available data included technical reports of the Nevada Department of Conservation and Natural Resources, U.S. Geological Survey Professional Papers, Water-Supply Papers, and Open-File Reports and cooperative reports on the regional carbonate aquifer study conducted in 1988. Characterizations of the regional setting, particularly those by Eakin (1964), Kirk and Campana (1988), and the recent publications by the U.S. Geological Survey, provide important, and accepted regional interpretations that are also of considerable use in evaluating Coyote Spring Valley.

Information on the status of water rights in Coyote Spring Valley was made available by Summit Engineering Corporation (SEC) in the form of water right abstracts. According to SEC, these abstracts were based upon a thorough compilation and review of the public documents available from the Nevada State Engineer Office, the regulatory authority governing water rights in Nevada.

METHODS

In assessing the water resources potential of Coyote Spring Valley, and developing a numerical simulation of the ground water conditions, only standard approaches and

Table 1. Water Level Data for Coyote Spring Valley.

Site No.	Location Long.	Location Lat.	T R S	Drill Date	Surface Elev.	Well Depth	Water Depth	Water Elev.	Source Unit[A]	Data Source[B]	Basin No.	Site Name
1*	1145954	370457	10S 62E 14a	-	2712	510	416	2296	V	1	210	Van Horn #1
2	-	-	10S 62E 24b1	05-02-58	2685	231	dry	dry	-	1	210	Van Horn #2
3*	1145929	365908	11S 62E 13db	-	2540	-	14	2526	V	1	210	Judy's Ranch
4*	1145913	365926	11S 62E 13dbcb1	06-24-70	2520	100	37	2483	V	1	210	C.S. Inc. (Buckhorn)
5*	1145910	365834	11S 62E 24dbad1	-	2490	149	89	2401	V	1	210	Unnamed #1
6	1145643	365231	12S 63E 29adcc1	11-13-80	2470	714	542	1928	V	2	210	CE-VF-1
7	1145543	365231	12S 63E 29adcc2	00-00-80	2470	710	547	1923	V	1	210	CE-DT-1
8	1145544	365227	12S 63E 29dacc	12-15-81	2467	1221	610	1857	C	2	210	CE-VF-2
9*	1145411	365008	13S 63E 11bacd1	00-00-54	2220	170	166	2054	U	1	210	Old Highway Well
10	1145332	364744	13S 63E 23ddd1	11-20-80	2180	669	345	1827	C	2	210	CE-DT-4
11	1145328	364741	13S 63E 26aaaa	04-14-81	2169	628	349	1820	C	2	210	CE-DT-5
12	1145245	364730	13S 63E 25a1	05-04-44	2159	353	332	1827	U	1	210	Perkins
13	1145530	364127	14S 63E 28addd	11-24-85	2414	780	589	1825	V	2	210	CSV-3
14	1150726	371700	08S 61E 2cb	00-00-47	3344	92	21	3323	V	1	209	Lamb
15	1150711	371607	08S 61E 11bb	-	3322	-	48	3274	V	1	209	VSF&W #1
16	1150104	371213	08S 62E 31cc	-	3200	64	22	3177	V	1	209	VSF&W #2
17	1151152	365711	11S 60E 36aa	00-00-86	3208	420	158	3050	U	1	169	DDL - 1
18	1151341	365502	12S 60E 10ad	00-00-89	3250	460	216	3034	C	1	169	DDL - 2
19	1145143	364601	13S 64E 31aad	10-16-85	2159	765	344	1814	V	2	219	CSV #1
20	1144713	364604	13S 64E 35acaa	05-21-81	2275	937	460	1815	C	2	219	CE-DT-6
21	1144320	364650	13S 65E 28bdac	10-26-85	2185	478	391	1795	C	2	219	CSV #2
22	-	-	15S 65E 23aa	-	-	-	-	1723	V	1	219	Unnamed #2
23	1145530	363306	16S 63E 9ddab	-	2649	920	831	1818	U	2	217	SHV-1

[A] Hydrogeologic unit in which well is completed; C=Carbonate, V=Valley-fill, U=Unknown
[B] 1. USGS Unpublished Data; 2. Berger, et al., (1988)
*Perched water, not used for water-level control (Eakin, 1964).

procedures were used. In this section, the methods and procedures that were used are identified and discussed, along with brief discussion of the numerical modelling code used.

Data Collection and Compilation

No collection of primary hydrologic data (i.e., new field measurements), were performed as part of this investigation. Data from the U.S.G.S. Water Resources Division's databases that included the most recent measurements available were provided through the District along with well drillers reports, published reports, and maps. A literature search was conducted to identify and compile data from available published sources.

The locations and data sources were verified by comparing reported or entered data point locations and parameters with field observations and/or the published source of information. Spatial data sets (e.g., water levels, water chemistry, and water right locations), were plotted at uniform scales and annotated. The resulting maps were inspected for anomalous values and further verification was performed to resolve any anomalous data points.

Numerical Model Development

The model used to simulate the ground-water regime of Coyote Spring Valley is a computer code prepared by the U.S. Geological Survey and referred to as MODFLOW (for "Modular Three-Dimensional Finite-Difference Ground-Water Flow Model"). The U.S. Geological Survey has prepared comprehensive documentation for this code in one of their series of manuals on techniques of water-resources investigations (McDonald and Harbaugh, 1988). An overview of the code, a discussion of the general approach used in modelling, and the specifics of the model developed for the basin are detailed in the "Steady-State Model Development" section.

GENERAL HYDROGEOLOGIC FEATURES

The development of numerical simulations of the proposed District ground-water withdrawals in Coyote Spring Valley requires a thorough understanding of the hydrologic regime of the basin. The information that is available concerning the valley, and adjacent or similar areas, is used to develop a conceptual model of the source of water in the valley, its occurrence and flow in the subsurface, and the relationship between the valley and adjacent areas. In this section, the regional and valley-specific hydrologic conditions in Coyote Spring Valley are described and discussed.

REGIONAL AND BASIN HYDROGEOLOGIC FEATURES

Coyote Spring Valley is situated in the Alluvial Basins Ground-water Region as defined by Heath (1984). Individual hydrographic basins in this region are characterized by alluvial basins that are underlain by bedrock, and are separated by the bedrock outcropping in the bounding mountain ranges, or, in some instances, by lower divides in alluvial terrain.

When ground water flows from one basin to another, the basins are termed a flow system. The Coyote Spring Valley hydrographic basin is located in the Colorado Flow System as defined by Harrill, et al. (1988). This flow system comprises 35 individual hydrographic basins as shown in Figure 4; thus some part of the ground water under Coyote Spring Valley is believed to have originated as rainfall in upland areas more than a hundred miles to the north. This water, after being discharged from the basin, ultimately reaches the Colorado River through a complicated pathway of ground-water flow, springs, and surface water flow.

The general patterns of interbasin flow in the White River Flow System are shown in Figure 5. The overall component of regional ground-water flow is to the south. Within individual valleys in the flow system, recharge from the bounding mountain ranges results in a local flow component that generally coincides with the topography (i.e, from the mountains toward the axes of the valleys or toward playas with downward vertical hydraulic gradients).

Coyote Spring Valley receives an appreciable amount of subsurface underflow primarily through the rocks that occur at the southern end of Pahranagat Valley, and unknown quantities of underflow from other adjacent basins. This water flows under the valley and discharges, through underflow, to the Muddy River Springs Area.

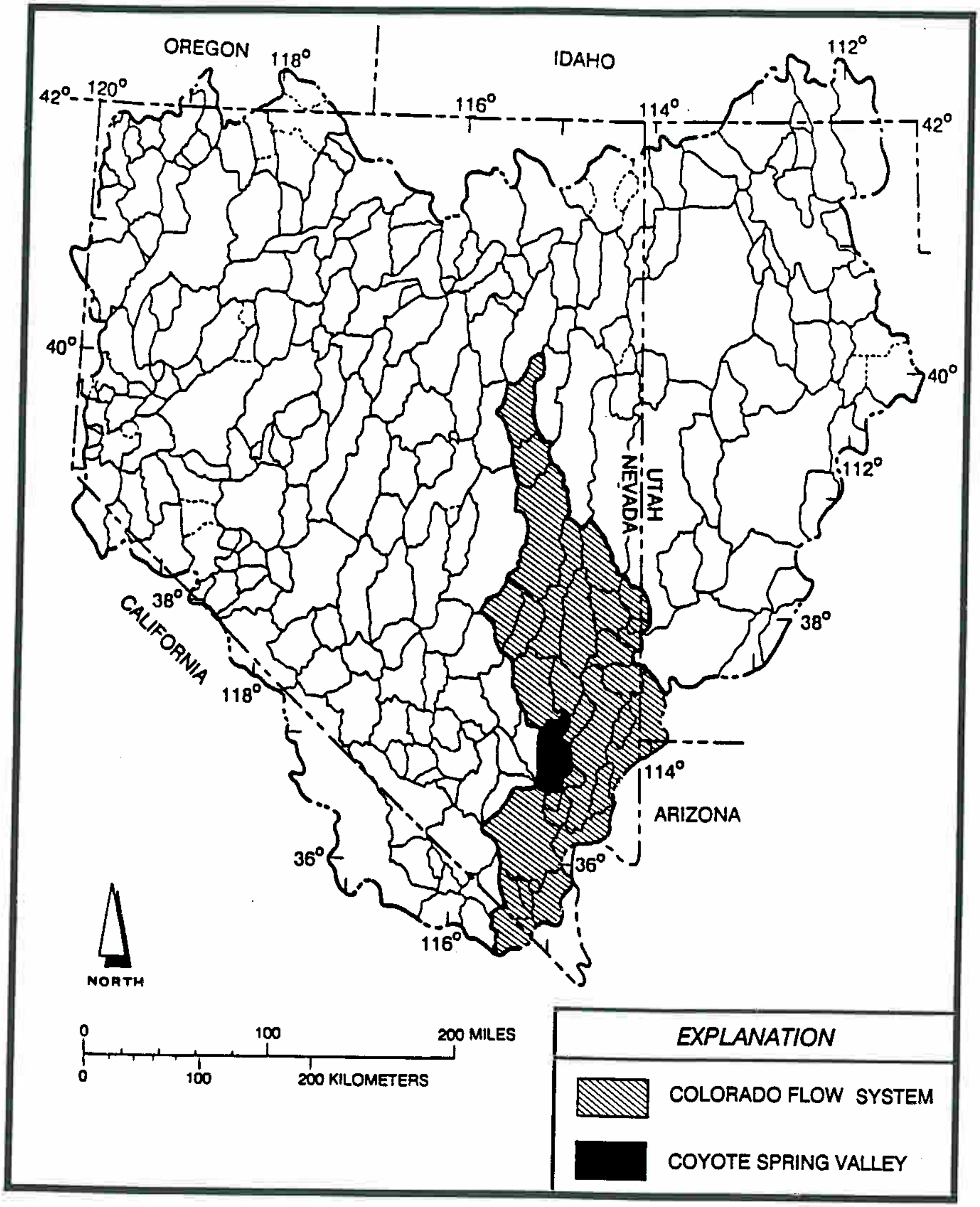

Figure 4. Hydrographic basins in the Great Basin (adapted from Harrill, et al. (1988)).

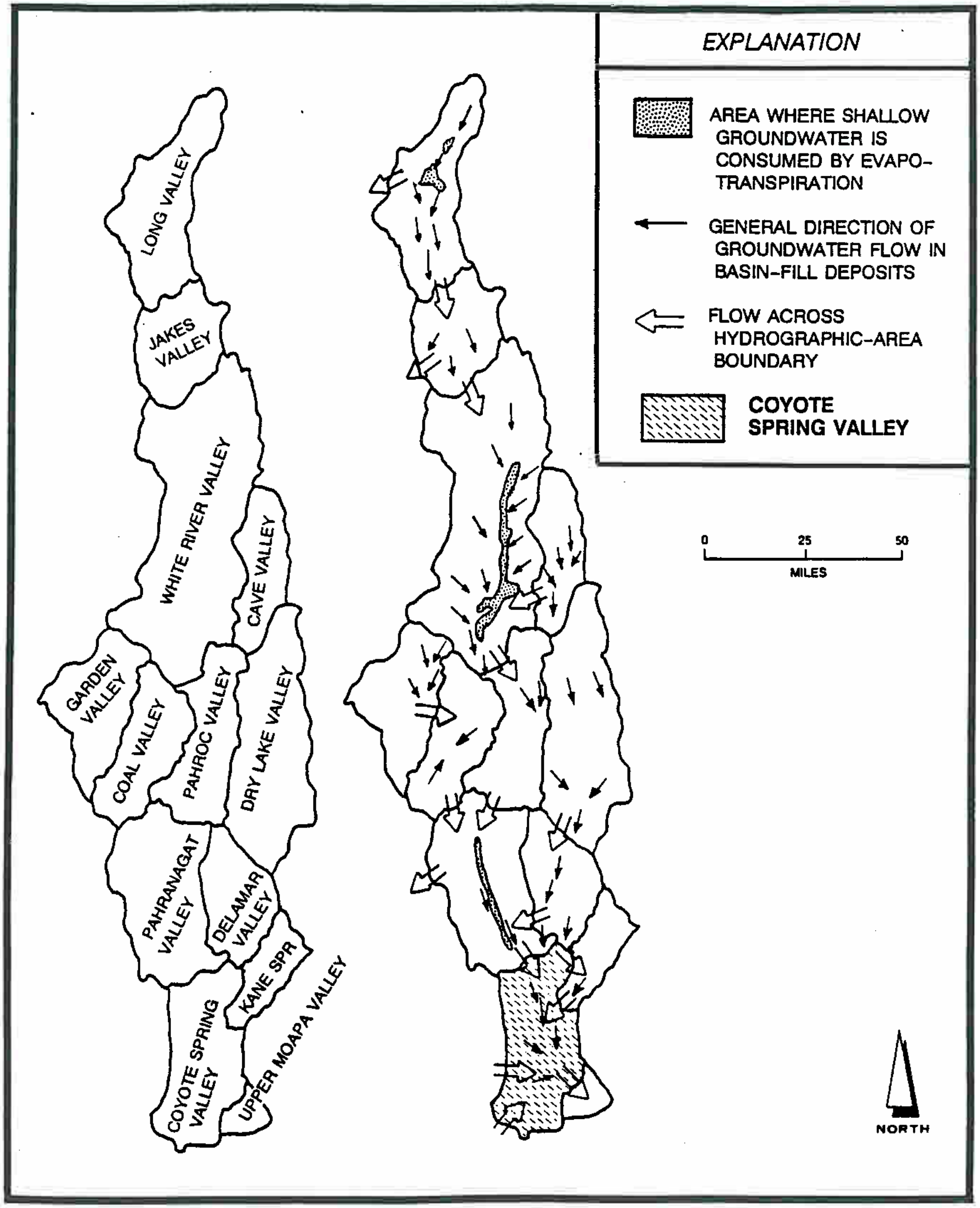

Figure 5. General patterns of interbasin flow in the White River Flow System (adapted from Harrill, et al. (1988)).

LITHOLOGIC AND HYDROLOGIC FEATURES

The geologic units present and their ability to store and transmit ground water are important considerations in developing both conceptual and numerical models of Coyote Spring Valley. The type, thickness, depth, and water-bearing properties of the geologic materials in the valley can be used to define the overall water resources potential. In this section, the geologic units present in Coyote Spring Valley and their hydraulic properties are described and discussed.

Hydrostratigraphy

The hydrostratigraphy of Coyote Spring Valley has been well defined. Based upon the work of Winograd and Thordarson (1975), and Ertec Western (1981), six consolidated rock hydrostratigraphic units in the valley comprising fourteen stratigraphic units were defined. These units, in descending order, include: 1) Tertiary volcanic rocks (aquitard); 2) Muddy Creek Formation (aquitard); 3) Bird Spring Formation, Monte Cristo Limestone, Sultan Limestone, Lone Mountain Dolomite, and Ely Springs Dolomite (aquifer); 4) Eureka Quartzite (aquitard); 5) Pogonip Group and Middle and Upper Cambrian Limestone and Dolomite (aquifer); and 6) Chisolm and Pioche Shales, Prospect Mountain Quartzite, and Precambrian clastic rocks (aquitard). For unconsolidated sediments, Eakin (1964) had previously identified two units that overlie this sequence, younger valley-fill and older valley-fill.

Based upon these reports, a hydrostratigraphic column for Coyote Spring Valley was developed (Figure 6). This column includes the younger and older alluvium, and the six units identified above. Although a total of at least sixteen hydrostratigraphic units are known to be present, for the purpose of the conceptual model, only four distinct hydrostratigraphic units are defined. They consist of 1) the alluvial sediments (the younger and older valley-fill deposits) including the Muddy Creek Formation; 2) the carbonate rocks of the Bird Spring Formation and other units above the Eureka Quartzite; 3) the Tertiary volcanics and 4) the Precambrian and Cambrian clastic aquitard. Figure 7 shows the distribution of each of the hydrostratigraphic units in Coyote Spring Valley.
Cross-sections of the subsurface geologic conditions in Coyote Spring Valley were prepared at two scales to graphically exhibit the distribution of geologic units and structures. Regional cross-sections, illustrating the major features described in the discussion of structural features found later in this report, are shown in Figure 8; these regional cross-sections span the valley and provide a general indication of the subsurface conditions. Larger scale cross-sections (Figures 9 and 10) were also prepared to illustrate the inferred geologic conditions in the immediate vicinity of the points of diversions listed on the District water right applications.

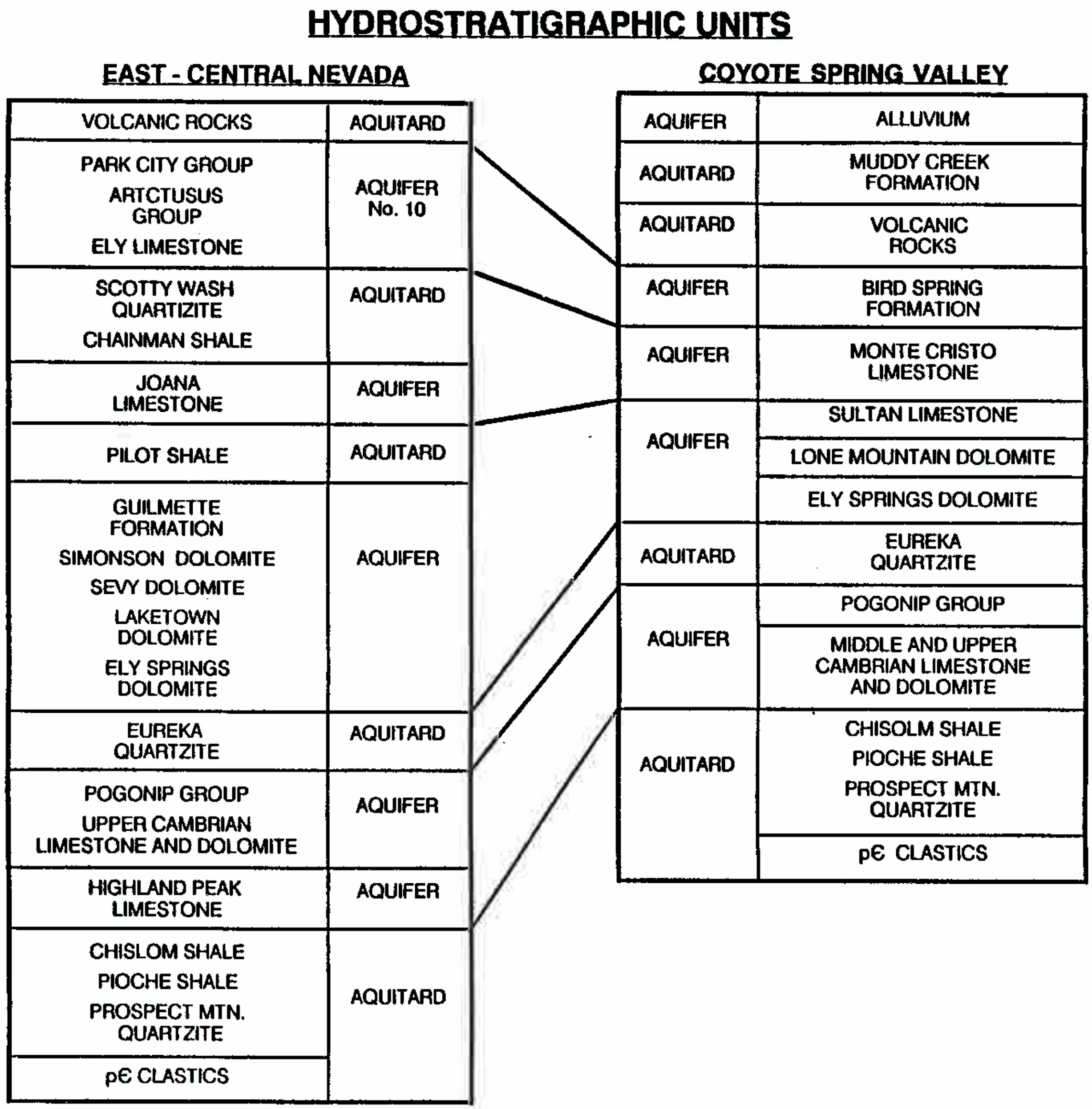

Figure 6. Relationship between hydrostratigraphic units and lithostratigraphic units (adapted from Ertec Western, 1981).

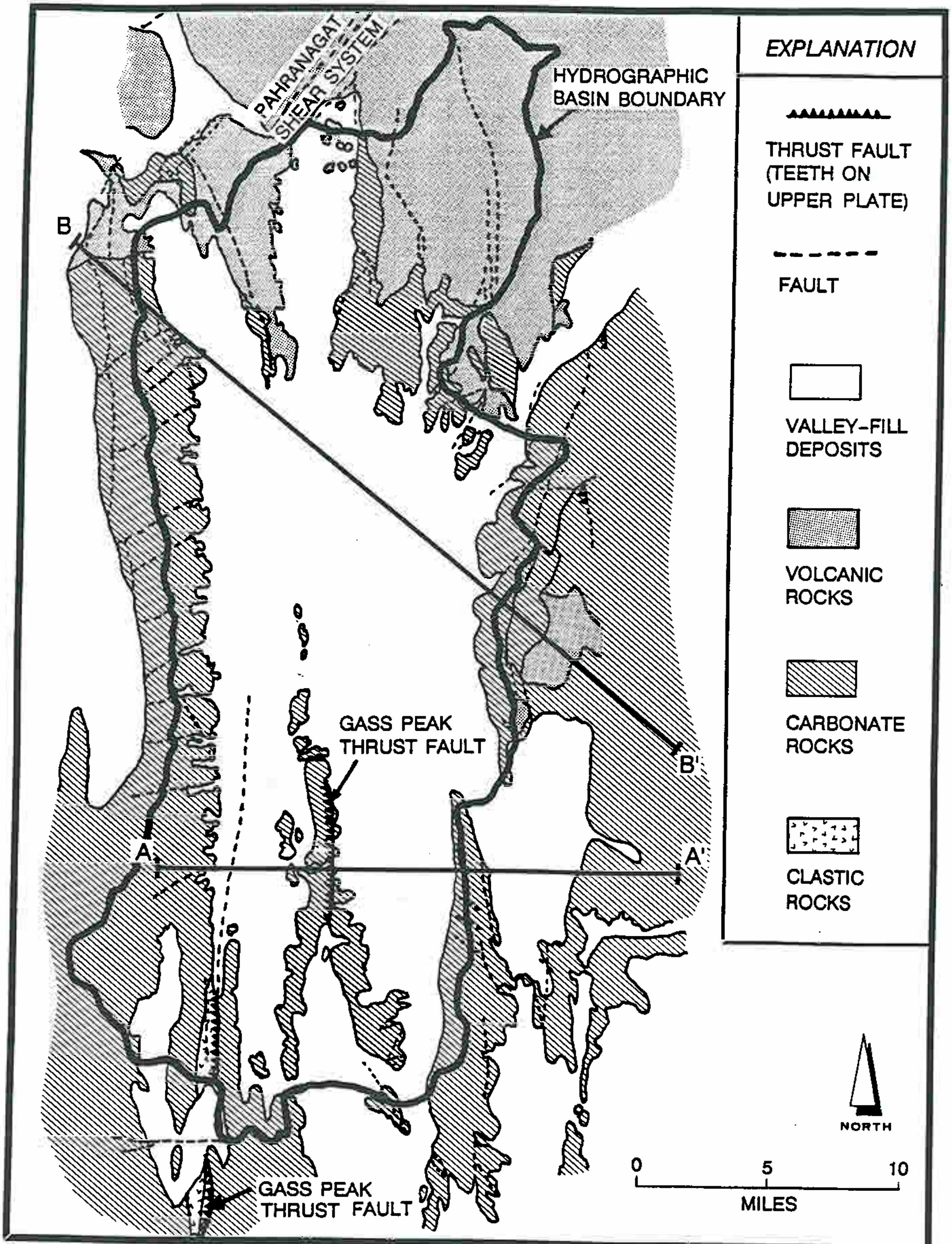

Figure 7. Hydrogeologic map of Coyote Spring Valley (adapted from Longwell, et al. (1965)).

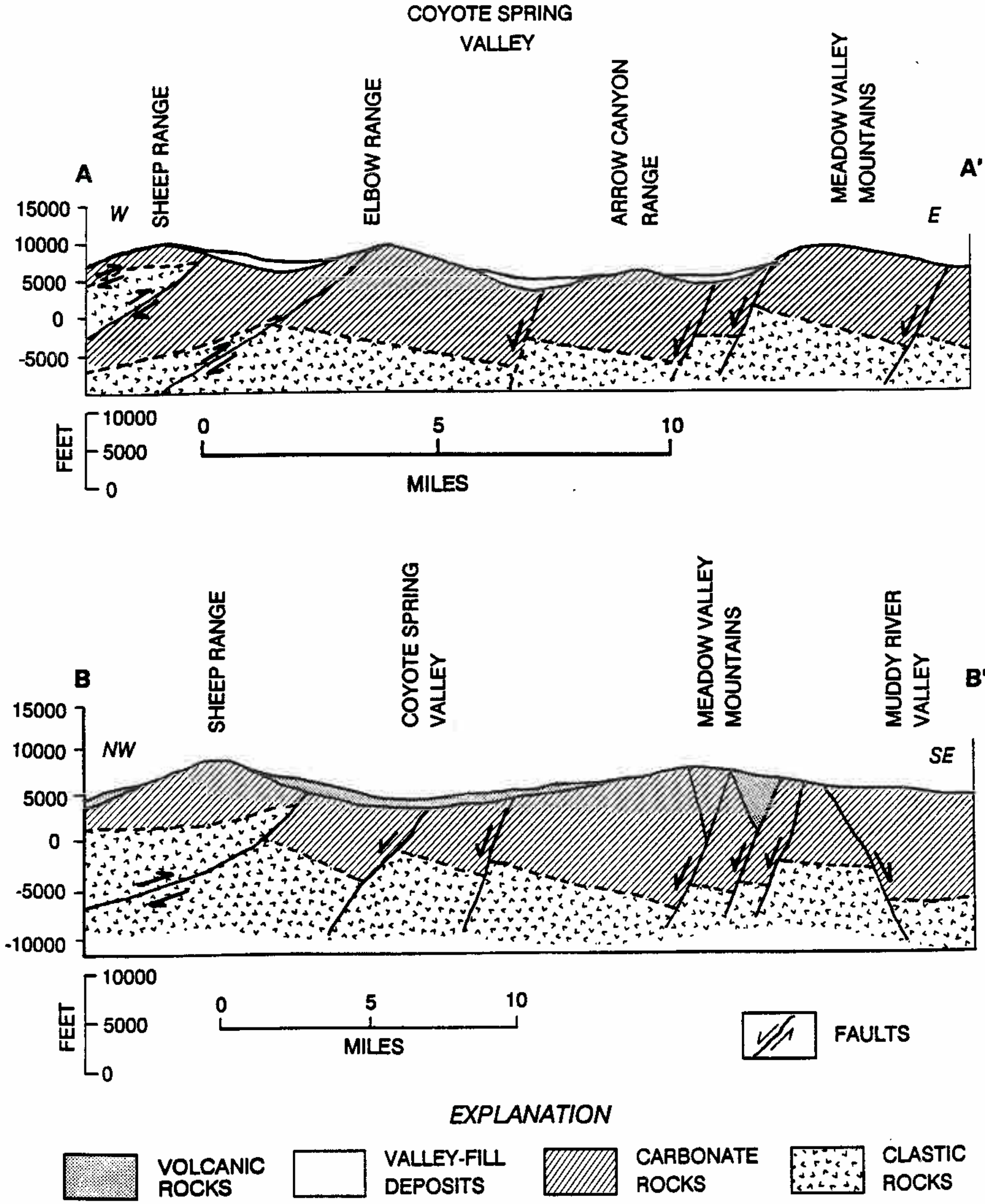

Figure 8. Regional cross–sections through Coyote Spring Valley (adapted from Longwell, et al (1965)).

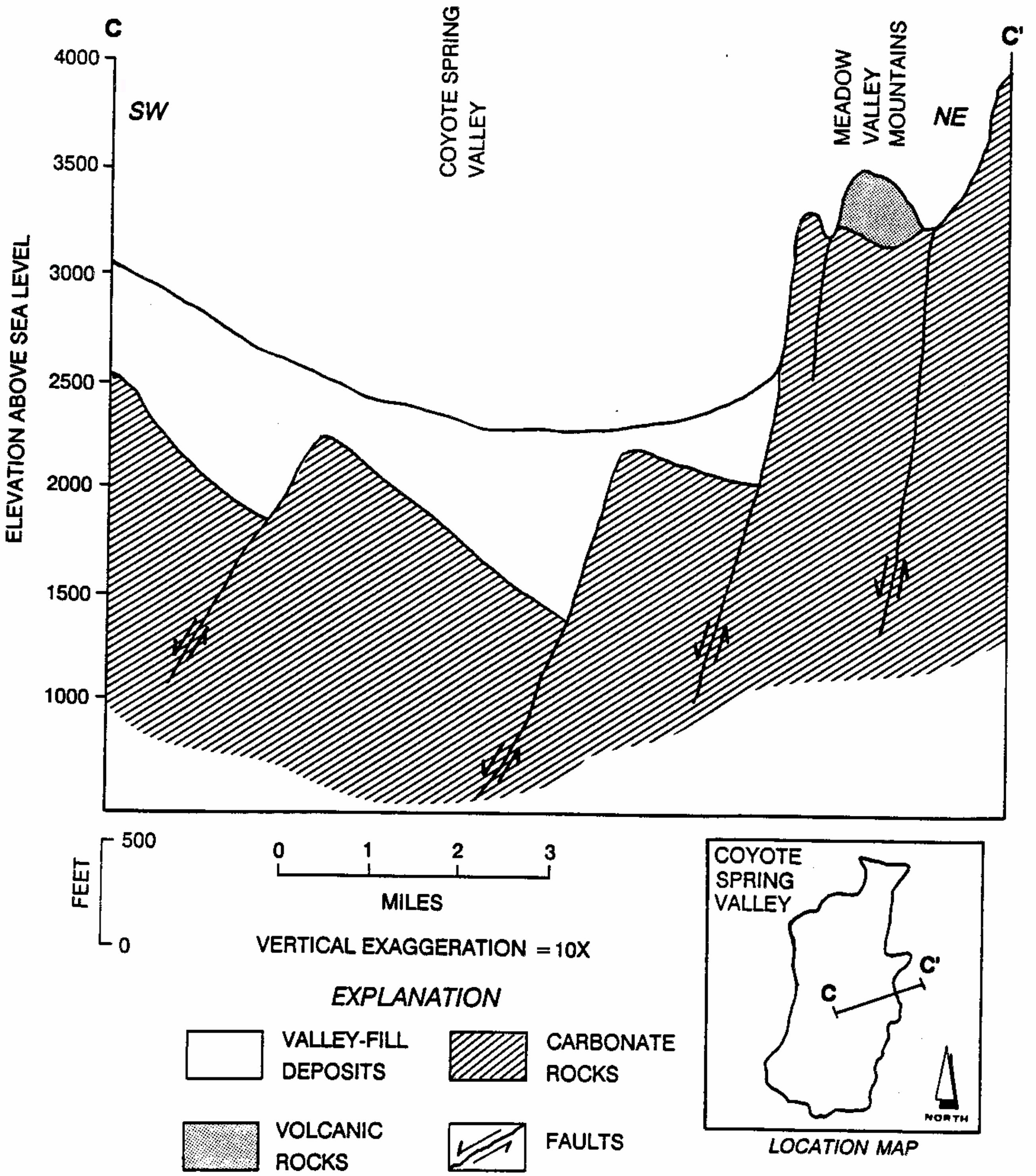

Figure 9. First conceptual hydrogeolgic cross–section through the proposed District well field.

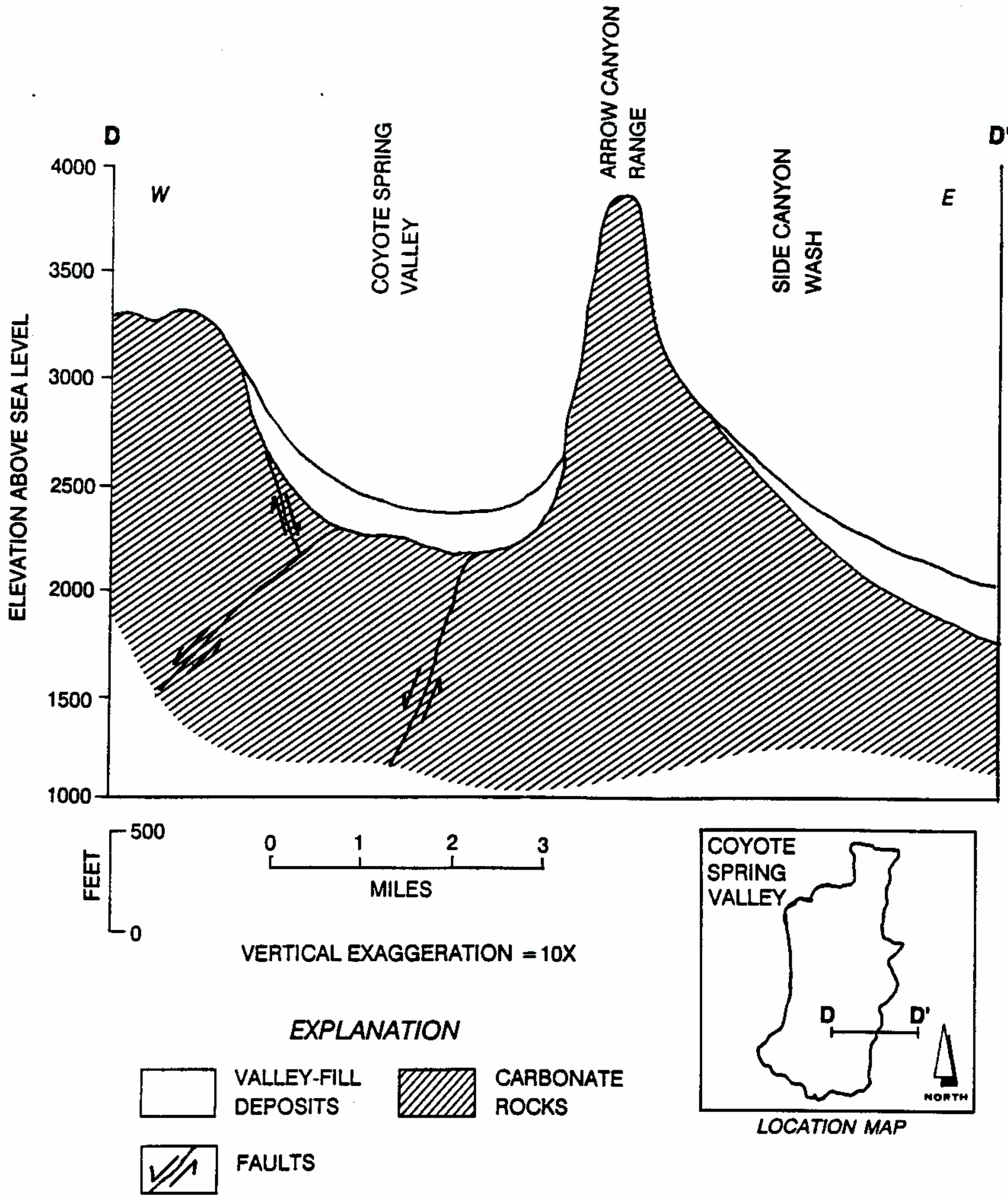

Figure 10. Second conceptual hydrogeolgic cross–section through the proposed District well field.

These localized cross-sections, although largely conceptual, provide a characterization of the expected hydrologic regime in the area targeted for development by the District.

Cross-section C-C' runs east-north-east to west-south-west, from the center of Coyote Spring Valley (Basin 210) generally eastward across the Meadow Valley Mountains and into the Lower Meadow Valley Wash (Basin 205). Elevation across the section ranges from a low of 2,240 feet in the center of Coyote Spring Valley to a high of 4,000 feet in the Meadow Valley Mountains. At the surface, the western three-quarters of the cross-section has a thick layer of alluvial valley-fill, while the easternmost quarter transects Paleozoic carbonates and Tertiary volcanics.

From west to east, Tertiary and Quaternary valley-fill covers fault blocks of the Paleozoic carbonate aquifer. Along the eastern portion of the cross-section, the Paleozoic carbonates are partly covered by Tertiary volcanics.

The valley-fill, largely Tertiary and Quaternary clays, sands, and gravels, ranges in thickness from 0 feet at the edge of the valley-filled sequence to almost 900 feet in the center of Coyote Spring Valley. Thickness of the valley fill is fault-controlled to a large degree. The water table in the alluvium is about 550 feet below the surface in the cross-section area. Saturated alluvium exists only in the center of the valley, and is about 350 feet thick at maximum.

The District water well applications #54055 and #54058 are located on the cross-section in the valley-filled alluvium. The District water well application #54059 is located three miles south of the cross-section, also situated in valley fill.

Cross-section D-D' runs east-west, from the center of Coyote Spring Valley (Basin 210) eastward across the Arrow Canyon Range, and into the Muddy River Springs Area (Basin 219). Elevation across the section ranges from 2,360 feet in the valley to 4,110 feet along the crest of the Arrow Canyon Range. A thick sequence of valley-fill is located along the western half of the cross-section at the surface. It is flanked on the west by Paleozoic carbonates and on the east by Paleozoic carbonates and Tertiary sediments.

From west to east, fault blocks of the Paleozoic carbonate aquifer are exposed at the surface and underlie the valley-fill. In the Arrow Canyon Range the Paleozoic aquifer crops out, but is partly obscured by the overlying valley-fill at the far east end of the cross-sectional area.

The valley-fill ranges in thickness along the cross-section between 0 feet at the edge of the valley fill to about 300 feet in the center of Coyote Spring Valley. Thickness of the valley fill is fault-controlled to a great degree. The valley fill is believed to be unsaturated in this area, based on sparse hydrologic data. The District water well application #54056 is located 2.8 miles north of the cross-section. This site is situated on the alluvium, and it is anticipated that the well will be completed in the valley fill. Table 2 presents the available data on the hydraulic characteristics of rocks and unconsolidated sediments that are present. These parameters, and other features, are discussed for each modelling unit in the following sections.

Valley-Fill Deposits

The valley-fill aquifer is composed of alluvial-fan, fluvial, fanglomerate, lake-bed, and mudflow deposits of Quaternary (Younger Alluvium) and Tertiary (Older Alluvium) age. The Older Alluvium is typically more consolidated than the Younger Alluvium, is more highly cemented, and, where saturated, exhibits lower hydraulic properties.

The grain size of these deposits decreases with distance from the source, and away from distributary channels on alluvial fans. Interbedding of fine and coarse-grained materials is common in the valley-fill deposits, which range from gravels and sand, in alluvial fans, to clay-sized material, in mudflows and playa deposits. Caliche deposits, which may impede the downward infiltration of water in the soil zone, may also be common in the valley-fill as evidenced by the extensive stands of Creosote Bush, a general indicator of well-developed calcic horizons.

The younger and older alluvium are present throughout the valley floor in Coyote Spring Valley. Tschanz and Pampeyan (1970) indicate that older alluvium (possibly Muddy Creek Formation) outcrops along Pahranagat Wash. Longwell, et al. (1965) indicate that the Muddy Creek Formation also outcrops to the east of Pahranagat Wash in the east-central part of Coyote Spring Valley. Based upon the available information, the Muddy Creek Formation is presumed to be similar, hydraulically, to the valley-fill sediments and, for the purposes of modelling, the older and younger valley-fill and the Muddy Creek Formation may be considered as one hydrostratigraphic unit.

The thickness of the valley-fill deposits in Coyote Spring Valley is greatest near the axis of the valley. A seismic refraction survey along State Route 7 between Pahranagat Wash and U.S. Highway 93 indicates thicknesses of the valley-fill no less than 250 feet (Ertec Western, 1981). A well located in the center of the valley (12S/63E-29db2) shows the valley-fill to be 850 feet thick (Ertec Western, 1981).

The flow of ground water through the valley-fill aquifer occurs primarily through the interstitial porosity. However, flow is controlled by the variations in the relative permeabilities of the interbedded materials. The fine-grained deposits of the Muddy

Table 2. Summary of Transmissivity and Hydraulic Conductivity Values in Southern Nevada.

TRANSMISSIVITY (ft^2/day)					
Aquifer	Minimum	Maximum	Median	Number of Samples	Reference
Valley Fill	321	4,478	1,470	7	Winograd and Thordarson (1975)
	25,920	259,200	-	2	Burbey and Prudic (1985)
Tuff/Volcanic	6.7	9,090	281	5	Winograd and Thordarson (1975)
	259	-	-	1	Burbey and Prudic (1985)
Carbonate	174	11,496	1,470	11	Winograd and Thordarson (1975)
	11	250,000	2,100	31	Unpublished USGS Data
	86	43,200	4,320	5	Burbey and Prudic (1985)

HYDRAULIC CONDUCTIVITY (ft/day)					
Aquifer	Minimum	Maximum	Median	Number of Samples	Reference
Valley Fill	0.02	140	74*	7	Plume and Carlton (1988)
Carbonate	0.01	940	5.40	38	Unpublished USGS Data
	0.02	1.53	0.18	8	Winograd and Thordarson (1975)
Clastic	0.006	0.02	0.10	4	Unpublished USGS Data

* Average value for 18 tests in 14 basins

Creek Formation and similar alluvial materials, although not tested in Coyote Spring Valley, can be expected to exhibit permeabilities several orders of magnitude smaller than sand and gravel. The interbedding of fine grained and coarse-grained sediments in the valley-fill deposits results in horizontal permeabilities that are considerably greater than vertical permeabilities.

On a regional basis, the transmissivity (a measure of the ability of an aquifer to transmit ground water) of the valley-fill ranges from about 321 to about 259,200 ft^2/day according to Burbey and Prudic (1985) and Winograd and Thordarson (1975). The transmissivity of the alluvium in a given valley or hydrologic setting is a function of both the permeability and the saturated thickness of the aquifer. Small values of transmissivity (less than 670 ft^2/day) generally indicate fair to poor well yield potential while high transmissivity wells (greater than 6,700 ft^2/day) may be capable of producing wells yields in the hundreds or even thousands of gallons per minute.

As with most of the rural basins in Lincoln and Clark Counties, and elsewhere in Nevada, data on the transmissivity of the valley-fill aquifer in Coyote Spring Valley is limited. For the tests that have been conducted, the transmissivity of the valley-fill aquifer was found to be on the lower end of this range, reflecting the generally fine-grained sediments present in the valley and the limited saturated thickness of alluvium present, relative to other valleys. Ertec Western Inc. (1981) reported a transmissivity of only 120 ft^2/day for the valley-fill aquifer at (12S/63E-29db1) based upon an aquifer test at Air Force well CV-VF-1.

Regionally, the hydraulic gradient (slope of the surface of the ground water) in the valley-fill aquifer is often less than 60 ft/mi, and is usually less than 30 ft/mi (Winograd and Thordarson, 1975). Because of the distribution of wells in Coyote Spring Valley, the calculation of gradients must be based upon widely separated clusters of wells and the inferred water surface between the wells. Based upon water level measurements taken at wells in and around Coyote Spring Valley, the gradient is believed to range from about 60 ft/mi to less than 20 ft/mi.

Consolidated Rock

The carbonate aquifer consists of thick sequences of Paleozoic limestones and dolomites. This unit comprises the numerous individual rock units that were previously discussed, and has an overall thickness of several thousand feet.

Flow through the carbonate aquifer is believed to occur primarily through fractures, and is likely to be concentrated in areas of greater fracture frequency. Except in areas of structural or stratigraphic anomalies, the hydraulic gradient in this aquifer is likely to be small because of high transmissivity.

The movement of ground water across the contact between the valley-fill aquifer and the carbonate aquifer depends on the potentiometric heads (elevation of the water table or piezometric surface) in each aquifer. In areas where the head is higher in the valley-fill, the ground water is semiperched and moves principally downward into the underlying carbonate, serving to recharge the regional carbonate aquifer. Where the head in the carbonate aquifer is higher than the valley-fill, ground water in the overlying alluvial material is derived through upward leakage of water from the carbonate rocks.

The carbonate aquifer underlies the alluvial deposits under most of Coyote Spring Valley. This aquifer, because of the absence of the Chainman Shale and the Pilot Shale in the central and southern portions of the valley, comprises three of the aquifers identified by Winograd and Thordarson (1975). In most of Coyote Spring Valley, these units form a continuous vertical sequence and, for the purposes of modelling, can be considered as a single hydrostratigraphic unit.

The transmissivity of the carbonate aquifer has been found to range from 11 to 250,000 ft^2/day (Winograd and Thordason (1975); Burbey and Prudic (1985); and unpublished U.S. Geological Survey data, with values as high as several hundred thousand ft^2/day possible in fractured areas (Winograd, 1963; Winograd and Thordarson, 1975). Variations in structural setting, proximity to faults, mechanical rock properties, depositional environment, and aquifer thickness are the chief parameters that account for the large variations in the transmissivity of carbonates.

The results of an MX carbonate well test reported by Ertec Western Inc. (1981) indicated that well CE-DT-5, located at (T13S-R63E, 23ddd1) has a transmissivity on the order of 250,000 ft^2/day. This well penetrated the lowermost 500 feet of the Monte Cristo Limestone. The high transmissivity calculated from a long-term (30 day) test of this well reflects the highly fractured and cavernous nature of the upper portion of the carbonate aquifer at this location. A video log of the well indicated the presence of oblique fracturing throughout the thickness of rock penetrated during drilling and a zone of horizontal fractures at a depth between 510 ft and 540 feet below land surface.

At another MX carbonate well in Coyote Spring Valley, well CE-DT-4, a transmissivity of 40,100 ft^2/day was reported by Ertec Western Inc. (1981). This well is located in a fault zone about 330 feet west of CE-DT-5, and also penetrates the lowest part of the Monte Cristo Limestone. A video log of CE-DT-4 shows that the highest degree of fracturing occurs between 580 feet and 669 feet below land surface.

In general, it is inferred that the transmissivity of the carbonate aquifer in Coyote Spring Valley is variable with the highest transmissivities occurring in the vicinity of major structural elements such as north-south trending normal faults typical of the Great Basin. In these areas, dissolution of the carbonates results in high secondary porosities and very high transmissivities. In the relatively undisturbed areas between such structural features the transmissivities are probably appreciably lower because of the inferred lesser degree of development of secondary porosity.

The Tertiary volcanic rocks that crop out in the northern part of the Sheep Range are believed to represent a hydraulic barrier between Pahranagat Valley and Coyote Spring Valley. These rocks consist of tuffs and other volcanoclastic rocks that generally form aquitards. Other Tertiary volcanic rocks, exposed at higher elevations in the Meadow Valley Mountains and the Delamar Mountains, are not of consequence in the development of a ground-water flow model because of their location within the valley.

The clastic aquitard is composed of Precambrian and Cambrian siltstones, quartzites, shales and sandstones. Ground water potentials are likely to be greatly affected by this unit because of the low transmissivity. In fact, recharge and discharge areas are often determined by the location and orientation of this unit. Ground water will tend to flow along the dip of this barrier rather than through it. The aggregate thickness of this unit is approximately 10,000 feet; however, local thickness varies with structure. With respect to ground water in Coyote Spring Valley, the clastic aquitard is of little significance because it is believed to occur at depths well below those considered economic for ground-water development.

The transmissivity of the clastic aquitard is low, estimated at approximately 135 ft^2/day or less, by Winograd and Thordarson (1975). No tests of this unit have been conducted in Coyote Spring Valley.

Structural Features

Structures within Coyote Spring Valley are consistent with features typical of the Basin and Range Province (i.e., horst and graben structures oriented along north and northeast-trending normal faults). The Basin and Range is dominated by north-south trending fault scarps and lineaments that cut through the alluvium. Several periods of regional tectonism have faulted, fractured, and displaced both bedrock and valley-fill materials. Two major structural features lie within Coyote Spring Valley, the Gass Peak Thrust Fault, and an east-west trending lineament through the Muddy Springs area that may be related to the Pahranagat Shear System. In combination with other features, these structures appear to influence the direction and rate of movement of ground water through the area.

West of the basin, in the Las Vegas Range, the Gass Peak thrust fault has placed Cambrian and late Precambrian carbonate and clastic rocks over rocks of the carbonate aquifer (Figure 7). The trace of the thrust trends roughly north-south, curving to the west at the southern end of the range. Both the thrust plane and the strata dip westward, though the fault plane dips at a steeper angle.

The Gass Peak thrust extends beneath the Sheep Range and Three Lakes Valley (Longwell, et al., 1965). The base of the upper plate of the thrust fault comprises the rocks of the lower clastic aquitard. Winograd and Thordarson (1975) inferred that this aquitard extends throughout much of northern Clark and southern Lincoln Counties at a relatively shallow depth below land surface.

Based on the presumed existence of this effective hydrologic barrier and its westward dip, Winograd and Thordarson (1975) stated that most of the recharge on the Sheep Range probably moves to the west toward southern Desert and Three Lakes Valleys. Though the presence of the spring at Corn Creek Ranch suggests that some recharge moves southward and eventually into the Las Vegas basin, they suggested, at that time, that it is very unlikely that significant quantities of ground water are able to flow across the lower clastic aquitard and the Gass Peak thrust.

Later authors have revised the interpretations of Winograd and Thordarson. Guth (1980) indicates that the rocks of the clastic aquitard lie at relatively shallow depth beneath the western side of the Sheep Range. The presence of this barrier appears to impede much of the westward flow of water that would be expected from the Gass Peak Thrust (Winograd and Thordarson, 1975), and causes nearly all of the recharge to flow north and east toward Muddy River Springs (Dettinger, 1989; and Thomas, 1988). Based on results derived from a discrete-state compartment model with deuterium as the tracer, Kirk and Campana (1988) concluded that an important part of the recharge to the Sheep range, about 5,000 acre-ft/yr., flows east to Coyote Spring Valley. Based upon the results of the analyses conducted during this investigation, it is believed that flow in this area is consistent with Winograd and Thordarson's interpretation (1975), i.e., to the west.

The Pahranagat Shear System consists of a northeast-striking set of left-lateral faults, and is evident in areas north of Coyote Spring Valley. This set of faults has a cumulative displacement of six to ten miles along its length (Tschanz and Pampeyan, 1970).

At the northern boundary of Coyote Spring Valley, outcropping volcanic rocks and zones of low permeability caused by the Pahranagat Shear System may present a barrier to southerly flow in the alluvium. The steep gradient at the northern end of the basin may be a result of this barrier. This structure may be forcing ground water beneath the volcanics and into the underlying carbonates. Kirk and Campana (1988) state that about

4,400 acre-ft/yr. of ground-water flows out of Pahranagat Valley to the west through the Pahranagat Shear System, therefore reducing the amount of ground-water inflow to Coyote Spring Valley.

Relatively recent faulting in the area has cut through the sediments and alluvial fan deposits of intermediate and older Tertiary age. Ertec Western (1981) considered the possibility that these recent faults in the northern portion of the valley might be responsible for the shallow perched aquifer and associated springs by acting as a partial hydrologic barrier within the valley-fill, but recognized, however, that stratigraphic control is also a possibility at this location.

As discussed previously, the areas in the vicinity of intersecting geologic structures in the carbonate aquifer exhibit high transmissivities and are hence favorable locations for ground-water development. The Air Force MX well CE-DT-5 was located near the intersection of two such structures, and was found to be capable of producing at least 3,400 gallons per minute, the maximum pumping capacity of the pump used to test the well.

WATER RESOURCES APPRAISAL

The ultimate goal of the numerical simulation of the Coyote Spring hydrogeologic system is the quantification of the effects of proposed ground-water withdrawals on that system. To determine those effects, the magnitude of the water resources available in the basin, the degree of that development, and the location of planned future development need to be defined. The following sections present the available information on the surface and ground-water resources of the valley.

SURFACE WATER

An accurate simulation of a hydrogeologic system requires an understanding of the surface water conditions and the significance of surface water in the overall water budget for a given hydrographic basin. This section describes the general conditions of the surface water regime of Coyote Spring Valley.

General Conditions

Surface water flow into Coyote Spring Valley occurs infrequently along Pahranagat Wash (sometimes referred to as the White River channel or Muddy River) and Kane Springs Wash. Pahranagat Wash, which drains Pahranagat Valley to the north, enters Coyote Spring Valley just south of Maynard Lake (T9S-R62E). Kane Springs Wash drains Kane Springs Valley, located to the northeast of Coyote Spring Valley. The confluence of the two washes is located in the north-central part of Coyote Spring Valley (T11S-R63E). Flow in the washes is ephemeral, occurring in response to the infrequent precipitation over the contributing hydrographic basins. No surface water measurements or estimates are available for either Pahranagat Wash or Kane Springs Wash, and Scott, et al. (1971) give the quantity of this flow as "some". Insofar as the infrequent inflows of surface water inflow into the valley are believed to be insignificant when compared to other components of the water budget for the valley, surface water inflow, for the purposes of simulating ground-water flow in the valley, may be considered to be zero.

Available Records

Because there are no perennial surface water bodies in the valley, there are no available records on surface water flow.

Runoff

The quantity of runoff from the mountains bounding Coyote Spring Valley is estimated to be 1,800 acre-feet per year (Scott, et al., 1971). Heavy runoff events may result in short-duration flows along reaches of Pahranagat Wash in the center of the valley; however, most runoff infiltrates along the upper portions of the alluvial fans, directly into open fractures in the consolidated rock areas, or into the coarse streambed deposits of the channels that drain the area, is transpired by vegetation, or simply evaporates. Scott, et al. (1971) did not include runoff as a separate term in the water budget for Coyote Spring Valley, therefore, it need not be directly included in a ground-water model of the basin; however, that portion of the precipitation over the basin that does not runoff, but infiltrates through the unsaturated zone to recharge the aquifers, must be accounted for in the model. Since the quantity of recharge represents the total precipitation minus the runoff and losses to evaporation, soil moisture in the unsaturated zone, and consumption by plants, each of these factors is indirectly accounted for in the recharge estimate.

GROUND WATER

It is necessary to understand the conditions and characteristics of the ground water in Coyote Spring Valley to develop an accurate numerical simulation. This section discusses the ground water occurrence, source, movement, chemical quality, and budget for Coyote Spring Valley.

Occurrence

Ground water occurs at depths ranging from about 10 feet below land surface in a perched aquifer in the vicinity of the old Butler Ranch, to between 350 and 545 feet below land surface for the water table aquifer throughout the valley floor area where wells have been drilled.

Figure 11 shows the regional potentiometric surfaces for Coyote Spring Valley based upon the water level data for the valley and an evaluation of potentiometric data for the entire Colorado Flow System. As shown, the elevation of the water table ranges from 3,000 feet AMSL, in northernmost Coyote Spring Valley, to less than 1,800 feet AMSL in the southeastern most part of the valley where the ground-water discharges into the Muddy River Springs area. For the purposes of modelling the potentiometric surface, water level data for some springs and wells believed to be completed in perched zones (Eakin, 1964) were disregarded.

Records of water levels in wells in the basin do not show appreciable variations or long-term trends. Hydrographs (graphs showing the elevation of the water in a well at various points in time) were developed for wells CE-DT-5, CE-DT-4, CE-VF-2, and CE-VF-1 (Figures 12 and 13). Several of these hydrographs show an initial rise in water level after

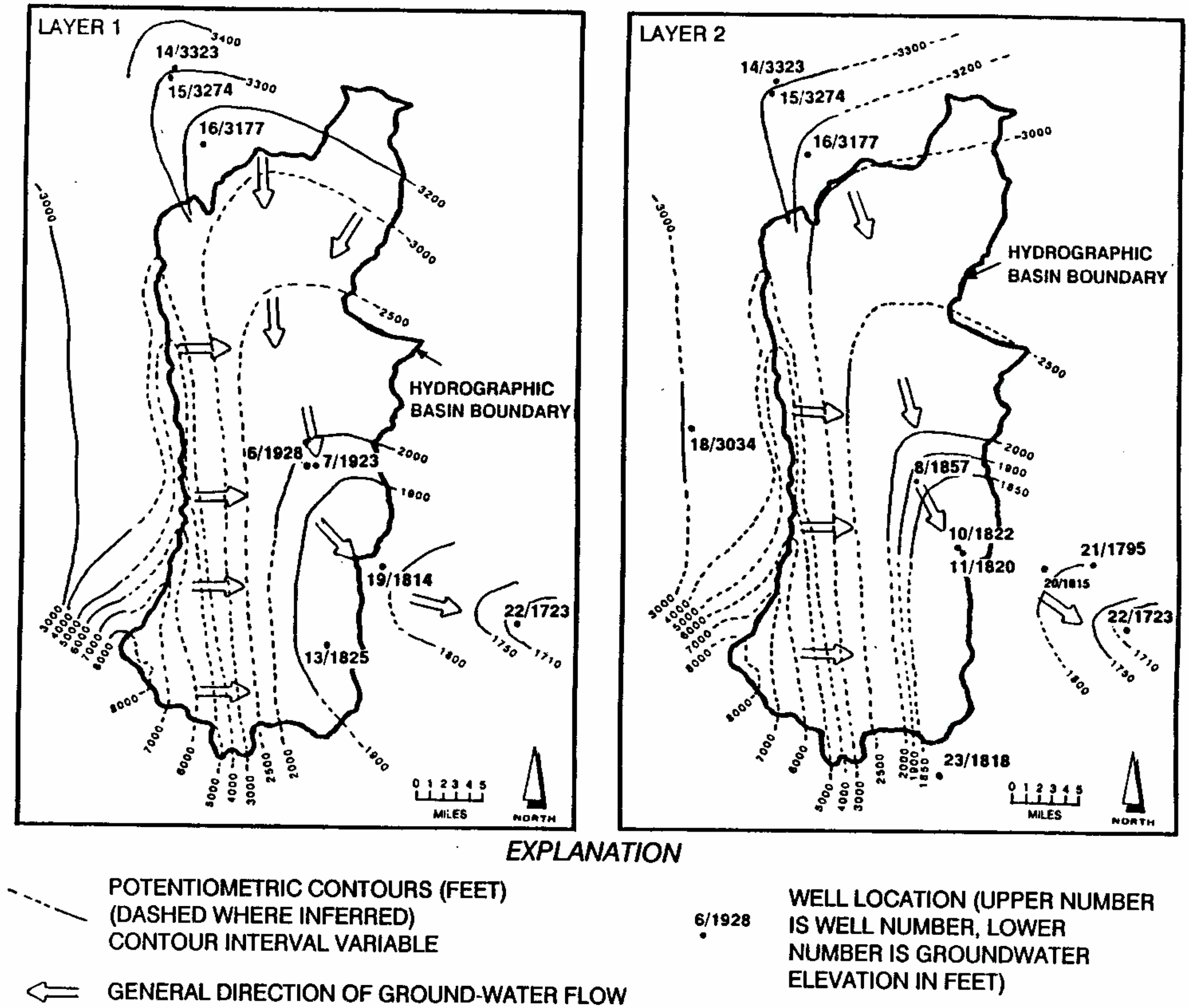

Figure 11. Potentiometric surfaces of Coyote Spring Valley.

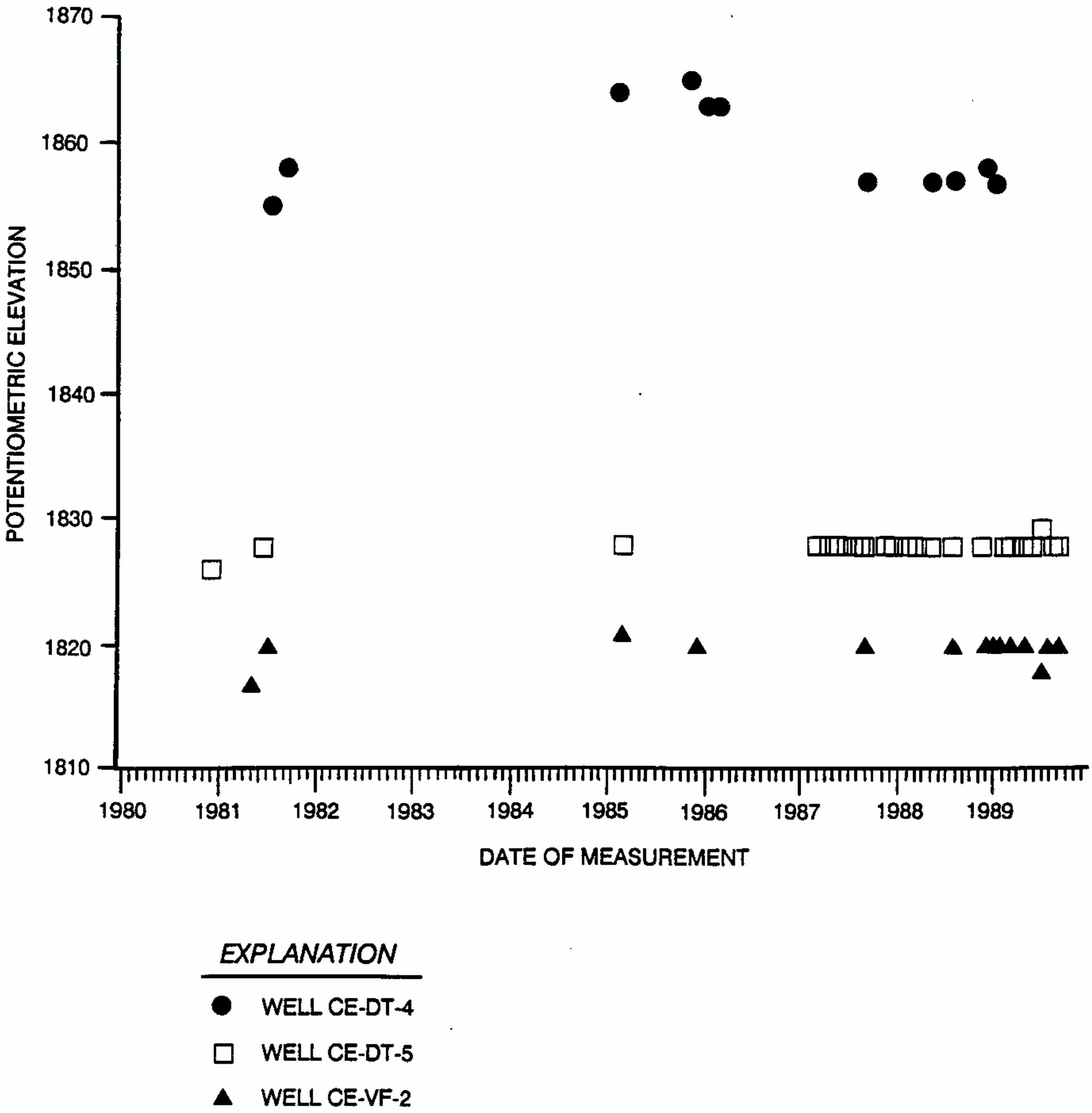

Figure 12. Hydrographs for selected wells in Coyote Spring Valley.

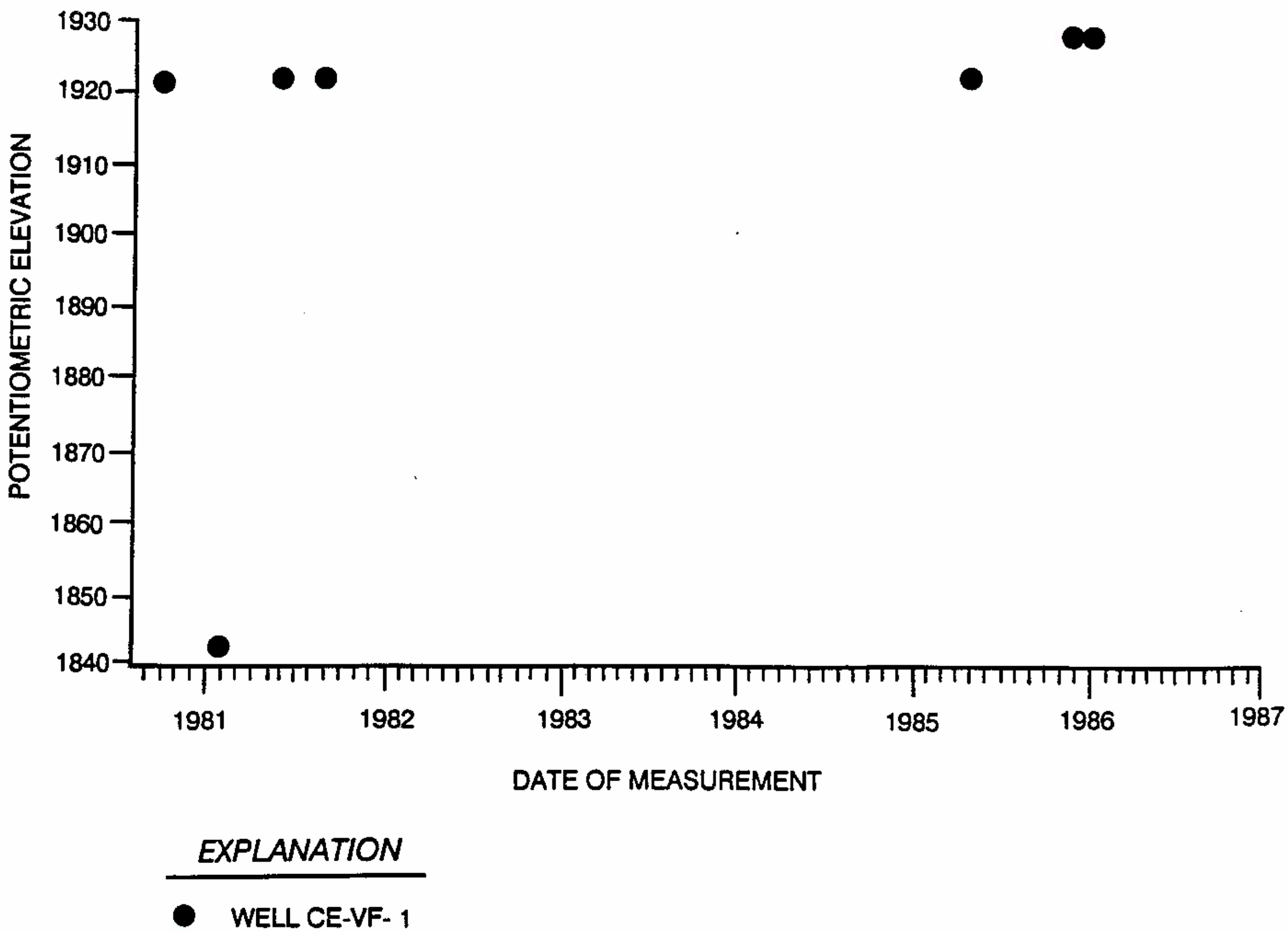

Figure 13. Hydrograph for well CE–VF–1 in Coyote Spring Valley.

completion of the well, followed by a period of little fluctuation. The hydrograph for well CE-VF-1 shows a rise in water level of six to eight feet in the 1985-1986 timeframe, approximately five years after the initial set of measurements were compiled; the hydrograph for well CE-VF-2 shows a similar trend during 1985 and 1986, then notes a decrease by 1987.

A cluster of wells near the center of the valley, including both valley-fill and carbonate wells, indicates that the difference between the potentiometric head in the valley-fill and the carbonate systems is about 70 feet at that location. Near Lower Pahranagat Lake, north of the basin, and Muddy Spring, east of the basin, the heads in both units are believed to be approximately equal.

Source

The source of ground water within Coyote Spring Valley is recharge from precipitation that falls on the basin, and subsurface inflow of ground water from Pahranagat Valley. Both of these sources must be accounted for in developing a flow model of the basin.

A minor amount of subsurface inflow occurs at the boundary of Kane Springs Valley, and possibly at other adjoining basins. These quantities are unknown, but are believed to be insignificant relative to other components of the water budget for the basin and, therefore, do not need to be included as discrete parameters in developing the model.

Movement

In general, ground water in the axial part of Coyote Spring Valley flows south from the area of Pahranagat Valley toward the discharge area near the Muddy River Springs Area. This southward flow is illustrated by the hydraulic gradient, which flattens from about 60 feet per mile between a well at 8S/62E-31caab in southern Pahranagat Valley, and well 10S/62E-14a1, to approximately 36 feet per mile between well 10S/62E-14a1 and well 13S/63E-25a1.

The steeper gradient at the northern end of the basin may be a result of the relatively low permeability of the volcanic rocks which lie across the flow path and/or a barrier possibly associated with the Pahranagat Shear System. The barrier at this location appears to be forcing ground-water beneath the volcanics and into the underlying carbonates.

An area of shallow perched water in the vicinity of the old Butler Ranch and Coyote Spring lies at depth of about ten feet. This water is perched on relatively impermeable valley-fill materials or faults within the alluvium (Ertec Western, 1981). Flow in the perched zone is toward the axis of the valley and then to the south (Ertec Western, 1981).

Chemical Quality

The chemical quality of the ground water in Nevada depends upon its location. The chemical concentration in recharge areas is normally very low; however, the ground water comes into contact with soluble rock materials for long periods of time as it moves towards discharge areas. The solubility, volume, distribution of rock materials, time of water contact with the rocks, temperature, and pressure in the ground-water system are factors that determine the extent to which the chemical constituents from the rock materials will be dissolved. The available chemical data for the Coyote Spring Valley area are summarized in tabular form in Appendix B. The National Drinking Water Standards are also included in Appendix C. The chemical data from Coyote Spring Valley have been examined with reference to these standards, and it has been determined that water from two wells exceeded the standards for two constituents. A sample from well CE-VF-1, taken January 6, 1988, exhibited values of 770 and 190 ug/l for iron and manganese, respectively. Both values were well above the respective standards of 300 ug/l for iron and 50 ug/l for manganese. A sample from well CSV-3, dated January 7, 1988, also exhibited a high manganese content of 80 ug/l. The specific conductance and temperature of the water are presented in Figure 14.

Budget

A ground-water budget consists of a complete accounting of all components of inflow and outflow for a hydrographic basin. The results of any model developed to simulate flow in a basin are dependent upon the accuracy of the budget. Table 3 summarizes the water-budget for Coyote Spring Valley. The following sections present the current estimates for recharge and discharge from Coyote Spring Valley.

Estimated Average Annual Recharge

Recharge to the basin consists of several components: precipitation, subsurface inflow, and secondary recharge. Estimates for these elements are provided in the following sections.

Precipitation

One source of recharge to the hydrologic system of Coyote Spring Valley is the infiltration of precipitation that falls over the basin. No meteorological stations are located in Coyote Spring Valley and the characterization of precipitation over the area is inferred from recording stations located in adjacent valleys. The total precipitation over Coyote Spring Valley is 220,000 acre-feet per year (Scott, et al., 1971). The volume of recharge derived from precipitation is reported by these same authors to

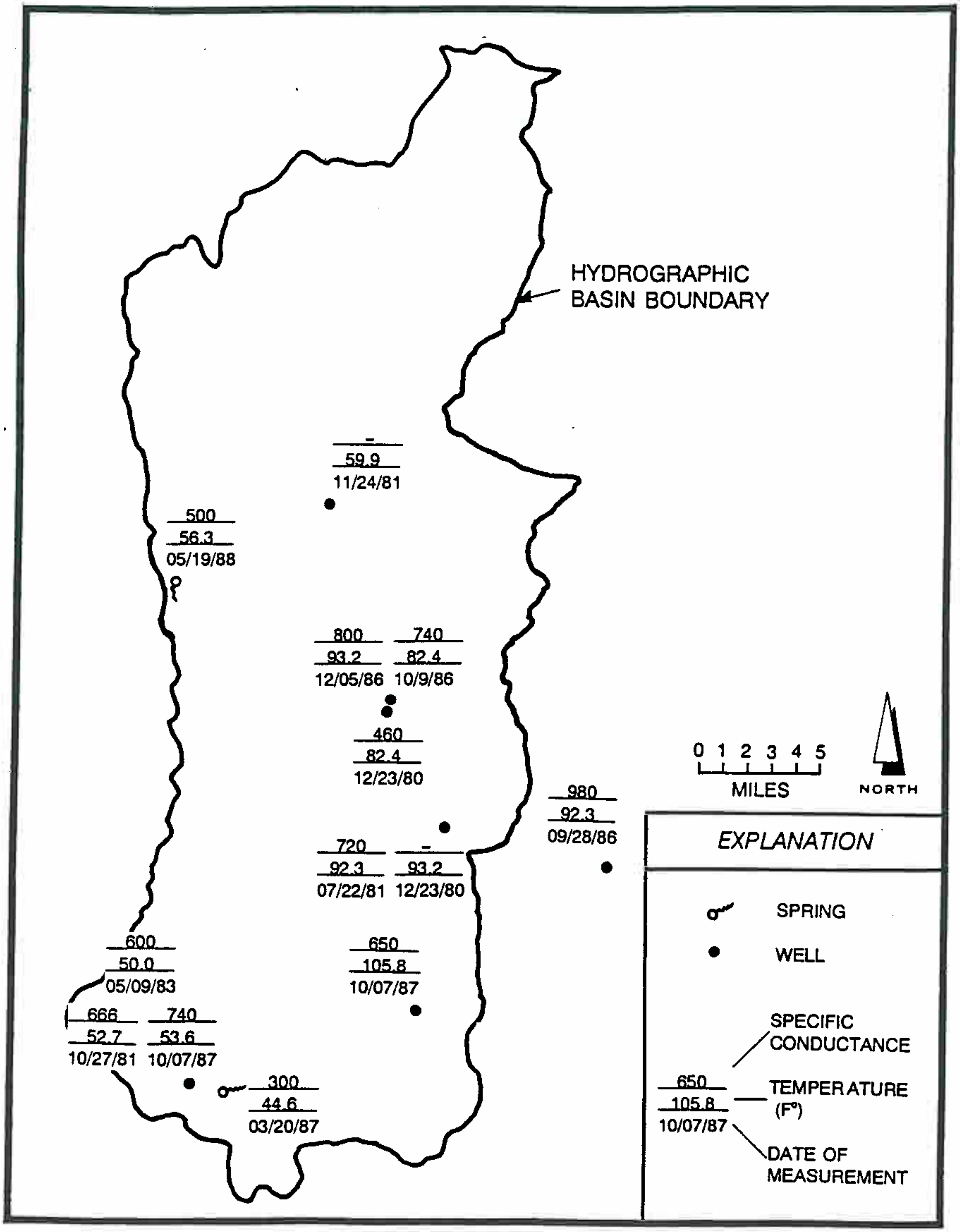

Figure 14. Specific conductance and water temperature of wells and springs in the vicinity of Coyote Spring Valley.

Table 3. Ground-Water Budget for Coyote Spring Valley (stated in acre-feet per year).

		Published Value
RECHARGE		
Precipitation (Recharge)		1,900 - 2,100
Subsurface Inflow		35,000
Secondary Recharge		---
	TOTAL	36,900+
DISCHARGE		
Evapotranspiration		Minor
Springs		41
Water Wells		0
Outflow		37,000
	TOTAL	37,041+

Source: Scott et al. (1971)

be 1,900 acre-feet per year, or about 1 percent of the precipitation. This estimate is consistent with the 2,600 acre-feet per year of recharge to both Coyote Spring and Kane Springs Valleys reported by Eakin (1964). Harrill, et al. (1988) reported the recharge from precipitation in Coyote Spring Valley to be about 2,100 acre-feet per year. Kirk and Campana (1988) estimated the recharge from the Sheep Range to Coyote Spring Valley to be 5,000 acre-ft/yr.

The infiltration of precipitation does not occur evenly over a large area. Rather, as determined by Maxey and Eakin (1949) and Quiring (1965), the distribution of precipitation, and hence, infiltration and recharge, in the desert valleys of Nevada, is primarily a function of elevation and latitude. Thus, for the purposes of developing a ground-water flow model of Coyote Spring Valley, recharge is distributed according to the zones summarized in Table 4.

Table 4. Recharge distribution zones for Coyote Spring Valley (Eakin, 1964).

Elevation Feet Above Sea Level	Precipitation Inches/Year	Recharge Flux Acre-Feet/Year Per Square Mile
8,000-9,000	15-20	144
7,000-8,000	12-15	49.3
6,000-7,000	8-12	15.4
<6,000	<8	0.0

Subsurface Inflow

The inflow of ground water to Coyote Spring Valley from upgradient basins is appreciable. It represents the largest input component of the water budget for the valley. An estimated 35,000+ acre-feet per year of ground water flows through the subsurface into Coyote Spring Valley (Scott, et al., 1971; and Harrill, et al., 1988). An estimated 35,000 acre-feet per year of this inflow is derived from Pahranagat Valley to the north, with a minor contribution from Kane Springs Valley to the northeast. According to Harrill, et al. (1988) unknown, but probably small, quantities of inflow may also be contributed from the South, from Tikaboo Valley along the western part of Coyote Spring Valley, and from the Las Vegas Basin along the southwestern part of the valley.

Recent examinations of the Sheep Range suggest that structures within the range may be causing nearly all the water falling on these mountains to flow north and east through Coyote Spring Valley (Guth, 1980; Thomas, 1988; and, Dettinger, 1989).

These unknown quantities of inflow are, based on potentiometric data, believed to be insignificant relative to other components of the water budget for the basin and, therefore, have not been included as discrete parameters in developing the model.

Geraghthy and Miller (personal communication, 1990) simulated the groundwater inflow from Tikaboo Valley to be 7,000 acre-feet per year which represents a significant part of the total water budget (20%). As a result, an alternate model was developed to evaluate the impact on the main model. The alternate model results are discussed in Appendix E.

Secondary Recharge

Secondary recharge is estimated based on the type of ground-water usage. Currently, no ground-water is being withdrawn in Coyote Spring Valley; secondary recharge is therefore zero.

Estimated Average Annual Discharge

Components of discharge include evapotranspiration, springs, well pumpage, and subsurface outflow. Estimates of the quantity of these components are included in the following sections.

Evapotranspiration (ET)

Because of the arid environment, the depth to ground water, and the negligible surface water network in Coyote Spring Valley, ET is a negligible component of ground-water discharge from the valley. Although Scott, et al. (1971) and Harrill, et al. (1988) reported ET to be zero, Eakin (1964) reported that ET in the vicinity of Coyote Spring (interpreted to be from a shallow semiperched water-bearing zone) is "not more than a few hundred acre-feet per year". This discharge also supports a stand of phreatophytes (Eakin, 1964) which can consume relatively large volumes of ground water. Because the water in this perched zone is believed to be hydraulically isolated from both the valley-fill and the carbonate aquifers, and the evapotranspiration probably consumes most, if not all of, the water discharged from the perched zone, the minor ET in Coyote Spring Valley need not be accounted for in developing a flow model of the basin.

Springs

In Coyote Spring Valley, springs are largely isolated to the upper flanks of the Sheep Range, as shown in Figure 15. Table 5 is a list of springs in the vicinity of Coyote Spring Valley hydrographic basin.

The springs in the highlands of Coyote Spring Valley are relatively small, meteoric springs (i.e., springs derived from local sources, usually snowmelt in the topographically higher portions of the mountains that bound the basin).

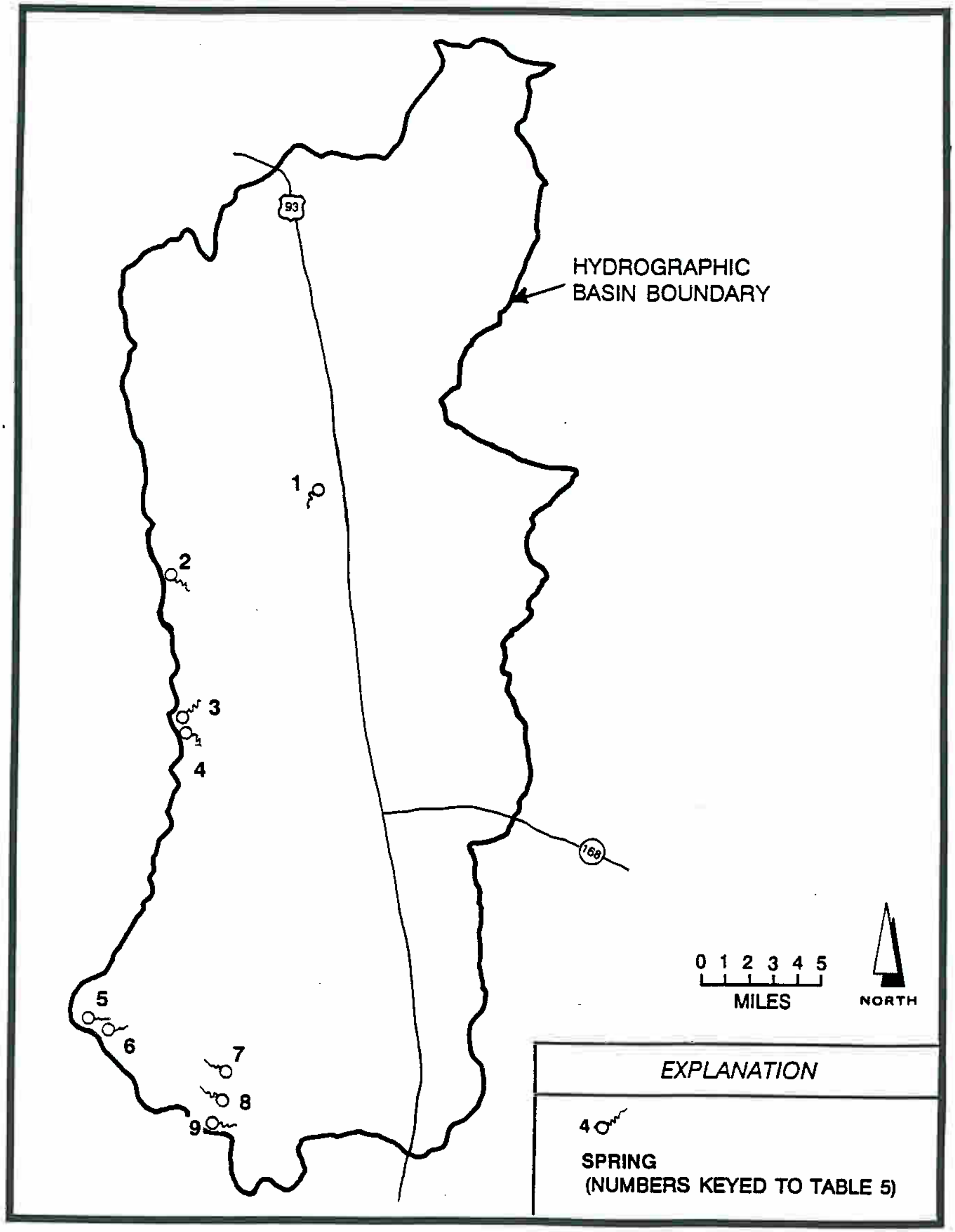

Figure 15. Springs in Coyote Spring Valley.

Table 5. Springs in the Vicinity of Coyote Spring Valley

Site No.	Location T R S	Surface Elev.(ft)[a]	Discharge gpm	Hydrographic Basin No.	Data Source[b]	Site Name
1	11S 62E 13	2542	<1	210	1	Coyote Spring
2	11S 61E 35dd	5709	ND[c]	210	2	Lamb Spring
3	12S 61E 36dba	4265	ND	210	2	Cherry Spring
4	12S 61E 36bba	4429	ND	210	2	Grapevine Spring
5	14S 61E 30dddb	8169	ND	210	2	Sawmill Spring
6	14S 61E 32dbcc	8120	ND	210	3	Un-named #1
7	15S 61E 24d	6690	<1	210	4	Mormon Well Spring
8	15S 62E 07db	5429	ND	210	2	Wamp Spring
9	15S 62E	5480	ND	210	3	Un-named #2

[a] Estimated using USGS Topographic Maps
[b] 1-Bunch & Harrill, 1984; 2-USGS Topographic Maps; 3-USGS Unpublished Data; 4 - Bateman, 1976.
[c] ND - No Data

The only reported spring discharge measurements are at Coyote Spring (T11S-R62E), measured in November 1980 (Bunch and Harrill, 1984), and Mormon Well Spring (T15S-R61E), measured in June 1975 (Bateman, 1976). The discharge from these springs was estimated to be less than one gpm each. This amounts to about 3.2 acre-feet per year for both, less than .01 percent of the estimated total discharge from the basin.

Eakin (1964) reported that "prior to development, [Coyote Spring] issued from the bluffs on the west side of White River Channel" (Pahranagat Wash). Eakin also reported that the discharge from this spring was derived from a "semiperched" zone in the older valley-fill deposits. The small volume of flow and localized nature of these springs indicates that the quantity of discharge associated with them is probably insignificant in terms of the overall water budget for Coyote Spring Valley, and, as a consequence, the presence of this minor spring discharge need not be simulated in a ground-water flow model of the valley. As mentioned in the background discussion, ground water that flows through the carbonate aquifer in Coyote Spring Valley is the principal source of discharge at the Muddy River Springs Area in Moapa Valley, and the identification of the potential for impacting these springs a major goal of developing a model of ground-water flow. The spring area comprises more than 23 individual natural springs and seeps. The area of discharge is on the south side of State Highway 7 at an elevation of about 1800 feet. The total cumulative discharge of these springs averages about 46 cfs but, as noted by Eakin (1964), this discharge volume is from a gaging station on the Muddy River downstream of the springs. Eakin (1964) reported that, if the evapotranspiration and infiltration of the spring discharge are taken into account, the total discharge is probably about 50 cfs.

The potential for impacting the springs discharging at the Muddy River Springs Area through the development of the ground-water resources in Coyote Spring Valley has already been extensively tested. In 1981, the U.S. Air Force was required by the Nevada State Engineer to evaluate the potential impacts of long-term water withdrawals from well CE-DT-5 on the Muddy Springs Area. To assess the potential for negative impacts, a 30 day constant discharge test of this well was conducted between August 28, 1981 and September 28, 1981. Water levels were monitored before, during, and after the test in the pumping well, at 3 observation wells completed in the carbonate aquifer, and at 2 wells completed in the valley-fill aquifer. Also monitored were spring discharge rates and basic water-quality parameters at the 5 nearest springs to the pumping well. The muddy springs that were monitored and their individual discharge rates, listed in order of increasing distance from Coyote Spring Valley, are as follows: 1) Baldwin Cut Spring, with a discharge rate of about 0.4 cfs; 2) Baldwin Spring, discharging about 0.6 cfs; 3) Muddy Big Spring, the largest of the springs, with a discharge rate of about 8 cfs; 5) Pederson Spring, at about 0.4 cfs; and 6) Warm Spring, with a discharge rate of about 0.2 cfs. The discharge rates are based upon measured daily discharges between June 27, 1981 and September 30, 1981. The total discharge rate from these springs was measured to range from 9.4 to 9.9 cfs, or about one-fifth of the total discharge from the Muddy Springs Area. The total annual discharge from these springs, based upon these measurements, is about 7,000 acre feet per year.

According to the published results for this testing and monitoring program (Ertec Western, 1981), no detectable impacts on the discharge or chemistry of the monitored springs occurred during the test. It was noted however, that although the test indicated no impacts on the springs after 30 days of large-volume pumping from the carbonate aquifer in Coyote Spring Valley, the long-term impacts were uncertain and monitoring of the springs should be continued if well CE-DT-5 were to be completed as a production well.

Water Wells

Several water wells exist in Coyote Spring Valley, but none of these wells are known to be operational at this time. According to information provided by Summit Engineering Corporation, no water right permits have been issued for these wells by the Nevada State Engineer Office. Therefore, the total pumpage within the Coyote Spring Valley hydrographic basin is zero.

Outflow

Discharge through subsurface flow is along the eastern boundary of Coyote Spring Valley into the Muddy River Springs Area (Scott, et al., 1971). Scott, et al. (1971) estimated the quantity of this outflow to be 37,000 acre-feet per year. The approximate location of this outflow is shown on Figure 5.

Total Discharge

Summit Engineering Corporation provided the information that there is 41 acre-feet per year of spring water that have stock-watering rights and other small consumption uses. Ground-water outflow in Coyote Spring Valley (from Scott, et al. (1971)) equals 37,000 acre-feet per year. Eakin (1964) estimated that the total evapotranspiration in Coyote Spring Valley is probably not more than a few hundred acre feet per year, occurring in the immediate vicinity of Coyote Spring. The total discharge from Coyote Spring Valley, based on these estimates of ground-water outflow and evapotranspiration, and spring discharge rates estimated on the basis of stockwatering rights, is estimated to be about 37,041+ acre-feet per year.

Perennial Yield

Scott, et al. (1971) define perennial yield as "the maximum amount of natural discharge that can be salvaged each year over the long term without depleting the ground water reservoir." The perennial yield of Coyote Spring Valley is reported to be 18,000 acre-feet per year (Scott et al., 1971).

Storage

The quantity of ground water stored in the geologic units underlying Coyote Spring Valley is large; the amount of recoverable ground water in storage in the valley reservoir is estimated to average about 10 percent of the volume of the saturated valley-fill (Scott, et al., 1971). For Coyote Spring Valley, Scott, et al. (1971) estimated the quantity of recoverable ground water to be 1.8 million acre-feet in the upper 100 feet.

No estimates have been made of the amount of ground water that is stored in the carbonate aquifer in Coyote Spring Valley. Although the storage capacity of the carbonates is believed to be less than that of the valley-fill, the large saturated thickness and extensive areal extent of the carbonate aquifer suggests that the quantity of recoverable water from storage may be even greater than that observed for the valley-fill deposits.

Dettinger (1989) reported that ground water in the regional carbonate aquifer is "enormous", and estimated that the total quantity of water stored in this regional aquifer south of Pioche and Tonopah is on the order of 800 million acre-ft. Adopting Dettinger's assumption of a total of one percent of the aquifer volume as being recoverable, then a rough estimate of the recoverable ground water in storage in Coyote Spring Valley can be made. Based upon this recovery factor, the subareal extent of the carbonate aquifer underlying the floor in the valley (approximately 240 square miles), and, an assumed saturated thickness of 2,000 feet (about the limit for economic Water well drilling), then the total recoverable ground-water storage in Coyote Spring Valley is estimated to be approximately 3.1 million acre-feet; however, the upper 100 feet of the rock aquifer only contains about 154,000 acre-feet.

INVENTORY OF WATER RIGHTS, PUMPAGE, AND LAND USE

An estimate of ground-water usage in a basin can be obtained from present water rights, pumpage, and application of pumped water to crops and other uses. These factors are examined in the following sections.

PRESENT DEVELOPMENT

The level of development of water resources in a basin can be illustrated by the water right allocations and the current ground-water pumpage within that basin. In Coyote Spring Valley, little ground water has been pumped historically, and none is presently being used. Although there are no current ground-water withdrawals from the basin, there are permitted water rights and a number of water right applications that have not yet been acted upon by the Nevada State Engineer. The status of water rights in Coyote Spring Valley is summarized in the following sections.

Water Right Status

Based on information supplied by Summit Engineering Corporation, the State Engineer has not allocated any ground water in Coyote Spring Valley. At one "surface water" site (spring), 93.75 acre-feet per year (consumptive use) have been apportioned for irrigation purposes in Sections 24 and 25 of T11S R62E. This 93.75 acre-feet per year of water is not currently being used, but has been developed and is believed to have been applied to beneficial use as recently as 1985. This water right was developed by the mining of a horizontal tunnel into the presumably perched aquifer in the vicinity of Coyote Spring. The development is presently in disrepair with a less than 1 gpm discharge to the surface observed in April 1990.

In addition to this appropriated and developed, but apparently abandoned, point of diversion, there are 15 surface water rights (springs), which total 41 acre-feet per year (consumptive use). These minor discharges are permitted for stockwatering and other small consumption uses.

There are currently 25 applications for ground-water appropriations that have been filed with the Nevada State Engineer, but for which no permit has been granted to date. Table 6 summarizes the current ground-water rights that have been granted and the water appropriation applications that have been filed in Coyote Spring Valley. These listed applications include the District's recent filings along with all applications that were filed prior to the District applications.

Table 6. Current water appropriations in Coyote Spring Valley (Summit Engineering Corp.)

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WATER BASIN 210
COYOTE SPRING VALLEY
PERMITS & APPLICATIONS

APPLICATION/ PERMIT/PROOF	CERTIFICATE	DATE OF PRIORITY	POINT OF DIVERSION 1/4 1/4	SECTION	TOWNSHIP	RANGE	DIVERSION RATE	CONSUMPTION AC.FT./YR.	USE	ACAD BLOCK	PLACE OF USE	NOTES
1353		03/08/15	NE SW	13	11S	63E	0.1250	1.68	STOCKWATERING	SURF_OTH	NE SW S13 T11S R63E	PERMIT 01353. "0" PREFIX NOT ACCEPTED BY DATA BASE
3294	1391	03/08/15	NW SE	24	11S	63E	0.0125	8.96	STOCKWATERING	SURF_OTH	NW SE S24 T11S R63E	
4545		10/24/85	E1/2 W1/2	24	11S	42E	0.3500	93.75	IRRIGATION	SURF_PE	S24, S25 T11S R62E	PERMIT 04545
6890	1251	04/28/23	NE NE	28	9S	64E	0.0015	1.12	STOCKWATERING	SURF_OTH	NE NE S28 T9S R64E	
10449	2721	12/04/39	NE NW	5	9S	64E	0.0125	8.96	STOCKWATERING	SURF_OTH	NE NW S5 T9S R64E	
10478	3946	03/18/40	SW SE	11	10S	62E	0.0000	5.00	STOCKWATERING	SURF_OTH	S11 T10S R62E	
10627	2615	02/21/41	NE NW	17	8S	64E	0.0100	7.28	STOCKWATERING	SURF_OTH	S17 T8S R64E	
11525	3356	03/26/46	SW NW	17	8S	64E	0.0030	2.24	STOCKWATERING	SURF_OTH	S17 T8S R64E	
11641	3370	07/26/46	NE SE	35	11S	61E	0.0010	0.72	WILDLIFE WATERING	SURF_OTH	S35 T11S R61E	
11644	3365	07/26/46	SW SW	20	14S	61E	0.0010	0.72	WILDLIFE WATERING	SURF_OTH	SW SW S20 T14S R61E	
11645	3366	07/26/46	NE SE	29	14S	61E	0.0010	0.72	WILDLIFE WATERING	SURF_OTH	NE SE S29 T14S R61E	
12632	3781	09/13/48	SE NE	1	13S	61E	0.0033	2.40	WILDLIFE WATERING	SURF_OTH	SE SE S1 T13S R61E	
13519	3785	10/16/50	NW NE	30	14S	61E	0.0001	0.72	STOCKWATERING	SURF_OTH	NW NE S30 T14S R61E	
19306	6011	11/01/60	SE SE	20	14S	61E	0.0002	0.12	STOCKWATERING	SURF_OTH	SE SE S30 T14S R61E	
19708	6069	03/31/61	NE SE	7	15S	62E	0.0001	0.07	WILDLIFE WATERING	SURF_OTH	NE SE S7 T15S R62E	
19709	6070	03/31/61	NE SW	12	15S	61E	0.0004	0.29	STOCKWATERING	SURF_OTH	NE SW S12 T15S R61E	
49414		09/27/85	SE SE	23	13S	63E	6.0000	0.00	INDUSTRIAL	WELL_PP	SEE NOTES FOR 49986, 49987	COMINGLED WITH 49987
49606		12/30/85	SE SE	23	13S	63E	10.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986,49987	COMINGLED WITH 49987
49607		12/30/85	SE SE	23	13S	63E	10.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986,49987	COMINGLED WITH 49987
49608		12/30/85	NW NE	26	13S	63E	10.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49609		12/30/85	NW NE	26	13S	63E	10.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49610		12/30/85	NW NW	25	13S	63E	10.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49660		01/27/86	SW NW	13	11S	63E	0.1380	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49661		01/27/86	SE SE	10	12S	63E	0.1380	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49662		01/27/86	SE NE	10	13S	63E	0.1380	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49978		07/15/86	SW NW	13	11S	63E	2.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49979		07/15/86	SE SE	28	11S	63E	2.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49980		07/15/86	NE NE	3	12S	63E	2.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49981		07/15/86	SE NW	10	12S	63E	2.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987

Table 6. Current water appropriations in Coyote Spring Valley (continued).

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WATER BASIN 210
COYOTE SPRING VALLEY
PERMITS & APPLICATIONS

APPLICATION/ PERMIT/PROOF	CERTIFICATE	DATE OF PRIORITY	POINT OF DIVERSION 1/4 1/4	SECTION	TOWNSHIP	RANGE	DIVERSION RATE	CONSUMPTION AC.FT./YR.	USE	ACAD BLOCK	PLACE OF USE	NOTES
49982		07/15/86	NW SE	29	12S	63E	2.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49983		07/15/86	NW NW	3	13S	63E	2.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49984		07/15/86	SE NE	10	13S	63E	2.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49985		07/15/86	NE NE	20	13S	63E	2.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49986		07/15/86	NE NE	21	13S	63E	2.0000	0.00	INDUSTRIAL	WELL_PP	SEC 1-5, 9-16, 21-24, E1/2, E1/2 W1/2 S8, E1/2 S17, E1/2 S20, N1/2 S25, N1/2 S26 13S R63E, SEC 2-11, 1-17, 20-23, 25-29, 32-36, CONTINUED IN NOTES	W1/2 S13, W1/2 S24, E1/2 S18, E1/2 S19, E1/2 S30, E1/2 S31, W1/2 W1/2 S12 T12S R63E, SEC 1-3, 10-15, 19-35 T11S R63E, S18,S19, CONTINUED IN POU FOR 49987
49987		07/15/86	NE NE	1	13S	63E	2.0000	4300.00	INDUSTRIAL	WELL_PP	(CONTINUED FROM 49986) N1/2 S30, W1/2, W1/2 SE S7, W1/2 S6, T13S R64E, W1/2 SW S31 T12S R64E	COMINGLED WITH 49416, 49606-49610, 49660-49662, 49978-49987. TOTAL DUTY LIMITED TO 4300.00 AC.FT./YR
51912		03/10/88	SW NE	25	13S	63E	15.4600	2577.86	ORE PROCESSING	WELL_PP	NE S25 T13S R63E	
54055		10/17/89	SE SW	5	13S	63E	6.0000	0.00	MUNICIPAL	WELL_LVP		
54056		10/17/89	SE SE	32	13S	63E	6.0000	0.00	MUNICIPAL	WELL_LVP		
54057		10/17/89	SE NW	16	13S	63E	6.0000	0.00	MUNICIPAL	WELL_LVP		
54058		10/17/89	NE NE	1	13S	63E	10.0000	0.00	MUNICIPAL	WELL_LVP		
54059		10/17/89	NW NW	19	13S	64E	10.0000	0.00	MUNICIPAL	WELL_LVP		
*** Total ***								7012.61				

Table 6. Current water appropriations in Coyote Spring Valley (continued).

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WATER BASIN 210
COYOTE SPRING VALLEY
UNDERGROUND APPLICATIONS

APPLICATION/ PERMIT/PROOF	CERTIFICATE	DATE OF PRIORITY	POINT OF DIVERSION 1/4 1/4	SECTION	TOWNSHIP	RANGE	DIVERSION RATE	CONSUMPTION AC.FT./YR.	USE	ACAD BLOCK	PLACE OF USE	NOTES
49414		09/27/85	SE SE	23	13S	63E	6.0000	0.00	INDUSTRIAL	WELL_PP	SEE NOTES FOR 49986, 49987	COMINGLED WITH 49987
49606		12/30/85	SE SE	23	13S	63E	10.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986,49987	COMINGLED WITH 49987
49607		12/30/85	SE SE	23	13S	63E	10.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986,49987	COMINGLED WITH 49987
49608		12/30/85	NW NE	26	13S	63E	10.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49609		12/30/85	NW NE	26	13S	63E	10.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49610		12/30/85	NW NW	25	13S	63E	10.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49660		01/27/86	SW NW	13	11S	63E	0.1380	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49661		01/27/86	SE SE	10	12S	63E	0.1380	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49662		01/27/86	SE NE	10	13S	63E	0.1380	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49978		07/15/86	SW NW	13	11S	63E	2.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49979		07/15/86	SE SE	28	11S	63E	2.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49980		07/15/86	NE NE	3	12S	63E	2.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49981		07/15/86	SE NW	10	12S	63E	2.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49982		07/15/86	NW SE	29	12S	63E	2.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49983		07/15/86	NW NW	3	13S	63E	2.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49984		07/15/86	SE NE	10	13S	63E	2.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49985		07/15/86	NE NE	20	13S	63E	2.0000	0.00	INDUSTRIAL	WELL_PP	SEE 49986, 49987	COMINGLED WITH 49987
49986		07/15/86	NE NE	21	13S	63E	2.0000	0.00	INDUSTRIAL	WELL_PP	SEC 1-5, 9-16, 21-24, E1/2, E1/2 W1/2 S8, E1/2 S17, E1/2 S20, N1/2 S25, N1/2 S26 13S R63E, SEC 2-11, 1-17, 20-23, 25-29, 32-36, CONTINUED IN NOTES	W1/2 S13, W1/2 S24, E1/2 S18, E1/2 S19, E1/2 S30, E1/2 S31, W1/2 W1/2 S12 T12S R63E, SEC 1-3, 10-15, 19-35 T11S R63E, S18,S19, CONTINUED IN POU FOR 49987
49987		07/15/86	NE NE	1	13S	63E	2.0000	4300.00	INDUSTRIAL	WELL_PP	(CONTINUED FROM 49986) W1/2 S30, W1/2, W1/2 SE S7, W1/2 S6, T13S R64E, W1/2 SW S31 T12S R64E	COMINGLED WITH 49414, 49606-49610, 49660-49662, 49978-49987. TOTAL DUTY LIMITED TO 4300.00 AC.FT./YR
51912		03/10/88	SW NE	25	13S	63E	15.4400	2577.86	ORE PROCESSING	WELL_PP	NE S25 T13S R63E	
*** Total ***								6877.86				

Table 6. Current water appropriations in Coyote Spring Valley (continued).

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WATER BASIN 210
COYOTE SPRING VALLEY
SURFACE PERMITS AND APPLICATIONS
OTHER USES

APPLICATION/ PERMIT	CERTIFICATE /PROOF	DATE OF PRIORITY	POINT OF DIVERSION 1/4 1/4	SECTION	TOWNSHIP	RANGE	DIVERSION RATE	CONSUMPTION AC.FT./YR.	USE	ACAD BLOCK	PLACE OF USE	NOTES
1353		03/08/15	NE SW	13	11S	63E	0.1250	1.68	STOCKWATERING	SURF_OTH	NE SW S13 T11S R63E	
3294	1391	03/08/15	NW SE	24	11S	63E	0.0125	8.96	STOCKWATERING	SURF_OTH	NW SE S24 T11S R63E	
6890	1251	04/28/23	NE NE	28	9S	64E	0.0015	1.12	STOCKWATERING	SURF_OTH	NE NE S28 T9S R64E	
10449	2721	12/04/39	NE NW	5	9S	64E	0.0125	8.96	STOCKWATERING	SURF_OTH	NE NW S5 T9S R64E	
10478	3946	03/18/40	SW SE	11	10S	62E	0.0000	5.00	STOCKWATERING	SURF_OTH	S11 T10S R62E	
10627	2615	02/21/41	NE NW	17	8S	64E	0.0100	7.28	STOCKWATERING	SURF_OTH	S17 T8S R64E	
11525	3356	03/26/46	SW NW	17	8S	64E	0.0030	2.24	STOCKWATERING	SURF_OTH	S17 T8S R64E	
11641	3370	07/26/46	NE SE	35	11S	61E	0.0010	0.72	WILDLIFE WATERING	SURF_OTH	S35 T11S R61E	
11644	3365	07/26/46	SW SW	20	14S	61E	0.0010	0.72	WILDLIFE WATERING	SURF_OTH	SW SW S20 T14S R61E	
11645	3366	07/26/46	NE SE	29	14S	61E	0.0010	0.72	WILDLIFE WATERING	SURF_OTH	NE SE S29 T14S R61E	
12632	3781	09/13/48	SE NE	1	13S	61E	0.0033	2.40	WILDLIFE WATERING	SURF_OTH	SE SE S1 T13S R61E	
13519	3785	10/16/50	NW NE	30	14S	61E	0.0001	0.72	STOCKWATERING	SURF_OTH	NW NE S30 T14S R61E	
19506	6011	11/01/60	SE SE	20	14S	61E	0.0002	0.12	STOCKWATERING	SURF_OTH	SE SE S30 T14S R61E	
19708	6069	03/31/61	NE SE	7	15S	62E	0.0001	0.07	WILDLIFE WATERING	SURF_OTH	NE SE S7 T15S R62E	
19709	6070	03/31/61	NE SW	12	15S	61E	0.0004	0.29	STOCKWATERING	SURF_OTH	NE SW S12 T15S R61E	
*** Total ***								41.00				

Table 6. Current water appropriations in Coyote Spring Valley (continued).

Page No. 1
06/29/90

WATER BASIN 210
COYOTE SPRING VALLEY
SURFACE PERMITS

APPLICATION/ PERMIT/PROOF	CERTIFICATE	DATE OF PRIORITY	POINT OF DIVERSION 1/4 1/4	SECTION	TOWNSHIP	RANGE	DIVERSION RATE	CONSUMPTION AC.FT./YR.	USE	ACAD BLOCK	PLACE OF USE	NOTES
4545		10/24/85	E1/2 W1/2	24	11S	62E	0.3500	93.75	IRRIGATION	SURF_PE	S24, S25 T11S R62E	
*** Total ***								93.75				

Table 6. Current water appropriations in Coyote Spring Valley (continued).

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06/29/90

WATER BASIN 210
COYOTE SPRING VALLEY
UNDERGROUND APPLICATIONS

APPLICATION/ PERMIT/PROOF	CERTIFICATE	DATE OF PRIORITY	POINT OF DIVERSION 1/4 1/4	SECTION	TOWNSHIP	RANGE	DIVERSION RATE	CONSUMPTION AC.FT./YR.	USE	ACAD BLOCK	PLACE OF USE	NOTES
*** Total ***								6877.86				

Table 6. Current water appropriations in Coyote Spring Valley (continued).

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WATER BASIN 210
COYOTE SPRING VALLEY
UNDERGROUND APPLICATIONS
LAS VEGAS VALLEY WATER DISTRICT

APPLICATION/ PERMIT/PROOF	CERTIFICATE	DATE OF PRIORITY	POINT OF DIVERSION 1/4 1/4	SECTION	TOWNSHIP	RANGE	DIVERSION RATE	CONSUMPTION AC.FT./YR.	USE	ACAD BLOCK	PLACE OF USE	NOTES
54055		10/17/89	SE SW	5	13S	63E	6.0000	0.00	MUNICIPAL	WELL_LVP		
54056		10/17/89	SE SE	32	13S	63E	6.0000	0.00	MUNICIPAL	WELL_LVP		
54057		10/17/89	SE NW	16	13S	63E	6.0000	0.00	MUNICIPAL	WELL_LVP		
54058		10/17/89	NE NE	1	13S	63E	10.0000	0.00	MUNICIPAL	WELL_LVP		
54059		10/17/89	NW NW	19	13S	64E	10.0000	0.00	MUNICIPAL	WELL_LVP		
*** Total ***								0.00				

A total of 34,389 acre-feet per year (consumptive use) of water rights have been applied for in Coyote Spring. The District filings request 27,511 acre-feet per year, with the remaining 6,878 acre-feet per year requested by a number of applicants for industrial and other purposes. The annual duty on the proposed District wells will be determined by the Nevada State Engineer.

Pumpage

The abstract provided by Summit Engineering Corporation showed the current total pumpage withdrawal in the basin to be zero. The wells in Coyote Spring Valley are currently unused, and no indications of recent ground-water withdrawals were found during reconnaissance trips to the valley.

Land Use

The western portion of Coyote Spring Valley is occupied by both the Desert National Wildlife Range and the Nellis Air Force Range; the remainder of the area is unused, BLM-administered land. Areas that were previously used for commerce or agriculture were found to be abandoned during a reconnaissance visit to Coyote Spring Valley in April 1990, as part of this investigation.

FUTURE DEVELOPMENT

The future development potential for Coyote Spring Valley is considered high because of the presence of a large tract of carbonate aquifer that underlies the valley. Two major developments by Aerojet, Inc. and Wylie Laboratories, Inc in the northern part of the valley could put appreciable acreage into use for industrial purposes; specifically, the testing of rocket engines. However, no schedule for this potential industrial development has been established.

STEADY-STATE MODEL DEVELOPMENT

In previous sections, the conceptual model of the hydrologic conditions in Coyote Spring Valley were described. In previous sections, the conceptual model of the hydrologic system of Coyote Spring Valley was described. This section presents all the steps taken to construct the numerical steady-state model based on the conceptual model. It includes descriptions of the modeling approach, the model set-up and assumptions, the initial parameter estimates and the steady-state calibration procedure. The resulting steady-state model along with an evaluation of the accuracy of the hydrologic database and model code used are also presented in this section.

MODELLING APPROACH

MODFLOW is a ground-water flow model that allows the simulation of a basin in the area of interest through a block-centered finite-difference approach. This approach basically consists of the solution of partial differential equations that describe ground-water flow in two-or-three dimensions. A more detailed description of the code is provided in Appendix D. A full treatment of the mathematics of the model can be found in the MODFLOW documentation (McDonald and Harbaugh, 1988) and concise summary descriptions of the development and use of numerical modelling can be found in Mercer and Faust (1980a, 1980b, and 1980c) and Faust and Mercer (1980a and 1980b).

The first step in developing a numerical flow model using MODFLOW is the formulation of a conceptual hydrogeologic model of the area to be mathematically represented by the model. This conceptual model is based upon the available hydrologic data, inferences based on observations of analogous hydrologic settings, and assumed conditions, or expected ranges of conditions for parameters that have not been measured and are not readily estimated. The conceptual model of the hydrologic regime, water resources potential, and present status of ground-water development in Coyote Spring Valley, key elements in formulating a numerical model of the basin, were described and discussed in preceding sections of this report.

Following, or concurrent with the development of the conceptual model, the development of the mathematical representation of the hydrologic system is initiated. First a grid system is overlain on a map of the area to be modelled as shown diagrammatically in Figure 16. This grid system can comprise either a single layer or multiple layers, as shown in Figure 17, if a 3-dimensional simulation is desired. The grid system represents a convention whereby each cell in the model can be uniquely identified by grid row, column, and layer designations (Figure 18).

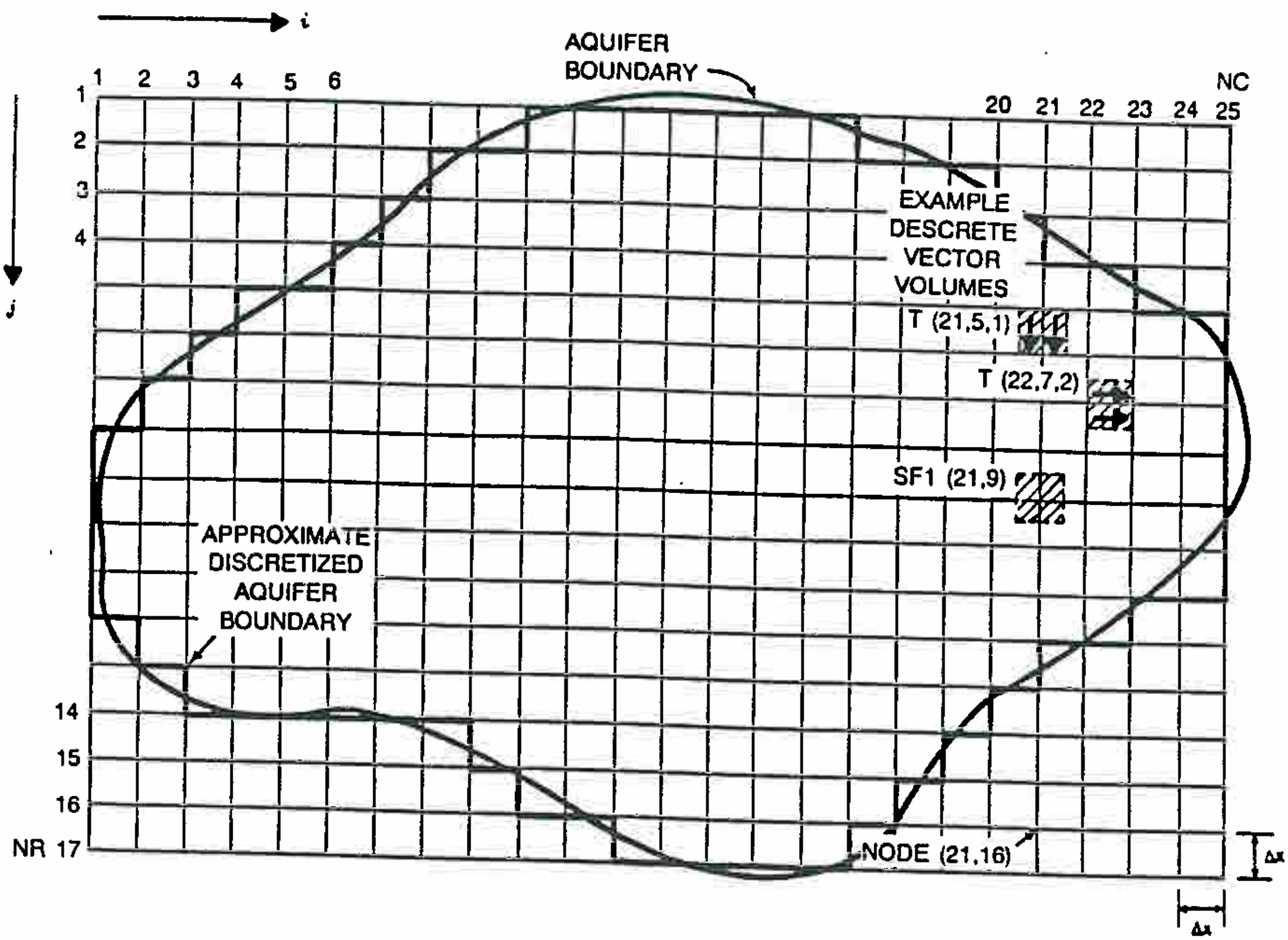
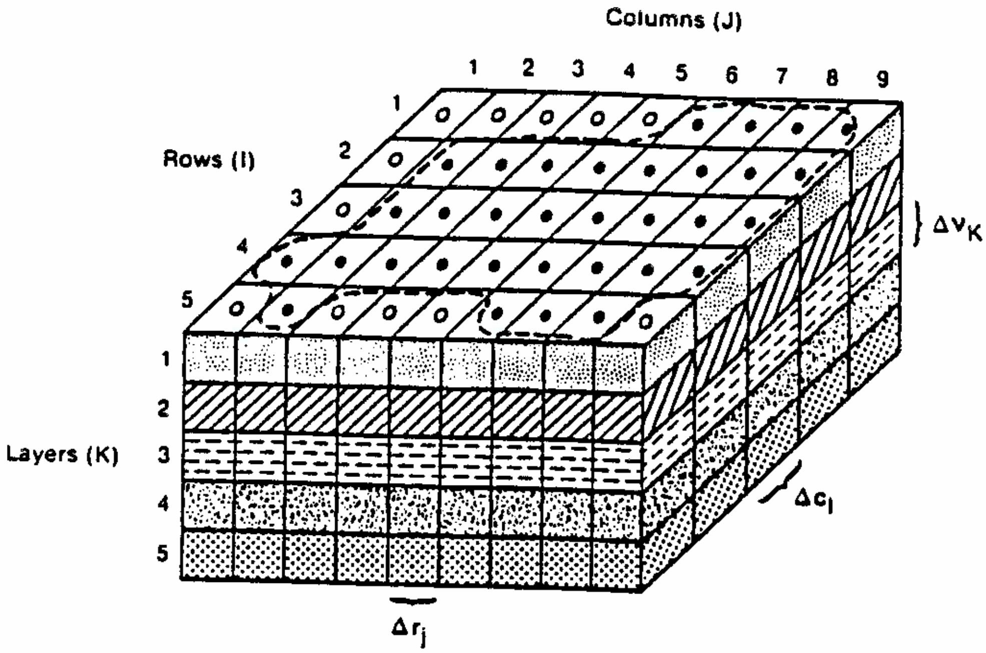


Figure 16. Example of finite difference grid overlain on an aquifer system (from Prickett and Lonnquist (1971)).



Explanation

- - - - Aquifer Boundary

• Active Cell

o Inactive Cell

Δr_J Dimension of Cell Along the Row Direction. Subscript (J) Indicates the Number of the Column

Δc_I Dimension of Cell Along the Column Direction. Subscript (I) Indicates the Number of the Row

Δv_K Dimension of the Cell Along the Vertical Direction. Subscript (K) Indicates the Number of the Layer

Figure 17. A hypothetical, multi-layered aquifer system represented by a three-dimensional grid cell (from McDonald and Harbaugh (1988)).

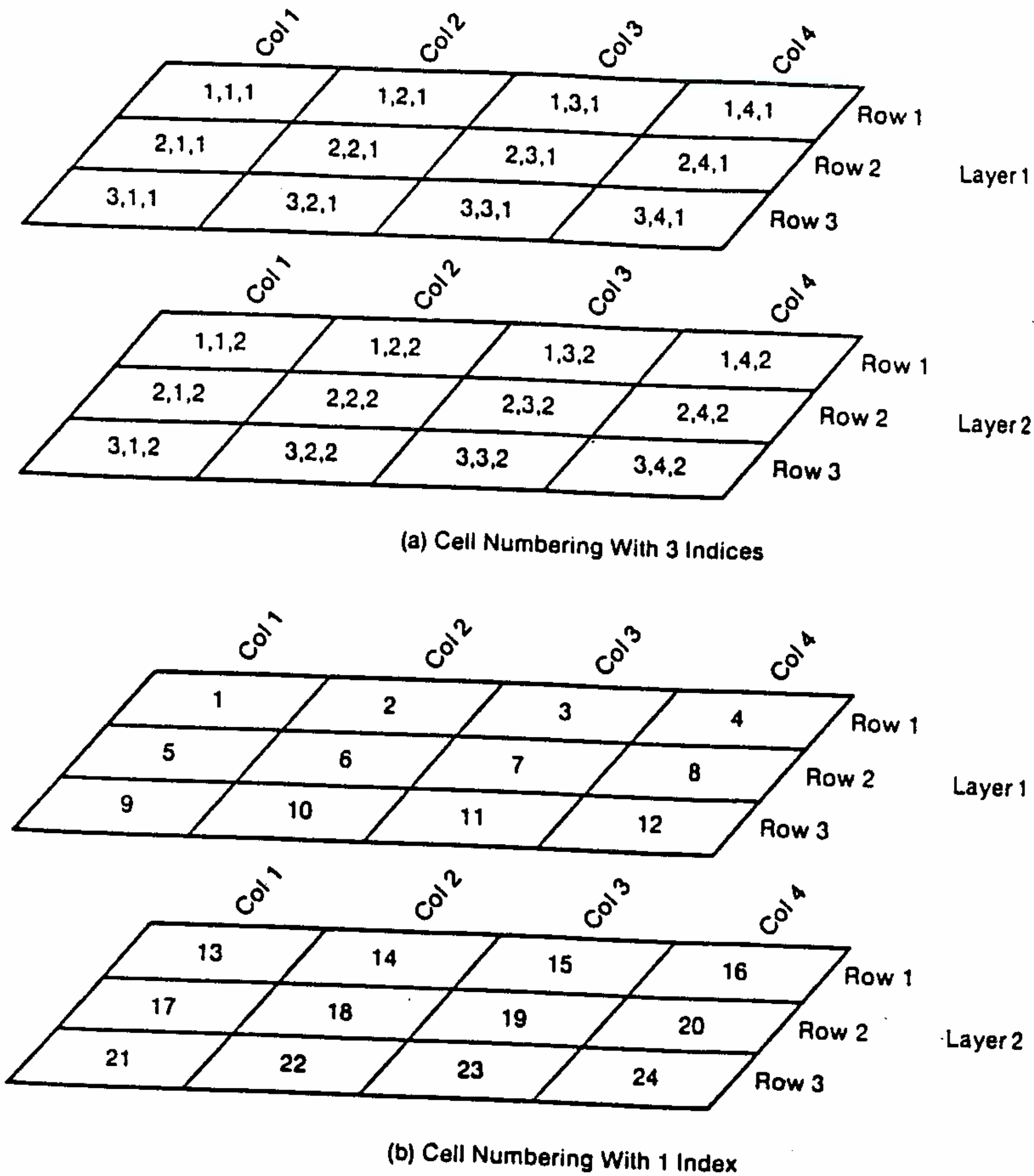


Figure 18. Three indices and single index cell designation schemes (from McDonald and Harbaugh (1988)).

Next, the input parameters required by the model are provided for each cell. For example, the areas of the grid that are outside the boundary of the basin can be set as inactive and cells that occur along the boundary of the area being modelled can be set with values to represent no-flow boundaries, general-head, constant-head, or variable-head cells, as shown in Figure 19. Codes or values for other hydrologic or model parameters are then input; Figure 20 shows the hypothetical configuration of recharge for a typical model. As shown on this figure, recharge can be simulated at any number of cells within a model. The ability to input areally (and vertically) distributed data into MODFLOW allows the modeler to develop a model that is consistent with the conditions that or known or inferred to be present in the area being modelled.

MODFLOW contains discrete modules that allow for the simulation of a number of hydrologic conditions in developing a model. Conditions that can be modelled using MODFLOW include confined, unconfined, and semi-confined hydraulic conditions, the discharge of water through evapotranspiration by plants, drains, wells, and streams, and the boundary conditions identified above. Sophisticated algorithms in the MODFLOW code also allow the simulation of phenomena that occur when an aquifer is stressed, including reductions in evapotranspiration rates and well yields in response to a lowering of the head in aquifer. Codes specifying the modules to be used and data values for each input grid to the model e.g., transmissivity, storativity, recharge, and water wells are input for each desired feature. A complete list of the MODFLOW options and data parameters is provided in Table 7. along with the identification of the options used and parameter values in the development of the main ground-water flow model of Coyote Spring Valley. The same options were used for the alternate model. Some of the parameters used were different as explained in Appendix E.

Figure 21 shows the Coyote Spring Valley basin boundary and the grid configuration established to represent that boundary, respectively. A 49 x 24 grid was employed with each grid cell one mile on each side.

MODEL SET-UP/ASSUMPTIONS

A three-dimensional finite-difference grid system comprising 2 layers was overlain on a map of Coyote Spring Valley, including the hydrologic boundary of the basin. The grid boundary was then designed to approximate the boundaries of the valley. A one-mile grid spacing was selected for use in all of the models, per discussions with the District. The one-mile grid spacing resulted in a 49 rows by 24 columns grid for Coyote Spring Valley. An areal view of the resulting grid system is shown on Figure 21. Additional model set-up input data are provided in Table 7.

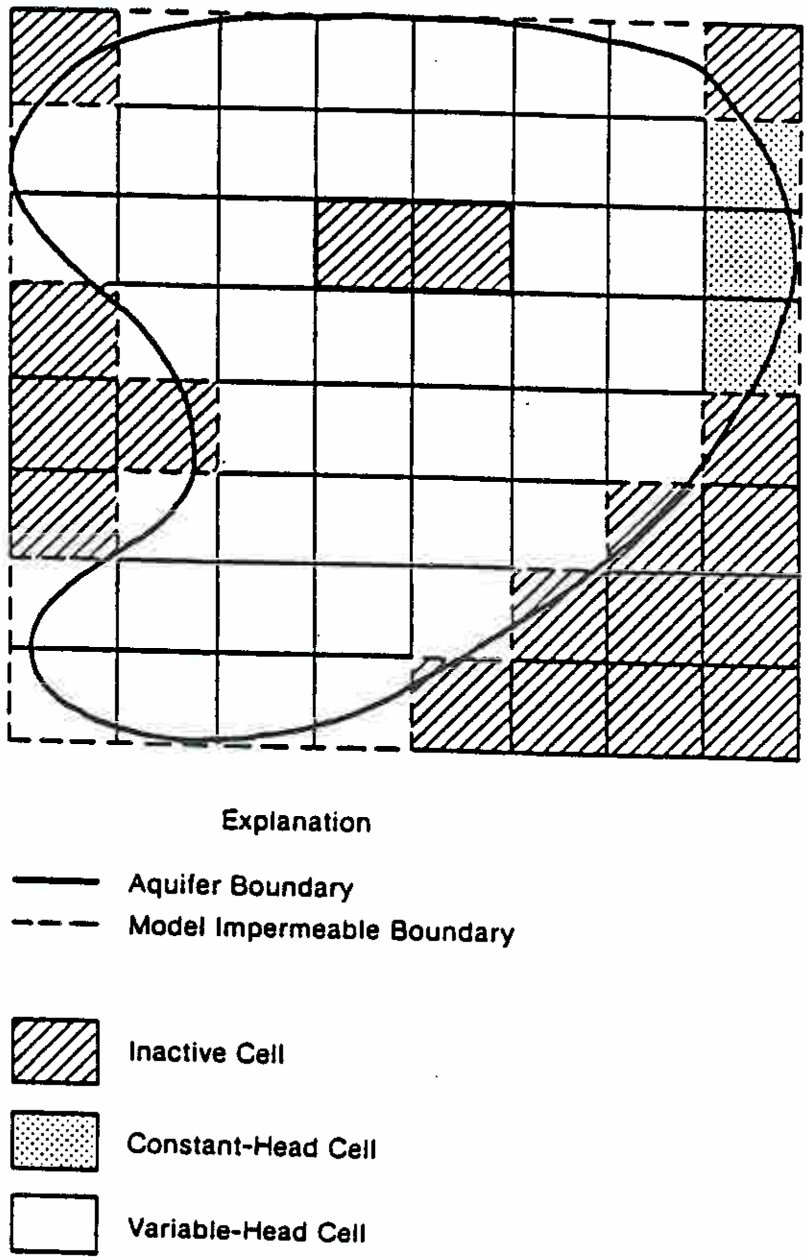


Figure 19. Example of boundaries and cell designation for a simple model (from McDonald and Harbaugh (1988)).

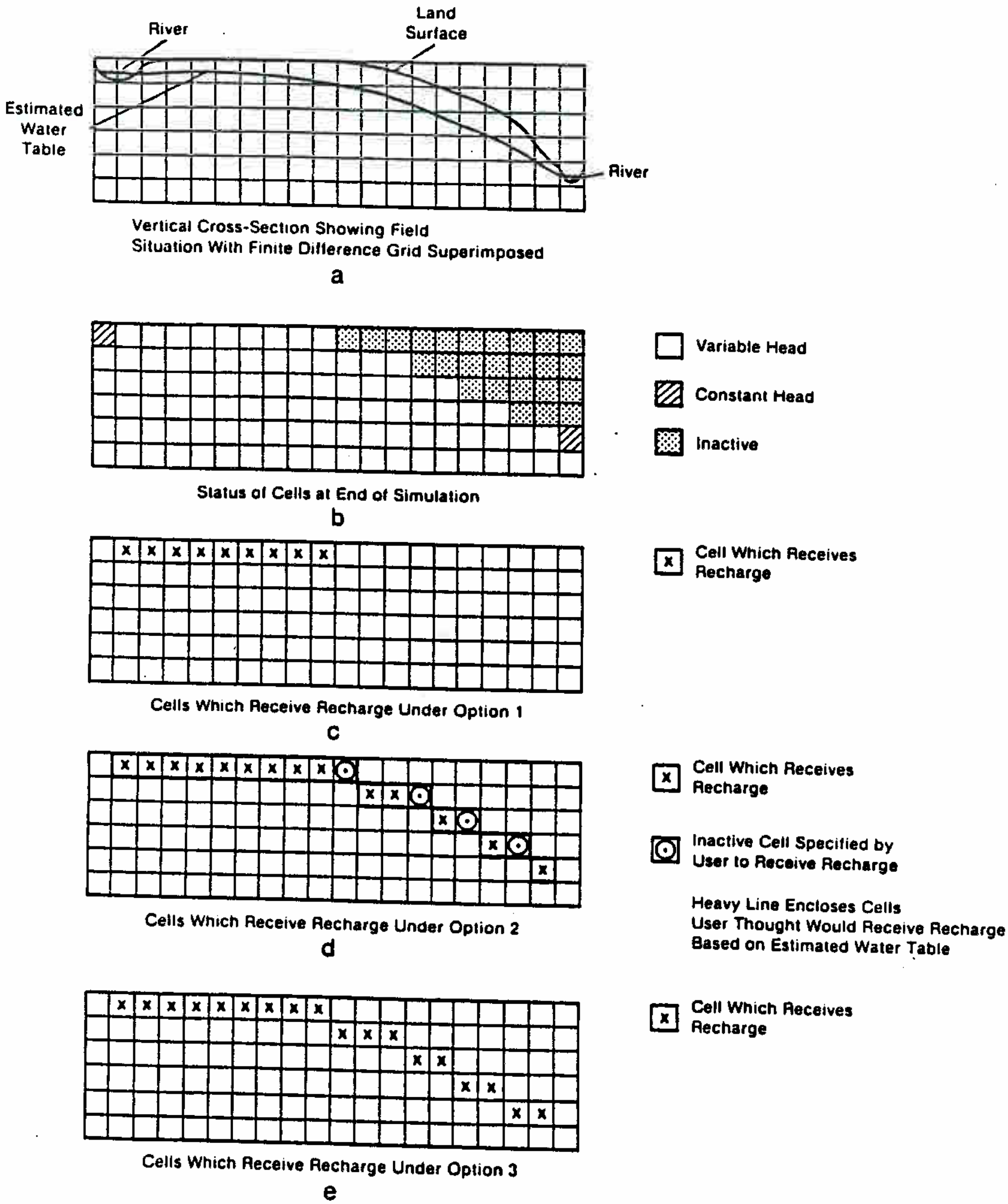


Figure 20. Hypothetical examples showing variable recharge distributions (from McDonald and Harbaugh (1988)).

Table 7. Modflow data parameters and values used for Coyote Spring Valley.

MODFLOW MODULE	DATA OR PARAMETER	VALUE FOR COYOTE SPRING VALLEY
BASIC PACKAGE INPUT	NUMBER LAYERS	2
	NUMBER ROWS	49
	NUMBER COLUMNS	24
	NUMBER STRESS PERIODS	1
	TIME UNIT	DAYS
	HEAD VALUES FOR INACTIVE CELLS	0
	INITIAL HEAD - TRANSIENT RUNS	NOT USED
	STRESS PERIOD LENGTH	0.00839 DAYS
BLOCK-CENTERED FLOW PACKAGE	LAYER TYPE	CONFINED
	ANISOTROPY FACTOR	ONE
	CELL DIMENSIONS	5,280' x 5,280'
	STORAGE COEFFICIENT	NOT USED
	TRANSMISSIVITY FOR CONF. LAYERS	SEE FIGURE 23[1]
	HYDRAULIC CONDUCTIVITY FOR UNCONF. LAYERS	NOT USED
	ELEVATION OF AQUIFER BOTTOM	NOT USED
	VERTICAL CONDUCTANCE OF CONF. LAYER	SEE FIGURE 24[1]
	SECONDARY STORAGE COEFFICIENCY	NOT USED
	TOP OF AQUIFER	NOT USED
RIVER PACKAGE	NUMBER OF RIVER REACHES ACTIVE (MAX)	NOT USED
	LAYER NUMBER	NOT USED
	ROW NUMBER	NOT USED
	COLUMN NUMBER	NOT USED
	STAGE	NOT USED
	CONDUCTANCE	NOT USED
	ELEVATION OF RIVER-BED BOTTOM	NOT USED
RECHARGE PACKAGE	LAYER NUMBER	1 (UPPER)
	ROW NUMBER	VARIABLE
	COLUMN NUMBER	VARIABLE
	QUANTITY	SEE FIGURE 22

Table 7. Modflow data parameters and values used for Coyote Spring Valley. (Continued)

MODFLOW MODULE	DATA OR PARAMETER	VALUE FOR COYOTE SPRING VALLEY
WELL PACKAGE	NUMBER WELLS (MAX)	NOT USED
	WELL LOCATION	NOT USED
	Q	NOT USED
DRAIN PACKAGE	NUMBER DRAINS (MAX)	NOT USED
	DRAIN LOCATION	NOT USED
	Q	NOT USED
	ELEVATION OF DRAIN	NOT USED
	HYDRAULIC CONDUCTANCE OF INTERFACE	NOT USED
EVAPOTRANSPIRATION PACKAGE	ELEVATION OF ET SURFACE	NOT USED
	MAXIMUM ET RATE	NOT USED
	ET EXTINCTION DEPTH	NOT USED
	LAYER INDICATOR	NOT USED
GENERAL HEAD BOUNDARY PACKAGE	NUMBER GENERAL HEAD BOUNDARY CELLS (MAX)	VARIABLE
	LAYER NUMBER	VARIABLE
	ROW NUMBER	VARIABLE
	COLUMN NUMBER	VARIABLE
	BOUNDARY HEAD	SEE FIGURES 11 & 25
	CONDUCTANCE	DERIVED FROM FIGURES 23 & 25[1]
STRONGLY IMPLICIT PROCEDURE PACKAGE	NUMBER ITERATIONS (MAX)	150
	NUMBER ITERATION PARAMETERS	5
	ACCELERATION PARAMETER	1.0
	HEAD CHANGE CRITERION	0.01
	ITERATION PARAMETER SEED	DEFAULT
SLICE-SUCCESSIVE OVER-RELAXATION PACKAGE	NUMBER ITERATIONS (MAX)	NOT USED
	ACCELERATION PARAMETERS	NOT USED
	HEAD CHANGE CRITERION	NOT USED

[1] These figures reflect final variable distributions.

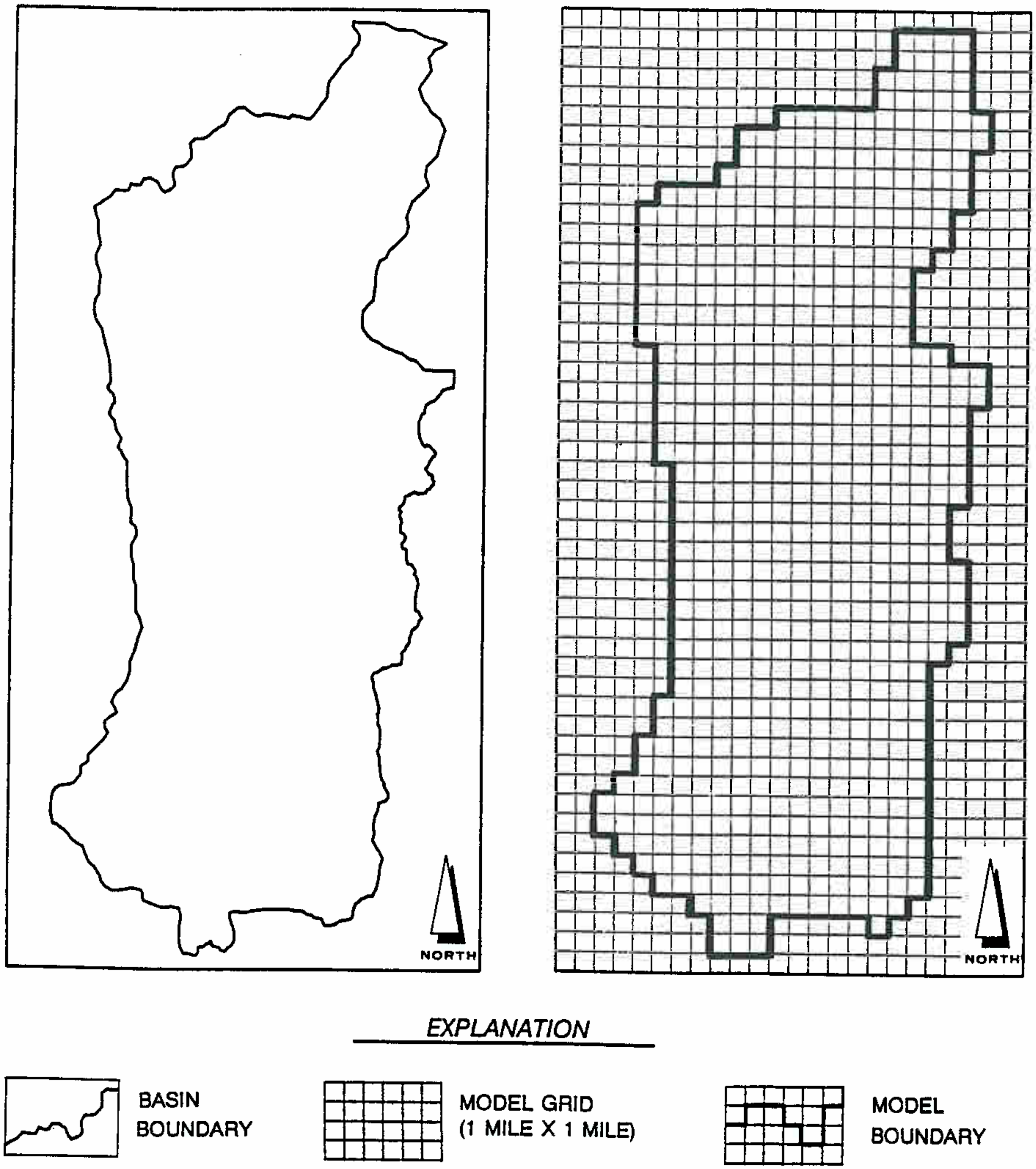


Figure 21. Basin boundary and model grid for Coyote Spring Valley.

The top layer (or layer 1) was designed to represent all of the saturated valley-fill present in the valley, and similar thicknesses of saturated carbonate or volcanic rocks present within the same horizon. The bottom layer (or layer 2) was designed to represent mostly the deeper saturated carbonate rocks and the saturated volcanic rocks where present at similar elevations.

Although the top layer is under unconfined conditions, both layers were modeled as being confined because the additional data required to model unconfined conditions (i.e. hydraulic conductivities and elevation of aquifer bottom) were not available. This assumption will not affect the steady-state model as the saturated thicknesses and therefore transmissivities remain constant under such time-independent conditions. Although not exactly representative of real conditions, this assumption should not introduce significant errors in the transient modeling results either, as long as the drawdowns caused by pumping remain small relative to the saturated thickness of the top layer. Actually, drawdowns observed in a confined aquifer are similar to those observed in an unconfined aquifer if the induced drawdowns are less than 20% of the saturated thickness.

INITIAL PARAMETER ESTIMATES

Following the finite-difference grid setup, preparation of data grids representing each of the MODFLOW input parameter requirements was initiated. Data grids were prepared for recharge, transmissivity and boundary conditions.

Recharge Distribution

Following the initial model setup, the primary input of data grids representing each of the MODFLOW input requirements was initiated; the first data grid prepared was the recharge layer, representing the rate of recharge to Coyote Spring Valley.

Primary

Primary recharge in Coyote Spring Valley is limited to the infiltration of rainfall over the valley and seepage of water into streambeds during the infrequent ephemeral flows that occur in the drainages.

There are no streamflow records available for Coyote Spring Valley, however, it is believed that, because of the low precipitation rate and frequency and the depth to water over most of the valley floor, little recharge occurs along the drainages.

The recharge derived from precipitation, as discussed in the Budget section, amounts to about 1,900 acre-feet per year, and is distributed as a function of elevation. In developing the numerical model of the valley, recharge was distributed according to the elevation as shown graphically in Figure 22; the resulting configuration of model cells that receive recharge is also shown.

Secondary

Because of the lack of land and water users in Coyote Spring Valley, secondary recharge is considered negligible at present. Only in the areas immediately downgradient of Coyote Spring and a few small seeps could any secondary recharge occur. However, because of the slight discharge from these areas and the evapotranspiration losses, it is likely that none of this discharge recharges the aquifer system.

Historically, up to 24 acres of land were under irrigation in northern Coyote Spring Valley, according to information made available by the Nevada State Engineer; however an inspection of this area during the reconnaissance of Coyote Spring Valley conducted as part of this investigation found that the area is now fallow with no signs of recent irrigation.

Because of the cessation of irrigation and the current lack of water use, secondary recharge in Coyote Spring Valley is considered negligible or nonexistent; therefore, no secondary recharge was input to the numerical model of the valley for the steady-state calibration or for transient simulations that included water users other than the District.

Hydraulic Characteristics

In developing a numerical model of a hydrographic basin, either measured or assumed values must be used to represent the hydraulic characteristics of the media being modelled. In this section, the values used as input to MODFLOW in developing a model of Coyote Spring Valley are discussed.

Transmissivity

The initial transmissivity distributions were assumed to be uniform for both layers. The initial values were based on average transmissivity values observed for the valley-fill and the carbonate aquifers regionally. In performing steady-state simulations for model calibration, these values were adjusted. The adjustments that were made, and the results, are presented in the Model Calibration and Modeling Results sections of this report.

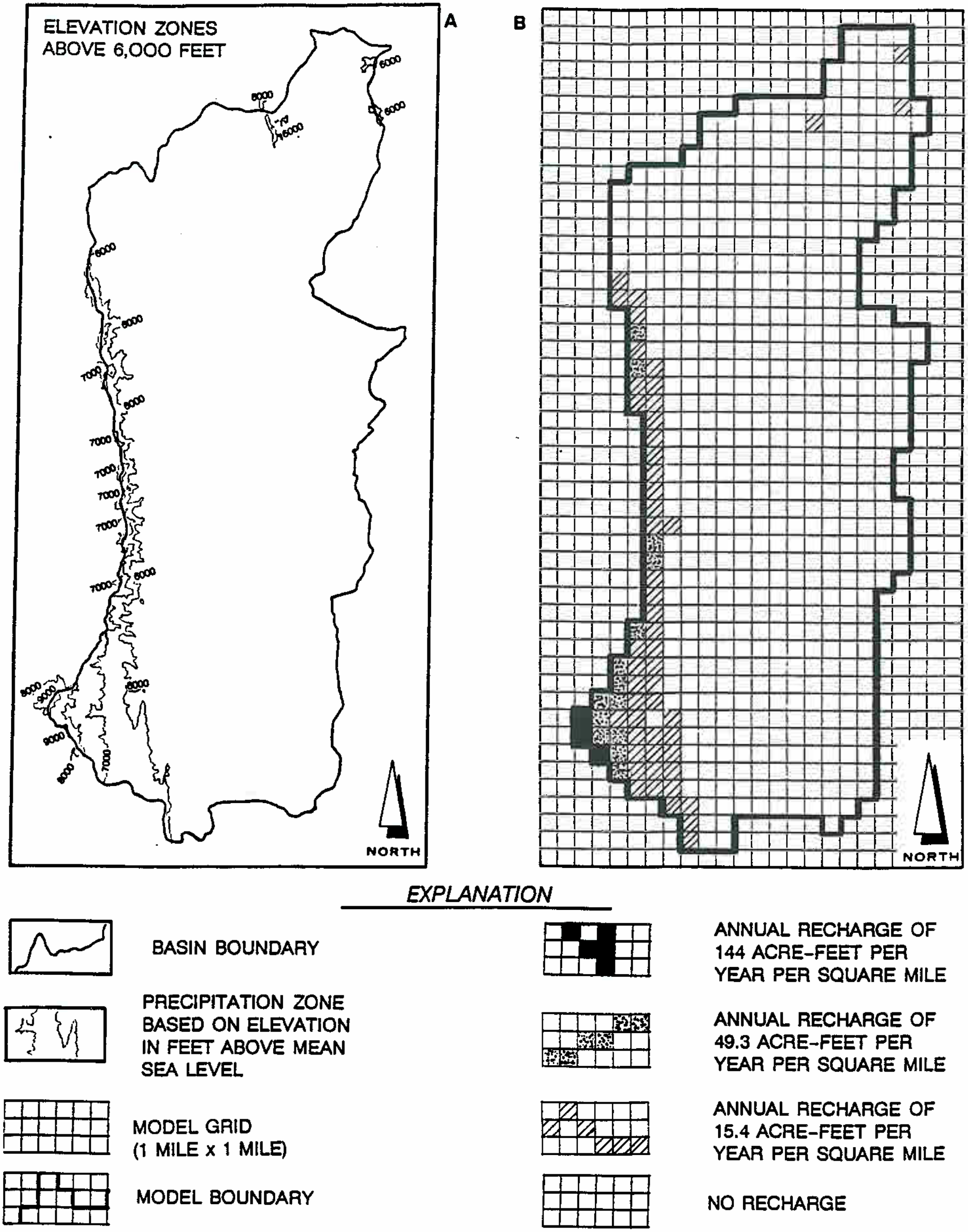


Figure 22. Primary recharge zones in Coyote Spring Valley.

The transmissivity of Layer 1 of the model is a special consideration for Coyote Spring Valley. As mentioned previously, it is believed that saturated valley-fill sediments only occur in the central portion of the valley. However, the data concerning both the thickness of the valley-fill and the static water level are limited thus the precise areal extent over which saturated alluvium occurs is unknown.

As a consequence, the upper layer of the model includes valley-fill, volcanic rock, and carbonate rock whose extent is unknown. It is not considered necessary to assign different values for transmissivity for each of the aquifer types because of the similarity of these units over much of the valley. As noted previously, high transmissivity zones in the carbonates are believed to be coincident with the major structural features in the valley.

Over most of the valley, however, the transmissivity of the carbonates in the upper layer of the model is expected to be appreciably lower, on the same order as the alluvium. This low transmissivity is reflective of the limited thickness of saturated rock present to the same depth as the base of the deepest alluvium in the valley and the smaller degree of fracturing.

Further, the assignment of transmissivity values during the model setup is independent of rock type. The adjustment of the transmissivity for model calibration similarly is independent, focusing rather on the hydraulic head distribution.

Vertical Leakance

Differences in heads between the valley-fill and carbonate aquifers in the central part of the valley show that the carbonate aquifer is under some degree of confinement. A layer of fine-grained lake deposits, located at the bottom of the alluvial deposits may be acting as the confining layer. As a result, the vertical leakance was assigned a relatively small initial value at all cells where both alluvium and carbonate rock are present, 1.0×10^{-7} per day. All other cells, corresponding to carbonate outcrops mostly, were assigned a higher initial value, 1.0×10^{-5} per day.

Storage Coefficients and Specific Yields

The assignment of values for storage coefficients or specific yield (collecting term storativity), although not a required parameter for steady-state simulations, is required for any transient simulations used to predict the performance of a pumping well or well field. Therefore, a discussion of this hydraulic characteristic is warranted.

Valley-specific data on the storativity of the aquifers in Coyote Spring Valley are lacking, but assumptions can be made on the basis of data available from other valleys in Nevada. For the valley-fill aquifer, the storativity generally ranges from .001 to .3. The lower value is typically measured at wells where semi-confined conditions exist, e.g. in the vicinity of playas and lacustrine deposits such as the Muddy Creek formation where fine-grained, but laterally discontinuous sediments overlie or are interbedded with more coarse-grained sediments. The higher value is more indicative of unconsolidated coarse-grained alluvial deposits that are well sorted, i.e. with minimal variations in grain size.

Of special note are the variations in storativity that are often observed with time. In general, the storativity of both unconfined and semi-confined aquifers tends to increase as the duration of pumping increases. Short term (less than 10 days) aquifer tests often yield estimates of storativity of 0.1 or less while long term pumping tests indicate higher storativities. Such variations are believed to reflect the inhomogeneity of the sediments and the gradation of the response of an aquifer from semi-confined to unconfined during actual pumping.

With respect to the carbonate aquifer, a value of 0.01 is considered appropriate. This value is consistent with the recoverable yield estimate presented by Dettinger (1988). The storativity of the carbonate aquifers in Nevada is likely to exhibit a wide range of values however, reflecting the high degree of variability in aquifer mechanics related to the degree of fracturing, the fracture aperture widths, spacing, and continuity, the degree of confinement, and the extent to which secondary porosity has resulted through dissolution. Walton (1984) presents a summary of storativity values from published sources with a range of 0.1 to 0.24 for limestone aquifers and .000001 for fractured rock. Walton further notes that "gravity drainage of interstices is not instantaneous and the water-yielding capacity increases at a diminishing rate as the time of drainage increases, gradually approaching the specific yield." Thus, the storativity of the extensive carbonate aquifers in southern Nevada can be expected to increase in time with pumping as the response of the aquifer transitions from the rapid dewatering of low storativity fractures to the much higher matric storativity of the limestone between the fractures.

Modeling of this phenomena is not considered appropriate however, insofar as the duration of pumping by District wells could well exceed 100 years. The use of the recoverable yield estimate of 0.01 reported by Dettinger is considered appropriate for use as it is conservative in that it should tend to overestimate the drawdown resulting from large-scale water withdrawals over an extended pumping period.

Boundary Conditions

The location and type of boundary conditions used in MODFLOW to represent the boundary conditions prevailing at Coyote Spring Valley are shown in Figure 23. The assumed conditions were selected on the basis of reported or inferred hydrologic conditions. For the first layer, where outcrops of relatively impermeable rocks (such as the clastic aquitard in the Sheep Range) occur, a no-flow boundary condition was assigned to the grid cells representing the area. Similarly, model grid cells representing the area of the natural ground-water divide between Coyote Spring Valley and adjoining basins are assigned no-flow boundary conditions. For the second layer, no-flow boundary conditions were restricted to the southern boundary and the central portion of the eastern boundary. The remaining boundary was assumed to be leaky and was assigned general-head boundary conditions. The head data necessary to define general-head boundary conditions were derived from head distributions shown on Figure 11. The initial conductance values were based on initial estimates of transmissivity data.

MODEL CALIBRATION

Model calibration is an iterative procedure that usually requires numerous steps. Each step consists of three major sub-steps: 1) running the model with the current parameters to simulate a matrix of corresponding heads; 2) comparing the simulated heads with known heads; and 3) adjusting the most sensitive parameters to reduce the difference between the simulated and observed heads. This step is repeated until the simulated heads match the observed heads. In addition, after a match is established between the heads, the simulated and observed basin water budgets are compared. If the two budgets do not match, the iterative procedure is continued until such a match occurs.

Calibration of the Coyote Spring steady-state model included adjusing of the transmissivity and leakance terms until the observed water levels and the flow budget matched. For the initial model runs, each grid cell within the effective area of the model was assigned the same value of transmissivity. The steady-state results of each model were then reviewed to evaluate the effects of the assigned boundary conditions and the water budget for the simulation. These evaluations found that, while a uniform model transmissivity resulted in a reasonably accurate simulation of the potentiometric surface in the lower portions of the valley, it did not accurately simulate the expected potentiometric highs under the recharge areas in the Sheep Range. Because recharge areas often provide a significant source of water, they can exert significant hydraulic controls on the performance of a well field, additional refinement of the transmissivity through the use of zoned transmissivity grids was done.

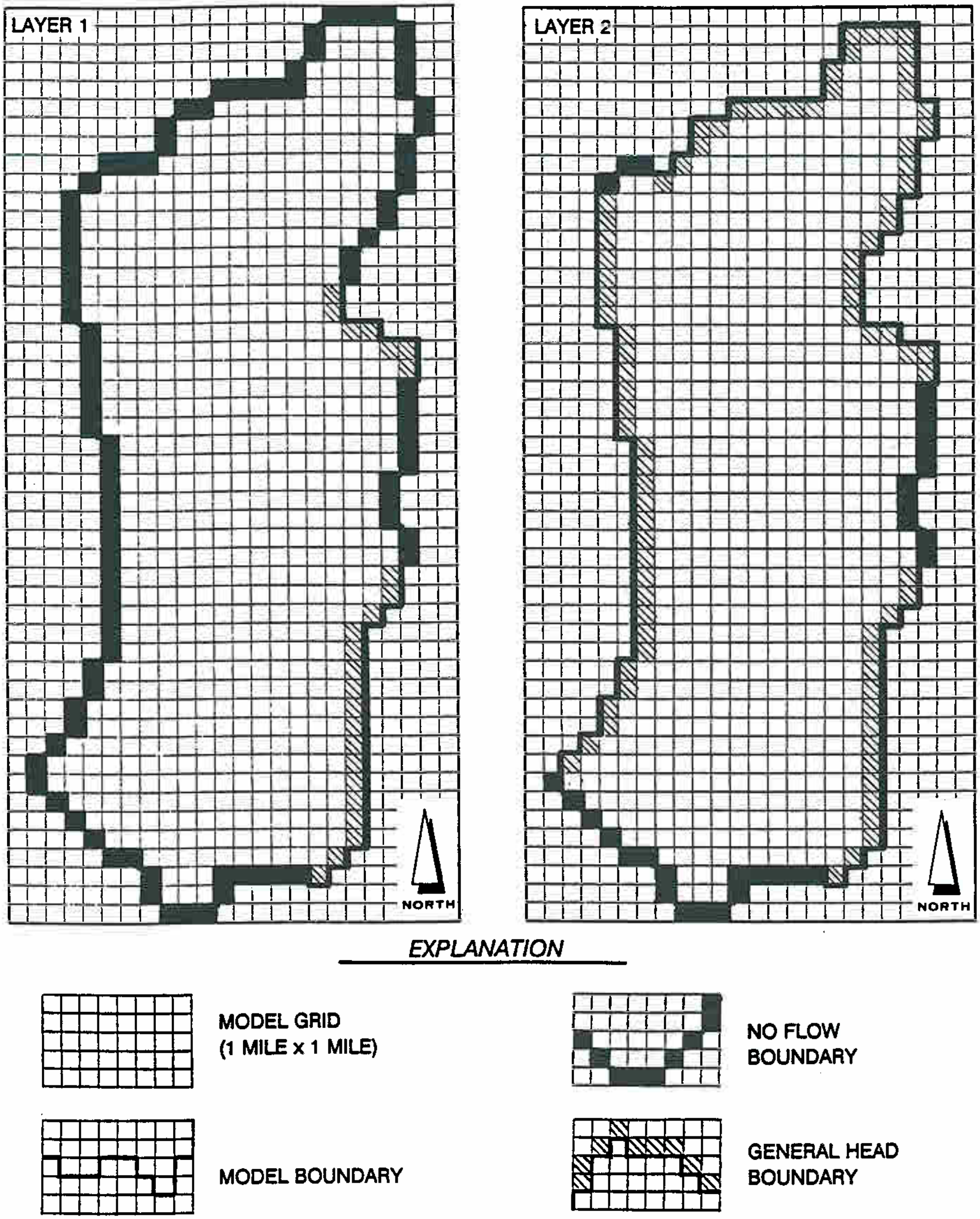


Figure 23. Boundary conditions used in the model of Coyote Spring Valley.

Transmissivity zones were established to reflect the known or inferred hydrologic conditions in the valley. As discussed in preceding sections, the geologic units that comprise the clastic aquitard crop out in the Sheep Range. Where the aquitard crops out or occurs at shallow depths, the saturated thickness, and hence transmissivity, of the overlying aquifer may be minimal. To simulate the presence of this condition, the grid cells representing the Sheep Range were assigned low transmissivity values. Additional model runs resulted in simulated steady-state water levels that clearly showed the presence of a ground-water mound under the major recharge source to Coyote Spring Valley, consistent with the conceptual model.

Adjustments to the leakance distribution were then made to account for the presence of confining materials in the central part of the valley. The conductances associated with the general-head boundary conditions, were continually updated as the transmissivities were varied throughout the model calibration process, based on the relationship between conductance and transmissivity given by McDonald and Harbaugh (1988).

Minor adjustments were then made to the transmissivity distributions to refine the calibration. Following each simulation, the hydraulic heads simulated by the model were compared both to the interpreted potentiometric surface of the basin and the individual grid cells representing locations with measured water levels. The water budget for the basin was also compared with the flow balance calculated by MODFLOW at the end of the simulation.

MODEL RESULTS

The results of the steady-state main model of Coyote Spring Valley are presented in this section. The results of the alternate steady-state model are presented in Appendix E.

The zones and associated values of transmissivity that provided the best correspondence between the overall water surface, individual measured water levels, and the published estimates of subsurface recharge and discharge for Coyote Spring Valley, are shown in Figure 24. The transmissivity values fall within the range of published values for both the valley-fill and carbonate aquifers (see Table 2). The final vertical leakance distribution was arrived at by calibration and is presented on Figure 25.

The calibrated model resulted in the simulated potentiometric surface shown in Figure 26. The heads simulated by MODFLOW closely agree with the regional potentiometric surface for the area (Figure 11). Both the configuration and the slope of the simulated potentiometric surface coincide, with only minor differences, with the map based upon observed potentiometric levels (Figure 11). The differences are believed to be due to pumping in the valley when head measurements were taken (a condition not simulated in the steady-state simulation) and factors inherent to the modelling of large hydrographic basins using MODFLOW, discussed in a later section.

The simulated quantity of ground-water discharge out of Coyote Spring Valley is 36,893 acre-feet per year. This simulated discharge rate agrees within 0.3 percent with the published discharge estimate of 37,000 acre-feet per year. This small difference is probably due to the rounding of water budget parameter values presented in the published estimates. The comparison between the published and simulated ground-water budgets for Coyote Spring Valley is summarized in Table 8.

Because of the close agreement between the simulated water budget and heads and the existing data, the steady-state simulation presented above is considered a reasonably calibrated and accurate mathematical representation of the naturally occurring hydrologic system of Coyote Spring Valley. The level of calibration achieved further indicates that the assumptions used and values assigned to grid sets for key MODFLOW parameters result in a numerical model that can serve as the basis for simulating the performance and potential impacts of the proposed District water withdrawals in the basin.

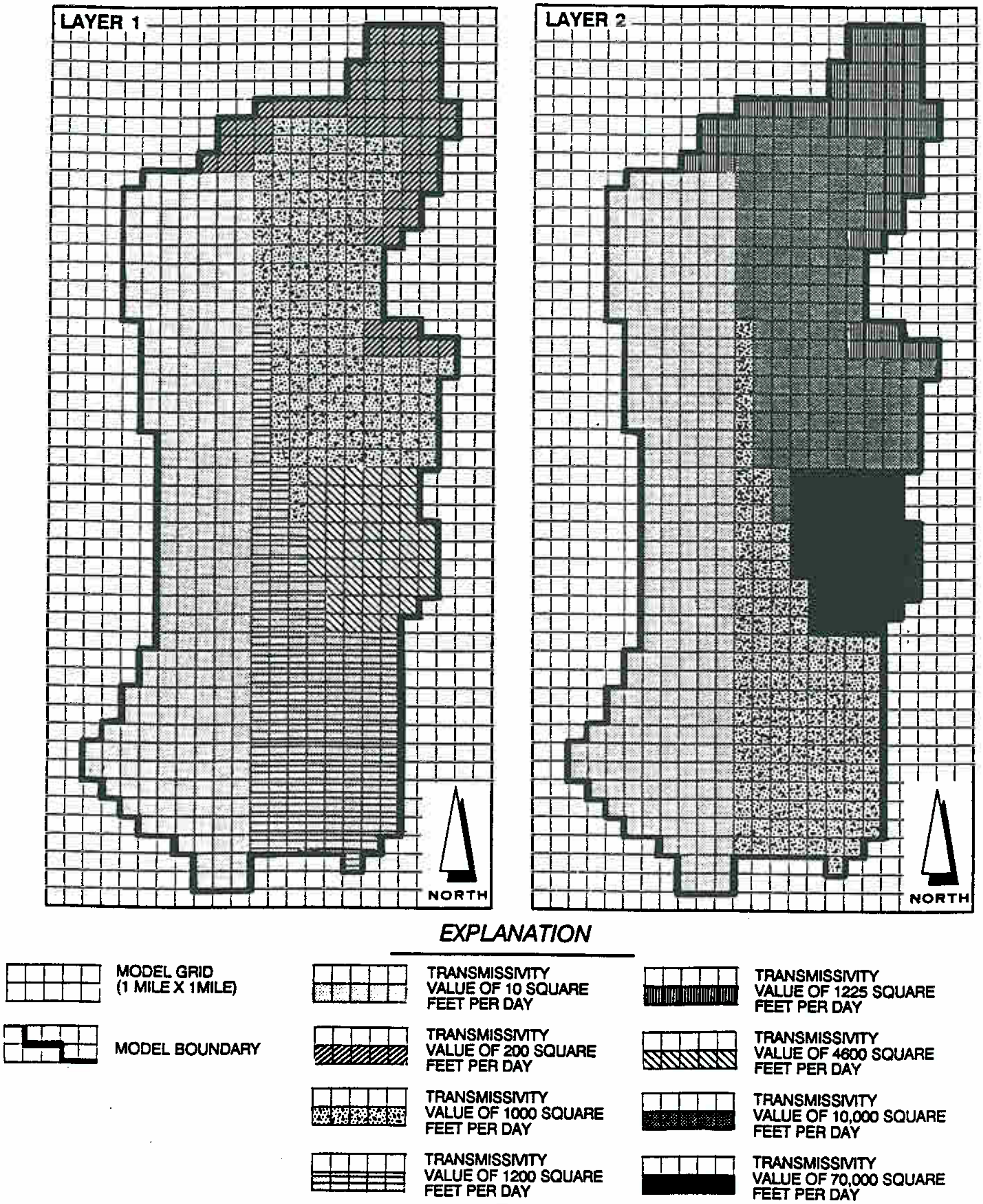


Figure 24. Distribution of transmissivity values in the model of Coyote Spring Valley.

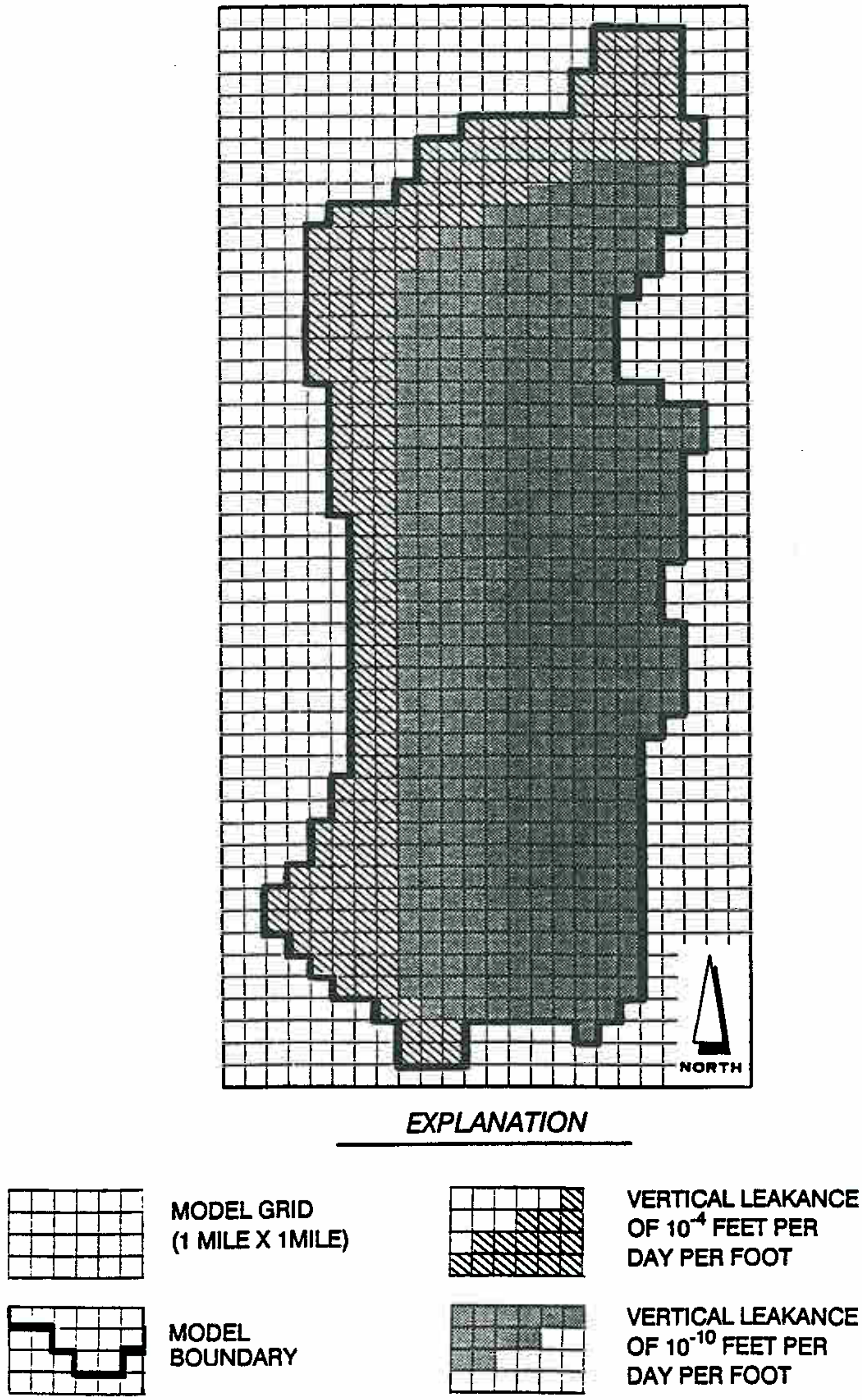


Figure 25. Distribution of vertical leakance values in the model of Coyote Spring Valley.

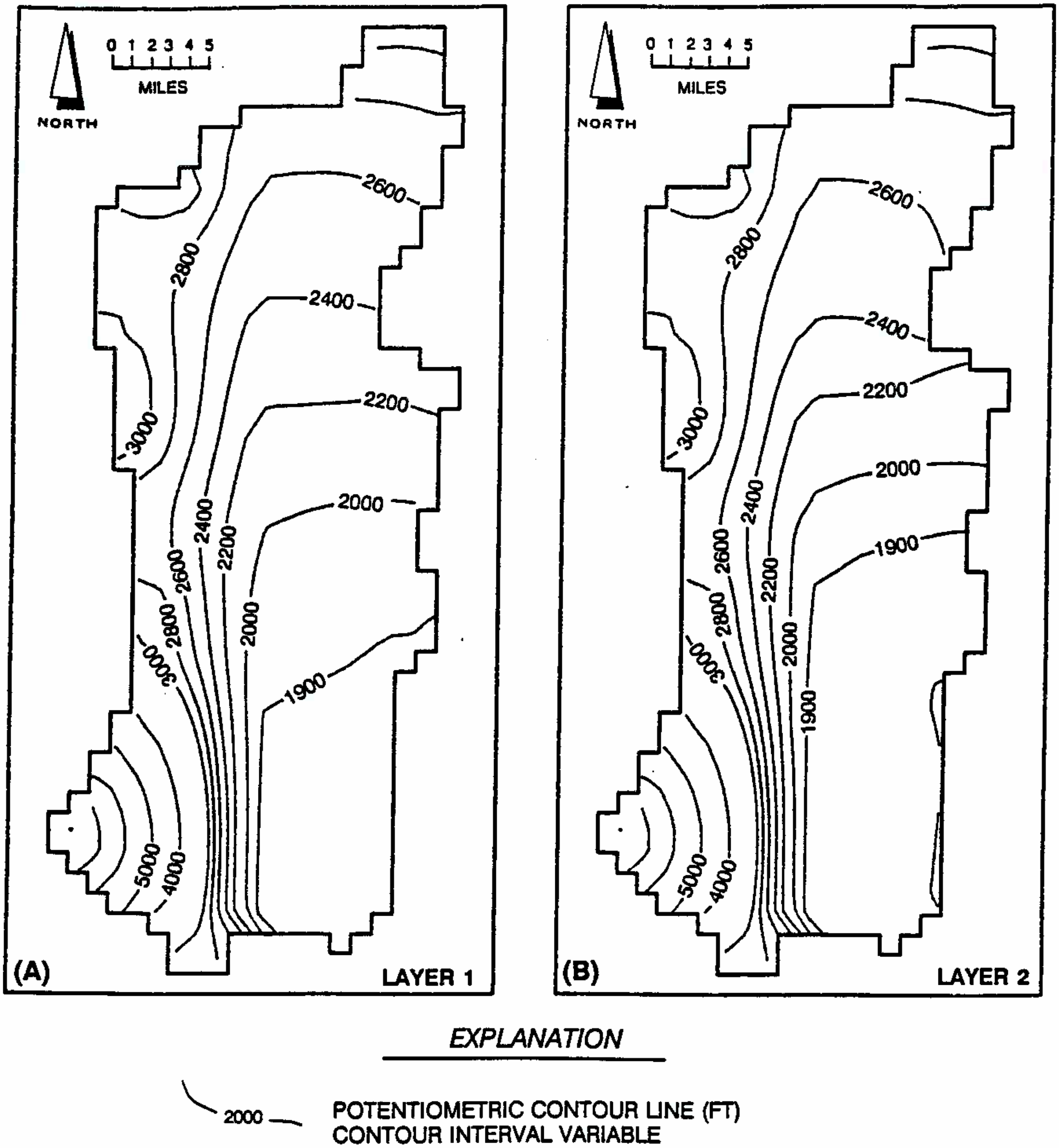


Figure 26. Simulated steady-state potentiometric surfaces of Coyote Spring Valley.

Table 8. Comparison between published and simulated groundwater budget for Coyote Springs Valley (stated in acre-feet per year (ac-ft/yr)).

	PUBLISHED VALUE	MODELED VALUE FOR STEADY-STATE
RECHARGE		
Precipitation (Recharge)	1,900-2,100	1908
Subsurface Inflow	35,000	34,988
Secondary Recharge	—	0
TOTAL	36,900+	36,896
DISCHARGE		
Evapotranspiration	Minor	0
Springs	41	0
Water Wells	0	0
Outflow	37,000	36,893
TOTAL	37,041+	36,893

The steady-state heads were compared with heads simulated in the U.S. Geological Survey's numerical model of the regional carbonate aquifer (Burbey and Prudic, 1985). The heads in both models agree in the central part of Coyote Spring Valley. There is disagreement at the western boundary, mostly because the USGS model does not account for local features, particularly the mounding of ground water caused by the recharge to the Sheep mountain range. The general trends and ground-water flow directions are however similar. The differences between the two models are believed to be an artifact of the two different grid spacings used and the selection of the contour interval. In the U.S. Geological Survey model, a 5 x 7.5 mile grid spacing was used while in the model presented herein, a 1 mile grid spacing was used. In distributing recharge and discharge, the U.S. Geological Survey model adds or withdraws water from larger cells, thus the resulting heads will be somewhat smoothed. The contour interval of 250 feet presented in the U.S. Geological Survey model does not indicate local variations that are apparent from the finer contour interval of 100 feet in the model presented herein. Despite the differences in approach and presentation, it is believed that the overall results of the two models are essentially similar.

The alternate model configuration was rejected because it necessitated high transmissivity values in the alluvium, which may be an indication of the presence of thick alluvial deposits in the valley. This is in contradiction with the existing well data in the valley which suggest that the alluvium is rather thin in Coyote Spring Valley. The alternate model steady-state results are shown in Appendix E.

ACCURACY OF HYDROLOGIC DATABASE AND MODEL CODE

The ability of numerical models to provide accurate representations of the hydrologic conditions within a basin is, to a large degree, a function of two factors, the hydrologic database, and the type of model that is used. In this section, the overall data quality and the limitations of MODFLOW are discussed.

The key limitations of the hydrologic database are the number of data points and their spatial distribution. Water wells are installed to serve developed areas with basic water service and, as a consequence, often are not present in undeveloped areas. This is especially true in the remote areas of Nevada where development may be limited to a few geographic areas within a basin or may even be totally lacking. Thus, the areas of development may have numerous wells completed within relatively short distances of each other while in undeveloped areas it is not uncommon for areas comprising hundreds of square miles to have no wells and hence, no direct data. In such instances, hydrologists must often infer the hydrologic conditions on the basis of regional data and analog models based upon similar environments in other basins.

As discussed previously, there are only thirteen existing water wells in Coyote Spring Valley and only five of them have water level data usable in the model. The other wells are either dry or perched. Three of these wells tap ground water from the carbonate aquifer and the remaining four from the alluvium. To address this data deficiency, wells located in the Valley and regional hydrogeologic characterizations were used to develop the conceptual model of Coyote Spring Valley.

In areas where data are not available within the basin or in adjacent valleys, the hydrologic conditions were inferred on the basis of known conditions in similar environments e.g., the bounding Sheep Range is known to be a source of recharge and that an elevated potentiometric surface under these mountains is to be expected.

If data from peripheral valleys are taken into account in this manner and supplemented with sound hydrologic interpretations of data deficient areas, then a valid conceptual model can be developed for valleys with limited, or no data. The development of a valid conceptual model of this nature is essential to the formulation of any mathematical simulations through modeling.

The data that were used in developing both the conceptual and numerical models of Coyote Spring Valley are believed to be accurate. The data used were derived from government agencies, particularly the U.S. Geological Survey, and from published sources. It is believed that the data were collected using the standard procedures of the individual organizations and represent reliable and accurate information.

Numerical simulations require the use of mathematical expressions that approximate the flow of ground water. The computer code for MODFLOW is well documented and widely used and is considered an appropriate code for simulations of ground-water flow of large basins such as those found in Nevada. There are, however, limitations in the model, as in all models, that should be taken into consideration in assessing the accuracy of any model output.

The distribution and variability of well data and the gradient of the potentiometric surface are two key constraints on the application of the MODFLOW code to hydrographic basins such as Coyote Spring Valley. MODFLOW uses a block-centered approach rather than a point-centered approach in representing an area. In a nodal approach, input values for hydrologic parameters and the output from the model are for the four corners of a grid cell. Thus each corner (or node) represents a single point in space and it is possible to interpolate between nodes.

In the block-centered approach, the input values for hydrologic parameters and the output from the model are for entire area represented by the grid cell, in the case of Coyote Spring Valley, one square mile. Thus, each grid cell is represented by a unique value for the elevation of the potentiometric surface. Where this difference becomes significant is in areas where the presence of hydraulic gradients results in lower potentiometric surface elevations on the downgradient edge of the area represented by the grid cell.

Over some of Coyote Spring Valley, the hydraulic gradient is more than one hundred feet per mile. MODFLOW cannot simulate such gradients within a cell but can, however, simulate gradients of this magnitude between adjacent cells. Thus, although the precise head in a single grid cell may not be reproducible, the overall configuration and elevation of heads in an area comprising multiple grid cells can be accurately simulated by MODFLOW.

The limitations discussed above are inherent to all models when they are applied to large areas and are not unique to the MODFLOW code that was used for this investigation. Because the MODFLOW code was able to provide simulations that closely approximate the configuration of the potentiometric surface (both elevation and slope) as well as the elevation of the potentiometric surface observed at single wells located in areas where these limitations do not occur, the resulting simulations are believed to be accurate representations of the hydrologic system present in Coyote Spring Valley.

SUMMARY

The hydrogeologic system of Coyote Spring Valley was characterized based on available existing data. A conceptual model of the hydrologic system was then assembled. Based on the conceptual model of the valley, a steady-state ground-water flow model was constructed. The flow model was calibrated to measured or inferred water levels in the valley and the estimated water budget of the valley. The resulting ground-water flow model is believed to provide an accurate representation of the steady-state hydrologic system of Coyote Spring Valley. The results of the analyses and numerical simulations sections indicate that there are undeveloped water resources available in Coyote Spring Valley, especially in the carbonate aquifer.

The developed model simulates time-invariant aquifer responses only, and is thus incapable of predicting responses to stress over time, such as the stress that would be imposed by pumping the proposed District wells. A transient model must be constructed, based on the steady-state model presented in this report before such predictive simulations may be performed. Such a transient model could also be used for as a tool for assessing individual well sites.

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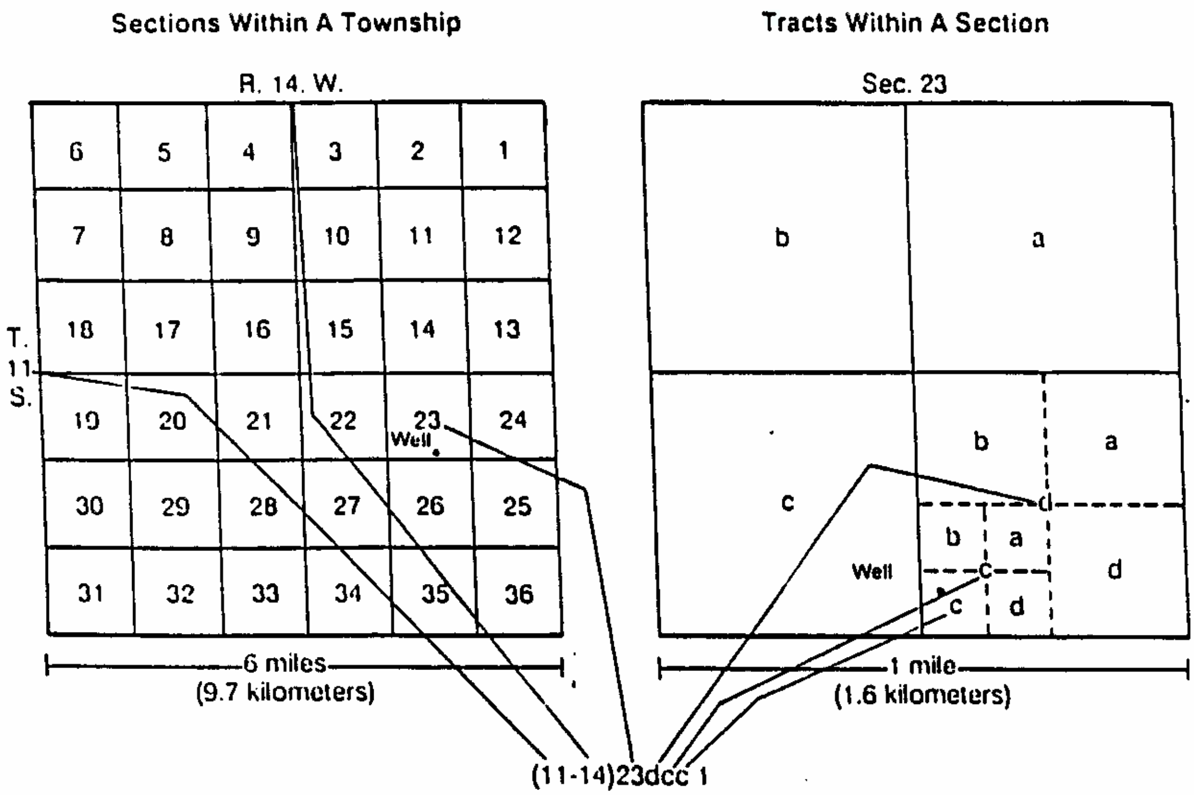
APPENDIX A

Location Designation



Well and spring locations are designated with respect to the Mount Diablo baseline and meridian as shown diagrammatically above. The first number within the parentheses represents the township south of the baseline and the second number represents the range east of the meridian. The section number follows along with the section 1/4, section 1/16th, and section 1/64th. The letter designations a, b, c, and d refer to the northeast, northwest, southwest, and southeast, respectively. If more than one well occurs within the same 1/64th section, a numerical identifier is added to the end of the designation. Thus (28-63) 27aba1 represents the first well of record in the northeast quarter-section of the northwest quarter-section of the northeast quarter-section of Township 28 South, Range 63 East, Section 27.

APPENDIX B

Water quality data for Coyote Spring Valley (USGS unpublished data).

Parameter	Station ID Numbers USGS Units	363830115041201	363838115055201	363838115055201	363838115055201
Station Name		210 S15 E62 18 Wamp Spring	210 S15 E61 0 Morman Well	210 S15 E61 0 Morman Well	210 S15 E61 0 Morman Well
Latitude		36 36 30 N	36 38 38 N	36 38 38 N	36 38 38 N
Longitude		115 04 12 W	115 05 52 W	115 05 52 W	115 05 52 W
Date		03/20/87	10/27/81	05/05/83	10/07/87
Temperature Water	Degrees C	7.00	11.50	10.00	12.00
Agency Collecting Sample		1028	1028	1028	1028
Agency Analyzing Sample		80020	80020	80020	80020
Specific Conductance	US/cm	320.00	666.00	600.00	740.00
Oxygen	mg/l			5.10	
pH, Field	Standard Units	8.15	7.26	7.60	7.36
pH, Lab	Standard Units	7.74	7.60	8.00	7.93
Carbon Dioxide Dissolved	mg/L as CO2		35.00	16.00	29.00
Alkalinity	mg/l as CaCO3	480.00			
Carbonate Water DIS IT	mg/l as CO3				
Bicarbonate Water WH IT	mg/l as HCO3	293.00	400.00	390.00	422.00
Bicarbonate Water DIS IT	mg/l as HCO3				
Nitrogen, Organic Total	mg/l as N	0.26			
Nitrogen, Ammonia	mg/l as N	0.04			0.01
Nitrogen, Nitrite	mg/l as N				
Nitrogen, Ammonia + Organic	mg/l as N	0.30			< 0.20
Nitrogen, NO2 + NO3 Dissolved	mg/l as N	< 0.10			0.16
Phosporous Dissolved	mg/l as P	0.01			0.03
Hardness Total	mg/l as CaCO3				
Hardness Noncarb, WH WAT Total	mg/l as CaCO3				
Calcium Dissolved	mg/L as Ca				
Magnesium Dissolved	mg/L as Mg				
Sodium Dissolved	mg/L as Na				
Sodium Adsorption Ratio					
Sodium	Percent				
Potassium Dissolved	mg/L as K				
Chloride Dissolved	mg/L as Cl				
Sulfate Dissolved	mg/L as SO4				
Fluoride Dissolved	mg/L as F	0.20	0.10	0.10	0.20
Silica Dissolved	mg/L as SiO2	24.00	16.00	16.00	17.00
Barium Dissolved	ug/l as Ba	430.00	29.00	23.00	30.00
Boron Dissolved	ug/L as B			110.00	
Beryllium Dissolved	ug/L as Be	< 0.50	< 1.00	0.50	< 0.50
Cadmium Dissolved	ug/L as Cd	< 1.00	< 1.00	< 1.00	< 1.00
Chromium Dissolved	ug/L as Cr				< 5.00
Cobalt Dissolved	ug/l as Co	< 3.00	< 3.00	< 3.00	< 3.00
Copper Dissolved	ug/L as Cu	< 10.00	< 10.00	< 10.00	< 10.00
Iron Dissolved	ug/L as Fe	10.00	< 10.00	11.00	5.00
Lead Dissolved	ug/L as Pb	< 10.00	< 10.00	< 10.00	< 10.00
Manganese Dissolved	ug/L as Mn	21.00	1.00	9.00	1.00
Molybdenum Dissolved	ug/L as Mo	< 10.00	< 10.00	< 10.00	< 10.00
Nickel Dissolved	ug/L as Ni				< 10.00
Silver Dissolved	ug/L as Ag				< 1.00
Strontium Dissolved	ug/L as Sr	230.00	0.03	170.00	180.00
Vanadium Dissolved	ug/L as V	< 6.00	< 6.00	< 6.00	< 6.00
Zinc Dissolved	ug/L as Zn	240.00	28.00	30.00	40.00
Aluminum Dissolved	ug/L as Al				
Lithium Dissolved	ug/L as Li	12.00	18.00	20.00	20.00
Tritium Total	pci/L				41.00
Uranium, Natural, Dissolved,	ug/l as U			1.00	
Solids, Sum of Constituents,	mg/l	422		360	402
Solids Dissolved	Tons per Day	0.00		0.00	0.00
Solids Dissolved,	Tons/Acre-Foot	0.57		0.49	0.55
Nitrogen, Ammonia Dissolved	mg/l as NH4	0.05			0.01

Water quality data for Coyote Spring Valley (USGS unpublished data).

Parameter	Station ID Numbers USGS Units	363830115044201	363838115055201	363838115055201	363838115055201
Nitrogen, Nitrate Dissolved	mg/l as NO3				
Bromide Dissolved	mg/L as Br				0.17
Elevation of Land Surface Datum	feet above NGVD	5450.00	6440.00	6440.00	6440.00
Depth of Well	Feet				
C-13/C-12 Stable Isotope Ratio	Per Mil			-9.90	
H-2/H-1 Stable Isotope Ratio	Per Mil		-92.50	-91.00	-92.00
O-18/O-16 Stable Isotope Ratio	Per Mil		-12.90	-12.50	-12.60
S-34/S-32 Stable Isotope Ratio	Per Mil			5.80	
U-238/U-238 Stable Isotope Ratio	Per Mil			4.90	
Carbon 14, Modern	Percent				
Sampling Method Codes		70.0		70.0	
Specific Conductance, Lab	us/cm	418	688	638	726

Water quality data for Coyote Spring Valley (USGS unpublished data).

Parameter	Station ID Numbers USGS Units	364050115103401	364050115103401	364127114553001	364601114514301
Station Name		21O S14 E61 32dbcc1 Sawmill Spring	21O S14 E61 32dbcc1 Sawmill Spring	21O S14 E63 28acdc1 CSV-3	21O S13 E64 31dead1 CSV-1
Latitude		36 40 50 N	36 40 50 N	36 41 27 N	36 46 01 N
Longitude		115 10 34 W	115 10 34 W	114 55 30 W	114 51 43 W
Date		05/19/88	05/19/88	10/07/87	05/18/88
Temperature Water	Degrees C			41.00	
Agency Collecting Sample		1028	1028	1028	1028
Agency Analyzing Sample		80020	80020	80020	80020
Specific Conductance	US/cm			650.00	
Oxygen	mg/l				
pH, Field	Standard Units			7.35	
pH, Lab	Standard Units	8.90		7.60	7.70
Carbon Dioxide Dissolved	mg/L as CO2			17.00	
Alkalinity	mg/l as CaCO3				
Carbonate Water DIS IT	mg/l as CO3	11.00	11.00	235.00	
Bicarbonate Water WH IT	mg/l as HCO3	162.00	162.00	239.00	
Bicarbonate Water DIS IT	mg/l as HCO3				
Nitrogen, Organic Total	mg/l as N				
Nitrogen, Ammonia	mg/l as N				
Nitrogen, Nitrite	mg/l as N				
Nitrogen, Ammonia + Organic	mg/l as N			1.50	
Nitrogen, NO2 + NO3 Dissolved	mg/l as N				
Phosperous Dissolved	mg/l as P			0.03	
Hardness Total	mg/l as CaCO3				1000.00
Hardness Noncarb, WH WAT Total	mg/l as CaCO3				1000.00
Calcium Dissolved	mg/L as Ca				260.00
Magnesium Dissolved	mg/L as Mg				93.00
Sodium Dissolved	mg/L as Na				160.00
Sodium Adsorption Ratio					2.00
Sodium	Percent				25.00
Potassium Dissolved	mg/L as K				30.00
Chloride Dissolved	mg/L as Cl				39.00
Sulfate Dissolved	mg/L as SO4				1300.00
Fluoride Dissolved	mg/L as F	0.2		1.20	1.20
Silica Dissolved	mg/L as SiO2	6.1		24.00	19.00
Barium Dissolved	ug/L as Ba	< 2.00		240.00	42.00
Boron Dissolved	ug/L as B				
Beryllium Dissolved	ug/L as Be	< 0.50		< 0.50	< 0.50
Cadmium Dissolved	ug/l as Cd	< 1.00		< 1.00	< 1.00
Chromium Dissolved	ug/L as Cr	< 5.00		< 5.00	< 5.00
Cobalt Dissolved	ug/L as Co	< 3.00		< 3.00	< 3.00
Copper Dissolved	ug/L as Cu	< 10.00		< 10.00	< 10.00
Iron Dissolved	ug/L as Fe	5.00		10.00	1600.00
Lead Dissolved	ug/L as Pb	< 10.00		< 10.00	< 10.00
Manganese Dissolved	ug/L as Mn	1.00		80.00	2900.00
Molybdenum Dissolved	ug/L as Mo	< 10.00		20.00	50.00
Nickel Dissolved	ug/L as Ni	< 10.00		< 10.00	< 10.00
Silver Dissolved	ug/L as Ag	1.00		< 1.00	2.00
Strontium Dissolved	ug/L as Sr	15.00		1700.00	8000.00
Vanadium Dissolved	ug/L as V	< 6.00		< 6.00	< 6.00
Zinc Dissolved	ug/L as Zn	18.00		550.00	8.00
Aluminum Dissolved	ug/l as Al				
Lithium Dissolved	ug/L as Li	< 4.00		210.00	750.00
Tritium Total	pci/L				
Uranium, Natural, Dissolved.	ug/l as U				
Solids, Sum of Constituents,	mg/l	160		350	1920
Solids Dissolved	Tons per Day	0.00		0.00	0.00
Solids Dissolved,	Tons/Acre-Foot	0.22		0.47	2.59
Nitrogen, Ammonia Dissolved	mg/l as NH4				
Nitrogen, Nitrate Dissolved	mg/l as NO3				

Water quality data for Coyote Spring Valley (USGS unpublished data).

Parameter	Station ID Numbers / USGS Units	364050115103401	364050115103401	364127114553001	364601114514301
Bromide Dissolved	mg/L as Br			0.32	1.8
Elevation of Land Surface Datum	feet above NGVD	8120.00	8120.00	2414.00	2559.00
Depth of Well	Feet			780	765
C-13/C-12 Stable Isotope Ratio	Per Mil				
H-2/H-1 Stable Isotope Ratio	Per Mil	-92.00		-75.00	-103.00
O-18/O-16 Stable Isotope Ratio	Per Mil	-12.85		-10.35	-13.55
S-34/S-32 Stable Isotope Ratio	Per Mil				
U-238/U-234 Stable Isotope Ratio	Per Mil				
Carbon 14, Modern	Percent				
Sampling Method Codes			70.0		
Specific Conductance, Lab	us/cm	272		625	2260

Water quality data for Coyote Spring Valley (USGS unpublished data).

Parameter	Station ID Numbers USGS Units	364601114514301	364604114471301	364744114533201	364744114533201
Station Name		21C S13 E64 31dead1 CSV-1	21D S13 E64 35acaa1 CE-DT-6	21C S13 E63 23dd1 Fugro Coyote V Deep	21C S13 E63 23dd1 Fugro Coyote V Deep
Latitude		36 46 01 N	36 46 04 N	36 47 44 N	36 47 44 N
Longitude		114 51 43 W	114 47 13 W	114 53 32 W	114 53 32 W
Date		05/16/86	05/28/86	12/23/80	07/22/81
Temperature Water	Degrees C	29.50	33.50	34.00	35.50
Agency Collecting Sample		1028	1028	1028	1028
Agency Analyzing Sample		80020	80020	80020	80020
Specific Conductance	US/cm	2200.00	980.00		720.00
Oxygen	mg/l		3.70	3.50	2.30
pH, Field	Standard Units		7.16	7.35	7.15
pH, Lab	Standard Units		7.90	7.20	7.70
Carbon Dioxide Dissolved	mg/l as CO2		30.00	21.00	34.00
Alkalinity	mg/l as CaCO3		223.00		
Carbonate Water DIS IT	mg/l as CO3				0.00
Bicarbonate Water WH IT	mg/l as HCO3		272.00	294.00	300.00
Bicarbonate Water DIS IT	mg/l as HCO3				
Nitrogen, Organic Total	mg/l as N				
Nitrogen, Ammonia	mg/l as N		0.02	0.01	
Nitrogen, Nitrite	mg/l as N			0.01	
Nitrogen, Ammonia + Organic	mg/l as N		< 0.20		
Nitrogen, NO2 + NO3 Dissolved	mg/l as N		0.46	0.34	
Phosphorous Dissolved	mg/l as P		0.01	0.01	
Hardness Total	mg/l as CaCO3		250.00	190.00	200.00
Hardness Noncarb, WH WAT Total	mg/l as CaCO3		26.00	0.00	0.00
Calcium Dissolved	mg/l as Ca		58.00	46.00	46.00
Magnesium Dissolved	mg/l as Mg		25.00	19.00	20.00
Sodium Dissolved	mg/l as Na		88.00	84.00	78.00
Sodium Adsorption Ratio			3.00	3.00	2.00
Sodium	Percent		42.00	47.00	45.00
Potassium Dissolved	mg/l as K		11.00	11.00	11.00
Chloride Dissolved	mg/l as Cl		53.00	35.00	34.00
Sulfate Dissolved	mg/l as SO4		160.00	110.00	100.00
Fluoride Dissolved	mg/l as F		2.10	1.90	1.90
Silica Dissolved	mg/l as SiO2		30.00	33.00	33.00
Barium Dissolved	ug/l as Ba		53.00	70.00	70.00
Boron Dissolved	ug/l as B			300.00	310.00
Beryllium Dissolved	ug/l as Be		< 0.50	< 1.00	< 1.00
Cadmium Dissolved	ug/l as Cd		< 1.00	< 1.00	< 1.00
Chromium Dissolved	ug/l as Cr				
Cobalt Dissolved	ug/l as Co		< 3.00	< 3.00	< 3.00
Copper Dissolved	ug/l as Cu		< 10.00	< 10.00	< 10.00
Iron Dissolved	ug/l as Fe		6.00	28.00	< 10.00
Lead Dissolved	ug/l as Pb		< 10.00	32.00	< 10.00
Manganese Dissolved	ug/l as Mn		< 1.0	36.00	5.00
Molybdenum Dissolved	ug/l as Mo		< 10.00	< 10.00	10.00
Nickel Dissolved	ug/l as Ni				
Silver Dissolved	ug/l as Ag				
Strontium Dissolved	ug/l as Sr		870.00	780.00	860.00
Vanadium Dissolved	ug/l as V		< 6.00	< 6.00	< 6.00
Zinc Dissolved	ug/l as Zn		8.00	5.00	< 3.00
Aluminum Dissolved	ug/l as Al				
Lithium Dissolved	ug/l as Li		140.00	140.00	130.00
Tritium Total	pci/L		1.80		2.00
Uranium, Natural Dissolved,	ug/l as U			3.30	3.30
Solids, Sum of Constituents,	mg/l		564	487	473
Solids Dissolved	Tons per Day		0.00	0.00	0.00
Solids Dissolved,	Tons/Acre-Foot		0.77	0.66	0.64
Nitrogen, Ammonia Dissolved	mg/l as NH4		0.03	0.01	0.33
Nitrogen, Nitrate Dissolved	mg/l as NO3			1.5	

Water quality data for Coyote Spring Valley (USGS unpublished data).

Parameter	Station ID Numbers USGS Units	364601114514301	364504114471301	364744114533201	364744114533201
Bromide Dissolved	mg/L as Br				
Elevation of Land Surface Datum	feet above NGVD	2159.00	2275.00	2180.00	2180.00
Depth of Well	Feet	765	934	669	669
C-13/C-12 Stable Isotope Ratio	Per Mil		-8.00		
H-2/H-1 Stable Isotope Ratio	Per Mil		-97.00	-103.00	-99.50
O-18/O-16 Stable Isotope Ratio	Per Mil		-12.95	-13.00	-12.90
S-34/S-32 Stable Isotope Ratio	Per Mil				12.96
U-238/U-236 Stable Isotope Ratio	Per Mil			3.10	3.20
Carbon 14, Modern	Percent		8.40	7.60	7.50
Sampling Method Codes			4040.0		
Specific Conductance, Lab	us/cm	2260	832	781	745

Water quality data for Coyote Spring Valley (USGS unpublished data).

Parameter	Station ID Numbers USGS Units	365230114564401	365230114564401	365232114554401	365642115062101
Station Name		210 S12 E63 29dabb VF-2	210 S12 E63 29dacc VF-2	210 S12 E63 29ddcc1 CE-VF-1	210 S11 E62 35dac1 Lamb Spring
Latitude		36 52 30 N	36 52 30 N	36 52 32 N	36 56 42 N
Longitude		114 58 44 W	114 56 44 W	114 55 44 W	115 06 21 W
Date		02/05/86	01/06/88	01/06/88	05/19/88
Temperature Water	Degrees C	34.00	28.00	28.00	13.50
Agency Collecting Sample		1028	1028	1028	1028
Agency Analyzing Sample		80020	80020	80020	80020
Specific Conductance	US/cm	800.00	740.00	460.00	500.00
Oxygen	mg/l	2.90			6.10
pH, Field	Standard Units	7.40		7.03	7.69
pH, Lab	Standard Units	7.90		7.60	8.00
Carbon Dioxide Dissolved	mg/L as CO2	19.00		23.00	9.40
Alkalinity	mg/l as CaCO3	248.00			
Carbonate Water DIS IT	mg/l as CO3				
Bicarbonate Water WH IT	mg/l as HCO3	303.00		156.00	289.00
Bicarbonate Water DIS IT	mg/l as HCO3				
Nitrogen, Organic Total	mg/l as N			1.00	
Nitrogen, Ammonia	mg/l as N	< 0.01		0.06	
Nitrogen, Nitrite	mg/l as N				
Nitrogen, Ammonia + Organic	mg/l as N	< 0.20		1.10	
Nitrogen, NO2 + NO3 Dissolved	mg/l as N	0.45		0.46	
Phosporous Dissolved	mg/l as P	< 0.01		0.01	
Hardness Total	mg/l as CaCO3	200.00		130.00	260.00
Hardness Noncarb, WH WAT Total	mg/l as CaCO3	0.00		6.00	24.00
Calcium Dissolved	mg/L as Ca	47.00		41.00	37.00
Magnesium Dissolved	mg/L as Mg	21.00		7.50	41.00
Sodium Dissolved	mg/L as Na	81.00		34.00	8.70
Sodium Adsorption Ratio		3.00		1.00	0.20
Sodium	Percent	45.00		35.00	7.00
Potassium Dissolved	mg/L as K	11.00		1.20	0.60
Chloride Dissolved	mg/L as Cl	34.00		42.00	8.60
Sulfate Dissolved	mg/L as SO4	90.00		20.00	24.00
Fluoride Dissolved	mg/L as F	1.70		0.50	0.20
Silica Dissolved	mg/L as SiO2	34.00		14.00	12.00
Barium Dissolved	ug/L as Ba	84.00		49.00	12.00
Boron Dissolved	ug/L as B				
Beryllium Dissolved	ug/L as Be	< 0.50		< 0.50	< 0.50
Cadmium Dissolved	ug/L as Cd	1.00		< 1.00	< 1.00
Chromium Dissolved	ug/L as Cr			< 5.00	< 5.00
Cobalt Dissolved	ug/L as Co	< 3.00		< 3.00	< 3.30
Copper Dissolved	ug/L as Cu	< 10.00		< 10.00	< 10.00
Iron Dissolved	ug/L as Fe	6.00		770.00	4.00
Lead Dissolved	ug/L as Pb	< 10.00		< 10.00	< 10.00
Manganese Dissolved	ug/L as Mn	15.00		190.00	12.00
Molybdenum Dissolved	ug/L as Mo	< 10.00		< 10.00	< 10.30
Nickel Dissolved	ug/L as Ni			< 10.30	< 10.30
Silver Dissolved	ug/L as Ag			< 1.00	< 1.00
Strontium Dissolved	ug/L as Sr	710.00		310.30	87.00
Vanadium Dissolved	ug/L as V	< 6.00		< 6.00	< 6.30
Zinc Dissolved	ug/L as Zn	360.00		6.00	15.00
Aluminum Dissolved	ug/L as Al				
Lithium Dissolved	ug/L as Li	110.00		21.00	6.30
Tritium Total	pci/L	< 1.00			
Uranium, Natural, Dissolved,	ug/l as U				
Solids, Sum of Constituents,	mg/l	472.00		240	274
Solids Dissolved	Tons per Day	0.00		0.00	0.30
Solids Dissolved,	Tons/Acre-Foot	0.64		0.33	0.37
Nitrogen, Ammonia Dissolved	mg/l as NH4			0.08	
Nitrogen, Nitrate Dissolved	mg/l as NO3				

Water quality data for Coyote Spring Valley (USGS unpublished data).

Parameter	Station ID Numbers USGS / Units	365230114564401	365230114564431	365232114554401	365642115062101
Bromide Dissolved	mg/L as Br	0.16		0.11	0.1
Elevation of Land Surface Datum	feet above NGVD			2464.00	5480.00
Depth of Well	Feet			714	
C-13/C-12 Stable Isotope Ratio	Per Mil	-6.10			
H-2/H-1 Stable Isotope Ratio	Per Mil	-101.00	-101.00	-94.00	-92.50
O-18/O-16 Stable Isotope Ratio	Per Mil	-12.95	-13.15	-12.65	-13.50
S-34/S-32 Stable Isotope Ratio	Per Mil				
U-238/U-236 Stable Isotope Ratio	Per Mil				
Carbon 14, Modern	Percent	7.00			
Sampling Method Codes			4020.0	4020.0	
Specific Conductance, Lab	us/cm	730.00		442	499

Water quality data for Coyote Spring Valley (USGS unpublished data).

Parameter	Station ID Numbers / USGS / Units	365908114592901
Station Name		210 S11 E52 13dbbc1 CSV-1 Well 8 Coyote
Latitude		36 59 08 N
Longitude		114 59 29 W
Date		11/24/81
Temperature Water	Degrees C	15.50
Agency Collecting Sample		1028
Agency Analyzing Sample		80020
Specific Conductance	US/cm	
Oxygen	mg/l	
pH, Field	Standard Units	7.80
pH, Lab	Standard Units	
Carbon Dioxide Dissolved	mg/L as CO2	6.50
Alkalinity	mg/l as CaCO3	
Carbonate Water DIS IT	mg/l as CO3	0.00
Bicarbonate Water WH IT	mg/l as HCO3	
Bicarbonate Water DIS IT	mg/l as HCO3	260.00
Nitrogen, Organic Total	mg/l as N	
Nitrogen, Ammonia	mg/l as N	
Nitrogen, Nitrite	mg/l as N	
Nitrogen, Ammonia + Organic	mg/l as N	
Nitrogen, NO2 + NO3 Dissolved	mg/l as N	
Phosperous Dissolved	mg/l as P	
Hardness Total	mg/l as CaCO3	220.00
Hardness Noncarb, WH WAT Total	mg/l as CaCO3	5.00
Calcium Dissolved	mg/L as Ca	37.00
Magnesium Dissolved	mg/L as Mg	30.00
Sodium Dissolved	mg/L as Na	36.00
Sodium Adsorption Ratio		1.00
Sodium	Percent	26.00
Potassium Dissolved	mg/L as K	3.10
Chloride Dissolved	mg/L as Cl	22.00
Sulfate Dissolved	mg/L as SO4	46.00
Fluoride Dissolved	mg/L as F	0.46
Silica Dissolved	mg/L as SiO2	21.00
Barium Dissolved	ug/L as Ba	
Boron Dissolved	ug/L as B	240.00
Beryllium Dissolved	ug/L as Be	
Cadmium Dissolved	ug/L as Cd	
Chromium Dissolved	ug/L as Cr	
Cobalt Dissolved	ug/L as Co	
Copper Dissolved	ug/L as Cu	
Iron Dissolved	ug/L as Fe	< 50.00
Lead Dissolved	ug/L as Pb	
Manganese Dissolved	ug/L as Mn	
Molybdenum Dissolved	ug/L as Mo	
Nickel Dissolved	ug/L as Ni	
Silver Dissolved	ug/L as Ag	
Strontium Dissolved	ug/L as Sr	
Vanadium Dissolved	ug/L as V	
Zinc Dissolved	ug/L as Zn	
Aluminum Dissolved	ug/L as Al	< 100.00
Lithium Dissolved	ug/L as Li	10.00
Tritium Total	pCi/L	
Uranium, Natural, Dissolved,	ug/l as U	2.20
Solids, Sum of Constituents,	mg/l	341
Solids Dissolved	Tons per Day	0.00
Solids Dissolved,	Tons/Acre-Foot	0.46
Nitrogen, Ammonia Dissolved	mg/l as NH4	
Nitrogen, Nitrate Dissolved	mg/l as NO3	18

Water quality data for Coyote Spring Valley (USGS unpublished data).

Parameter	Station ID Numbers USGS Units	365538114592901
Bromide Dissolved	mg/l as Br	
Elevation of Land Surface Datum	feet above NGVD	2523.00
Depth of Well	Feet	
C-13/C-12 Stable Isotope Ratio	Per Mil	
H-2/H-1 Stable Isotope Ratio	Per Mil	-106.00
O-18/O-16 Stable Isotope Ratio	Per Mil	-12.60
S-34/S-32 Stable Isotope Ratio	Per Mil	
U-238/U-234 Stable Isotope Ratio	Per Mil	4.00
Carbon 14, Modern	Percent	
Sampling Method Codes		
Specific Conductance, Lab	us/cm	260

APPENDIX C

National Drinking-Water Standards.

Part A. National Interim Primary Drinking-Water Standards[a]*, Accepted Detection Limits, and Maximum Contaminant Levels.*

Constituent	Detection Limits (ug/l)[b]	Maximum Contaminant Level (MCL)[c]
Arsenic dissolved	1	0.05
Barium dissolved	100	1
Cadmium dissolved	1	0.010
Chromium dissolved	10	0.05
Lead dissolved	5	0.05
Mercury dissolved	.1	0.002
Nitrate (as N) total	TBD	10
Selenium dissolved	1	0.01
Silver dissolved	1	0.05
Fluoride dissolved	TBD	1.4-4.0
Coliform bacteria	1/100 ml	1/100 ml (mea
Endrin total	.01	0.0002
Lindane total	.01	0.004
Methoxychlor total	.01	0.1
Toxaphene total	.1	0.005
2,4-D total	.01	0.1
2,4,5-TP Silvex total	.01	0.01
Total trihalomethanes[d]	.01	0.10
Radionuclides (dissolved):		
Radium 226 and 228 (combined)	.1	5 pCi/L
Gross alpha particle activity	TBD	15 Pci/L
Gross beta particle activity	TBD	4 mrem/yr

Part B. National Secondary Drinking-Water Standards[e].

Constituent	Maximum Contaminant Level (MCL)[f]
Chloride	250
Color	15 Color Units
Copper	1
Corrosivity	Noncorrosive
Dissolved solids	500
Foaming agents	0.5
Iron	0.3
Manganese	0.05
Odor	3 (threshold odor number)
pH	6.5-8.5 Units
Sulfate	250
Zinc	5

[a] Data from EPA (1982a), 40 CFR Part 141.

[b] Detection limits are those typically achievable using approved analytical procedures and may vary by lab and state requirements.

[c] Data are given in milligrams per liter (mg/l) unless otherwise specified.

[d] The sum of the concentrations of bromodichloromethane, dibromochloromethane, tribromomethane (bromoform) and trichloromethane (chloroform).

[e] Data from EPA (1982b), 40 CFR Part 143.

[f] Data are given in milligrams per liter (mg/l) unless otherwise specified.

APPENDIX D

APPENDIX D

STEADY STATE MODEL CALIBRATION AND INPUTS

A steady state simulation is a simulation in which recharge and pumping rates are held constant with no change in ground-water storage, so that model-predicted ground-water levels are representative of long-term stabilized ground-water conditions in the natural environment. Therefore, the steady-state simulation will agree with historic measured water levels if appropriate hydraulic parameters are used in the simulation model. Model hydraulic parameters are adjusted until the steady-state simulation closely approximates the historical ground-water levels. The adjusted parameters must be reasonable. Both the number of differing and discernable values and the range of these values must be consistent with the occurrence of strata which possess these properties and the estimated range, or variabilities of these properties, based on field observations and testing of these properties of the strata.

The primary purpose of the steady-state simulations is to calibrate the model. Transmissivity can be calibrated if sufficient water level elevations are known. This was done as a part of the present study. Calibration of the Coyote Springs Basin ground-water model was accomplished using several constraints that were identified in the Model Calibration section of this report.

The calibration of the model was carried out so that the total quantity of ground-water flow was held fixed to the Maxey-Eakin estimate made in Eakin (1964). Additional quantities of water allowed to flow into and through the basin model as a part of the White River flow system were based upon Harrill (1988). Therefore, the transmissivities of the modeled units, the leakance between these units, and the conductances used in the general head boundary conditions that connect the modelled area to the adjacent portions of the White River ground-water flow system are constrained so that only these quantities of water are available.

The calibration of the model was also carried out so that observed ground-water levels and the gradient or changes between these levels within the modeled area were also matched as well as possible with little subjective changes in the model parameters. All of the initial parameters of the model were set at the initial estimates for the hydrogeologic strata that comprised the aquifer units. As most of the inflow to and outflow from the modelled area of the basin occurs through the White River flow system, the properties, or parameters, related to these mechanisms of flow are constrained by the estimated rates of these flows. In particular, the ground-water inflow to the modeled area occurs almost exclusively through the lower carbonate aquifer from the Pahranagat Basin so that the transmissivities and general head conductances relevant to this unit must result in the flow of this quantity of water under the known ground-water gradient.

The ground-water levels in the wells shown in Table 1 were used during the calibration, as were the elevations of the springs shown in Figure 15 and described in Table 5. However, Coyote Springs and the wells noted in Table 1 and as discussed in the report as being perched were not considered to be representative of the valley-fill, ground-water system and were not considered to be as important to calibration as the remainder of the wells and springs. The ground-water levels, resulting from the calibration are shown in Figure 26 and together with the observed ground-water levels in the figures of this appendix.

Table 1: Wells used in Calibration

								Results of Sensitivity Runs									
Well Location	Land Surf.	Date of Meas.	Depth to Water	M [2]	R/C [3]	Actual	Δ [4]	L1 T1 [5]	L1 T2	L1 T3	L1 T4	L2 T1	L2 T2	L2 T3	L2 T4	TK 1	TK 2
Valley Fill																	
210 S11 E62 13DBCB1[1]	2520	1970	37.00	R	19 13	2483	218	-11	-11	-28	20	5	-9	52	3	0	-1
210 S11 E62 24DBAD1[1]	2490	1985	89.42	S	20 13	2401	173	-11	-10	-34	22	6	-8	47	3	0	-1
210 S12 E63 29ADCC1	2470	1986	542.1	T	27 15	1928	-51	-11	-6	-81	31	7	-3	19	1	0	0
210 S12 E63 29ADCC2	2470	1980	547.00	R	27 15	1923											
210 S12 E63 29DABC1	2464	1991	548.7	T	27 16	1915	-61	-10	-6	-81	30	7	-3	18	1	0	0
210 S12 E63 29DB 2	2490	1980	547.00	R	27 15	1943											
210 S13 E63 11BACD1[1]	2220	1985	166.34	S	30 18	2054	121	-9	-5	-67	11	7	-2	15	1	0	0
210 S13 E63 23DDD 1	2180	1980	353.00	R	32 19	1827	-77	-9	-4	-57	-2	6	-2	13	1	0	0
210 S13 E63 25A 1	2518	1944	332.00	R	33 19	2186	296	-8	-4	-53	-8	6	-1	12	1	0	0
210 S14 E63 10 1	2320	1944	332.00	R	37 17	1988	124	-13	-4	-53	-4	8	-2	9	0	0	0
210 S14 E63 28ACDC1	2414	1991	589.6	T	40 17	1825	-20	-14	-3	-51	-3	10	-1	7	0	0	0
Carbonate Rock																	
210 S12 E63 29DABC2	2467	1991	609.7	T	27 16	1857	-51	0	-1	2	0	-1	-3	-69	24	0	-8
210 S13 E63 23DDDC1	2173	1991	351.9	T	32 19	1821	-39	0	-1	1	0	-1	-1	-52	1	0	0
210 S13 E63 26AAAA1	2169	1991	349.14	S	33 19	1820	-34	1	0	1	0	-1	0	-50	-2	0	0

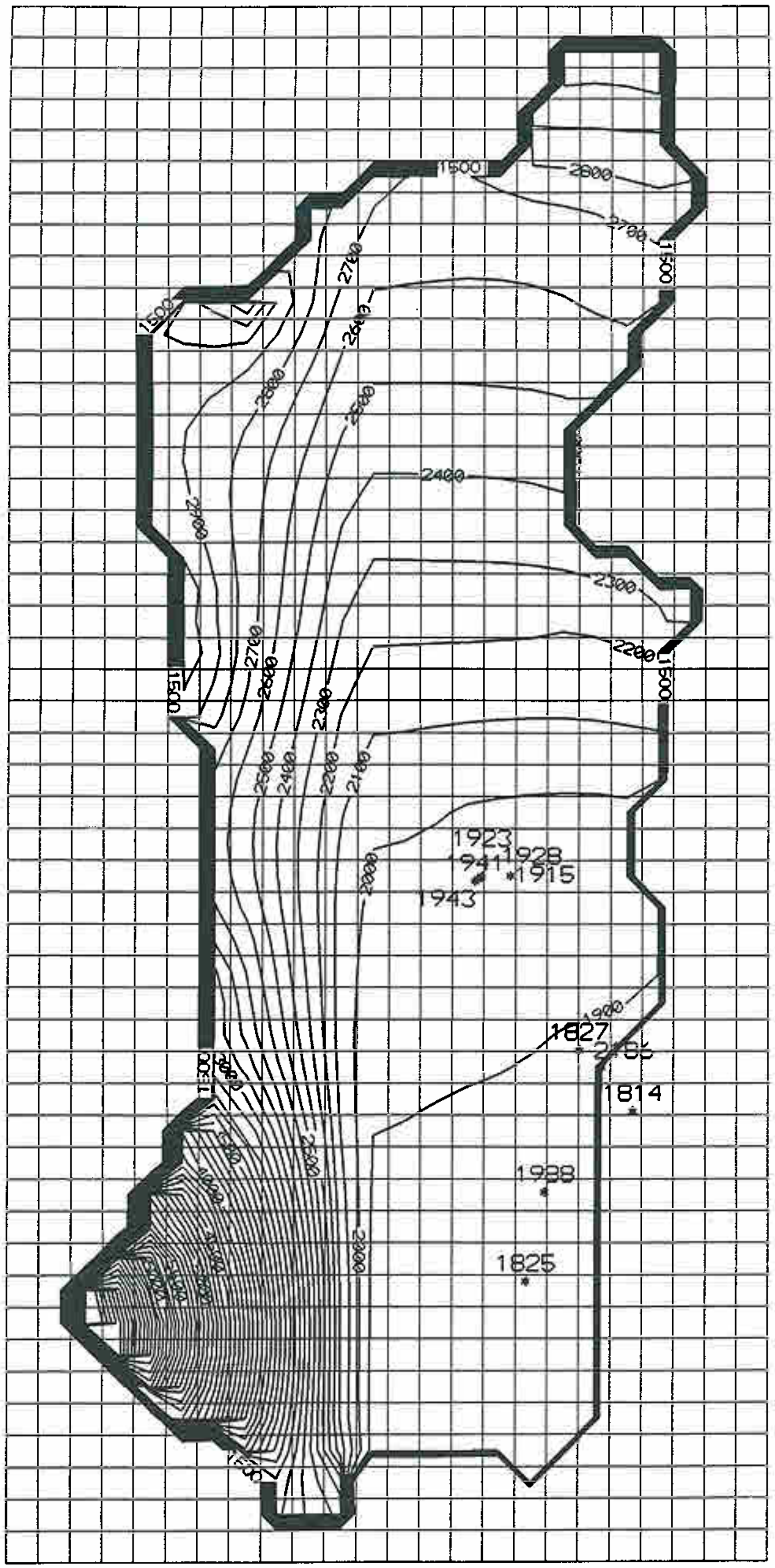
1) Possibly a perched water table (Eakin, 1964)
2) M = method; R - reported; S - steel tape; T - electric tape
3) R / C = row / column
4) Difference between actual and model water level
5) Variable - Layer 1, Transmissivity 1

Model Parameter Sensitivities

Sensitivity simulations were done to determine the effects of each parameter on the ground-water levels and flows. These parameters are the zonal transmissivities (L1T1, L2T1, etc.), zonal leakances (TK1, TK2), and the general head conductances. The sensitivities were performed about the calibrated values of the model and represent the linearized change in water level elevation that would occur with a change in the specific parameter value. The results of these sensitivity simulations are discussed briefly. These results are shown in the accompanying Table of this appendix. The sensitivities represent the estimated change in ground-water level at the wells with a 100 percent increase (or decrease) in the calibrated values that have been previously reported in the Model Calibration section of this report.

Analyses of the sensitivity simulations resulted in several general observations and estimated model properties. First, the transmissivity of the alluvial, valley-fill aquifer produced less significant changes in ground-water levels and flows over the modeled area than did similar changes in the lower, carbonate aquifer transmissivities. The large transmissivities in the carbonate aquifer produced less significant changes in ground-water levels and flows than did the more extensive, intermediate transmissivities (zones) in both the valley fill and carbonate aquifer. These intermediate, zones of transmissivity (of about 1000 to 10,000 ft^2/day) produced the greatest changes in water levels, but had to be constrained to produce water levels and flows that were near to initial estimates and/or observations. The transmissivity of the clastic confining layer, prevalent in the west and southwest areas of the basin and in particular in the Sheep Range produced the most significant changes in ground-water levels but not flows and only in those areas that it exist. Therefore, this lowest transmissivity zone was important in producing ground-water levels that would be consistent with the spring elevations of the Sheep Range, but was not, in general, significant in the overall model area for flows or for ground-water levels near the observation wells. The zoned leakances between the aquifer units did not produce significant changes in ground-water levels or flows within the modelled basin.

Also included in this Appendix are the model generated heads in the upper and lower layer as well as conductance values and elevations used for both upper and lower general heads.



-N-

EXPLANATION

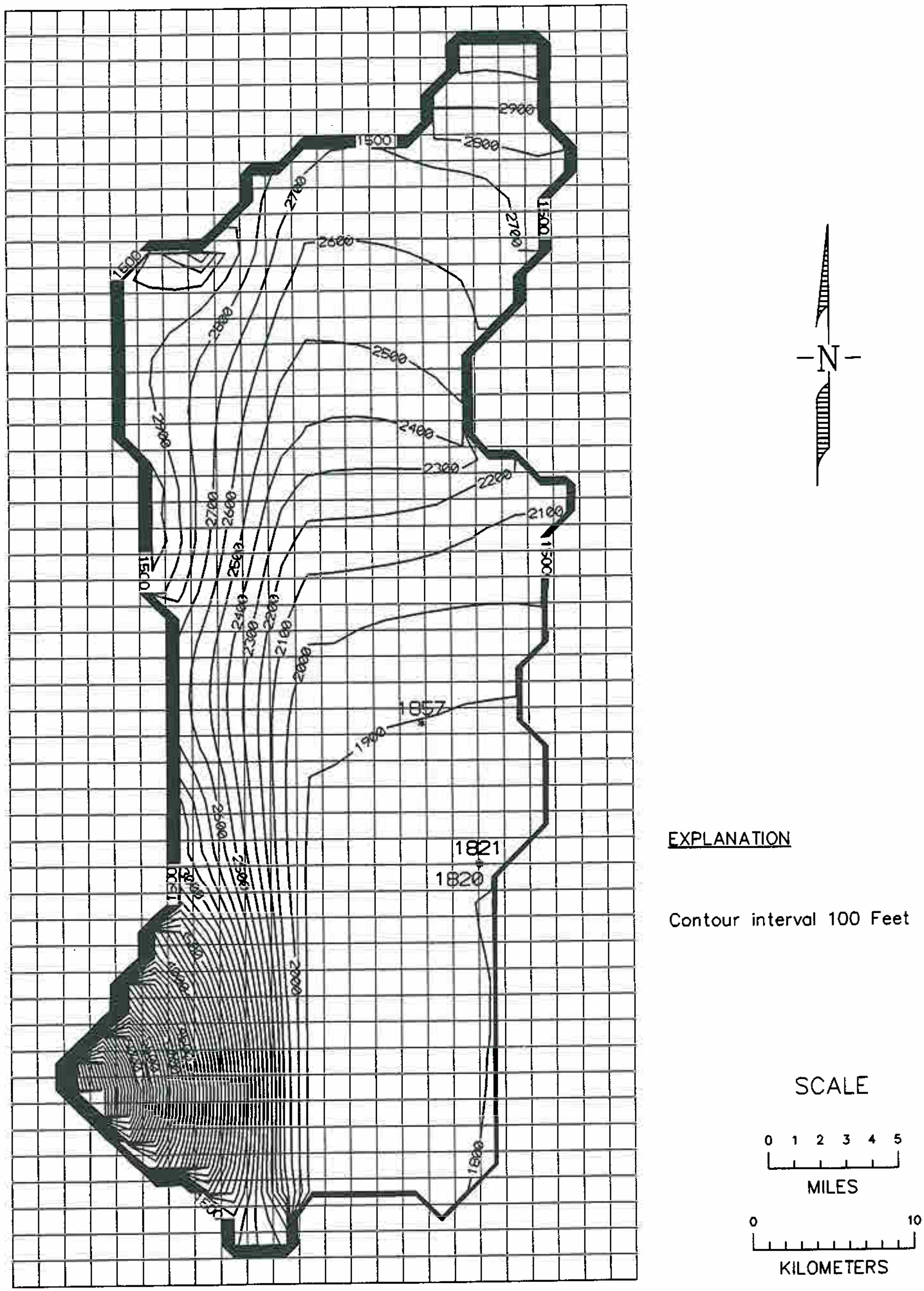
Contour interval 100 Feet

SCALE

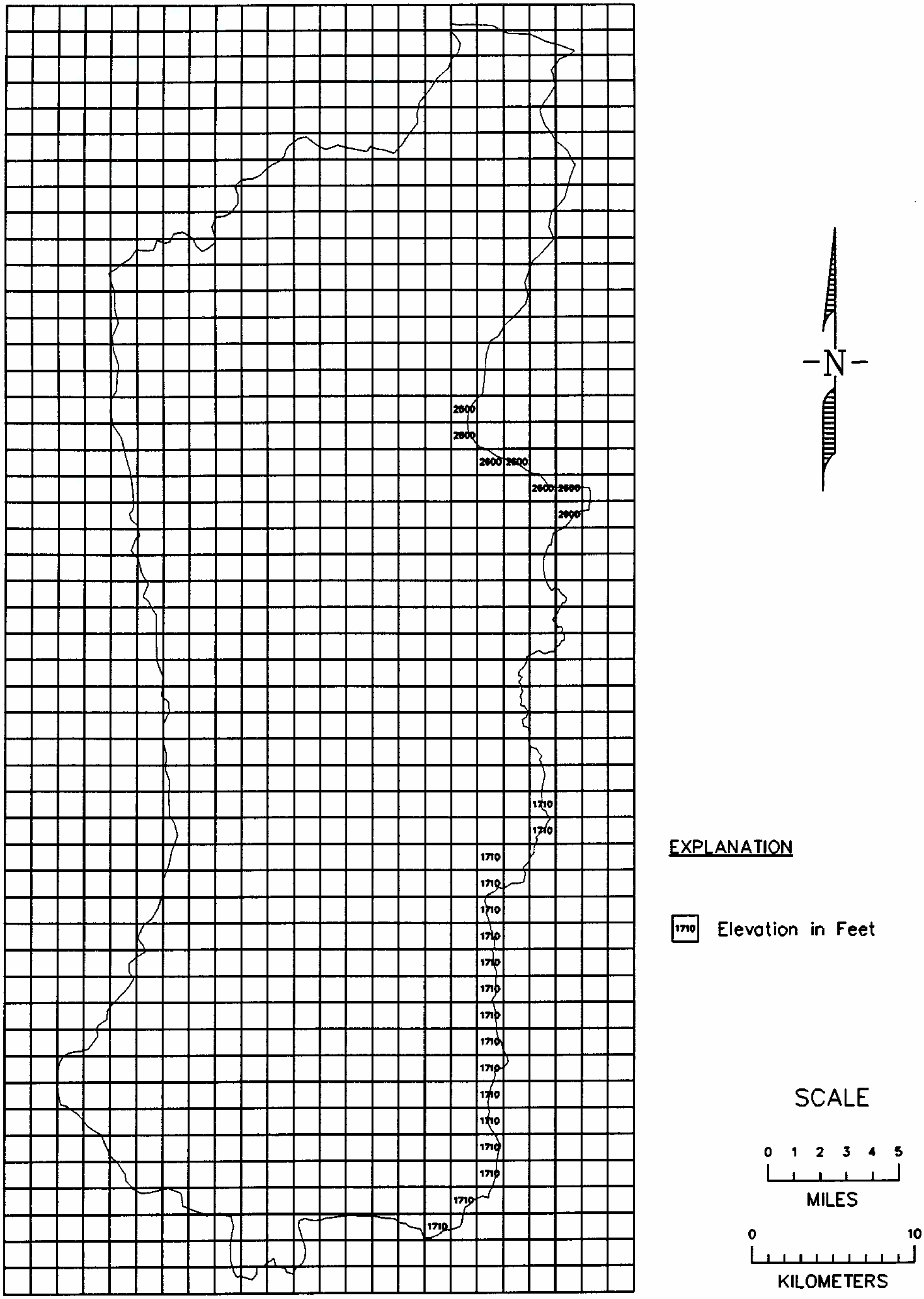
0 1 2 3 4 5
MILES

0 10
KILOMETERS

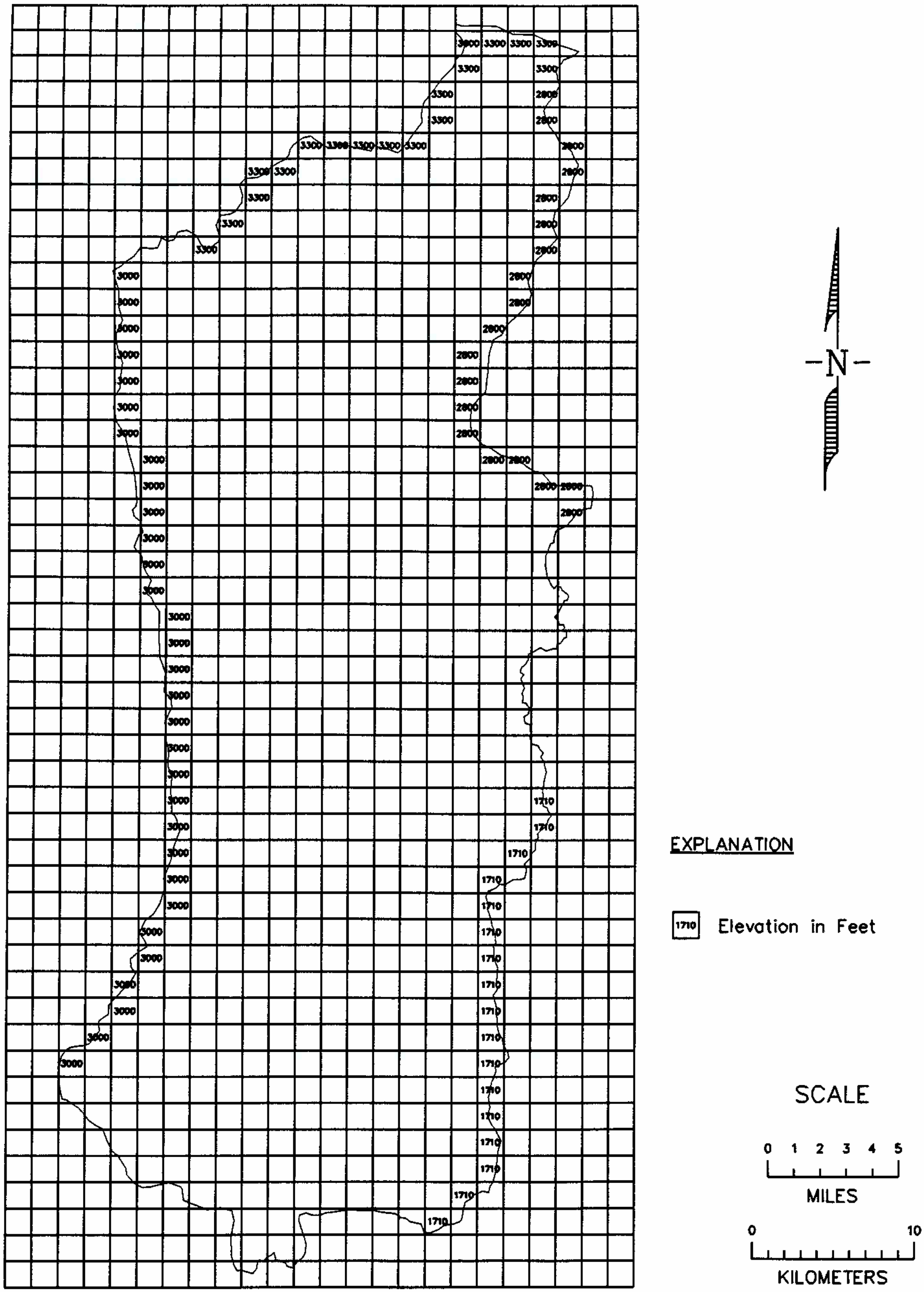
Head in upper layer, Coyote Springs Valley (Basin 210), Nevada



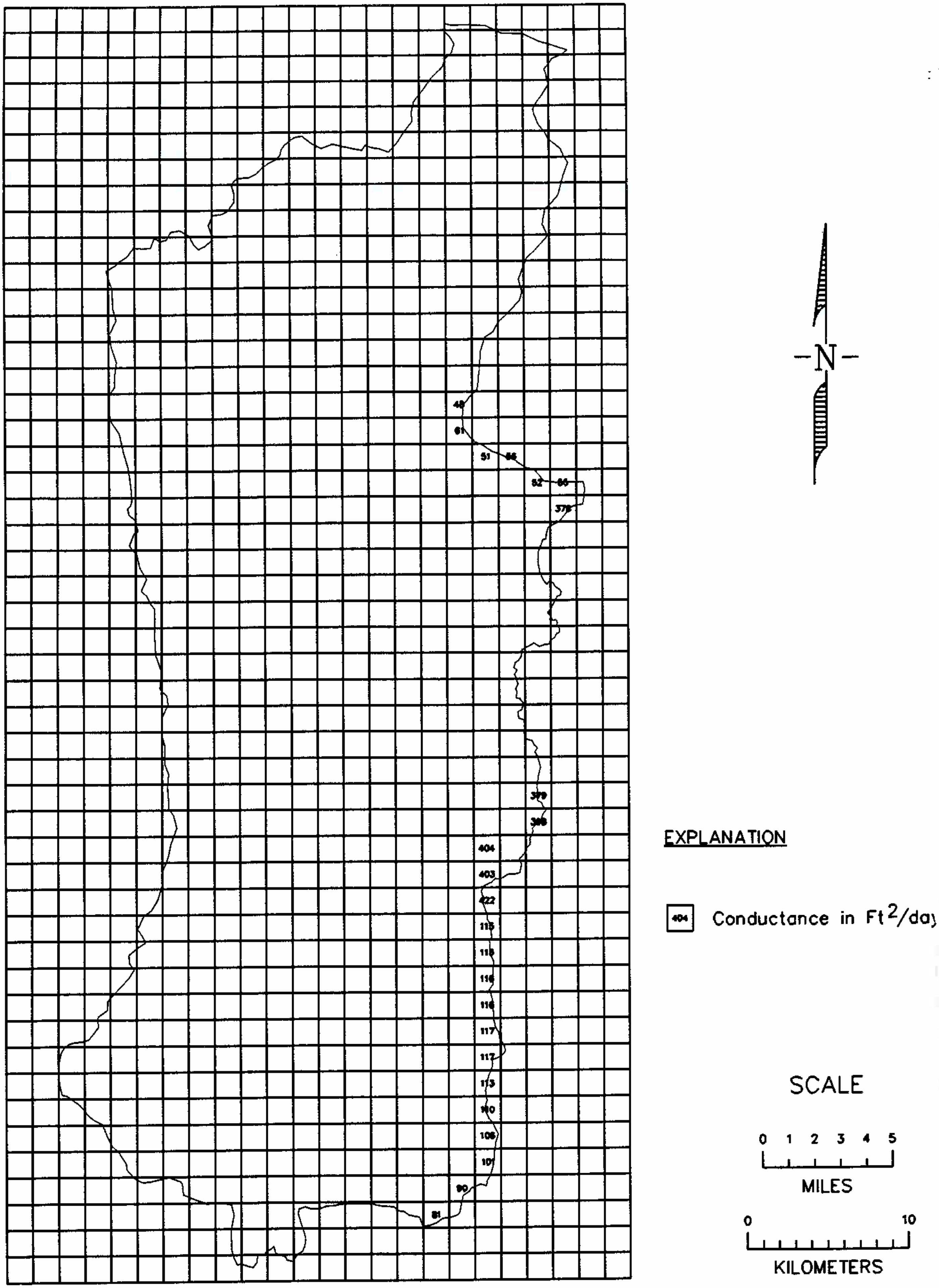
Head in lower layer, Coyote Springs Valley (Basin 210), Nevada



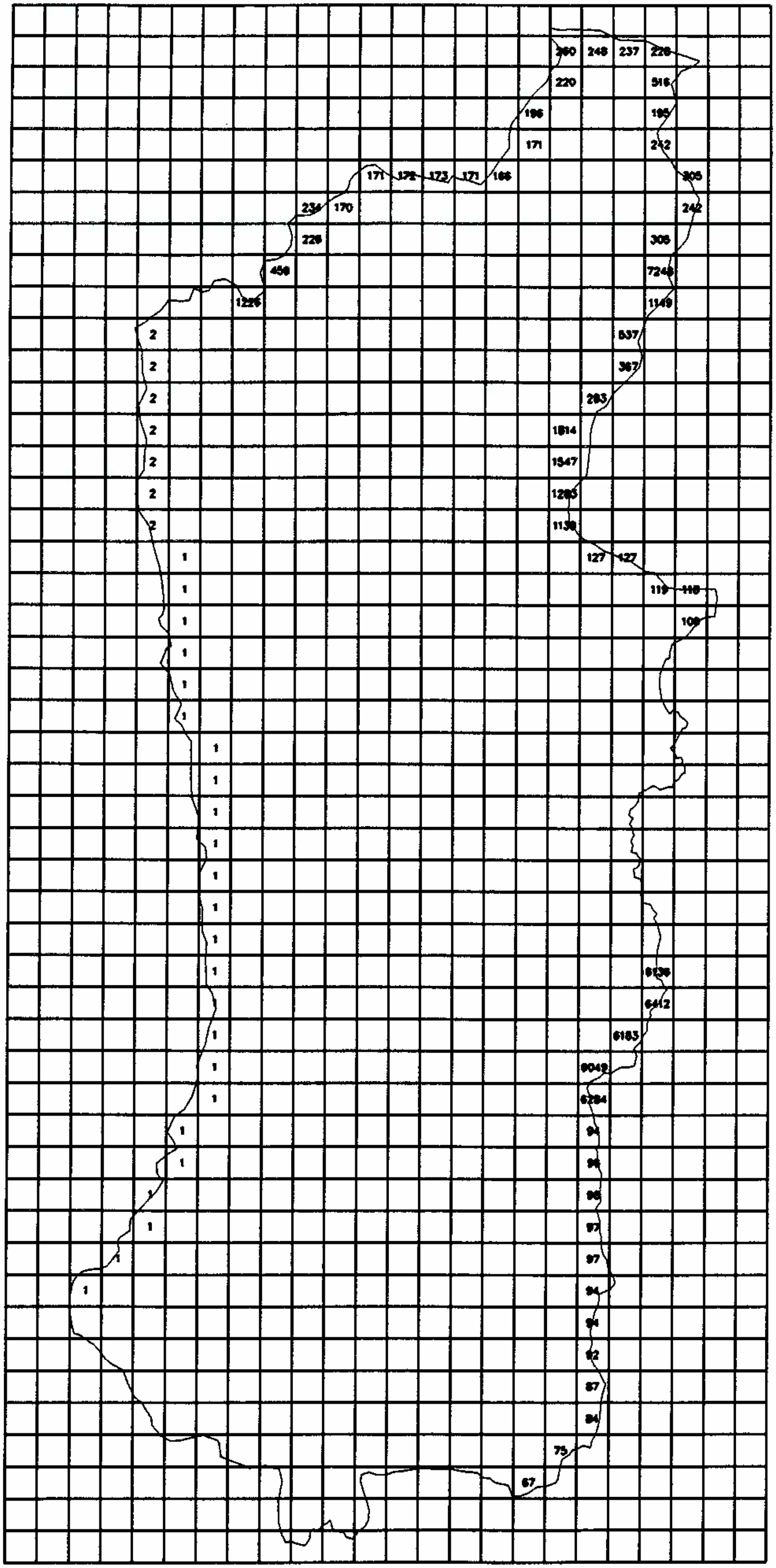
Elevations in upper layer, Coyote Springs Valley (Basin 210), Nevada

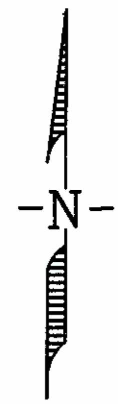


Elevations in lower layer, Coyote Springs Valley (Basin 210), Nevada



Conductance in upper layer, Coyote Springs Valley (Basin 210), Nevada





EXPLANATION

[94] Conductance in Ft^2/day

SCALE

0 1 2 3 4 5
MILES

0 10
KILOMETERS

Conductance in lower layer, Coyote Springs Valley (Basin 210), Nevada

APPENDIX E

APPENDIX E

ALTERNATE MODEL RESULTS

This appendix presents the assumptions and results of the alternate model steady-state simulations.

Almost all of the assumptions underlying the alternate model for Coyote Spring Valley are identical to those of the main model discussed in the report itself. The difference is in the origin of the ground-water inflow to Coyote Spring Valley from adjacent valleys. In the main model, most of the subsurface inflow (35,000 acre-feet per year) is assumed to come from Pahranagat Valley. In the alternate model, an important portion of that amount (7,000 acre-feet per year) is assumed to come from Tikaboo Valley.

In the alternate model, the ground-water inflow from Tikaboo Valley is assumed to enter Coyote Spring Valley through the carbonate aquifer (layer 2) because the alluvial aquifer (layer 1) is topographically closed on the western boundary of the valley. As a consequence, the transmissivity of the carbonate aquifer (layer 2) was increased on the western side of the valley to simulate the subsurface inflow rate of 7,000 acre-feet per year from Tikaboo Valley.

Figure E-1 shows the calibrated potentiometric head distributions for layers 1 and 2. The heads were calibrated to existing head elevations in both layers. These head distributions are similar to those simulated using the main model in the center and eastern parts of the valley, but significantly different in the northern and western parts of the valley. No head elevation data were available for these areas to confirm which configuration is more suitable.

The calibrated transmissivity distributions for the alternate model are shown in Figure E-2. the differences in assumptions between the two models lead to significantly different transmissivities. Note that the transmissivity in the thickest part of the alluvium is 5 times larger than that obtained in the main model: 25,000 square-feet per day as compared to 5,000 square-feet per day. This high transmissivity of the alluvium is very unlikely because wells drilled in the valley show a relatively thin layer of alluvium.

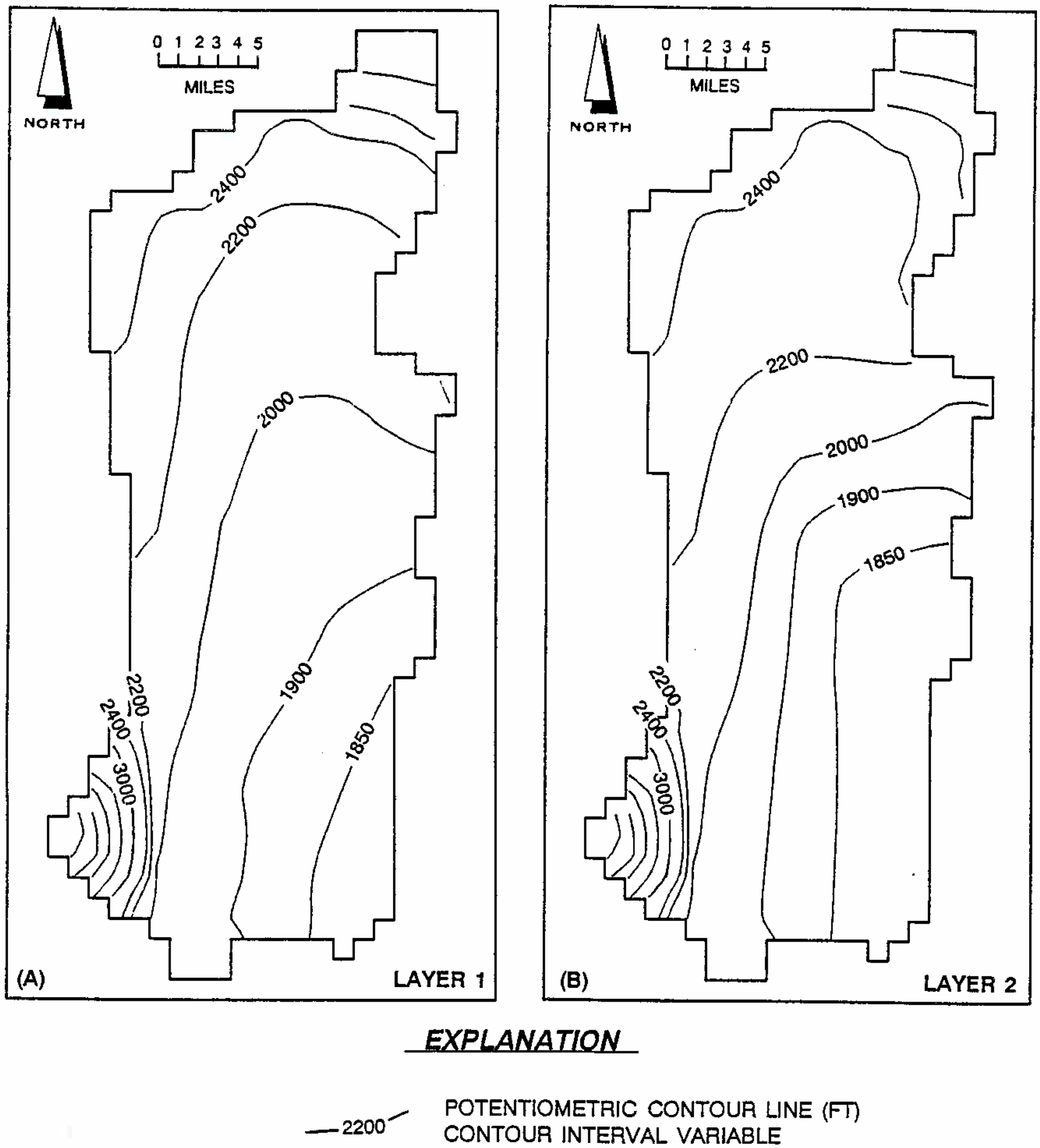
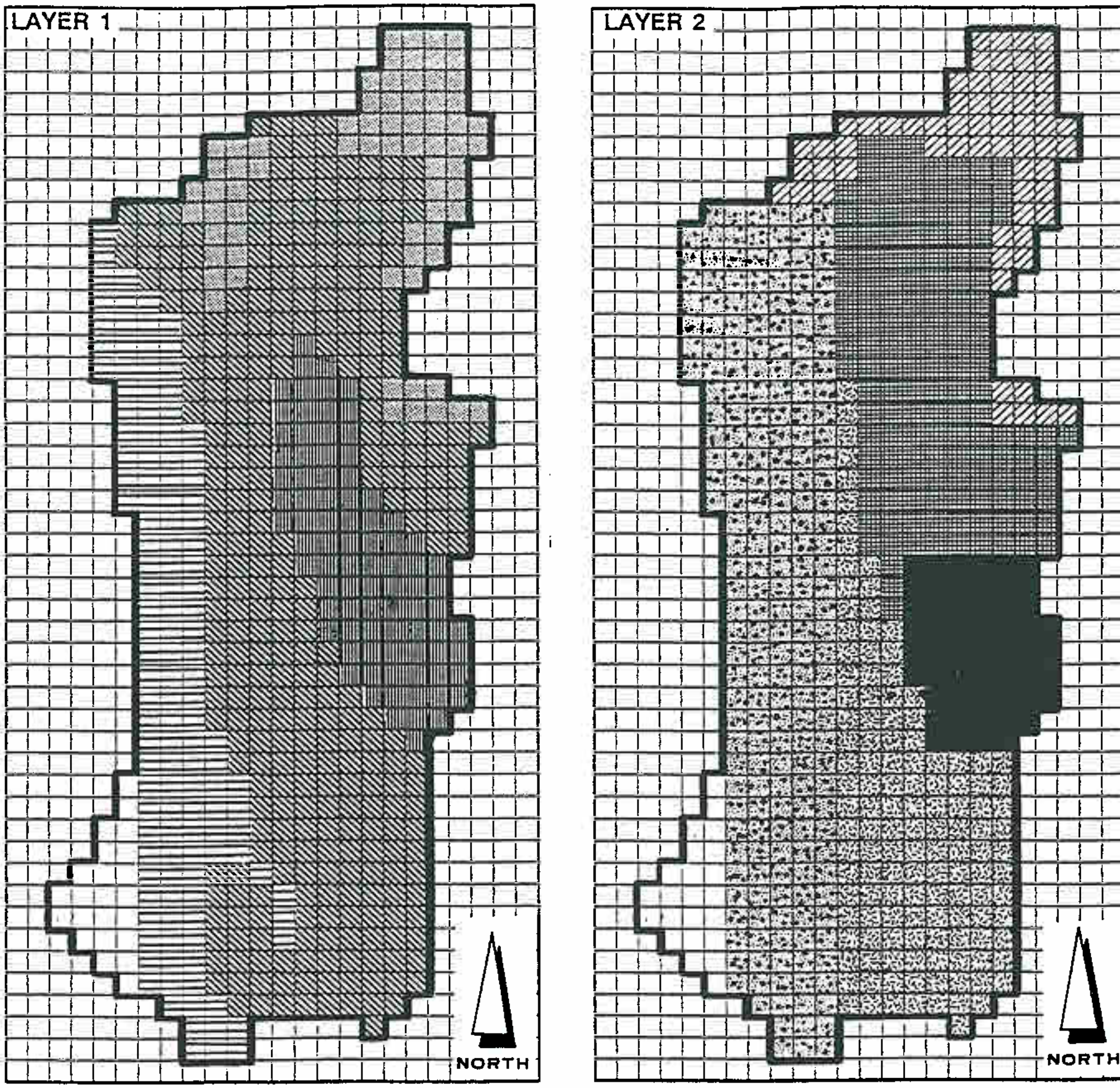


Figure E-1. Alternate model -- simulated steady-state potentiometric surfaces of Coyote Spring Valley.



EXPLANATION

- MODEL GRID (1 MILE X 1 MILE)
- MODEL BOUNDARY
- TRANSMISSIVITY VALUE OF 10 SQUARE FEET PER DAY
- TRANSMISSIVITY VALUE OF 50 SQUARE FEET PER DAY
- TRANSMISSIVITY VALUE OF 200 SQUARE FEET PER DAY
- TRANSMISSIVITY VALUE OF 350 SQUARE FEET PER DAY
- TRANSMISSIVITY VALUE OF 400 SQUARE FEET PER DAY
- TRANSMISSIVITY VALUE OF 1000 SQUARE FEET PER DAY
- TRANSMISSIVITY VALUE OF 1200 SQUARE FEET PER DAY
- TRANSMISSIVITY VALUE OF 8500 SQUARE FEET PER DAY
- TRANSMISSIVITY VALUE OF 25,000 SQUARE FEET PER DAY
- TRANSMISSIVITY VALUE OF 70,000 SQUARE FEET PER DAY

Figure E-2. Alternate model -- distribution of transmissivity values of Coyote Spring Valley.