WATER RESOURCES AND GROUND-WATER MODELING IN THE WHITE RIVER AND MEADOW VALLEY FLOW SYSTEMS

Clark, Lincoln, Nye and White Pine Counties, Nevada

by

Las Vegas Valley Water District

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LAS VEGAS VALLEY WATER DISTRICT

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Kay Brothers, Director of SNWA Resources
Las Vegas Valley Water District

STAFF
Jeff Johnson, Project Manager
Stephen Y. Acheampong, Hydrogeologist
Andrew Burns, Hydrogeologist
David Donovan, Ground-Water Specialist
Michael Wallen, Geographic Information System Analyst

CONSULTANTS
Gary Dixon
Bart Ekren
Peter Rowley
Southwest Geology, Inc.
Blackfoot, Idaho

Terry Katzer
Cordilleran Hydrology, Inc.
Reno, Nevada

Timothy J. Durbin
Debra Schilling
Integral Consultants
Fair Oaks, California

James Thomas
Desert Research Institute
Reno, Nevada

Front cover picture insets from top left: Iverson Spring at Muddy Springs near Moapa (May 2001), discharge from MX-5 well after pump start-up (February 1998), spring flow below Pederson Spring at Muddy Springs near Moapa (May, 2001). Background picture of Coyote Spring Valley near MX-4 and MX-5 with pump rig in background.

List of Acronyms and Abbreviations

amsl	Average mean sea level
%	Percent
3-D	Three-dimensional
afy	Acre-feet per year
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
cfs	Cubic feet per second
CRBP	Colorado River Basin Province
CRBPN	Colorado River Basin Province of Nevada
CSI	Coyote Spring Investment LLC
DEM	Digital Elevation Model
DOI	U.S. Department of Interior
DRI	Desert Research Institute
DTW	Depth-to-water
ESA	Endangered Species Act
ESRI	Environmental Systems Research Institute
ET	Evapotranspiration
ft	Foot (feet)
ft/d	Foot (feet) per day
GIS	Geographic Information System
gal/min (gpm)	Gallon(s) per minute
gpd	Gallons per day
GWSI	Groundwater Site Inventory
in.	Inch(es)
K	Hydraulic conductivity
K_x, K_y	Horizontal hydraulic conductivity
K_z	Vertical hydraulic conductivity
LDS	Latter Day Saints
LVVWD	Las Vegas Valley Water District
ME	Maxey-Eakin
mi	Mile(s)
mi^2	Square mile(s)
MBPI	Moapa Band of Paiute Indians
MVWD	Moapa Valley Water District
MVIC	Moapa Valley Irrigation Company
NDOW	Nevada Department of Wildlife
NDWR	Nevada Department of Water Resources
NPC	Nevada Power Company
NPS	National Park Services
NRCS	Natural Resources Conservation Service
NWIS	National Water Information System
NV	Nevada
P	Precipitation

PRISM	Parameter-elevation Regressions on Independent Slopes Model
r_e	Natural recharge efficiency
SNWA	Southern Nevada Water Authority
S_s	Storage coefficient
S_y	Specific yield
T	Transmissivity
TNC	The Nature Conservancy
U.S.	United States
USAF	U.S. Air Force
USBR	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
WRCC	Western Regional Climate Center
yr	Year

TABLE OF CONTENTS

Section **Page**

TABLES

FIGURES

PLATES

APPENDICES

Section **Page**

APPENDICES FIGURES

APPENDICES TABLES

APPENDIX A

APPENDIX B

APPENDIX C

WATER RESOURCES AND GROUND-WATER MODELING IN THE WHITE RIVER AND MEADOW VALLEY FLOW SYSTEMS, Clark, Lincoln, Nye and White Pine Counties, Nevada

EXECUTIVE SUMMARY

This Executive Summary is a synopsis of the report entitled, *Water Resources and Ground-water Modeling in the White River and Meadow Valley Flow Systems, Clark, Lincoln, Nye and White Pine Counties, Nevada*, prepared by the Las Vegas Valley Water District (LVVWD). This report has been prepared in support of the Las Vegas Valley Water District's ground-water applications (54055 through 54059 inclusive) in Coyote Spring Valley; applications have a total combined duty of 27,512 acre-feet per year.

Introduction

Urban development in southern Nevada is continuing and is now expanding to include the regions adjacent to Las Vegas Valley along the Interstate-15 corridor, including communities like Moapa Valley. In addition, numerous power-generating companies have expressed interest in building facilities in the same area. In Coyote Spring Valley, just north of Las Vegas and the "I-15 Corridor," there are over 16,000 acre-feet of ground-water permits owned by the Southern Nevada Water Authority (SNWA), Nevada Power Company (NPC), and Coyote Spring Investment Inc (CSI). In addition to the existing ground-water permits there are 27,512 acre-feet of ground-water applications filed in 1989 by the Las Vegas Valley Water District (LVVWD).

This report was prepared to define the regional hydrology and geology of the White River and Lower Meadow Valley Flow Systems, estimate their ground-water and surface water budgets, and simulate potential impacts on the regional ground-water and surface water resources from development of the LVVWD applications. However, due to the lack of hydrologic data and minimal ground-water development, the large-scale response of the aquifer system is poorly understood and prediction of future ground-water development is difficult to assess. For this reason ground-water development from the regional carbonate rock aquifer should be accompanied by monitoring to protect existing water right holders and environmental resources.

Hydrogeologic Setting

A regional hydrogeological evaluation was made of the entire White River and Meadow Valley Flow Systems. The geologic framework was defined and numerous cross-sections were constructed to help understand the movement of ground water through these two flow systems. New precipitation-altitude relationships were defined based on data collected over the last thirty years. Because of these additional data and revised methods, these relationships led to an estimate of more ground-water recharge than estimated by previous investigators. Ground-water discharge by evapotranspiration was also estimated at greater volumes than estimates by previous investigators.

The water-resources budget for the entire area shows ground-water recharge estimated at 324,000 acre-feet/year. Of this amount about 275,000 acre-feet/year is utilized by vegetation leaving a remainder of nearly 50,000 acre-feet/year to discharge from the two flow systems in the carbonate aquifer. About 10,000 to 20,000 acre-feet/year of this discharge is surface water in the Muddy River that actually flows into Lake Mead. The water-resources budget for the ground-water model area, a subset of valleys, including Coyote Spring Valley, at the southern end of these two flow systems, shows inflow from the regional carbonate aquifer plus local ground-water recharge to equal 117,000 acre-feet/year. Evapotranspiration consumes about 67,000 acre-feet/year leaving about 50,000 acre-feet/year of discharge out of the area.

The geochemical data base for the area was re-evaluated by the Desert Research Institute (University of Nevada System) and a deuterium-mass-balance model was developed. This geochemistry model, which has some commonality with the estimation of the water budget, is consistent with the hydrogeological model. The data from these two models were used to develop a numerical ground-water model.

Simulated Impacts

A three-dimensional ground-water flow model was developed to assist in understanding the response of the ground-water system from developing LVVWD ground-water applications in Coyote Spring Valley. The results based on the regional evaluation and model simulations are described below:

The ground-water flow model is calibrated based on predevelopment conditions and reasonably replicates responses to the hydrologic system from existing pumping through the year 2000. However, the model predicts a two cubic feet/second decline in the flow of the Muddy Springs that is not observed. Thus, the model tends to over estimate somewhat the response of the ground-water system.

Baseline for ground-water development is the pumping of the existing permits, about 44,000 acre-feet per year in the valleys (Coyote Spring Valley, Garnet Valley, California Wash, Lower Meadow Valley Wash, Muddy River Springs, and Black Mountain) where pumpage occurs in the model area. The simulated net response between pumping the permitted water rights, 18,000 acre-feet/year and the applications, 27,500 acre-feet/year, is 2.5 cubic feet/second decrease in the Muddy Springs.

Rogers and Blue Point Springs are not affected by the baseline (permitted) pumping or the addition of the proposed pumping as a result of the applications. The model predicts that the impact to the Muddy Springs in 61 years of pumping the permitted water rights will be a decrease of about four cubic feet per second. However, as stated above the model predicted a decline in spring flow of about two cubic feet per second in the year 2000, which has not been observed.

A model is only a tool dependent upon accurate hydrogeologic data. The availability of data in the model area is extremely limited. Therefore, the results from the model are very limited. The impacts of future ground-water development in the carbonate aquifer will remain largely unknown and speculative until there are opportunities to evaluate transient responses to significant, long-term ground-water pumping from the carbonate-rock aquifer. As data is collected from ground-water development the model will be continually refined and used for analysis of potential impacts.

1 INTRODUCTION

Urban development in southern Nevada is continuing and is now expanding to include the regions adjacent to Las Vegas Valley along the Interstate-15 corridor, including communities like Moapa Valley. In addition, numerous power-generating companies have expressed interest in building facilities in the same area.

Increased land development includes the need for additional water. In Coyote Spring Valley, just north of Las Vegas and the "I-15 Corridor," there are over 16,000 acre-feet of ground-water permits owned by the Southern Nevada Water Authority (SNWA), Nevada Power Company (NPC), and Coyote Spring Investment Inc (CSI). In addition to the existing ground-water permits there are 27,512 acre-feet of ground-water applications filed in 1989 by the Las Vegas Valley Water District (LVVWD). Also, there are over 100,000 acre-feet of ground-water applications more recently filed by CSI in 1997 and 1998, for a potential residential and golf course development in Coyote Spring Valley.

It is uncertain how many of the ground water applications in Coyote Spring Valley can be developed without impacting the down-gradient Muddy Springs in Upper Moapa Valley. The Muddy Springs are managed by the U.S. Fish and Wildlife Service (USFWS) and are the home of the Moapa dace (U.S. Fish and Wildlife Service, 1995), a protected species of fish listed as endangered under the Endangered Species Preservation Act of 1966 on March 11, 1967 (32 Federal Register 4001). Other aquatic species of concern that occur in the Muddy River ecosystem are three fish, two snails, and two insects. There are also springs in hydrologic basins near Coyote Spring Valley on lands managed by the U.S. Park Service (USPS) and Bureau of Land Management that are of concern to those agencies and the public who uses them.

Because there is need for development in the I-15 Corridor and Coyote Spring Valley and because impacts on nearby springs are unknown, LVVWD has carried out a detailed analysis in an attempt to understand the origin, movement, volume, and fate of ground-water in the general area. This report summarizes those findings. It is also a supporting document for the hearing scheduled before the Nevada State Engineer in July 2001 for water rights applications 54055 through 54059 (inclusive) held by LVVWD.

1.1 PURPOSE AND SCOPE

The purpose of this study is to further define the ground-water flow systems that are contributory to the Muddy Springs in Upper Moapa Valley and to determine if there is ground-water flow that bypasses the springs. The scope of the study is to estimate a water-resource budget for the White River Flow System, including the Meadow Valley Flow System component. This was done using additional precipitation data, the results of recent geologic investigations, geochemistry, and interpretive techniques that were not available to earlier investigators. Finally, a ground-water model was constructed to evaluate the hydrogeologic processes and to assess the future spring flow impacts of permitted and potential additional groundwater pumpage using various pumping simulations.

1.2 DEFINITION OF STUDY AREA OF THIS REPORT

The Muddy Springs and Muddy River represent a major discharge point in the White River and Meadow Valley Flow System that drains to the Colorado River. There are 27 hydrographic basins in eastern and southern Nevada that are part of the Colorado River Basin drainage (**Figure 1-1**). These basins form the White River and Meadow Valley Flow Systems; in this report, these basins are referred to collectively as the Colorado River Basin Province of Nevada. Much of the area is accessible by mule and rail. There are several other valleys in Nevada that are also tributaries to the Colorado River drainage, but are not within the study area.

The Muddy Springs and Muddy River, in part the focus of this study, are located in the eastern edge of Upper Moapa Valley (Eakin, 1964, Plate 1) and are the source of the Muddy River. There are 20-30 separate spring orifices that make up the Muddy Springs and these are located over an area of about three square miles (3 mi^2). Additionally there are undoubtedly diffuse seeps to the Muddy River and to the alluvial ground-water system within the Upper Moapa Valley that are undefined. The collective spring flow represents part of the discharge from the White River Flow system.

The study area includes all of the valleys that make up the White River Flow system as first defined by Eakin (1964) and we have included Hidden, Garnet, California Wash, Black Mountain Basin and Lower Moapa Valley. Also part of the study are all of the valleys that are tributary to, and including, Meadow Valley Wash as described by Rush and Eakin (1963), and Rush (1964). All valleys in the study area are listed in **Table 1-1** along with their appropriate references. The area modeled is much smaller and is shown on **Figure 1-1**. The detailed geologic interpretations are mostly confined to the area modeled.

Not all 27 basins are represented in the ground-water model constructed for this study, but their collective hydrologic resources are used. The net ground-water flow across the model boundary in both the alluvial aquifer system and the underlying, interconnected, regional carbonate aquifer system represents a valuable resource.

The study area encompasses about 7,734,000 acres (12,080 square miles) and covers significant parts of White Pine, Lincoln, and Clark Counties and a small part of Nye County. The highest points in the study area are Currant Mountain (11,513 feet) in the White Pine Range and Troy Peak (11,298 feet) in the Grant Range.

Most of the valleys within the study area have no surface outflow, yet all are tributaries to the Colorado River drainage through ground-water discharge. All of these valleys are in the classic Basin and Range physiographic region, as described by Fenneman (1931). The Basin and Range is a series of parallel to sub-parallel, north trending mountain ranges separated by elongated valley lowlands and are further classified by Heath (1984), as being in the Alluvial Basins Ground-Water Region. These basins are also part of the carbonate rock province of eastern-southern Nevada and western Utah as described by Plume and Carlton (1988). The carbonate rock province represents a regional aquifer system that underlies the entire area. The hydraulic

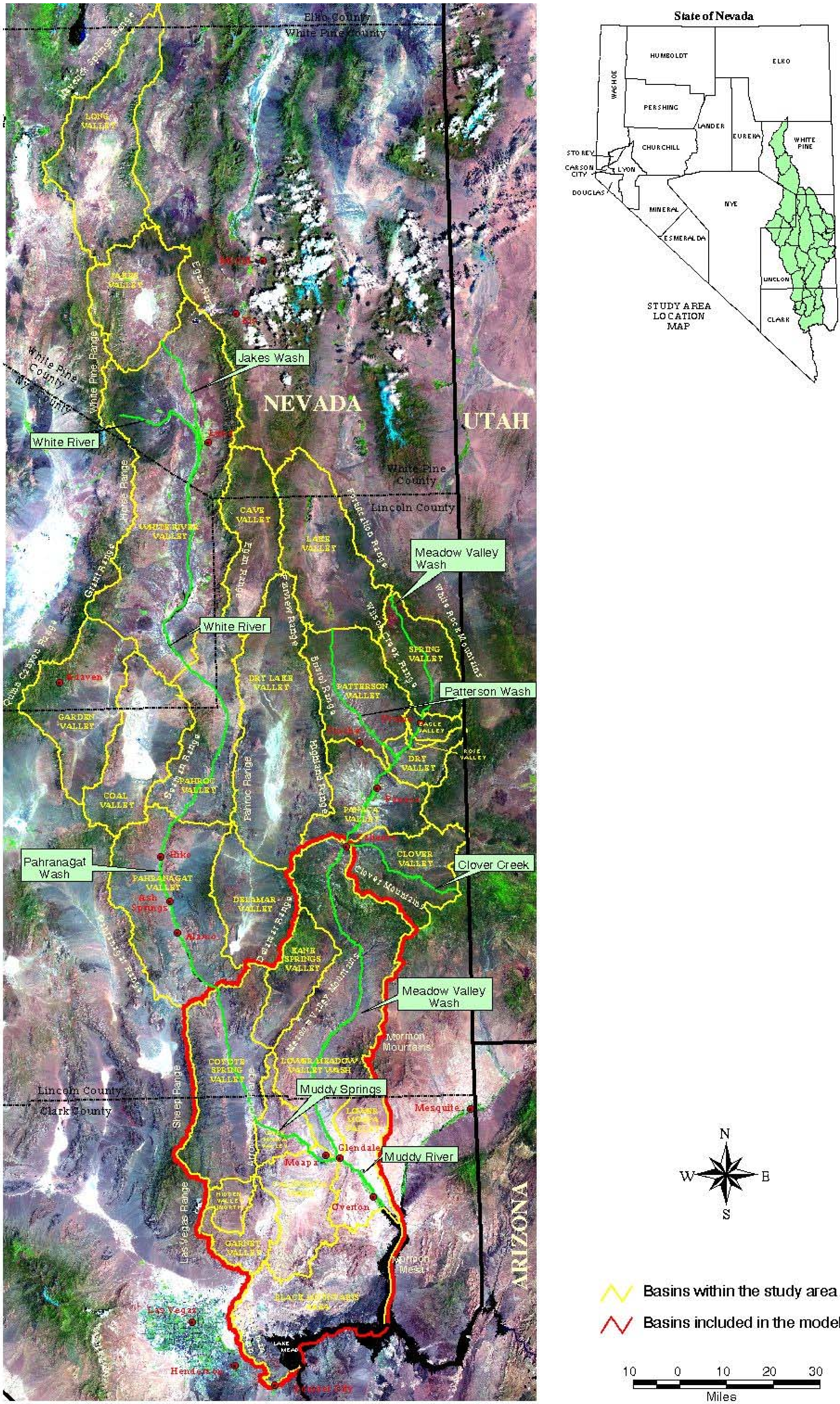


Figure 1-1. Location of Study area drainage basins and basins included within the model.

connectivity of this aquifer system is believed to be large, but there may be structural blocks that compartmentalize different parts of the flow system. Most of these valleys are part of the White River ground-water flow system first described by Eakin (1966). These 27 basins are collectively referred to here as the Colorado River Basin Province of Nevada (CRBPN).

The northwestern part of the study area is bounded by a long continuous northeasterly trending mountain range which includes the White Pine, Grant and Quinn Canyon Range. The northwestern part of the study is also bounded by parts of the northerly Egan Range. The southwestern part is bounded by the northerly trending Sheep Range and the smaller northwesterly trending Pahranagat Range. The extreme southwestern part is bounded by the Las Vegas Range and Frenchman Mountain.

The eastern part of the study area is bounded by the northwesterly trending Fortification Range, parts of the northwesterly Wilson Creek Range and parts of the basically east-west Clover Mountains. The southeastern boundary transects the Mormon Mountains and Mormon Mesa and the Overton arm of Lake Mead. The southern boundary is Lake Mead in Nevada and Arizona. All of the northeasterly trending Delamar, Meadow Valley and virtually all of the Clover Mountains are within the study as are numerous small ranges like the Fairview, Bristol, Highland Peak, Seaman, and North and South Pahroc Ranges.

The largest hydrographic basin in the study area is the White River Valley at about 1,017,000 acres, and the smallest, Rose Valley is about 8,000 acres. Most of the western side of the study area is composed of large valleys bounded by high mountain ranges. The eastern side is composed of smaller valleys nestled in amongst generally rugged terrain.

1.3 PREVIOUS INVESTIGATIONS

The U. S. Geological Survey (USGS) has evaluated the hydrology of the entire study area **(Figure 1-1)** through a series of building block studies that began in the early 1960s. Most of these were at a reconnaissance level in a cooperative program with the state of Nevada with a few additional in-depth studies. Scott and others (1971) summarized hydrologic data for many of the hydrographic basins in the state. Winograd and Thordarson (1975) in their investigation of the regional hydrogeologic framework for the Nevada Test site provided insights into the recharge and direction of ground-water flow from the Sheep Range.

As part of the MX Missile investigations numerous wells were drilled in many of the valleys and Ertec Western (1981) conducted an extensive aquifer test in Coyote Spring Valley in well No. CE-DT-5, commonly known as MX No. 5. This well pumped at least 3,400 gallons per minute (gpm) for a 30-day test with virtually no drawdown at the wellhead. According to Buqo and others (1992, p. 28) the 3,400 gpm was the capacity of the pump used to test the well so the aquifer system was not significantly stressed.

The USGS Regional Aquifer Systems Analyses (RASA) started in the 1980s and continued on into the 1990s. The RASA project was funded in total by the USGS and resulted in the development of a three-dimensional finite difference ground-water flow model that includes all of the entire carbonate-rock province of Nevada, Utah, and California and covers all of the valleys of interest for this study. According to Prudic et al. (1995, p. D 38) the model results are only conceptual. The Department of the Interior Agencies (DOI) funded the USGS to take this conceptual steady state ground-water model and run transient scenarios. These scenarios were based on proposed ground-water withdrawals by the Las Vegas Valley Water District through out much of the carbonate-rock province.

According to the authors of the modeling effort, Schaefer and Harrill (1995, p. 2 and 7) the results of this 200 year simulation need to be viewed with caution. Also in the mid 1980s the USGS initiated the Carbonate Aquifer program in cooperation with the LVVWD, City of North Las Vegas, Desert Research Institute (DRI) and the U. S. Bureau of Reclamation (USBR).

Other studies by the USGS, DRI, the LVVWD, and SNWA focused on specific disciplines or a combination of disciplines such as geochemistry, geophysics, geology, evapotranspiration (ET) and hydrology. Kirk and Campana (1990), as part of a regional, multi-agency study of the carbonate rock aquifer, developed a ground-water flow model for the White River Flow System based on geochemistry.

LVVWD developed ground-water models for many of the valleys as part of their regional investigations of ground-water basins in eastern and southern Nevada. Prudic and others (1993) developed a conceptual evaluation of regional flow in the carbonate rocks of eastern and southern Nevada through the use of a ground-water flow model. Dettinger and others (1995) studied the distribution of the carbonate-rock aquifers and their potential for development and have indicated the best way to develop ground water from the carbonate aquifer is a staged approach with adequate monitoring of related effects. Thomas (1996) synthesized ground-water flow in southern Nevada through the use of geochemistry and Plume (1996) described the hydrogeologic framework of the carbonate rock province in Nevada, Utah, and California. Katzer (1996) developed a conceptual model for the ground-water flow system in Coyote Spring Valley. Bredehoeft and Hall, (1996) developed a ground-water model for the Upper Muddy River Valley. They observed that pumping from the Arrow Canyon Well will ultimately reduce the flow of the river and springs by an equal amount.

In another study within the California Wash, Johnson and others, (2001) concluded that long-range impacts from proposed pumping (7000 AFY) on the Muddy Springs discharge is minimal. There are also studies referenced that include Master of Science thesis, consultant's reports, and reports by the U. S. Air Force (USAF) for the MX Missile-siting project. **Table 1-1** lists the various studies that have contributed to the understanding of the complex hydrogeology of this vast area. The geologic references are many and are referenced in the geology section of this report and are not included in **Table 1-1.**

All of these publications are referenced in the text and are listed alphabetically by senior author and chronologically by year in the Reference Section.

Table 1-1. Previous hydrologic investigations in the study area of the Colorado River Basin Province of Nevada.

VALLEY and Hydrologic Site No.		TYPE OF STUDY Valley	Regional	REFERENCE[1]
WHITE RIVER FLOW SYSTEM				
Long	175	X	X	R-3, B-33, W-1409,1475 L, P-1628, O-96-469
Jakes	174	-	X	B-33, W-1409, 1475 L, P-1628, O-96-469
White River	207	X	X	B-8, 33, W-365, 1409, 1475 L, O-96-469
Garden	172	X	X	R-18, B-33, W-365, 1409, 1475 L, L-8, O-96-469
Coal	171	X	X	R-18, B-33, W-365, 1409, 1475 L, L-8, O-96-469
Cave	180	X	X	R-13, B-33, W-365, 1409, 1475 L, L-11, O-96-469
Pahroc	208	X	X	R-21, B-33, W- 365, 1409, 1475 L, L-10
Dry Lake	181	X	X	R-16, B-33, W- 365, 1409, L-16, O-96-469
Delamar	182	X	X	R-16, B-33, W- 365, 1409, L-16, O-96-469
Pahranagat	209	X	X	R-21, B-33, W- 365, 1409, 1475 L, WRI- 91-4146
Kane Springs	206	X	X	R-25, B-33, W-365, 1409, WRI- 91-4146
Coyote Spring	210	X	X	R-25, B-33, W-224, 365, 1409, L-3, OP, O-96-469, WRI- 91-4146
Upper Moapa	219	X	X	R-50, B-33, W-224, 365, 1409, O-96-469, WRI-91-4146
Lower Moapa	220	X	X	R-50, W-224, 365, 1409, WRI- 91-4146
Hidden	217	X	X	R-50, W-224, 365, 1409, WRI- 91-4146
Garnet	216	X	X	R-50, W-224, 365, 1409, WRI- 91-4146
California Wash	218	X	X	R-50, W-224, 365, 1409, WRI- 91-4146
Black Mountains	215	X	X	R-50, W224, 365, 1409, P-295, 298, WRI- 91-4146
MEADOW VALLEY FLOW SYSTEM				
Lake	183	X	X	R-24, W-365, W-1409, 1475 L
Patterson	202	X	X	R-27, B-7, W-1409, 1475 L, O-96-469
Spring	201	X	X	R-27, B-7, W-365,1409, 1475 L, WRI- 91-4146
Eagle	200	X	X	R-27, B-7, W-365,1409, 1475 L, WRI- 91-4146
Rose	199	X	X	R-27, B-7, W-365,1409, 1475 L, WRI- 91-4146
Dry	198	X	X	R-27, B-7, W-365,1409, 1475 L, WRI- 91-4146
Clover	204	X	X	R-27, B-7, W-365,1409, 1475 L, WRI- 91-4146
Panaca	203	X	X	R-27, B-7, W-365,1409, 1475 L, WRI- 91-4146
Meadow Valley Wash	205	X	X	R-27, W-224, 365, 1409, 1475 L, WRI- 91-4146

1. *USGS Publications: R - Reconnaissance Series Report; W- Water-Supply Paper; Professional Paper-P, Water-Resource Investigations Report-WRI, B - Nevada Water Resources Bulletin, and O - Open-File Report. DRI Publications- D. LVVWD Publications-L., and Other Publications-OP.*

1.4 AVAILABILITY OF DATA

A variety of data and information from numerous sources were compiled for the purposes of this study and the construction of a ground-water flow model. Since much of the study area is located in remote and undeveloped areas, few data are available. However, significant data and information were acquired in the form of published and unpublished documents and data sets for the various parameters required for the development of a conceptual model of the study area and the construction of a flow model. To assist in the development of records, information was garnered from site reconnaissance and field investigations and from numerous interviews with local, state, and federal agencies and various ground-water consultants working within the boundary of the study area.

Historical records of (climatic) precipitation were acquired from the DRI Western Regional Climatic Center website, www.wrcc.dri.edu/summary/climsmnv.html. Additional precipitation station data were obtained from NDWR unpublished records. For the period 1984 to 2000, high-elevation precipitation data was compiled from Water Resources Data reports published annually by the USGS.

Well and spring data were compiled from numerous sources including data collected by SNWA and data obtained from the USGS Ground-water Site Inventory database (GWSI), NDWR Well Log Database and Water Rights Database, and published and unpublished reports, hydrogeologic investigations, and maps. A significant portion of the water-level and ground-water production data were compiled from MVWD and NPC hydrologic monitoring reports submitted to NDWR. Interviews conducted with representatives of MVIC, MVWD, NDWR, and various consultants working within the study area were used to assist in the development of the various historical records.

Surface-water data, including stream flow and spring discharges, were compiled from the USGS National Water Information System database and published USGS Water Resources Data reports for water years 1913 to 2000. Continuous records of stream-flow were compiled for water years 1944 to 2000 for the Moapa gaging station, and 1950 to 2000 for the Glendale gauging station. Data for water-year 2000 have not yet been fully published and is considered preliminary.

Selected coverages depicting spatial (vector) data were acquired from the USGS Eros Data Center and developed through site reconnaissance and field investigations by SNWA. USGS 30-meter seamless digital-elevation-model data were acquired from the USGS National Elevation Dataset. Satellite imagery for the years 1981 and 1998 was acquired from the USGS Eros Data Center. Aerial photography for 1953 was acquired from the USGS Eros Data Center, and for 1997-2000 from the private sector. Geologic data (geologic outcrop and fault maps) were acquired from the Nevada Bureau of Mines and Geology and the USGS.

Additional data acquired for the purposes of this study and ground-water modeling effort that are not discussed in this section are discussed in subsequent sections of this report.

2 HYDROLOGIC SETTING

The valleys that make up the White River and the Meadow Valley Flow Systems are in the Colorado River Basin Province of Nevada **(Figure 2-1)**. These two parallel flow systems are probably in hydraulic continuity with each other at depth and both discharge ground water from the deep seated carbonate aquifer. These valleys are part of the Basin and Range Province and are characterized as bounded by north- to northeast trending sub-parallel mountain ranges. The mountain ranges, depending on location, are made up of a mixture of marine sedimentary rocks from the Paleozoic and Mesozoic Eras and volcanic rocks of Tertiary age. The valleys' unconsolidated sediments reflect the erosion process from the mountain blocks and are filled with sediments that range in size from clay to boulders. Carbonate rocks, mostly of Paleozoic age underlie virtually all the valley aquifer systems, thus providing continuity of ground-water flow throughout the entire area. Ground-water storage and flow in the carbonate rocks are enhanced by dissolution and an extensive fracture system. In some valleys volcanic rocks are on top of carbonate rocks and underneath the valley unconsolidated aquifer system.

The dominant hydrologic features of the area are the several large springs scattered throughout the area that represent flow from the carbonate aquifer system. The largest of these are the Muddy Springs located near the central part of Upper Moapa Valley that collectively discharge about 37,000 acre-feet/year (adjusted for evapotranspiration). This spring flow is virtually unchanged since it was first estimated by Eakin (1966). The Muddy Springs are the headwaters of the Muddy River, which historically was a tributary to the Virgin River, but now flows to Lake Mead because of the construction of Hoover Dam.

The White River flows several thousand afy from its headwaters in the White Pine Range and is a continuous drainage to its junction with Lake Mead. The channel, once it leaves White River Valley is ephemeral and is a remnant of the wetter climate dating back to the late Pleistocene time (Eakin, 1966). The drainage is known as Pahranagat Wash once it reaches Pahranagat Valley and turns into the Muddy River in Upper Moapa Valley.

There are other perennial streams mostly in the higher mountain blocks in the northern parts of the area such as in the White Pine and Eagan Ranges in the White River Valley drainage and Clover Mountains that drain to Clover Valley. Meadow Valley Wash is perennial to intermittent for most of its length starting in Spring Valley (east side of the Wilson Creek Range) and flowing generally to a point about 10 miles north of Moapa.

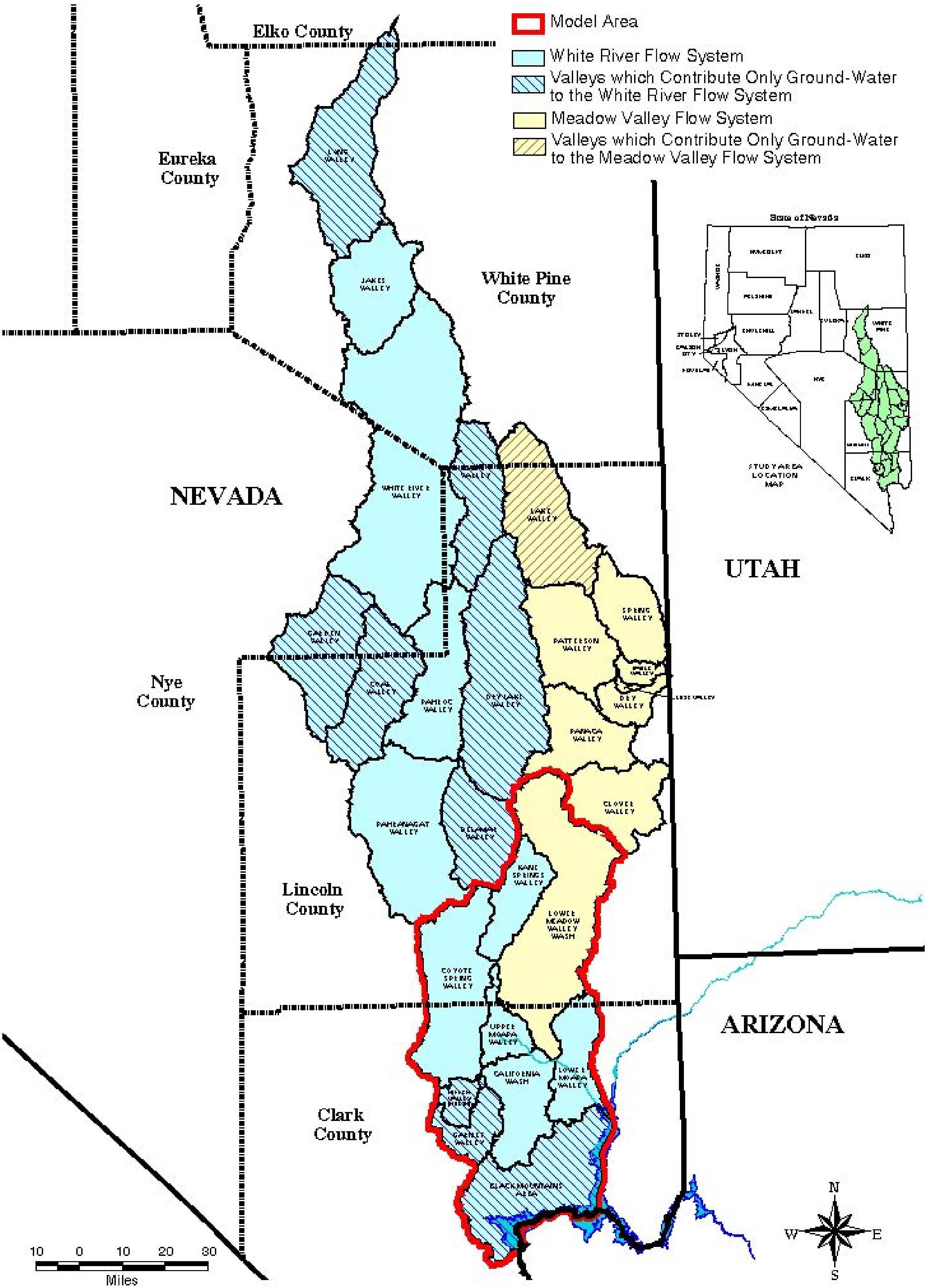


Figure 2-1. Location map for White River and Meadow Valley Flow Systems.

3 GEOLOGY

3.1 GENERAL GEOLOGY

The exposed bedrock in the ranges in the northern part of the modeled area consists generally of fresh volcanic rocks, which continue to south of the Lincoln County-Clark County line. Most of these volcanic rocks are ash-flow tuffs, which form thin, widespread planar sheets of brittle rock. The area also contains two major eruptive centers, the Caliente caldera complex at and just south of Caliente, and further to the south, the Kane Springs Wash caldera complex. The volcanic centers are the source of most of the tuffs in the area. In the southern part of the study area, thick Paleozoic carbonate rocks are exposed and they form the carbonate-rock aquifer of eastern and southern Nevada. The valley-fill overlying these carbonate rocks are made up of poorly to moderately consolidated Quaternary to latest Tertiary clastic basin-fill deposits that are also aquifers. **Plate 1** and **Plate 2** show the regional geology and hydrogeology and the locations of the cross-sections. **Figure 3-1** describes the hydrogeologic units displayed in the cross-sections. Geologic cross-sections sections A-A' through K-K are **Figure 3-2, Figure 3-3**, and **Figure 3-4**, and are referred to throughout this section.

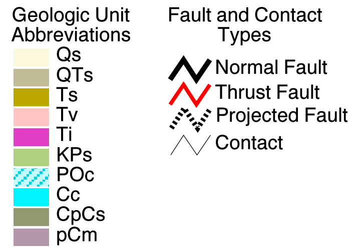
The modeled area is in the Basin and Range physiographic province, which is characterized by the most severe extension (pulling apart) of continental crust in the World (Rowley and Dixon, 2000, in press). Ground-water flow in the study area may be controlled in part by faults of two major Tertiary extensional episodes. They are equally important in terms of magnitude of structural deformation, but the younger episode is more important in terms of producing structures that may facilitate ground-water flow. The older of these episodes, the middle Cenozoic pre-basin-range episode, has formed many of the faults in the study area. However, these faults may be less conducive to ground-water flow because they are older and thus their accompanying fractures tend to have rehealed, since stress was transtensional rather than pure extensional. The faults that led to the older fracturing generally strike (that is, are oriented) northeast and northwest. Offset along these faults is known as oblique slip, that is, it combines normal-slip and strike-slip movement. The age of this episode is from about 25 to 14 million years, in the Miocene. Fault deformation was accompanied by volcanism that formed most of the tuffaceous volcanic rocks in the area, including their two eruptive centers. The faults in the Caliente area are the best examples of this fault type because this area, within the Caliente caldera complex, has been less affected by the younger of the two episodes of deformation.

The younger of the two episodes of deformation is the late Cenozoic basin-range episode. This episode blocked out the present topography into north-striking ranges and intervening basins. These basins and ranges were created by north-striking normal faults, which formed when the crust was pulled apart (extended) in an east-west direction. In parts of the study area, however, range front faults trend northeast, as along the northwestern side of the Meadow Valley Mountains and southern Delamar Range. The fault along the northwestern side of the southern Delamar Mountains continues southwest of the study area as the Pahranagat shear zone, which was mapped by Ekren and others (1977). The Pahranagat shear zone is a left-lateral strike-slip transfer fault zone, which connects at both ends with northeast-striking normal faults. These northeast-striking faults, then, “transfer” the strain of east-west pulling apart along a different

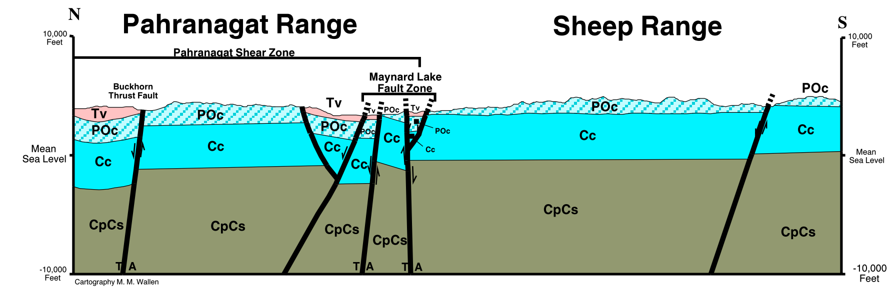
HYDROGEOLOGIC UNITS DISPLAYED IN CROSS-SECTIONS

Unit	Description
Qs QTs Ts	QTs – Quaternary and Tertiary sediments. Composite unit in the ground-water model locally divided on cross-sections into Qs and Ts. The Qs unit is chiefly unconsolidated alluvium and colluvium of Quaternary age deposited in basins. Thickness ranges from 0 to 2,500 feet. Unit is highly permeable. The Ts unit is chiefly the Muddy Creek Formation that is predominately siltstones, sandstone, and conglomerates. The Muddy Creek Formation is of Tertiary age and variable in thickness (up to 3,000 feet). Unit is very permeable where sandy and coarse grained, poorly permeable where clays are present. In the southern part of the flow system, unit includes Lovell Wash-Bitter Ridge basin rocks, Thumb Formation, and rocks of the Rainbow Gardens.
Tv	Tv --Tertiary volcanic rocks. Includes non to densely welded ash-flow tuffs, rhyolites, basalt flows, volcanic breccias, andesites, quartz latites, and tuffaceous sediments. Volcanic rocks are much thicker in the northern part of area but present to the south near the southern border of flow system. Volcanic rocks are Tertiary in age and range in thickness from 0 to greater than 10,000 feet. Unit is moderately permeable, especially where fractured.
Ti	Ti – Tertiary intrusive volcanic and granitic rocks. Primarily associated with the Caliente Caldera complex, Kane Spring Caldera, and the Cleopatra/Black Mountain intrusive as ring fractures, stocks, dikes, and resurgent domes. Unit has very poor permeablilty.
KPs	KPs -- Cretaceous through Permian clastic (siliciclastic) rocks. Permian and Mesozoic rocks of the Colorado Plateau. Includes unnamed Permian red beds possibly equivalent to the Supai Formation. Also includes: Kaibab and Toroweap Formations (cherty limestones with abundant gypsum, sandstone, and shale, these two formations are lithologically similar but separated by an unconformity), (Kayenta Formation (silty shale and sandstone), Moenave Formation (sandstone, conglomerate, and mudstone), Chinle Formation (mudstone, shale, and conglomerate), and Moenkopi Formation (mudstone, sandstone, siltstone) with several members that are chiefly siltstones, shales, silty limestones, dolomites, sandstones, and conglomerates. Unit is thin to the north (less than 1,000 feet) to over 10,000 feet in the south central part of the area. Overall the unit has low permeability, however where limestones predominate, the unit is moderately permeable.
POc	POc – Permian through Ordovician carbonate rocks. Upper Paleozoic carbonate section (a.k.a. "upper carbonate aquifer"). Includes the Bird Spring Formation (limestone and minor dolomites), Monte Cristo Group that includes Yellowpine Limestone, Bullion Dolomite, Ancor Limestone, and the Dawn Limestone (limestone, minor dolomite, interbedded cherts in lower part of section), Guilmette Formation with upper and lower members of predominately limestones and dolomites, Simonson Dolomite and Laketown Dolomite of Silurian age, through the Ely Springs Dolomite to the Eureka Quartzite. With the exception of shales in the Mississippian and the Eureka Quartizite, the unit is very permeable. Accumulative thickness of approximately 15,000 feet.
Cc	Cc -- Cambrian carbonate rocks. Lower Paleozoic carbonate section (a.k.a. "lower carbonate aquifer"). Composed of all carbonate rocks below Eureka Quartzite and therefore includes units that are, in part, lower Ordovician, and upper pre-Cambrian. Includes Antelope Valley Limestone, Goodwin Limestone, and the carbonate part of the Nopah Formation. Unit is approximately 3,500 feet thick and generally very permeable and was therefore combined with overlying unit (POc) in the associated ground-water model of this study.
CpCs	CpCs -- Cambrian and pre-Cambrian siliciclastic rocks. Lower clastic aquitard. Includes Cambrian Prospect Mountain Quartzite, Zabriskie Quartzite and Wood Canyon Formation which is composed of shales, quartzites, quartzose sandstones, and metasedimentary rocks. Unit is greater than 3,500 feet thick of poorly permeable to impermeable rock.
pCm	pCm – pre-Cambrian igneous and metamorphic rocks. Gniess, schists, quartzites, granites, and metasedimentary rocks. Unit forms the core of Mormon Mountains, Virgin Mountains, and Gold Butte. Unit is very impermeable. Combined with the overlying unit (CpCs) and represented as a "no-flow" boundary at the base of the associated ground-water model in this study.

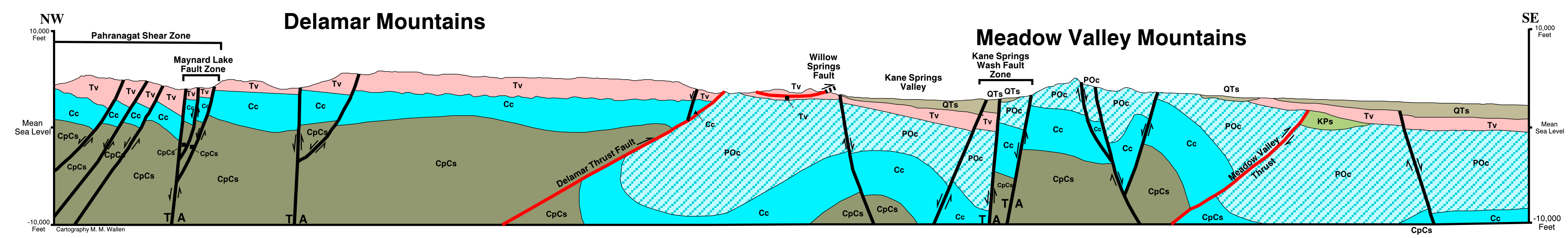
Figure 3-1. Hydrogeologic unit descriptions.



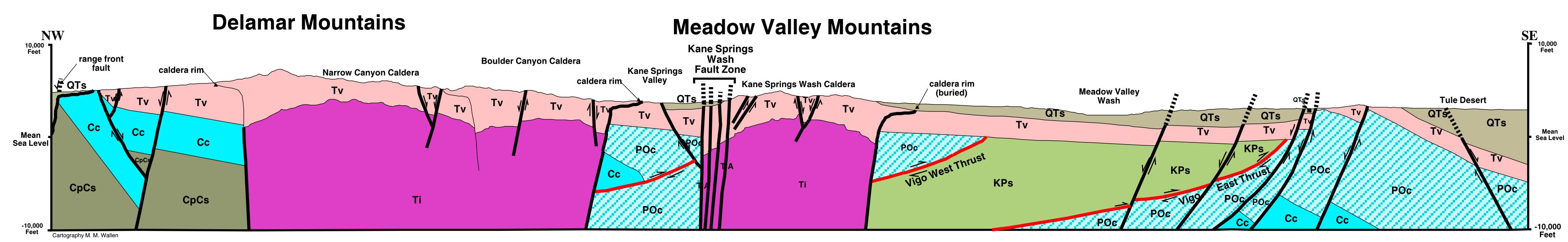
Hydrogeologic descriptions are on Figure 3-1.
Hydrogeologic units conform to Plate 2.



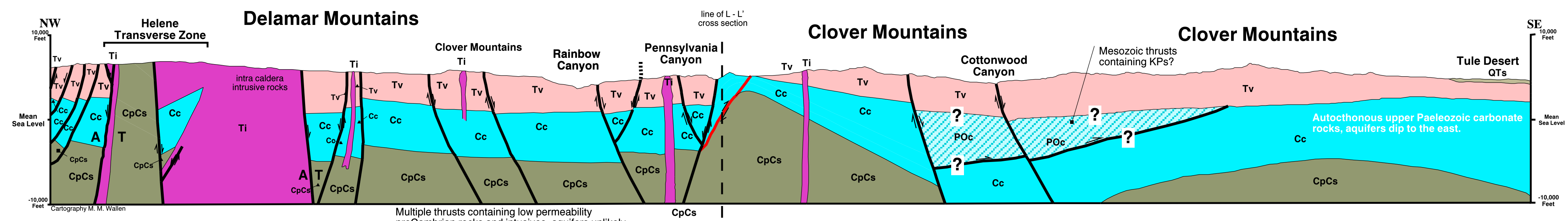
SECTION A-A'



SECTION B-B'



SECTION C-C'



SECTION D-D'

Scale = 1:200,000

Figure 3-2. Hydrogeologic cross sections A-A', B-B', C-C', and D-D'.

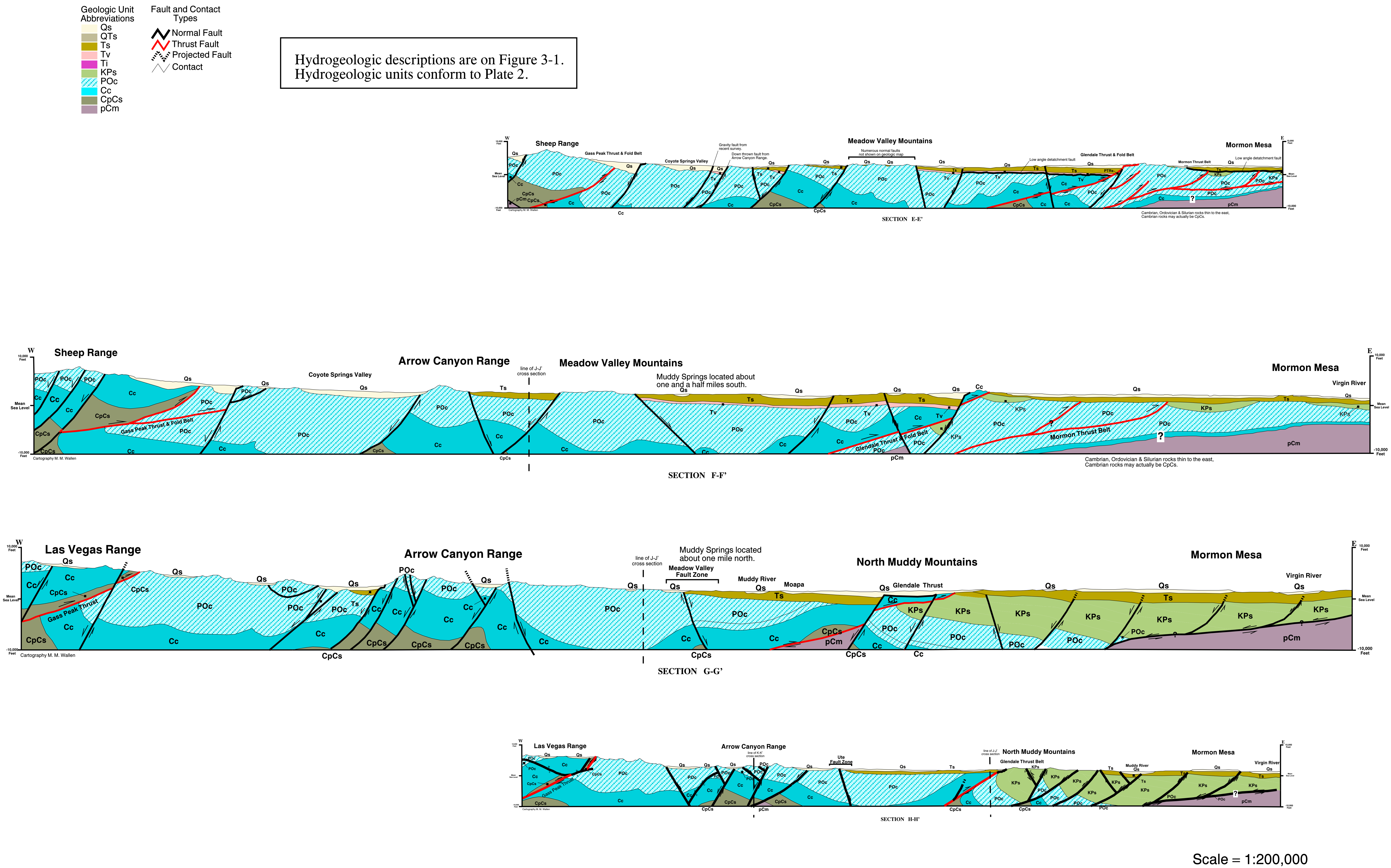


Figure 3-3. Hydrogeologic cross sections E-E', F-F', G-G' and H-H'.

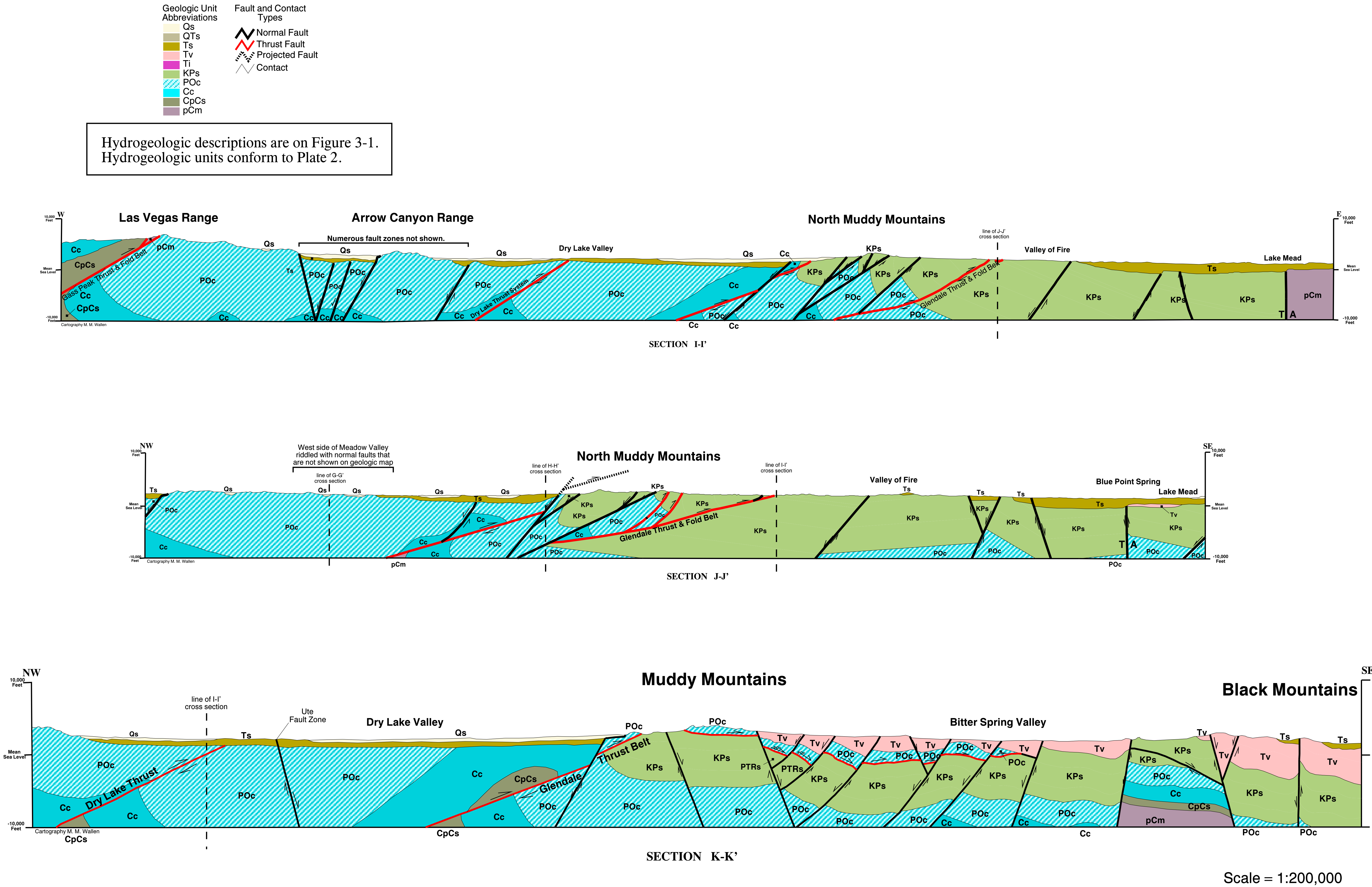


Figure 3-4. Hydrogeologic cross sections I-I', J-J, and K-K'.

(northeast) fracture. More than likely, this younger northeast-striking fracture followed older northeast-striking oblique faults of the middle Cenozoic episode. The normal and left-lateral faults of the basin-range episode in most places obscure the faults and fractures of the middle Cenozoic episode. The basin-range episode formed some time after about 12 million years ago and continues today, as evidenced by young north-striking faults that cut Quaternary basin-fill sediments in many parts of the study area. In places, basin-range faults were synchronous with sparse rhyolite tuffs and basalt lava flows in the study area. Because these basin-range faults, and the parallel fractures (joints) formed by them, are recent, they can remain open as conduits for ground water.

One other structural type, which is synchronous with the faulting and volcanism of both the middle and late Cenozoic episodes, consists of zones of major east-striking faults, fractures, dikes, folds, and eruptive centers known as transverse zones. Two of these zones cut through north of the model area and probably impact ground-water flow to unknown extent. These are the Timpahute and the Helene transverse zones, which respectively bound the northern side and southern side of the Caliente caldera complex (Ekren and others, 1976, 1977; Rowley, 1998; Rowley and others, 1998). In other words, the Timpahute zone passes through the north of Caliente, whereas the Helene passes through the ghost mining towns of Delamar and Helene.

3.2 STRUCTURAL SETTING

3.2.1 <u>Western Clover Mountains and Northern Delamar Range</u>

Rainbow Canyon separates the western Clover Mountains on the east from the western Delamar Range on the west (geologic cross section B-B’, C-C’, and D-D’).

The southern Panaca basin, and Caliente area have been geologically mapped, first at 1:250,000 scale (Ekren and others, 1977) and later at 1:24,000 scale (Rowley and Shroba, 1991; Rowley and others, 1992, 1994). Between Panaca Basin and the area of the railroad siding of Boyd, in central Rainbow Canyon, Meadow Valley Wash cuts through the Caliente caldera complex, one of the largest caldera complexes in the conterminous U.S. The caldera extends about 50 miles east-west and about 21 miles north-south and it underlies an area from Delamar Valley on the west, through the highest parts of the northern Delamar Range (7800 ft) and Clover Mountains (7500 ft), to the western Bull Valley Mountains of Utah on the east. The age of the Caldera Complex ranges from at least 23 to 13 million years (Nealey and others, 1995; Rowley and others, 1995; Unruh and others, 1995; Snee and Rowley, 2000; Rowley and others, in press). It consists of intracaldera rhyolite ash-flow tuff and local rhyolite volcanic domes that are several kilometers thick. The northern and southern sides of this east-elongated caldera complex are controlled by east-striking transverse zones: the Timpahute on the north and the Helene on the south (Ekren and others, 1976, 1977; Rowley and others, 1995, in press; Scott and others, 1996).

The faults bounding and within the Panaca basin are abundant and consist entirely of basin-range normal faults that strike northerly (Rowley and Shroba, 1991; Rowley and others, 1994). Many of these faults appear to pass across the east-striking faults of the Timpahute transverse zone. Within the caldera complex, northwest-striking oblique-slip faults of the middle Cenozoic tectonic episode are abundant and long (Ekren and others, 1977; Rowley and Shroba, 1991; Rowley and others, 1992, 1994; P.D. Rowley, unpub. mapping, 1995). Younger less common, north-striking basin-range faults, also continue southward. Although the Helene transverse zone may form a local barrier to southward flow of ground water through the caldera complex, the abundant north- to northwest-striking faults cutting through this transverse zone probably act as conduits for ground-water flow through the barrier.

South of the caldera complex and the stratovolcanoes and intrusions that mark the southern side of the complex (Helene transverse zone), the volcanic rocks consist of much thinner outflow ash-flow tuffs and intermediate-composition lava flows. These volcanic rocks unconformably overlie apparently east-dipping, thick Proterozoic to lower Cambrian quartzite (Sterling Quartzite, Wood Canyon Formation, Zabriskie Quartzite) and thick lower Cambrian carbonates (Highland Peak Formation). Although heavily faulted and fractured, the quartzite is likely an aquitard, whereas the Paleozoic carbonate rocks are aquifers. Here, at the latitude of the southern part of Rainbow Canyon (the southern end is just south of Elgin), the older northwest-striking oblique slip faults and presumably younger (basin-range) north-striking faults continue to dominate the structural pattern (Ekren and others, 1977). The same pattern is seen east of Rainbow Canyon, in the Clover Mountains, including the small Pennsylvania gold district. And at Delamar, a major gold mining district, controlled by east-striking faults, dikes, and eruptive centers of the Helene transverse zone, northwest-striking oblique-slip faults and north-striking normal faults likewise are common (Rowley, unpub. mapping, 1995). But increasingly, farther southward, north-northwest-striking faults pass into north-striking faults; strike-slip movement decreases southward and normal faults become dominant. This is especially apparent along the western margin of the Delamar Range, which trends northward and is formed by the Delamar Valley basin-range fault zone (Scott and others, 1995a) that uplifts the range with respect to Delamar Valley at and north of the latitude of Elgin. The Delamar Valley fault zone has significant Quaternary normal displacement on it.

3.2.2 Southern Delamar Range

South of the latitude of Elgin, the southern Delamar Range trends northeast and is cut by many north- and northeast-striking faults (geologic cross section C-C'). The western range front fault, however, trends northeast and is defined by one strand (Maynard Lake fault zone) of the northeast-striking Pahranagat shear zone (Ekren and others, 1977). To the northeast, this strand passes into the north-striking Delamar Valley fault zone. Elsewhere, all southwest and northeast ends of strands of the shear zone pass into major north-striking normal faults of the basin-range episode (Ekren and others, 1977; Scott and others, 1990a, b, 1993, 1995a; Swadley and Scott, 1990). The shear zone thus is a transfer fault zone that formed, like the basin-range faults, in an environment of east-west extension and transferred displacement to the northeast (Ekren and others, 1976, 1977; Scott and others, 1995a, 1996; Rowley, 1998).

Farther to the south in the Delamar Range, the 17-12-Ma Kane Springs Wash caldera complex (geologic cross section C-C') (Harding and others, 1995; Scott and others, 1995a, b, 1996) underlies an area about 18 miles by 15 miles in the southern Delamar Range, and extending eastward into part of the Meadow Valley Mountains. As with the Caliente caldera complex, intracaldera tuffs of at least several kilometers thickness were deposited in the calderas, and intracaldera intrusions have been emplaced into these tuffs, although they are exposed only locally. The caldera complex is likely a barrier to southward flow of ground water in the Delamar Range, but in Kane Springs Valley it is cut and offset left-laterally about 3 miles by the north-northeast-striking oblique-slip (left lateral and down-to-the-west normal) Kane Springs Valley fault zone. This major fault zone underlies the north-northeast-trending Kane Springs Valley and uplifts the Meadow Valley Mountains on the east with respect to the Valley. The Kane Springs Wash caldera complex and adjacent parts of the southern Delamar Range have been mapped in detail by Scott and others (1990a, b, c, 1991, 1993), Swadley and Scott (1990), and Swadley and others (1994). South of the caldera complex, north-striking faults characterize the southern end of the Delamar Range and probably provide ground-water pathways from southern Delamar Valley into Kane Springs Valley.

3.2.3 Kane Springs Valley and Meadow Valley Mountains

The northern Meadow Valley Mountains are separated from the southern Clover Mountains by a deep canyon cut by Meadow Valley Wash (geologic cross section C-C'). From there, the mostly low altitude Meadow Valley Mountains extend southwest to just past the Lincoln County line into Clark County. The northern part of the range consists, except for the faulted eastern lobe of the Kane Springs Wash caldera complex (Harding and others, 1995), of mostly outflow ash-flow tuffs that are as much as 2 km thick (Pampeyan, 1993). These volcanic rocks, as well as underlying Tertiary sedimentary rocks less than 300 ft thick, thin southward and pinches out north of the southern end of the range. Pre-Cenozoic sedimentary rocks, which unconformably underlie the Cenozoic rocks, are exposed in the central to southern part of the range (Pampeyan, 1993; Page and Pampeyan, 1996). Pampeyan (1993) showed these pre-Cenozoic rocks occupying several north-striking, east-verging Sevier thrust sheets. In one of these thrust sheets, exposed in the central part of the range, the youngest of the pre-Cenozoic rocks are the Triassic Moenkopi and Chinle Formations. These formations include a thick, Lower Permian redbed sequence and, where not removed by Triassic erosion, thin eroded parts of the Lower Permian Kaibab Limestone and Toroweap Formation. These fine-grained clastic rocks are about one mile thick and likely represent an aquitard. In the other thrust sheets, the rocks are about 2 miles thick ad dominated by carbonates of Ordovician to late Permian age. They are underlain by Cambrian rocks that are exposed to a thickness of about a half mile thick and also are dominated by carbonates. Both of these carbonate packages are important aquifers in Nevada and are, in turn, underlain by the thick Cambrian to Proterozoic quartzite (aquitard) section.

Northeast-trending Kane Springs Valley bounds the Meadow Valley Mountains on the west. The basin-fill sediments in the valley consist mostly of Quaternary deposits that overlie deposits at least as old as latest Miocene or early Pliocene (Scott and others, 1991; Pampeyan, 1993; Swadley and others, 1994). The Meadow Valley Mountains were uplifted relative to Kane Springs Valley by the major oblique Kane Springs Valley fault zone (Scott and others, 1991, 1995a; Pampeyan, 1993; Swadley and others, 1994). Despite its oblique motion, most if not all of the motion along the fault zone is considered part of the basin-range extensional episode. Some of that offset is Quaternary, and recent mapping by G.L. Dixon (unpublished) indicates that, like the major oblique-slip Pahranagat shear zone, at least the southern end of the Kane

Spring Valley fault zone passes southward into a north-striking basin-range fault. The western edge of the southern end of the Meadow Valley Mountains, changes trend southward from northeast to north, and the basin-range fault that causes this north-trending range front continues due south to define the western edge of the Arrow Canyon Range as well (Page and Pampeyan, 1996). The northeastern end of the Kane Springs Valley fault zone, which passes northeastward across Meadow Valley Wash into the southern Clover Mountains, is less apparent from the topography and has not yet been mapped completely. But mapping by Scott and Rowley (unpub. mapping, 1995) suggests that it also changes strike direction, from northeast to north and northwest. Thus the Kane Springs Valley fault zone is another transfer fault, like the Pahranagat shear zone.

Because the structure of the generally narrow Meadow Valley Mountains is dominated by the Kane Springs Valley fault zone, faults in the range likewise strike northeast (Scott and others, 1991, 1995a; Pampeyan, 1993; Swadley and others, 1994). Farther south, as the range widens and, at its southern end where it bends south, most faults strike north and normal slips dominate (Pampeyan, 1993; Page and Pampeyan, 1996). Large fractures filled with veins of coarsely crystalline calcite represent orifices of ancient spring discharge are well exposed in the Wildcat Wash area of the southern Meadow Valley Mountains, north of Nevada Highway 168 (Page and Pampeyan, 1996).

3.2.4 Lower Meadow Valley Wash

The basin referred to as the Glendale basin by Schmidt (1994), that is occupied by lower Meadow Valley Wash, is broad and contains a thick sequence of basin-fill clastic sediments (geologic cross sections E-E' and F-F'). A small part of the basin has been geologically mapped in reconnaissance or detail. The youngest part of the basin-fill sequence is made up of unconsolidated Quaternary sediments. These are underlain by clastic sedimentary deposits that Pampeyan (1993) lumped together as the Pliocene (?) and Miocene Muddy Creek Formation. The northern most area where detailed investigation of the basin – fill sediments has been undertaken in the Farrier quadrangle (Schmidt, 1994), along the Lincoln-Clark County line. The oldest deposits of the basin-fill sequence here belong to the Horse Spring Formation, correlated with deposits of the same name studied in the Lake Mead area (Bohannon, 1984). In the Farrier area, it consists largely of conglomerate considered by Schmidt (1994) to range from 20 to 12 Ma and to represent syn-extensional deposition during opening and deepening of the basin during the basin-range episode. The Horse Spring is overlain by the Muddy Creek Formation, considered by Schmidt to range from 12 to 5 Ma. in age Schmidt (1994) proposed that the Muddy Creek here represents deposition of finer grained clastic and lacustrine sediments that largely postdate the main extensional development of the basin. In the Riverside area (lower Virgin Basin), about 12 miles to the east and outside the study area, Williams and others (1997) mapped the Muddy Creek likewise as Miocene, however, continuing eastward to the Mesquite area, it is coarsely clastic (well exposed along U.S. Highway I-15) and thus clearly is not post-extensional. Some of the faults mapped in basin-fill deposits in the Farrier quadrangle strike north-northeast and north-northwest; these cut deposits as old as the Horse Spring, suggesting that they represent deformation of the pre-basin-range tectonic episode. More abundant basin-range faults that strike north cut deposits as young as Quaternary. Schmidt (1994) concluded that the Muddy

Creek Formation is the youngest unit representing closed-basin deposition and that, at least in the Glendale basin (Lower Meadow Valley Wash), integration began at about the end of the Miocene or beginning of the Pliocene. Pliocene sediments that Schmidt mapped are primarily alternating cut and fill stream sediments that contain abundant carbonate spring deposits, evidence of a wetter climate in the Pliocene.

In the Moapa and Glendale area to the south, at the southern end of the basin (geologic cross section E-E'), the stratigraphy of the basin-fill deposits is generally the same as that in the Farrier quadrangle, although an underlying limestone member of the Horse Spring Formation is also exposed (Schmidt and others, 1996). North-striking basin-range faults, some associated with Pliocene carbonate spring deposits, are abundant throughout the area.

3.2.5 Western Mormon Mountains

The Mormon Mountains are a high (about 7500 feet altitude) domal mountain range whose crest is on the eastern side of the Glendale basin and the study area (geologic cross section F-F'). To the north of the Mormon Mountains, a low, south-pointing prong of the Clover Mountains, and to the south of the Mormon Mountains, another south-trending ridge at the same longitude also mark the eastern edge of the Glendale basin (Lower Meadow Valley Wash) and the eastern edge of the model area. The Mormon Mountains are underlain by about 2,000 m of Cambrian through Pennsylvanian carbonate rocks. Cambrian and younger rocks were thrust eastward over Mississippian and Pennsylvanian rocks in the area of the range during Sevier deformation (Wernicke and others, 1985). The present form of the range has been suggested by Wernicke and others (1985) and Axen and others (1990) to result from a gently west-dipping Tertiary detachment fault that partly followed the Sevier thrusts and passed westward in the subsurface beneath the Meadow Valley Mountains. In places on the western side of the range, the low-angle normal fault rests on Proterozoic crystalline metamorphic and igneous rocks, and elsewhere at shallow depth below the Cambrian rocks, these basement rocks are exposed. During and after the suggested detachment, the deroofed footwall block to the east apparently arched upward, as a core complex, to form the present dome shape of the Mormon Mountains (Axen and others, 1990). Flat-lying Muddy Creek Formation in the Glendale basin unconformably overlies the low-angle normal fault.

Anderson and Barnhard (1993a, b) and Anderson and Bohannon (1993) criticized the detachment model for the Mormon Mountains and adjacent areas. They concluded that extension in the area was accompanied by major vertical structural uplift of the Mormon Mountains and adjacent ranges that produced structural thinning (attenuation) of the rocks on the crest of the uplifts. As mapped by Wernicke and others (1985), most normal faults at the surface in the Mormon Mountains are low angle but, based on tilts of strata in the hanging walls of these faults, Anderson and Barnhard (1993a, b) interpreted that the faults become steeper with depth, as in basement-cored uplifts in Wyoming and other parts of the Rocky Mountains. Such an interpretation seems more reasonable. But, regardless of the geologic model for the evolution of the Mormon Mountains, the Proterozoic basement rocks beneath the Mormon Mountains form an aquitard that blocks ground-water flow through the range. We interpret this large regional domal uplift not only to impede ground-water flow through the range, but also acts as a barrier to ground-water moving from the Tule Desert into the lower Meadow Valley Wash. Glancy and Van Denburgh (1969) indicated Tule Desert is part of the Lower Virgin River Valley, as did subsequent investigators (Brothers et al. (1992); and Dixon and Katzer (in review, 2001)).

Wernicke and others (1985) noted that, in the Mormon Mountains area, "No evidence was found for a younger episode of widely spaced high-angle normal faults ("Basin and Range" faulting)." Yet the youthful age of the Mormon Mountains suggests to us that this is an example of the basin-range episode of faulting, which here was expressed as low-angle normal faults at the surface, rather than as high-angle normal faults. The south-trending ridge of the Clover Mountains just north of the Mormon Mountains is underlain by east-dipping Tertiary volcanic rocks (Ekren and others, 1977) bounded by a high-angle basin-range fault on its western side. Similarly, the south-trending ridge south of the Mormon Mountains is bounded by a high-angle basin-range fault along its western side. This latter fault, in fact, abruptly changes its northern strike at the northern end of the ridge, just south of the Mormon Mountains, and strikes east-northeast, where its motion is oblique left lateral (G.L. Dixon, unpub. data, 2000). Then, east of the study area, the fault abruptly turns northward and bounds the western side (Carp road fault and Sam's camp fault of Axen and others, 1990) of the East Mormon Mountains, a low north-trending range east of the Mormon Mountains that was mapped by Axen and others (1990), Anderson and Barnhard (1993a, b), and Anderson and Bohannon (1993). This left-lateral part of the fault, like the Pahranagat shear zone and the Kane Springs Valley fault zone, represents another example of a transfer fault that passes into north-striking normal faults at both of its ends (G.L. Dixon, unpub. mapping, 2000).

3.2.6 Sheep Range, Las Vegas Range, and Elbow Range

The Sheep Range is an abrupt (almost 10,000 ft high in the wider southern part of the range; 7500 ft high in the narrow northern part), north-trending range that bounds the southwestern side of the study area. Its rocks are mainly Cambrian through Devonian carbonate sedimentary rocks that dip generally eastward (Guth, 1980) (geologic cross sections G-G', H-H', and I-I'). The main basin-range fault that creates the range is on its western side, but the eastern side also is uplifted along a north-striking normal fault; thus the range is a large horst block. Within the range, minor north-striking faults dominate, but some cross-faults that strike east to east-northeast also have been mapped. The northern end of the main Sheep Range is terminated against the southern strand (Maynard Lake fault zone) of the east-northeast-striking left-lateral oblique-slip Pahranagat shear zone (Jayko, 1990) (geologic cross section A-A'). We interpret that the western part of this strand of the shear zone joins the main normal fault and defines the western side of the main Sheep Range. Under this interpretation, the Maynard Lake zone is a transfer fault that transfers east-west pulling apart into left lateral shear. In other words, where faults strike north, all east-west extension is taken up by normal movement down the dip of the fault plane; where faults strike northeast, east-west pulling apart is taken up partly by left slip and partly by normal slip, in other words oblique movement.

A small north-trending range, whose northern end also terminates against the Maynard Lake fault zone, lies just to the east of the northern end of the main Sheep Range. This lessor range is also called the Sheep Range, but it forms a separate basin-range tilt block that consists largely of east-dipping volcanic rocks (Jayko, 1990). These rocks rest unconformably on Pennsylvanian and Permian carbonate rocks making up what Jayko (1990) calls the Coyote Spring syncline. Numerous north-striking normal faults that uplifted this tilt block occur on its western side. Minor north-striking faults occur within the smaller range. All these faults, which terminate against the Maynard Lake fault zone, are interpreted to pass into the Maynard Lake transfer zone and likewise transfer the slip northward from normal slip to oblique slip. In addition to these north-striking normal faults, Jayko (1990) projects the buried north-striking trace of the Gass Peak thrust fault (Sevier age) beneath the normal faults. The valley between the northern end of the main Sheep Range and the tilt block to the east is the northern part of Coyote Spring Valley.

East of the eastern tilt block of the northern Sheep Range is a valley occupied by U.S. Highway 93 and by Pahranagat Wash, which drains southward from Maynard Lake (dry) and other parts of Pahranagat Valley into northern Coyote Spring Valley. Basalt lava flows that issued from vents along the Maynard Lake fault zone are exposed along and beneath the wash as it drains southward. This valley, referred to as Evergreen Flat, continues southward and joins Coyote Spring Valley about 4 miles to the south. This gap is the boundary between the bedrock ridges of the northeastern Sheep Range to the west and the southwestern Delamar Range to the east. On the eastern side of Evergreen Flat, however, a north-striking basin-range fault zone several miles east of the gap uplifts the southwestern end of the Delamar Range. Here, Cambrian through Devonian carbonates overlain by volcanic rocks are uplifted and tilted to the east.

The western side of the model area is the crest of the Sheep Range and at the southern end of the Sheep Range, the boundary runs eastward along a series of hills making up the broad southeastern part of the range. From there the boundary swings south, then east across the southern Las Vegas Range, a low north-trending basin-range east of the southern Sheep Range. The boundary of the model area continues east to just south of Apex in Garnet Valley. The Las Vegas Range northwest of Apex is defined by the Gass Peak thrust, which transports rocks as old as the Cambrian Wood Canyon Formation over Mississippian, Pennsylvanian, and Permian carbonates of the thick Bird Spring Formation (Maldonado and Schmidt, 1991) (geologic cross section F-F’). Most of the Las Vegas Range is made up of folded Bird Spring limestones and minor dolomites, with the Gass Peak thrust striking north along its western side and continuing beneath Quaternary deposits east of the main part of the Sheep Range (Maldonado and Schmidt, 1991; Page, 1998). The small Elbow Range, which bounds the Las Vegas Range on the northeast, is made up of thrusted and folded Bird Spring Formation (Page and Pampeyan, 1996). The folds and faults in the range strike north and may provide conduits for ground-water flow.

3.2.7 Coyote Spring Valley and the Arrow Canyon Range

The Arrow Canyon Range is a sharp, narrow north-trending basin range consisting of a syncline of Cambrian to Mississippian carbonates. It is uplifted along its western side by normal faults of the Arrow Canyon Range fault zone (Page and Pampeyan, 1996; Schmidt and Dixon, 1995; Page, 1998) (geologic cross section I-I’). The trace of the north-striking Dry Lake thrust, which carries Cambrian rocks over Silurian through Permian carbonates, is exposed and projected north just east of the Range (Schmidt and Dixon, 1995). East of the Dry Lake thrust, the Silurian through Permian rocks form a series of low unnamed, north-trending hills. These hills are controlled by north-striking normal faults, along some of which are Pleistocene carbonate spring-mound deposits that indicate that the faults formerly carried significant ground water (Schmidt and Dixon, 1995).

3.2.8 Northern Muddy Mountains, and Muddy Mountains, and Dry Lake Range

The southern end of the study area is defined by north-striking ridges of the North Muddy Mountains and, to the south, the northern and northwestern parts of the larger Muddy Mountains (Bohannon, 1983) (geologic cross sections H-H', I-I, and K-K'). The North Muddy Mountains separate the Glendale basin on the west from the Mesquite basin to the east. The Muddy Mountains occupy the northern side of Lake Mead. The southernmost part of the study area extends southwest to include the small Dry Lake Range east of Apex. This range is made up mostly of Bird Spring carbonates. A bedrock gap at Apex connects the Dry Lake Range with the southern Arrow Canyon Range/Las Vegas Range. This gap most probably was a pathway for Tertiary and Quaternary basin-fill sediments entering the Las Vegas Valley, just southwest of the study area. The gap also is along the trace of the Dry Lake Thrust (Page and Dixon, 1996) Basin-fill sediments to the northeast along the I-15 corridor (Glendale basin) thus are not connected with those in the Las Vegas Valley and, from limited mapping in the area, are not correlated with those in the Las Vegas Valley. In the Muddy Mountains and in the North Muddy Mountains, faults strike north-northeast (Bohannon, 1983), and the gap between the two ranges, now occupied by Tertiary and Quaternary basin-fill sediments, likely also is underlain by fractures of the same strike. The northern Muddy Mountains and North Muddy Mountains contain significant Jurassic sedimentary rocks (Bohannon, 1983), some of which (Aztec Formation) make up a prominent aquifer in southwestern Utah (where it is called the Navajo Sandstone), but here the sandstone has very low permeabilities and forms an aquitard, as do other Jurassic rocks in the area. The northwestern side of the North Muddy Mountains contains carbonates. Nonetheless, the Mesozoic sediments create a barrier to most southward flow that might pass through them into Lake Mead. An additional ground-water flow barrier is provided by east-striking faults of the northern Muddy Mountains, notably the northeast–verging Glendale thrust (Bohannon, 1983). Bohannon interpreted this structure as the northern continuation of the Keystone Thrust system which has been displaced approximately 40 miles right laterally by the Las Vegas Shear Zone. As with the Keystone/Glendale Thrust system, the Dry Lake Thrust (thrust fault system just west of the Keystone/Glendale thrust) has been displaced 40 miles by the same shear zone and its southern equivalent is the Deer Creek Thrust in the Spring Mountains.

The southeastern part of the study area, where the Muddy and Virgin Rivers enter the Overton Arm of Lake Mead, is probably an area of ground-water discharge. Basin-fill sediments, dominated at the surface by resistant Quaternary calcretes also underlie Mormon Mesa and its northward extension. This prominent calcrete is underlain by Pliocene to upper Miocene basin-fill deposits that underlie the southwestern end of the Mesquite basin The Black Mountains and Gold Butte areas form the eastern margin of the study area in a series of complex Proterozoic metamorphic rocks which extends from the southwestern Virgin Mountains south to the southern edge of Lake Mead. Numerous fault zones have been mapped in this area including faults that are discharge points of Rogers and Blue Point springs in the Lake Mead National Recreation

Area. These faults most likely are related to a series of faults that strike to the northeast, have oblique dip-slip motion, and are part of the Lake Mead Fault Zone (Anderson and Barnhard, 1993a).

4 GROUND-WATER FLOW SYSTEM

The ground-water flow system for the Colorado River basins **(Figure 1-1)** in the study area covers an extensive area of about 12,084 mi^2 and is roughly a north-south zone marked by major mountain blocks. From north to south the western boundary is: Maverick Springs Range, the White Pine Range, the Grant and Quinn Canyon Ranges, the Pahranagat Range, and the Sheep Range. The eastern boundary is the mountain blocks of: Butte Mountains, Egan Range, Wilson Creek Range, Clover Mountains, and the Mormon Mountains. This is a very large part of the carbonate rock province of eastern Nevada described by numerous investigators, most recently Dettinger et al. (1995), Prudic et al. (1995), Thomas et al. (1996), and Plume (1996). The hydrologic properties have a great deal of similarity throughout this area, however, the hydrologic connectivity is not known exactly. It is for certain though that ground-water flow begins at the higher altitudes in the northern edge of the province and moves to the south gaining in flow volume as recharge from the various mountain blocks enters the ground-water system in the carbonate rocks. Undoubtedly the carbonates discharge some water to the overlying alluvial aquifer systems.

Part of the ground water in the White River Flow System discharges into the Muddy River ground- and surface-water system (Muddy Springs) with the remainder discharging through the carbonate rocks underlying Hidden and Garnet Valleys, and California Wash. A minor amount of this flow in California Wash probably flows to the Black Mountain Area discharging at Roger and Blue Point Springs. The remainder of the ground-water flow discharges into the Muddy River system and from great depth in the carbonate rocks discharges either into the Virgin and Colorado Rivers or further to the south at undefined locations.

The Meadow Valley Flow System, both surface- and ground-water, is also tributary to the Muddy River and Lower Moapa Valley and like the White River system discharges from great depth through the carbonate rocks underlying Lake Mead and the Colorado River.

The individual valleys in the two flow systems are generally connected by surface drainage, such as White River and Meadow Valley Wash, and in some valleys, ground-water flow in the alluvial aquifer systems such as between Dry Lake and Delamar Valley and between several of the Valleys in the Meadow Valley Flow System. However, it is at varying depths in the underlying carbonate rocks that there is a complete hydrologic connection. It is also this part of the flow system that is the most difficult to define. There are water-level maps such as by Rush (1974) and Harrill and Prudic (1998), Thomas et. al. (1986), based on sparse data, that show the general direction of ground-water flow in the carbonate rocks, but the data points are generally in the valley lowlands and virtually nothing is known about the mountain blocks. There may be ground-water mounding in some blocks that act as barriers or partial barriers to flow from one block to another. There are also differences in permeability between the various carbonate rocks that create preferred directions of flow. High permeable zones within the carbonate rocks are probably caused by mineral dissolution in the rock and fractures caused by faults. Volcanic rocks are less permeable than carbonate rocks, but where fractured are able to readily transmit ground water. There are low-permeability rocks within the study area that act as a barrier to ground-water flow such as clastic sedimentary rocks and crystalline basement and granitic rocks.

4.1 GROUND-WATER SOURCE

All ground water, regardless of where it is starts out as surface water, is from precipitation in the form of rain and snow on the mountain blocks, which are the main recharge areas. Water that has evaporated from principally the Pacific Ocean moves inland as atmospheric water, condenses and falls as rain and snow upon the mountain blocks. Undoubtedly summer storms provide significant amounts of moisture, but it is winter storms that are the most important for water resources because the effect of summer storms at higher altitudes is minimal. Storm tracts are eastward and northeastward from the South Pacific Ocean and the Gulf of California, and in the more northern basins the tracks are more to the southeast from the northern Pacific Ocean.

Once water falls on the ground some of it evaporates immediately and returns to the atmosphere (sublimation takes its toll from snow packs), some of it runs off into stream channels where it may infiltrate to the water table as the streams transect alluvial fans. Most of the water infiltrates the shallow soil mantle overlying the bedrock and is used by the plant life and returns to the atmosphere by way of transpiration. That amount of water that is excess to the plant's needs and exceeds the moisture holding content of the soil infiltrates through the soil mantle into the underlying bedrock. Ultimately the water reaches the water table and becomes part of the ground-water system. Over large parts of many of the mountain blocks the soil cover is thin to non-existent and the water infiltrates directly into the bedrock. Ground-water recharge is generally greater and mountain front runoff is less in carbonate rocks compared to volcanic rocks.

4.2 PRECIPITATION

Precipitation in Nevada is strongly controlled by orographic effect because there is a definite increase of precipitation with altitude. Most researchers also assume the natural recharge efficiency (the percent of precipitation that becomes ground water recharge) increases with altitude and this increase is proportional to the precipitation. This results in an interpretation that the surrounding mountain ranges of any valley are the most important areas for analyzing climate and natural recharge.

The orographic effect in eastern Nevada although distinct is relatively minor compared to the Sierra Nevada or other major ranges of the Pacific Coast. Those ranges are transverse to the paths of storms and large rain shadows are located downwind of the ranges. West central Nevada is in the rain shadow of the central Sierra Nevada. Eastern Nevada commonly receives precipitation from Pacific Winter storms moving around the south end of the Sierra then north northeastward across eastern Nevada. The larger ranges in eastern Nevada are usually northeasterly (Grant, Quinn Canyon, Clover) subparallel with storm tracks and the windward (wetter) may be on the eastern rather than western side of these ranges.

Microclimates or local altitude-precipitation relationships are probably quite common but the details of most of them are unknown because of the low density of precipitation gages. The low density of gages in Nevada is partially related to the low density of population and the gages that exist with records of sufficient length are concentrated near population centers, in the valley lowlands. Like most natural systems, precipitation, is time dependent in addition to being a spatial phenomenon, and a distinction is usually made between weather (daily to yearly variations) and climate (10's to 1000's of years). Climate is of primary interest to ground-water hydrology, but both weather and climate are of interest to surface-water hydrologists. Long-term precipitation records become climatic data once sufficient data is collected to minimize the effects of yearly variations. Climatologists usually assume thirty years of record is required to minimize the yearly variation, however, some data is always better than none.

4.2.1 Existing Precipitation Estimates and Maps in the Study Area

Bixby and Hardman (1928, p. 8-9) documented the first estimate of orographic effects (local altitude-precipitation relationships) in Clark County. In the same report, they mentioned, but did not formally reference, two previous reports where the precipitation increase with altitude was estimated. L. H. Taylor in the Truckee River Basin, estimated an increase of 12.8 inches per 1,000 feet of altitude rise in the Sierra Nevada. The other report by W. O. Clark and C. W. Riddell estimated an increase of 4.5 inches per 1,000 feet of altitude rise in Steptoe Valley. Bixby and Hardman (1928) assumed this altitude precipitation relationship applied over most of central and eastern Nevada including Clark County and most of the orographic effect occurs between 6,000 and 9,000 feet of altitude. They also assumed that 8 inches of precipitation occurs approximately at 6,000 feet of altitude and there is minimal orographic effect below 6,000 feet and above 9,000 feet of altitude.

These same estimates and assumptions are well embedded in the literature. Hardman's first state-wide precipitation map was created in 1936 (Hardman, 1936) this map was published in 1949 (Hardman and Mason, 1949, p. 10), and was revised in, July 1965 (Hardman, 1965). The 1965 map was used to create the Nevada Division of Water Resources precipitation map (NDWR, 1971) published in the State Water Plan of 1972 (Bruce Scott, formerly with NDWR, personal communication, 2000). Both of the Hardman (1936, 1965) maps were not widely disseminated and are very difficult to obtain. Notes on both the 1965 map and in Hardman and Mason indicate this map, (Hardman and Mason, 1949, p. 10), is an exact reproduction of the 1936 Hardman map.

Both versions of Hardman's map have contour intervals of 5, 8, 12, 15, and 20. The 8-inch contour is usually close to 6,000 feet in eastern Nevada, at higher altitude in west-central Nevada, probably due the Sierra rainshadow effect, and at lower altitude in eastern and southern Clark County due to monsoonal storms. The NDWR 1971 precipitation map has slightly different intervals (uniform 4-inch intervals between 4 and 20).

Basin reports published by NDWR and USGS used the Hardman (1936, 1965) precipitation maps because no other source was available. Earlier reports reference either the 1936 map or Hardman and Mason, and later reports reference the 1965 map. The similarity between the Hardman maps (1936, 1965) and the Maxey-Eakin (Maxey and Eakin, 1949, p. 40) methodology extends to the choice of contour intervals (8, 12, 15, and 20) but as summarized by Eakin in 1966 (p. 260 - 262), and in several other reports, precipitation was generally estimated from altitude intervals of the 1:250,000 scale maps rather than directly from the Hardman maps. Avon and Durbin (1992, p.12) reported that USGS investigators deviated from the "standard" Maxey-Eakin technique about 37 percent of the time, for various reasons.

Precipitation maps, for Nevada and the rest of the United States, have been created since the early 1990s using a climatic model called the Parameter-elevation Regressions on Independent Slopes Model (PRISM) by Daly and others (1994) of the Oregon Climatic Service. As the name implies PRISM is a model or process and the maps of precipitation and other climatic variables are revised fairly often. These maps have been widely distributed through the Internet since the late 1990s. Their widespread use is related, in part, to availability, cost (free), and the format of the maps. The maps can be downloaded and directly imported into the "ARC" geographic information system (GIS) software of Environmental Systems Research Institute (ESRI), the most commonly used GIS software.

PRISM is specifically designed for use in mountainous terrain but uses the thirty year 1961-1990 climatic mean data. This means the data set in Nevada at high altitude was quite limited, because the USGS high altitude bulk precipitation gages were not installed until the mid 1980's. Long-term precipitation records in Nevada are generally uncommon and it appears never have been collected in some valleys. The May, 1997 version of the PRISM precipitation map was used in conjunction with an evapotranspiration and basin budget study by Nichols (2000, a, b, c) in east-central Nevada.

4.2.2 Differences between This and Other Estimates of Precipitation

Precipitation in this study was estimated using a modified Maxey-Eakin technique pioneered by Donovan and Katzer (2000) in Las Vegas Valley. The total estimate of precipitation for the study area (~ 6,636,000 acre-feet per year) by the modified Maxey-Eakin technique pioneered by Donovan and Katzer (2000) in Las Vegas Valley is significantly larger than the NDWR 1971 map (~ 5,516,000 acre-feet per year) but smaller than the May 1997 version of PRISM (~ 6,985,000 acre-feet per year). The maps vary in detail but the primary difference in interpretation between the older and more recent precipitation distributions is the amount of precipitation between 4,000 and 7,000 feet. This altitude interval contains 67 percent (2/3) of the total area and is composed of 12 percent between 4,000 and 5,000 feet, 30 percent between 5,000 and 6,000 feet and 25 percent between 6,000 and 7,000 feet.

On the NDWR 1971 and the Hardman (1936, 1965) precipitation maps significant parts of Long and Jakes Valleys, above 6,000 feet, are characterized as receiving less than 8 inches of precipitation but in general the 8-inch precipitation contour occurs close to 6,000 feet of altitude. Alternatively, on the PRISM precipitation map all of the study area above 4,000 feet is interpreted as receiving greater than 8 inches of precipitation.

Also large blocks (millions of acres) were assumed to have similar altitude-precipitation relationships. In the USGS and NDWR basin reports 19 out of the 27 valleys studied for this report were assumed to have the same ("standard" Maxey-Eakin) altitude-precipitation relationship summarized in Eakin (1966, p 260-262). Of the other eight, five have another relationship that is significantly "wetter" although the increase with altitude was the same, one is similar to the "standard" although slightly "dryer" and two are unreported.

4.2.3 Available Precipitation Data

The precipitation data used for this study are color coded by agency on **Figure 4-1**. The precipitation data for this analysis were selected for both quality of record and spatial distribution. The precipitation data in this analysis came from three sources, Desert Research Institute's Western Regional Climate Center (WRCC), Nevada Department of Conservation and Natural Resources, Division of Water Resources (NDWR), and the U.S. Geological Survey's (USGS) High Altitude Precipitation Network. The precipitation data used for this study are listed in **Table 4-1**.

The WRCC data were accessed through their website (http://www.wrcc.dri.edu) and includes historical (climatological) data for the National Oceanic and Atmospheric Admisistration's National Weather Service precipitation sites. These are daily low altitude gages with generally long periods of record. One issue associated with these sites are missed daily readings. These missed readings have a very high probability of occurring on days when precipitation actually occurred as the record commonly indicates either the station keeper could not access the gage (due to bad weather) or a mechanical failure became apparent to the station keeper because the gage did not record known precipitation. Because these missed readings have a high probability of occurring on a days when precipitation actually occurred, and precipitation is a rare event, this can be very serious problem in short duration records and may significantly underestimate the station's "average precipitation". Therefore only station with low percentages (< 7 %) of "missed" days were used for this analysis.

The NDWR data are from bulk precipitation gages measured annually and were installed in the mid 1950s and mid 1960s. At these gages, vandalism is the usual reason for "missing data". Because vandalism is a random event, not related to weather, these years of missing data may or may not bias the gage averages. The primary reason for under reporting of precipitation at these sites, if it occurs, would be related to insufficient gage size to contain very large snowfalls. This type of error would be difficult to detect or demonstrate.

The USGS High Altitude Precipitation Gage Network was established in the mid 1980's in support of the Carbonate Rock Study. The gages are measured semi-annually and are 12 feet in height, 1 foot in diameter and are designed to the Department of Agriculture, National Resources Conservation Service's (NRCS), Snowpack Telemetry (SnoTel) specifications. These gages are bulk precipitation gages, however, and not telemetered. Both the height of the gage and the periodicity of measurement are designed to minimize under reportage of precipitation. Vandalism and even forest fires have destroyed some of these gages and affected the records.

Over estimation of precipitation from gage data can also quite commonly occur, either because the data were collected in unrepresentative years or because of poor gage placement. The under estimates are "compensated" by the over estimates, however both can be serious problems and can significantly affect the representativeness of any particular gage record. The period of record

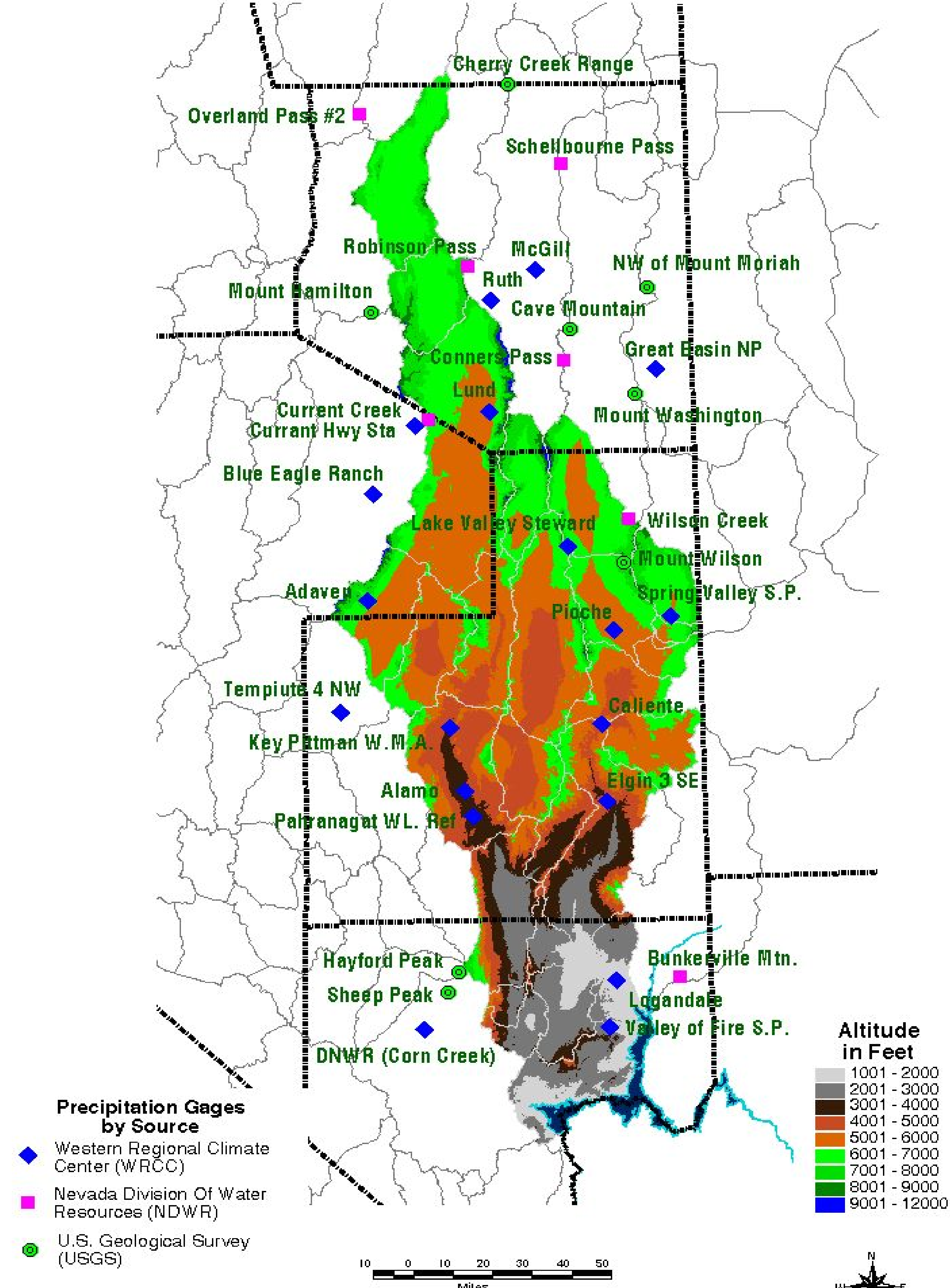


Figure 4-1. Altitude distribution in study area with precipitation gages.

Table 4-1. Precipitation data used in this analysis.

Site No.	Site Name	P[1]	Agency [2]	UTM[3]-X	UTM[3]-Y	Altitude	Years of Record		Average Annual Precipitation
				Meters	Meters	feet	start	last	Inches
				Group 1 ("Western" or "Dry")					
1	DNWR (Corn Creek)	D	WRCC	647,271	4,033,702	2,920	1948	1998	4.41
2	Bunkerville Mountain	A	NDWR	751,159	4,055,820	3,250	1967	1998	6.18
3	Pahranagat WL. Ref.	D	WRCC	666,997	4,125,914	3,400	1964	2000	6.40
4	Alamo	D	WRCC	663,824	4,136,951	3,600	1948	1962	4.88
5	Key Pittman W.M.A.	D	WRCC	657,394	4,164,575	3,950	1964	1989	7.94
6	Blue Eagle Ranch Hk	D	WRCC	626,385	4,265,782	4,780	1978	2000	9.38
7	Tempiute 4 NW	D	WRCC	613,161	4,171,251	4,890	1972	1985	7.87
8	Lund	D	WRCC	673,561	4,301,824	5,570	1957	2000	10.37
9	Currant Hwy Station	D	WRCC	643,286	4,295,668	6,240	1963	1977	10.59
10	McGill	D	WRCC	692,309	4,363,337	6,300	1914	2000	8.84
11	Great Basin Natl. Pk.	D	WRCC	741,040	4,320,255	6,830	1948	2000	13.11
12	Ruth	D	WRCC	673,940	4,349,949	6,840	1958	2000	12.17
13	Schellbourne Pass	A	NDWR	702,954	44089648	7,100	1954	1998	13.28
14	Conners Pass	A	NDWR	703,749	4,323,830	7,732	1954	1998	13.98
15	Robinson Pass	A	NDWR	665,000	4,364,560	7,800	1954	1998	12.70
16	Sheep Peak	S	USGS	656,987	4,049,883	9,600	1985	1999	16.95
17	Cherry Creek Range	S	USGS	680,671	4,443,452	9,700	1985	1999	14.74
18	Hayford Peak	S	USGS	660,932	4,058,248	9,840	1985	1999	16.52
				Group 2 ("Eastern or "Wet")					
19	Logandale	D	WRCC	725,069	4,055,097	1,410	1968	1992	5.14
20	Valley of Fire St. Pk.	D	WRCC	722,612	4,034,678	2,000	1972	2000	6.70
21	Elgin 3 SE	D	WRCC	721,539	4,132,729	3,300	1965	1985	14.07
22	Caliente	D	WRCC	719,183	4,165,980	4,440	1928	2000	9.06
23	Spring Valley St. Pk.	D	WRCC	747,214	4,213,053	5,950	1974	2000	12.31
24	Pioche	D	WRCC	723,958	4,206,828	6,180	1948	2000	13.38
25	Adaven	D	WRCC	624,188	4,219,501	6,250	1928	1982	12.73
26	Lake Valley Steward	D	WRCC	705,452	4,243,357	6,350	1971	1998	15.69
27	Overland Pass #2	A	NDWR	620,902	4,430,358	6,790	1966	1998	14.10
28	Wilson Creek	A	NDWR	730,287	4,254,672	7,200	1954	1998	16.45
29	Current Creek	A	NDWR	649,041	4,297,624	5,999	1954	1998	13.17
30	Mount Wilson	S	USGS	728,196	4,235,885	9,200	1985	1999	22.49
31	NW of Mount Moriah	S	USGS	737,769	4,355,738	9,300	1985	1999	18.28
32	Mount Washington	S	USGS	732,842	4,309,177	10,440	1985	1999	25.80
33	Mount Hamilton	S	USGS	625,636	4,344,581	10,600	1985	1999	21.81
34	Cave Mountain	S	USGS	706,185	4,337,345	10,650	1985	1999	21.40

[1] *P = Periodicity of measurement, D (Daily), A (Annual), S (Semi-Annual)*
[2] *Proper names of agencies, Western Regional Climate Center (WRCC), Nevada, Division of Water Resources (NDWR), U.S. Geological Survey (USGS)*
[3] *UTM = Universal Transverse Mercator, North American Datum 1927 (NAD27)*

annual averages reported in **Table 4-1** of the precipitation gages are assumed to be representative of the precipitation at the site of the gage and over a relatively large area (millions of acres). This assumption, however, may introduce errors into this or any other precipitation analysis.

A significant issue in this analysis was the low density of precipitation data. Precipitation data are available from existing or recently existing sites in 11 of the 27 valleys in the study area. No records were found for gages in the other valleys. Because of the low density, precipitation data from adjacent valleys were used to augment the data set. This low density of data also effects any precipitation analysis.

4.2.4 Development of Altitude-Precipitation Relationships

The precipitation-altitude relationships used in this study were estimated slightly differently than was done in Las Vegas Valley (Donovan and Katzer, 2000). Las Vegas Valley is a much smaller area, has a higher density of data, and much more apparent variability. The historic precedents all assumed the altitude-precipitation relationships were different in the two major mountain ranges (Spring Mountains and Sheep / Las Vegas Ranges). Donovan and Katzer (2000) simply used the gage data to better define the differences between the two mountain ranges. The plot of the data (Donovan and Katzer, 2000; Figures 1 and 2) displays some very obvious geographic groupings consistent with historical analysis. In Las Vegas Valley the data were simply separated into four groups and regressed.

The historical precedents for this current study all assumed the altitude-precipitation relationship was similar throughout the entire area. The one general distinction was a difference between northern basins (dryer) and southern basins (wetter). This difference was presumably related to the influence of summer monsoonal precipitation. Therefore it was originally thought that one uniform altitude-precipitation relationship could serve to characterize the area.

The first step in developing an altitude-precipitation relationship is plotting the station period of record averages **(Figure 4-1** and **Figure 4-2)** to determine if a geographic relationships exist. The precipitation gages on **Figure 4-2** are shape-varied by the source of the data.

This general regression appears to generally explain the altitude-precipitation relationship but the coefficient of determination is not very high (Adjusted r^2 = 0.78) indicating 22 percent of the variation is not explained by the regression.

Rather than northern-southern, a general eastern-western relationship was observed. That is; stations on the eastern side, of the study area, tended to plot above the regression line ("wetter" than predicted) and stations on the western side tend to plot below the regression line ("dryer" than predicted). Therefore it was hypothesized that the western part of the study area (White River Flow System) is "dryer" than the eastern (Meadow Valley Flow System) part and use of a "general" altitude-precipitation relationship would tend to over estimate precipitation in the White River Flow System and under estimate precipitation in the Meadow Valley Flow System.

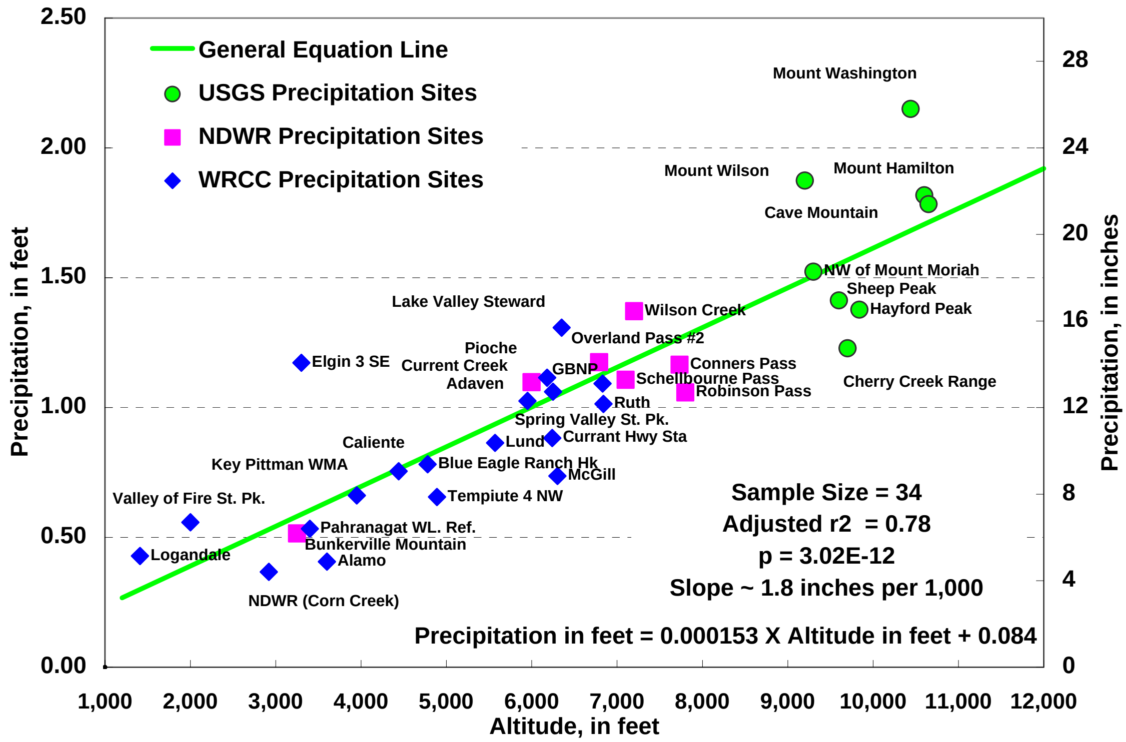


Figure 4-2. General regression of precipitation gage data in this study.

"Dryer" implies that a location at a specific altitude in one area receives less precipitation than in other areas at the same altitude. This "dryness" is also most obvious on the valley floors where most humans interact with the environment. Use of "dryer" and "wetter" is unsatisfying because these terms do not differentiate between reduction in the slope of the local altitude-precipitation relationship and "regional dryness" associated with large and perhaps overlapping rainshadows.

The period of record averages were separated into two groups simply based on whether the point plotted below (**Table 4-1**, Group 1) or above (**Table 4-1**, Group 2) the general regression line, with one exception. Caliente was included in the "wet" group (Group 2) to balance the influence of the Elgin precipitation station. These observed groupings were thought to be a combination of; overlapping rainshadows, general geometry of the valleys, including the height of the ranges above the valley floors, and orientation of the ranges with respect to storm tracks. The data and regressions are portrayed on **Figure 4-3** (Group 1) and **Figure 4-4** (Group 2).

The "dry" regression includes some of the same data used to create the "Sheep Range" altitude-precipitation relationship in Las Vegas Valley (Donovan and Katzer, 2000) which is "dryer" (both slightly shallower slope and smaller intercept). This appeared reasonable because the physical meaning of this regression suggests the valleys included within this particular analysis are relatively "dry" but not as "dry" as the nearby region within Las Vegas Valley.

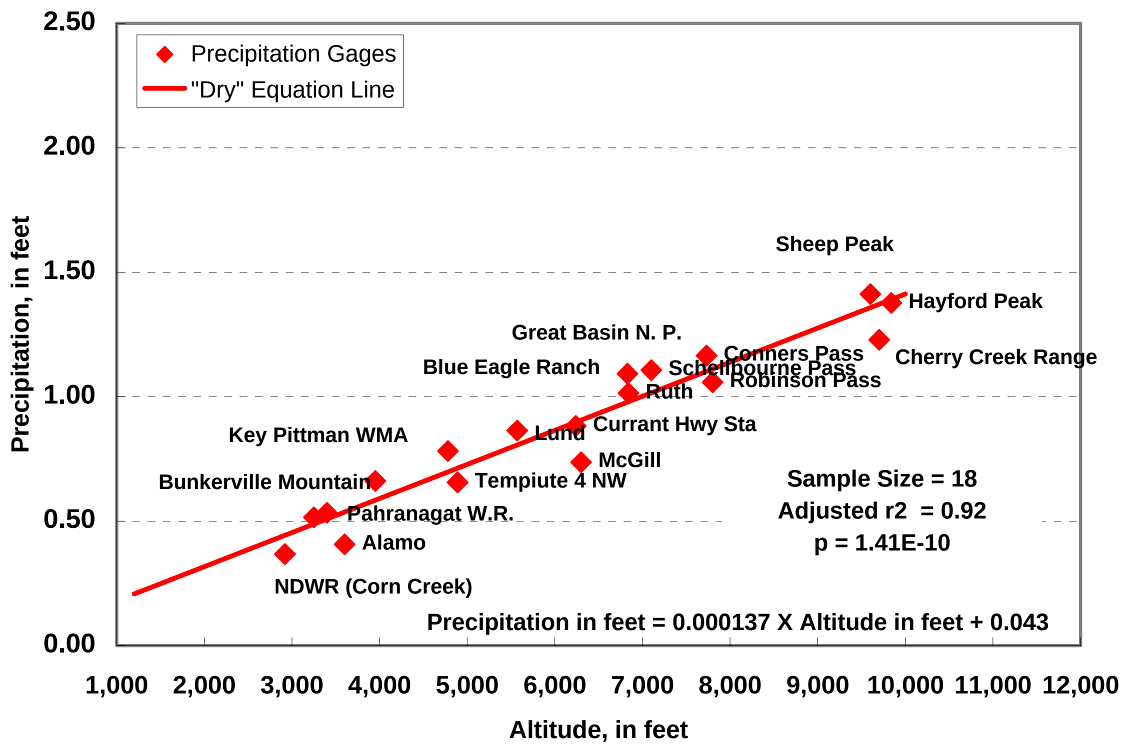


Figure 4-3. Data and regression of the "dry" group (Group 1).

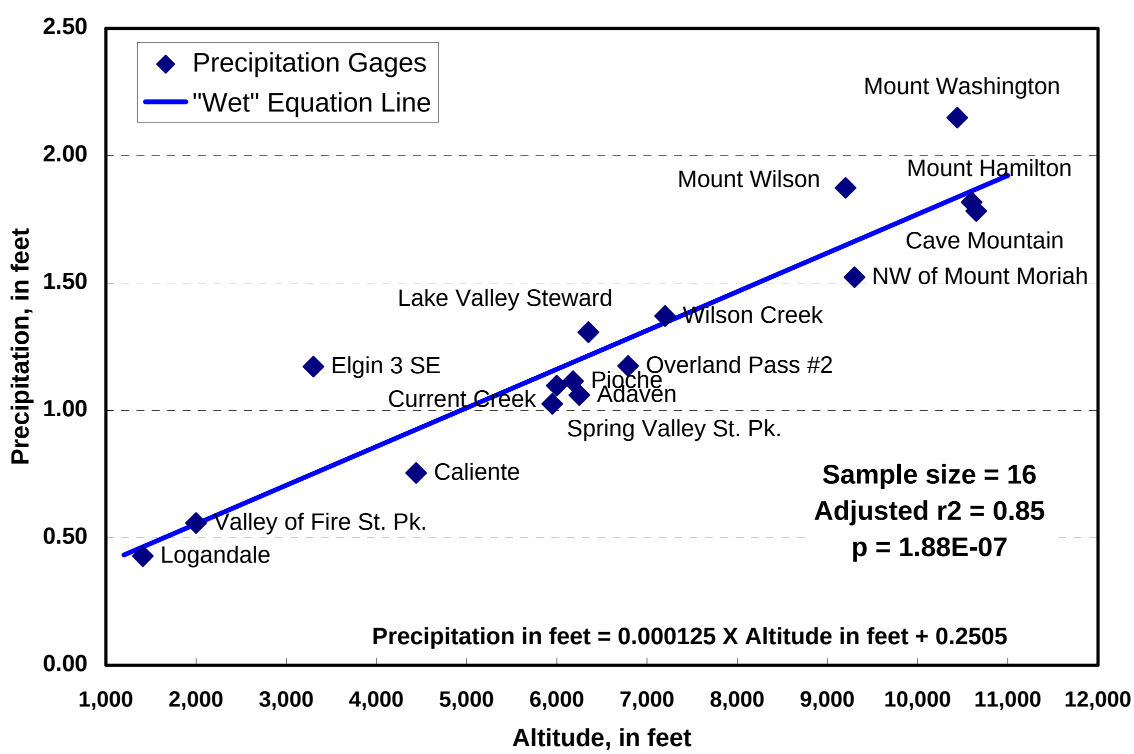


Figure 4-4. Data and regression of the "wet" group (Group2).

These regression analyses resulted in two roughly parallel equations with slopes that are slightly shallower (less steep) than the general altitude-precipitation relationship. The regression coefficient are somewhat improved (adjusted r^2 = 0.92 and 0.85) but generally not as good as observed in Las Vegas Valley (Donovan and Katzer, 2000).

It was also observed from plotting the data on **Figure 4-1** and **Figure 4-2** that stations in the northern White River Flow System were generally "dry" on the valley floors and "wet" in the mountain ranges. This implies the altitude-precipitation relationship is relatively steep in this area. It was also recognized that the highest ranges (from valley floor) in the study area are generally along the western margin of the study area and that the Quinn Canyon, Grant, and White Pine Ranges form a long continuous range.

The precipitation stations in and near the northern White River Flow System were then separated and regressed as a separate group. This part of the White River Flow System is dominated by White River Valley proper and therefore was called the "White River Valley" regression. This resulted in the fourth (altitude-precipitation) regression of this study, shown in **Figure 4-5**. Unlike the other regressions the intercept is negative. This was thought to be unimportant because the physical meaning of the intercept is the value of precipitation at 0 feet of altitude. No part of this study area is less than 1,200 feet of altitude and no part of the northern White River Flow System where this estimate was used is less than 5,000 feet of altitude.

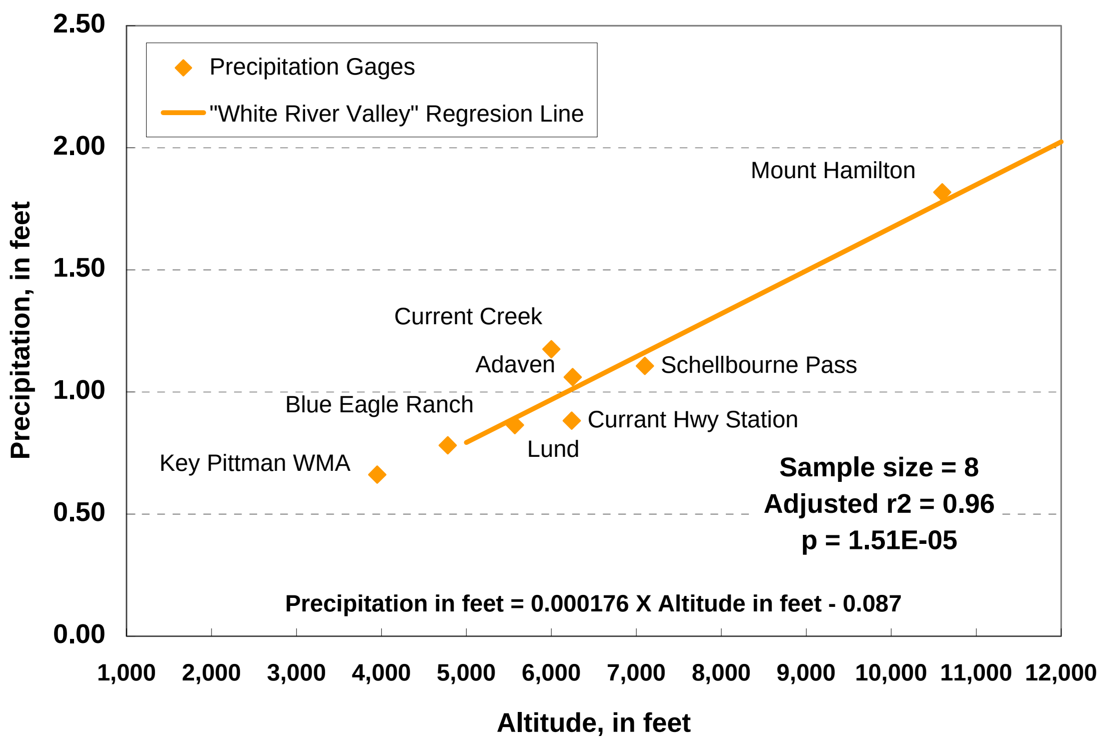


Figure 4-5. "White River Valley" precipitation data and regression.

Once the altitude-precipitation relationships were developed they were applied to various valleys within the study area. This was done to reduce the precipitation estimate of the entire study area and provide an appropriate altitude-precipitation relationship. The choice was determined by the locations of the various precipitation gages and physiography of the various valleys. This reduces the total estimate of precipitation in the study area by about 3 percent from 6,827,000 afy (general relationship, **Figure 4-2**.) to 6,636,000 afy, the sum of the precipitation based on all relationships.

The regression line as portrayed on **Figure 4-2** through **Figure 4-5** intentionally does not cover the entire altitude interval of the study area. The regression line portrays only the altitude intervals where the regression equation was applied. **Table 4-2** summarizes which of the various precipitation gages averages were used to create the various regression equations and then how the regression equations were applied. The predicted precipitation column is denoted to indicate which altitude-precipitation relationship was considered appropriate for the various sites ("general", "dry", "wet", "WRV"). **Figure 4-6** displays the spatial distribution of where the equations were applied. The hydrographic basin number (Valley Number) included in **Table 4-2** to minimize confusion caused by using valley names. There is precipitation data from two "Spring Valleys" in the precipitation analysis. One is the large valley (184) between the Schell Creek and Snake Ranges, the other (201) is located near Ursine.

Once the altitude-precipitation relationships were created through the four regressions, precipitation was estimated by multiplying the area of the 1,000-foot altitude intervals (in acres) in each valley by the predicted precipitation (in feet per year). This results in a estimated amount of precipitation in afy. The totals of the 1,000 foot altitude intervals are summed for in each valley and then for the total area. For any one 1,000-foot altitude interval, the rate of precipitation was calculated from one of the altitude-precipitation relationships. Only one altitude-precipitation relationship was used in each of the 27 valleys. **Table 4-3** summarizes the precipitation analysis for each valley. The full analysis is included in Appendix A

Although this precipitation analysis is characterized as a "modified Maxey-Eakin" the precipitation estimates cannot be directly compared to the precipitation estimates in the various basin reports. Commonly, precipitation was not estimated for areas that receive less than eight inches of precipitation and therefore the reported value reported may or may not be an estimate of the "total" precipitation in any one valley. Both total precipitation and the precipitation for the area that receives greater than eight inches of precipitation are listed in **Table 4-3**. All of the values reported in **Table 4-3** are rounded to the nearest 1,000 unless the estimated value is less than 1000.

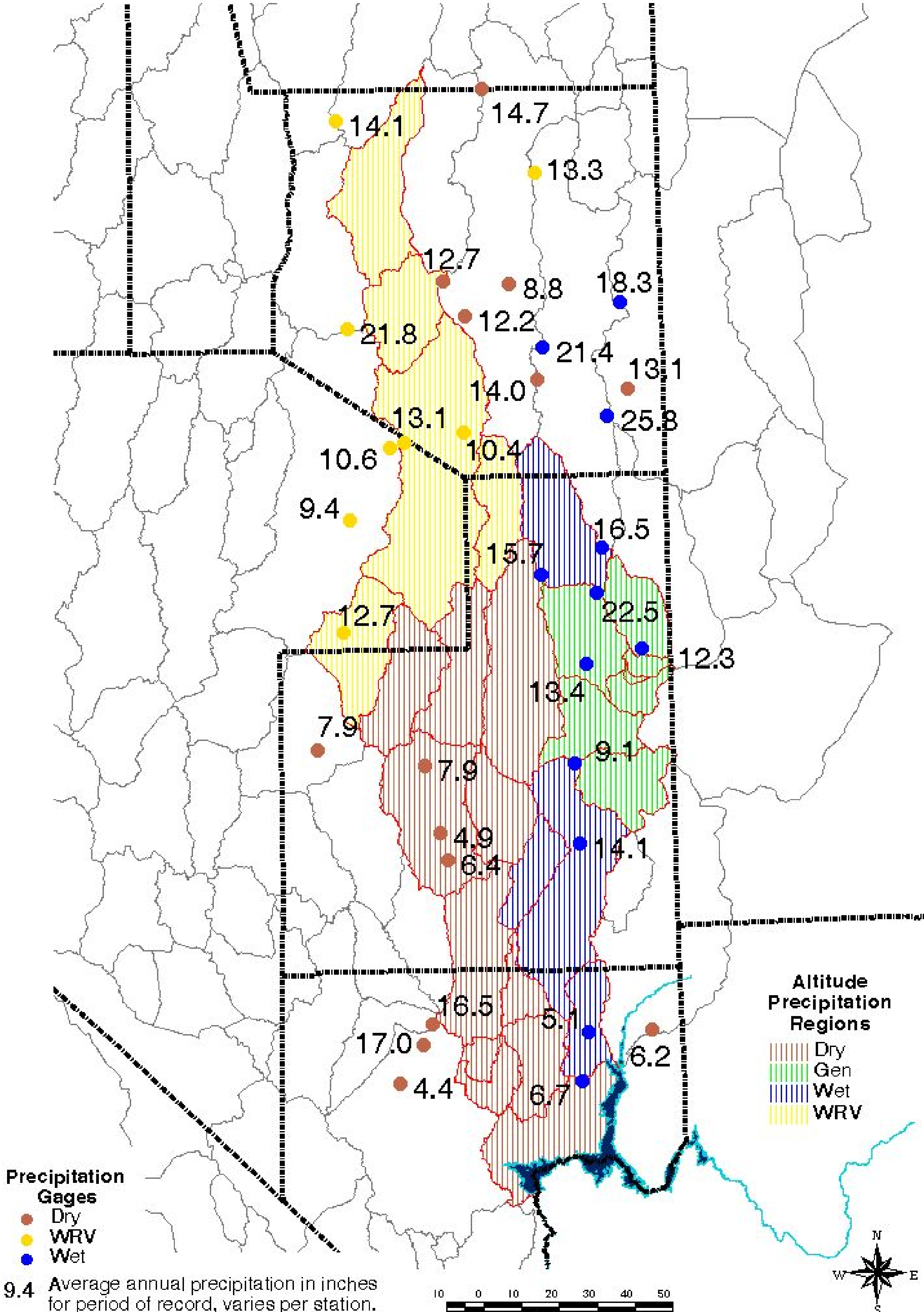


Figure 4-6. Distribution of local altitude - precipitation relationships and precipitation gage locations.

Table 4-2. Use of data and application of regression equations at precipitation gage sites.

Site No.	Valley No.	Valley Name	Grp.[1]	Use of data for regression	Application of regression	Site contained within study area	Actual Average Precip. (ft)	Predicted Precip. (ft)
1	212	Las Vegas	1	Dry	N/A	OUT	**0.43**	0.44[b]
2	223	Gold Butte	1	Dry	N/A	OUT	**0.56**	0.49[b]
3	209	Pahranagat	1	Dry	Dry	IN	**0.37**	0.51[b]
4	209	Pahranagat	1	Dry	Dry	IN	**0.52**	0.54[b]
5	209	Pahranagat	1	WRV	Dry	IN	**1.17**	0.58[b]
6	173B	Railroad	1	WRV	N/A	OUT	**0.41**	0.75[d]
7	170	Penoyer	1	Dry	N/A	OUT	**0.66**	0.71[b]
8	207	White R. V.	1	WRV	WRV	IN	**0.76**	0.89[d]
9	173B	Railroad	1	WRV	N/A	OUT	**0.78**	1.01[d]
10	179	Steptoe	1	Dry	N/A	OUT	**0.66**	0.91[b]
11	195	Snake	1	Dry	N/A	OUT	**0.86**	0.98[b]
12	179	Steptoe	1	Dry	N/A	OUT	**1.03**	0.98[b]
13	179	Steptoe	1	WRV	N/A	OUT	**1.12**	1.16[d]
14	179	Steptoe	1	Dry	N/A	OUT	**0.88**	1.10[b]
15	179	Steptoe	1	Dry	N/A	OUT	**1.06**	1.11[b]
16	212	Las Vegas	1	Dry	N/A	OUT	**0.74**	1.36[b]
17	178B	S. Butte V.	1	Dry	N/A	OUT	**1.31**	1.37[b]
18	210	Coyote	1	Dry	Dry	IN	**1.18**	1.39[b]
19	220	L. Moapa	2	Wet	Wet	IN	**1.09**	0.46[c]
20	215	Black Mtns.	2	Wet	Dry	IN	**1.01**	0.55[c]
21	205	L. MVW	2	Wet	Wet	IN	**1.11**	0.75[c]
22	203	Panaca	2	Wet	Gen	IN	**0.53**	0.76[a]
23	201	Spring V. (L)	2	Wet	Gen	IN	**1.37**	0.99[a]
24	202	Patterson	2	Wet	Gen	IN	**1.30**	1.03[a]
25	172	Garden	2	WRV	WRV	IN	**1.17**	1.01[d]
26	183	Lake	2	Wet	Wet	IN	**1.06**	1.22[c]
27	176	Ruby V..	2	WRV	WRV	OUT	**1.87**	1.11[d]
28	183	Lake.	2	Wet	Wet	IN	**1.52**	1.34[c]
29	207	White R. V.	2	WRV	WRV	IN	**1.10**	1.00[c]
30	183	Lake	2	Wet	Wet	IN	**1.23**	1.65[c]
31	184	Spring V.	2	Wet	N/A	OUT	**1.38**	1.66[c]
32	184	Spring V.	2	Wet	N/A	OUT	**2.15**	1.84[c]
33	154	Newark	2	WRV	N/A	OUT	**1.82**	1.78[d]
34	184	Spring V.	2	Wet	N/A	OUT	**1.78**	1.87[c]

[1] Grp. = Indicates in which group (1 or 2, "dry" or "wet") the site was initially included. All stations were used in the "general" regression.
[a] Indicates precipitation was estimated using the "general" altitude-precipitation relationship.
[b] Indicates precipitation was estimated using the "dry" altitude-precipitation relationship.
[c] Indicates precipitation was estimated using the "wet" altitude-precipitation relationship.
[d] Indicates precipitation was estimated using the "WRV" altitude-precipitation relationship.

Table 4-3. Summary table of precipitation analysis.

Hydro-graphic No.	Valley Name	Area (ac.)	Total Precipitation (af.)	Precipitation greater than 8 inches (af.)
175	Long Valley	417,000	460,000 [d]	460,000 [d]
174	Jakes Valley	271,000	312,000 [d]	312,000 [d]
207	White River Valley	1,017,000	1,032,000 [d]	1,032,000 [d]
172	Garden Valley	318,000	320,000 [d]	320,000
171	Coal Valley	290,000	234,000 [b]	201,000 [b]
180	Cave Valley	230,000	258,000 [d]	258,000 [d]
208	Pahroc Valley	325,000	260,000 [b]	219,000 [b]
181	Dry Lake Valley	574,000	455,000 [b]	343,000 [b]
182	Delamar Valley	232,000	176,000 [b]	108,000 [b]
209	Pahranagat Valley	497,000	344,000 [b]	139,000 [b]
206	Kane Springs Valley	150,000	140,000 [c]	139,000 [c]
210	Coyote Springs Valley	392,000	224,000 [b]	72,000 [b]
219	Muddy River Springs Area	93,000	38,000 [b]	200 [b]
220	Lower Moapa Valley	176,000	101,000 [c]	12,000 [c]
217	Hidden Valley	52,000	28,000 [b]	5,000 [b]
216	Garnet Valley	102,000	45,000 [b]	5,000 [b]
218	California Wash	206,000	76,000 [b]	15 [b]
183	Lake Valley	354,000	437,000 [c]	437,000 [c]
202	Patterson Valley	267,000	275,000 [a]	275,000 [a]
201	Spring Valley	185,000	212,000 [a]	212,000 [a]
200	Eagle Valley	34,000	37,000 [a]	37,000 [a]
199	Rose Valley	8,000	7,000 [a]	7,000 [a]
198	Dry Valley	76,000	77,000 [a]	77,000 [a]
204	Panaca Valley	232,000	224,000 [a]	224,000 [a]
203	Clover Valley	220,000	205,000 [a]	205,000 [a]
205	Lower Meadow Valley Wash	606,000	523,000 [c]	437,000 [c]
215	Black Mountains Area	409,000	132,000 [b]	200 [b]
Total		**7,734,000**	**6,636,000**	**5,540,000**

[a] *Indicates precipitation was estimated using the "general" altitude-precipitation relationship.*
[b] *Indicates precipitation was estimated using the "dry" altitude-precipitation relationship.*
[c] *Indicates precipitation was estimated using the "wet" altitude-precipitation relationship.*
[d] *Indicates precipitation was estimated using the "WRV" altitude-precipitation relationship.*

4.2.5 Discussion of Precipitation Analysis Related to Previous Studies

The strong conservativeness of the earlier precipitation estimates can be demonstrated by plotting the gage averages **(Figure 4-7)** on the NDWR 1971 precipitation map. The precipitation gage data from Caliente (9.1 inches, altitude 4,400 feet) in Panaca Valley, Key Pittman Wildlife Refuge (7.9 inches, altitude 3950 feet) in Pahranagat Valley and Elgin (14.1 inches, altitude 3,300 feet) in Lower Meadow Valley Wash all suggest the altitude of eight inches of precipitation is about 4,000 rather than 6,000 feet of altitude and is probably lower in Lower Meadow Valley Wash. In addition, the altitude-precipitation relationship is not as steep as

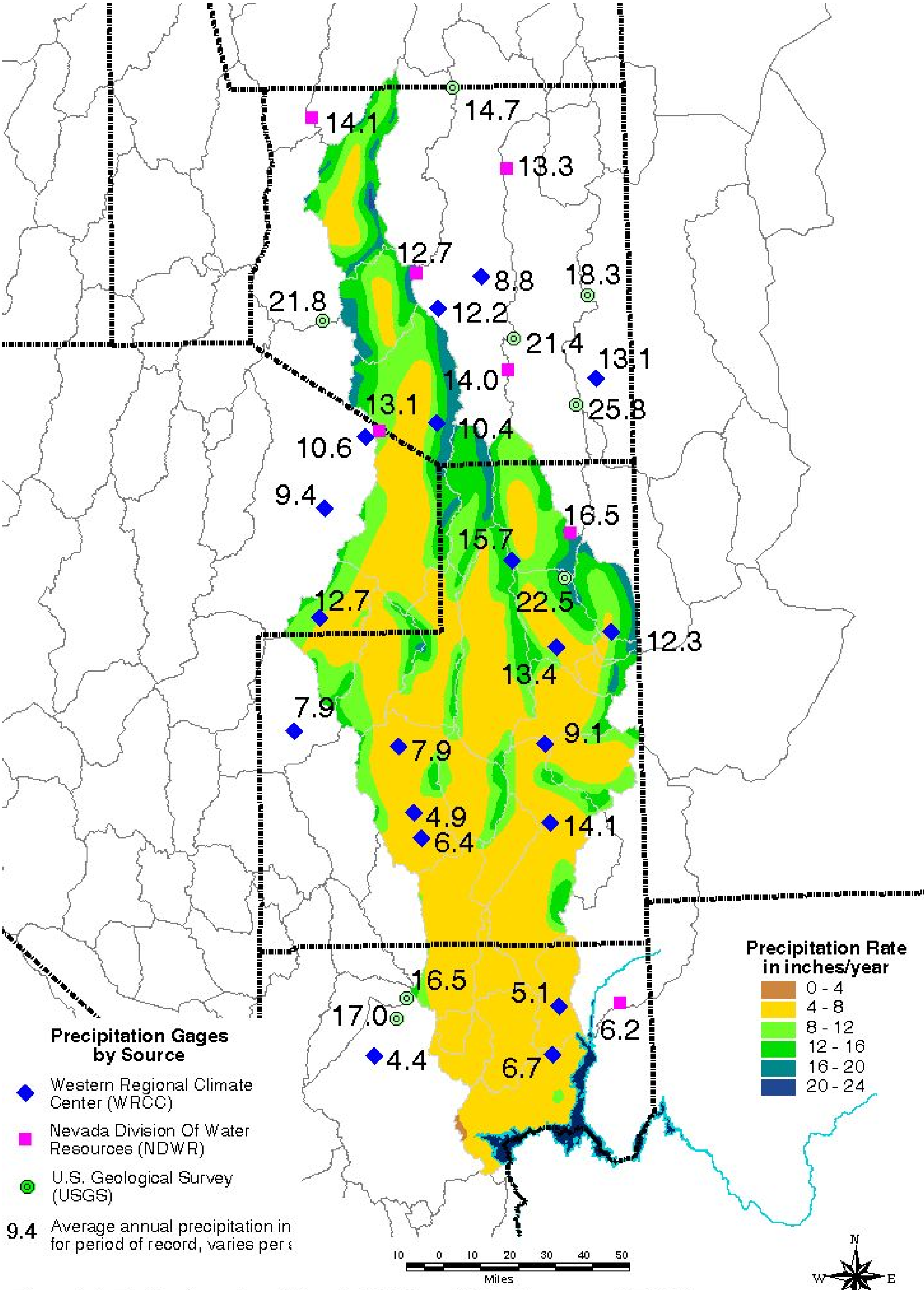


Figure 4-7 Digitized version of Nevada Division of Water Resources (NDWR) 1971 precipitation map with precipitation gages.

reported by Bixby and Hardman (1928) (4.5 inches per 1,000 feet of altitude rise) but rather approximately 1.8 inches per 1,000 feet **(Figure 4-2)** of altitude rise. This altitude-precipitation relationship also appears to apply over the entire range of altitude.

This is a very different conclusion than would be expected from the Hardman (1936, 1965) or NDWR (1971) precipitation maps. This implies all of the acreage above 6,000 feet of altitude (36 percent) and 5,000 feet (66 percent) and potentially all of the acreage above 4,000 feet (78 percent) may receive "effective" precipitation that at least partially becomes natural recharge.

This can also be demonstrated by comparing the composite altitude-precipitation relationships in the various precipitation maps with the actual precipitation data **(Figure 4-8)**. This is fairly simple when comparing the precipitation data with a Maxey-Eakin analysis (including the modified form used here), because the altitude-precipitation relationship used in a particular valley or region is clearly stated. When using a precipitation map this relationship can only be determined either by visual inspection (visually comparing the altitude intervals and precipitation intervals) or GIS analysis (combining two digital geographic data sets, then determining the numerical relationship between them, typically by weighted averages). The curves determined by GIS analysis of the two precipitation maps (NDWR 1971) and PRISM are presented on **Figure 4-8** for comparative purposes and were created using standard GIS processing techniques. The GIS technique was preferred over visual inspection because it is reproducible.

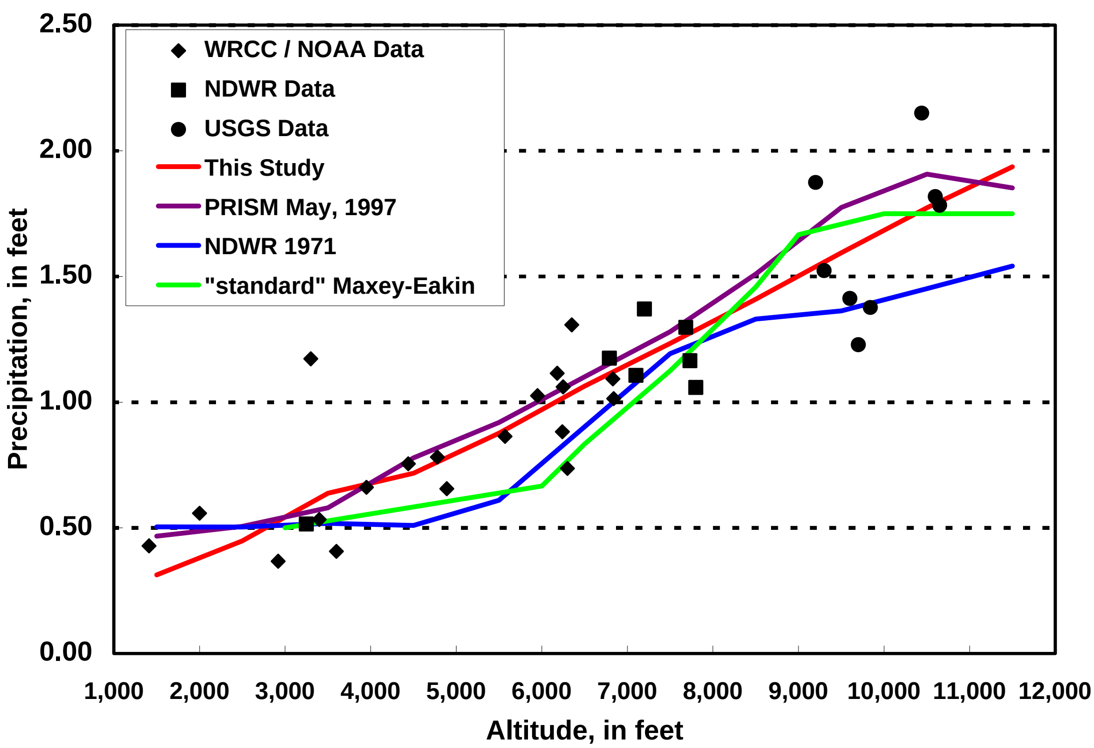


Figure 4-8. Composite altitude-precipitation relationships compared to gage data.

The line presented as "This study" is a weighted average line influenced by the relative size and altitude of the regions where the four altitude-precipitation relationships were used and was presented on this graphic for comparison with the other precipitation maps. This is a relatively straight line because the four altitude-precipitation relationships are similar. Four very different altitude-precipitation relationships would combine to create a very curved line. The four altitude-precipitation relationships were created simply to better characterize individual valleys within the study area; the four are local altitude-precipitation relationships that apply to specific valleys within the entire study area.

The distribution of precipitation presented in this study, although at variance with USGS and NDWR basin reports, is similar to the PRISM map. The PRISM precipitation distribution map, downloaded May 1997, has a similar but more generous distribution of precipitation. For the three precipitation maps, the total estimate of precipitation (~ 6,636,000 afy) in this study is significantly larger than the NDWR 1971 map (~ 5,516,000 afy) but smaller than the May 1997 version of PRISM (~ 6,985,000 afy).

Figure 4-9 is included for comparison with **Figure 4-7**. Precipitation was estimated by the modified Maxey-Eakin technique pioneered by Donovan and Katzer (2000) in Las Vegas Valley. In this technique, precipitation was estimated using 1,000-foot altitude interval tables and therefore a precipitation map was not required. The map is included here only for comparative purposes.

In Donovan and Katzer's (2000) precipitation estimation technique the altitude-precipitation relationship is determined by regression of the available precipitation data. This altitude-precipitation relationship is then applied to summary tables of 1,000-foot altitude intervals. Both the use of 1,000 foot intervals and the fact that the amount of precipitation is estimated from altitude intervals are features of the Maxey-Eakin technique as summarized by Eakin (1966, p. 260-262). Because of the similarities in the manner in which precipitation and natural recharge is estimated, Donovan and Katzer's (2000) method is characterized as a "modified Maxey-Eakin" rather than a new technique.

4.3 GROUND-WATER MOVEMENT

Ground-water in the study area flows from areas of high head in the upper altitudes of the basins to areas of lower head (lower altitude) in response to gravity. There is a change in altitude from the northern edge of the study area in Long Valley (Valley floor ~ 6,100 feet altitude) to the Colorado River (downstream from Hoover Dam ~ 600 feet altitude) of about 5,500 feet. Several of the mountain blocks have peaks that add an additional 4000-5,000 feet to this head change.

Ground water movement from areas of higher head, such as recharge areas, is toward the carbonate aquifer systems that underlie the entire Colorado River Basin Province of Nevada. Most of the valley fill aquifer systems are directly on top of the carbonate aquifer system and the movement of ground water is upwards from the carbonate aquifer to the alluvial aquifers. There are numerous valleys where these two aquifer systems are separated by a sequence of volcanic rocks, such as is in Dry Lake, Delamar, and Pahranagat Valleys. There is undoubtedly ground-water movement upward from the carbonate rocks through the overlying volcanic rocks to the

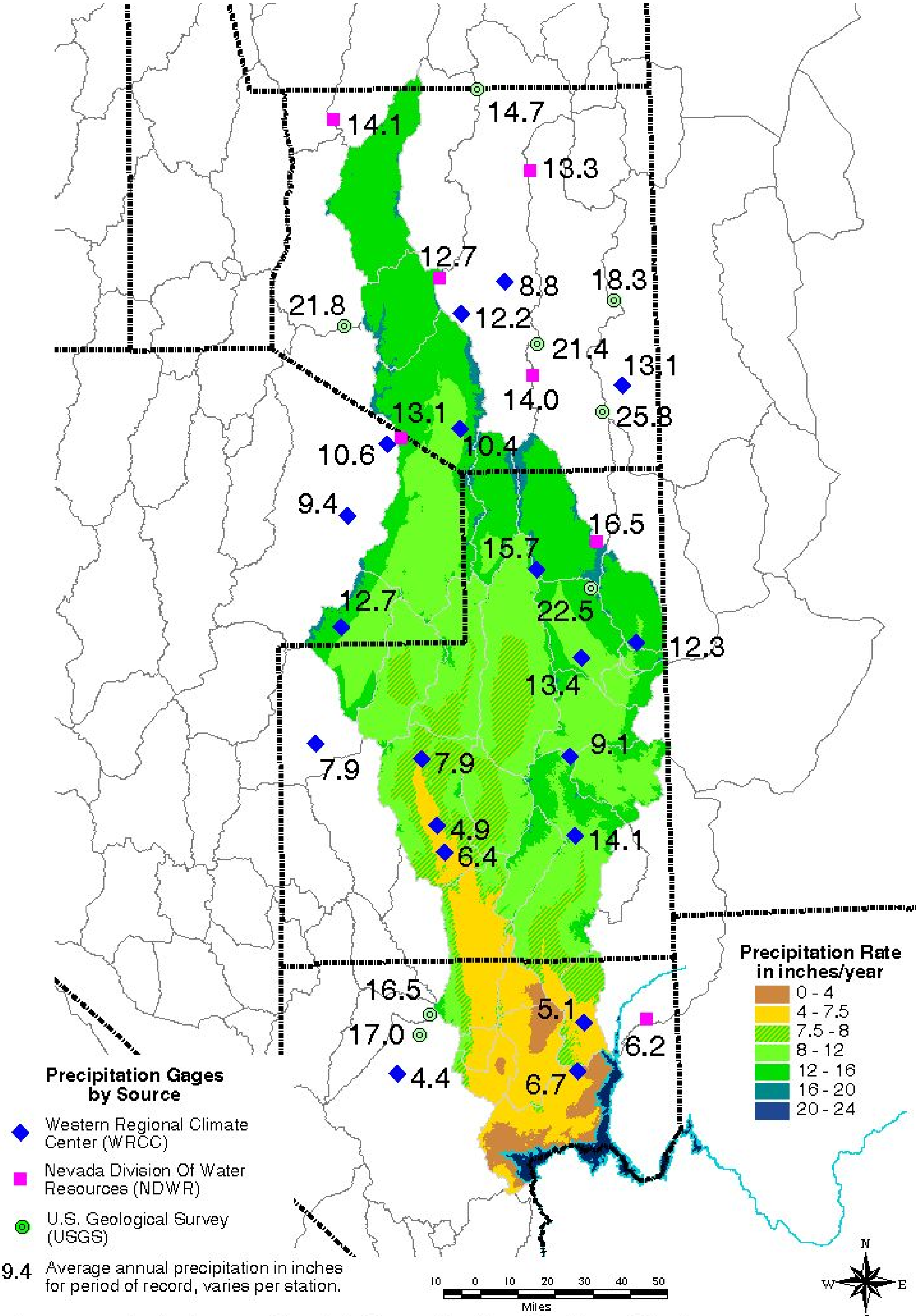


Figure 4-9. Distribution map of precipitation used in this study with precipitation gages.

alluvial aquifer systems. Ground water also moves down through the volcanic rocks, in the recharge areas to the alluvial aquifer with lateral downgradient flow. There is ground-water movement from recharge areas at low altitude, such as in alluvial fans, directly down to the alluvial aquifer system and perhaps in some cases there may be flow from the alluvial aquifer through the volcanic rocks to the carbonate aquifer. There also may be flow from one basin to another through the connecting alluvial aquifer system such as in Dry Lake and Delamar Valleys. There is ground-water flow in the carbonate aquifer from the northern end of the system to the southern end, specifically from the carbonates underlying Long Valley to the carbonate rocks underlying Lake Mead and the Colorado River. The same holds true for the carbonates underlying Lake Valley at the north end of the Meadow Valley Flow System, for these carbonate rocks are also connected to the same carbonates underlying Lake Mead and the Colorado River. Even though this ground water system is extremely complex with ground-water mounding, degrees of permeability, varying lithologies, and structural complexities, there is most probably some degree of hydraulic connectivity throughout the study area.

4.3.1 White River Ground-Water Flow System

Ground water begins its circuitous path in the mountains and alluvial slopes of Long Valley exiting the valley in the underlying carbonate rocks to Jakes Valley. Local recharge in Jakes Valley from the Eagan and White Pine Ranges joins the outflow from Long Valley and moves south into White River Valley. Large springs in White River Valley discharge a significant amount of water from the underlying carbonate rocks. Recharge to the basin's alluvial ground-water system is from spring discharge from local recharge and from the underlying carbonate aquifer. There is also a component of local recharge in some of the springs, but most of the local recharge from the surrounding mountain blocks becomes part of the regional flow in the underlying carbonate aquifer.

Cave Valley, immediately east of White River Valley, contributes ground water to either the south end of White River Valley in the vicinity of the Shingle Pass fault zone or to the north end of Pahroc Valley. The width of the flow section in northern Pahroc Valley stretches from the Quinn Canyon Range on the west (including Garden and Coal Valleys) to the Bristol Range on the east (including Cave, Dry Lake, and Delamar Valleys). It is uncertain where the ground-water recharge from Garden and Coal Valleys actually joins the regional carbonate aquifer, but the ground water from both valleys may move east and south along a series of north trending faults until finally moving into the regional carbonate aquifer underlying Pahranagat Valley. East of Pahranagat Valley ground-water recharge from Dry Lake and Delamar Valleys is probably moving mostly to the south with some westerly component. The recharge from these two valleys originates mostly in the carbonates of the Bristol-Highland Range and the volcanic rocks of the Delamar Mountains.

Ground-water flow out of Delamar Mountains into Kane Springs Valley and Coyote Spring Valley must move through the Caliente caldera complex, an assemblage of tuffaceous and basaltic rocks. These rocks have undergone extensive structural deformation that allows ground water to flow through the caldera complex along numerous north trending fault structures. It is these same faults that breach the Pahranagat Valley shear zone, a northeast structure that cuts through the south end of Pahranagat Valley. The ground-water gradient across this shear zone was first defined by Eakin (1966, Figure 5) who attributed the steep gradient (based on sparse data) to a barrier effect caused by structure. We suggest the steep gradient is caused by an increase in permeabilities in the volcanic rock across this fault zone as the flow moves downward and southward into the underlying carbonate rocks in Coyote Spring Valley. Conversely there may not be a gradient and the water is simply perched above the regional carbonate flow system. Winograd and Friedman (1972) thought the barrier described by Eakin (1966) deflected about 6,000 acre-feet/year of regional ground water from the White River Flow System to the west toward the Amargosa Desert (not shown on **Figure 1-1**). According to Jim Thomas (DRI, oral commun.,2001) ground water in the carbonate rocks west of this theoretical barrier does not need the geochemical imprint from the White River Flow System to be explained, because local recharge, for instance from the Spring Mountains, has the same geochemical signature. Thus, the evidence is inconclusive and we have chosen to construct our ground-water model so ground water does not leave the White River ground-water system in this area.

The exact nature of the ground water flowing south in the carbonate rocks in Coyote Spring Valley is unknown, but in the northern part of the valley it probably moves differentially across a broad front. This front extends from the top of a ground-water mound in the Sheep Range bounding the valley on the west, through the Meadow Valley Mountains, to a similar ground-water mound under the Morman Mountains. White River ground water in the northern part of Coyote Spring Valley is moving mostly south and not mixing significantly with Meadow Valley Wash water, but it is connected hydraulically. The range front fault on the east side of the Sheep Range is highly permeable and is a major conduit for the southward moving ground water. Additional preferential flow is thought to occur along the range front fault on the west side of the Meadow Valley Mountains including the course of Pahranagat Wash. Groundwater from the valley moves as fracture flow to the east-southeast along the general course of Pahranagat Wash through Arrow Canyon to discharge at the Muddy Springs. According to Thomas et al. (2001) the temperature of the ground water in MX wells 4 and 5 is nearly the same, (30^o and 31^o C) and compares favorably with the Muddy Springs water temperature at 32.1^oC ; these elevated temperatures indicate vertical flow paths of several thousand feet. The remainder of the ground water exiting Coyote Spring Valley continues to the south and is somewhat split by the Arrow Canyon Range causing some flow into Hidden and Garnet Valleys with the remainder into California Wash. Some ground water in Coyote Spring Valley moves along the range front fault on the east side of the Sheep and Las Vegas Ranges and flows into Hidden Valley and on into Garnet Valley. The southern edge of Garnet Valley is bounded, in part, by a thick section of Muddy Creek Formation sediments that are thought to have low permeabilities. Additionally, the Dry Lake thrust, and further to the northeast the Glendale thrust, appear to act as partial barriers to, not only White River ground-water flow, but also Meadow Valley ground-water flow, because ground-water levels are fairly uniform on the north side of these thrust systems over a large area, about a 15-20 mile radius from the Muddy Springs. Thus the southern end of these two ground-water flow systems merge into one large system with a very flat gradient to the east-southeast. Even though these fault structures act as barriers to ground-water flow, permeabilities across the fault zones are sufficient to allow a flow of about 36,000 afy to leave the area.

A greater part of ground-water flows from Garnet and Coyote Spring Valleys flows to California Wash with a minor amount moving to the south through the Dry Lake thrust to Black Mountain

Basin. According to Thomas et al., (2001) the spring discharge and phreatophyte ET (~ 2,000 acre-feet/year) at Rogers and Blue Point Springs on the eastern edge of Black Mountain Basin is made up of about 1/3 local recharge with the remainder coming from the White River Flow System. It is also possible that the discharge at these springs is from the Meadow Valley Flow System. If there is additional flow from Black Mountain Basin greater than spring flow and ET, it undoubtedly discharges from the carbonate rocks underlying Lake Mead and the Colorado River. The remainder of the ground water in California Wash probably discharges to the Muddy River up gradient from the Glendale thrust complex with some amount moving through the complex to discharge from the carbonate rocks beneath Lake Mead and the Colorado River.

4.3.2 Meadow Valley Ground-Water Flow System

The Meadow Valley Flow System is very similar to the White River Flow System with numerous valleys linked together by the carbonate rock aquifer and a ground-water gradient to the south. This flow system also discharges in part to the Muddy River in Lower Moapa Valley with the remainder of the flow discharging from the lower carbonate aquifer beneath Lake Mead and the Colorado River.

Lake Valley is the most northern valley in this flow system and ground-water recharge from the Fairview, Fortification and the Wilson Creek Ranges provides most of the ground-water outflow from this valley. As this flow moves south to Patterson Valley it increases in volume from recharge in the southern part of the Fairview Range, the Bristol Range and the southwest part of the Wilson Creek Range. This ground-water flow is separated by topographic divides from valleys to the east, (Spring, Eagle, Rose, and Dry), but is undoubtedly connected hydraulically with them. Flow patterns in these eastern valleys are complicated by several thousand feet of volcanic rocks that overlie the carbonate rock aquifer. Nevertheless, some amount of ground-water recharge occurs in the volcanic rocks and ultimately reaches the underlying carbonate rocks. Because volcanic rocks have considerably less permeability than carbonate rocks some of the potential recharge does not reach the deeper ground-water system, but ends up as surface flow in Meadow Valley Wash

Panaca Valley receives a mixture of ground-water flow from up-gradient areas; carbonate water from Lake and Patterson Valleys and water from volcanic rocks in Spring, Rose, Eagle, and Dry Valleys. There is a significant amount of local recharge in Panaca Valley, mostly from the Highland Range (carbonate rock) to the west and the Clover Mountains (volcanic rock) to the east. All of this flow is tributary to Lower Meadow Valley Wash and the ground-water outflow from Clover Valley.

Ground-water flow in Lower Meadow Valley Wash moves to the south and is in hydraulic connection with ground water from the White River Flow System in the volcanic rocks of the Caliente caldera near Kane Springs Valley. Ground-water flow from Lower Meadow Valley Wash ultimately discharges at great depth from the volcanic rocks to the carbonate rocks and near the southern boundary of the valley is constrained by the northeast end of the Glendale thrust. This thrust, as discussed previously, is in part responsible for the pooling effect defined by wells in the carbonate rocks that have nearly the same water-level in a 15-20 mile radius centered on the Muddy Springs. This reduction in permeability at the fault zone is in part caused by the lower permeabilities of the Mesozoic clastic rocks. However, ground-water flow across and through this thrust does take place along zones of structural weakness and in the fractured carbonate rocks of Paleozoic age and probably to a lessor extent in some of the Mesozoic rocks.

Ground-water outflow from both flow systems is toward the southeast. Some of the outflow surfaces in the Muddy River in Lower Moapa Valley, but most of the flow discharges probably into several fault structures that define the present trace of the Colorado River or to undefined areas to the south.

4.4 GROUND-WATER RECHARGE

Ground-water recharge to the various aquifer systems within the CRBP in the study area starts as precipitation on the recharge areas. Precipitation in the form of snow is probably the most important source of recharge, but winter rain and summer convection storms also add appreciable volumes of water to the general area. Ground-water recharge processes have not been fully defined and there are significant differences in the amount of recharge in the various geologic terrain dependent on rock types and the degree of permeability. Rocks with greater permeability, such as carbonates, have greater amounts of recharge than other types of rocks within the study area. Although we recognize the actual recharge rate is strongly affected by rock type and other factors, the method used to estimate natural recharge in this study, Maxey-Eakin, has been used for over half a century, all over Nevada, in a wide variety of geologic terrains and climatic settings.

4.4.1 Development of Natural Recharge Estimates from Altitude-Precipitation Relationships

Natural recharge for the basins in this study were estimated from precipitation by a technique pioneered in Las Vegas Valley (Donovan and Katzer, 2000). It is conceptually similar to, and borrows heavily from, the Maxey-Eakin technique (Maxey and Eakin, 1949) and is characterized in the report as a "modified Maxey-Eakin". The primary variation between the two techniques is the relationship between altitude and precipitation. Nichols (2000) has also pioneered a new technique for estimating natural recharge but his technique varies significantly from the Maxey-Eakin technique in both the manner in which precipitation and the assumed recharge efficiency (recharge coefficients) are estimated. Nichols' (2000) technique is specifically for use with a modified version of the May 1997 Parameter-elevation Regressions on Independent Slopes Model (PRISM) map by Daly and others (1994) of the Oregon Climatic Service.

The "standard" Maxey-Eakin technique as summarized by Eakin (1966, p. 260-262) has been in use for over a half century and has probably been applied to every valley in Nevada although the estimate may not have been published. When the U.S. Geological Survey (USGS) and the Nevada Division of Water Resources (NDWR) estimated most of the basin budgets, either the standard or variants of the Maxey-Eakin technique were used. Avon and Durbin (1994, p.102) reported investigators deviated from the standard form of the method about 37 percent of the time.

In the "standard" Maxey-Eakin technique the acreage of an individual valley was divided into five altitude intervals listed below in **Table 4-4** (Eakin, 1966, Table 2):

Table 4-4. "Standard" Maxey-Eakin assumptions.

Precipitation Zone (in.)	Altitude Zone (ft.)	Average Annual Precipitation (ft.)	Recharge Efficiency (%)
< 8	< 6,000	Variable	Negligible
8 to 12	6,000 to 7,000	0.83	3
12 to 15	7,000 to 8,000	1.12	7
15 to 20	8,000 to 9,000	1.46	15
> 20	> 9,000	1.75	25

The acreage of the altitude intervals was multiplied by the average precipitation in feet, then multiplied by the recharge efficiency (the percentage of precipitation that becomes natural recharge), then summed to estimate the natural recharge as shown in **Table 4-5**. Typical variation of the technique was modification of the altitude intervals. Implicit in the technique, is that the recharge efficiency is a function of precipitation rather than altitude and at least two precipitation maps Hardman (1936 and 1965) were used in the USGS and NDWR basin reports.

The acreage of the valleys as reported in this study are within 3 percent of the acreage as reported in the various basin reports with exception of Coyote Spring and Muddy Springs Valleys. These small differences are mostly related to round-off, digitizing errors, and map scales. The major increase (~ 25 percent) in Muddy Springs Valley is due to the inclusion of Wildcat Wash which was historically included in Coyote Spring Valley on USGS hydrographic basin maps.

In the modified Maxey-Eakin technique (Donovan and Katzer, 2000), the available precipitation data is selected based on quality (length of record, percentage of record completeness). The data are separated into geographic regions, and processed through regression analysis to determine the local altitude-precipitation relationships. The development of the four local altitude-precipitation relationships, ("general", "dry", "wet", and "WRV") used in this study was described and presented in the Precipitation (4.2) section.

Donovan and Katzer (2000) introduced a slight variation in calculating the Maxey-Eakin natural recharge efficiency coefficients. The coefficients are calculated directly from the precipitation rate using the equation $r_e = 0.05\,(P)^{2.75}$ where r_e is the natural recharge efficiency coefficient and P is equal to precipitation rate in feet per year. The only purpose of this equation was to minimize calculation errors and the time required to calculate the estimate of natural recharge. The assumptions of mathematical approximation used by Donovan and Katzer (2000) were the same as Maxey-Eakin; Precipitation falling on areas that receive less than 8 inches is considered ineffective for producing ground-water recharge, the maximum recharge efficiency (25 percent) occurs at 20 inches and the recharge efficiency of the intervening intervals are the same. Donovan and Katzer (2000, p. 1142) reported that the mathematical approximation of the Maxey-Eakin efficiency coefficients reduced the natural recharge estimate by 3 percent when compared to the traditional methodology.

Table 4-5. Comparison of this study to previous Maxey-Eakin (1949) natural recharge estimates.

<table>
<tr><th rowspan="2">Valley</th><th rowspan="2">Acres</th><th colspan="2">Volume of Precipitation (afy)</th><th colspan="2">Ground-water Recharge (afy)</th></tr>
<tr><th>Maxey-Eakin[1]</th><th>This Study</th><th>Maxey-Eakin</th><th>This Study</th></tr>
<tr><td>Long Valley</td><td>416,966</td><td>296,940</td><td>459,937</td><td>10,300</td><td>31,112</td></tr>
<tr><td>Jakes Valley</td><td>271,493</td><td>NR</td><td>312,462</td><td>13,000</td><td>24,194</td></tr>
<tr><td>White River Valley</td><td>1,016,871</td><td>NR</td><td>1,032,143</td><td>40,000</td><td>62,133</td></tr>
<tr><td>Garden Valley</td><td>318,055</td><td>137,080</td><td>320,039</td><td>10,000</td><td>19,153</td></tr>
<tr><td>Coal Valley</td><td>289,998</td><td>62,038</td><td>234,361</td><td>2,000</td><td>7,002</td></tr>
<tr><td>Cave Valley</td><td>229,755</td><td>206,495</td><td>258,445</td><td>14,000</td><td>19,595</td></tr>
<tr><td>Pahroc Valley</td><td>325,289</td><td>56,764</td><td>260,197</td><td>2,200</td><td>7,545</td></tr>
<tr><td>Dry Lake Valley</td><td>574,417</td><td>117,562</td><td>454,998</td><td>5,000</td><td>13,254</td></tr>
<tr><td>Delamar Valley</td><td>231,582</td><td>33,530</td><td>176,189</td><td>1,000</td><td>4,597</td></tr>
<tr><td>Pahranagat Valley</td><td>497,312</td><td>42,640</td><td>344,195</td><td>1,800</td><td>7,407</td></tr>
<tr><td>Kane Springs Valley</td><td>150,429</td><td rowspan="2">48,878</td><td>140,218</td><td rowspan="2">2,600</td><td>6,757</td></tr>
<tr><td>Coyote Spring Valley</td><td>391,621</td><td>224,278</td><td>4,000</td></tr>
<tr><td>Muddy River Springs Area</td><td>92,541</td><td>NR</td><td>38,380</td><td>Minor</td><td>237</td></tr>
<tr><td>Lower Moapa Valley</td><td>175,656</td><td>1,160</td><td>101,358</td><td>50</td><td>1,354</td></tr>
<tr><td>Hidden Valley</td><td>52,435</td><td>11,400</td><td>27,512</td><td>400</td><td>339</td></tr>
<tr><td>Garnet Valley</td><td>101,981</td><td>10,600</td><td>45,268</td><td>400</td><td>393</td></tr>
<tr><td>California Wash</td><td>205,550</td><td>2,000</td><td>75,608</td><td>100</td><td>311</td></tr>
<tr><td>Lake Valley</td><td>354,246</td><td>228,930</td><td>437,170</td><td>13,000</td><td>41,320</td></tr>
<tr><td>Patterson Valley</td><td>267,430</td><td>136,860</td><td>275,015</td><td>6,000</td><td>15,761</td></tr>
<tr><td>Spring Valley</td><td>184,945</td><td>176,600</td><td>212,364</td><td>10,000</td><td>16,151</td></tr>
<tr><td>Eagle Valley</td><td>34,458</td><td rowspan="6">197,810</td><td>36,927</td><td rowspan="6">8,000</td><td>2,349</td></tr>
<tr><td>Rose Valley</td><td>7,647</td><td>7,349</td><td>352</td></tr>
<tr><td>Dry Valley</td><td>76,339</td><td>77,388</td><td>4,237</td></tr>
<tr><td>Panaca Valley</td><td>220,435</td><td>204,587</td><td>9,041</td></tr>
<tr><td>Clover Valley</td><td>231,964</td><td>223,852</td><td>10,557</td></tr>
<tr><td>Lower Meadow Valley Wash</td><td>605,723</td><td>523,247</td><td>22,823</td></tr>
<tr><td>Black Mountains Area</td><td>408,919</td><td>132,254</td><td>132,254</td><td>100</td><td>438</td></tr>
<tr><td>Total</td><td>7,734,059</td><td>1,899,541</td><td>6,635,742</td><td>147,950</td><td>332,413</td></tr>
</table>

[1] *Only represents precipitation greater than 8 inches.*

In estimating the precipitation for this study, the standard assumption that precipitation less than 8 inches is "ineffective" had no impact on the estimation of natural recharge in valleys where the "general" and "WRV" local altitude-precipitation relationship was used. These are generally high northern valleys with minimal or no acreage below 5,000 feet. All of the local altitude-precipitation relationships predict, and the available gage suggests, that all of the acreage above 5,000 feet of altitude in the study area receive greater than 8 inches of precipitation. This assumption also had no effect on the only northern valley (Lake) where precipitation was estimated using the "wet" local altitude-precipitation relationship.

It was observed, however, (**Figure 4-9**) that, in valleys where the "wet" local altitude-precipitation equation was used to estimate precipitation the interval between 3,000 and 4,000 feet of elevation is about 7.6 inches. It was also noted that, in valleys where the "dry" local altitude-precipitation equation was used to estimate precipitation the interval between 4,000 and 5,000 feet of elevation is about 7.9 inches.

These transitional altitude intervals are a significant amount of acreage in the valleys in the central and southern parts of the study area. If the standard Maxey-Eakin assumptions are used, the precipitation in these intervals could either be considered "ineffective" (none of the precipitation in these areas becomes natural recharge), or partially effective (part of the precipitation could have been included in the recharge estimate). Another possibility exists however.

When Pohlmann and others (1998) analyzed the springs in the Lake Mead area, using stable and radio isotopes they concluded that the recharge sources of one-third of springs are "local" and low altitude. The area described in Pohlmann and others (1998) is the southernmost valley (Black Mountains Area) of this current study area **(Figure 4-1)**. Most of the area is at low altitude (< 3,000 feet) and the highest peak, Muddy Peak, is at an altitude of 5,363 feet. The use of the term "local" introduces the idea that precipitation below 8 inches may be "effective" although the recharge efficiency is very low (less than a percent). Eakin's (1966, p. 260-262) summary of the Maxey-Eakin method characterizes recharge in areas that receive less than 8 inches of precipitation as "negligible" rather than "none".

The Maxey-Eakin technique, as originally developed, is a step function designed for use with paper maps, planimeters, and adding machines. As long as the precipitation is reported by the same irregular intervals (8, 12, 15 and 20 inches of precipitation) of the traditional method no confusion exists as to the appropriate recharge efficiency coefficients. If an alternative precipitation map with either regular intervals (NDWR, 1971), other irregular intervals (some variations of the PRISM map), or in units other than feet and inches (meters, centimeters, millimeters) questions arise about the appropriate recharge efficiency coefficients to use near the break points. Because the Donovan and Katzer's (2000) mathematical approximation of the Maxey-Eakin efficiencies is a continuous function it can easily be used in conjunction with non-traditional precipitation maps and estimates.

Donovan and Katzer (2000) examined the potential use of the equation to estimate the natural recharge efficiency directly from the precipitation estimate of a given altitude interval ($r_e = 0.05 (P)^{2.75}$) for estimating the recharge efficiency coefficients for areas that receive less than 8 inches of precipitation. The increase in the Las Vegas Valley natural recharge estimate would have been about 5 percent.

Because of the large size of the transitional altitude areas in this current study, the same logic was applied. The increase in the natural recharge estimate in the whole area is about 3.5 percent from about 321,000 afy to 332,000 afy. As mentioned previously, modification of the assumption that precipitation of less than 8 inches is "ineffective" has no effect on the recharge estimate of the high altitude northern valleys and a minor increase (5 percent) in the Lower Meadow Valley natural recharge estimate. The largest percentage increases are in the 5 small valleys (including the Black Mountains Area) where recharge is estimated to be less than 500 afy and the one valley

(Lower Moapa) where the recharge is estimated to be about 1,400 afy. In the center of the study area where there are large areas of the transitional altitude zones, the natural recharge estimate for the valleys increased by about 20 percent. The 20 percent increase in the natural recharge estimate was assumed to be similar to the increase that would have occurred if the altitude intervals were adjusted, as was done on many Maxey-Eakin analysis, to include part of the acreage (the part of the area that receives greater than 8 inches) of the transitional altitude intervals.

Table 4-6 summarizes the natural recharge estimates used in this study. The complete analysis is included in Appendix A. Note: The recharge within the modeled area is reported as 37,000 afy because it is rounded off to the nearest 1,000 afy. The actual estimated natural recharge within the modeled area is 36,652 afy, which was rounded to 37,000 afy in the ground water model.

Although this approach is a partial modification of the Maxey-Eakin assumptions, there are several advantages. One advantage is that the distribution of the Maxey-Eakin natural recharge efficiency coefficients for precipitation greater than 8 inches is preserved within Donovan and Katzer (2000) mathematical approximation. The Maxey-Eakin technique and the USGS and NDWR basin reports have well served the citizens of Nevada, for over half a century by consistent use of a simple, easy to understand, natural recharge estimation technique with a reasonable distribution of the relationship between precipitation and natural recharge coefficients. Another advantage of the approach used in this study is consistency, because a uniform methodology is applied to all of the precipitation that is estimated to fall on any valley. Two natural recharge analyses using two radically different precipitation maps can be compared directly on the influence of the precipitation estimate alone rather than on a combination of the precipitation distribution and the technique used to estimate natural recharge. The Hardman precipitation maps (1936, 1965) are no longer the only estimates of precipitation distributions available. Since the early 1990s, PRISM through it's widespread availability on the Internet, support by, and linked to, websites of important sources of climatic information like Desert Research Institute's Western Regional Climate Center (WRCC) (http://www.wrcc.dri.edu/precip.html), and The U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS, formerly Soil Conservation Service, SCS) (http://www.ftw.nrcs.usda.gov/prism/prism.htmldistribution), is the most commonly used precipitation distribution map.

There are also disadvantages to the approach used to estimate natural recharge in this study. The approached used is a modified Maxey-Eakin therefore the advantages of the method are the advantages of the Maxey-Eakin (consistency, ease of use) and the disadvantages are the same as those of the Maxey-Eakin. Although the relationship between precipitation and natural recharge is reasonable, it is an assumption (non-unique), since the natural recharge estimate is strongly dependent on the precipitation estimate. The relationship between natural recharge and mountain front runoff is not intuitive. No factor that actually determines what portion of precipitation becomes natural recharge is actually included in the estimation technique. A short list of these factors includes: rock type, vegetation, average temperature, soil type, form (snow or rain) of the precipitation, typical storm size and duration, and the time of year when the precipitation occurs.

Table 4-6. Summary of annual natural recharge estimated for this study.

Valley No.	Valley Name	Area (ac.)	Total Estimated Precipitation (af.)	Natural Recharge Estimate (af) A	B	Within Model Area
175	Long Valley	417,000	460,000[4]	31,000	31,000[a]	Tributary
174	Jakes Valley	271,000	312,000[4]	24,000	24,000	Tributary
207	White River Valley	1,017,000	1,032,000[4]	62,000	62,000	Tributary
172	Garden Valley	318,000	320,000[4]	19,000	19,000	Tributary
171	Coal Valley	290,000	234,000[2]	6,000	7,000	Tributary
180	Cave Valley	230,000	258,000[4]	20,000	20,000	Tributary
208	Pahroc Valley	325,000	260,000[2]	7,000	8,000	Tributary
181	Dry Lake Valley	574,000	455,000[2]	11,000	13,000	Tributary
182	Delamar Valley	232,000	176,000[2]	4,000	5,000	Tributary
209	Pahranagat Valley	497,000	344,000[2]	5,000	7,000	Tributary
206	Kane Springs Valley	150,000	140,000[3]	7,000	7,000	Modeled
210	Coyote Spring Valley	392,000	224,000[2]	3,000	4,000	Modeled
219	Muddy River Springs Area	93,000	38,000[2]	5	200	Modeled
220	Lower Moapa Valley	176,000	101,000[3]	400	1,400	Modeled
217	Hidden Valley	52,000	28,000[2]	150	300	Modeled
216	Garnet Valley	102,000	45,000[2]	150	400	Modeled
218	California Wash	206,000	76,000[2]	0	300	Modeled
183	Lake Valley	354,000	437,000[3]	41,000	41,000	Tributary
202	Patterson Valley	267,000	275,000[1]	16,000	16,000	Tributary
201	Spring Valley	185,000	212,000[1]	16,000	16,000	Tributary
200	Eagle Valley	34,000	37,000[1]	2,000	2,000	Tributary
199	Rose Valley	8,000	7,000[1]	400	400	Tributary
198	Dry Valley	76,000	77,000[1]	4,000	4,000	Tributary
203	Clover Valley	220,000	205,000[1]	11,000	11,000	Tributary
204	Panaca Valley	232,000	224,000[1]	9,000	9,000	Tributary
205	L. Meadow Valley Wash	606,000	523,000[3]	22,000	23,000	Modeled
215	Black Mountains Area	409,000	132,000[2]	5	400	Modeled
	Totals	**7,734,000**	**6,636,000**	**321,000**	**332,000**	**37,000[5]**

Recharge estimate "B" is the estimate used in this study, Estimate "A" is provided only for comparison.
[1] Precipitation was estimated using the "general" local altitude-precipitation relationship (Section 4.2)
[2] Precipitation was estimated using the "dry" local altitude-precipitation relationship (Section 4.2)
[3] Precipitation was estimated using the "wet" local altitude-precipitation relationship (Section 4.2)
[4] Precipitation was estimated using the "WRV" local altitude-precipitation relationship (Section 4.2)
[5] Total natural recharge of modeled area, Actual estimate = 36,652 acre-feet per year, Area = 2,186,000 acres, Total estimated precipitation = 1,307,000 acre-feet per year
[a] Only 23,000 afy is used in total because of ground-water outflow to non-White River Flow System Valleys based on proportionality of outflow defined by Nichols (2000).

Maxey-Eakin is one of numerous natural recharge estimation techniques, although it is the oldest and most commonly used in Nevada. In addition to numerous geochemical techniques, which include: conservative ion (usually Chloride), stable isotopes (Hydrogen and Oxygen), radiogenic isotopes (Chloride, Carbon, Uranium, etc..), tracers (chemical and isotopic) and combinations of the various technique appropriate at the "local" or regional scale. There are other empirical precipitation "budget" types techniques conceptually similar and dissimilar to Maxey-Eakin. There are also manual and computerized (models) techniques related to the Darcy equation. There are other runoff estimation techniques that may or may not include an estimate of the natural recharge. At least one natural recharge technique is strongly tied to soil types. All of these grow out of standard assumptions from Civil Engineering, Chemistry, Hydrology, Climatology and Soil Physics, and Biological Sciences.

An example of an empirical precipitation "budget" type of technique that are dissimilar to the Maxey-Eakin was discussed in Harrill and Prudic (1998, p A25). This technique is defined by the equation: $\log Q_r = -1.74 + l.10 \log P_{p>8}$. Where Q_r is equal to the total natural recharge estimate in afy and $P_{p>8}$ is equal to the total volume of precipitation, where average annual precipitation is greater than 8 inches. This was developed following the example of Anderson (1985, p. 102-103) for the Southwest Alluvial Basins study area. Anderson's equation for southern Arizona is: $\log Q_r = -1.40 + 0.98 \log P_{p>8}$. Use of these equations implies that the <u>total natural recharge estimate can be estimated directly from the total "effective" precipitation and all of the "effective" precipitation is equally "effective".</u> This is very different conceptually from the Maxey-Eakin because the various recharge efficiency zones are distributed over the range of precipitation. The primary assumption in the Maxey-Eakin method is that higher precipitation <u>rates</u> yield a higher <u>percentage</u> of natural recharge, they further specify that the distribution of the percentages increase in a specific non-liner relationship with respect to increases in precipitation.

4.4.2 <u>Mountain-Front Runoff</u>

Mountain front runoff has its origin in precipitation that falls on mountain blocks. It is one component of precipitation that exits the mountain block in three ways. The other two are ground water recharge and evapotranspiration. Even though these are separate processes they are greatly interrelated. Mountain front runoff is defined as the volume of surface water that crosses the contact between the consolidated rocks of the mountain block and the unconsolidated sediments of the alluvial basin. How does it occur? It is caused when water from melting snow or rain literally runs off of the mountain block. This occurs when the infiltration capacity of the soil and rock and the evapotranspiration rate is exceeded by the volume of available water. Precipitation that infiltrates through the soil mantel and escapes evapotranspiration and moves down-gradient is often intersected by a drainage channel or is brought to the surface by springflow. Also fractures in the mountain block intercept ground water flow and provide a conduit to the surface where the water emerges from spring orifices. Thus ground water, which started as surface water, reappears through specific springflow orifices or as diffuse springflow and is considered once again to be surface water. This surface water is subject to evapotranspiration during its transient time to the valley and also, depending on other hydrogeologic parameters, may reinfiltrate to the ground water system. Springflow that does not reach a channel in sufficient volume to create runoff either evapotranspires or reinfiltrates to the ground water system once more becoming ground water recharge. Depending on the individual drainage, surface water runoff in perennial streams probably always has a component of ground water in it when it reaches the mountain front contact.

There is a significant amount of runoff into many of the valleys from ephemeral drainages, which do not have a ground-water component. The flow in these channels is generally sudden and last for perhaps just a few short days one or more times a year. In an effort to account for some of this runoff that potentially can become ground-water recharge we have extended the recharge efficiencies down to the lowest altitude in those basin that receive precipitation less than 8 inches as defined by the altitude precipitation relationships discussed previously. In an effort to collaborate this low-altitude recharge process we evaluated the ephemeral flow in Kane Springs and Coyote Spring Valleys using a technique described by Hedmen and Osterkamp (1982). This technique is based on certain channel characteristics that are formed by the discharge of water and sediment in a natural channel. The magnitude, duration, and frequency of flows dictate stream channel geometry, with additional control imposed by the distribution and size of sediment on the channel bed and banks. The channel characteristic measured in the ephemeral tributaries was the active channel width and the equations governing its use are found in Hedman and Osterkamp (1982, Table 2, p. 13, equations 12 -15). The standard error for these equations has not been determined, but is believed to be large, perhaps as much as 50 percent. The results of these measurements are listed in **Table 4-7** and the sites are shown on **Figure 4-10**. Measurements could not be made at some sites for a variety of reasons and the notation of ND (not determined) is indicated.

The results of this limited investigation show there may be a minimum of ~3,000 afy of runoff in Kane Springs Valley and nearly the same amount in Coyote Spring Valley that is lost from the respective channels. In reality there is probably much more, but because of tributary inflow and lack of reliable data, sites measurements could not be made. Some amount of this water that saturates the channel beds is lost to the atmosphere through ET and the remainder, probably a large percentage because of the coarse-grained nature of the channel sediments, infiltrates through the channel bed and moves down the soil column to the water table as ground-water recharge.

In this study all of Kane Springs Valley is in the precipitation zone that produces ground-water recharge, yet there is a significant amount of runoff from the mountain block that may be unaccounted for in the Maxey-Eakin method. If this is true then the amount of ground-water recharge estimated for this valley is conservative. Conversely this runoff may simply be rejected recharge from the mountain block because of the low permeabilities of the volcanic rock. In Coyote Spring Valley parts of the basin are below the effective precipitation threshold of 8 inches and by extending the Maxey-Eakin method to include this area results in an additional 1,000 afy (**Table 4-6**) of ground-water recharge. This value is within the estimated ground-water recharge that takes place as a result of mountain front runoff. This process of ground-water recharge from ephemeral channels has been discussed by other investigators such as Glancy and Van Denburgh (1969), Osterkamp et al (1994), Berger (2000a and b), and Savard (1998).

4.5 GROUND-WATER DISCHARGE

Discharge from the basins in pre-development times was by spring flow, evapotranspiration, and ground- and surface-water outflow. In some of the basins there has been no significant development and hydrologic conditions remain unchanged. In other basins there has been a high degree of water-resource development and pumpage for agriculture has replaced or is additive to spring flow use by phreatophytes. In some basins evapotranspiration increases yearly as

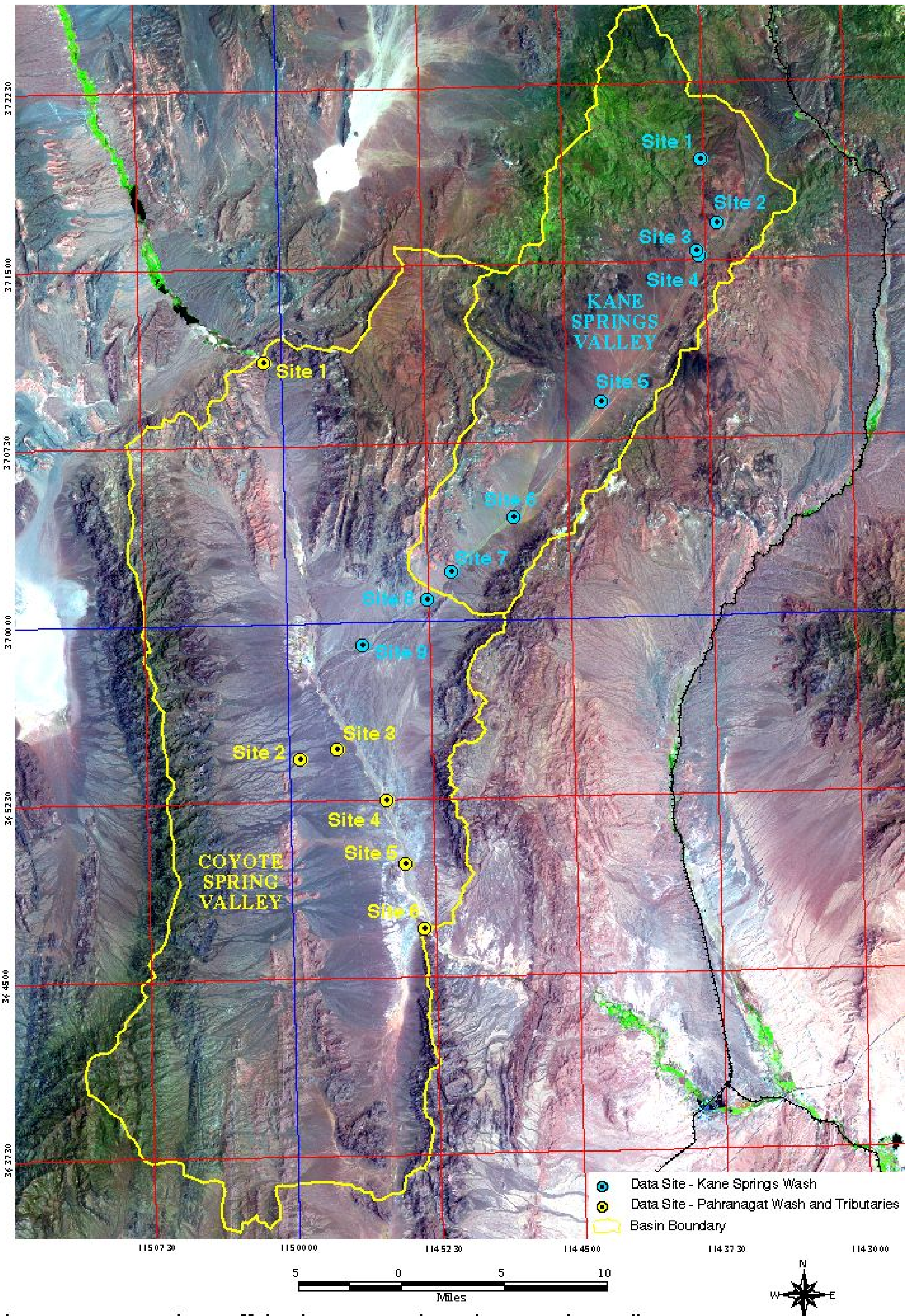


Figure 4-10. Mountain runoff sites in Coyote Spring and Kane Springs Valleys.

urbanization continues. Regardless of the amount of ground-water pumpage ground-water outflow remains about the same in many of the basins simply because of the vast amount of ground water in storage in the various aquifer systems.

Discharge from the Colorado River Basins is by ground-water outflow and ET. Many of the basins have significant discharge by both processes, but it is the discharge through the ET that dominants the hydrologic system. Little of this discharge can be actually measured and inter-basin flow can only be inferred with large potential errors. The value that represents this flow is usually the difference between the estimated recharge and the estimated ET. There are several large springs that discharge from carbonate rocks and are assumed to represent part of the inter-basin flow. The most critical of these springs with regard to the purpose of this study are the Muddy River Springs. The measured discharge from these springs represents a significant amount of ground-water flow from the White River flow system. A lessor amount of flow has also been gaged from Rogers and Blue Point Springs. These are the only points in the lower part of the flow systems where actual measurements with time have been made.

Ground-water outflow from the model area occurs over a broad front as described in the Ground-Water Movement and Model Section. The fate of this outflow is unknown, but believed to be the fault structure that contains the lower Virgin/Muddy River or even the Colorado River. How is it possible that 36,000 afy could be tributary to a river system yet unknown by geologists mapping the Colorado River prior to the construction of Hoover Dam? The only model we have to answer such a question is the Littlefield Springs in the Lower Virgin River in Arizona. These springs have been described by Glancy and Van Denburgh (1969), Trudeau (1979), and Cole and Katzer (2000). The average discharge of these springs is about 50 - 60 cfs, not dissimilar to the outflow from the study area, and provides the base flow of the Lower Virgin River. Well over a hundred spring orifices and seeps discharge directly to the river from the channel bed and banks over about eight miles, which equals an acreation rate of about 7 cfs per linear mile of channel. Most of these orifices are within the low-water channel and can not be seen unless the river is at very low flow and there is virtually no sediment being transported. This is a condition never seen in the Colorado River, which by contrast is wide, deep and carries a large sediment load that would preclude the observation of springs emanating from its bed and lower banks. This is one explanation of several for ground-water outflow from the White River and Meadow Valley Flow Systems.

Table 4-7. Mountain Front Runoff at Selected Sites in Coyote Spring and Kane Springs Valley.

Site No. on Figure	Active Channel Width (ft.)	Annual Runoff (af.)	Estimated Channel Loss (afy)	Channel Sediment Characteristics
COYOTE SPRING VALLEY				
1	7	200		Some cobbles, gravel and sand
2	18	880	700	Cobbles, gravel and sand
3	7	200		Gravel
4	26	1,600		Course sand
5	43	3,400	2200	Minor gravel, coarse sand
6	22	1,200		Gravel, coarse sand, some silt
KANE SPRINGS VALLEY				
1	25	1,460	700	Boulders ~ 4 ft., cobbles, gravel
2	17	800	}200	Boulders, cobbles, gravel, coarse sand
3	14	600		Boulder, cobbles, gravel
4	29	1,840		Gravel, sand; cobbles/boulders
5	30	1,940	700	Gravel and coarse sand
6	22	1,200		Gravel and coarse sand, some cobbles, and silt
7	36	2,600	}400	Gravel and coarse sand
8	33	2,250	}400	Gravel and coarse sand
9	29	1,850		Gravel and coarse sand
Total			**5,300**	

4.5.1 Evapotranspiration

Evapotranspiration (ET) is the process whereby water is returned to the atmosphere through evaporation from soil, wet plant surfaces, open water bodies and transpiration from plants. The type of plants we are most concerned with are termed phreatophytes as first defined by Meinzer (1927) as "plants that habitually grow where they can send their roots down to the water table or the capillary fringe immediately overlying the water table and are then able to obtain a perennial and secure supply of water". The plant assemblage of interest is composed primarily of greasewood (*Sarcobatus vermiculatus*), saltgrass (*Distichlis spicata*), rabbitbrush (*Chrysothamnus nauseosus*), saltbush (*Atriplex canescens*), spiny hopsage (*Grayia spinosa*), shadscale (*Atriplex confertifolia*), and big sagebrush (Artemisia tridentata). There is also a riparian plant assemblage that is of interest and this includes cottonwood (*Populus fremontii*), willow (*Chilopsis linearis*), saltcedar (*Tamarix ramosissima*), mesquite (*Prosopis glandulosa*), and tules (*Typha sp.*).

Water-use rates for phreatophytes in the study area were first estimated starting nearly a half century ago. More recently, in the last ten years, research has shown that the early estimates of water use were low. This recent research in Nevada was conducted mainly by the University of Nevada, Department of Biological Sciences, and the USGS. Of particular importance is the work of Devitt et al., (1998) who conducted a three year study of ET from a stand of salt cedar on the floodplain of the lower Virgin River about 3 miles upstream from Lake Mead. The ET rate varied from a low of 2.8 af to a high of 4.8 af and these values may not represent the actual minimum and maximum caused by climatic differences. This particular ET rate is controlled by the availability of relatively shallow ground water provided by recharge from stream flow, canopy development, atmospheric demand, and the degree of advection (Devitt et al., 1998). Smith et al. (1998) have indicated that the leaf-level transpiration rates along the Virgin River are similar to native species, but in general have a higher transpiration rate than do other native plants. These interpretations probably apply in general to ET throughout the study area and in particular to Lower Meadow Valley Wash and the Muddy River area. In Las Vegas Valley Devitt et al. (in review, 2000) reevaluated ET first estimated by Malmberg (1965) for pre-development conditions in 1905. This reevaluation shows an increase in ET over the original USGS estimate by about 60 percent.

USGS research conducted by Nichols (2000) in 16 valleys in central and eastern Nevada also dramatically increases the ET compared to the original estimates made by earlier USGS investigators. Nichols (2000) increased the ET by an average factor of about 2.7. To match this discharge requires an increase in ground-water recharge of about 2.8 times the original estimates. Nichols (2000) showed that ET rates vary widely, and are similar to the variability defined by Devitt et al. (1998) along the Virgin River. This variability of ET with time and changing climatic conditions casts some uncertainty into ground-water budgets that rely on annual averages.

The two valleys that are common to this study and the study by Nichols (2000) are Long and Jakes Valleys. The ground-water recharge and discharge for these two valleys used in this study are based entirely on the techniques and data described in this study. We did use Nichols' (2000) estimate of ET for both valleys and his distribution of outflow by percent from Long Valley. In other valleys of this study (White River, Garden, Cave, Pahranagat, Lake, Patterson, Spring, Eagle, Rose, Panaca, and Clover) the ET rate for phreatophytes was estimated based on plant density, usually estimated between 10 and 20 percent and an average leaf area index of 2. These factors were substituted into Nichols equation No. 3 (2000, Chapter A, p. A6) to estimate the annual ET rate based on plant cover. The ET rate is very sensitive to densities under 35 percent and, for instance, a 5 percent increase from 15 to 20 percent nearly doubles the rate.

ET rates for Valleys in the model area are based on the work of Devitt et al. (1998, and in review 2001). The same ET rate of 5 af/acre/year is used throughout this area for agriculture and phreatophytes. This rate was used by the USGS and is in the range reported by the HRCS.

The land use and acreage were determined from LANDSAT scenes (July 1998) and virtually all areas were field checked. In the southern end of the flow systems aerial photographs for 1953 and 2000 were used in addition to LANDSAT scenes. Water-use rates used in this study are listed in **Table 4-8** and are compared to rates used by previous USGS investigators for phreatophytes and the Natural Resource Conservation Service (NRCS, formally the Soil Conservation Service) for agriculture. Additionally, and not referenced in **Table 4-8**, are the evaporation rates from open water; these values were taken from Shevenell (1996). The specifics of the valleys in the study area are discussed as follows:

Table 4-8. Water-use rates for valleys with significant ground-water discharge.

Valley	Land use[1] and area (ac.)	Water-Use Rates				
		Acre-feet/acre/year[2]			Volume (afy)	Total Volume (afy/valley)
		This study	USGS[3]	NRCS[4]	This study	This study
Long[5]	P/21,882	--	Variable	--	--	11,000
Jakes[5]	P/416	--	Variable	--	--	600
White River[6]	P/147,211	0.3	6/	--	44,736	
	A/14,736	2.0	--	2 - 4.5	29,472	
	W/1,975	3.0	--	--	5,925	79,560
Garden[7]	P/6,144	0.75	--	--	4,608	4,608
Cave[8]	P/9,272	0.3	--	--	2,781	
	A/1,021	2.0	--	2 – 4.5	2,042	4,823
Pahranagat[6]	P/1,431	0.45	6/	--	644	
	A/6,256	5.0	--	3.5 - 6	31,280	
	W/1,289	5.0	--	--	6,445	38,369
Upper Muddy	P/1,016	5.0	5.0	--	5,080	5,080
California Wash	P/1152	5.0		--	5,760	5,760
Lake	P/6,654	0.45	0.1 – 1.5	--	2,994	
	A/6,883	3.0	--	2.5 -5	20,649	23,643
Patterson	A/1,607	3.0	--	2.5 - 5	4,821	4,821
Spring	P/1,548	0.45	0.1 – 1.5	--	697	
	W/45	3.0	--	--	135	832
Eagle	A/549	2.0	3.0	2.5 - 5	1,098	1,098
Rose	A/350	2.0	3.0	2.5 - 5	700	700
Dry	P/153	0.45	0.1-0.2	--	69	
	A/2,039	2.0	3.0	2.5 - 5	4,078	
	W/58	4.0	--	--	232	4,379
Panaca	P/145	0.45	0.1-0.2	--	65	
	A/8,649	3.0	3.0	2.5 - 5	25,947	26,012
Clover	P/101	0.45	0.2-0.5	--	45	
	A/1,066	2.0	3.0	2 - 4	2,132	2,177
L. Meadow Valley Wash	P/3,854	5.0	0.1-3	--	19,270	
	A/1,576	5.0	5.0	3 - 7	7,880	27,294
Lower Moapa	P/5,301	5.0	--	5 - 7	26,505	26,505

1 *Abbreviations: P, Phreatophytes; A, Agriculture; and W, open water.*
2 *If no value is listed then no estimate was made or the estimate was not available.*
3 *Values referenced are from appropriate USGS Reconnaissance and Bulletin Series.*
4 *Consumptive use values according to the Natural Resource Conservation Service (NRCS, formally the Soil Conservation Service,1981), taken from sites closest to indicated valley (rounded to nearest half foot) and represent the range for alfalfa and pasture.*
5 *Nichols (2000, p. C42-43).*
6 *Eakin (1966, Table 1) indicates that evapotranspiration is equal to regional spring discharge.*
7 *Land use acreage includes several hundred acres of undifferentiated agriculture*

4.5.1.1 White River Valley

There are three types of ET that represent current conditions; ET from phreatophytes, agriculture, and open water. Clearly this was not the case in predevelopment times, because there was no agriculture. However, phreatophytes and open water under natural conditions most likely covered the land that is currently being irrigated. There are some irrigated lands on higher parts of the alluvial fans that undoubtedly did not support phreatophytes, but it was beyond the scope of this project to make this determination. Eakin (1966) did not map the phreatophytes, but simply indicated that ET probably took up the spring discharge of 37,000 acre-feet/year. We believe the valley, under natural conditions, had a very high water table near land surface over large areas with extensive marsh land and that the ET rate was much greater than estimated by Eakin. Ground-water levels remain high today along the central axis of the valley, in spite of the numerous wells used for irrigation. Thus ground-water discharge and associated land areas under natural conditions are replaced by pumping for agriculture. We assume the higher rate of ET for agriculture verses the ET rate for phreatophytes is justified to represent natural conditions. The total ET for this valley is estimated at 80,000 acre-feet/year and it falls within the range and magnitude for other large valleys where ET was estimated by Nichols (2000), such as Railroad Valley to the west and Steptoe and Spring Valleys to the east.

4.5.1.2 Garden Valley

There are agriculture lands that are adjacent to perennial drainages such as Cherry and Pine Creeks. These are prime areas for phreatophytes and we believe under natural conditions the lower reaches of these drainages and their relatively small flood plains were covered with phreatophytic vegetation. Many of the canyons draining the east slope of the Quinn Canyon Range and the southern end of the Grant Range have numerous springs of varying discharge. Most of this water is captured by local ET, but some undoubtedly infiltrates to the valley ground-water system. Eakin (1966, Table 1) estimated 2,000 acre-feet/year for ET and we have increased this estimate to 5,000 acre-feet/year.

4.5.1.3 Cave Valley

The single estimate of ET is reported by Eakin (1966, Table 1) to be a few hundred acre-feet/year, however there is a large playa with a healthy stand of greasewood in the south end of the valley. A monitoring well constructed on the southwest side of the playa within the greasewood assemblage showed the water table to be about 30 feet below land surface. The water is obviously perched because most of the other wells (Brothers et al., 1993, Table 1, p. 6) have reported depths over 100 feet to water. Even though part of the ground-water system is perched it is still part of the total water resource for the valley. If the water were not perched it would have infiltrated to the main valley aquifer. The playa altitude is about 6,000 feet, nearly 1,000 feet lower than the north end of the valley so ground water could have reached the playa from the north. However, because the valley floor is well within altitudes commonly accepted as recharge areas we believe there is a component of ground-water recharge that takes place directly from the valley floor and is the principal source of the perched water table. There are other numerous springs in the mountain blocks and there is some agriculture of mostly meadow grass. We estimate the ET for this valley at 5,000 acre-feet/year.

4.5.1.4 Pahranagat Valley

This long and narrow valley floor has been converted from phreatophytes to agriculture. Under natural conditions the floor was probably covered by a dense growth of phreatophytes that, according to Eakin (1966, Table 1) consumed only the estimated regional spring discharge of 25,000 acre-feet/year. Our rationale for increasing this amount to 38,000 acre-feet/year is the same as discussed previously for White River Valley. Water levels were probably shallow and resulted in large marshy areas in the southern and northern parts of the valley. The now breached and dry Maynard Lake at the extreme south end of the valley probably indicates the abundance of water during natural conditions and a redistribution of ET under current conditions.

4.5.1.5 Upper Muddy Springs

The hydrographic area for the Muddy Springs has about 5,000 afy of natural ET. The distribution of ET upstream and downstream of the USGS gage (Muddy River near Moapa) is about 3,000 and 2,000 acre-feet/year respectively. The estimated ET (this study) upstream from the river gage agrees closely with Eakin's (1966, Table 1) original estimate of 2,300 acre-feet/year. Unlike ET estimates in other valleys current conditions for ET were not estimated. The reason for this is natural ET conditions were needed to determine if there were any impacts to total spring discharge. Within error of all hydrologic measurements by many investigators, the volume of spring discharge today appears to be equal to predevelopment conditions.

4.5.1.6 California Wash

Phreatophytic vegetation along the Muddy River corridor during predevelopment conditions was probably dominated by Mesquite and salt grass. The relatively flat flood plain where these phreatophytes grew has been converted to agriculture. We estimate the predevelopment ET was about 6,000 afy.

4.5.1.7 Lake Valley

Spring discharge along the west side of the valley undoubtedly accounted for much of the predevelopment ET. The larger springs are in the northwest part of the valley and under natural conditions there would have been an even larger marshy area than there is today. There is a large amount of agriculture land currently under production that is irrigated by ground-water pumpage and water levels are within a few 10s of feet of land surface throughout much of the valley. We believe that most, if not all, of this land was type converted from natural areas of phreatophytes, mostly the greasewood assemblage, to agriculture. ET for this valley is estimated at 24, 000 afy and is assumed to represent predevelopment conditions.

4.5.1.8 Patterson Valley

There are no remnants of natural ET left in this valley. The estimated ET today of about 5,000 afy is based on agriculture usage. Under natural conditions there was probably a much higher water table than currently exists and Patterson Wash would have had a significant amount of phreatophytes, mostly greasewood, particularly along its lower reach.

4.5.1.9 Panaca Valley

The predevelopment water table in this valley was undoubtedly very near land surface, and despite large scale agricultural development, large areas of standing water are common. Meadow Valley Wash is perennial today and even though there are significant still flows several thousand afy. So under natural conditions the flow was probably much larger. Additionally permeable carbonate rocks are at land surface and are in contact with less permeable volcanic rocks which tends to bring water closer to land surface. Phreatophytes and marsh land probably occupied much of the lands now under agriculture, and the predevelopment ET is estimated to be about 26,000 afy.

4.5.1.10 Remaining Valleys in the White River Flow System

Coal, Pahroc, Dry Lake, Delamar, Kane Springs, Coyote Spring, Hidden, and Garnet Valleys have only small amount of ET. The ET from Hidden and Garnet Valleys is virtually zero. The ET was estimated at a token 1,000 acre-feet/year for each of the other valleys to account for local spring discharge that is consumed including evaporation from bare soil. Most of the springs in these valleys are in the mountain blocks, some have been developed for stock watering. The hydrology of Black Mountain is dominated by surface flow in Las Vegas Wash and also the ET along the wash. These components are not part of this study

Estimates of ET and ground-water outflow are listed in **Table 4-9** and are compared to previous USGS estimates. In general the ET has been increased significantly in this study compared to previous estimates, although only minimally in some valleys. Ground-water outflow is also increased because the ground-water recharge is much higher than previously estimated.

4.5.2 Spring Flow in Model Area

Surface-water discharge in the model area occurs in Kane Springs Wash, Coyote Spring Valley, Lower Meadow Valley, California Wash, the Muddy Springs Area, and Black Mountains Area. The major springs in the model area are shown in **Figure 4-11**.

Several small springs discharge in Kane Springs Wash, Coyote Spring Valley, and California Wash at rates generally less than a few hundred acre-feet per year. The discharge from these springs is consumed locally through ET. In Kane Springs Valley the numerous small “local” springs are not part of the large regional carbonate aquifer system. These local springs are generally in volcanic rock and reflect local recharge and discharge. A single discharge point at the location of Kane Springs was used in the ground-water model to represent the diffuse local

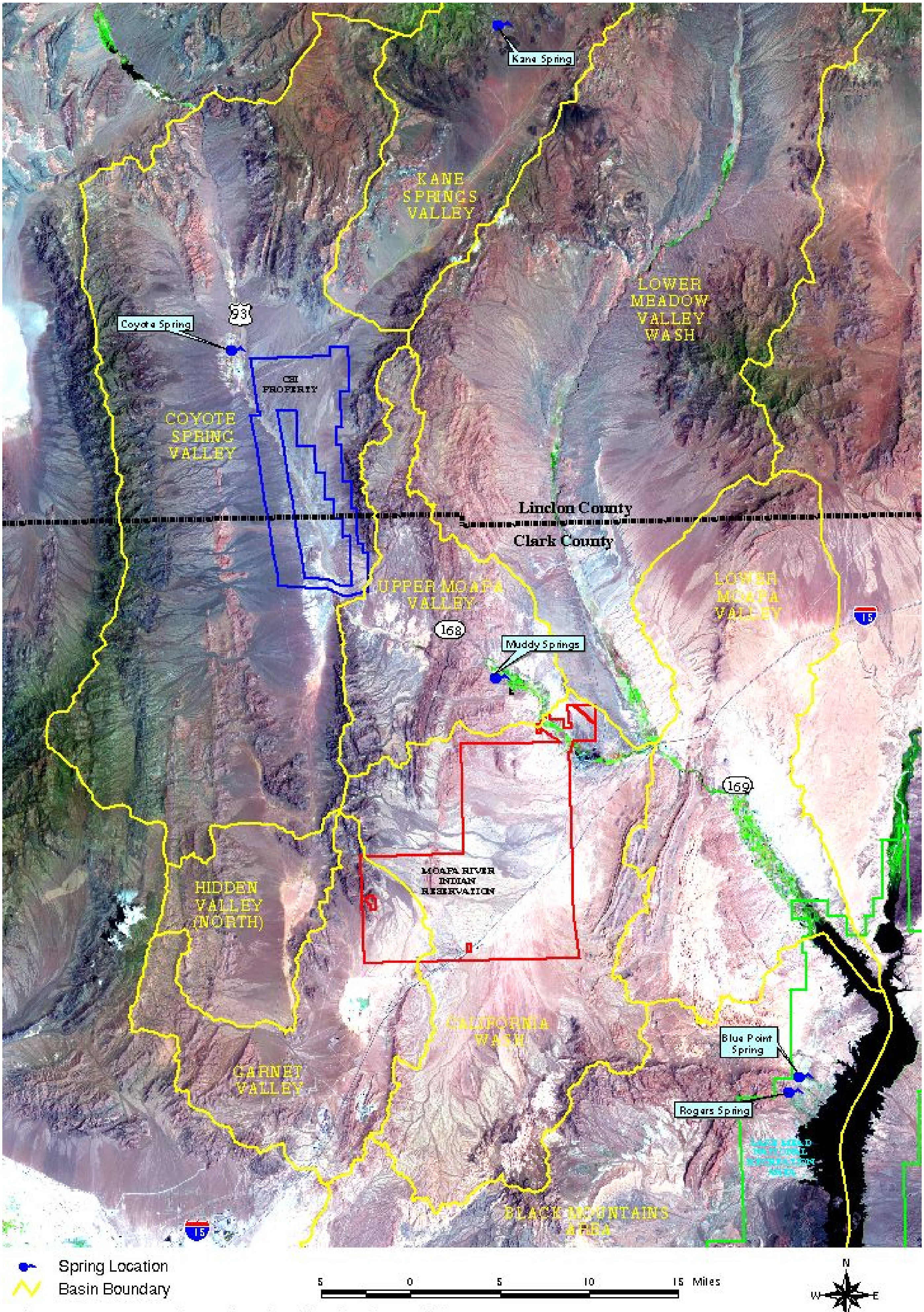


Figure 4-11. Locations of spring flow in the model area.

springs and associated ET in Kane Springs Valley. In Coyote Spring Valley several small springs exist in the mountain block, but a single discharge point at Coyote Spring, located on the valley floor in the northern end of the valley was utilized as the location of ET for the water budget and ground-water model in this study. California Wash has a couple of small local seeps south of the Muddy River that discharge very small volumes of water. These seeps were not considered significant in the overall water budget.

Table 4-9. Comparison of discharge estimated by previous USGS investigators and this study, in acre-feet/year. Numbers in *italics* are this study.

Valley	**Discharge**			**Total Discharge**	
	ET	**Ground-water Outflow**			
WHITE RIVER FLOW SYSTEM					
Long	2,200[a]/*11,000*	8,000[a]/*12,000*		10,200/*23,000*	
Jakes	Minor/*600*	17,000/*35,000*		17,000/*36,000*	
Cave	<1,000/*5,000*	14,000/*15,000*		14,000/*20,000*	
White River	37,000/*80,000*	40,000/*32,000*		77,000/*112,000*	
Garden	2,000/*5,000*	8,000/*14,000*		10,000/*19,000*	
Coal	Minor/*1,000*	10,000/*20,000*		10,000/*21,000*	
Pahroc	Minor/*1,000*	42,000/*59,000*		42,000/*60,000*	
Pahranagat	25,000/*38,000*	35,000/*28,000*		60,000/*66,000*	
Dry Lake	Minor/*1,000*	5,000/*12,000*		5,000/*13,000*	
Delamar	Minor/*1,000*	6,000/*16,000*		6,000/*17,000*	
Kane Spring	Minor/*1,000*	NR/6,*000*		NR/7,*000*	
Coyote Spring	<1,000/*1,000*	36,000/*53,000*		36,000/*54,000*	
Hidden	0/*0*	300/	*17,000*	600/*17,000*	
Garnet	0/*0*	600/			
California Wash	/6,*000*	1/*41,000*		/*47,000*	
Black Mountains	1,200/*2,000*	400/*0.3*		1,600/2,*000*	
Upper Moapa	2,300/*5,000*	36,000/*32,000*[b]		38,000/*37,000*	
MEADOW VALLEY FLOW SYSTEM					
Lake	8,500/*24,000*	3,000/*17,000*		11,500/*41,000*	
Patterson	80/*5,000*	*7,000*[c]	*28,000*	27,000[c]	*33,000*
Spring	1030/*1,000*		*15,000*		*16,000*
Eagle	290/*1,000*		*16,000*		*17,000*
Rose	10/*700*		*16,000*		*17,000*
Dry	10/4,*000*		*16,000*		*20,000*
Panaca	530/*26,000*		*27,000*		*53,000*
Clover	210/*2,000*		*9,000*		*11,000*
Meadow Valley Wash	20,000/*27,000*		*32,000*		*59,000*
Lower Moapa	25,000/*26,000*	11,000[b]/*48,000*[b]		36,000/*74,000*	

a. Eakin (1961), Not Nichlos (2000).
b. Combination of ground and surface water.
c. Rush (1964) lumped all ET, added ET to estimated outflow and subtracted from ground-water recharge.

The major spring flow in the model area occurs in the Muddy Springs Area, Lower Meadow Valley Wash, and the Black Mountains Area. The Muddy Springs Area has several discrete springs orifices (possibly 30) with varying discharge as described by Eakin (1964). Numerous channels funneling the spring discharge into the Muddy River. These springs are the major surface-water outflow for the White River Flow System. The Muddy Springs are characterized in this study using 3 large springs and the discharge is calibrated to the measured flow as described in Section 5 and Section 8.

Lower Meadow Valley Wash has two carbonate springs at Rox and Ferrier. These springs were not explicitly defined in the model but were treated as part of the ET discharge within the valley.

In the Black Mountains Area along the shore of Overton Arm of Lake Mead, there are several springs referred to as the North Shore Complex (Pohlmann et al., 1998). These springs are located along a series of faults that are part of the Lake Mead Fault Zone (Anderson and Barnhard, 1993a). These springs are idealized as two springs, Rogers and Blue Point Springs and the discharge was calibrated to the measured flow as described in Section 5.0 Surface Water in Model Area.

5 SURFACE WATER IN MODEL AREA

Surface-water flow in the model area occurs in the Muddy Springs area of Upper Moapa Valley, the Black Mountains Area, and Lower Meadow Valley Wash. The dominate surface-water flow is at the Muddy Springs area which flows as the Muddy River through Upper Moapa Valley, California Wash, and Lower Moapa Valley terminating in Lake Mead. The USGS has maintained gaging stations at various locations in some of the Valleys in the modeled area since 1913 **(Figure 5-1)**. The long-term records from these gages are used in the water budget calculations in conjunction with the development and calibration of the ground-water flow model in this study.

5.1 MEASURED FLOWS

5.1.1 Moapa Gage

The largest volume of water discharged in the model area is to the Muddy Springs and is the principal source of ground-water discharge in the White River Regional Flow System (Eakin, 1964). USGS gaging station *09416000 Muddy River near Moapa, NV* (Moapa gage) is located downstream of the springs and measures the baseflow of the springs (i.e. the Muddy River) less surface-water diversions and ET between the gage and the springs (**Figure 5-2**). Records of flow were collected intermittently from 1913 to the present (U.S. Geological Survey Water-Data Reports, Water Years 1913 through 1999).

Runoff from local precipitation events contributes additional stream flow measured at the Moapa gage, which is referred to as flood flows in this study. These flood flows need to be removed from the daily mean flows to determine the actual baseflow at the gage. To remove the flood flows from the daily mean flows, all days with flood flows were identified and the median monthly flow used in its place. This method is described in Johnson (1999, Appendix 2.1 to the *Las Vegas Wash Comprehensive Adaptive Management Plan*).

The annual average flow at the Moapa gage from 1913 to 1947, based on available data without flood flows, is approximately 33,900 afy (47 cfs) **(Figure 5-3)**. This period, for the purposes of this study, represents pre-development conditions, because the first well in Upper Moapa Valley was drilled in 1947 according to the NDWR Well Log Database. Eakin (1964) calculated the average flow of the Muddy Springs to be 46.5 cfs (33,700 afy) based on 25 water years from 1914 to 1962. Eakin further estimated that approximately 2,000 to 3,000 afy of spring flow was being consumed by phreatophytes between the springs and the Moapa gage, which means the spring discharge must be approximately 36,000 to 37,000 afy (50 to 51 cfs).

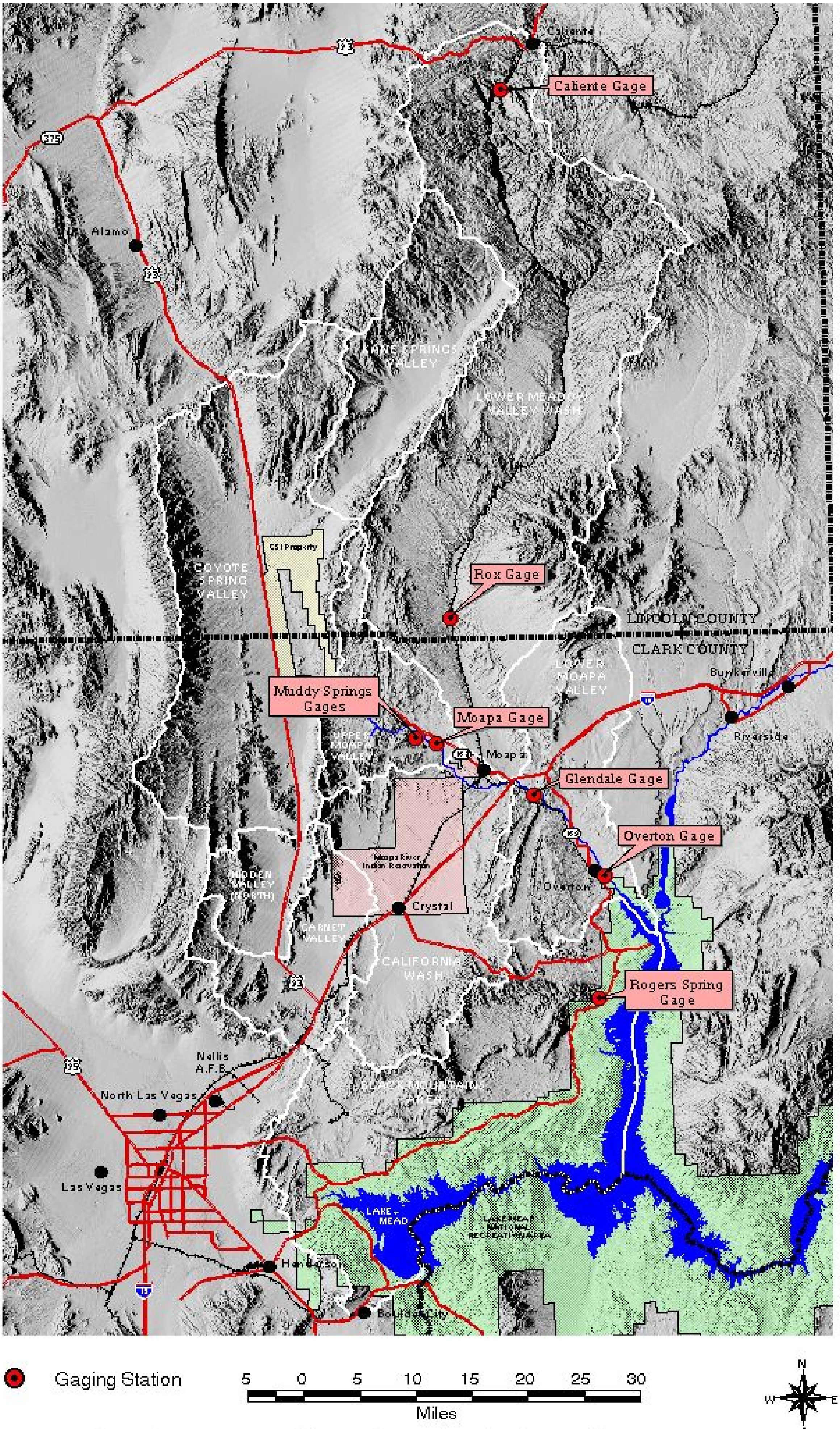


Figure 5-1. Locations of USGS streamflow gaging stations in the model area.

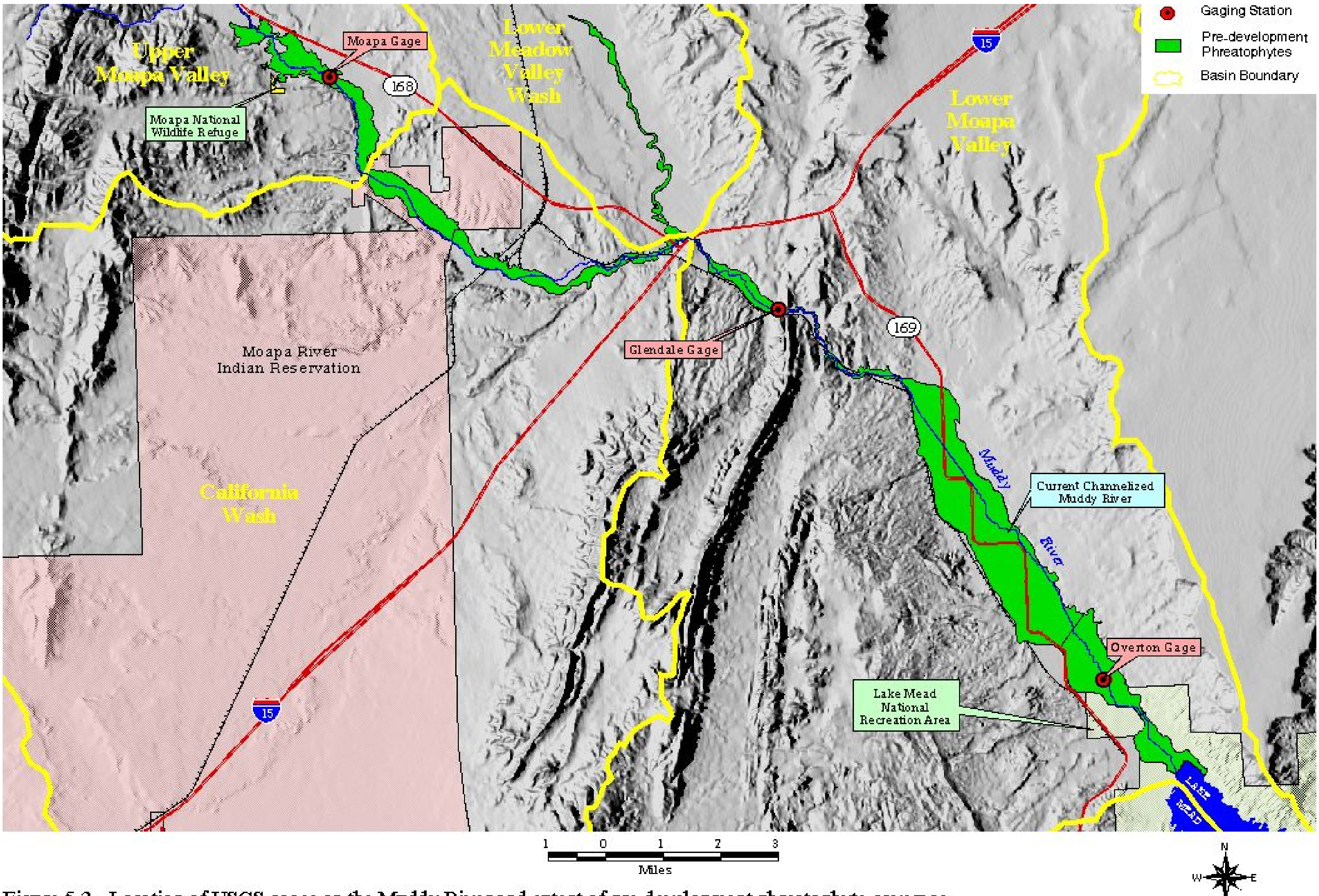


Figure 5-2. Location of USGS gages on the Muddy River and extent of pre-development phreatophyte coverage.

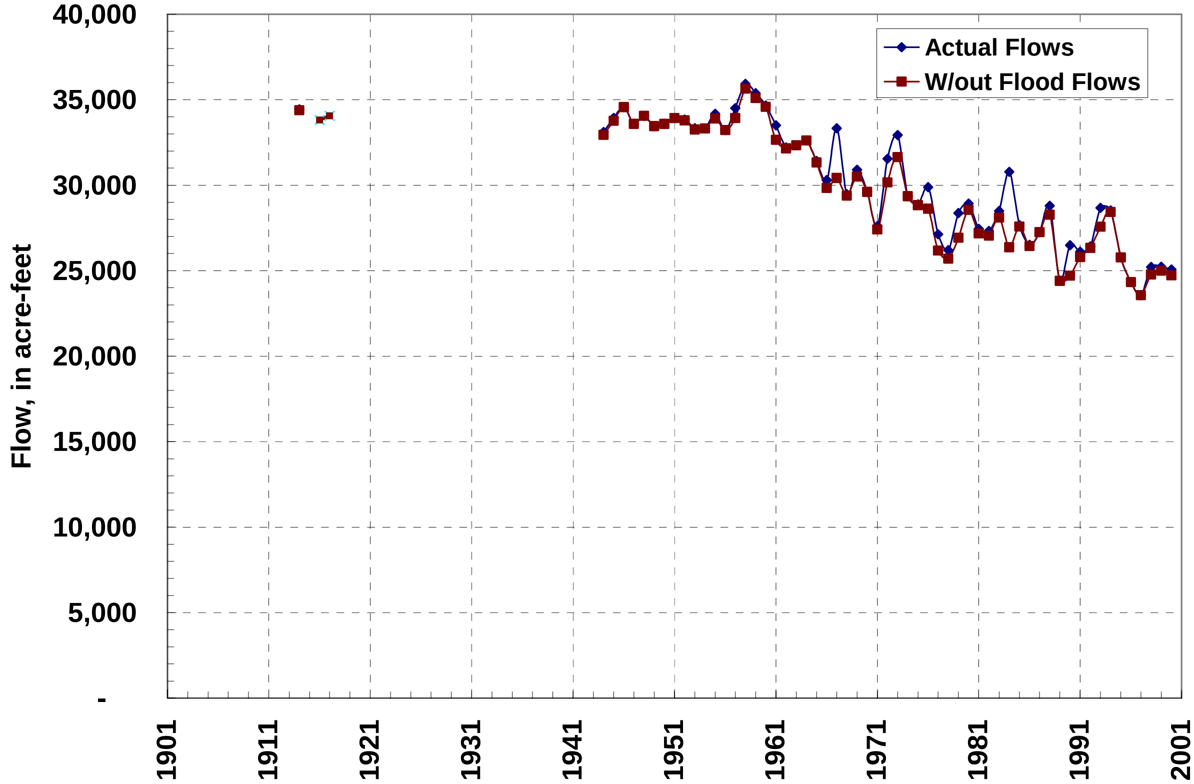


Figure 5-3. Annual flow with and without flood flows at USGS gaging station *09416000 Muddy River near Moapa, NV*

Analysis of October 1953 aerial photography of the Muddy Springs area, which shows phreatophytes and established agriculture, and September 2000 aerial photography, which shows limited active farming, demonstrated that approximately 600 acres of native phreatophytes existed prior to ground-water development **(Figure 5-4)**. Applying a consumptive use factor of 5 ft per acre per year (Eakin, 1964) results in 3,000 afy of ET above the Moapa gage, which places the annual average spring discharge at 37,000 afy. This flow record is used to develop the water budget and for the calibration of the ground-water flow model.

The annual flow at the Moapa gage was approximately 25,000 af for water year 2000. This reduction in flow is due to nearby ground-water production and surface-water diversions above the gage and is discussed in detail in Section 5.2.

5.1.2 Glendale Gage

USGS gaging station *09419000 Muddy River near Glendale, NV* (Glendale gage) is located in Lower Moapa Valley and measures a depeleted baseflow of the Muddy River along with periodic flood flows from the Muddy River, California Wash, and Lower Meadow Valley Wash. This is discussed in greater detail in Section 5.2. **Figure 5-5** depicts the annual flows at the Glendale gage with and without flood flows (U.S. Geological Survey Water-Data Reports, Water Years

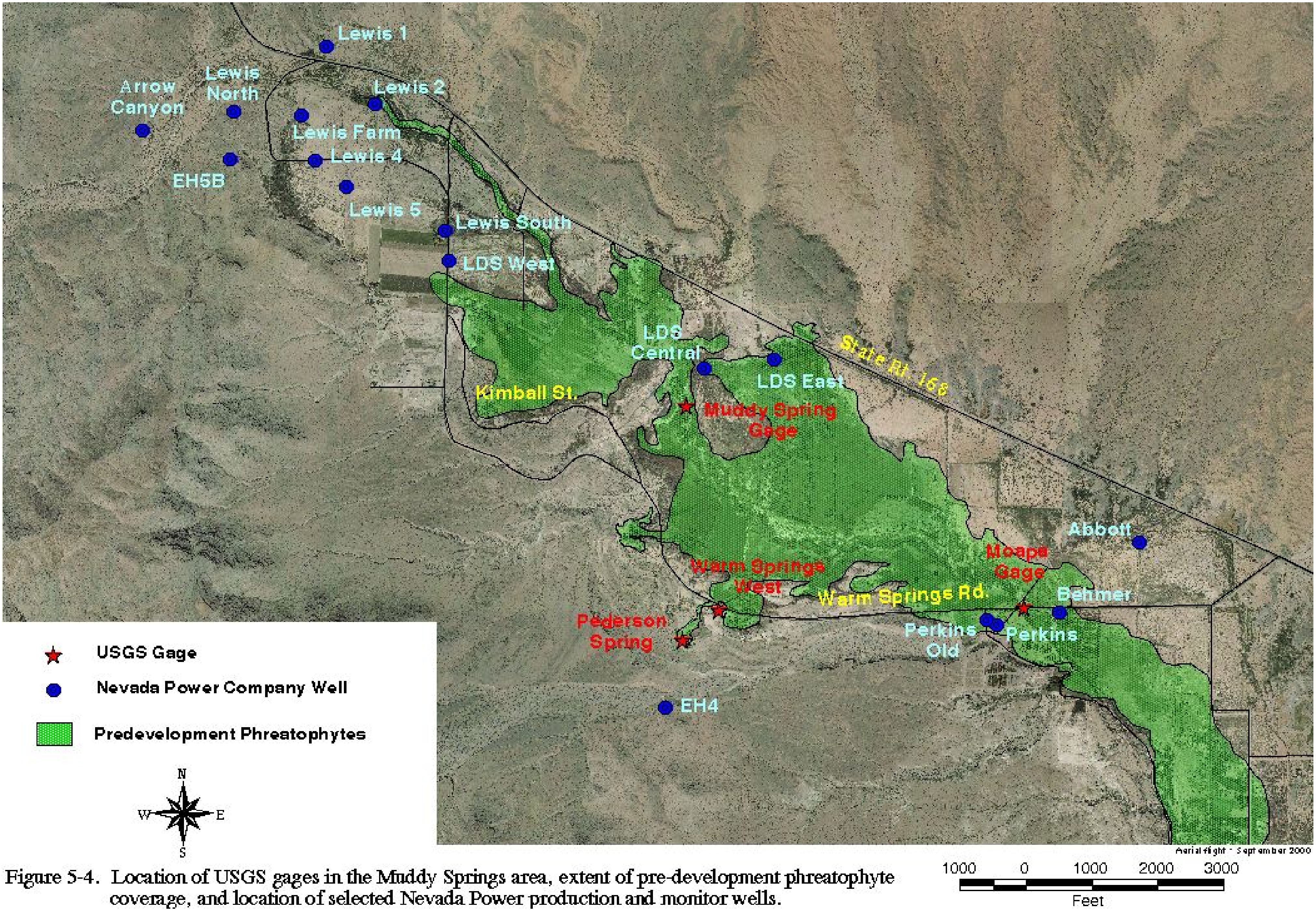


Figure 5-4. Location of USGS gages in the Muddy Springs area, extent of pre-development phreatophyte coverage, and location of selected Nevada Power production and monitor wells.

1951 through 1999). The annual average flow at the Glendale gage from 1951 to 1960 after removing flood flows is 33,600 afy. This gaged flow record is used to develop the water budget and for the calibration of the ground-water flow model.

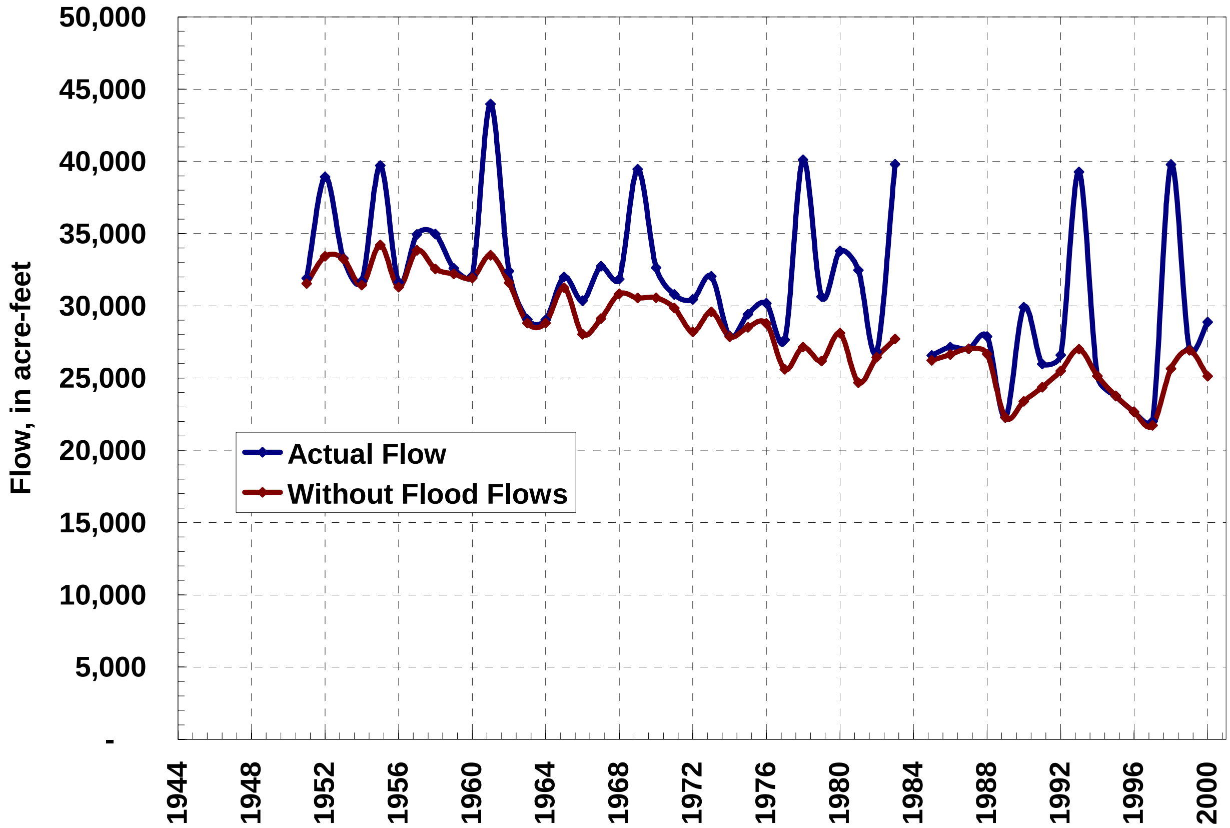


Figure 5-5. Annual flow with and without flood flows at USGS gaging station *09419000 Muddy River near Glendale, NV*

5.1.3 Overton Gage

USGS gaging station *09419507 Muddy River at Lewis Avenue at Overton, NV* (Overton gage) is located in Lower Moapa Valley approximately 1.5 miles above Lake Mead. Flows at the gage are predominantly irrigation returns, because the entire flow of the Muddy River is diverted for agricultural use by the Muddy Valley Irrigation Company at Wells Siting approximately 7 miles upstream; although, there may be ground-water inflows reflected in the flow record of the gage. This gage was installed in August 1997, and the annual flows for water years 1998 and 1999 are 12,960 af and 10,430 af respectively including flood flows. The flow record of the gage is used in the development of the water budget and during the calibration of the ground-water flow model to approximate the magnitude of surface-water flows into Lake Mead. Obtaining the current measured flows at the Overton gage was not an objective of the modeling effort, because the majority of flow is irrigation returns and a detailed analysis of the current acreage of agricultural in Lower Moapa Valley was not conducted in this study.

5.1.4 Lower Meadow Valley Wash

The USGS gaging station *09418500 Lower Meadow Valley Wash near Caliente, NV* (Caliente gage) has been operational since water year 1951. The annual average flow during water years 1951-1999 is 8,160 afy (U.S. Geological Survey Water-Data Reports, Water Year 1999) (**Figure 5-6**). Flow at the gage is influenced by snow melt, which causes the seasonal variability in the flow at the gage. Surface-water flow from the upper portion of Lower Meadow Valley Wash generally does not extend into Clark County except during flood flows. An annual average surface-water inflow of 10,000 afy from Panaca Valley is utilized in the water budget of this study, which accounts for streamflow losses due to ET above the Caliente gage within Lower Meadow Valley Wash.

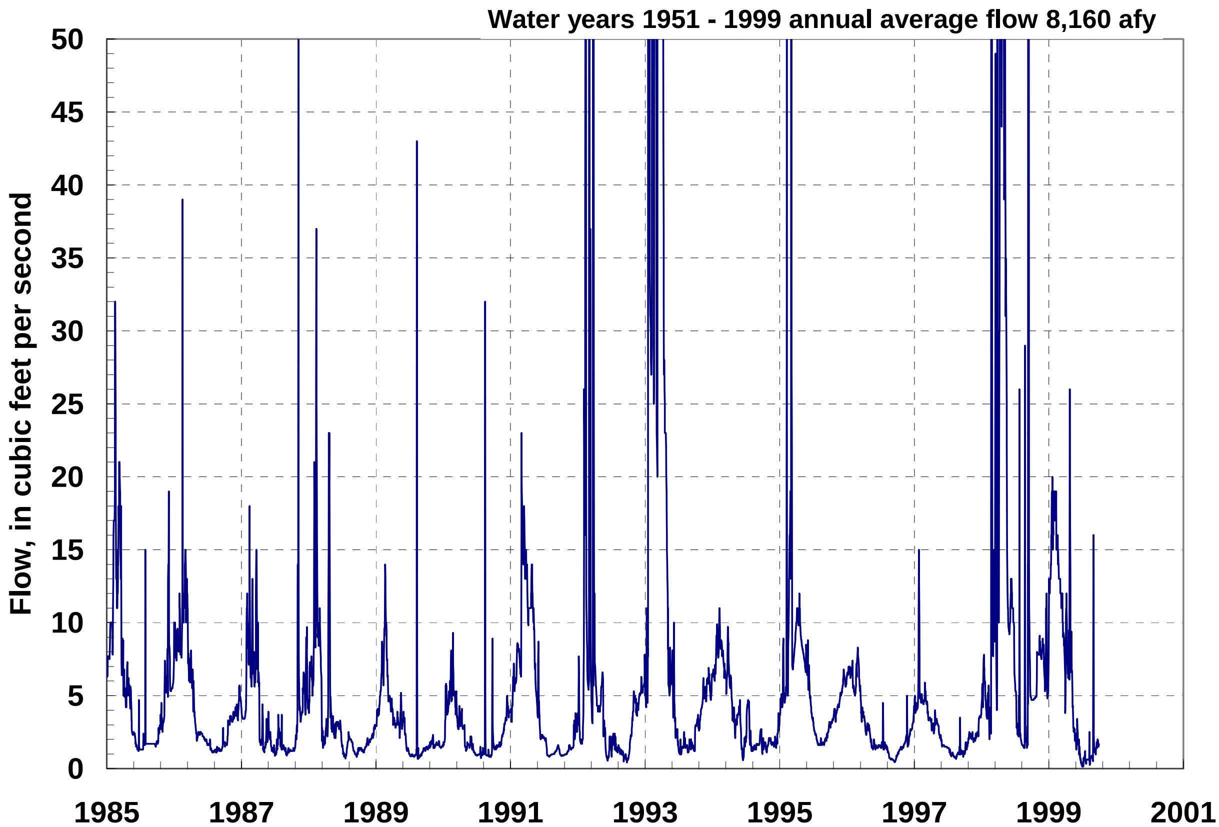


Figure 5-6. Daily mean flow at USGS gaging station *09418500 Lower Meadow Valley Wash near Caliente, NV.*

Spring flow in Lower Meadow Valley Wash also exists near Rox and Ferrier based on field investigations and historic USGS gaging stations *09418700 Meadow Valley Wash near Rox, NV* **(Figure 5-7)** and station *09418750 Meadow Valley Wash below Ferrier near Rox, NV.* Relatively small volumes of water are discharged at these sources and the water is entirely consumed through ET. These locations are utilized as ET areas in the ground-water flow model.

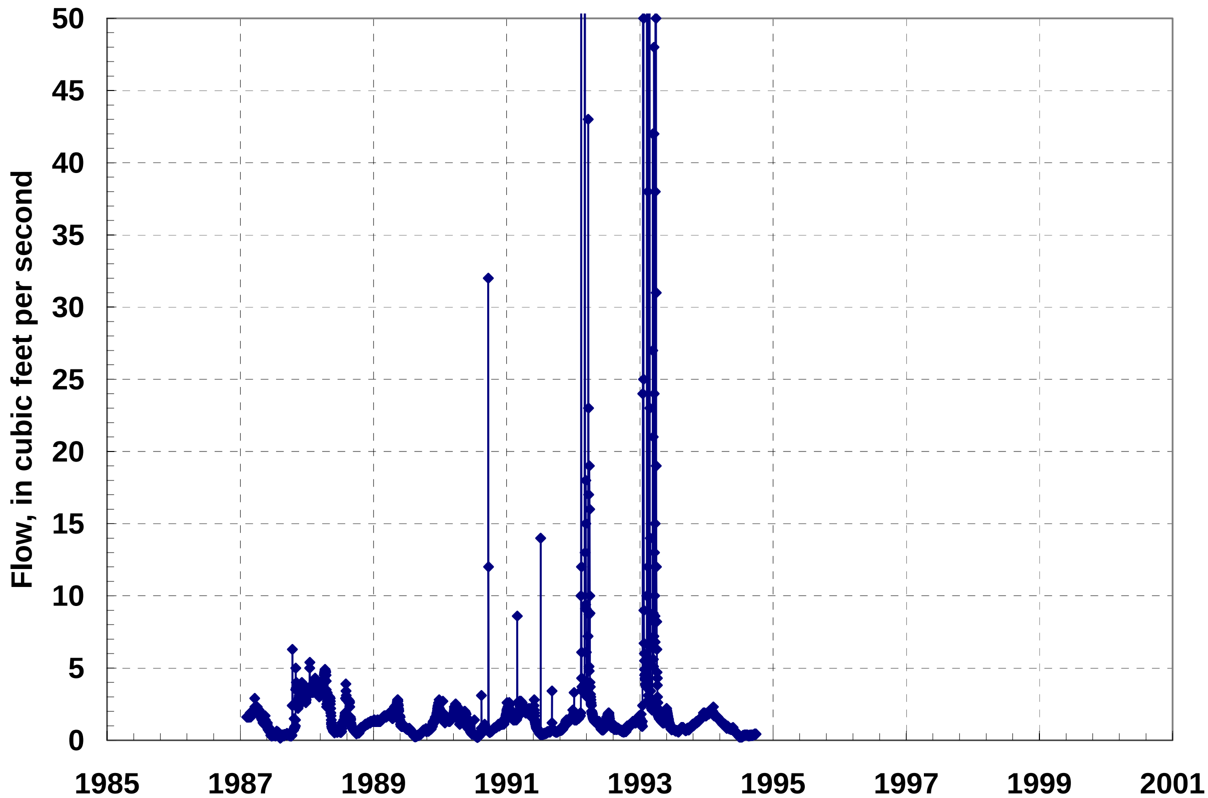


Figure 5-7. Daily mean flow at USGS gaging station *09418700 Lower Meadow Valley Wash near Rox, NV*

5.1.5 Blue Point and Roger Springs (North Shore Complex)

Springs located on the west side of the Overton Arm of Lake Mead, as a group, have been termed the North Shore Complex (Pohlmann et al., 1998). Two of the most notable springs in this complex are Rogers and Blue Point Springs. The USGS has measured Rogers Spring since October 1985, and the average flow has been relatively constant at 1.6 cfs **(Figure 5-8)** (USGS Water-Data Reports, Water Years 1984 through 1999). The average flow of Blue Point spring is 0.6 cfs. Combining these measured flows with additional flow from smaller springs in the complex, an annual average discharge of approximately 2,000 afy is utilized in the water budget and during calibration of the ground-water flow model.

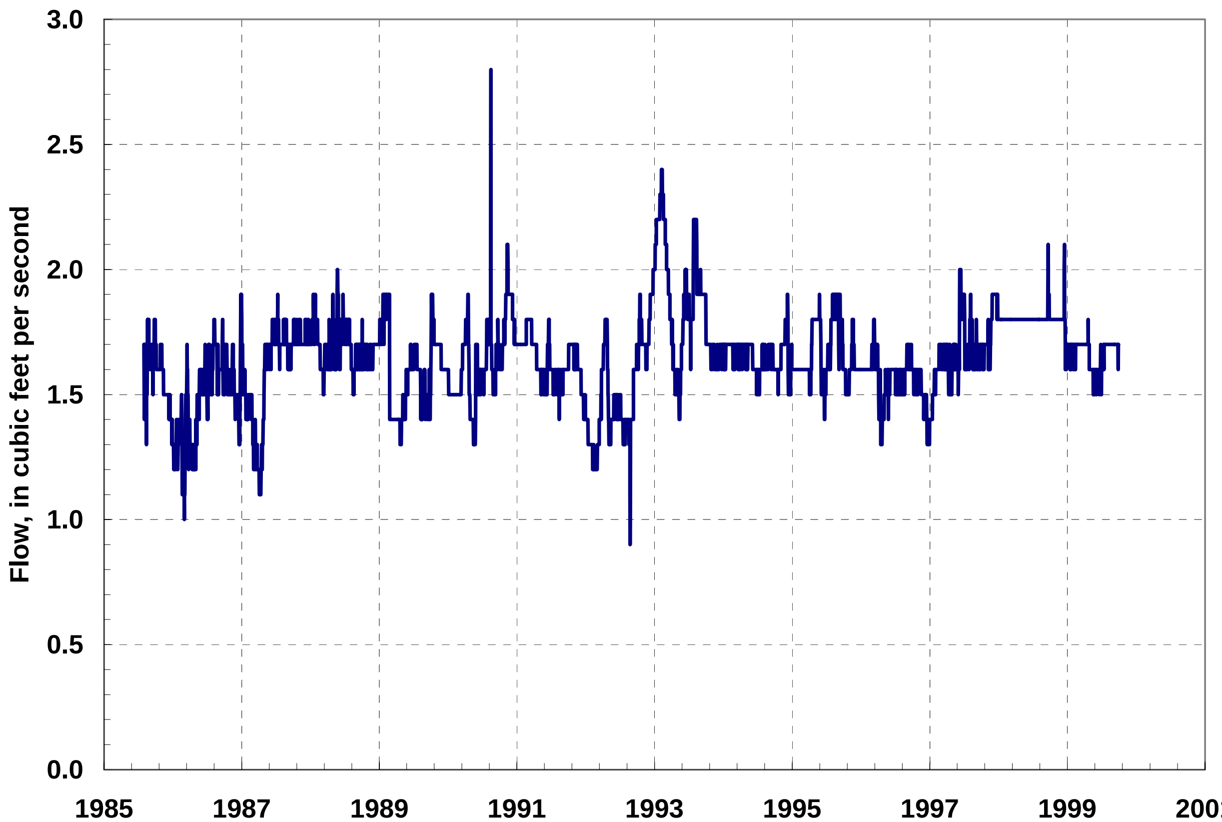


Figure 5-8. Daily mean flow at USGS gaging station *09419550 Rogers Spring near Overton Beach, NV.*

5.2 GROUND WATER AND SURFACE WATER INTERACTION

5.2.1 Muddy Springs Area

Development of water resources in the Muddy Springs area began around 1947 when the first well was drilled as described in Section 8 and Appendix B. Diversions of surface water upstream of the Moapa gage began in 1968 when the Nevada Power Company leased 1920 decreed Muddy River water rights from the Muddy Valley Irrigation Company.

A correlation exists between the ground-water pumpage in the Muddy Springs area of Upper Moapa Valley and the decline in stream flow at the Moapa gage. The measured flow at the Moapa gage without flood flows and the corresponding volume of ground-water pumpage and surface-water diversion, which are described in Section 8 and Appendix B, are shown on **Figure 5-9**. Subtracting ground-water pumpage and surface-water diversions from the pre-development stream flow of water year 1946 for each water year from 1947 to 2000 equals a theoretical flow that closely approximates the actual measured flow **(Figure 5-10)**. This suggests the decline in gage flow at the Moapa gage is directly related to ground-water pumpage and surface-water diversions. The exception to this is water years 1998 to 2000. To correct for this, only the valley-fill ground-water pumpage and surface-water diversions are subtracted from the pre-development stream flow of water year 1946 (carbonate ground-water pumpage is excluded), and a better comparison is achieved for water years 1998 to 2000 **(Figure 5-11)**. Inclusion of the carbonate pumpage yields a difference from the gage flow, while the exclusion of the carbonate pumpage yields a closer comparison to the gage record. This suggests that ground-water pumpage from the carbonate aquifer may not be having an effect on the flows at the Moapa gage. Future observations of stream flow and ground-water pumpage will need to be collected to further corroborate this hypothesis. The comparison of gage flow and pumpage/surface-water diversion records does not directly answer the question if spring flow is decreasing. Therefore the gage records at spring orifices were also examined.

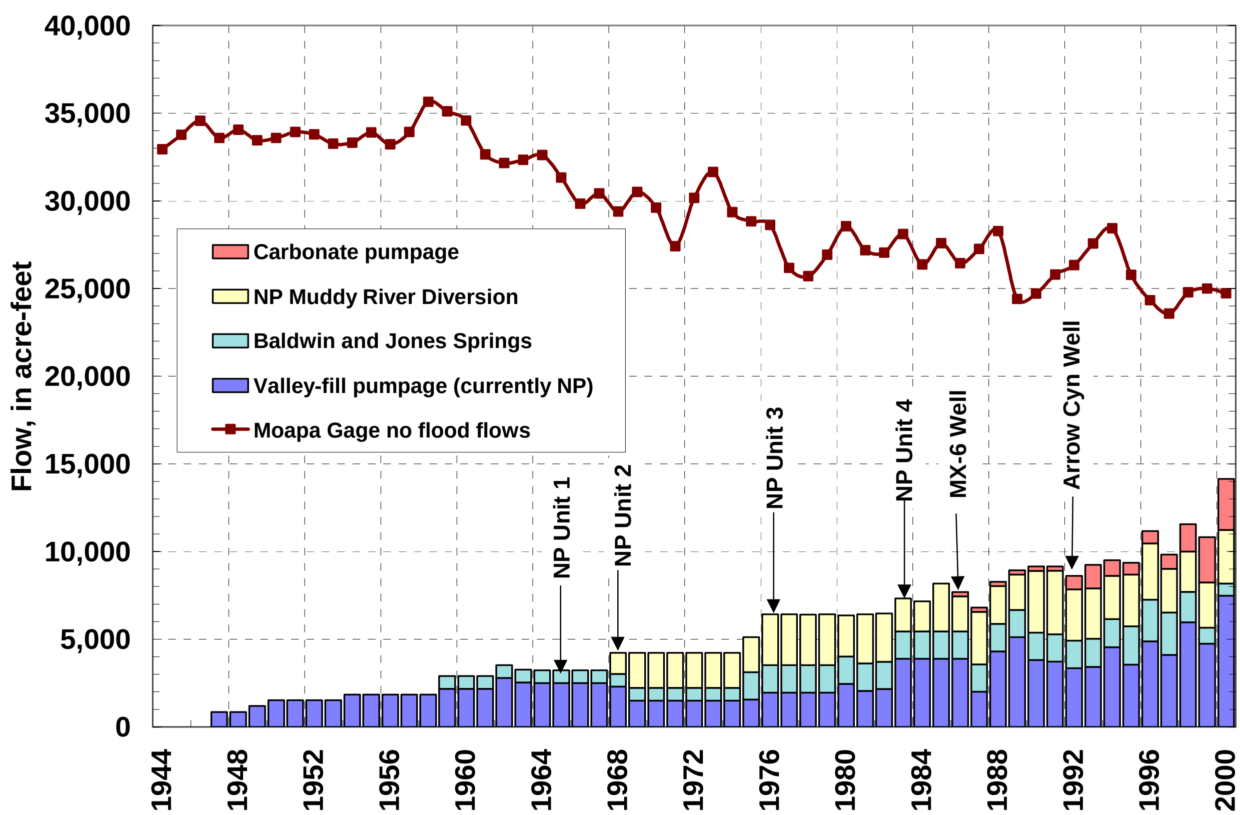


Figure 5-9. Annual flow without flood flows at USGS gaging station *09416000 Muddy River near Moapa, NV*, compared to ground-water pumpage and surface-water diversions. The year key production wells became operational as well as each generating unit at Nevada Power Company's Reid Gardner power generation station is also indicated.

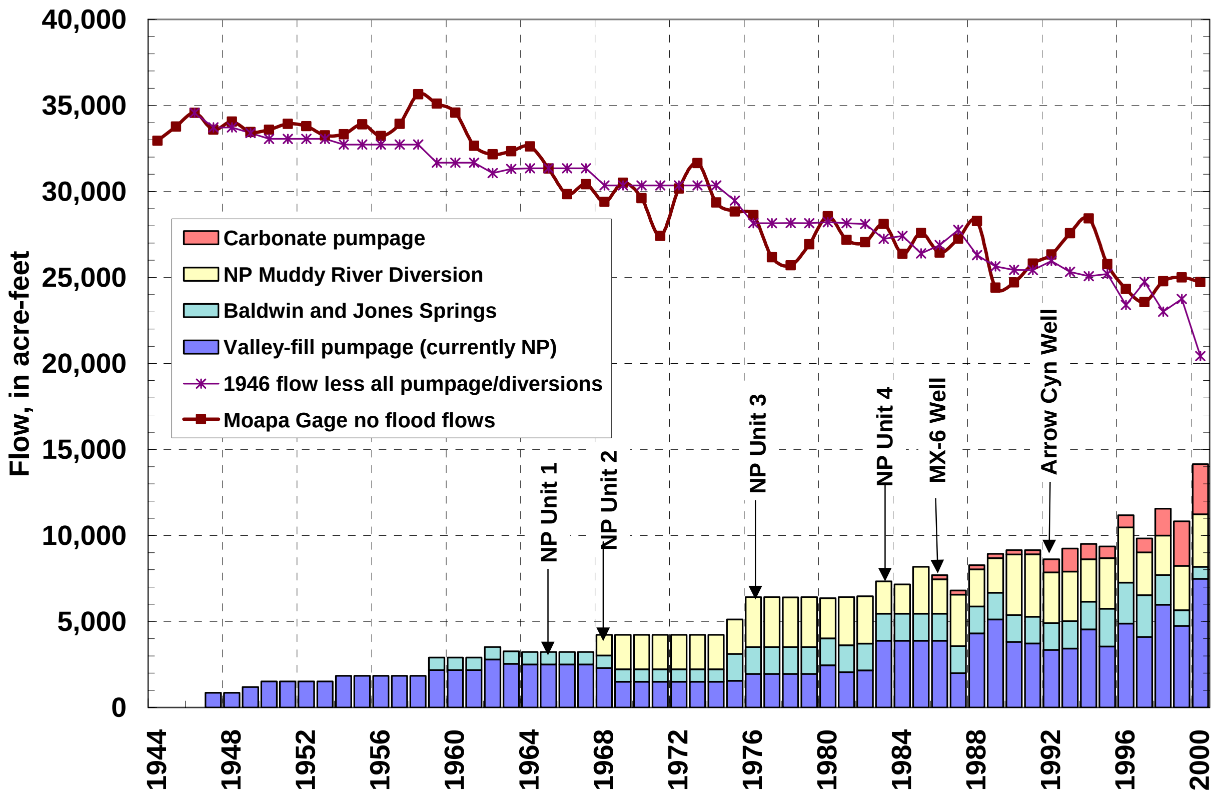


Figure 5-10. Comparison between decline in flow at the Moapa gage and nearby ground-water pumpage and surface-water diversions.

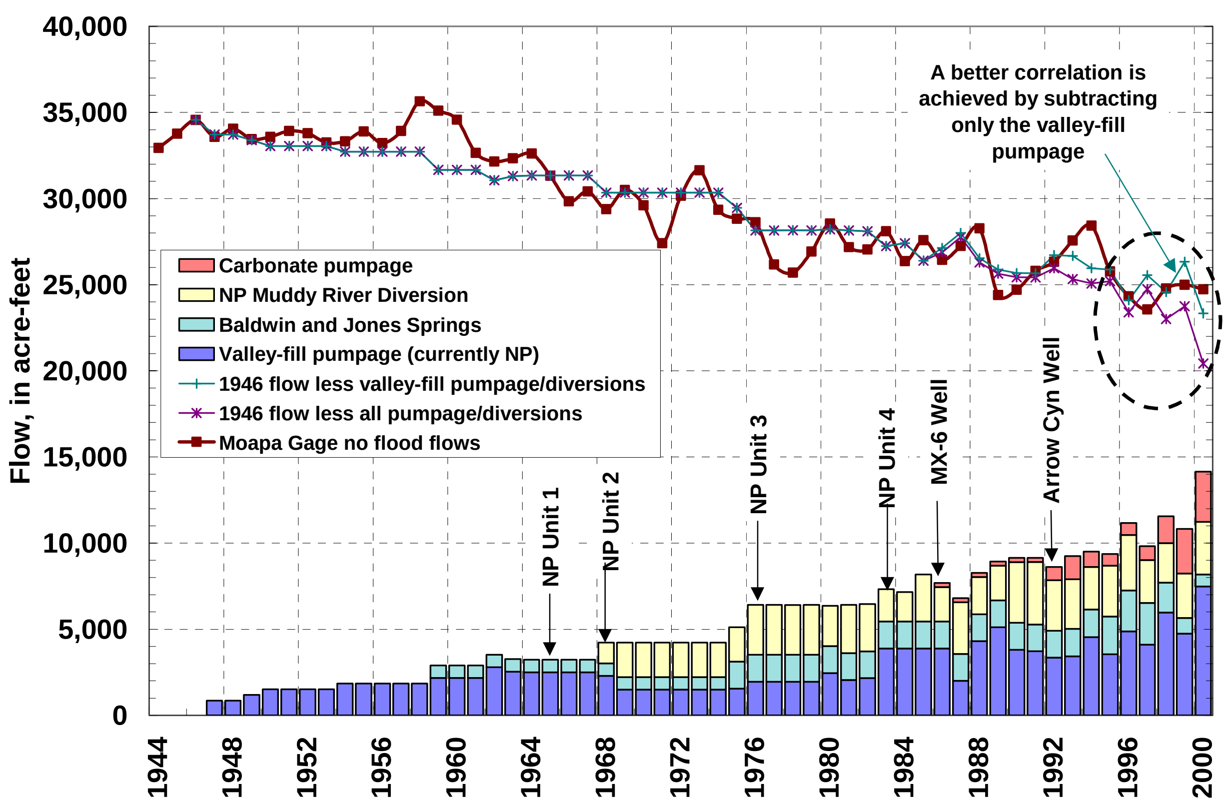


Figure 5-11. Comparison between decline in flow at the Moapa gage and valley-fill vs. carbonate ground-water pumpage and surface-water diversions

Spring discharge at USGS gaging stations: Muddy Springs at LDS Farm near Moapa, NV; Pederson Spring near Moapa, NV; and Warm Springs West near Moapa, NV show a relatively constant flow during the period of record for the gages **(Figure 5-12** and **Figure 5-4)**. This spring discharge remains constant when ground-water pumpage and surface-water diversion are at an all time high. This constant flow combined with the observations at the Moapa gage that the valley-fill pumpage has caused the decline in the streamflow at the gage supports Eakin's (1964) conclusion "…ground water in the valley fill, which is a natural reservoir, is recharged largely from the springs." and "In effect, the natural regimen of the springs is one of relatively constant flow year round."

Eakin's (1964) conclusions are also supported by the fact that seasonal valley-fill ground-water pumpage occurring in the Muddy Springs area above the Moapa gage has not caused long-term, declining water levels even though they have been pumped for up to 50 years (See **Appendix C** for hydrographs on Lewis north and Lewis south wells).

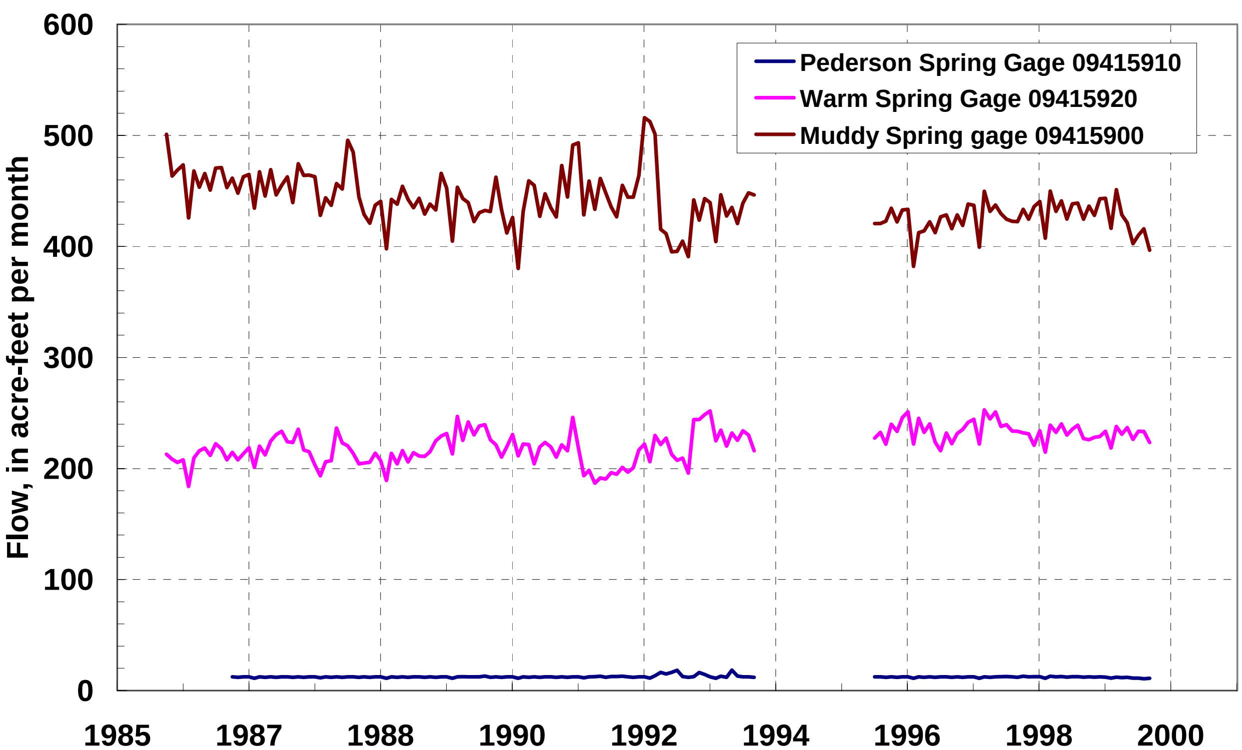


Figure 5-12. Monthly mean spring flow at three USGS gaging station*s* in the Muddy Springs area.

5.2.2 Moapa Gage to Glendale Gage

Approximately 1,830 acres of phreatophytes existed between the Moapa and Glendale gages under pre-development conditions. Using a consumptive use rate of 5 ft/acre the phreatophytes consume approximately 9,000 afy. Under current conditions the phreatophytes have been replaced with agricultural fields on the Moapa River Indian Reservation and the Hidden Valley

Ranch. Utilizing September 2000 aerial photography, the current estimated consumptive use continues to be approximately 9,000 afy, which is also supported by the Moapa/Glendale gage correlation discussed below.

Flows at the Glendale gage correspond to flows at the Moapa gage and do not show the 9,000 afy loss due to ET **(Figure 5-13)**. Based on the close comparison between the two gages and the calculated losses between the gages, additional inflow from California Wash and/or Lower Meadow Valley Wash is suggested. In this study approximately 9,000 afy of ground-water inflow is estimated to occur between the Moapa and Glendale gages (6,000 afy from California Wash and Upper Moapa Valley below the Moapa gage and 3,000 afy from Lower Meadow Valley Wash), thus matching the historical gage records.

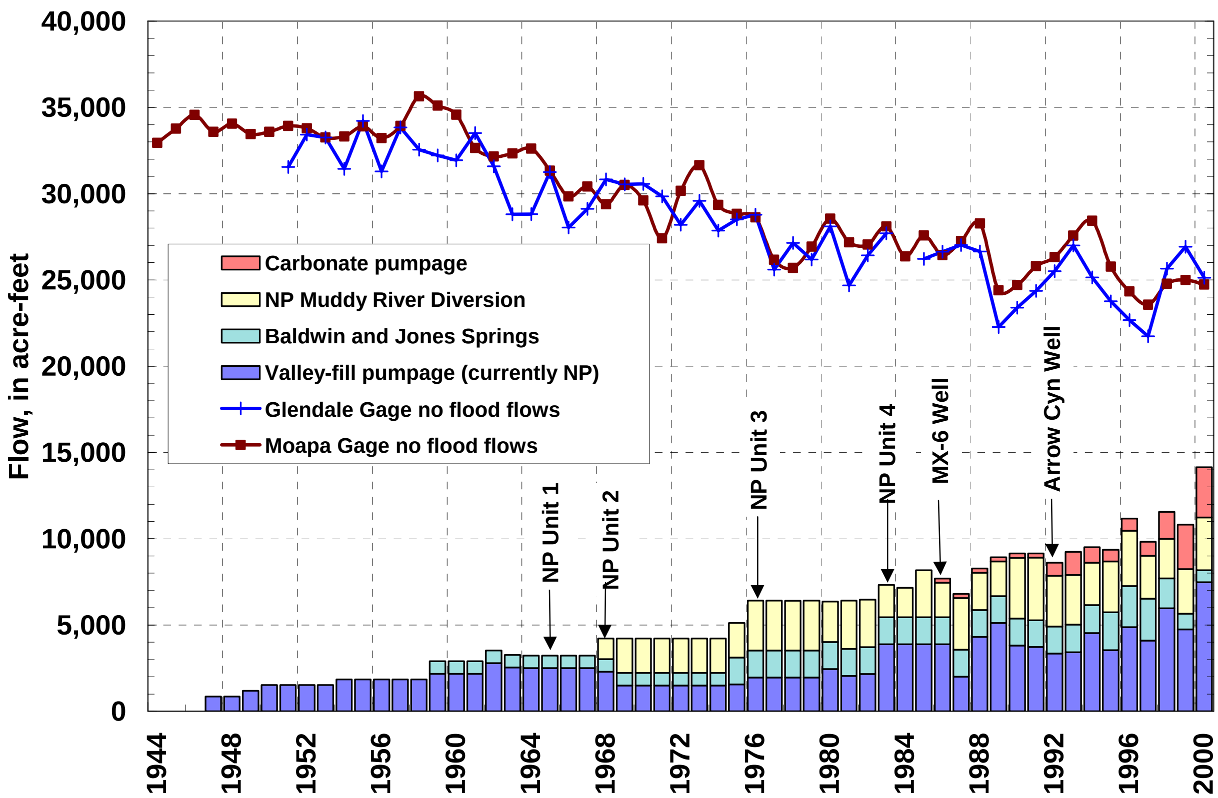


Figure 5-13. Comparison between the measured flow at the Moapa and Glendale gages without flood flows.

5.2.3 Glendale Gage to Overton Gage

The surface-water flow of the Muddy River was decreed under Nevada State Statute in 1920. Virtually all of the decreed surface-water rights in the early 1900's were utilized in Lower Moapa Valley, and based on 1944 and 1974 water right maps (Plan of Muddy River showing decreed water rights, U.S. Dept. of Interior, Office of Indian Affairs and map accompanying proof of beneficial use under permits 21847 and 21873 to 21877 respectively), the entire flood plain of the lower Muddy River was under cultivation. Due to limited availability of information about cropping patterns in Lower Moapa Valley, a detailed analysis of diversions, consumptive uses, and irrigation returns in the flood plain of Lower Moapa Valley was not performed. As stated in Section 5.1.3 the Overton gage is utilized in the development of the water budget and during model calibration only to approximate the magnitude of surface-water flows into Lake Mead since the majority of flow is irrigation returns and a detailed analysis of the current acreage of agricultural in Lower Moapa Valley was not conducted in this study.

6 WATER RESOURCE BUDGET

6.1 WATER RESOURCE BUDGET IN THE STUDY AREA

The water-resources budget for each valley in the study area is an accounting of ground-water inflow and outflow based on the local ground-water recharge, ground-water inflow if it occurs, and the local evapotranspiration. The ground-water outflow is the residual between inflow and evapotranspiration. These values are listed in **Table 6-1** and shown in **Figure 6-1**. Most of the valleys have ground-water inflow and all have ground-water outflow. The ground-water outflow from a valley becomes the inflow to the adjacent down gradient valley. There are some unknowns in this routing of ground water between valleys. We do not know, for instance, if Cave Valley is tributary to White River Valley or to Pahroc. Large structural features in the west-central part of the South Eagan Range may be an avenue for ground-water flow from Cave Valley to White River Valley. Sparse water-level data indicate the flow may be to Pahroc Valley out of the south end of Cave Valley. It makes little difference in the overall project goal, however, it does cause discontinuity between the interpretation in this routing and the geochemistry model by Thomas et al. (2001). The same is true for the ground-water flow from Coal Valley either into Pahroc Valley or Pahranagat Valley. In terms of the ground-water model this is not a problem because the model boundary has a ground-water flux across it that represents the residual ground-water outflow from all the up-gradient valleys.

In the model area for this section there is a lumping of ground- and surface-water flows together as inter-basin flow. As an example, ground-water discharge forms the surface water of the Muddy Springs and the springs become the Muddy River which is considered inter-basin flow from Upper Moapa Valley to California Wash and on into Lower Moapa Valley. Ground-water flow into the model area from Panaca Valley has a surface-water component that is not separated out. In the ground-water model the distinction is made between ground and surface water regardless of where it occurs. **Table 6-2** lists the sum of the budget components for the entire study area. The water-resources budget for the model area is listed in **Table 6-3**. These three budget variations are considered a water-resources budget which is dominated by ground water, based on the values listed in **Table 6-1**.

6.2 GROUND-WATER YIELD

Historically, in the ground-water basins of Nevada, the perennial yield for a ground-water system was based on the amount of discharge by ET that could be reasonably captured and the value varies per basin. The concept of perennial yield can also extend to the capture of ground-water outflow from major flow systems such as the White River and Meadow Valley through deep seated carbonate rocks underneath Lake Mead and the Colorado River. However, the complexity of the relationship between surface and ground-water, recharge and discharge, and geology and hydrology is such that generally the total discharge can never be captured, no matter if the discharge is from ET or ground-water outflow. This is further complicated by the vast amounts of water in storage in the carbonate aquifer and the overlying alluvial aquifers and the long transient time, measured in hundreds to thousands of years (Thomas et al., 1991), for ground water to move from recharge areas to discharge areas.

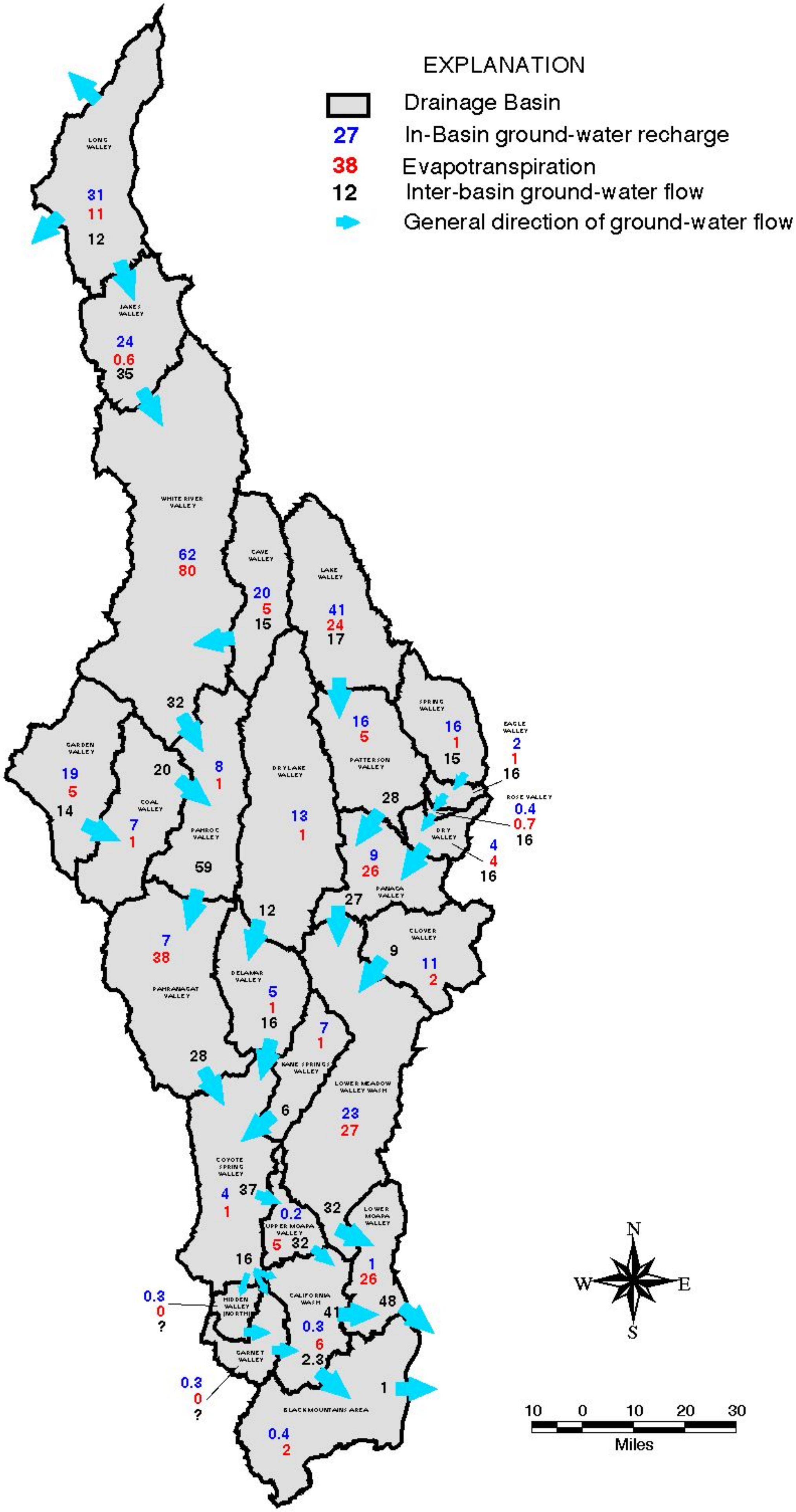


Figure 6-1. Generalized ground-water recharge, evapotranspiration, and inter-basin flow of the White River and Meadow Valley Flow Systems, units in thousands of acre-feet per year.

Table 6-1. Ground-water recharge, discharge, and inter-basin flow for selected Colorado River Basins in Nevada, in thousands of acre-feet/year (rounded).

Valley	Recharge from precipitation	Ground-water inflow	ET	Ground-water outflow	
				To	Volume
WHITE RIVER GROUND-WATER FLOW SYSTEM					
Long	31[a]	0	11	Jakes	12
Jakes	24	12	.6	WRV	35
Cave	20	0	5	WRV	15
WRV	62	50	80	Pahroc	32
Garden	19	0	5	Coal	14
Coal	7	14	1	Pahroc	20
Pahroc	8	52	1	Pahranagat	59
Pahranagat	7	59	38	Coyote	28
Dry Lake	13	0	1	Delamar	12
Delamar	5	12	1	Coyote	16
Kane	7	0	1	Coyote	6
Coyote	4	50	1	U. Muddy	37
				Hidden	16
				Garnet	
Hidden	0.3	16	0	California Wash	17
Garnet	0.3		0		
U. Moapa	0.2	37	5	California Wash	32
California Wash	0.3	49	6	L. Moapa	41
				Black Mtn.	2.3
Black Mountain	0.4	2.3	2	Carbonate outflow	1
Subtotals	200.5		158.6		
MEADOW VALLEY WASH GROUND-WATER FLOW SYSTEM					
Lake	41	0	24	Patterson	17
Patterson	16	17	5	Panaca	28
Spring	16	0	1	Eagle	15
Eagle	2	15	1	Rose	16
Rose	0.4	16	0.7	Dry	16
Dry	4	16	4	Panaca	16
Panaca	9	44	26	LMVW	27
Clover	11	0	2	LMVW	9
LMVW	23	36	27	L. Moapa	32
L. Moapa	1	73	26	Carbonate outflow	48
Subtotals	123		116.7		
Totals	**324**		**275**		

a. Only 23,000 acre-feet included in totals, remainder to non-White River flow system valleys (Nichols, 2000).

Table 6-2. Water-resources budget for the White River and Meadow Valley flow systems.

INFLOW	Volume (afy)
Precipitation (6,635,741)	
Ground-water recharge	324,000
Total	**324,000**
OUTFLOW	**Volume (afy)**
Evapotranspiration	275,000
Ground water	36,000
Surface water	13,000
Total	**324,000**

Table 6-3. Water-resources budget for the model area.

INFLOW	Volume (afy)
Ground water	80,000
Local Recharge	37,000
Total	**117,000**
OUTFLOW	**Volume (afy)**
Ground water	36,000
Surface water	13,000
Evapotranspiration	68,000
Total	**117,000**

To salvage or capture ground-water that is being discharged through ET requires lowering the water table through ground-water pumping. Once the water table is lowered beyond the depth phreatophytes can reach with their roots then the ground water is considered salvaged. This simple concept is difficult to put into practice. For example in Las Vegas Valley where ground-water pumping has been ongoing for over a hundred years and the water table, at one time and in one area, was drawn down about 300 feet and in other parts of the valley there are still living remnants of phreatophytes, the mesquite forest, that once blanketed much of the valley (Pete Duncombe, horticulturist, LVVWD, oral commun., 2001).

In the Carbonate Rock Province of Nevada the alluvial system, which contains the phreatophytes, is on top of the carbonate rocks. Thus, recharge to the alluvial aquifers is mostly dependent on the recharge in the carbonate rock aquifers, and attempts to capture the perennial yield by developing wells in the carbonate aquifer are difficult. This is particularly true because of the vast distances between areas of large ET volumes, such as Pahranagat and White River Valleys and areas of potential high development of ground water, such as the southern end of the White River Flow System. Thus the concept of the perennial yield regarding phreatophytes has certainly limited application in this instance. This same assumption also applies to the Meadow Valley Flow System. Virtually all of the ET located in the northern valleys such as Lake, Patterson, and Panaca is associated with agriculture. In Lower Meadow Valley Wash, much of the ET is associated with the perennial flow in the wash; for both phreatophytes and agriculture (see **Table 4-8** for a breakdown of ET by phreatophytes and agriculture). This surface flow is the result of ground-water discharge to the wash from the thin narrow strip of alluvium that occupies the canyon bottom.

It may seem simpler to capture ground-water outflow from the numerous basins, but it is not. Ground-water flow in carbonate rocks is probably along preferred pathways caused by fractures, which are related to earth movements and to some extent dissolution of the rock-aquifer. While we generally believe fault systems have a higher probability of being conduits for ground-water flow rather than retarding flow as a barrier it is difficult to define the ground-water flow along these pathways which in turn makes predicting impacts very uncertain. The net discharge from the two ground-water flow systems, White River and Meadow Valley, occurs at great depth through the carbonate rocks underneath Lake Mead and possibly into or underneath the Colorado River and is estimated to be 49,000 acre-feet/year. This outflow includes about 10,000-20,000 afy of surface water from the Muddy River to Lake Mead.

In summary the perennial yield for the entire Colorado River Basin Province in Nevada can not be defined as it has been in the past for individual basins without regard for interbasin flow. Furthermore, capturing or salvaging this outflow is nearly impossible to do simply because of the complexity of the fracture-flow system, the vast amounts of water in transient storage, and the long transient time of ground-water movement.

The "Safe Yield" is also equally difficult to apply and has some commonality with perennial yield. The two yields differ because "Safe Yield" does not depend on estimating "Perennial Yield". This term as indicated by Lohman (1972, p. 61) "….has about as many definitions as the number of people who have defined it." Meinzer (1920, p.330) first defined the term as "….The rate at which the ground water can be withdrawn year after year, for generations to come, without depleting the supply." Todd (1959, p. 200) states "The safe yield of a ground-water basin is the amount of water that can be withdrawn from it annually without producing an undesired result." Lohman (1972, p. 62) offers his own definition as " The amount of ground water one can withdraw without getting into trouble". There are many other definitions for this term that are directed to specific cases, but the one by Lohman (1972, p.62) has the most appeal. "Getting into trouble" is to cause undesirable impacts, which can mean a wide variety of resultant actions and in particular a decrease in discharge of Muddy, Rogers or Blue Point Springs. This is an impact that can be avoided with monitoring and mitigation.

Therefore, we believe an alternative definition for ground-water yield from the Colorado River Basin Province is the <u>*Available Yield*</u>. We define this as the amount of water that potentially is available over hundreds of years from the ground-water system. This term does not recognize economic constraints, but relies entirely on the volume of water in storage, the long transient times, and the annual recharge to the ground-water system. The amount of ground water in transient storage is enormous. If, for example, we consider just that part of the carbonate aquifer in the modeled area **(Table 6-4)** the estimated specific yield as reported by Dettinger et al. (1995, Table 13, p. 72) is 0.01 (dimensionless) so there may be as much as two million acre-feet of water in storage in every 100 feet of saturated carbonate rock. The combined alluvial aquifers of the above valleys are smaller in area and contain over four times as much water as the carbonate rocks, assuming a specific yield of 15 percent (~ 9 million acre-feet). So the amount of available yield as storage in just the top 100 feet of saturated carbonate rock and alluvial aquifer dwarfs the estimated annual recharge of about 117,000 acre-feet to these valleys. We are not advocating allocating the vast amount of water in storage, but we do believe there are sufficient uncertainties in the components of the water budget that cannot be resolved in the short term and there is probably more water available than we have defined. Thus a portion of the transient storage can be used safely, particularly with a monitoring plan in place, to further the economic interests of the state and at the same time provide much needed hydrogeological data.

Table 6-4. Estimated transitional ground-water storage in modeled area.

Valley	Estimate ground-water storage in upper 100 feet of saturated zone, in acre-feet.		Total (afy)
	Alluvial Basin	Carbonate Rock	
Kane Springs	529,000	150,000	679,000
Coyote Spring	2,546,000	392,000	2,938,000
Hidden	150,000	52,000	202,000
Garnet	500,000	102,000	602,000
California Wash	1,000,000	206,000	1,206,000
Black Mountain Area	1,113,000	409,000	1,522,000
Lower Meadow Valley Wash	2,800,000	606,000	3,406,000
Upper Moapa	30,000	93,000	123,000
Lower Moapa	800,000	176,000	976,000
TOTAL	**9,468,000**	**2,186,000**	**11,654,000**

7 ISOTOPE GEOCHEMISTRY

For this study, Thomas et al. (2001) conducted a reevaluation of the geochemistry of the White River and Meadow Valley ground-water flow systems. The executive summary for this report is provided below:

Deuterium data were used to evaluate new ground-water recharge and discharge (evapotranspiration) rate estimates developed by the Las Vegas Valley Water District (LVVWD, 2001) for the regional ground-water flow systems in southeastern Nevada. A deuterium-calibrated mass-balance model was constructed for the White River, Meadow Valley Wash, and Lake Mead (introduced here) ground-water flow systems. This model was used to evaluate if proposed ground-water recharge rates, evapotranspiration rates, sources, and mixing are possible or not. If model-calculated deuterium values for ground-water in the regional aquifers match measured values (within 2 permil), then proposed recharge rates, evapotranspiration rates, sources, and mixing for these flow systems are possible. However, the deuterium mass-balance model developed for the water budget of these flow systems produces a non-unique solution, because a proportionate decrease or increase in both recharge and ET rates, or a different combination of ground-water sources and mixing, can produce the same results.

Results of the deuterium mass-balance model show that:

> New estimates of ground-water recharge and evapotranspiration rates (Section 4.2), and proposed groundwater sources and mixing for the White River, Meadow Valley Wash, and Lake Mead flow systems are consistent with the results of a deuterium-calibrated mass-balance model.
>
> The White River Flow System acts as one continuous carbonate-rock aquifer from Long Valley in the north to Upper Moapa Valley (Muddy River Springs area) in the south.
>
> The results of the deuterium mass-balance model of the White River Flow System are consistent with 53,000 acre-feet per year (afy) of groundwater flowing out of Coyote Springs Valley to the Muddy River Springs area in Upper Moapa Valley (37,000 afy) and to the south-southeast in the carbonate-rock aquifers (16,000 afy).
>
> The Meadow Valley Flow System acts as a two-layer flow system with a carbonate-rock aquifer flow system to the north and west and a volcanic-rock alluvial-fill aquifer system to the east and south that overlies the carbonate-rock aquifer flow system.
>
> The results of the deuterium mass-balance model of the Meadow Valley Flow System are consistent with measured deuterium values in Panaca Valley for a two-layer regional flow system, but deuterium data are lacking for the underlying carbonate-rock aquifer in Lower Meadow Valley Wash, so the estimated 32,000 afy of groundwater flowing out of Lower Meadow Valley Wash to Upper Moapa Valley cannot be evaluated.
>
> The Lake Mead Flow System is primarily a carbonate-rock aquifer flow system that transports groundwater from the White River and Meadow Valley flow systems to Lake Mead.

The results of the deuterium mass-balance model of the Lake Mead Flow System are consistent with 16,000 afy of groundwater flowing from the Coyote Springs Valley-Upper Moapa Valley area to the Hidden Valley-Garnet Valley-California Wash Valley area.

The deuterium mass-balance model of the Lake Mead Flow System cannot evaluate the inflow of 32,000 afy from Lower Meadow Valley Wash and 8,000 afy from California Wash Valley to Upper Moapa Valley because of the lack of deuterium data for groundwater in the carbonate-rock aquifer in Upper Moapa Valley.

The deuterium mass-balance model of the Lake Mead Flow System indicates that ground-water discharging in the Rogers and Blue Point springs area is mostly regional ground-water flow in the carbonate-rock aquifers with some local recharge. However, on the basis of deuterium data, another water source for the spring area from Upper Moapa Valley cannot be ruled out.

Preliminary analyses of oxygen-18 and geochemical data show that these data are consistent with the deuterium mass-balance model of the regional flow systems.

More work needs to be done to better define deuterium compositions of recharge-area ground-waters (many recharge areas have little or no data) and the variability of deuterium values of springs in recharge areas over time.

8 GROUND-WATER FLOW MODEL

A ground-water model was developed for the southern part of the study area **(Figure 8-1)**. The geographic extent of the model includes Coyote Spring Valley, Kane Springs Valley, Garnet Valley, Hidden Valley, California Wash, Lower Meadow Valley Wash, Upper Moapa Valley, Lower Moapa Valley, and Black Mountains area. This region, which is referred to as the model area, has an area of approximately 3,400 mi^2, and an elevation range of 1,200 to 10,000 ft above sea level.

The model was developed for three purposes: First, to test the hydrogeologic and hydrologic conceptualization of the modeled area; second, to examine the impacts of current and past water use on spring flows and ground-water levels; and third, to identify the effects of future water use on spring flows and ground-water levels. To accomplish these purposes, the model was constructed to represent the 56-year historical period 1945-2000 and the 61-year future period 2001-2061. The model simulates these periods using one-year time steps.

8.1 DESCRIPTION OF CONCEPTUAL MODEL

8.1.1 Hydrogeologic Conceptualization

The hydrogeologic conceptualization of the modeled area includes six hydrogeologic units (described in the Geology section). These include basement rocks of Cambrian and older age, carbonate rocks of Cambrian to upper Paleozoic age, clastic rocks of predominately Mesozoic age, volcanic and intrusive rocks of Tertiary age, and alluvial deposits of upper Tertiary to Quaternary age. The stratigraphic relationships among units are shown on **Figure 8-2**, which diagrammatically shows the presence or absence of each hydrogeologic unit in the modeled area, based on the geographic delineations shown on **Figure 8-3a** through **Figure 8-3d**. The subareas referenced on **Figure 8-2** relate to the structure blocks shown on **Figure 8-4**.

The basement rocks include the Lower Cambrian Prospect Mountain Quartzite, Wood Canyon Formation, and the Proterozoic Vishnu Schist, and Gold Butte Metamorphic Complex. These rocks consist of clastics (quartzite) and metamorphics, and they are non-water-bearing relative to the overlying carbonate rocks. Correspondingly, the top of the basement rocks form the base of the ground-water system.

The carbonate rocks **(Figure 8-3a)** include the Ordovician to Pre-Cambrian Antelope Valley Limestone and Goodwin and Nopah Formations. These rocks are overlain by the Ordovician Eureka Quartzite. The overlying Ordovician to Permian consists of Simonson and Laketown Dolomite, Guilmette Formation, Monte Cristo Group and the Bird Spring Formation. Within the modeled area, these rocks are as much as 27,000 ft in thickness. The carbonate rocks underlie essentially all of the modeled area except in the north where intrusive volcanic rocks penetrate the carbonate rocks, and in the southeast where clastic rocks directly overlie the basement rocks. The carbonate rocks are broadly folded, highly faulted, and fractured. Faulting occurs on both regional and local scales. On the regional scale, large-scale faults **(Figure 8-4)** that are nearly perpendicular to ground-water flow tend to restrict ground-water flow. On the local scale, small-

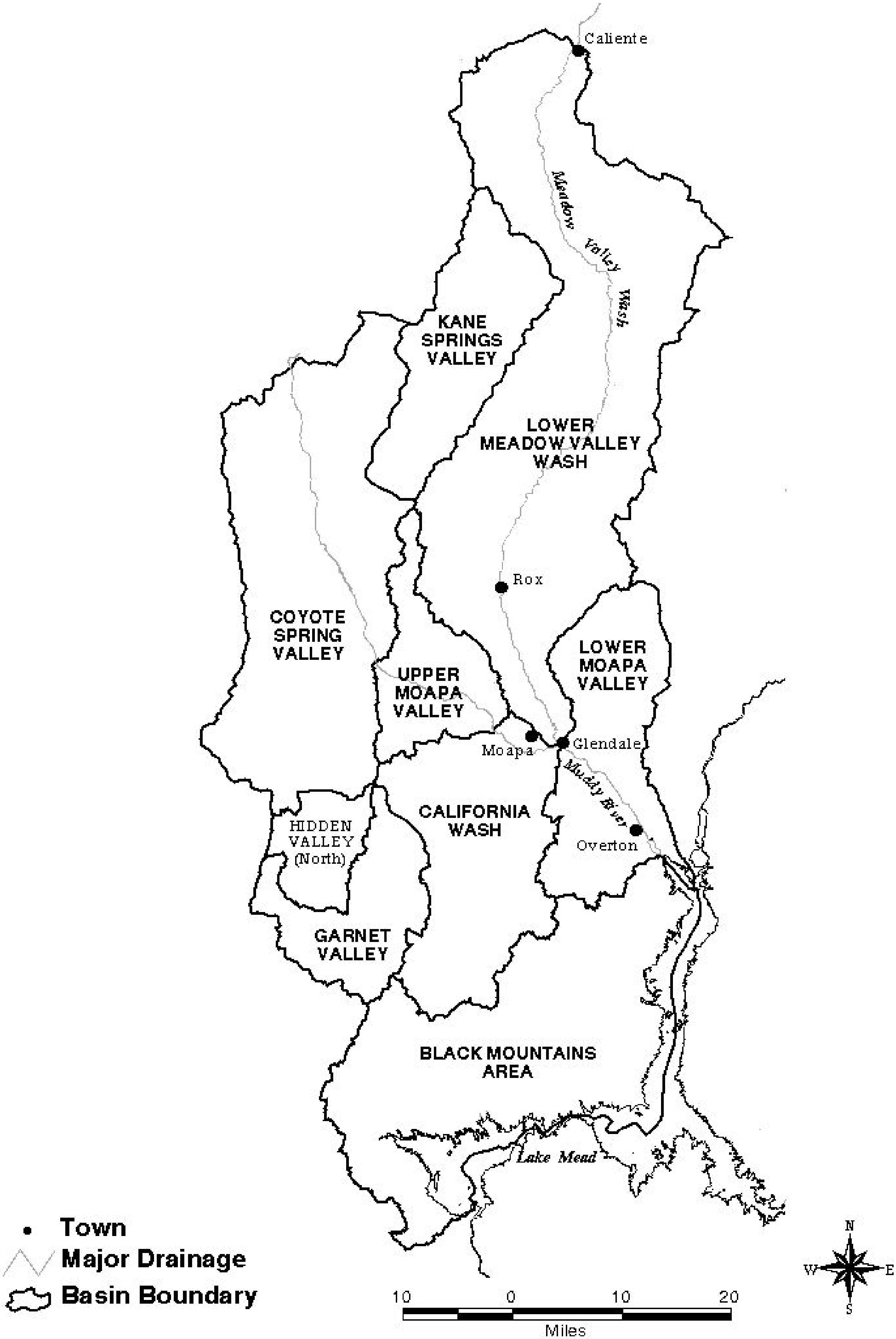
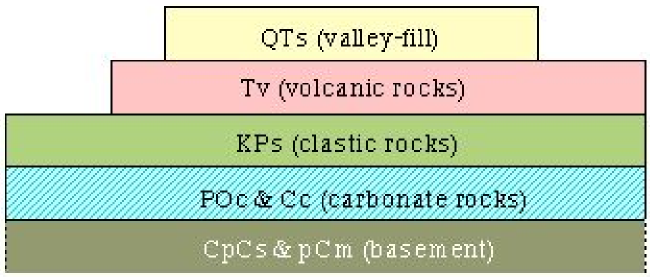
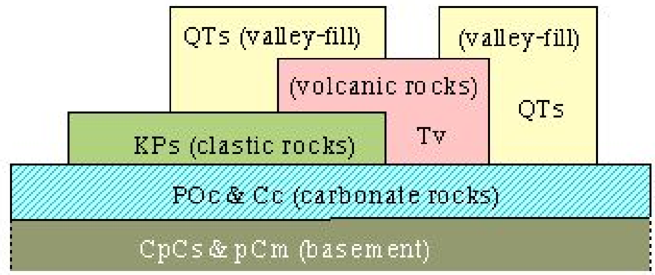


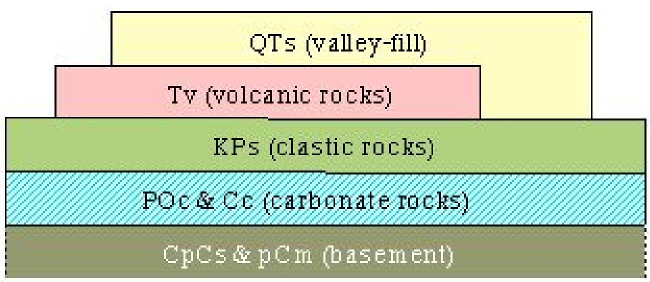
Figure 8-1. Model Area



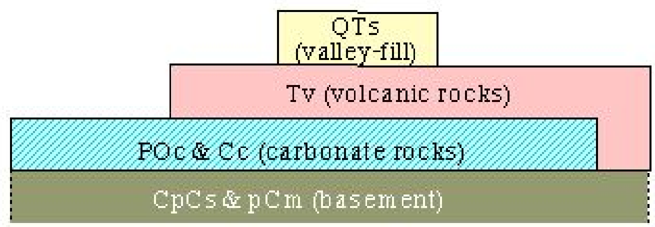
Lake Mead Subarea



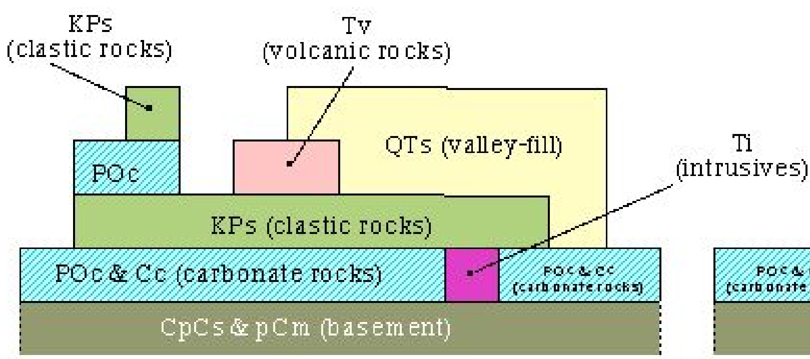
Muddy Spring Subarea



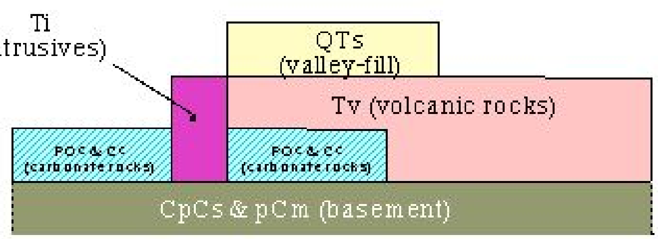
Black Mountains Subarea



Meadow Valley Mountains Subarea



Lower Moapa Subarea



Kane Springs Subarea

Figure 8-2. Stratigraphic relations within structural blocks.

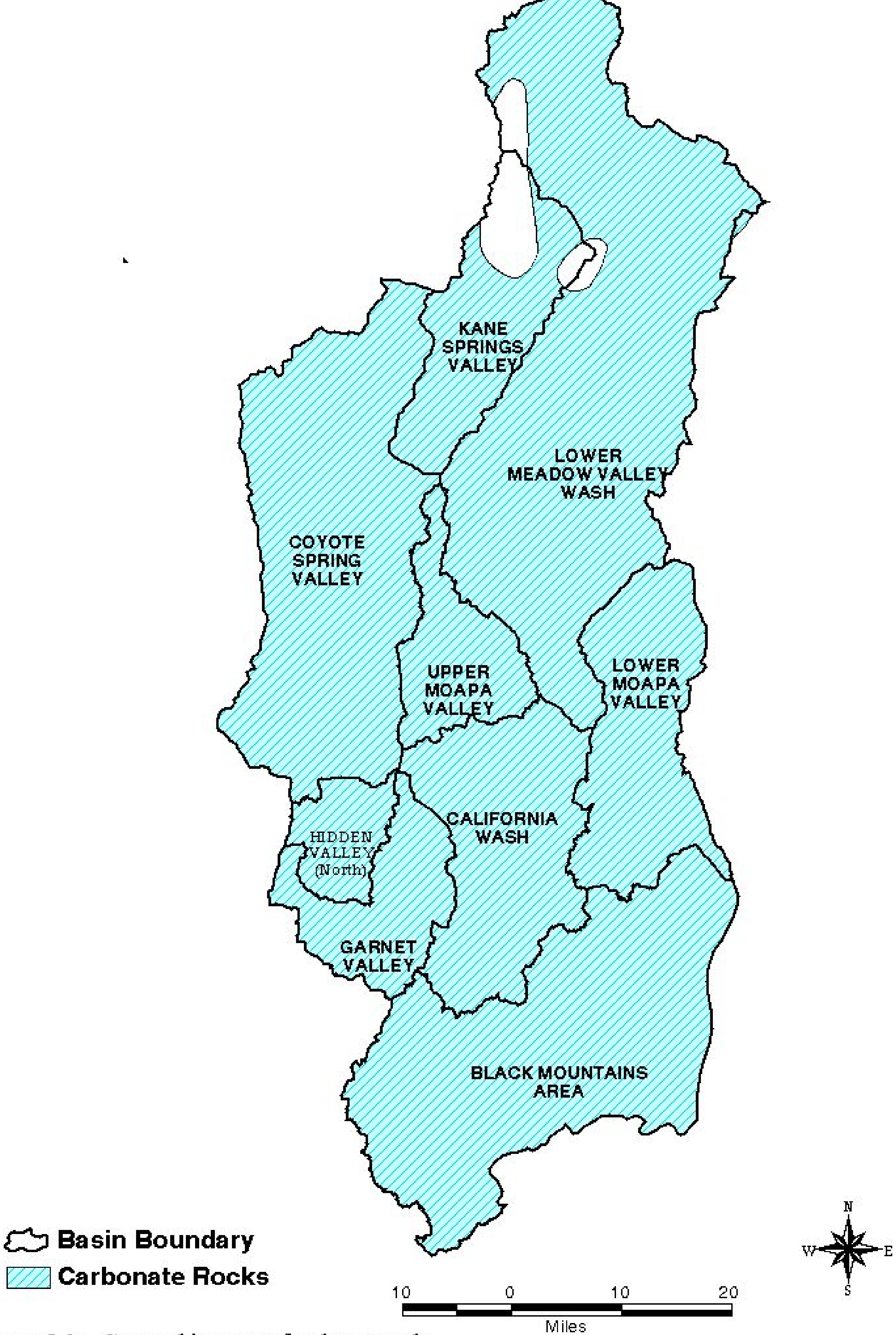


Figure 8-3a. Geographic extent of carbonate rocks.

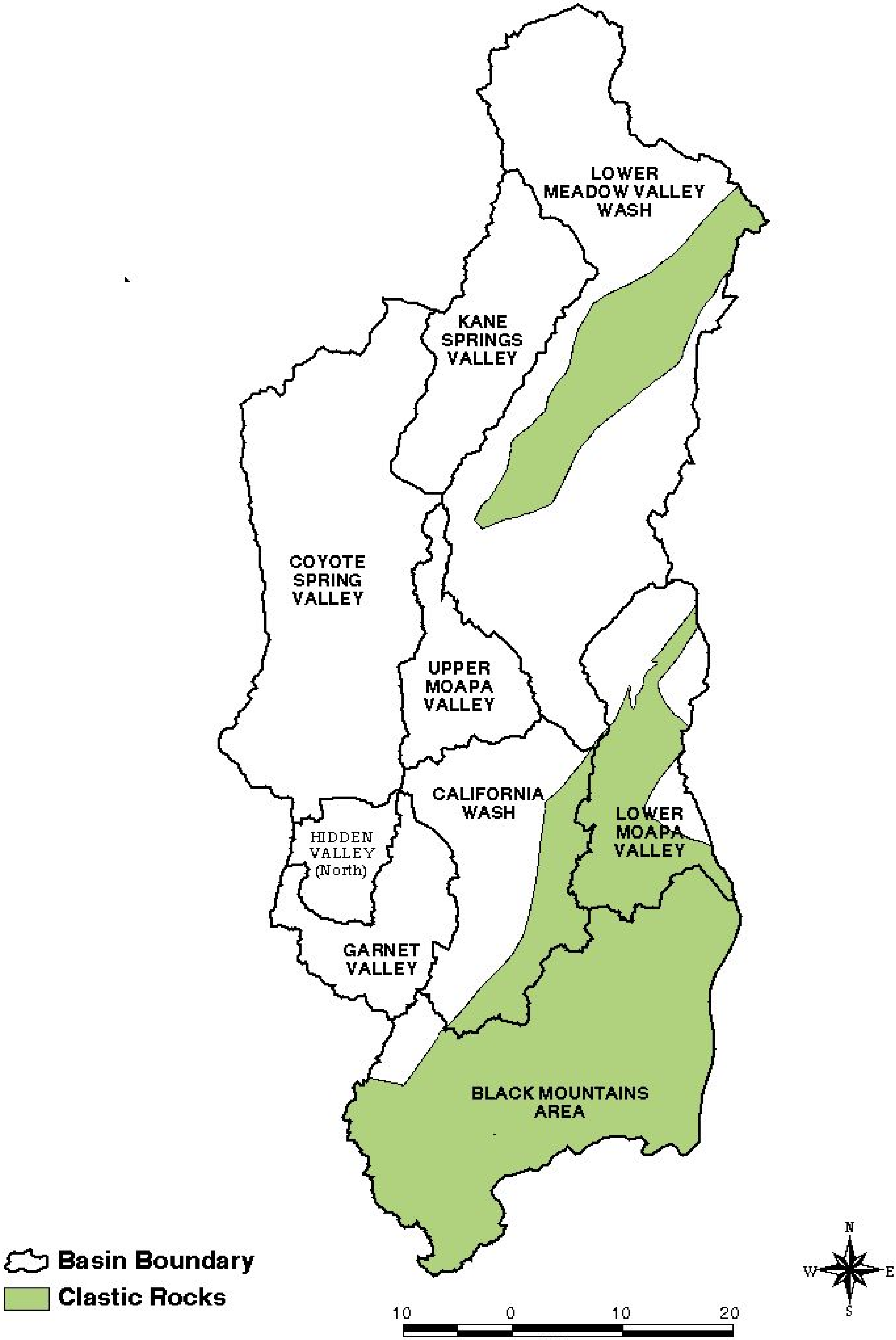


Figure 8-3b. Geographic extent of clastic rocks.

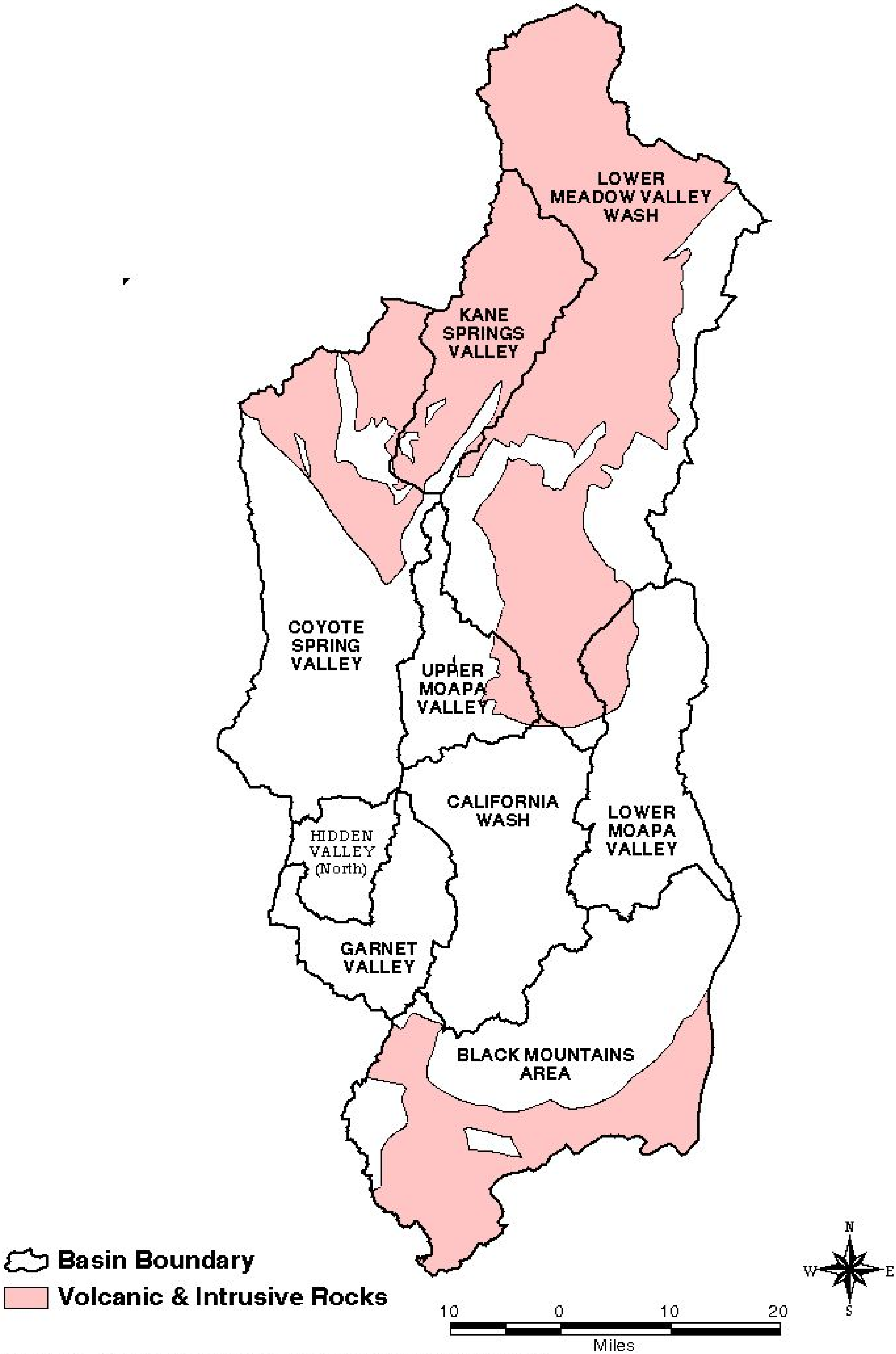


Figure 8-3c. Geographic extent of volcanic and intrusive rocks.

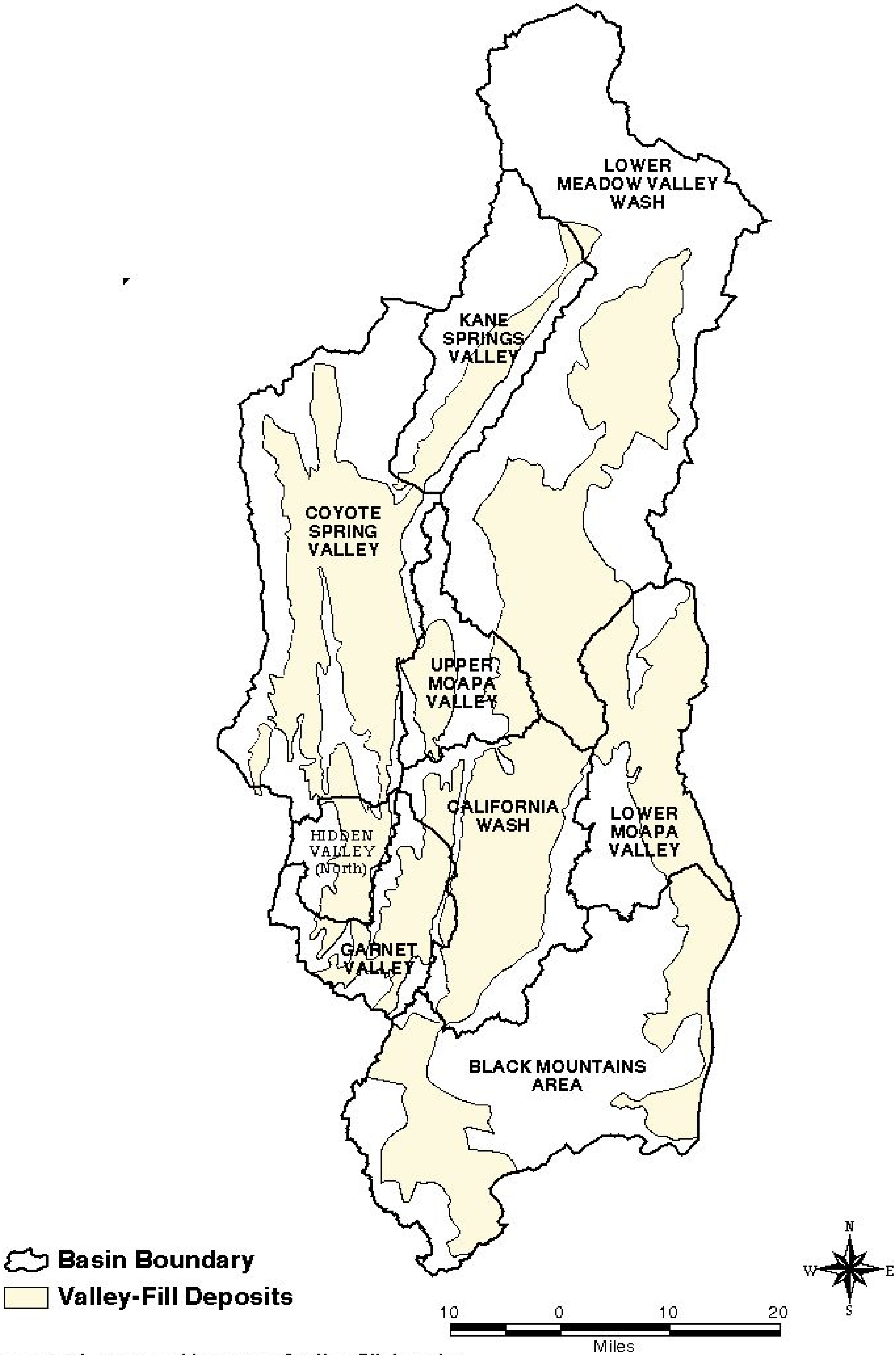


Figure 8-3d. Geographic extent of valley-fill deposits.

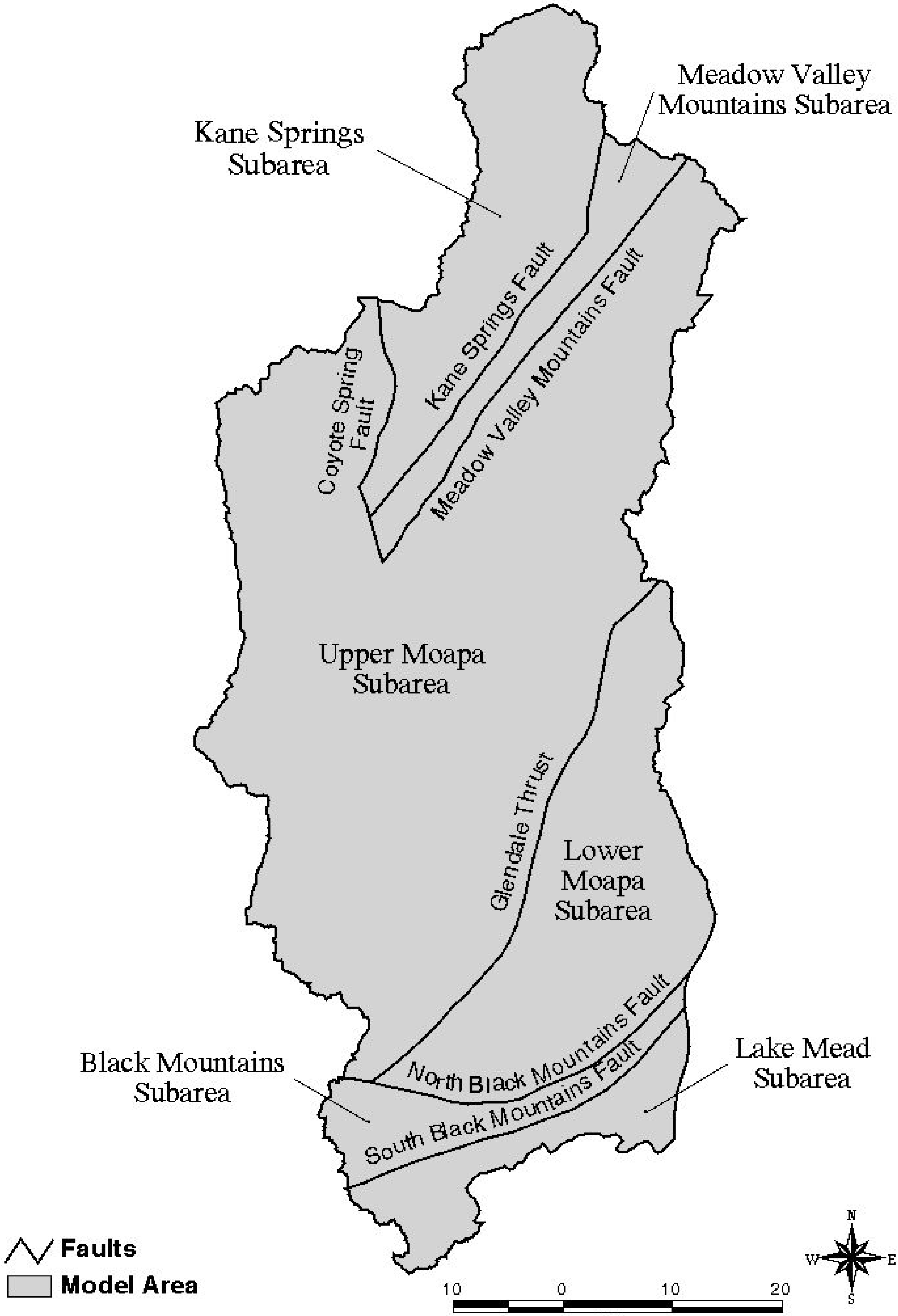


Figure 8-4. Structural blocks within the model area.

scale faults likely produce conduits for ground-water movement. Similarly, fractures likely produce conduits for ground-water flow. Most regional and local ground-water flow within the carbonate rocks occurs within the secondary permeability produced by faults and fracturing, and associated solution channels.

The clastic rocks **(Figure 8-3b)** include the Jurassic Aztec Formation, the Triassic Moenkopi and Chinle Formations and the Lower Permian red bed sequence, Kaibab Limestone and Toroweap Formation. Within the modeled area these rocks are as much as 10,000 ft in thickness. The clastic rocks underlie only a portion of the modeled area in the central and southern area. The clastic rocks have low permeability and form an aquitard overlying the carbonate rocks. While the clastic rocks are fractured, the fracturing has not produced significant secondary permeability vertically through these rocks.

The volcanic rocks **(Figure 8-3c)** include both intrusive and volcanic-flow units. Intrusive rocks occur principally in the northern part of the modeled area. The volcanic rocks occur principally in the northern and to a lesser extent, in the southern part of the modeled area. Within the modeled area, volcanic rocks are as much as 10,000 ft in thickness. The volcanic rocks have low permeability and tend to form an aquitard where they overlay the carbonate rock. Additionally, the volcanic rocks retard vertical ground-water flow where they overlay the clastic rocks, which also have low permeability.

The valley-fill deposits **(Figure 8-3d)** include Quaternary alluvial deposits, the Muddy Creek Formation, and the Horse Spring Formation. The alluvial deposits consist of unconsolidated sediments, the Muddy Creek Formation consists of fine-grained clastic and lacustrine sediments, and the Horse Springs Formation consists primarily of conglomerate. The valley-fill deposits overall are moderately permeable; however, the alluvial deposits tend to be more permeable than the Muddy Creek Formation. The valley-fill deposits tend to be thin relative to underlying units, but locally they are as much as 4,000 ft in thickness.

Regional faults partition the modeled area into hydrogeologic subareas **(Figure 8-4)**. The faults retard ground-water movement between the subareas. While local faulting has enhanced the secondary permeability of the carbonate rocks and perhaps other rocks, extensive lateral and vertical displacements on regional faults have had an opposite effect. This occurs because faulting has juxtaposed low-permeability beds opposite higher-permeability beds so as to block ground-water flow within higher-permeability beds. Additionally, the extensive displacements tend to be correlated with the formation of fault gouge or secondary mineralization along the fault plane. Both of these occurrences tend to restrict ground-water flow within the fault plane and transverse to the fault plane.

The regional faults partition the modeled area into six subareas **(Figure 8-4)**. The north Black Mountains Fault and south Black Mountains Fault divide the southern part of the modeled area into three subareas. South of the southern fault is the Lake Mead subarea, between the faults is the Black Mountains subarea, and north of the northern fault is the Lower Moapa subarea, where the Black Mountain subarea is displaced upward relative to the Lake Mead and Lower Moapa subareas. The vertical displacements are up to 2,000 to 3,000 ft on both faults. The Glendale Thrust separates the Lower Moapa subarea from the Upper Moapa Valley subarea (Muddy Springs). The horizontal displacement along the thrust is about 30,000 ft. The Kane Springs Fault and Meadow Valley Mountains Fault divide the modeled area into two additional subareas.

The vertical displacements are 500 to 1,000 ft on the Kane Springs Fault and 2,000 to 3,000 ft on the Meadow Valley Mountains Fault. The Meadow Valley Mountains Fault separates the Upper Moapa Valley subarea from the Meadow Valley Mountains subarea, and the Kane Springs Fault separates the Meadow Valley Mountains subarea from the Kane Springs subarea. Additionally, the Coyote Spring Fault separates the Upper Moapa subarea from the Kane Springs subarea. The Meadow Valley Mountains subarea is displaced upward relative to the Upper Moapa and Kane Springs subareas.

8.1.2 Hydrologic Conceptualization

The hydrologic system within the model area includes ground water and surface water as shown on **Figure 8-5**. This system is conceptualized into the regional ground-water system and local streams and riparian ground water. The sources of ground-water include underflow from adjacent areas and precipitation within the modeled area. The discharges of ground-water include spring discharges, consumption of diverted streamflow and riparian ground water, seepage to stream channels, pumping, and underflow to the Colorado River. The sources of surface water include spring discharges and seepage to stream channels. The discharges include consumption of diverted streamflow and riparian ground water and surface water outflow to the Colorado River.

Ground-water enters the modeled area as underflow within the carbonate rocks from valleys upgradient **(Table 8-1)**. Underflow enters Coyote Spring Valley **(Figure 8-5a)** from Pahranagat and Delamar Valleys. These underflows are 28,000 afy from Pahranagat and 16,000 afy from Delamar Valley. Underflow enters the Lower Meadow Valley Wash basin from Panaca and Clover Valleys. These underflows are 17,000 afy from Panaca Valley and 9,000 afy from Clover Valley. Additionally, streamflow from the Meadow Valley Wash enters the model area from Panaca Valley and is estimated at 10,000 afy. The cumulative estimated underflow and streamflow into to the modeled area is 80,000 afy **(Table 8-1)**.

Ground-water recharge occurs within the modeled area from precipitation **(Table 8-1)**. Most of that recharge occurs in the mountain areas, but some recharge occurs from ephemeral streamflow on alluvial fans and valley floors. Snowmelt and rainfall in mountain areas infiltrates rocks or seeps into fractures. Much of that water is consumed by native vegetation. However, part of the snowmelt and rainfall percolates downward past the root zone and eventually becomes ground-water recharge within the mountain area. When the snowmelt rate or precipitation rate exceeds the infiltration capacity of soils or fractured rocks, streamflow occurs. Within alluvial-fan or valley-fill areas, streamflow infiltrates into channel beds. Part of the infiltrated water percolates downward to become ground-water recharge. These processes act such that the ground-water recharge from precipitation on the modeled area is about 37,000 afy.

Ground-water discharges from the modeled area as spring discharges, ground-water seepage to channels, and pumping **(Table 8-1)**. The principal spring discharge occurs at the Muddy Springs. The discharge from the springs is about 37,000 afy, including ground-water seepage to the

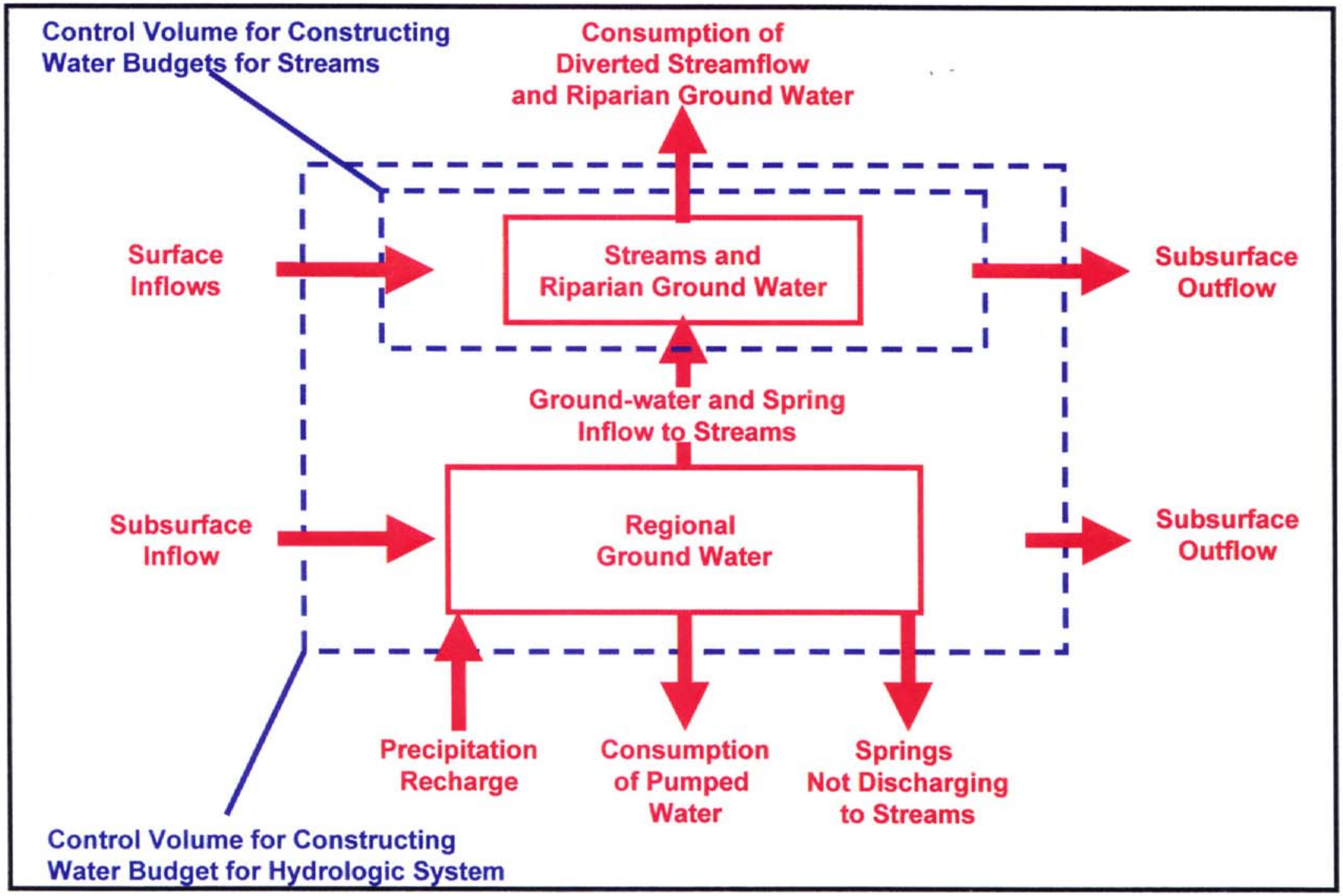


Figure 8-5 Conceptualization of hydrologic system.

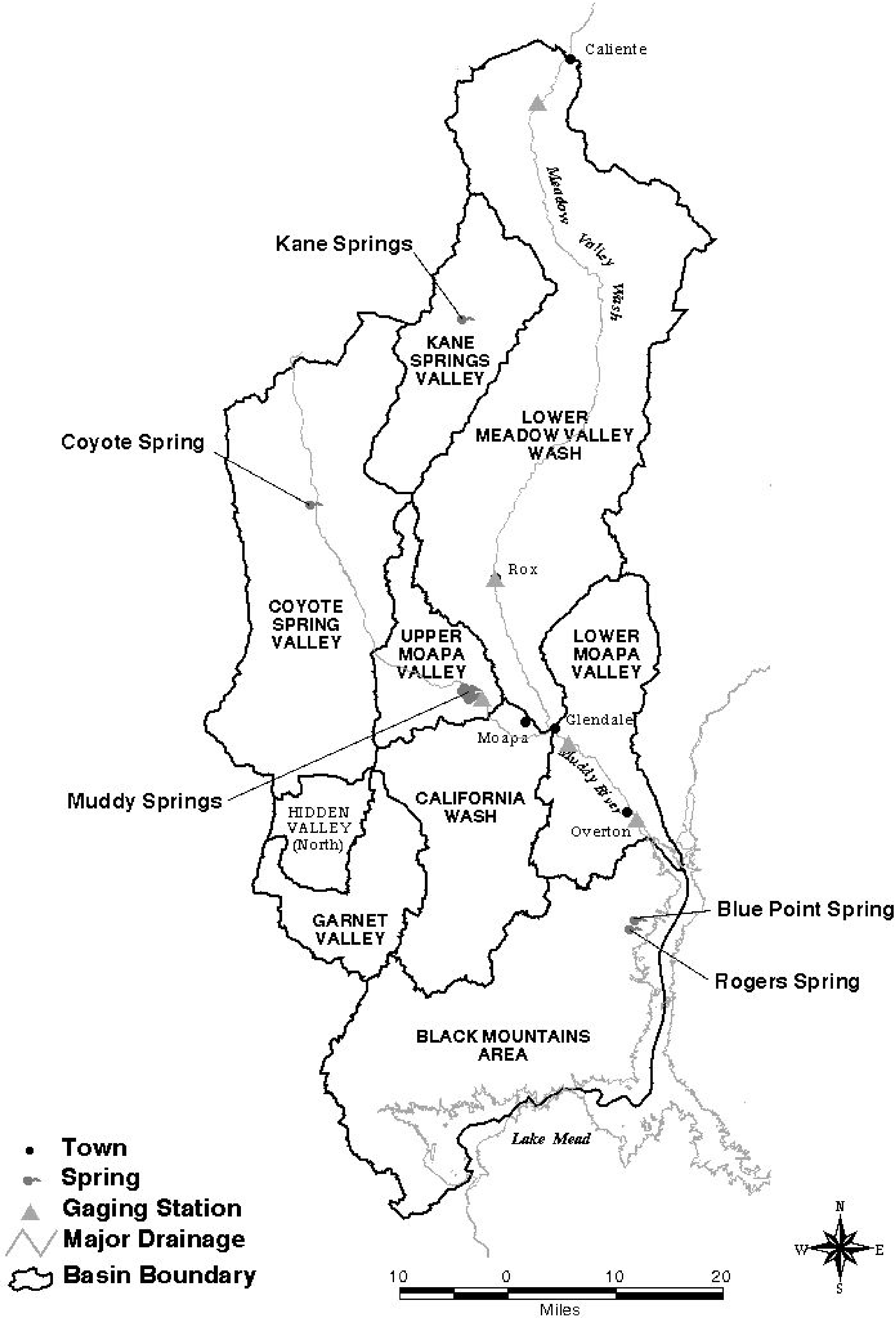


Figure 8-5a. Hydrologic features within the model area.

Table 8-1. Water budgets for streams and hydrologic systems; historical pumping and diversions in 1945 and 2000[1].

Budget Component	Historical Pumping / Diversions 1945	Historical Pumping / Diversions 2000
WATER BUDGETS FOR MEADOW VALLEY WASH AND MUDDY RIVER		
Inflows – Meadow Valley Wash		
• Streamflow at model boundary	10,000	10,000
• Ground-water inflows above Rox	11,000	9,000
• Ground-water inflows Rox to mouth	4,000	3,000
Total	**25,000**	**22,000**
Outflows – Meadow Valley Wash		
• ET above Rox[2]	21,000	20,000
• ET from Rox to mouth[2]	2,000	0
• Streamflow at mouth	2,000	2,000
Total	**25,000**	**22,000**
Inflows – Muddy River		
• Meadow Valley Wash streamflow at mouth	2,000	2,000
• Ground-water inflows above Moapa	38,000	31,000[3]
• Ground-water inflows Moapa to Glendale	6,000	6,000
• Ground-water inflows Glendale to Overton	7,000	7,000
Total	**53,000**	**46,000**
Outflows – Muddy River		
• ET above Moapa[2]	3,000	5,000
• ET Moapa to Glendale[2]	9,000	9,000
• ET Glendale to Overton[2]	25,000	25,000
• Streamflow at Overton	16,000	8,000
Total	**53,000**	**47,000**
HYDROLOGIC SYSTEM		
Inflows		
Ground-water underflow - Pahranagat Valley	28,000	28,000
Ground-water underflow - Delemar Valley	16,000	16,000
Ground-water underflow - Panaca Valley	17,000	17,000
Ground-water underflow - Clover Valley	9,000	9,000
Meadow Valley Wash streamflow at boundary	10,000	10,000
Boundary underflows	0	0
Precipitation recharge	37,000	37,000
Total	**117,000**	**117,000**
Outflows		
Ground-water pumpage	0	18,000
Surface-water outflow - Muddy River	16,000	8,000
Ground-water discharge to Colorado River	37,000	37,000
ET – Coyote Springs	1,000	1,000
ET – Kane Springs	1,000	1,000
ET – Rogers Springs	1,000	1,000
ET – Blue Point Springs	1,000	1,000
ET – Meadow Valley Wash above Rox	21,000	20,000
ET – Meadow Valley Wash below Rox	2,000	0
ET – Muddy River above Moapa	3,000	5,000
ET – Muddy River – Moapa to Glendale	9,000	9,000
ET – Muddy River – Glendale to Overton	25,000	25,000
Total	**117,000**	**126,000**
STORAGE CHANGE	**0**	**-9,000**

[1] *See Figure 8-5 for definition of control volumes.*
[2] *ET includes consumption of diverted streamflow and riparian ground water.*
[3] *After-effects of diversions and ground-water pumping above Muddy River streamgaging station near Moapa.*

Muddy River along the reach from the springs to the Moapa gage **(Figure 8-5)**. The cumulative discharge from other springs within the modeled area is about 4,000 afy. The individual discharges are 1,000 afy for Blue Point Spring, 1,000 afy for Rogers Spring (representing 2,000 afy for the North Shore Spring Complex), 1,400 afy from Coyote Spring, and 600 afy from Kane Springs. The discharge at the Muddy Springs, Blue Point Spring, and Rogers Spring is from deep carbonate rocks where fault intersections facilitate the discharge. The discharge at Kane Springs is from volcanic rocks, and the discharge from Coyote Spring is from valley-fill deposits. Ground-water discharges to the Muddy River channel from below the Muddy Springs to Lake Mead. Ground-water discharges toward the lower Virgin River channel in the vicinity of Fisherman's Cove and may actually not surface until it is constrained by the fault structure that defines the Colorado River. Finally, ground-water discharges to the Meadow Valley Wash along discontinuous reaches from Caliente to near Rox **(Figure 8-5)**. Additional discharge occurs near the confluence of Meadow Valley Wash with the Muddy River. The cumulative discharge to the Muddy River between Muddy Springs and the Overton gage is about 13,000 afy, which is in addition to the Muddy Springs discharge above the Moapa gage. The cumulative discharge to the Meadow Valley Wash between the Caliente gage to near the Rox gage is about 9,000 afy. The additional discharge to Meadow Valley Wash near its confluence with the Muddy River is 3,000 afy.

Ground-water is pumped within the modeled area for agricultural, industrial, and municipal uses **(Table 8-1)**. Additionally, minor ground-water is pumped at various locations for residential and commercial purposes. The agricultural and industrial pumping is located along the Muddy River from near the Muddy Springs to Overton. About 35 active wells occur along this reach, and the current consumptive pumpage is about 11,000 afy. Ground-water pumping along the Muddy River started in 1947 for irrigation. During 1947-2000 pumping tended to increase from year to year, but during the middle of this period, most agricultural pumping was replaced with industrial pumping. The industrial pumping is mostly for cooling at Nevada Power's Reid Gardner Station. The current consumptive industrial pumping is about 7,500 afy. Additional pumping for export to Lower Moapa Valley municipal and industrial uses began in the early 1990s, and has increased steadily to a current export of approximately 3,000 afy.

Spring discharges and ground-water seepage to streams are used consumptively within the modeled area **(Table 8-1)**. Consumption results from irrigation diversions or direct ground-water use by phreatophytes. Along Meadow Valley Wash, streamflow resulting from ground-water discharges is consumed. Streamflow enters the modeled area at Caliente, and is diverted for irrigation and consumed within the modeled area. The water use along the Meadow Valley Wash in year 2000 is such that streamflow almost ceases near Rox, except for occasional flood flows. The consumption along the wash is about 20,000 afy. Along the Muddy River, streamflow resulting from ground-water discharges is diverted for irrigation or industrial uses and consumed. The water use along the Muddy River is such that a substantial amount of the streamflow is consumed above the Overton gage. Nevertheless, some streamflow reaches Lake Mead. The consumption along the river is about 39,000 afy.

Ground-water discharges to Lake Mead and the Virgin River as upward ground-water flow to the lake or stream channel **(Table 8-1)**. The carbonate rocks within the modeled area terminate in the vicinity of Lake Mead where they transition into rocks of the Colorado Plateau series. The carbonate rocks are juxtaposed against low permeability rocks at that boundary, and ground-water flow in the carbonate rocks is forced upward. Prior to the construction of Hoover Dam in

1935, the current ground-water discharge to the Colorado River. With the dam and Lake Mead constructed, the current ground-water discharge to Lake Mead on the lower Virgin River is about 37,000 afy.

8.2 DEVELOPMENT OF NUMERICAL MODEL

A three-dimensional model was developed based on the hydrogeologic and hydrologic conceptualizations described above. The model was constructed using the U.S. Geological Survey computer program FEMFLOW3D (Durbin and Bond 1998). This program solves the governing equations of ground-water flow using the finite-element method, which is one of several mathematical techniques used in ground-water models. The program consists of modules for simulating inflows and outflows for a ground-water system. Those utilized within the current model include the specified-flux module, specified-head module, stream-aquifer module, and variable-flux module (Durbin and Bond, 1998). Additionally, the model utilizes the flexible-grid module (Durbin and Berenbrock, 1985).

The model utilizes a three-dimensional mesh that is specified as an assemblage of nodes and elements, and the modules for simulating ground-water inflows and outflows relate those quantities to nodes within the model mesh. The specified-flux module assigns recharge and discharge rates to specified mesh nodes. The specified-head module specifies a relation for a mesh node between discharge and the simulated ground-water level for the node. The stream-aquifer module specifies a relation for a mesh node between ground-water discharge to a stream and the simulated ground-water level at the stream. The variable-flux module specifies a relation for a mesh-boundary node between the boundary discharge and ground-water conditions outside the model area.

The flexible-grid module adjusts the grid geometry to account for the position of the ground-water table. As the water-table elevation changes during a simulation, the module adjusts mesh nodes upward or downward such that the node elevation equals the water-table elevation (Durbin and Berenbrock, 1985).

8.2.1 Representation of Hydrogeology

The ground-water model represents five hydrogeologic units **(Figure 8-6)**. These include the carbonate rocks, clastic rocks, intrusive rocks, volcanic rocks, and valley-fill deposits. The geographic extents and thickness of these units were derived from the geologic cross sections **(Figure 3-2** through **Figure 3-4** in Section 3**)**. **Figure 8-3a** through **Figure 8-3d** show the geographic extent of each unit.

The hydrogeologic units and structural features within the model area are represented in the ground-water model using a three-dimensional mesh. The mesh is an assemblage of vertically oriented prismatic elements. A typical element is shown on **Figure 8-7**. The elements project a triangle on a horizontal cross-section, which is represented by the top and bottom faces shown on the figure. The elements project a trapezoid on a vertical plane, which is represented by the

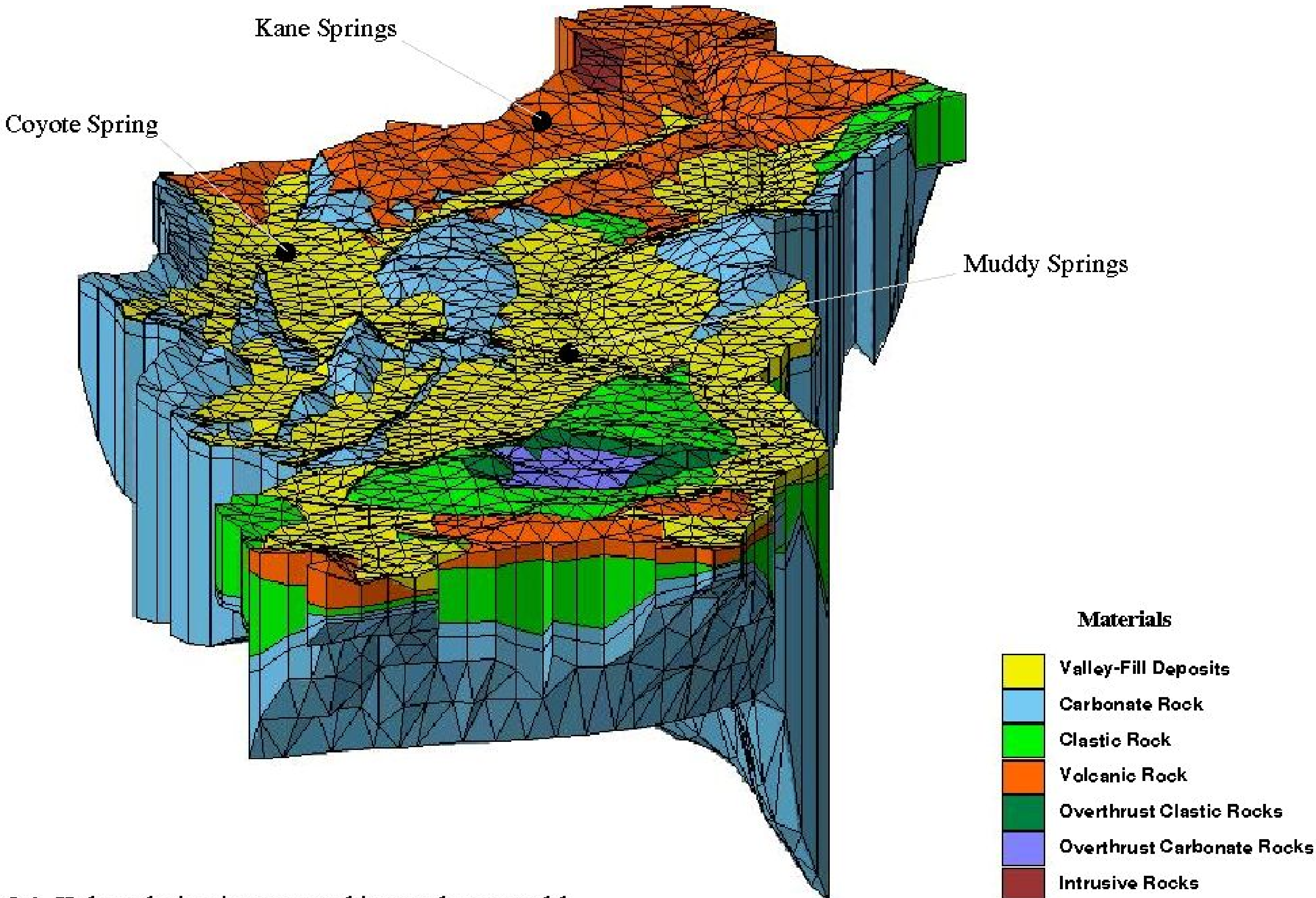


Figure 8-6. Hydrogeologic units represented in ground-water model.

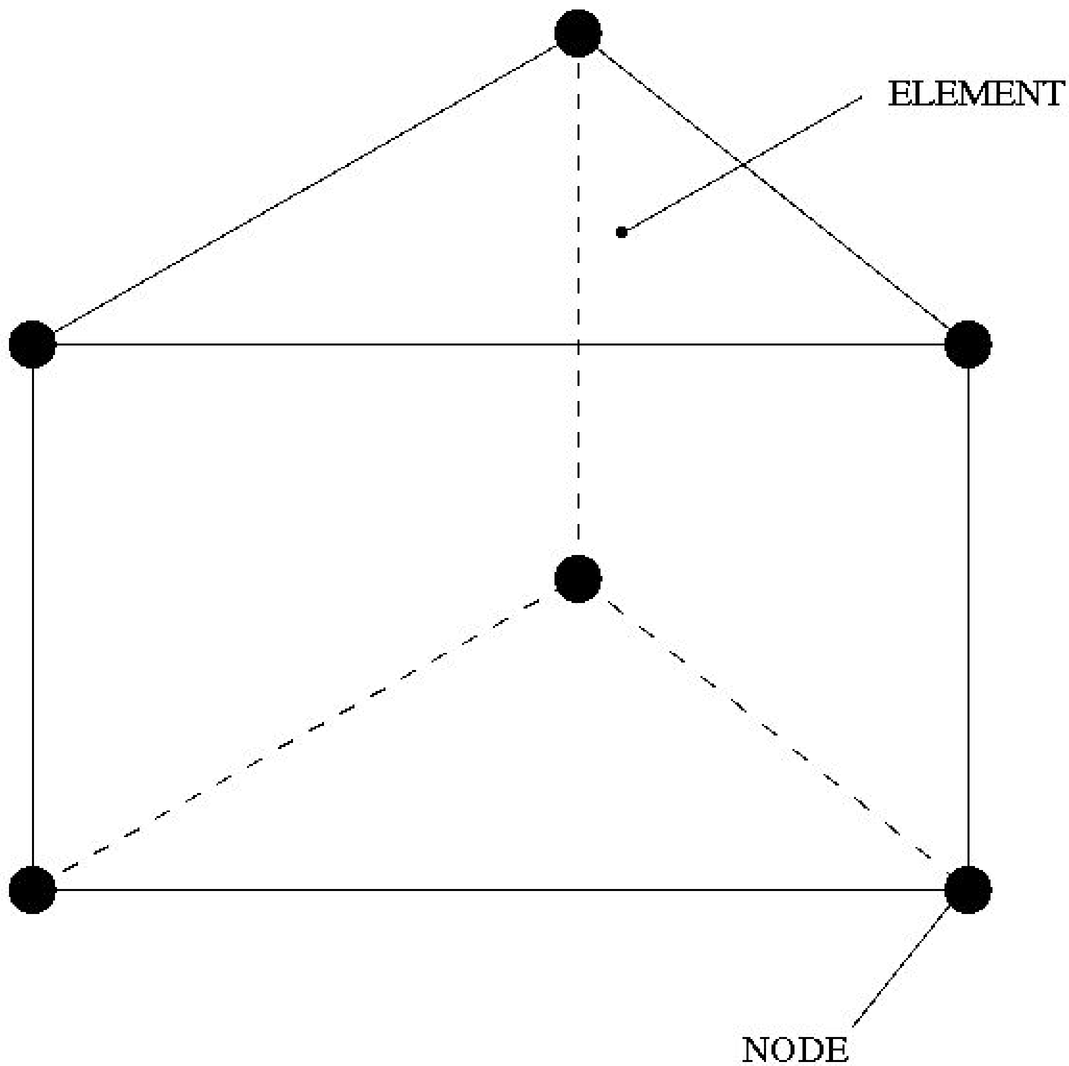


Figure 8-7. Typical element within finite-element mesh.

vertical faces shown on the figure. The particular size and spatial position of an element is specified by the three-dimensional coordinates representing the vertices of the prism, which are referred to as nodes. Laterally and vertically adjacent elements share nodes, which establish the continuity of the ground-water system within the modeled area.

The finite element mesh is shown on **Figure 8-8,** and **Figure 8-9a** through **Figure 8-9e**. **Figure 8-8** shows the geographic layout of the mesh. The mesh is constructed geographically to define the extents to the hydrogeologic units. As shown on **Figure 8-8**, element top or bottom faces define surface contacts between units. The mesh is constructed vertically to define the thickness and elevations of the hydrogeologic units. The layering of elements within the three-dimensional mesh represents the layering of the hydrogeologic units. Additionally, the mesh is constructed to represent location of regional faults. As shown on **Figure 8-8**, faults are represented in the mesh as linear assemblage of narrow elements.

Using the flexing-grid module of FEMFLOW3D, the mesh adjusts so that the top of the surface represents the ground-water table. The top surface of the mesh initially is the land surface, and nodes in the top surface are assigned an elevation equal to the land-surface elevation. If the ground-water table fluctuates during a transient-state simulation, the top surface of the finite-element mesh correspondingly fluctuates. This is accomplished by appropriately expanding or contracting the mesh. If the ground-water table rises or falls during a simulation, the top surface of the mesh rises or falls so that the local elevation of the top surface always equals the local computed elevation for the ground-water table.

While the mesh itself defines spatial relationships within the ground-water system, the assignment of material properties to elements defines the hydraulic characteristics of the ground-water system. Each element is assigned values for horizontal permeability, vertical permeability, and specific storage. Elements forming the top surface of the mesh also are assigned a value for specific yield. The collection of elements representing a particular hydrologic unit or fault is assigned material properties characterizing the unit or fault. In the model inputs, each element is assigned a material type taken from a list of materials. Each material is assigned a horizontal permeability, vertical permeability, specific storage, and specific yield, and material-type assignment correspondingly assigns values to elements. Elements are assigned hydraulic properties from a list of thirty-nine materials **(Table 8-X)**. The list contains material properties for each hydrogeologic unit and each subarea. Additionally, the list contains material properties for each fault. The specification of values for material properties was derived from a model calibration, which is a process for selecting material properties so that the ground-water model best fits historical conditions. That process is described later.

8.2.2 Representation of Natural Recharge

Using the specified-flux module of FEMFLOW3D, the model replicates natural recharge to the ground-water system, where the total recharge to the model area is about 107,000 afy groundwater and 10,000 afy surface-water **(Table 8-1)**. Natural ground-water recharge to the ground-water system includes precipitation recharge and subsurface inflows. Recharge from precipitation within the modeled area is based on a modified Maxey-Eakin method as described

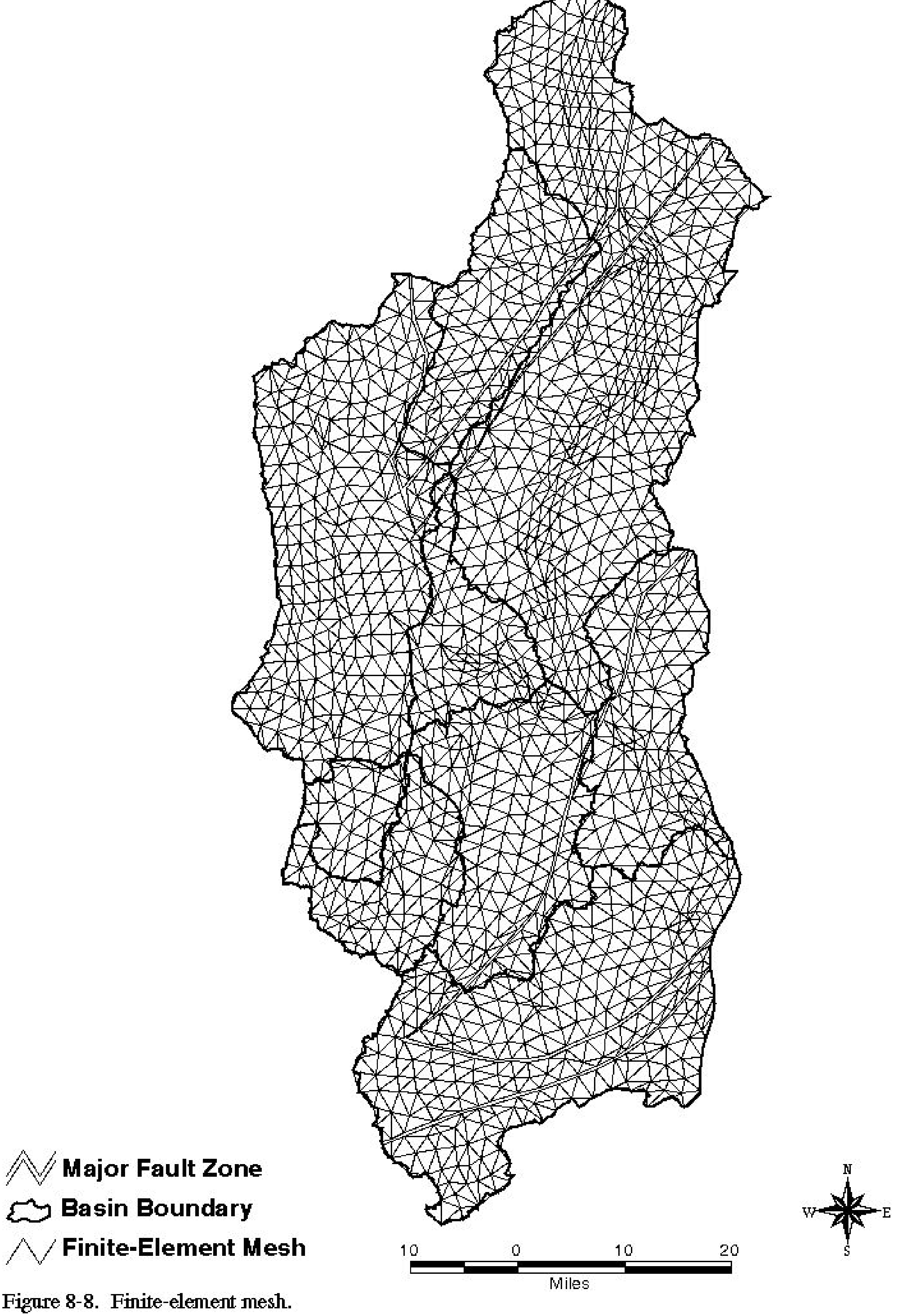


Figure 8-8. Finite-element mesh.

Figure 8-9a. Geographic extent of valley-fill deposits within finite-element mesh, layer one.

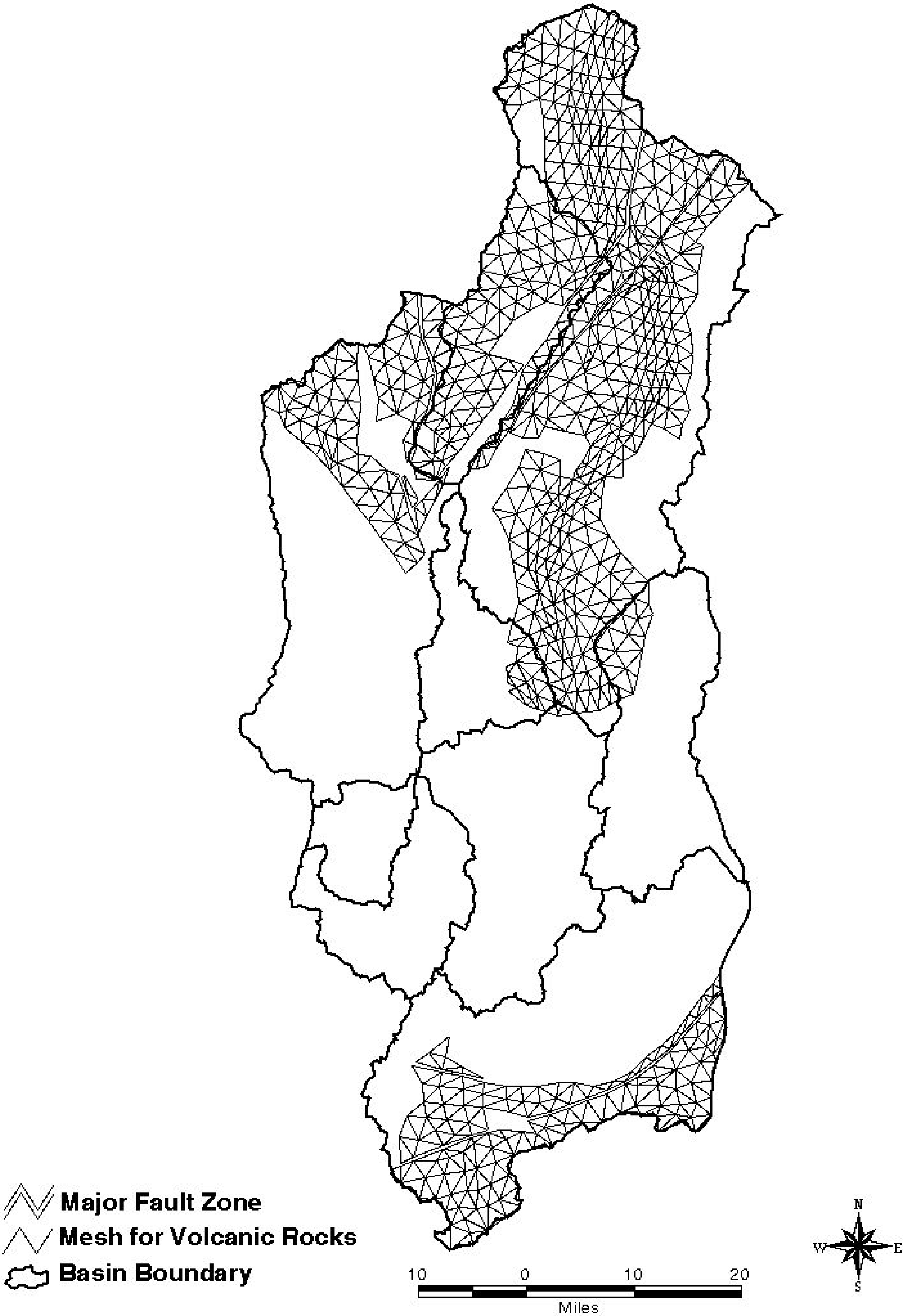


Figure 8-9b. Geographic extent of volcanic rocks within finite-element mesh, layer two.

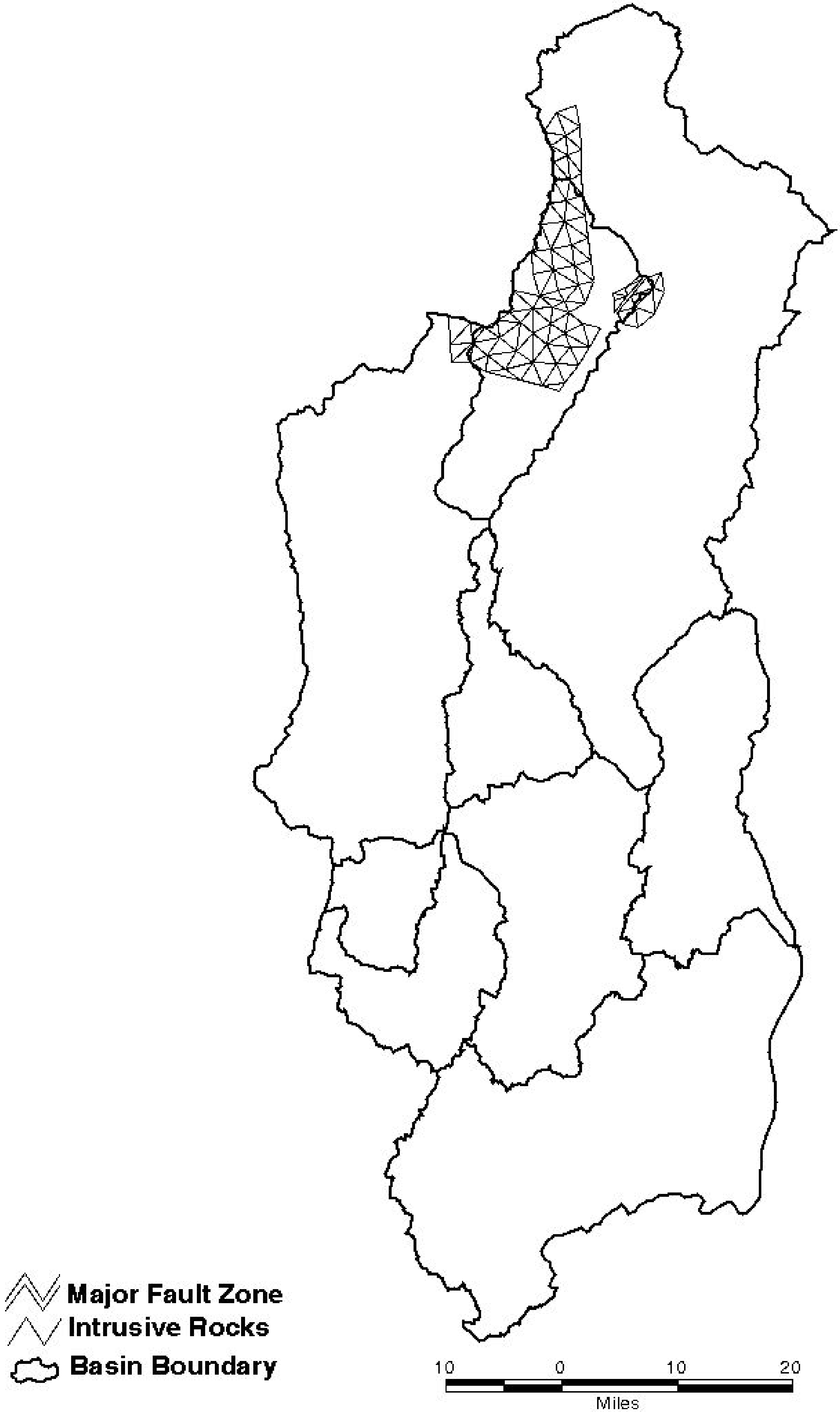


Figure 8-9c. Geographic extent of intrusive rocks within finite-element mesh, layer three.

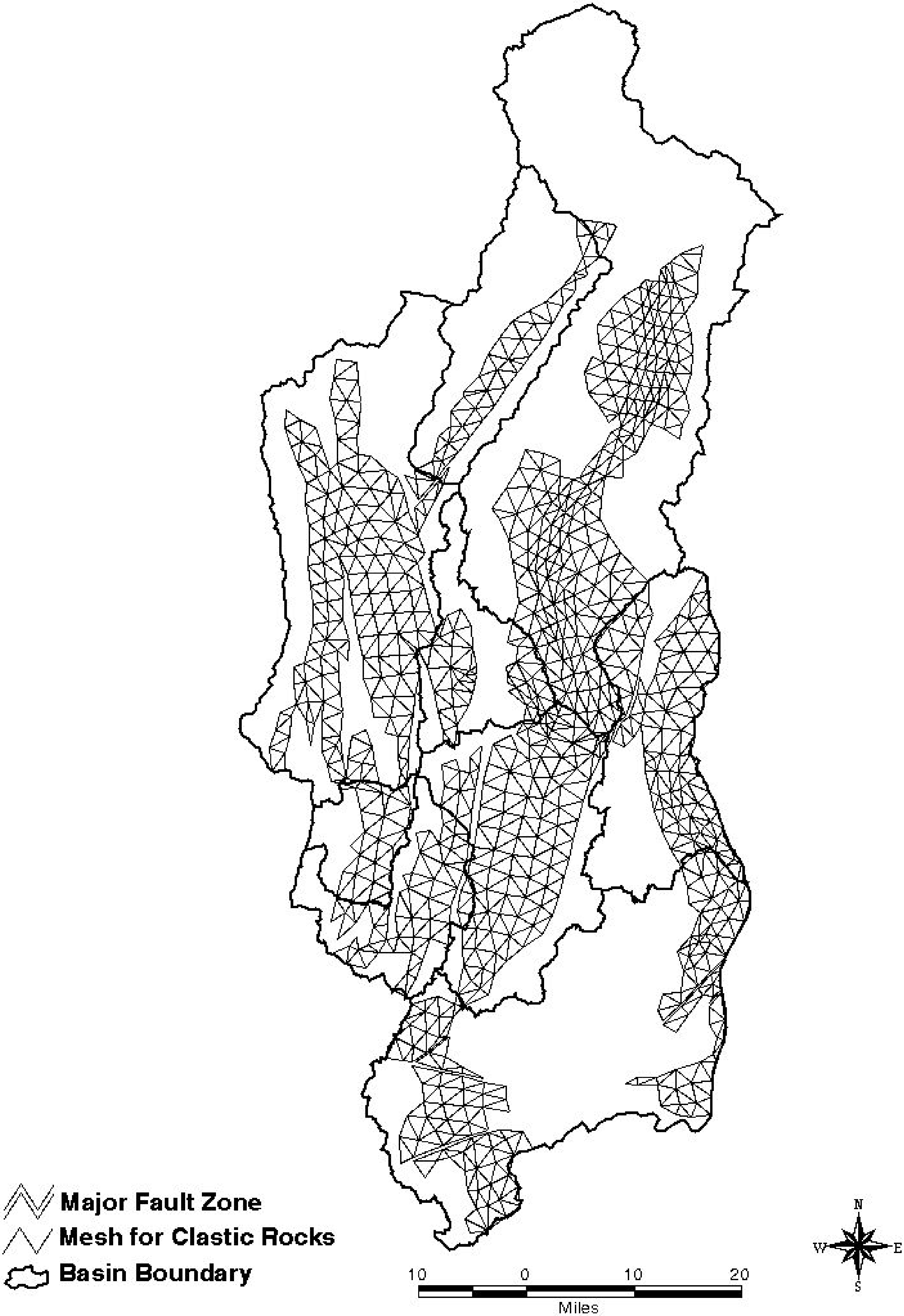


Figure 8-9d. Geographic extent of clastic rocks within finite-element mesh, layer four.

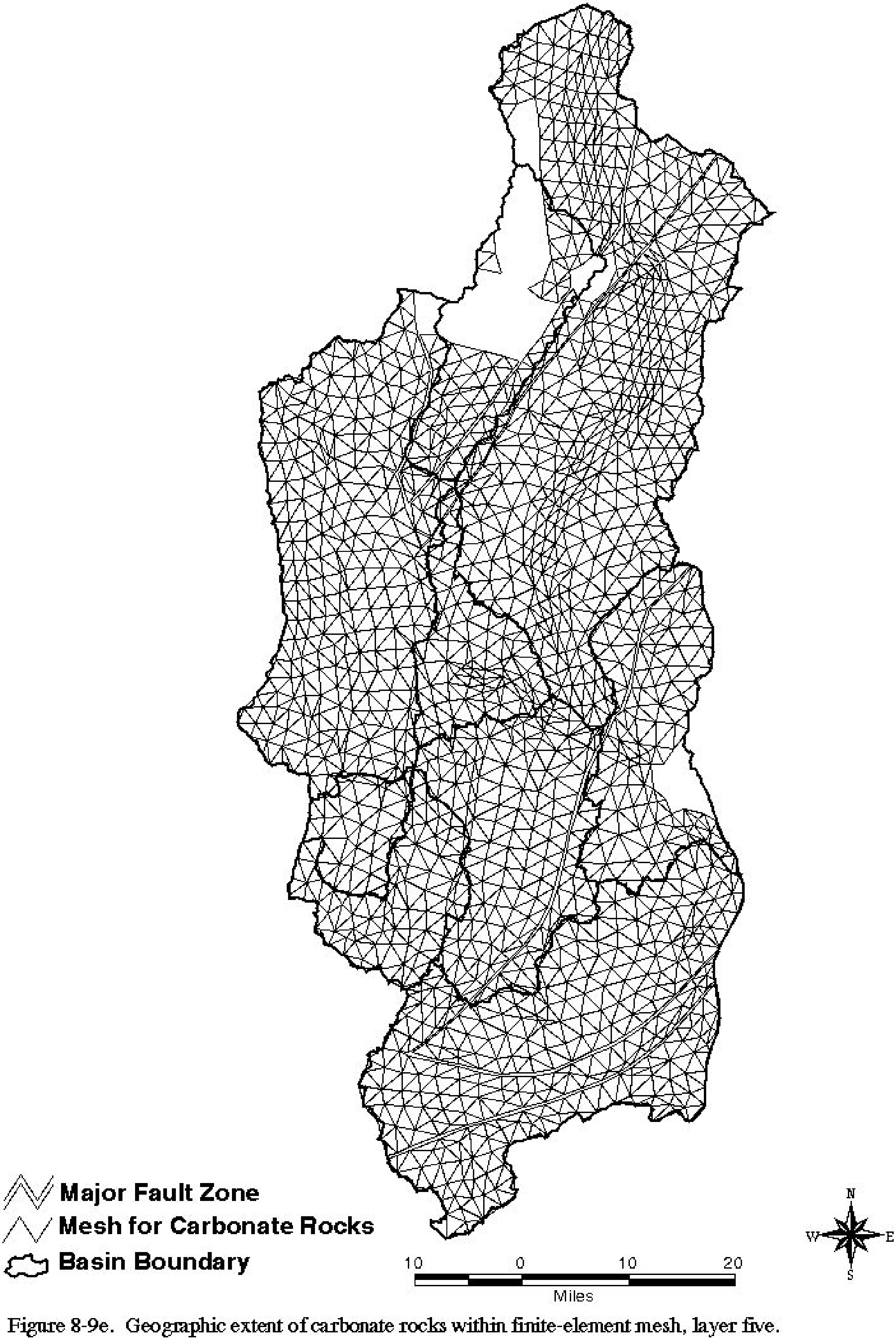


Figure 8-9e. Geographic extent of carbonate rocks within finite-element mesh, layer five.

in Section 4.4. Likewise, the subsurface inflows to the modeled area are based in part on the application of this modified Maxey-Eakin method to the source area, which is the study area upgradient from the modeled area. The resulting subsurface inflows represent the precipitation recharge within the source area less the consumption within that area.

Natural recharge is incorporated in the model by assigning recharge values to nodes within the model mesh that correspond to areas where recharge occurs. Precipitation recharge within the model area is assigned to nodes in the top surface of the model mesh. The recharge value assigned to a particular node represents the integration of the local recharge per unit area over the local area associated with the node. The integration translates local recharge expressed as depth per unit time to a nodal recharge expressed as a volume per unit time. The sum of the volumetric values for all nodes equals the total precipitation recharge for the model area. The subsurface inflows to the modeled area are assigned to nodes in the vertical surface of the model mesh at the boundary of the modeled area. Where mesh nodes occur on that vertical surface, a set of nodes occur as a column. The bottom three nodes in the column represent the carbonate rocks, and the subsurface inflows are assigned to the carbonate rocks at the bottom two nodes. **Figure 8-10** shows the locations where subsurface inflows are assigned to the model mesh.

8.2.3 Representation of Natural Discharge

Using the specified-head, stream-aquifer, and specified-flux modules of FEMFLOW3D, the model represents natural discharge from the ground-water system, where the total natural discharge from the model area is about 117,000 afy **(Table 8-1)**. Natural ground-water discharge includes spring discharges, ground-water seepage to streams, and subsurface outflows. Spring discharges and ground-water seepage are calculated internally within the model based on the simulated ground-water levels, except that valley-fill springs are simulated in the model as a specified discharge. Subsurface outflows are represented either as a head-dependent condition or a specified discharge.

For a carbonate spring, when the hydraulic head within the source aquifer for the spring is above the spring-orifice elevation, the spring discharge in the model is proportional to the difference between the spring-orifice elevation and the source-aquifer head. Otherwise, the spring discharge equals zero. The coefficient of proportionality is the spring leakance. For a stream, when the ground-water level in the underlying aquifer for the stream is above the stream-surface elevation **(Figure 8-11a** and **Figure 8-11b)**, the ground-water seepage to the stream in the model is proportional to the difference between the stream-surface elevation and the underlying ground-water level. Otherwise, streamflow is lost from the channel. The constant of proportionality is the stream leakance, which is related in the model to streamflow depth **(Figure 8-12)**, streamflow width **(Figure 8-13)**, streambed permeability, streambed thickness, and reach length.

Ground-water discharge to carbonate springs and streams is incorporated in the model by identifying the spring and stream nodes. For the spring nodes **(Figure 8-14)**, the spring-orifice elevation and spring leakance are assigned. For the stream nodes **(Figure 8-15)**, the streambed elevation, thickness, and permeability are assigned. Additionally, a channel network is specified in order to link the nodes **(Figure 8-15)**, and channel-geometry relations are specified. Those

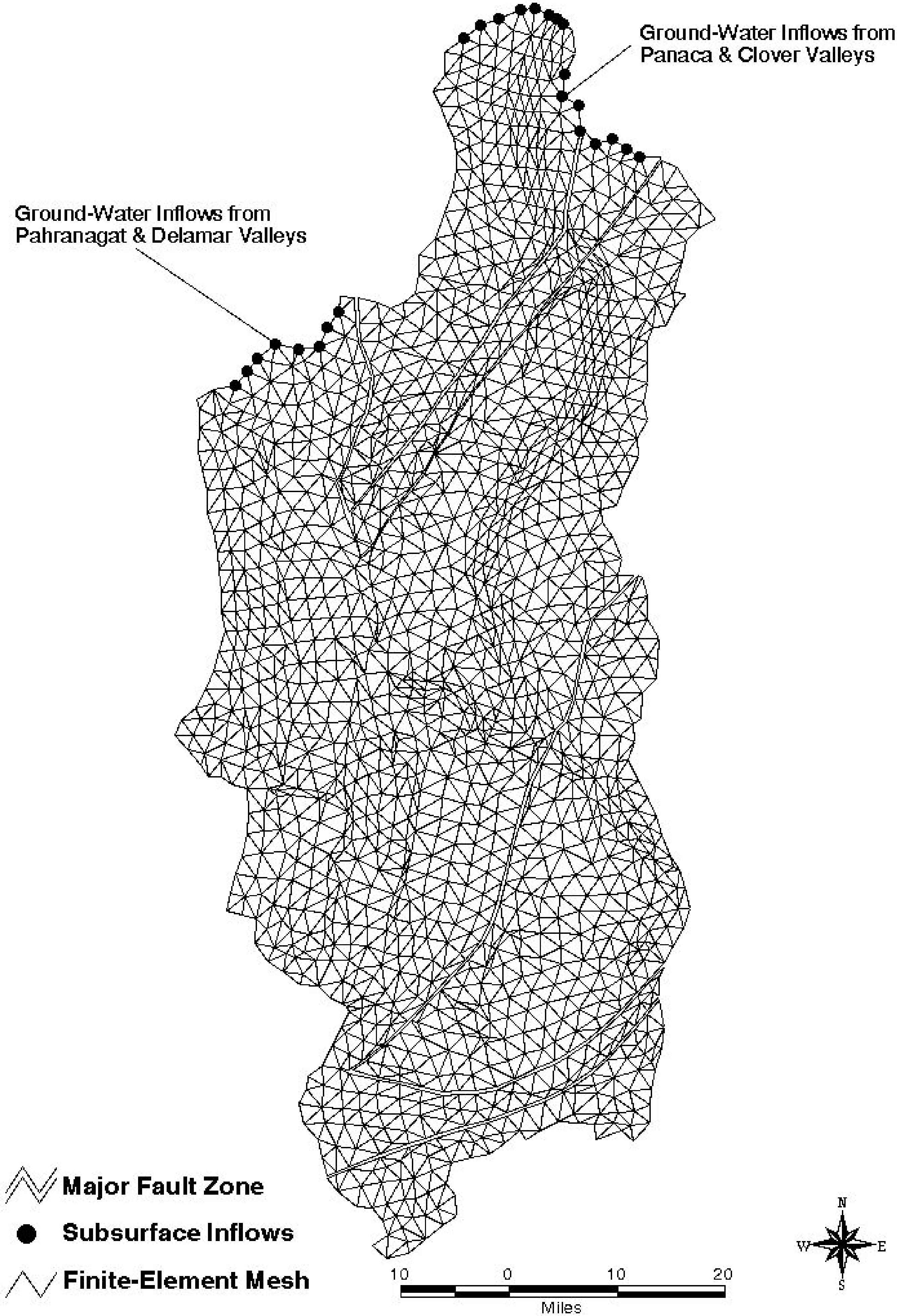


Figure 8-10. Location of subsurface inflows represented in model.

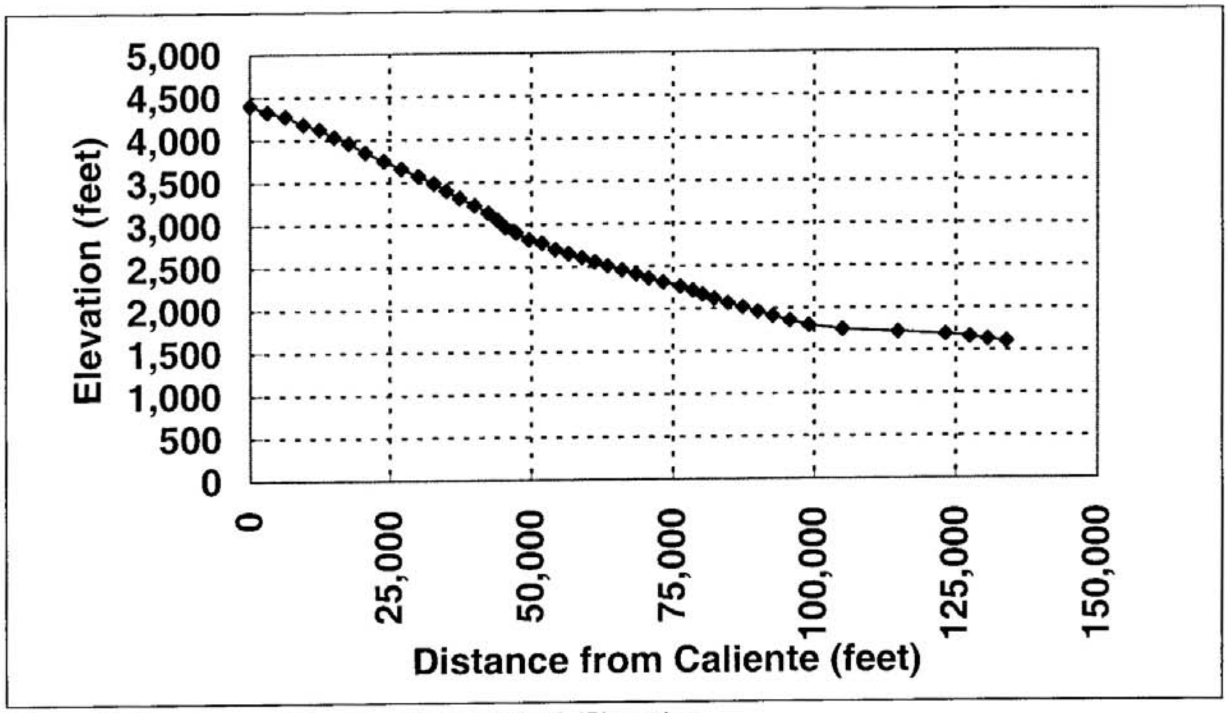


Figure 8-11a Lower Meadow Valley Wash Elevation.

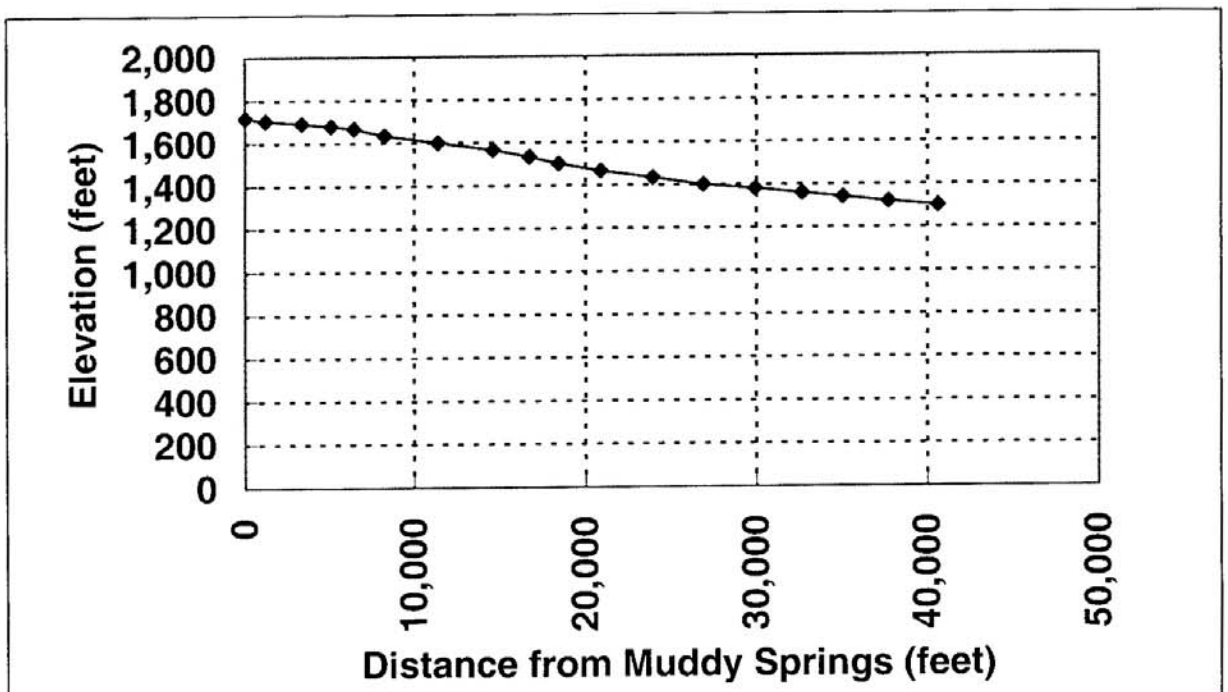


Figure 8-11b Muddy River Elevation.

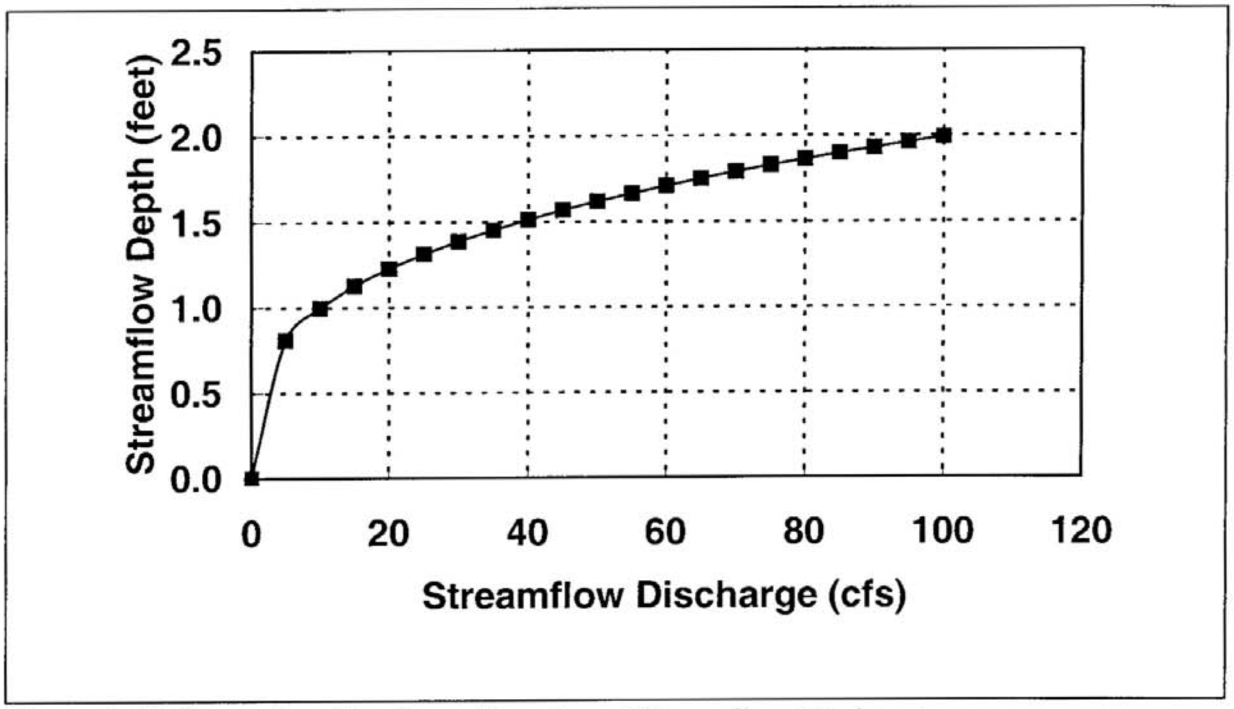


Figure 8-12 Streamflow Depth as a Function of Streamflow Discharge.

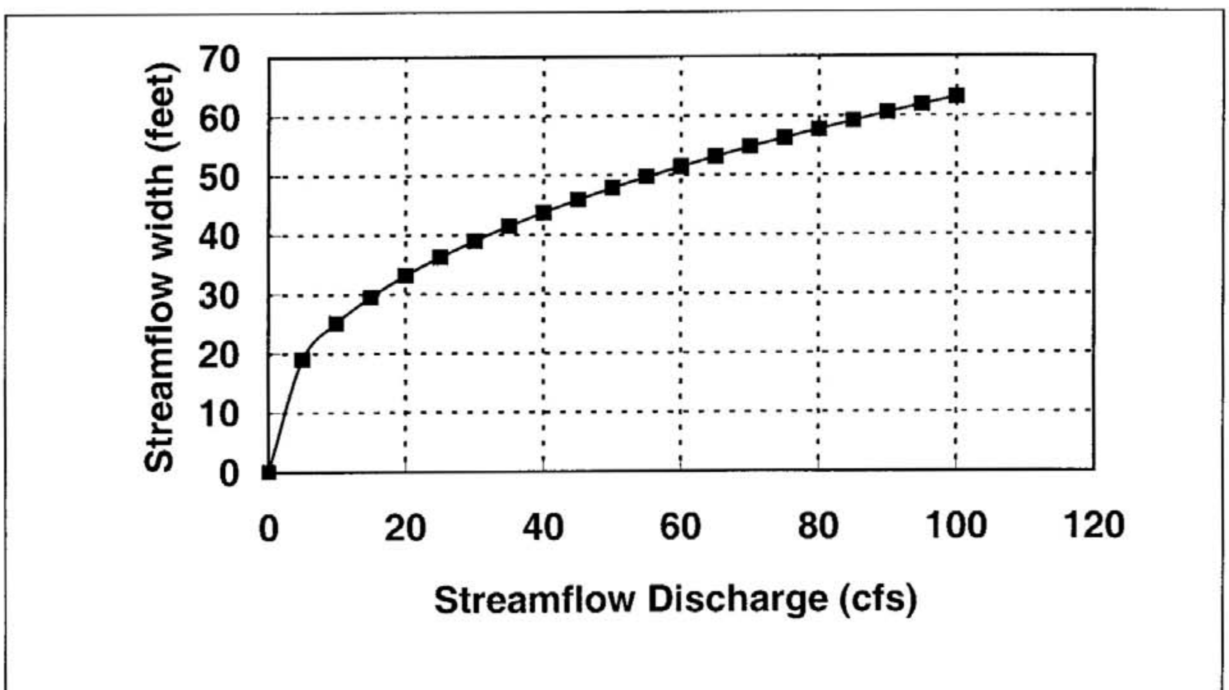


Figure 8-13 Streamflow Width as a Function of Streamflow Discharge.

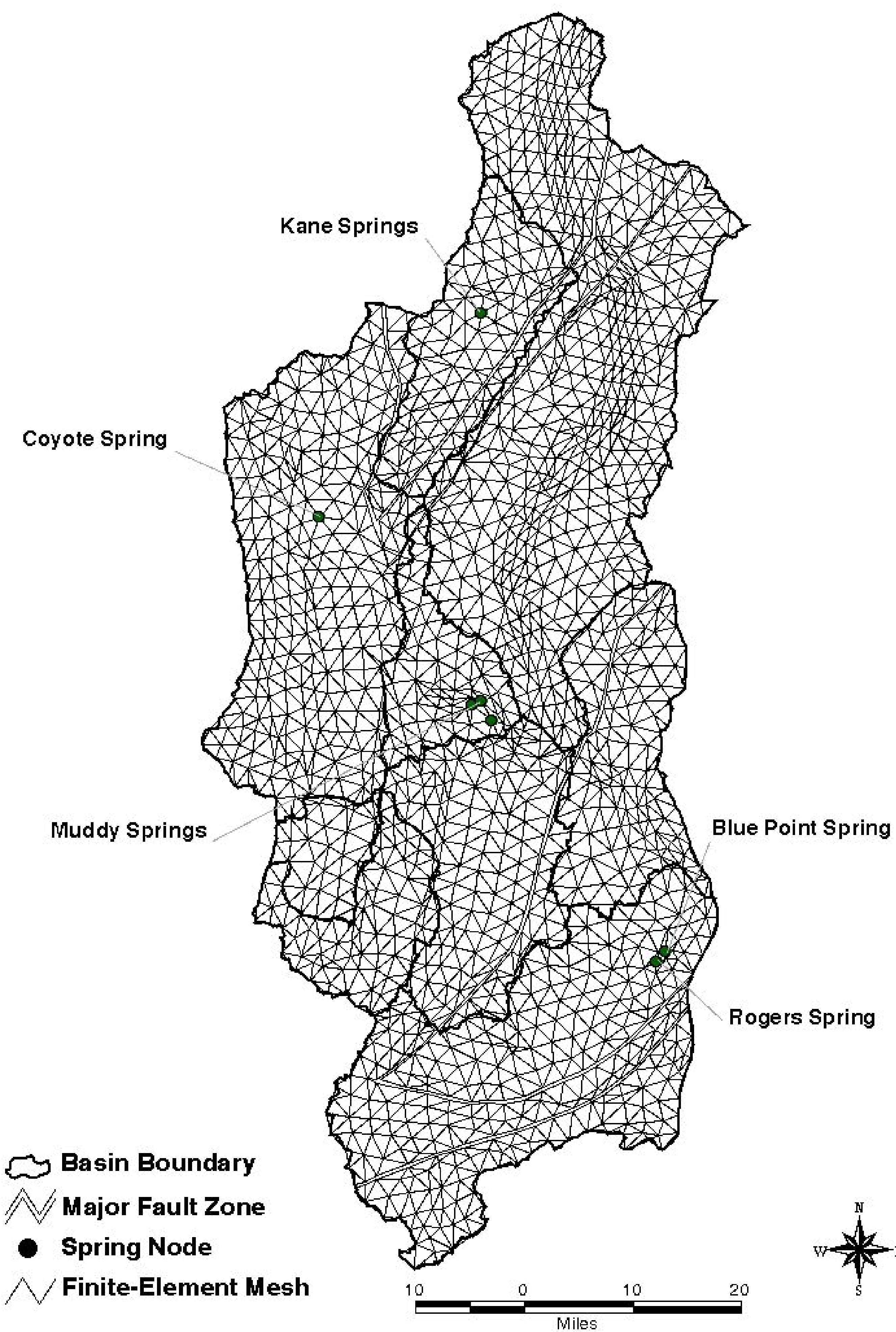


Figure 8-14. Location of spring nodes represented in model.

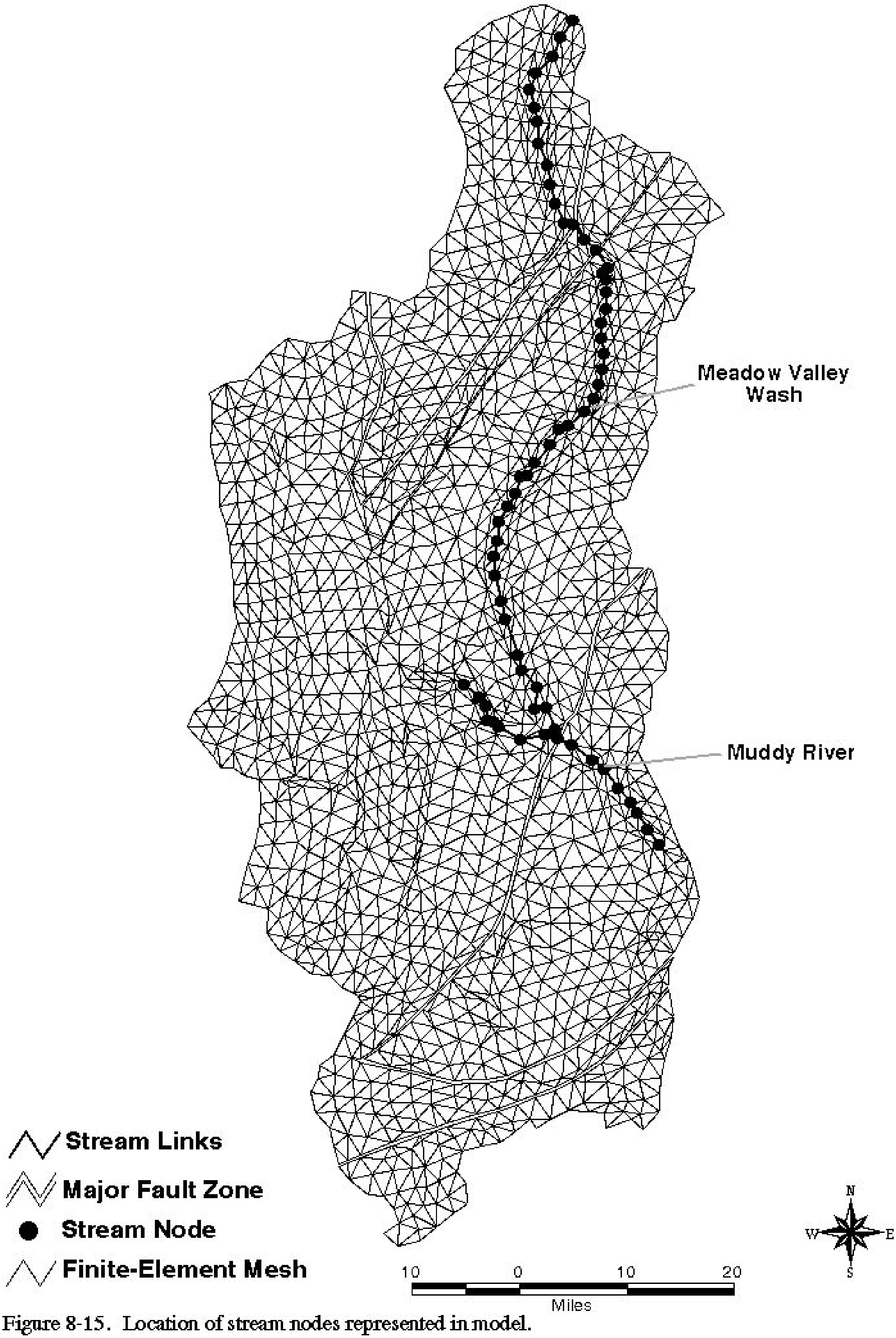


Figure 8-15. Location of stream nodes represented in model.

relations define the streamflow depth and width as functions of streamflow discharge **(Figure 8-12** and **Figure 8-13)**.

Ground-water discharge to Lake Mead is represented as a specified-head boundary condition, and subsurface outflow from the modeled area toward the Virgin River is represented as a specified discharge. Ground-water discharge to Lake Mead is represented by specified-head nodes on the top surface of the model mesh at the locations shown on **Figure 8-16**. Subsurface discharge toward the Virgin River is represented in the model as specified-discharge nodes within the carbonate aquifer at the locations shown on **Figure 8-17.** The discharge at a particular geographic location is assigned to the carbonate rocks at the bottom two nodes within the local model mesh.

8.2.4 Representation of Pumpage

The model represents pumping from the ground-water system, where the total pumping from the model area is about 18,000 afy in year 2000 **(Table 8-1)**. Ground-water pumping includes agricultural, industrial, and municipal pumping. Minor residential and commercial pumping within the model area is not represented in the model.

Pumping from a well is represented in the model by assigning a discharge to a node within the model mesh. The location of a well is represented by assigning the well to the geographically nearest node column. The depth of a well is represented by assigning the well to an appropriate node within a node column. Valley-fill wells are assigned to the top node within the node column, and carbonate wells are assigned to the second node from the bottom of the node column.

Pumping from 60 valley-fill wells and 11 carbonate wells is represented in the model in year 2000. The location of pumping-wells is shown on **Figure 8-18**. The total annual pumping from valley-fill wells is shown on **Figure 8-19** for 1945-2000, and the total annual pumping from carbonate wells is shown on **Figure 8-20**. The annual pumping for individual wells is listed in Appendix B.

Historically, ground-water development within the model boundary has been limited to areas located within the flood plains of the Muddy River and Meadow Valley Wash in Lower Moapa Valley, Lower Meadow Valley Wash, and the Upper Moapa Valley near the southeast portion of the modeled area. Ground water has principally been developed to supply water for agriculture in these areas, but has also been developed in the Upper Moapa Valley to supply water to the Reid Gardner facility located in California Wash and owned and operated by NPC. Until recently, there has been little to no ground-water development in the other basins comprising the remainder of the modeled area (Black Mountains, California Wash, Garnet Valley, Hidden Valley). However, since 1990, various commercial enterprises have been granted ground-water withdrawal permits within the Black Mountains Area and Garnet Valley, of which, only a few have been certified.

Records of ground-water production for each basin within the model boundary were developed for the period 1945 to 2000 based on data and information acquired from DRI, MVWD, NDWR,

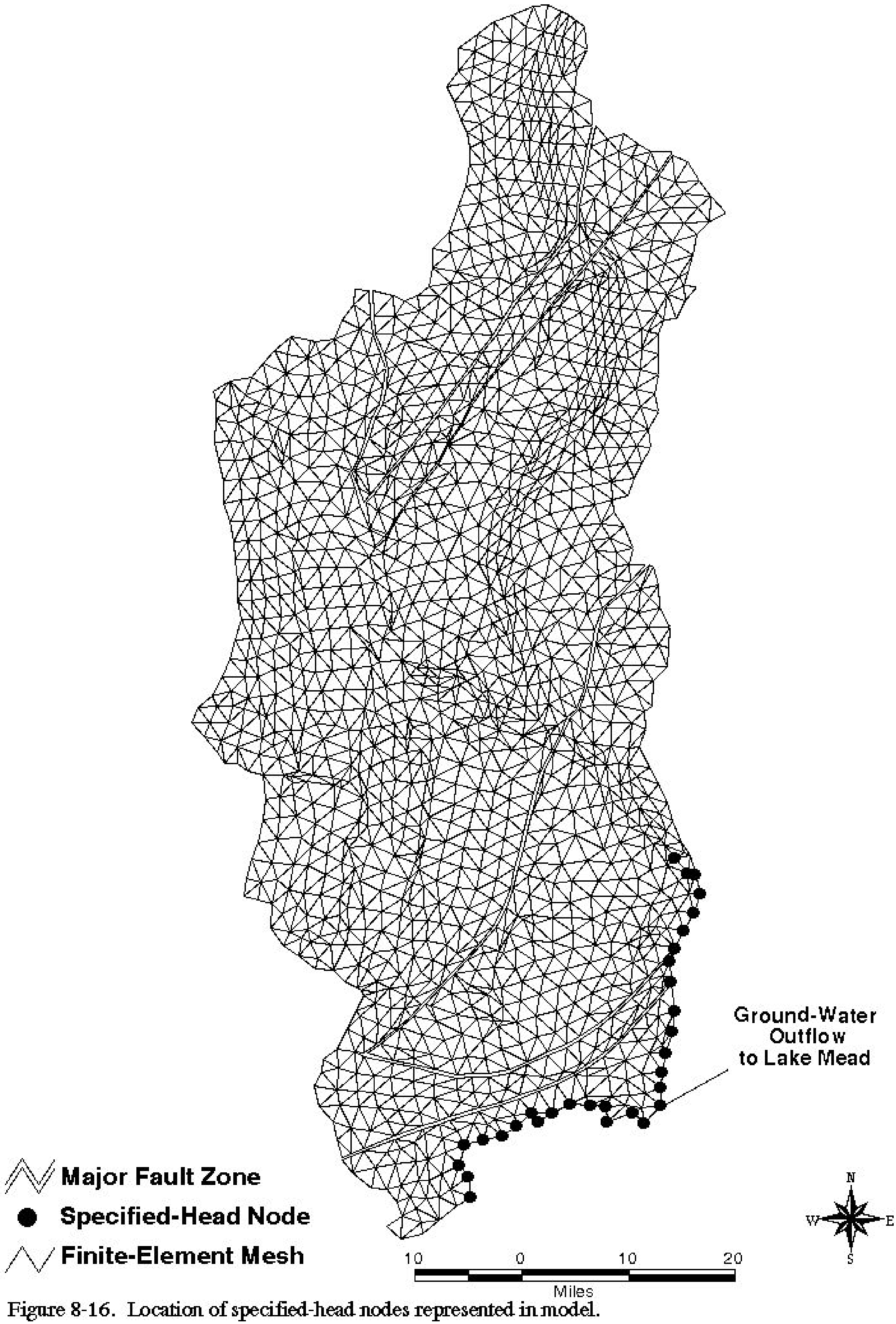


Figure 8-16. Location of specified-head nodes represented in model.

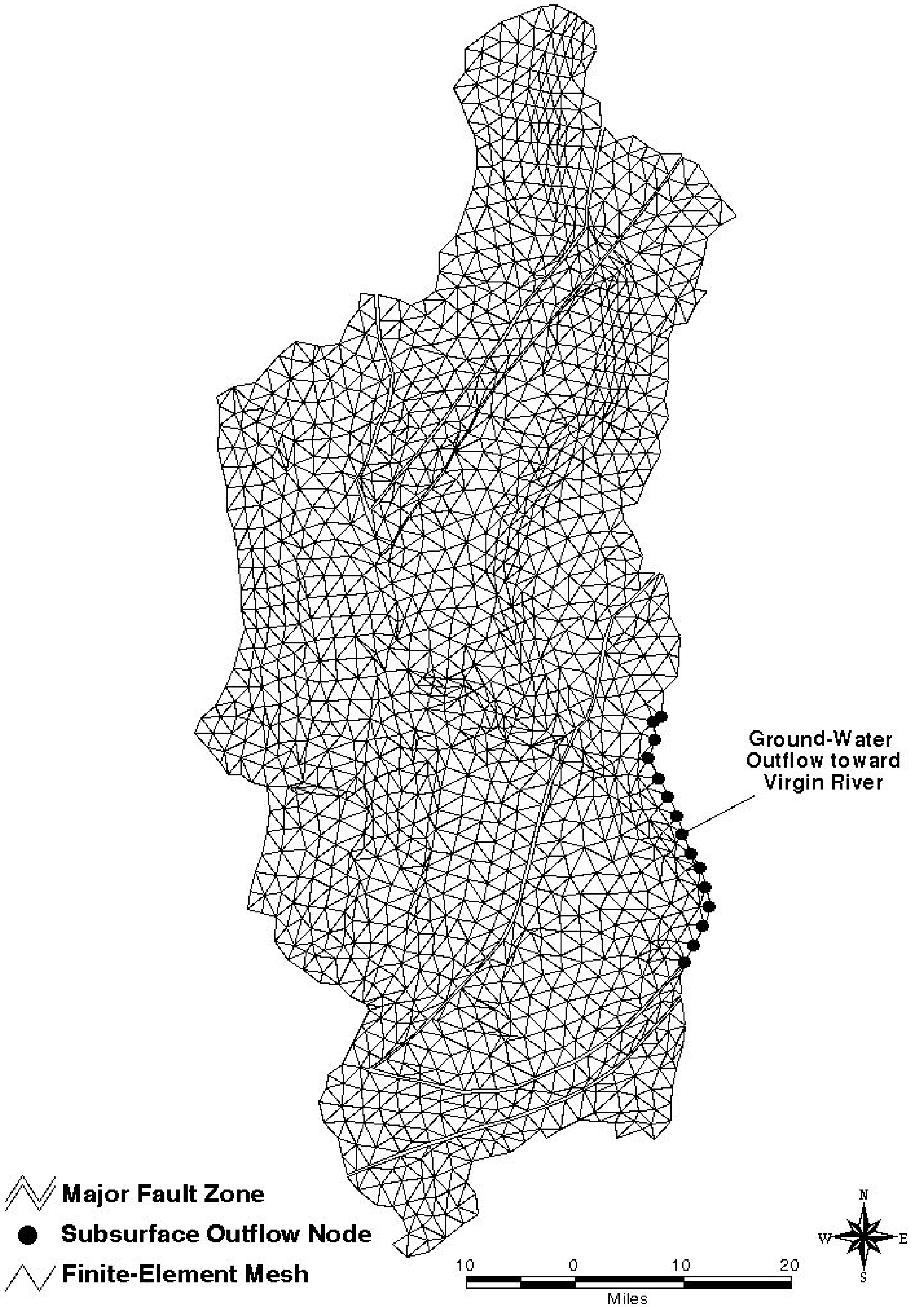


Figure 8-17. Location of subsurface outflow nodes represented in model.

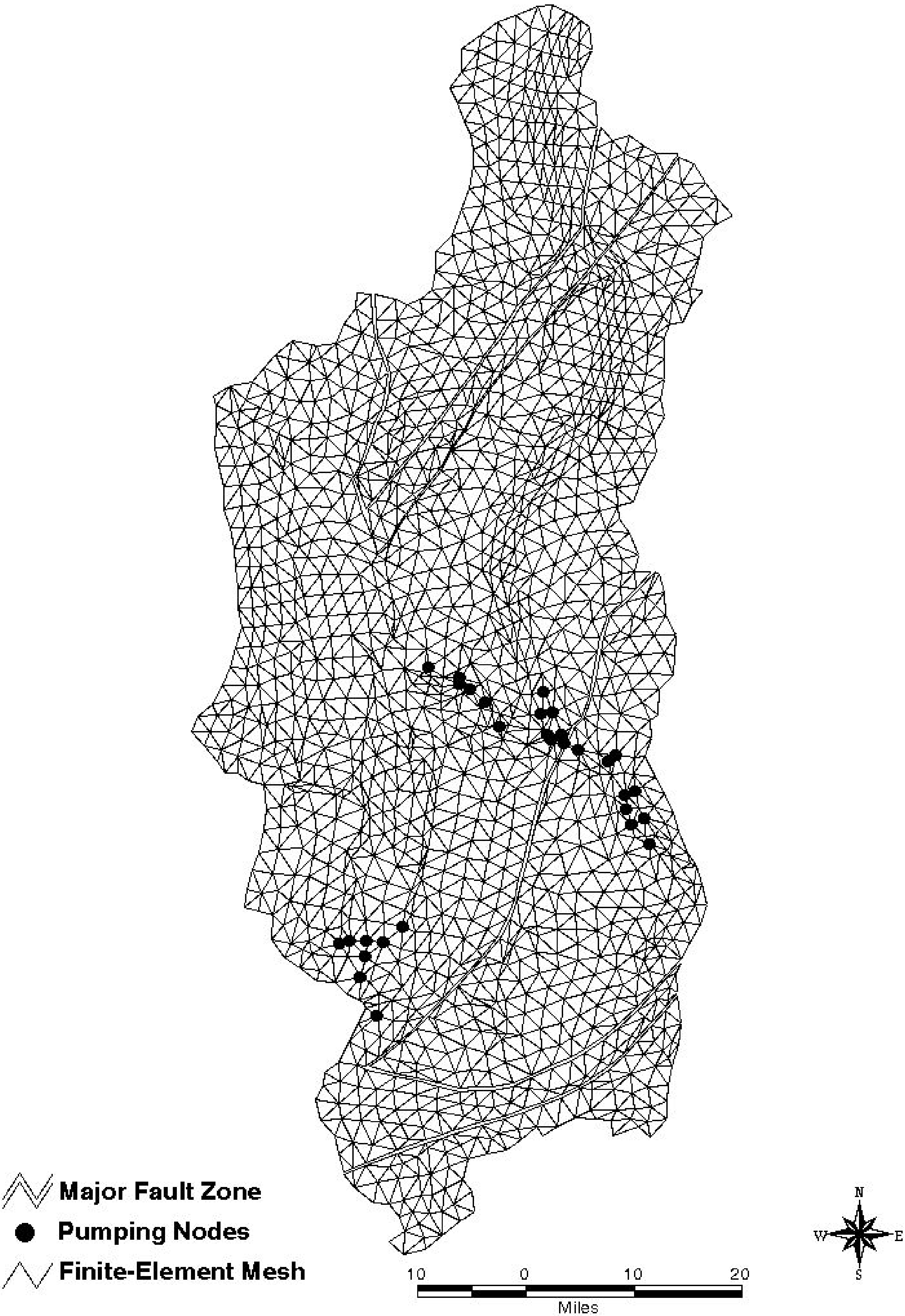


Figure 8-18. Location of pumping nodes represented in model.

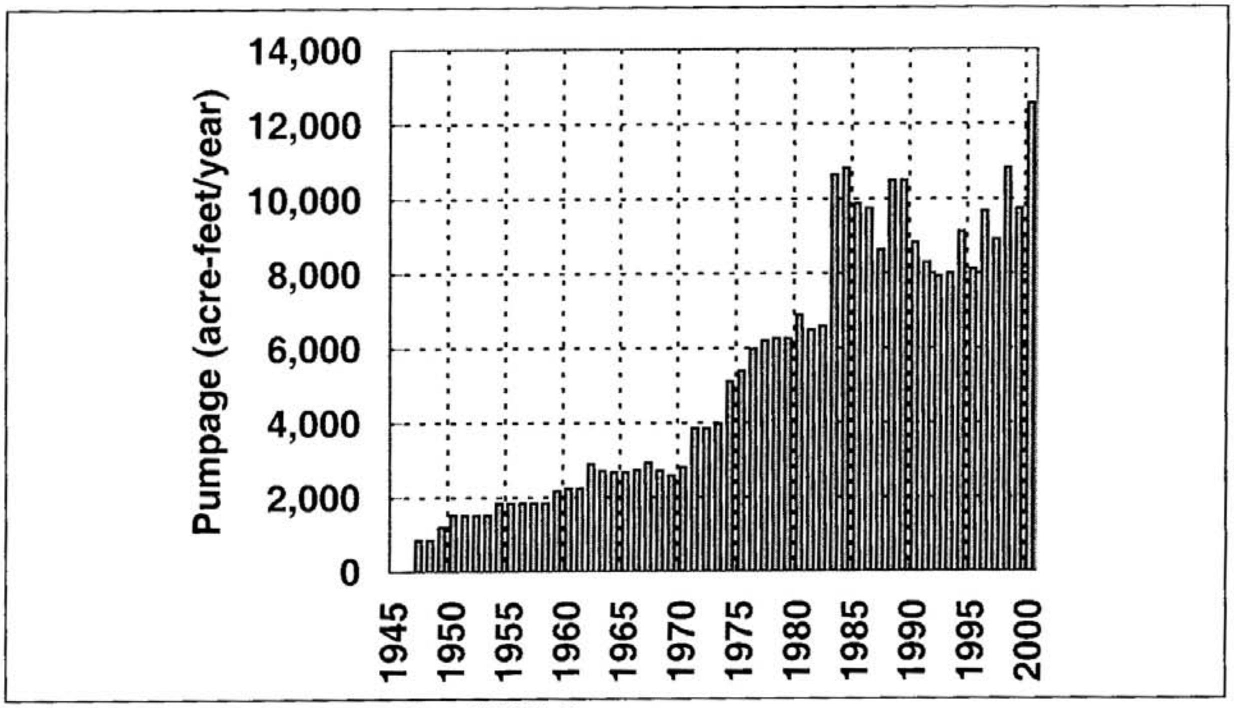


Figure 8-19 Pumping from Valley-fill Wells.

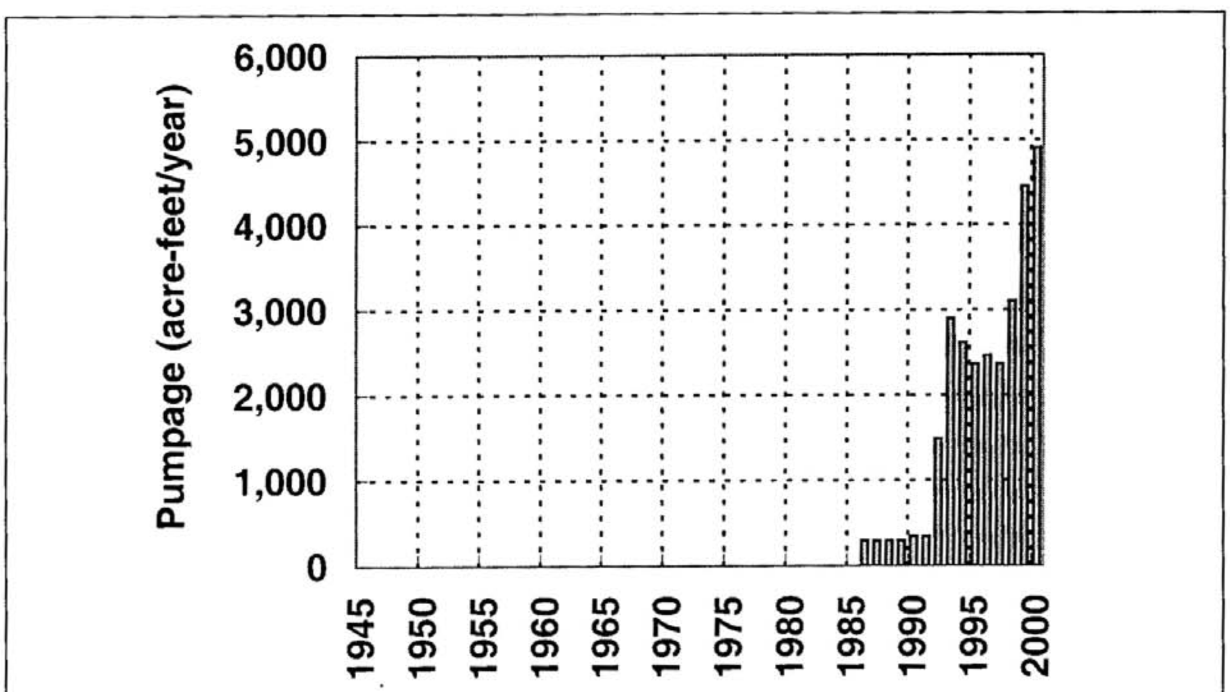


Figure 8-20 Pumping from Carbonate Wells.

NPC, and the USGS. **Figure 8-21** depicts the location of pumping wells used to simulate transient conditions during calibration of the ground-water flow model. Data and information for these wells were acquired in the form of published and unpublished documents and data sets. In addition, numerous interviews were conducted with representatives of MVIC, MVWD, NDWR, and various consultants working within the boundary of the modeled area to assist in the development of the records.

Few recorded data are available for years prior to 1987; therefore, information garnered from literature review and the interview process, water-right abstracts, land-use maps, aerial photography, and satellite imagery was relied upon to construct estimates of ground-water development for each basin for the period 1945 to 1986. Although all available data and information were used to develop the estimates, the fact that records do not exist or are unavailable for this period lend uncertainty to these estimates. Conversely, relatively complete records of ground-water production for the Black Mountains Area, Garnet Valley, and Upper Moapa Valley exist for the period 1987 to 2000. The Upper Moapa Valley has the most complete record due to monitoring programs established by DRI, MVWD, and NPC, and hydrologic investigations conducted by DRI and the USGS. Estimated totals of annual ground-water production for selected basins within the model boundary are listed in **Table 8-2.** A summary of ground-water development by MVWD and NPC in the Muddy River Springs Area for the period 1987 to 2000 is provided in **Table 8-3.**

Table 8-2. Estimates of ground-water production for selected sub-basins within the model boundary, in acre-feet.

	Estimated annual ground-water production					
Sub-basin	1950	1960	1970	1980	1990	2000
Black Mountains Area	0	0	0	0	0	1,693
Garnet Valley	0	0	50	150	496	952
Lower Moapa Valley	0	63	378	1,197	881	462
Meadow Valley Wash	0	0	880	3,080	3,740	3,960
Muddy River Springs Area	1,513	2,171	1,495	2,455	4,056	10,393

Table 8-3. Ground-water development in the Upper Moapa Valley since 1987 by MVWD and NPC, in acre-feet.

Year	MVWD	NPC
1987	245	2,304
1988	245	4,309
1989	245	7,126
1990	245	7,337
1991	245	7,342
1992	758	6,293
1993	1,345	6,287
1994	894	6,890
1995	678	6,414
1996	705	7,972
1997	808	6,589
1998	1,557	8,262
1999	2,579	7,333
2000	2,908	10,548

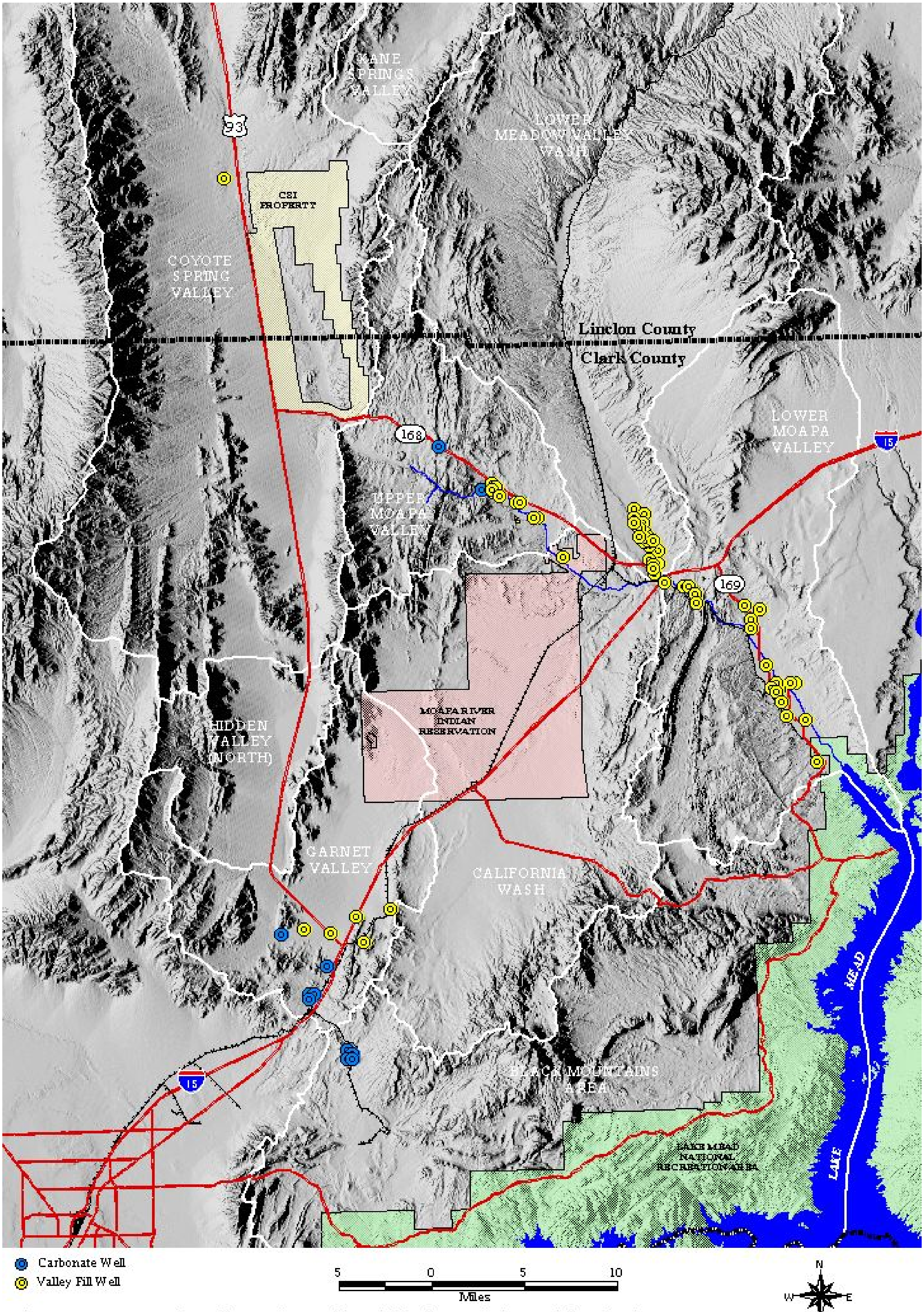


Figure 8-21. Location of pumping wells within the model area, historical 1945-2000.

Appendix B provides a detailed discussion of the methods used to estimate and distribute ground-water pumping in each basin within the model boundary for the period 1945 to 2000. Included, are annual ground-water production totals for MVWD and NPC as reported by MVWD, DRI, and NPC, as well as, recent data submitted to NDWR by various water users in the Black Mountains Area and Garnet Valley.

8.2.5 Representation of Consumptive Use

The model represents the consumption of surface water and ground water, which results from vegetation and municipal and industrial use.

Vegetative consumption occurs where soils are moist owing to irrigation or shallow ground-water. About 5,000 acres produce consumption along Meadow Valley Wash from Caliente to its confluence with the Muddy River. About 4,000 acres occurs above the Rox gage, and about 1,000 acres occurs near the confluence with the Muddy River. About 7,400 acres produce consumption along the Muddy River from Muddy Springs to Lake Mead. Along the Muddy River, about 600 acres occurs along the river above the Moapa gage, about 1,800 acres occurs along the river from the Moapa gage to the Glendale gage, and about 5,000 acres occurs along the river from the Glendale gage to Lake Mead.

The annual consumption within the model area is about 5 ft per acre. Correspondingly, the consumption along Meadow Valley Wash is about 23,000 afy, and the consumption along the Muddy River from Muddy Springs to Lake Mead is about 37,000 afy. Along Meadow Valley Wash, the consumption is 20,000 afy above the Rox gage and 4,000 afy near the confluence with the Muddy River. Along the Muddy River, the consumption is 3,000 afy along the river above the Moapa gage, about 9,000 afy along the river from the Moapa gage to the Glendale gage, and about 25,000 afy along the river from the Glendale gage to Lake Mead.

This consumption most likely has remained essentially constant over a long period. This is the case even though water-use patterns have changed. Prior to the introduction of agriculture, the consumption resulted from water use by native phreatophytes. With the introduction of agriculture, the phreatophytes were replaced with forage and other crops, which have been irrigated from shallow ground water, streamflow diversions, and pumping. The acreage has remained essentially unchanged, the consumption per unit area has remained unchanged, and the total consumption has remained unchanged. This is the case except for lands along Meadow Valley Wash near its confluence with the Muddy River, which presently are irrigated with ground-water. Prior to the agricultural development of those lands, about 400 acres were covered with phreatophytes. Currently, about 1,000 acres are irrigated or covered with phreatophytes.

These conditions are represented in the model using the stream-aquifer module of FEMFLOW3D. The module simulates stream-aquifer interactions and the accretion or depletion of streamflow along a channel owing to the stream-aquifer interactions and upstream inflows. Consumption is represented by diversions from streamflow. Where irrigation occurs from actual diversions, the specified local diversion is the net diversions, which is the diversion less ground-water returns and surface-water returns. Where irrigation occurs from shallow ground-water, the specified local diversion is the net consumption, which is the vegetation ET. By this representation, the streamflow diversion is a surrogate in the model for the consumption of ground water **(Figure 8-5)**. **Figure 8-22** shows the location where consumptive diversions are represented in the model.

Ground water is pumped for supplemental irrigation along the Muddy River and Meadow Valley Wash. That pumping is represented in the model as the net pumping, which is the consumption of the pumped water. Where supplemental ground-water is used, the local streamflow diversion expressed in the model is reduced by the local net pumping. Correspondingly, supplemental pumping replaces diversions such that the total consumption is unchanged. The supplemental pumping and reduced diversions are shown on **Figure 8-23a** through **Figure 8-23c**, which are the values represented in the model. **Figure 8-23a** shows in particular the pumping and reduced diversions for the Meadow Valley Wash below the Rox stream gaging station. As shown on the figure, the supplemental pumping exceeds the initial local diversion after 1970. This represents a case where the total vegetative consumption is not unchanged, but it increases owing to supplemental pumping that exceeds the consumption prior to any pumping.

8.2.6 Representation of Boundary Shifts

While the boundaries of the modeled area follow drainage divides, pumping causes the boundary location to shift. Under the 1945 steady-state conditions, the model boundaries correspond to the boundaries of the modeled area, which follow drainage divides. Topographic divides correspond with ground-water boundaries owing to the higher recharge beneath mountain areas. Post-1945 pumping has induced ground-water flow across the prior steady-state boundaries such that the boundaries moved outward. However, because post-1945 carbonate aquifer pumping has had little effect on Muddy River flows, the regional water-level declines have been small and the boundary shift has been slight. Nevertheless, the proposed future pumping is sufficient to shift this boundary further outward.

To account for this phenomenon, the variable-flux module of FEMLOW3D is utilized in the model. That module specifies a boundary condition that in effect extends the model area by attaching an analytical solution representing a one-dimensional aquifer to mesh nodes at the model boundary (Durbin and Bond, 1998). The extension occurs when pumping within the modeled area causes a water-level decline at the boundary of the modeled area. The module simulates subsurface flows at the boundary that occur in response to a water-level decline at the boundary. This approach has some similarities to the general-head boundary utilized in the modeling program MODFLOW (McDonald and Harbaugh, 1988), but it differs in that the variable-flux boundary incorporates the changes in ground-water storage outside the model area.

Figure 8-24 shows the geographic locations where a variable-flux boundary is assigned to mesh nodes. That boundary condition is assigned to the carbonate aquifer using the second from the bottom node in the model mesh. At that vertical position, the aquifer thickness specified for the boundary condition is the overall thickness of the carbonate aquifer.

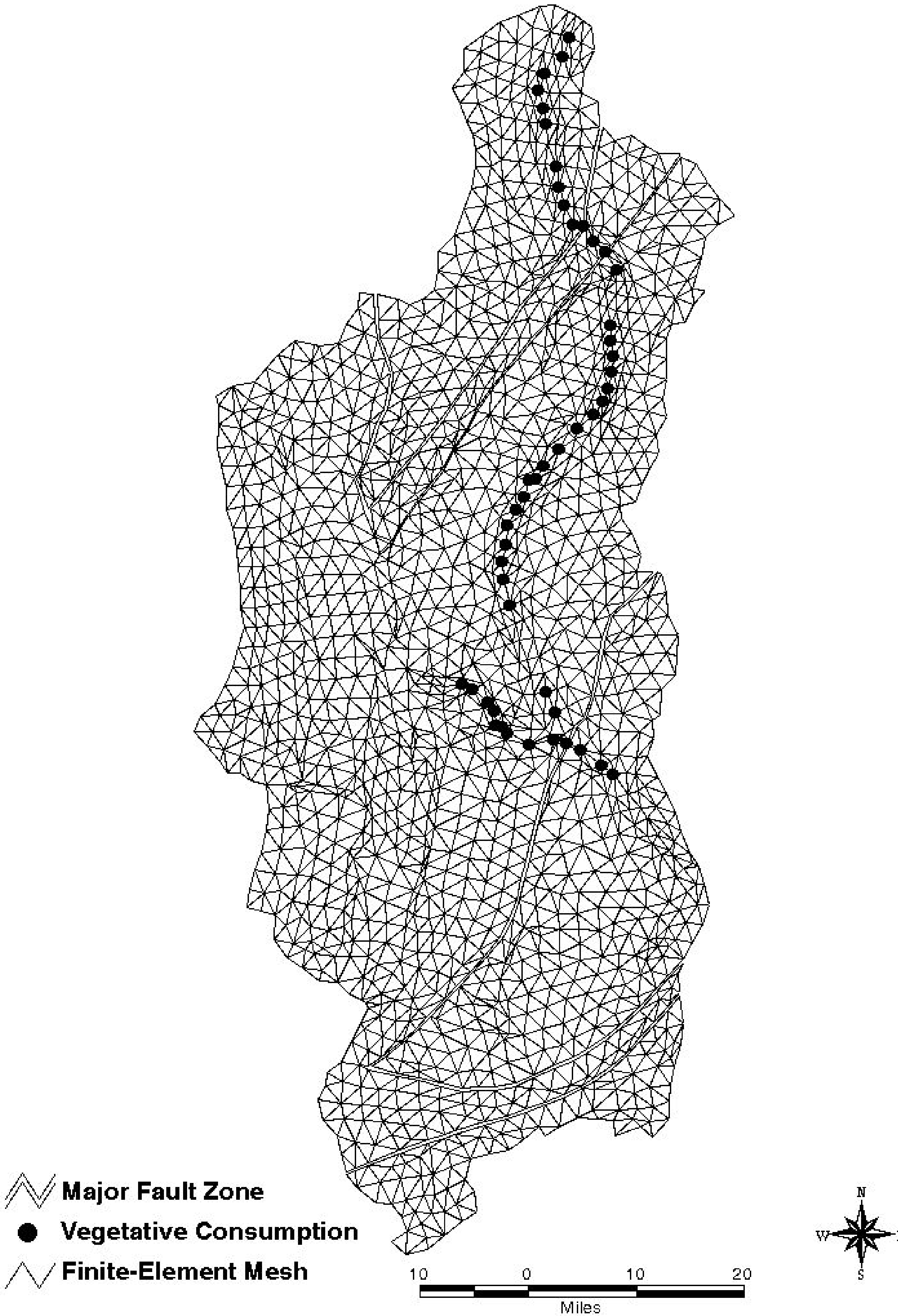


Figure 8-22. Location of vegetation consumptive use represented in model.

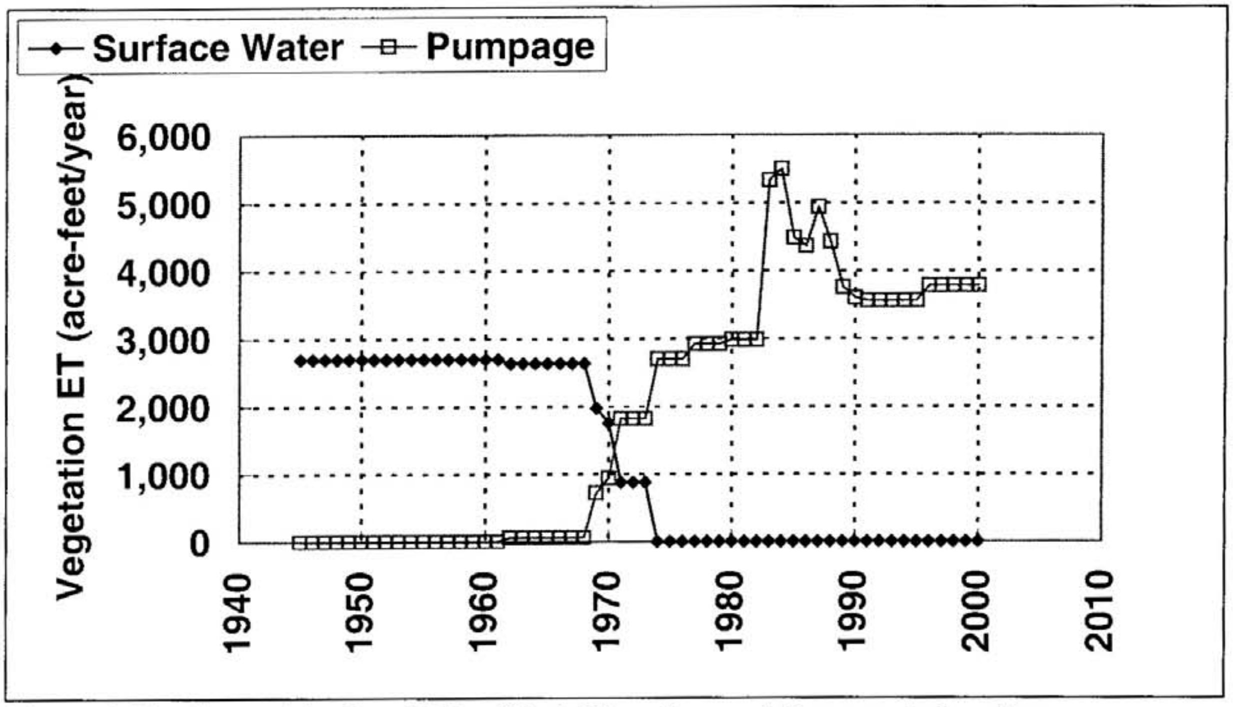


Figure 8-23a Lower Meadow Valley Wash Diversions and Pumpage below Rox.

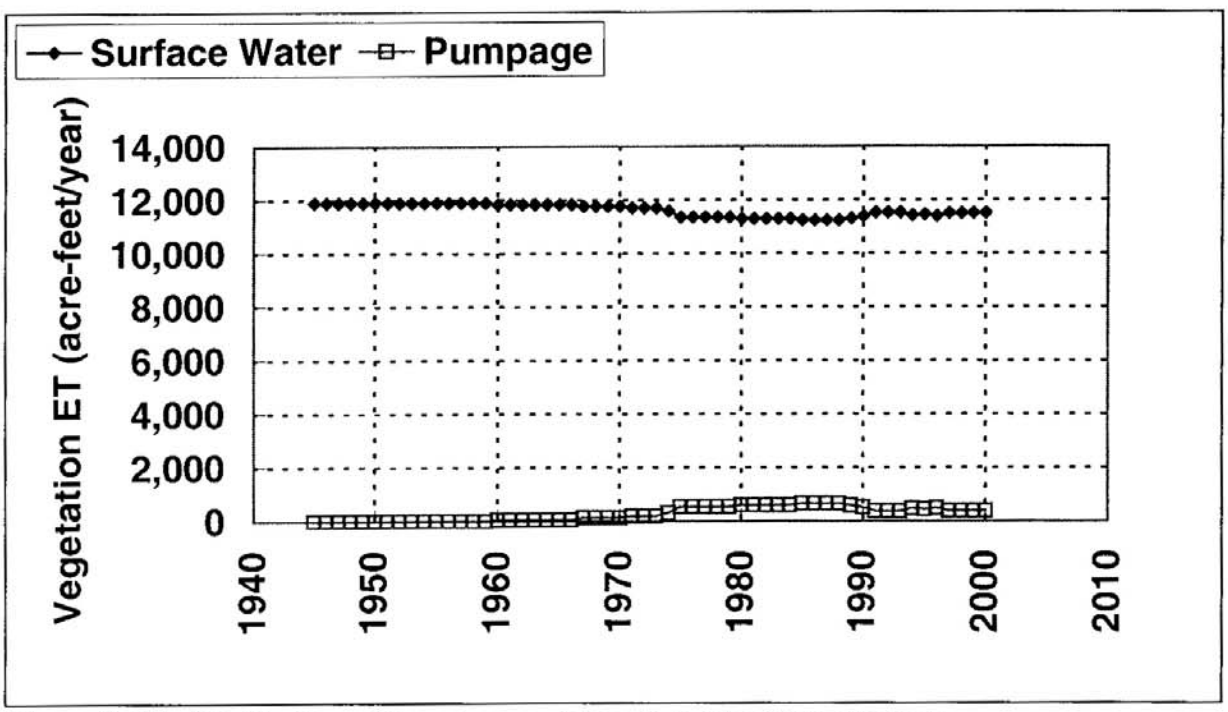


Figure 8-23b Muddy River Diversions and Pumpage Moapa to Glendale.

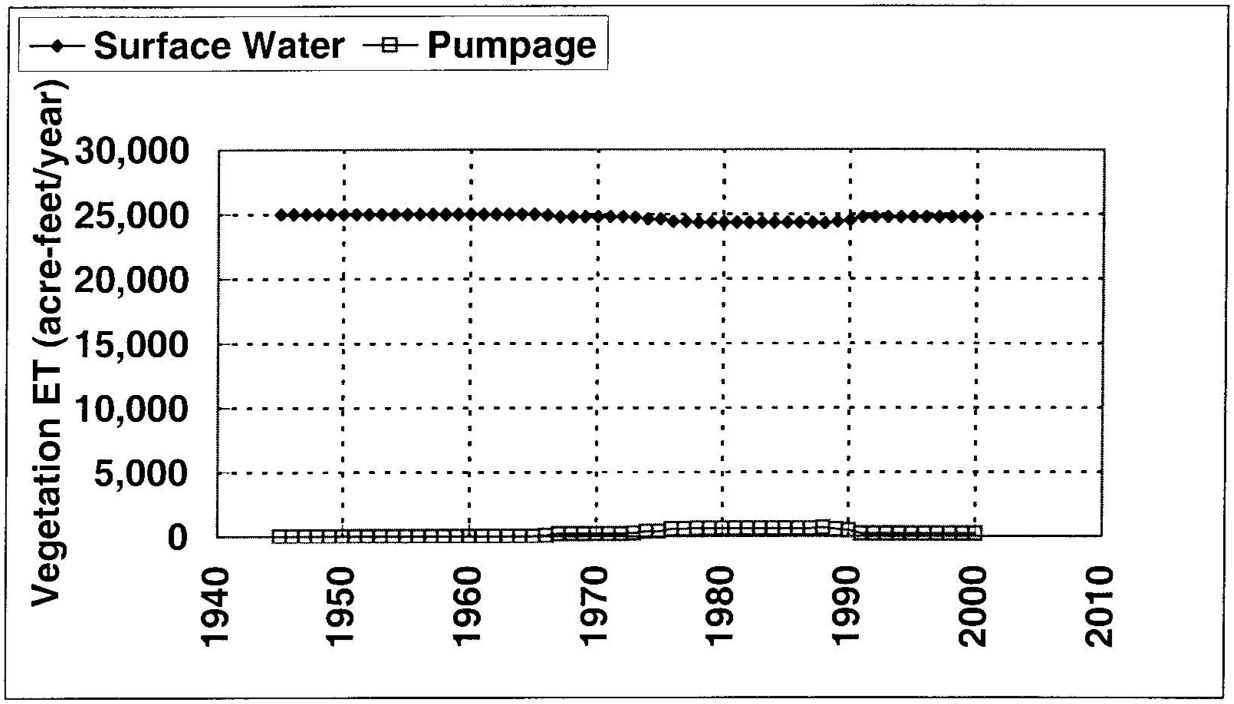


Figure 8-23c Muddy River Diversions and Pumpage Glendale to Overton.

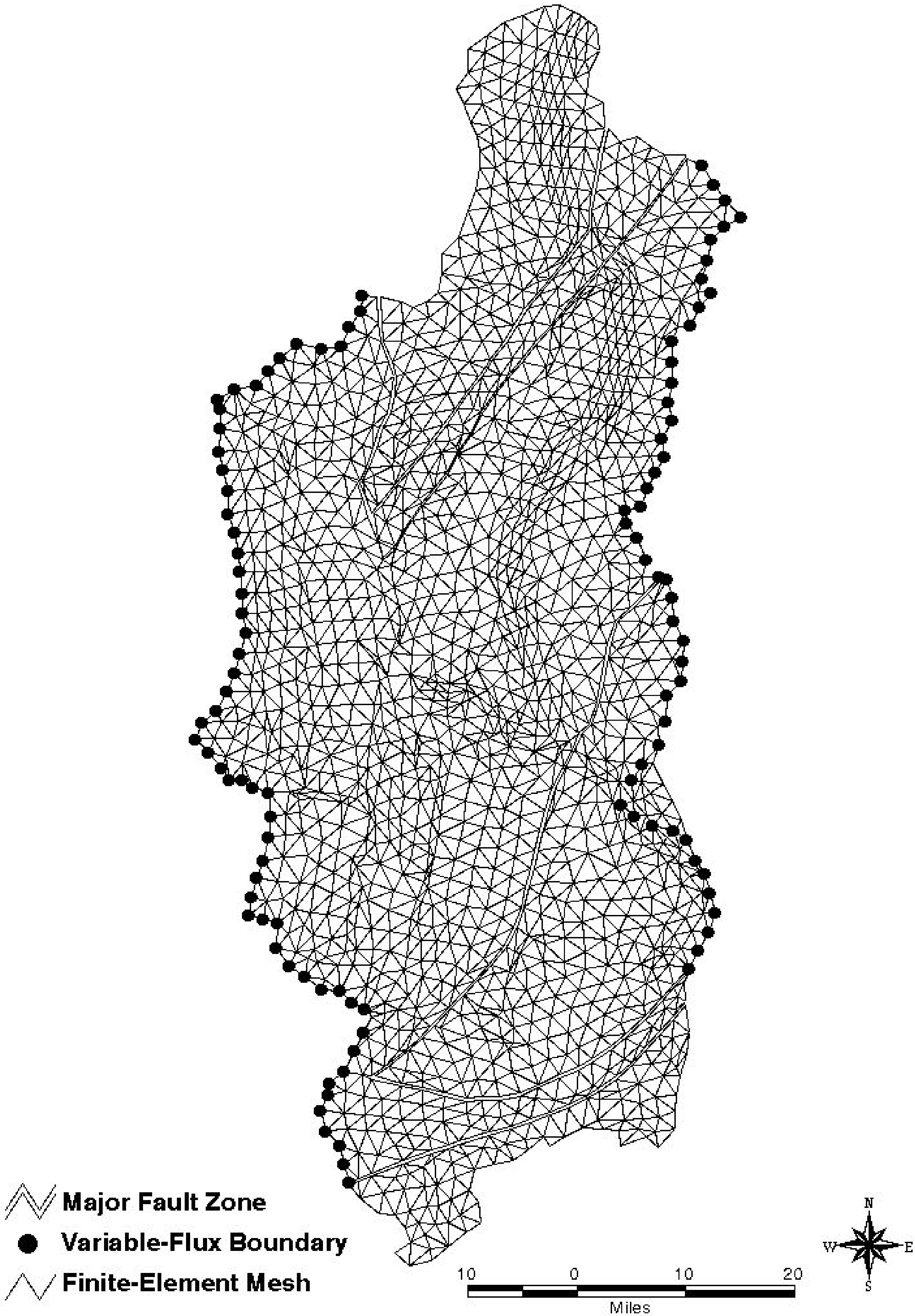


Figure 8-24. Location of variable-flux boundaries represented in model.

8.2.7 Identification of Model Parameters

8.2.7.1 Calibration Approach

Parameter values for the model were identified by calibrating the model to measured ground-water levels, spring flows, and streamflows. The model parameters include the permeability, specific storage, and specific yield for each hydrogeologic unit; the leakance for each spring or spring group; and the bed permeability for each stream channel. The calibration involved finding a set of parameter values such that the model best fit measured ground-water levels, spring flows, and streamflows. The model was used to simulate these quantities, and the simulated values were compared with the corresponding measured values in order to assess the model fit. Based on that comparison, parameter values were adjusted iteratively by a trial-and-error process to improve the model fit.

Both steady-state and transient-state simulations were used to calibrate the model. The calibration period was 1945-2000. Starting with a steady-state simulation for 1945, a transient-state simulation was made for 1946-2000. Correspondingly, the model was calibrated to the 1945 steady-state conditions and to the 1946-2000 transient-state conditions. The model was calibrated to streamflows, spring flows, and ground-water measurements representing 1945, including data collected later but nevertheless representative of 1945 conditions. Based on a steady-state simulation, these data were used to identify permeability for each hydrogeologic unit, permeability for the represented faults, and leakance for the carbonate springs. Additionally, the model was calibrated to streamflow, spring flow, and ground-water measurements during 1946-2000. Based on a transient-state simulation, these data were used to identify the specific storage and specific yield for each hydrogeologic unit.

Streamflow, spring flow, and ground-water data collected by the U. S. Geological Survey, Southern Nevada Water Authority and others were used in the model calibration. Streamflow data include those for the Caliente gage, Rox gage, Moapa gage, Glendale gage, and Overton gage. The location for these stream-gaging stations is shown on **Figure 8-5**, and annual streamflows are shown on **Figure 8-26** and **Figure 8-27** for the Moapa and Glendale gages. Spring flow data for Rogers Spring and Blue Point Spring are also included. Ground-water data include water-level measurements made by the U. S. Geological Survey and others in both valley-fill and carbonate wells. The well locations are shown on **Figure 8-25a** and **Figure 25b**, and represent wells in which repeated water-level measurements have been made over an extended period.

Ground-water levels were used to estimate hydraulic heads that were then compared to those simulated by the ground-water flow model during the calibration process. Hydraulic heads are a measure of the potential energy at a single point, and provide a measure of the driving energy that causes water to flow through permeable rocks. The difference between observed water levels and simulated hydraulic heads is a measure of how well the model simulates the ground-water flow system. Water-level data may also be used to estimate the direction of ground-water

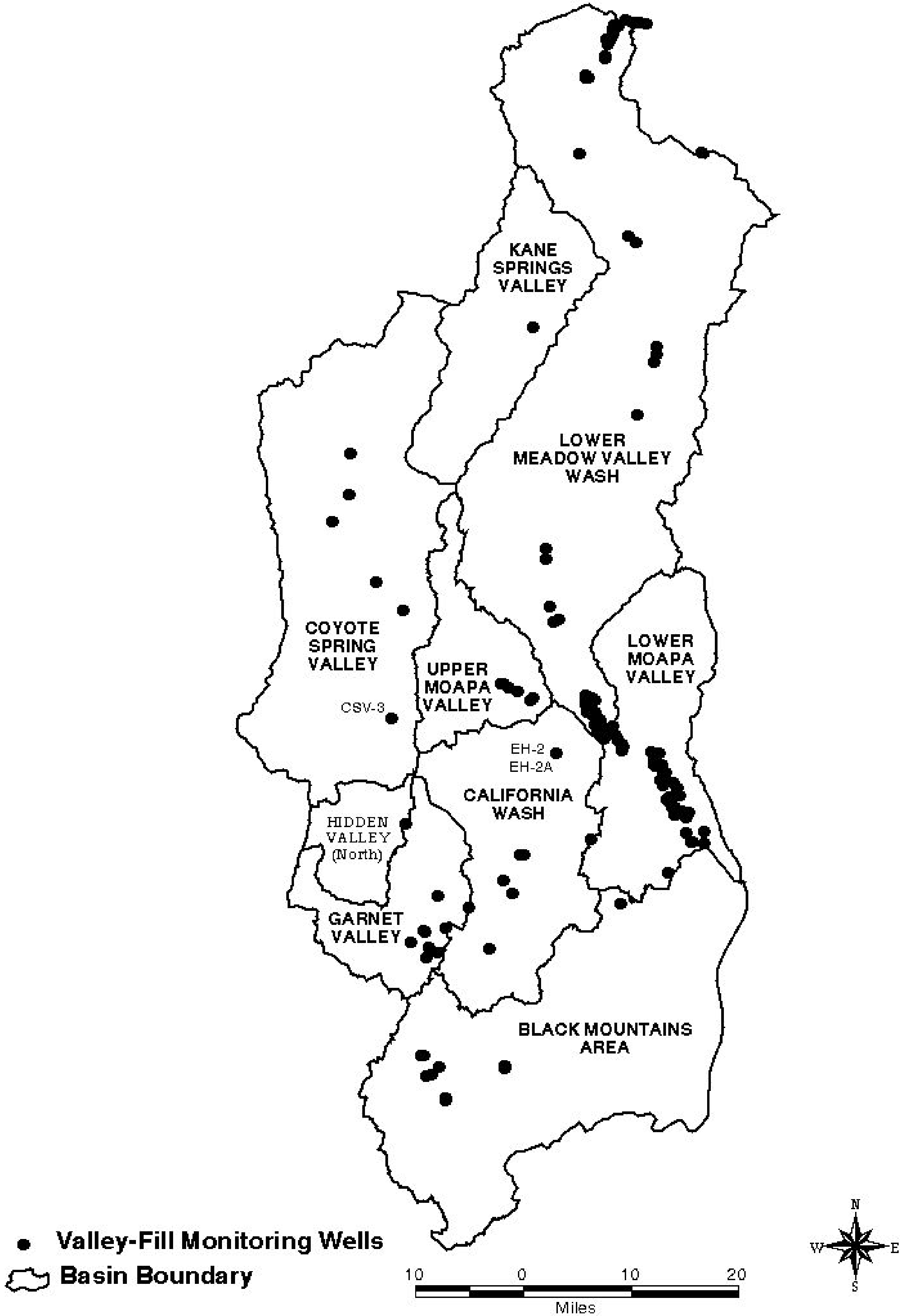


Figure 8-25a. Location of valley-fill monitoring wells used in model calibration.

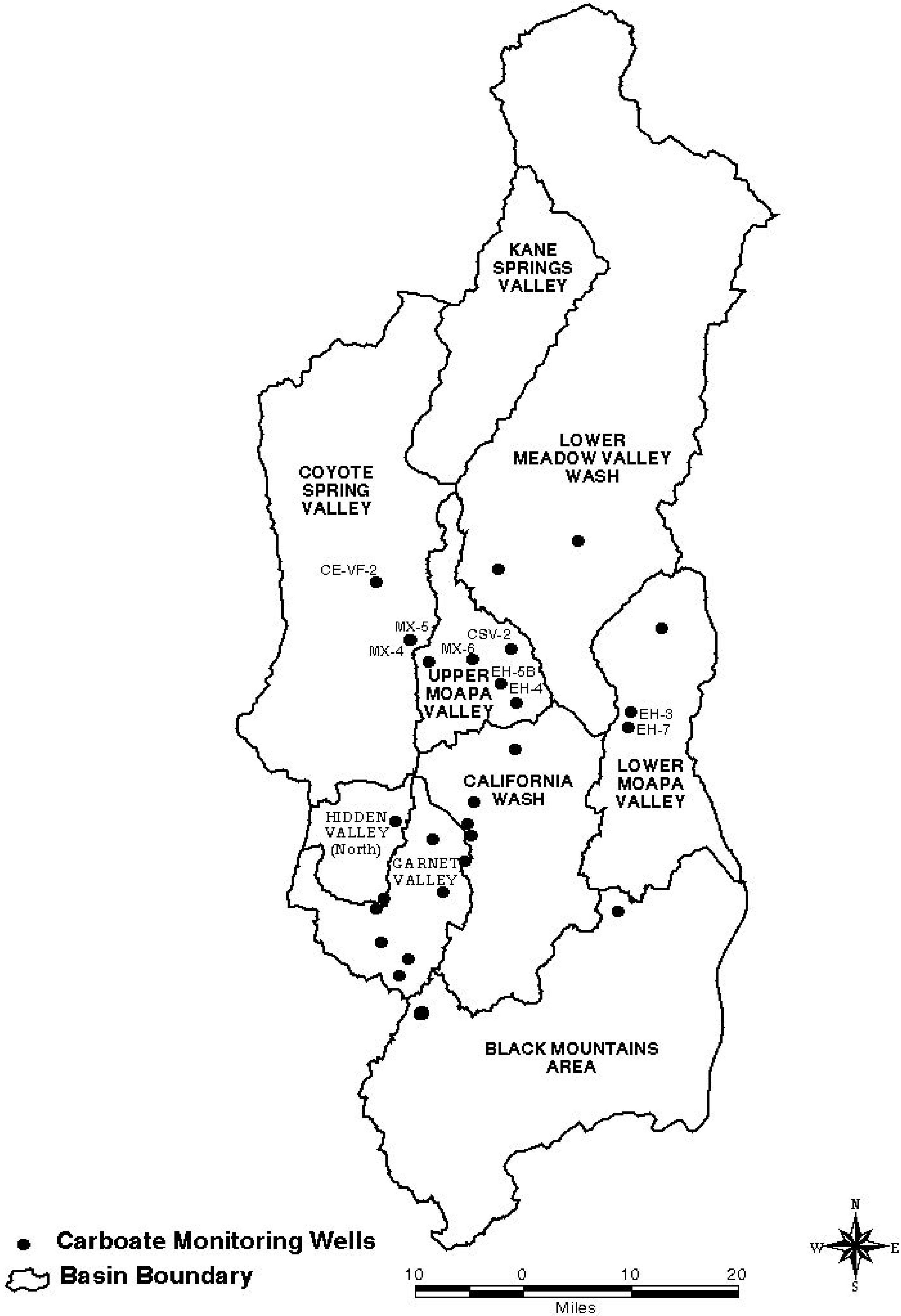


Figure 8-25b. Location of carbonate monitoring wells used in model calibration.

flow. For these purposes, water-level data was an integral part in developing the ground-water flow model. The greater the density of quality water-level data the greater certainty in the calibration process and subsequent model results.

Water levels are typically expressed temporally and spatially as elevations above mean sea level, requiring the following known parameters: location coordinates, measuring point elevation, depth-to-water, and date and time of measurement. Each of these parameters has some inherent uncertainty. Measurement error and procedural deficiencies lead to uncertainty in depth-to-water measurements. Expressing water levels as elevations introduces additional uncertainty related to the accuracy of the methods used to determine the measuring point elevation.

Well data containing these parameters were compiled from numerous sources including data collected by SNWA and data obtained from the USGS Ground-water Site Inventory database (GWSI), NDWR Well Log Database, and various reports and maps. Data compilation focused on well data for known carbonate wells and wells known to have a significant record of depth-to-water measurements (e.g. greater than 5-years of record). As **Figure C-1** in Appendix C illustrates, nearly all of these wells are located in Coyote Spring Valley and the Muddy River Springs Area. Many of the wells have limited historical records since they were completed in the early to mid-1980s as part of USGS hydrologic investigations, the U.S. Airforce MX-Missile program, and NPC ground-water-monitoring program. Appendix C provides individual hydrographs for these wells. Site information and depth-to-water data compiled for wells within the model boundary are also included in Appendix C **(Table C-1** and **Table C-2)**.

Water-level data used to construct the hydrographs for wells ABBOTT, BEHMER, EH-2, EH-2A, EH-3, EH-4, EH-5B, EH-7, LDS-CENTRAL, LDS-WEST, LEWIS-NORTH, and LEWIS-SOUTH were compiled from NPC monitoring reports. Water-level data used to construct the hydrographs for wells CE-VF-1, CE-VF-2, CSV-1, CSV-2, CSV-3, MX-4, MX-5, and SHV-1 were compiled from SNWA records and the USGS GWSI database. Water-level data for these wells is considered good although methods by which the depth-to-water measurements were made and the accuracy of the measuring-point elevation are generally unknown.

Other well data compiled from Johnson et al. (2001, Appendix C) includes water-level data for additional carbonate monitoring wells, however many of the wells were completed in recent years and do not have a significant long-term record. Johnson et al. reported discrete carbonate water-level elevations for wells ECP-1, ECP-2, ECP-3, TH-1, TH-2, M-1, M-2, and M-3 located on the Moapa River Indian Reservation in California Wash. Also reported, were discrete water-level elevations for wells owned by Nevada Cogeneration Associates, Georgia Pacific Corporation, and U.S. Chemical Lime Company in the Black Mountains Area and Garnet Valley. These data are also provided in Appendix C in Table C-1 and C-2.

The remaining well data provided in Appendix C were compiled from individual well log records listed in the NDWR Well Log database. Few of these data were used for calibration purposes due to the high uncertainty of the methods used to determine depth-to-water and measuring point elevations. These data were used with great caution and only as a last resort to provide water-level control in areas where no other data were available.

Figure C-2 depicts the location of primary wells with significant water-level records. As stated previously, many of these wells were completed recent years in areas where ground-water development is occurring. However, due to the sparseness of quality water-level data within the model boundary, some were used during the calibration process.

8.2.7.2 Calibration Results

The parameter values produced from the model calibration are listed in **Table 8-4**. Permeability, specific storage, and specific yield values are listed separately in the table for each subarea within the modeled area, except that values are listed for northern and southern parts of the Upper Moapa Valley subarea. That subarea was subdivided to represent a region of higher permeability that occurs within a geographic band overlying the Glendale Thrust. Within this band, higher permeability is indicated by nearly flat hydraulic gradients, which presumably correspond to secondary faulting and fracturing that is associated with the Glendale Thrust.

Based on the listed parameter values, the streamflows and spring flows simulated with the calibrated model are summarized on **Figure 8-26** through **Figure 8-30**. **Figure 8-26** and **Figure 8-27** show hydrographs of computed and measured streamflow for the Moapa and Glendale gages. The simulated streamflow at the Overton gage is shown on **Figure 8-28**. There is no long-term historical record for the Overton gage. **Figure 8-29** and **Figure 8-30** show a hydrograph of computed springflow for the Muddy Springs and Rogers and Blue Point Springs. The ground-water levels simulated with the calibrated model are summarized on **Figure 8-31** through **Figure 8-33m**. **Figure 8-31** and **Figure 8-32** show scatter diagrams of measured and computed streamflow respectively for valley-fill and carbonate wells. **Figures 8-33a** through **Figure 8-33m** show hydrographs of measured and computed ground-water levels for selected valley-fill and carbonate wells.

Simulated ground-water levels for the model area are shown on **Figure 8-34** through **Figure 8-37**. **Figure 8-34** shows contours of ground-water elevation at the top of the carbonate aquifer for 1945, and **Figure 8-35** shows contours of ground-water elevation at the ground-water table. Likewise, **Figure 8-36** and **Figure 8-37** show those contours for 2000.

Table 8-4. Hydraulic properties assigned to hydrogeologic units and faults.

Material Name	Structural Block	Material	Kx ft/d	Ky ft/d	Kz ft/d	Ss 1/ft	Sy
Valley-Fill Deposits	Lake Mead Subarea	1	1.00	1.00	$1.80x10^{-3}$	$1.00x10^{-6}$	0.05
Valley-Fill Deposits	Black Mountains Subarea	2	1.00	1.00	$1.80x10^{-3}$	$1.00x10^{-6}$	0.05
Valley-Fill Deposits	Lower Moapa Subarea	3	1.00	1.00	$1.80x10^{-3}$	$1.00x10^{-6}$	0.05
Valley-Fill Deposits	Upper Moapa Subarea	4	1.00	1.00	$1.80x10^{-3}$	$1.00x10^{-6}$	0.05
Valley-Fill Deposits	Meadow Valley Mountains Subarea	5	1.00	1.00	$1.80x10^{-2}$	$1.00x10^{-6}$	0.05
Valley-Fill Deposits	Kane Springs Subarea	6	1.00	1.00	$1.80x10^{-2}$	$1.00x10^{-6}$	0.05
Volcanic Rocks	Lake Mead Subarea	7	$1.50x10^{-1}$	$1.50x10^{-1}$	$2.70x10^{-2}$	$1.00x10^{-6}$	0.01
Volcanic Rocks	Black Mountains Subarea	8	$1.50x10^{-1}$	$1.50x10^{-1}$	$2.70x10^{-2}$	$1.00x10^{-6}$	0.01
Volcanic Rocks	Lower Moapa Subarea	9	$1.50x10^{-1}$	$1.50x10^{-1}$	$2.70x10^{-2}$	$1.00x10^{-6}$	0.01
Volcanic Rocks	Upper Moapa Subarea	10	$1.50x10^{-1}$	$1.50x10^{-1}$	$2.70x10^{-2}$	$1.00x10^{-6}$	0.01
Volcanic Rocks	Meadow Valley Mountains Subarea	11	$1.50x10^{-1}$	$1.50x10^{-1}$	$2.70x10^{-2}$	$1.00x10^{-6}$	0.01
Volcanic Rocks	Kane Springs Subarea	12	$1.50x10^{-1}$	$1.50x10^{-1}$	$2.70x10^{-1}$	$1.00x10^{-6}$	0.01
Intrusive Rocks	Lake Mead Subarea	13	$1.50x10^{-2}$	$1.50x10^{-2}$	$2.70x10^{-2}$	$1.00x10^{-6}$	0.01
Intrusive Rocks	Black Mountains Subarea	14	$1.50x10^{-2}$	$1.50x10^{-2}$	$2.70x10^{-2}$	$1.00x10^{-6}$	0.01
Intrusive Rocks	Lower Moapa Subarea	15	$1.50x10^{-2}$	$1.50x10^{-2}$	$2.70x10^{-2}$	$1.00x10^{-6}$	0.01
Intrusive Rocks	Upper Moapa Subarea	16	$1.50x10^{-2}$	$1.50x10^{-2}$	$2.70x10^{-2}$	$1.00x10^{-6}$	0.01
Intrusive Rocks	Meadow Valley Mountains Subarea	17	$1.50x10^{-2}$	$1.50x10^{-2}$	$2.70x10^{-2}$	$1.00x10^{-6}$	0.01
Intrusive Rocks	Kane Springs Subarea	18	$1.50x10^{-2}$	$1.50x10^{-2}$	$2.70x10^{-2}$	$1.00x10^{-6}$	0.01
Clastic Rocks	Lake Mead Subarea	19	$2.00x10^{-1}$	$2.00x10^{-1}$	$3.60x10^{-1}$	$1.00x10^{-6}$	0.01
Clastic Rocks	Black Mountains Subarea	20	$2.00x10^{-1}$	$2.00x10^{-1}$	$3.60x10^{-1}$	$1.00x10^{-6}$	0.01
Clastic Rocks	Lower Moapa Subarea	21	$2.00x10^{-1}$	$2.00x10^{-1}$	$3.60x10^{-1}$	$1.00x10^{-6}$	0.01
Clastic Rocks	Upper Moapa Subarea	22	$2.00x10^{-1}$	$2.00x10^{-1}$	$3.60x10^{-3}$	$1.00x10^{-6}$	0.01
Clastic Rocks	Meadow Valley Mountains Subarea	23	$2.00x10^{-1}$	$2.00x10^{-1}$	$3.60x10^{-1}$	$1.00x10^{-6}$	0.01
Clastic Rocks	Kane Springs Subarea	24	$2.00x10^{-1}$	$2.00x10^{-1}$	$3.60x10^{-1}$	$1.00x10^{-6}$	0.01
Carbonate Rocks	Lake Mead Subarea	25	2.00	2.00	$3.60x10^{-1}$	$1.00x10^{-6}$	0.01
Carbonate Rocks	Black Mountains Subarea	26	2.00	2.00	$3.60x10^{-1}$	$1.00x10^{-6}$	0.01
Carbonate Rocks	Lower Moapa Subarea	27	2.00	2.00	$3.60x10^{-1}$	$1.00x10^{-6}$	0.01
Carbonate Rocks	Upper Moapa Subarea (South)	28	$2.00x10^{+1}$	$2.00x10^{+1}$	$3.60x10^{-1}$	$1.00x10^{-6}$	0.01
Carbonate Rocks	Upper Moapa Subarea (North)	39	$3.50x10^{-1}$	$3.50x10^{-1}$	$9.00x10^{-2}$	$1.00x10^{-6}$	0.01
Carbonate Rocks	Meadow Valley Mountains Subarea	29	$3.50x10^{-1}$	$3.50x10^{-1}$	$9.00x10^{-2}$	$1.00x10^{-6}$	0.01
Carbonate Rocks	Kane Springs Subarea	30	$3.50x10^{-1}$	$3.50x10^{-1}$	$9.00x10^{-2}$	$1.00x10^{-6}$	0.01
Overthrust Clastic Rocks	Lower Moapa Subarea	31	$2.00x10^{-1}$	$2.00x10^{-1}$	$3.60x10^{-2}$	$1.00x10^{-6}$	0.01
Overthrust Carbonate Rocks	Lower Moapa Subarea	32	$2.00x10^{-1}$	$2.00x10^{-1}$	$3.60x10^{-1}$	$1.00x10^{-6}$	0.01
South Black Mountains Fault		33	$1.00x10^{-2}$	$1.00x10^{-2}$	$1.80x10^{-2}$	$1.00x10^{-6}$	0
North Black Mountains Fault		34	$1.00x10^{-2}$	$1.00x10^{-2}$	$1.80x10^{-2}$	$1.00x10^{-6}$	0
Glendale Thrust		35	$3.50x10^{-2}$	$3.50x10^{-2}$	$3.50x10^{-2}$	$1.00x10^{-6}$	0
Meadow Valley Mountains Fault		36	$2.00x10^{-1}$	$2.00x10^{-1}$	$3.60x10^{-2}$	$1.00x10^{-6}$	0
Kane Springs Fault		37	$2.00x10^{-1}$	$2.00x10^{-1}$	$3.60x10^{-2}$	$1.00x10^{-6}$	0
Coyote Spring Fault		38	$2.00x10^{-1}$	$2.00x10^{-1}$	$3.60x10^{-2}$	$1.00x10^{-6}$	0

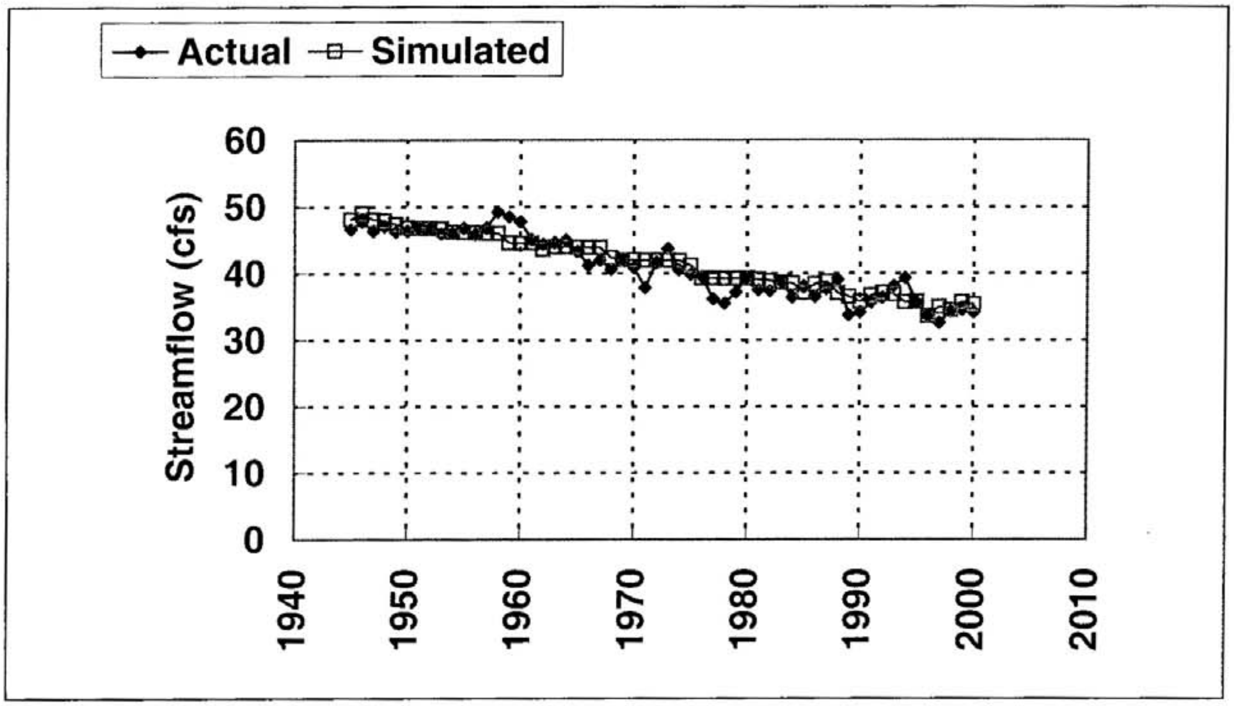


Figure 8-26 Muddy River Streamflow at Moapa Gage.

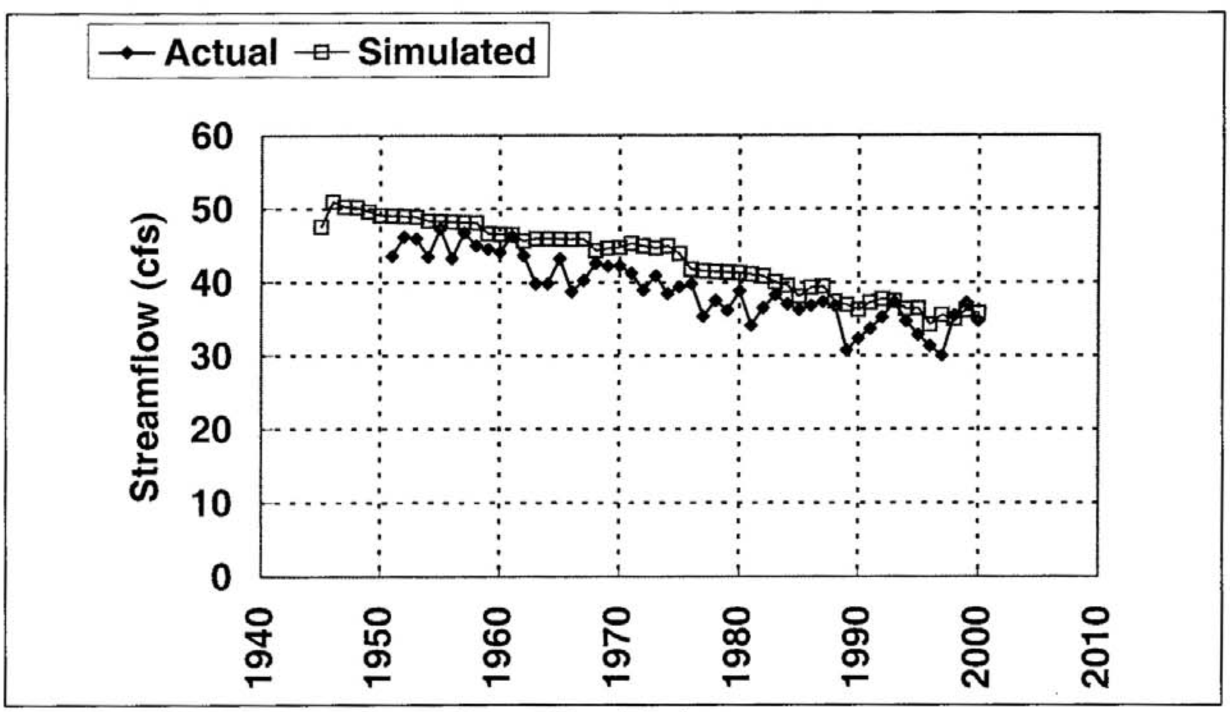


Figure 8-27 Muddy River Streamflow at Glendale Gage.

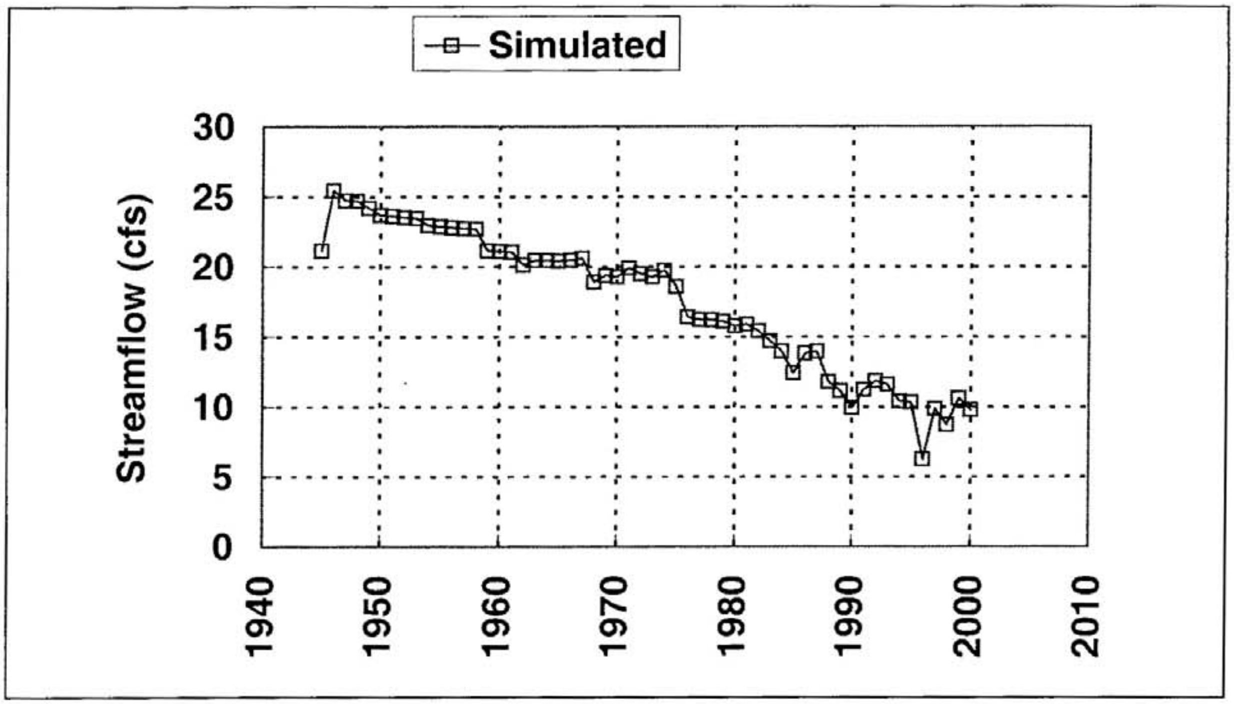


Figure 8-28 Muddy River Streamflow at Overton.

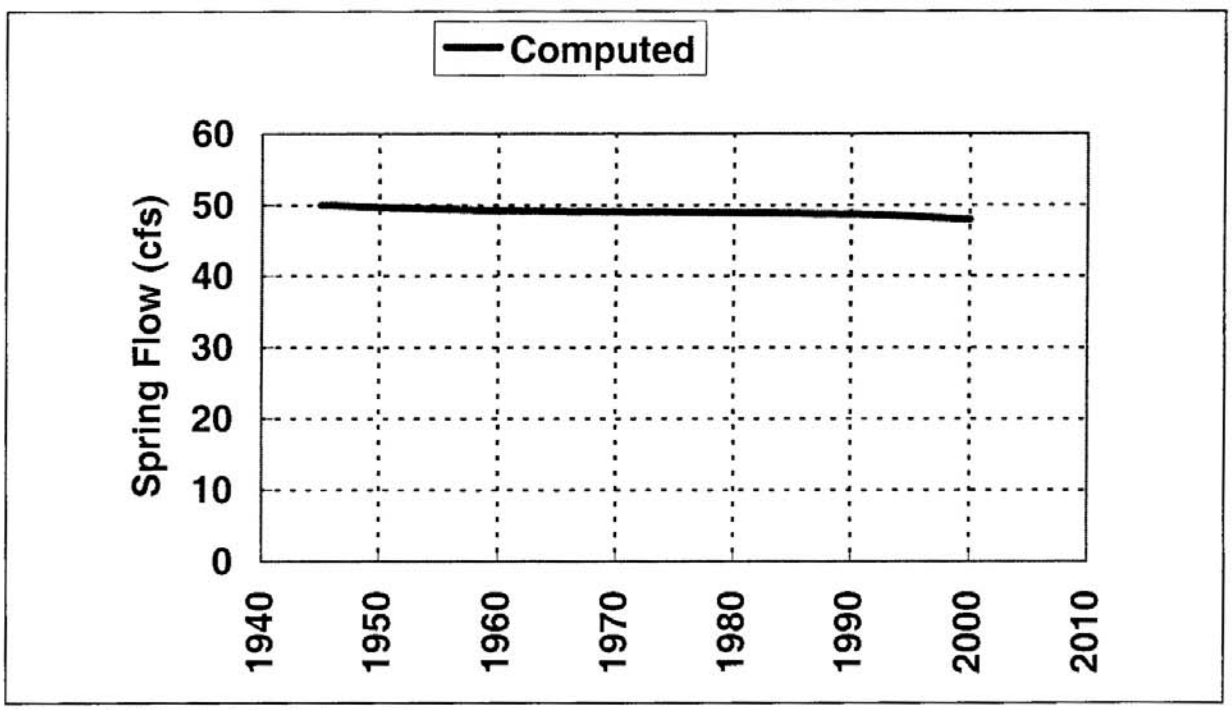


Figure 8-29 Muddy Springs Flow.

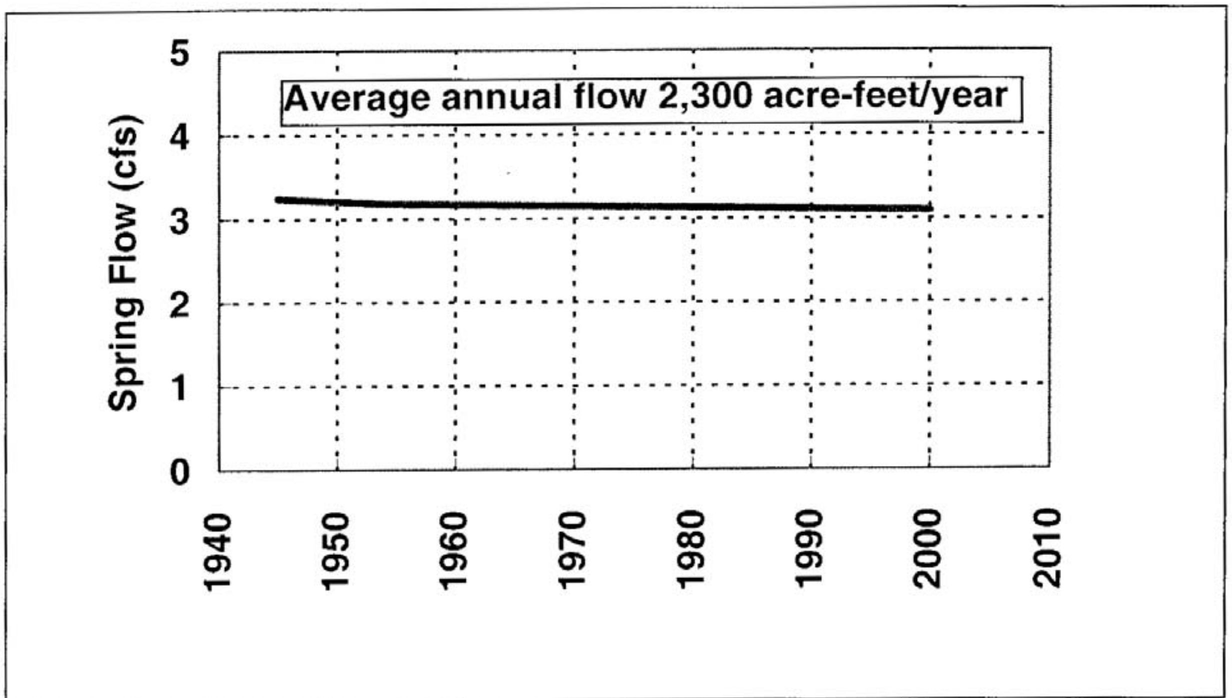


Figure 8-30 Rogers and Blue Point Springs Flow (represents North Shore Spring Complex).

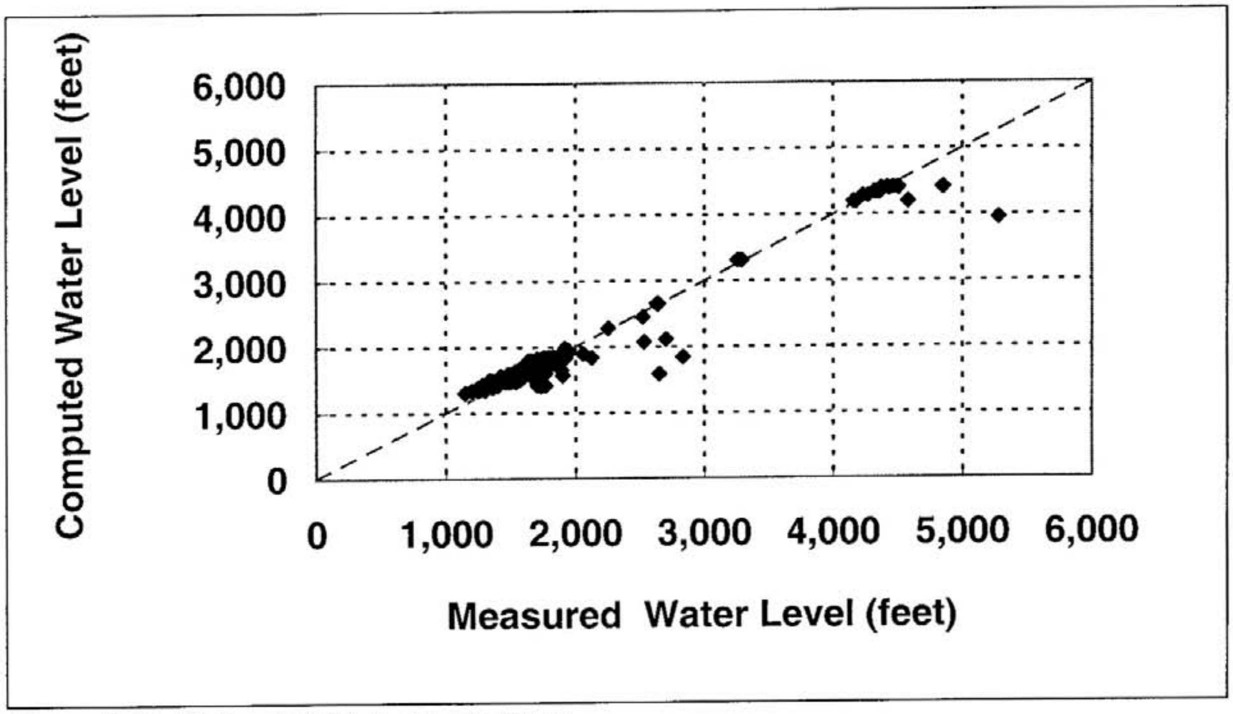


Figure 8-31 Valley-fill Wells Steady State.

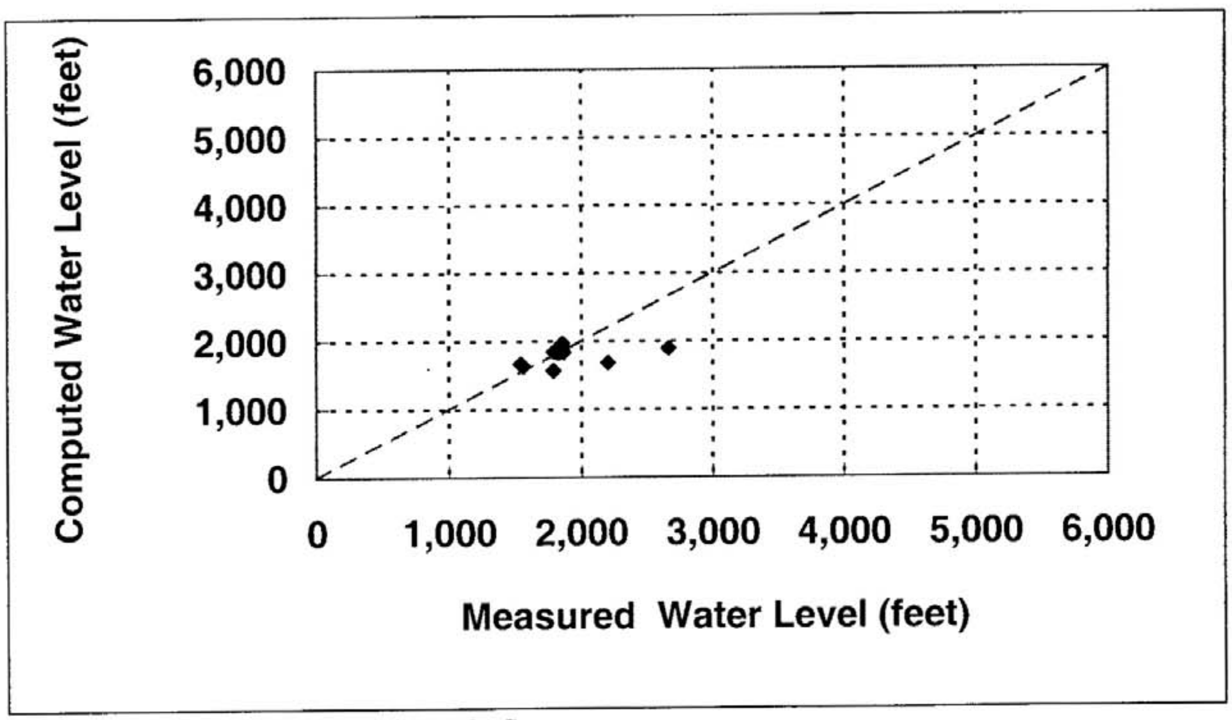


Figure 8-32 Carbonate Wells Steady State.

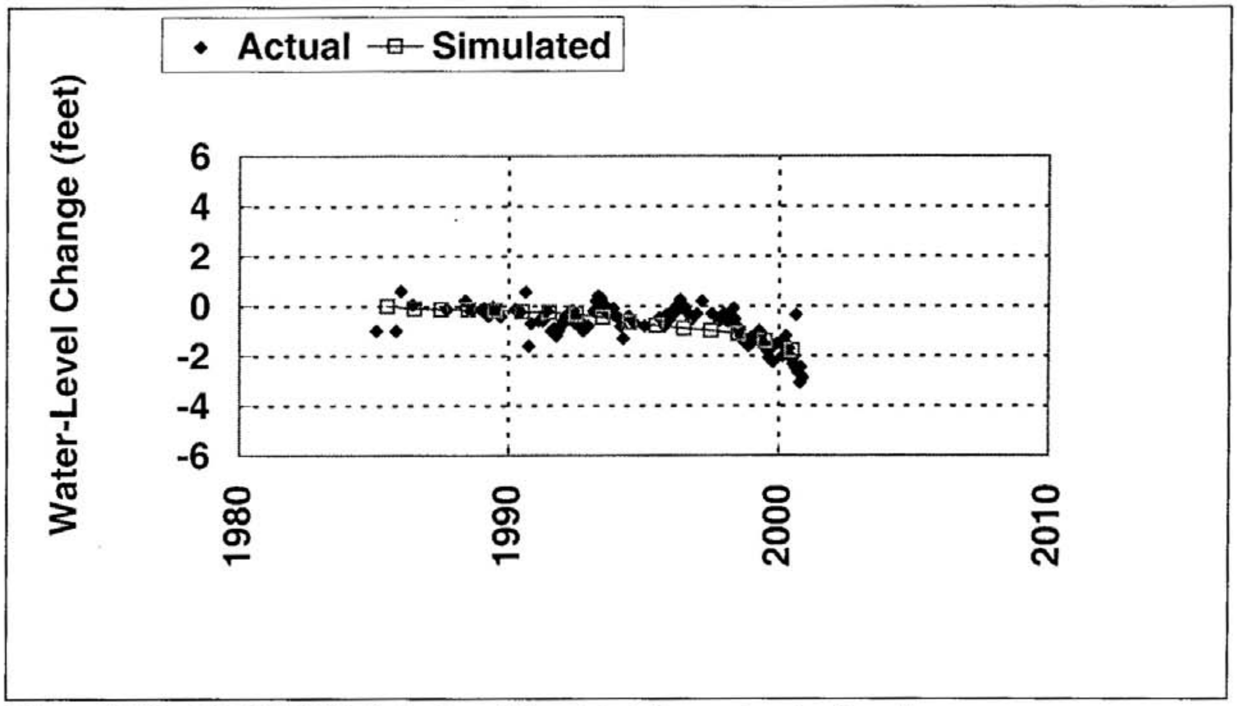


Figure 8-33a Well CSV-2 Actual and Simulated Ground-water Levels.

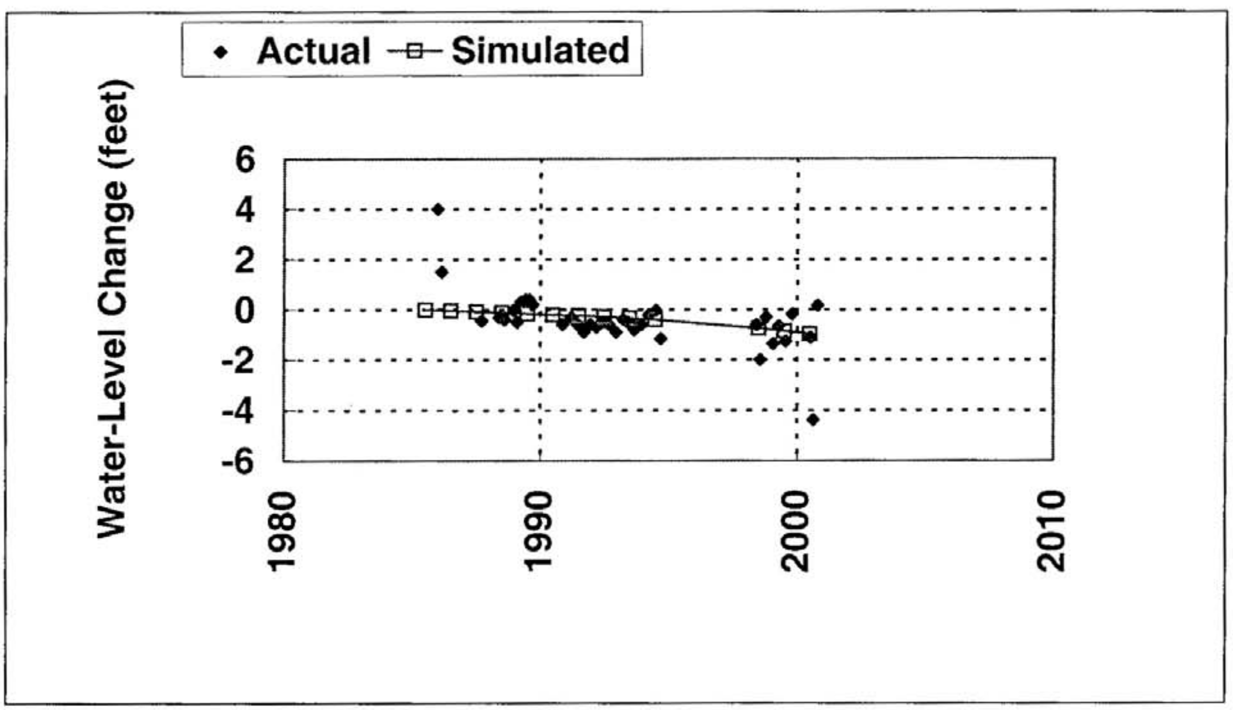


Figure 8-33b Well CSV-3 Actual and Simulated Ground-water Levels.

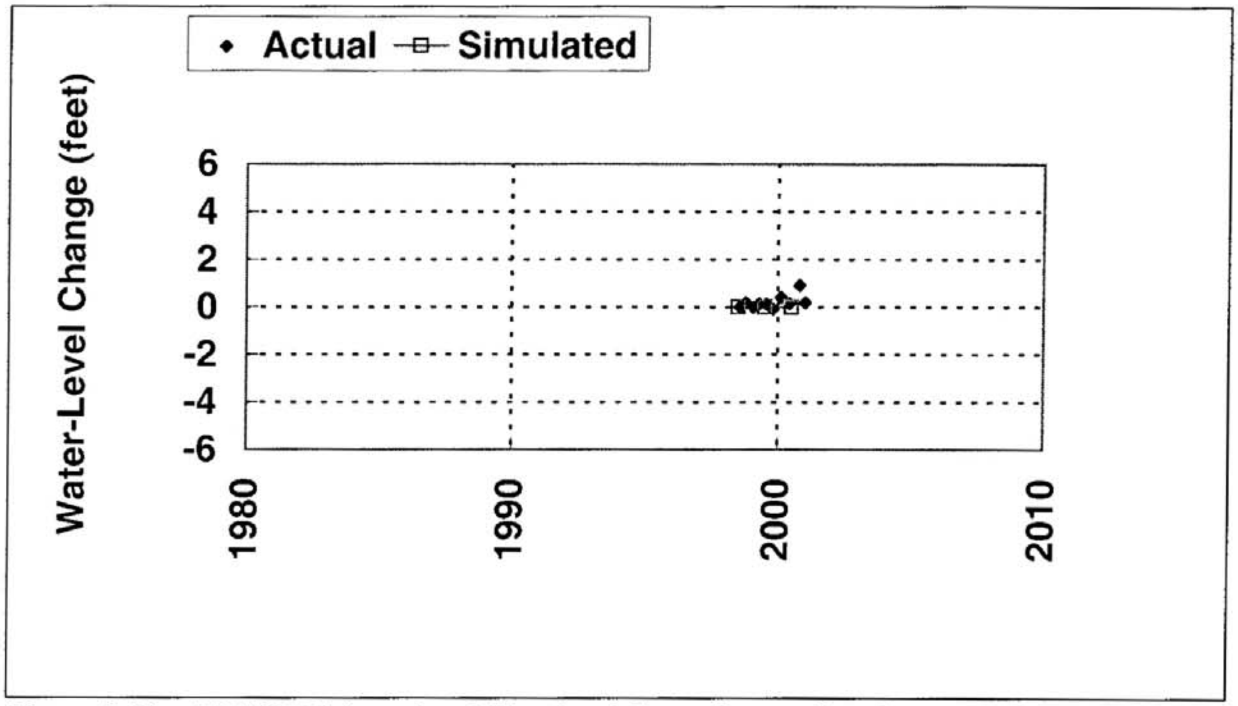


Figure 8-33c Well DF-1 Actual and Simulated Ground-water Levels.

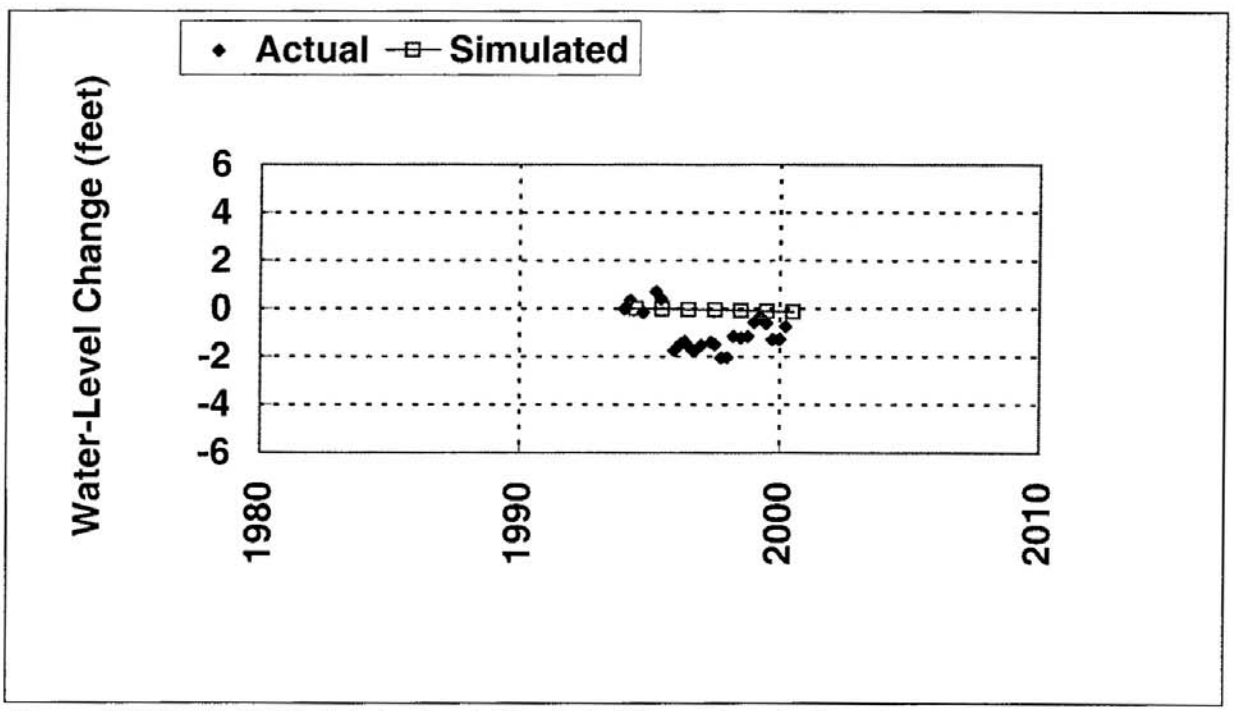


Figure 8-33d Well EH-2 Actual and Simulated Ground-water Levels.

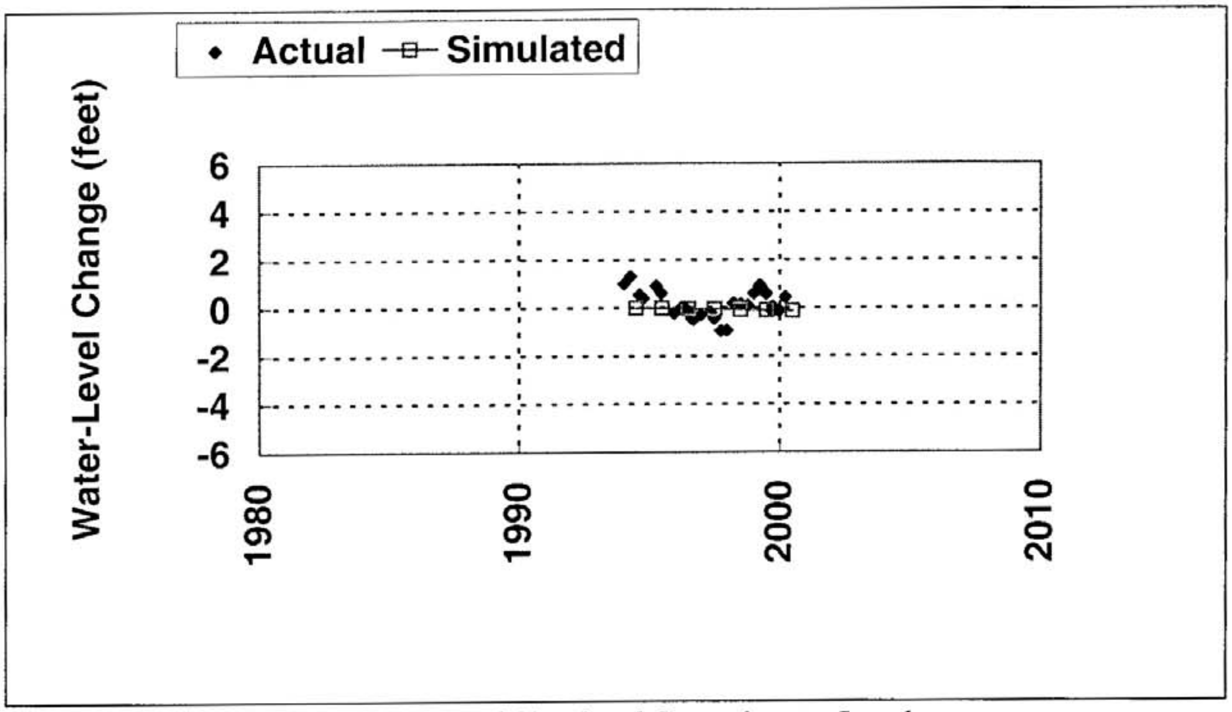


Figure 8-33e Well EH-2A Actual and Simulated Ground-water Levels.

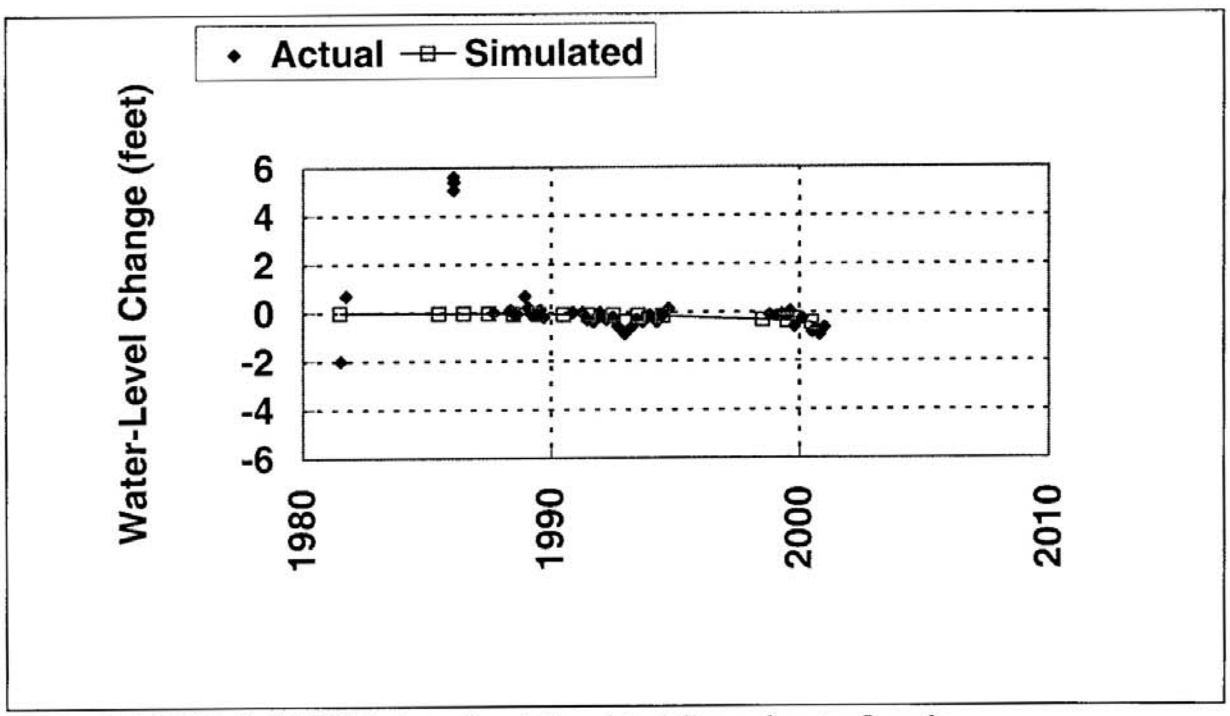


Figure 8-33f Well CE-VF-2 Actual and Simulated Ground-water Levels.

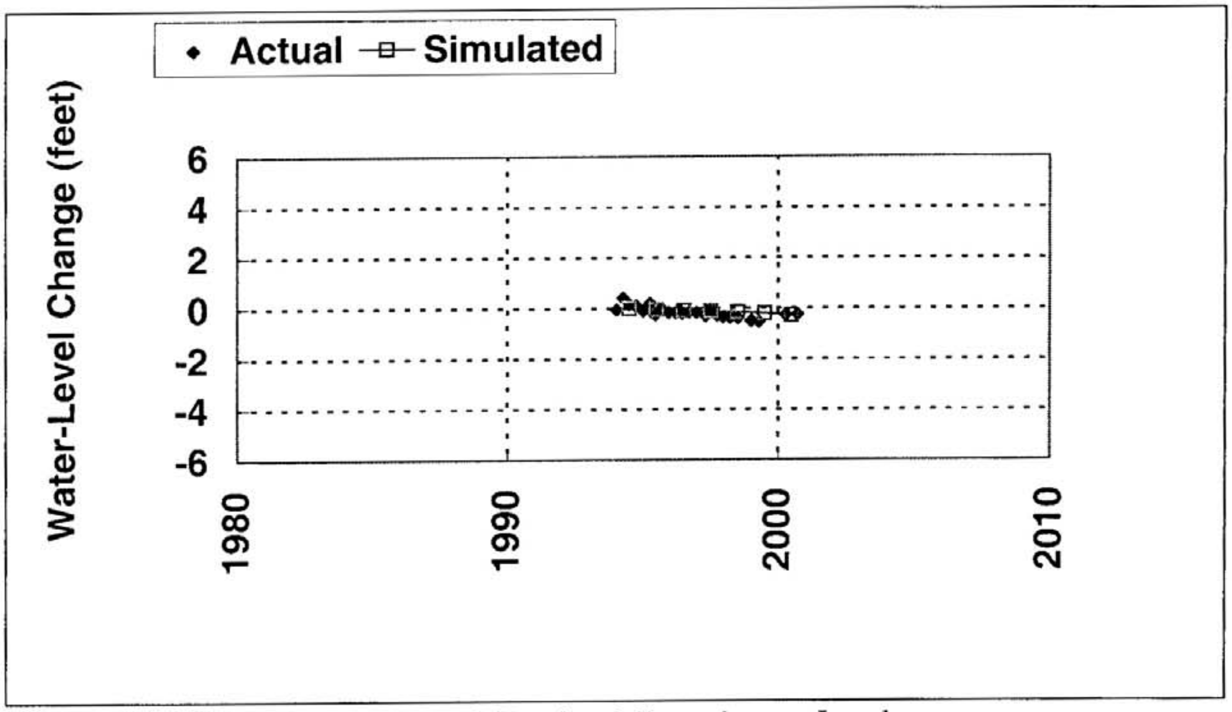


Figure 8-33g Well EH-3 Actual and Simulated Ground-water Levels.

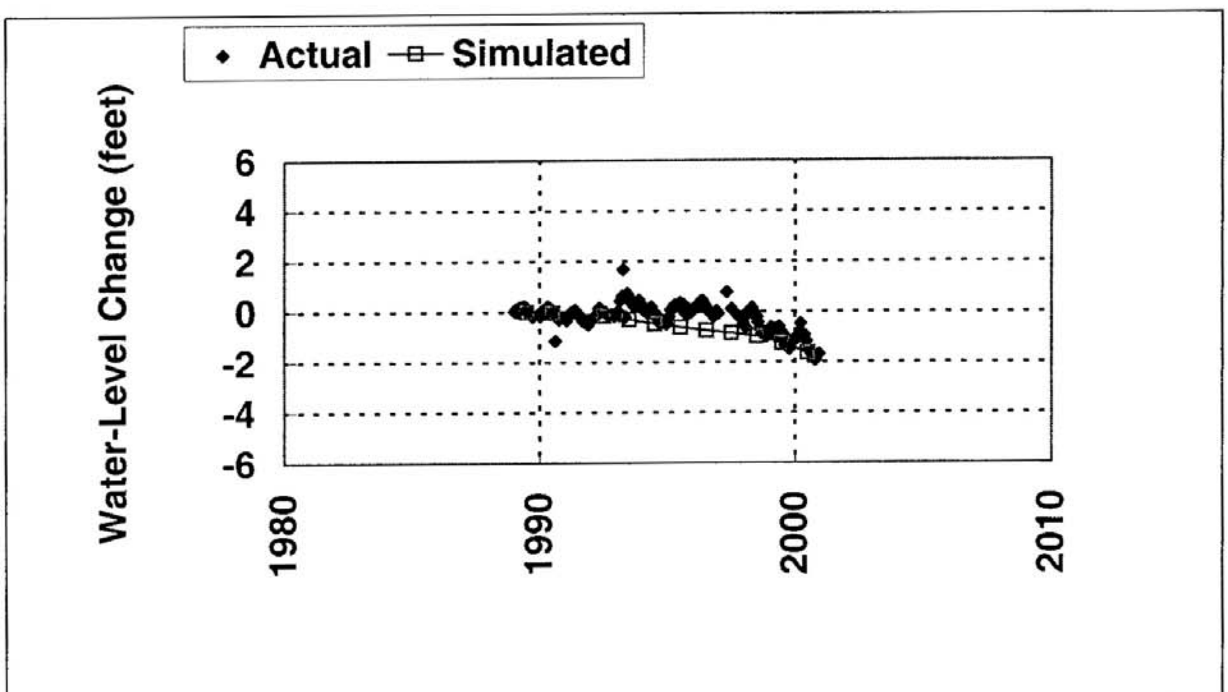


Figure 8-33h Well EH-4 Actual and Simulated Ground-water Levels.

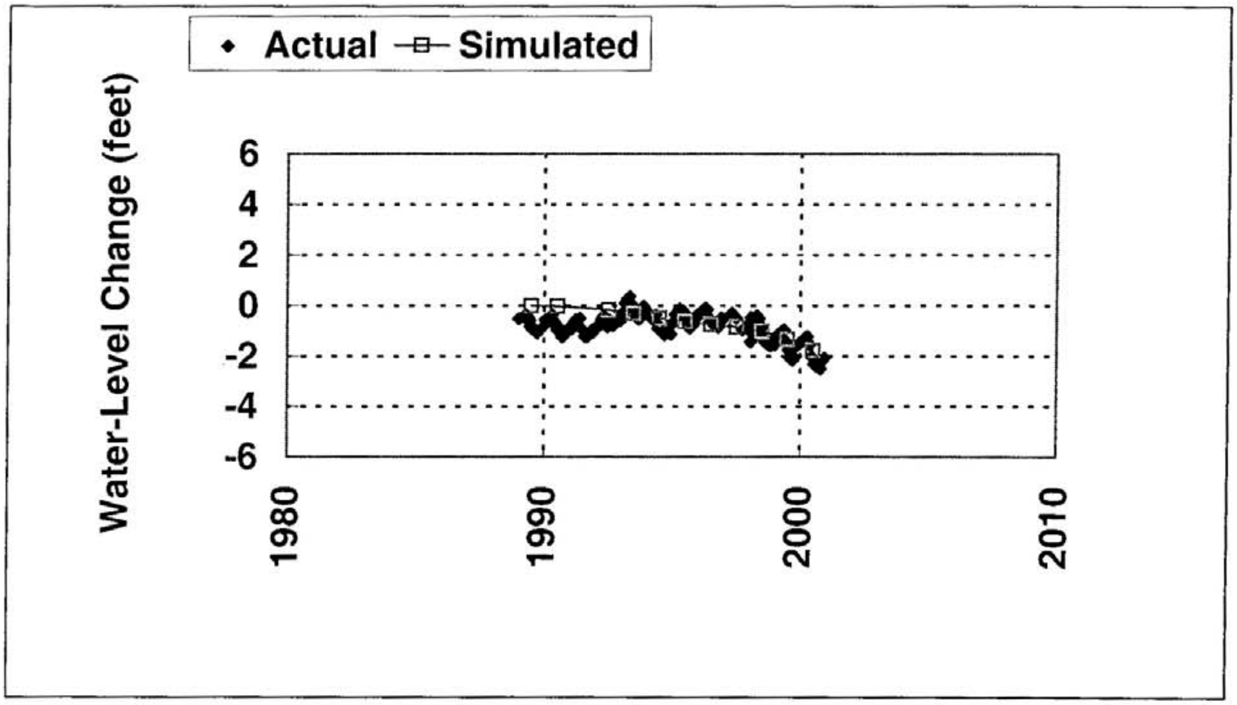


Figure 8-33i Well EH-5B Actual and Simulated Ground-water Levels.

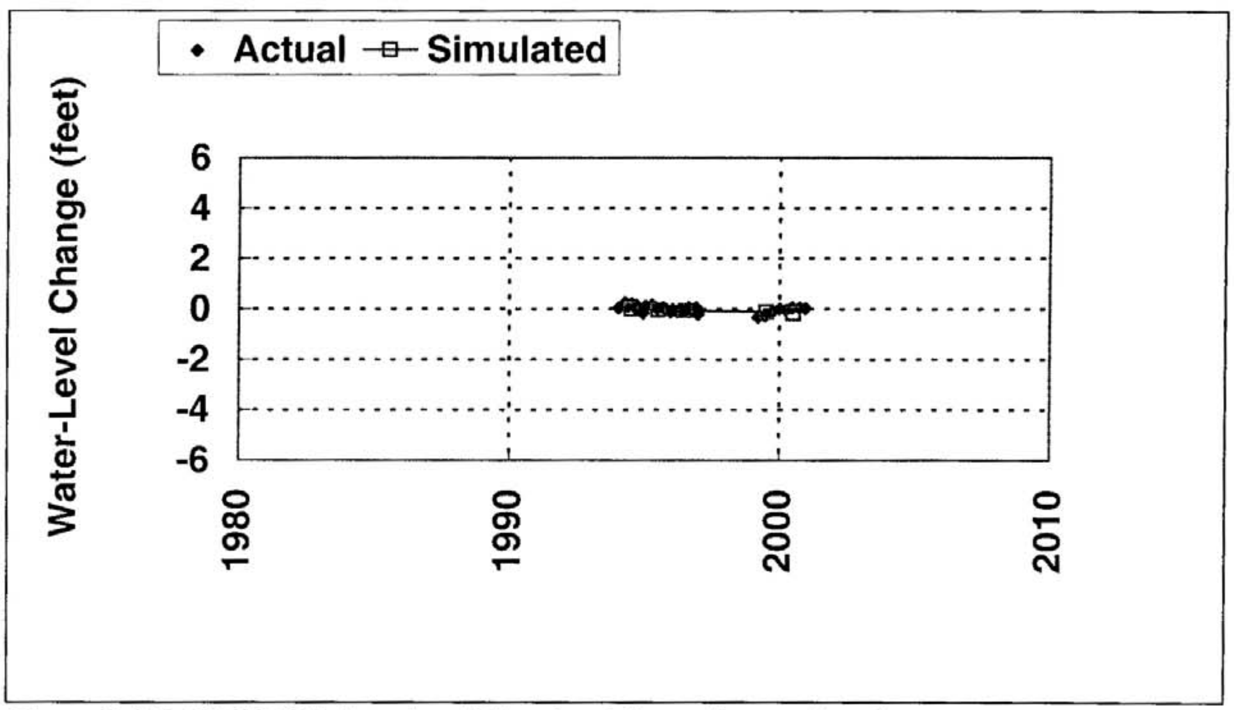


Figure 8-33j Well EH-7 Actual and Simulated Ground-water Levels.

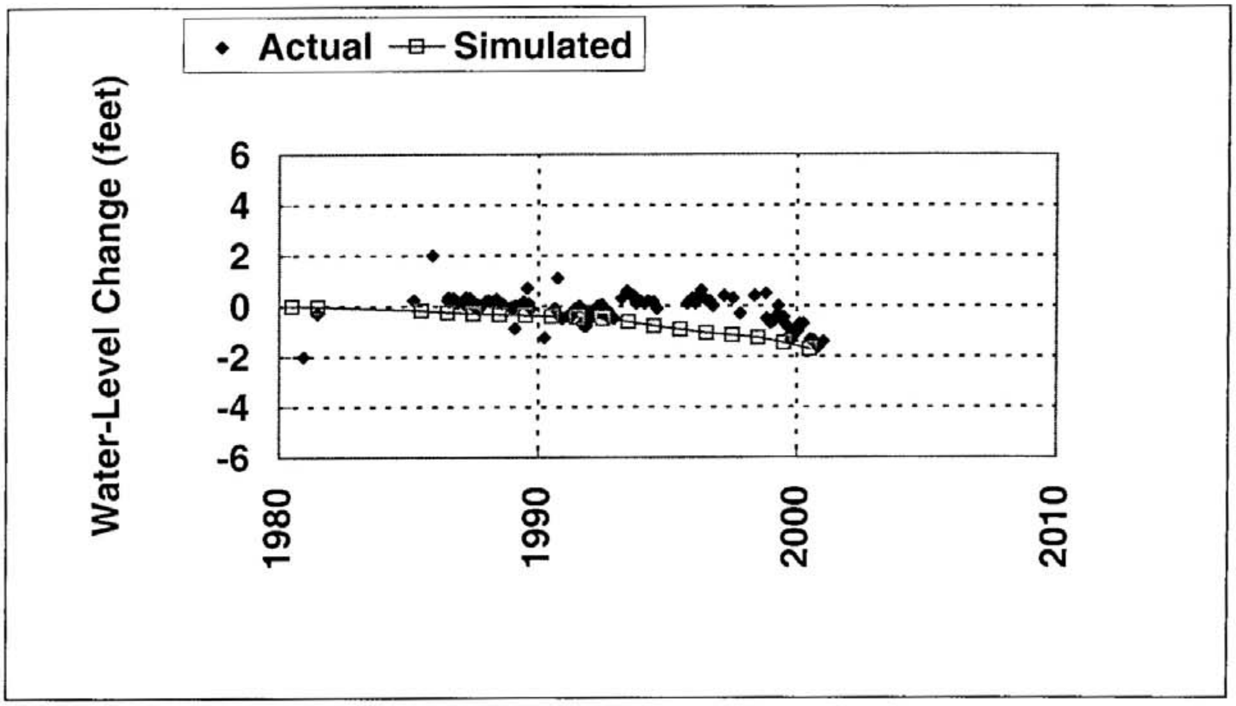


Figure 8-33k Well MX-4 Actual and Simulated Ground-water Levels.

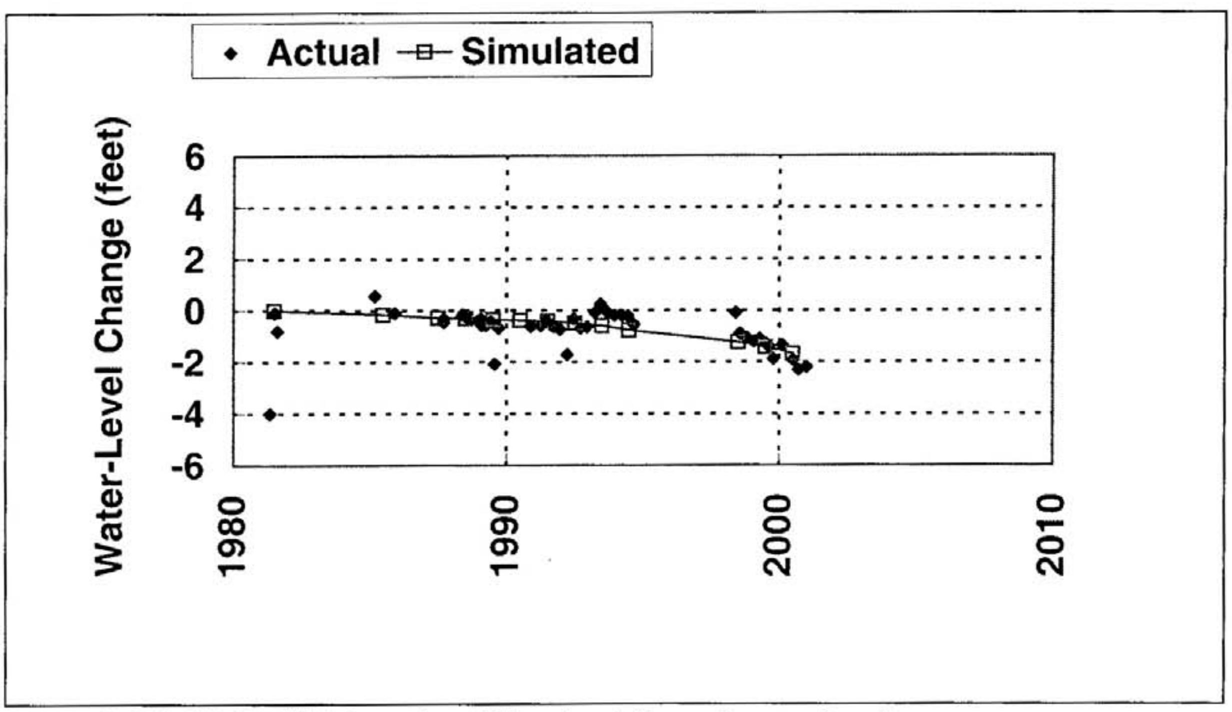


Figure 8-33l Well MX-5 Actual and Simulated Ground-water Levels.

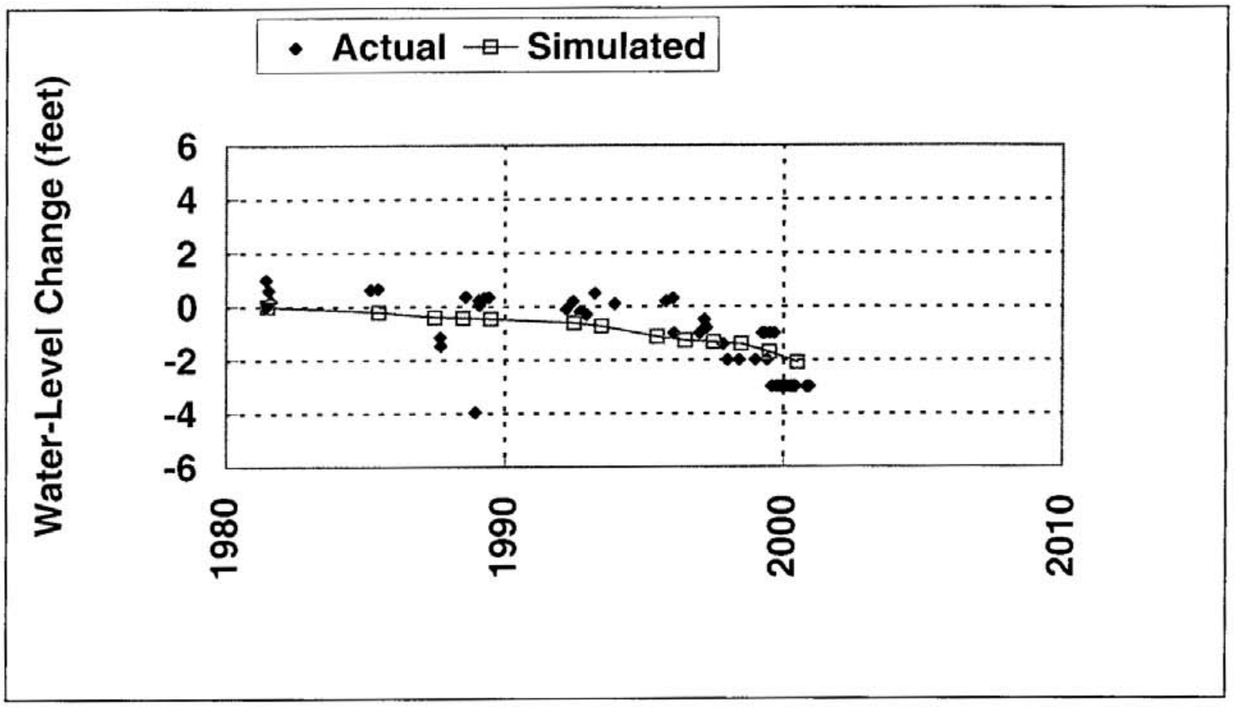


Figure 8-33m Well MX-6 Actual and Simulated Ground-water Levels.

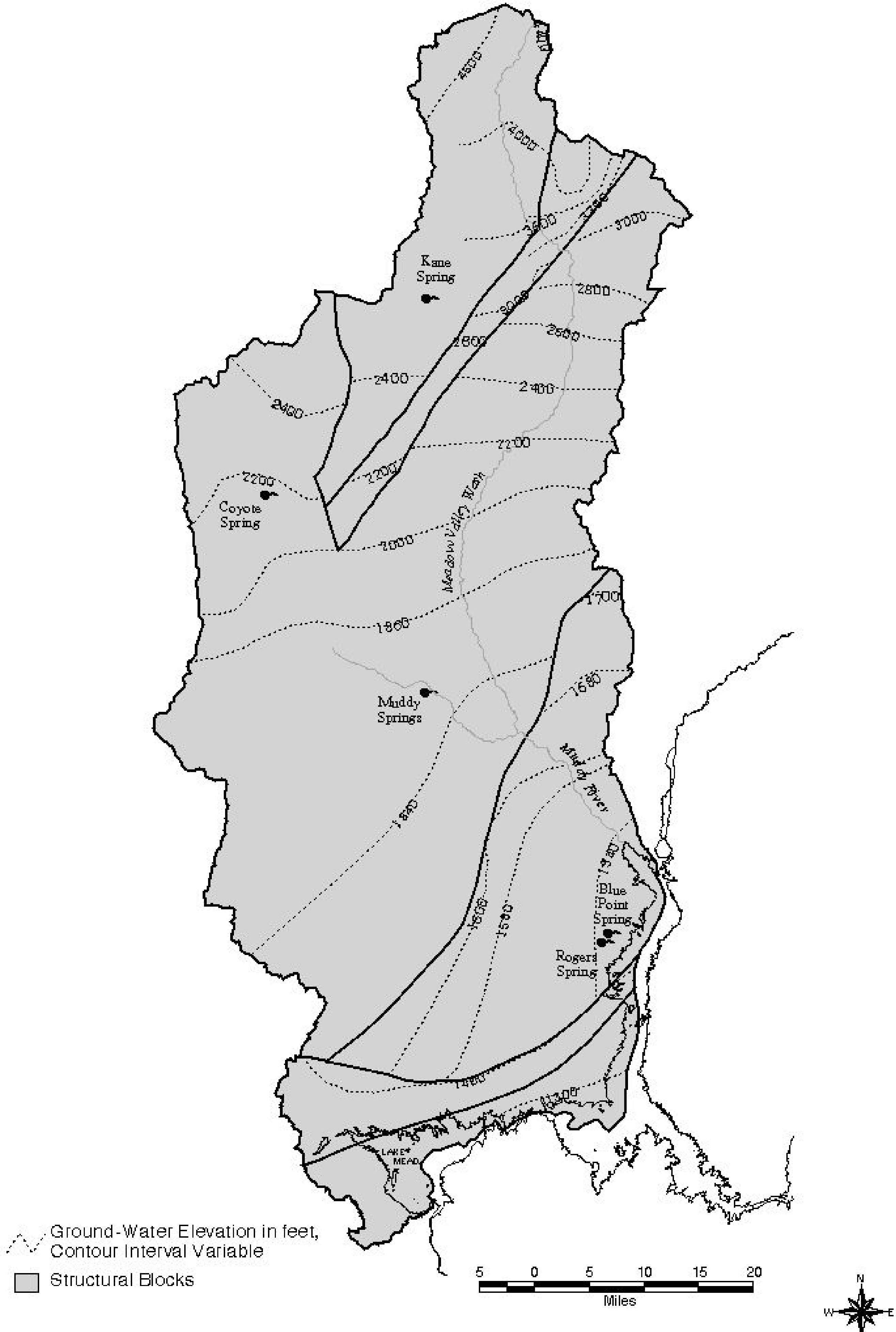


Figure 8-34. Simulated ground-water elevation at top of carbonate aquifer, 1945.

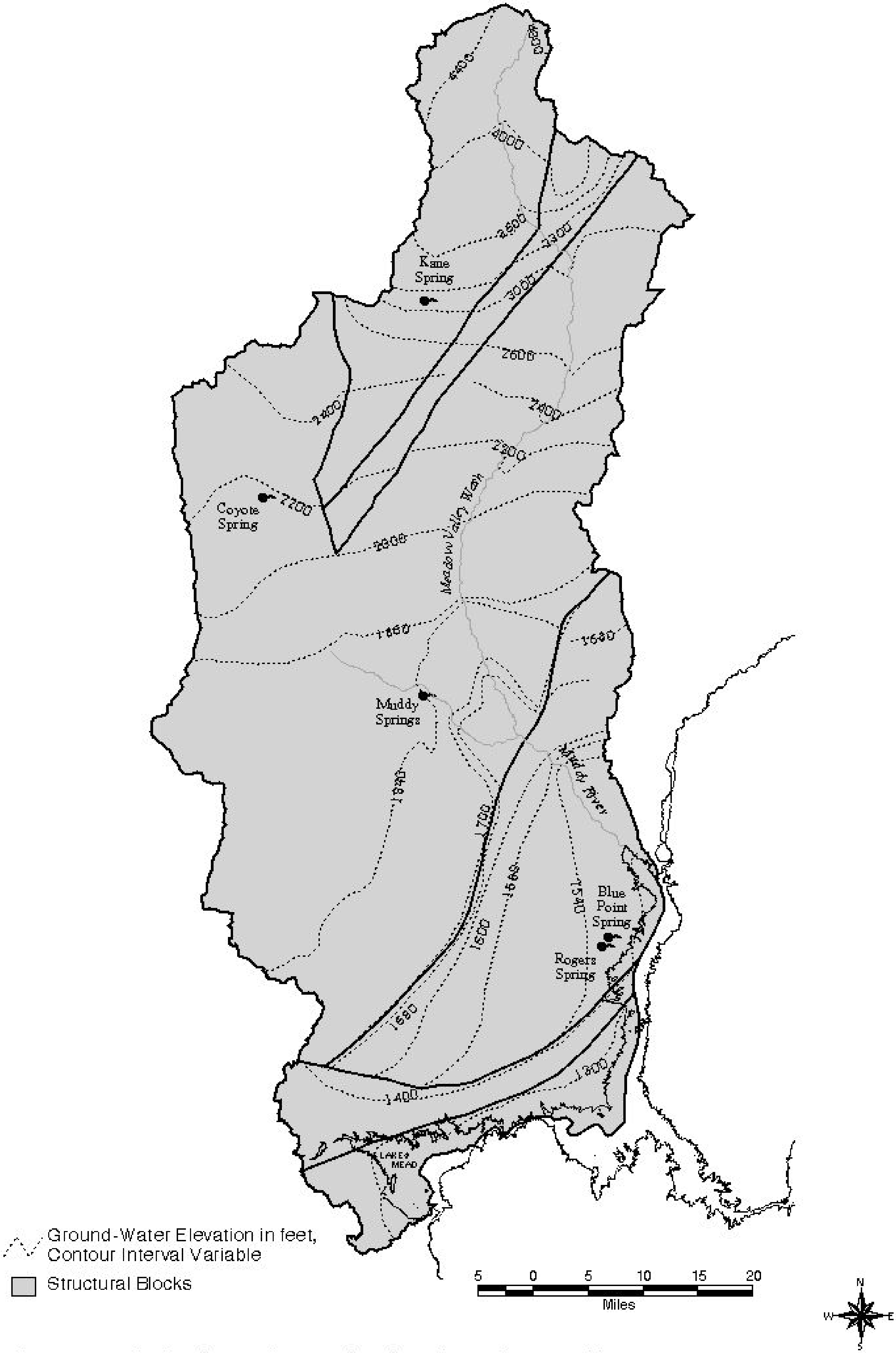


Figure 8-35. Simulated ground-water elevation of ground-water table, 1945.

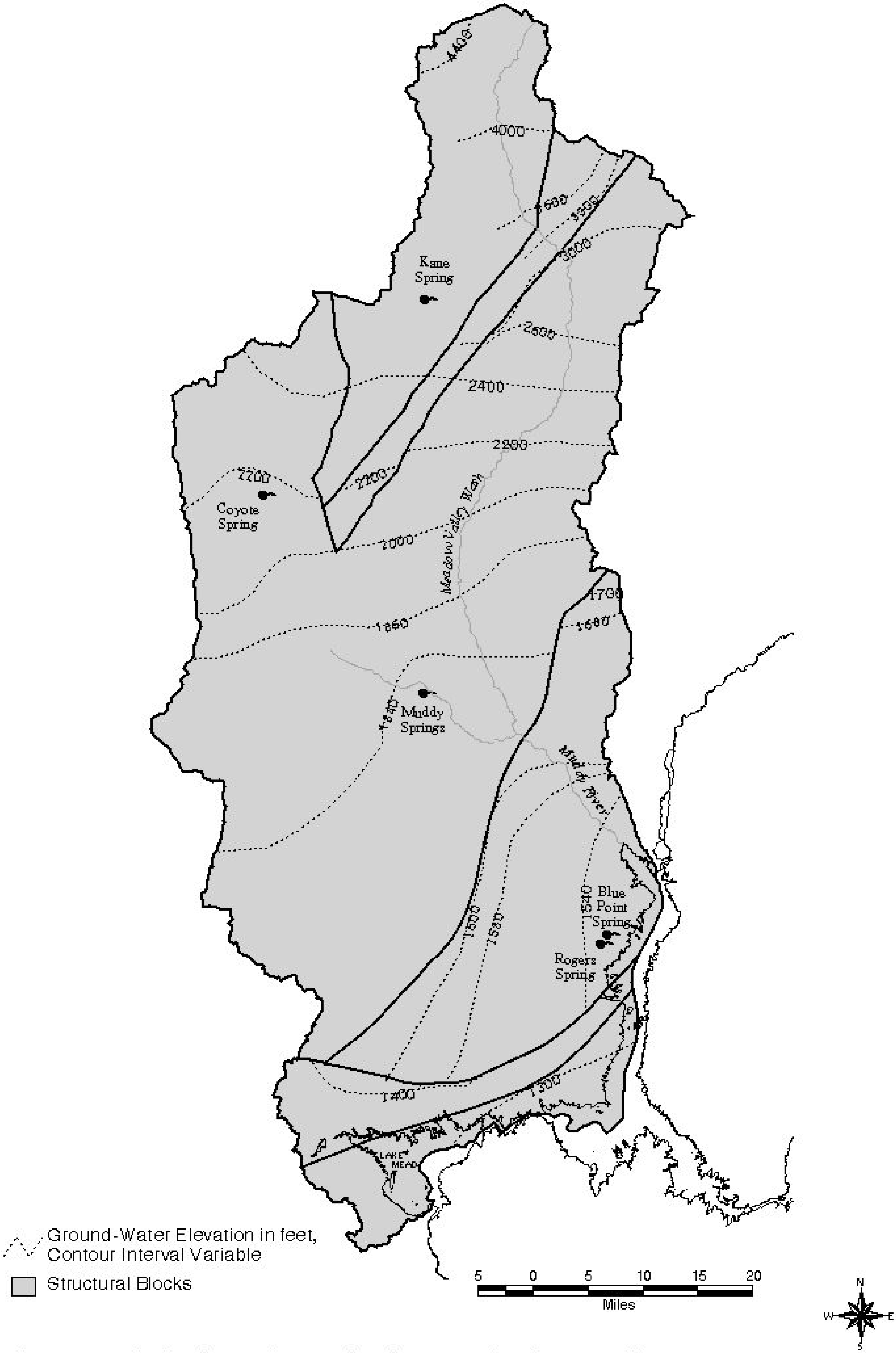


Figure 8-36. Simulated ground-water elevation at top of carbonate aquifer, 2000.

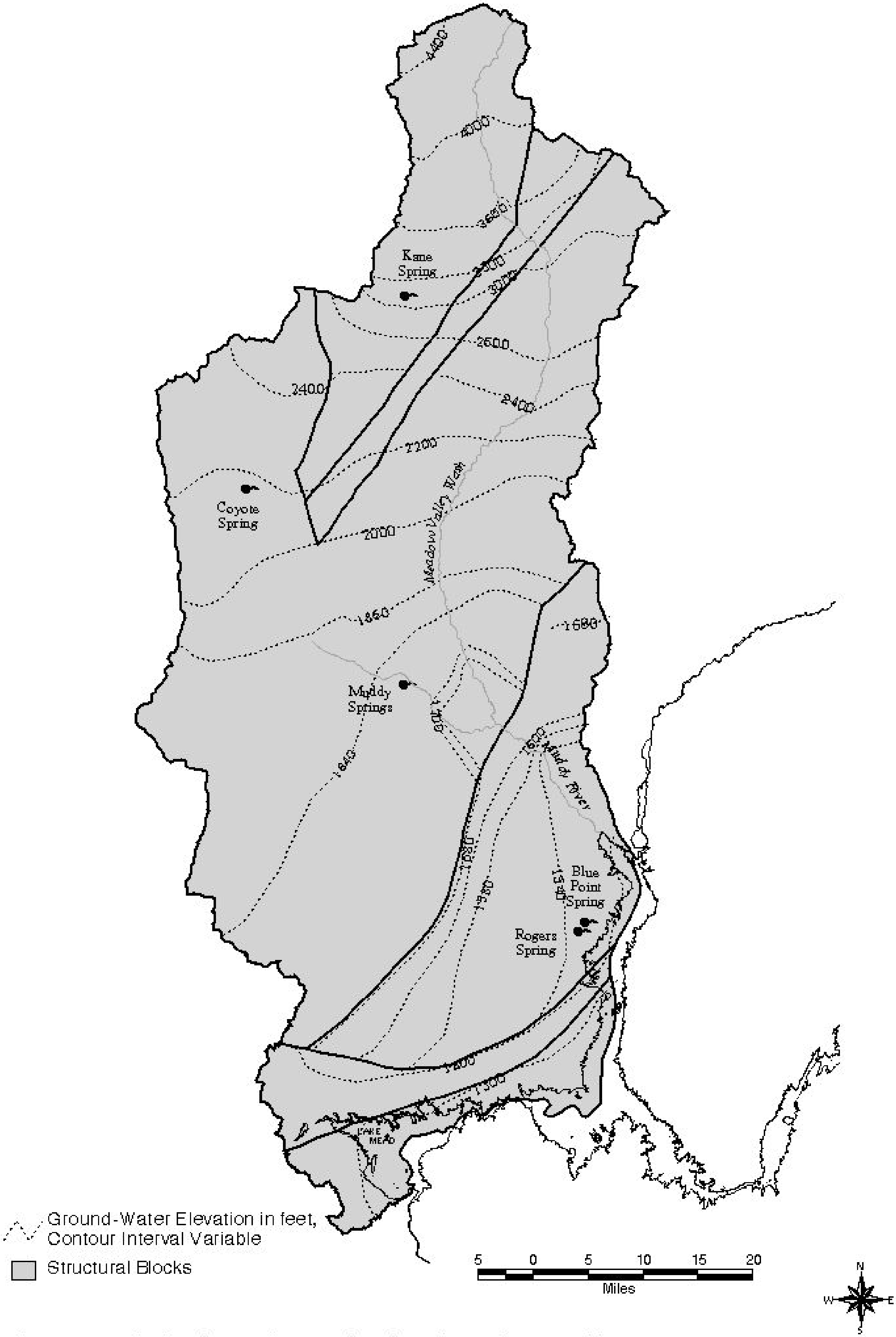


Figure 8-37. Simulated ground-water elevation of ground-water table, 2000.

8.2.7.3 Calibration Evaluation

The adequacy of the model can be evaluated only with respect to the intended use. The principal intended use of this model is to evaluate the impact of increased regional pumping on spring flows. For that purpose, the model adequately represents the ground-water system. The reliability of the evaluation in this regard depends on the difference between two model simulations. That difference tends to contain less uncertainty than its components, because some uncertainties in the components are canceled by the subtraction process (i.e., by each other). The components adequately represent the ground-water system, and the difference correspondingly better represents the ground-water system.

The model adequately reproduces the measured streamflows. **Figure 8-26** and **Figure 8-27** show the measured annual non-flood streamflows for the Moapa and Glendale gages. These are the annual streamflows that result from filtering daily values to remove streamflows resulting from runoff events. The filtered streamflows are those resulting from spring flows, ground-water inflows, and irrigation returns. The simulated non-flood streamflows adequately match the corresponding measured streamflows with respect to both magnitude and temporal trend. For the Moapa gage, the 1945-measured streamflow is 34,000 afy, and streamflow tends to decrease 200 afy per year. Correspondingly, the 1945 computed streamflow is 35,000 afy, and the streamflow tends to decrease 200 afy per year. As described in Section 5.2 the decline in streamflow at the Moapa gage correlates to alluvial ground-water pumpage, and spring flow data suggest spring flow has remained constant. For the Glendale gage, the 1945-measured streamflow is 34,000 afy, and streamflow tends to decrease 200 afy per year. Correspondingly, the 1945 computed streamflow is 35,000 afy, and the streamflow tends to decrease 200 afy per year.

The model adequately reproduces measured spring flows. **Figure 8-29** shows the simulated Muddy Springs discharge. As shown on the figure, the simulated spring flow changes little during 1945-2000. A corresponding measured discharge is not shown because the total Muddy Springs discharge is not measured. Muddy River streamflow is measured below the springs, but the streamflow at that site is impacted by upstream diversions, pumping, and consumption. However, selected spring discharges have been measured since 1986, and the measured spring flows display no long-term trend as discussed in Section 5.2.

Figure 8-30 shows the simulated Rogers Spring and Blue Point Spring discharge. As shown on the figure, the simulated spring flow does not change during 1945-2000. The Rogers Spring discharge has been measured since 1985, and the Blue Point Spring discharge has been measured since 1997. These records indicate that the spring flows are not displaying long-term changes.

The model adequately reproduces measured ground-water levels. **Figure 8-31** and **Figure 8-32** show the simulated ground-water levels correspond to the measured levels. On this scatter diagram, the deviation of simulated ground-water levels from the measured level is represented by the vertical deviation from diagonal line shown on **Figure 8-31** and **Figure 8-32**. If the simulated ground-water level is higher than the measured level, the scatter point representing the values will be positioned above the diagonal line by the difference between the values. Likewise, if the simulated ground-water level is lower than the measured level, the scatter point representing the values will be positioned below the diagonal line by the difference between the values. Most of the simulated ground-water levels are positioned near the diagonal relative to the total range of values, which means in statistical terms that the model explains a large part of the total variance in the measured ground-water levels.

The deviations that do occur between a simulated ground-water level and the corresponding measured level result from at least three factors. They result first because the model does not represent phenomena that impact the measured ground-water level. As a first example, computed ground-water levels are extracted from the model based on the mesh node that is nearest the well with respect to both geographic location and depth. Except by chance, a mesh node will not coincide with the three-dimensional center of a well screen, and even with a perfect model, the simulated ground-water-level will deviate from the measured level. As a second example, simulated ground-water levels represent average conditions over large three-dimensional scales. The horizontal averaging is on scales of 20,000 ft or more, and the vertical averaging is on scales of 2,000 ft or more. However, the ground-water level measured in a well represents averaging over much smaller scales. Depending on the complexity of the local hydrogeologic setting, the horizontal averaging is on scales of 2,000 ft or less, and the vertical averaging is on scales of 200 ft or less. Accordingly, the model represents not every measured ground-water level, but the average of the measured ground-water levels over model scales. As a third example, the available ground-water data are noisy. While measurements of ground-water depth are likely reliable, the corresponding ground-water elevation is often unreliable because the measuring-point elevation is uncertain. Owing to that uncertainty, the simulated ground-water-level will deviate from the measured level.

In addition to being noisy, the ground-water data are so geographically sparse that ground-water levels are unknown over large parts of the model area. Ground-water data for alluvial wells are limited mostly to wells located along Meadow Valley Wash and the Muddy River. Additionally, data are available for a few locations within the modeled area. Ground-water data are available for carbonate wells at scattered locations within the modeled area. However, for large parts of the modeled area, ground-water data are absent not only for carbonate wells but also for alluvial wells. Additionally, a few monitoring wells identified as carbonate wells **(Figure 8-38)** actually may be alluvial wells.

Even though ground-water data for the modeled area are few, the model is an adequate tool for interpolating and extrapolating the available ground-water data. The model can be used spatially or temporally to interpolate between measurement points, and it can be used to extrapolate to locations and times for which data are not available. While some other approach might be used to interpret the available ground-water data, the interpolations and extrapolations based on the model have the advantage that they are based on explicit hydrogeologic and hydrologic characterizations of the ground-water system that are coupled with the mathematical laws of ground-water flow. As a result, the model simulations of ground-water levels are more constrained and correspondingly more reliable than less quantitative approaches to describing the ground-water levels. The simulated ground-water levels are constrained by not only the measured ground-water levels but also the measured streamflows and spring flows.

8.3 UTILIZATION OF THE GROUND-WATER MODEL

The calibrated ground-water model was used to simulate the effects of future pumping within the modeled area. The model was used to simulate the resulting streamflows, spring flows, and ground-water levels from existing permitted rights and LVVWD applications.

8.3.1 Description of Simulations

The simulations describe future pumping for the 61-year period 2001-2061. The simulations are similar in the assumption that the current pumping within the modeled area will continue. The simulations differ in the specification of additional pumping. The particular specifications for each simulation are as follows:

8.3.1.1 Simulation of Existing Permitted Rights

The existing-permits simulation involved the pumping of 17,660 afy of all existing water permits within the Coyote Spring Valley, Garnet Valley, Lower Meadow Valley Wash, Lower Moapa Valley, Upper Moapa Valley, and the Black Mountain Area to observe the pumping impacts on spring discharge and ground-water heads decades into the future. The total rights within the Coyote Spring Valley includes 7,500 afy of SNWA water rights for the MX-5 well, 2,500 afy of NPC rights, and 6,100 afy of CSI rights (includes 5,000 afy purchased from NPC). The Garnet Valley water rights include 2,200 afy for SNWA, and 178 afy for Dry Lake LLC. Within the Lower Meadow Valley Wash, 5,000 afy of water rights belonging to the MVWD for the PG&E power plant is included. Existing water rights in the Black Mountains area that were included in the pumping simulation are 1,392 afy for Dry Lake LLC and 1,870 afy for the Nevada Cogeneration. An additional 4,981 afy of MVWD rights for the Arrow Canyon and MX-6 wells were added in the pumping simulation.

The simulation assumes that the pumpage will be distributed to the wells shown on **Figure 8-38**. None of the wells were sited within the Moapa Paiute Indian Reservation. For the SNWA water rights, 7,500 afy was pumped out of MX-5 well and the rights of 2,200 afy within Garnet Valley were divided between two wells. We assumed that the MVWD water rights of 5,000 afy within the Lower Meadow Valley Wash is temporary and that pumping within the Lower Meadow Valley Wash will be reduced by 5,000 afy beginning in year 2031.

The representation of simulating existing permitted rights in the model is shown on **Figure 8-38**. **Figure 8-39** shows the geographic distribution of annual pumpage to regions within the modeled area.

8.3.1.2 Simulation of LVVWD Ground-Water Applications

The simulation of LVVWD applications involved the pumping from the previous simulation in addition to the 27,512 afy of LVVWD applications. The amount of 27,512 afy requested was

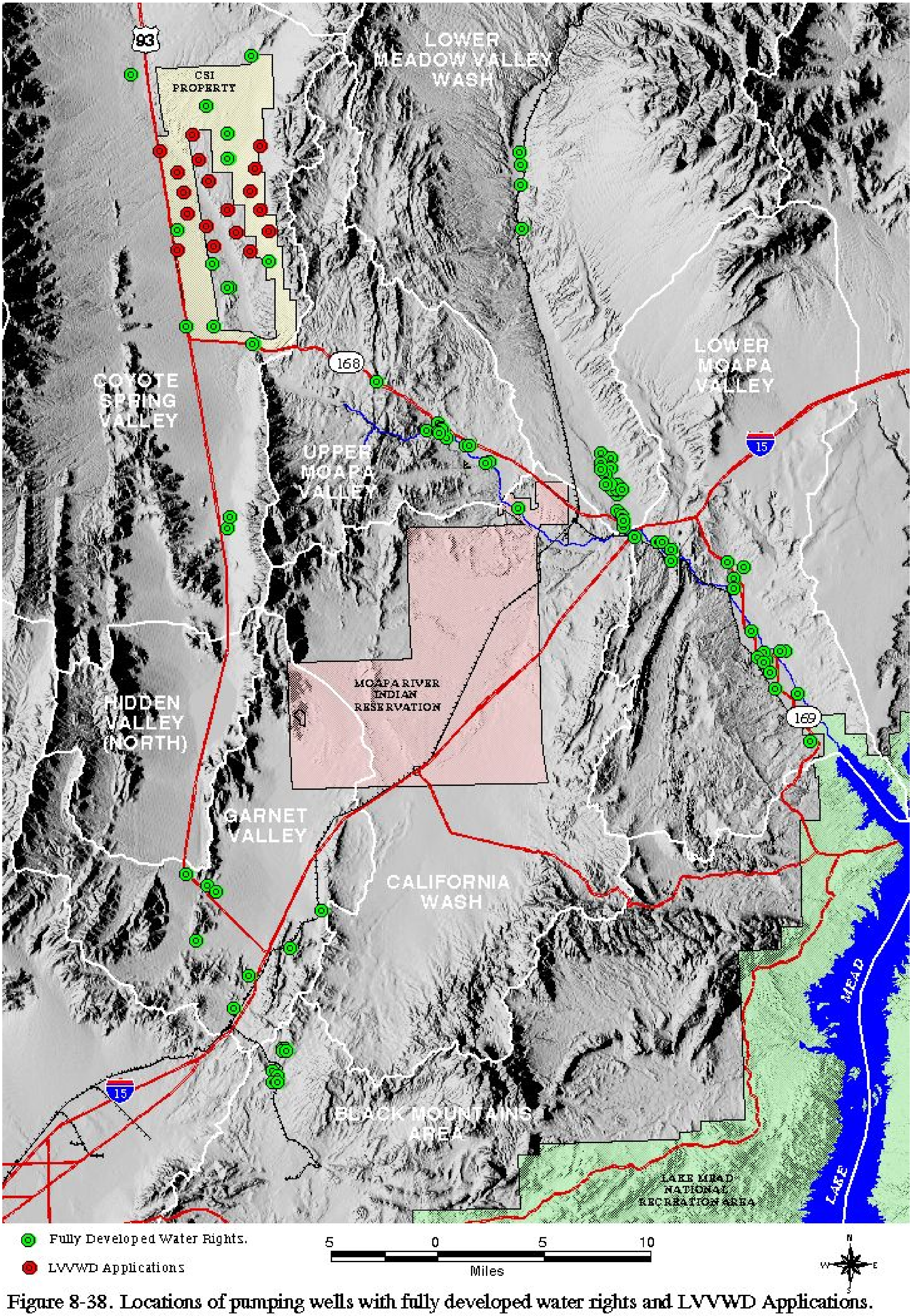


Figure 8-38. Locations of pumping wells with fully developed water rights and LVVWD Applications.

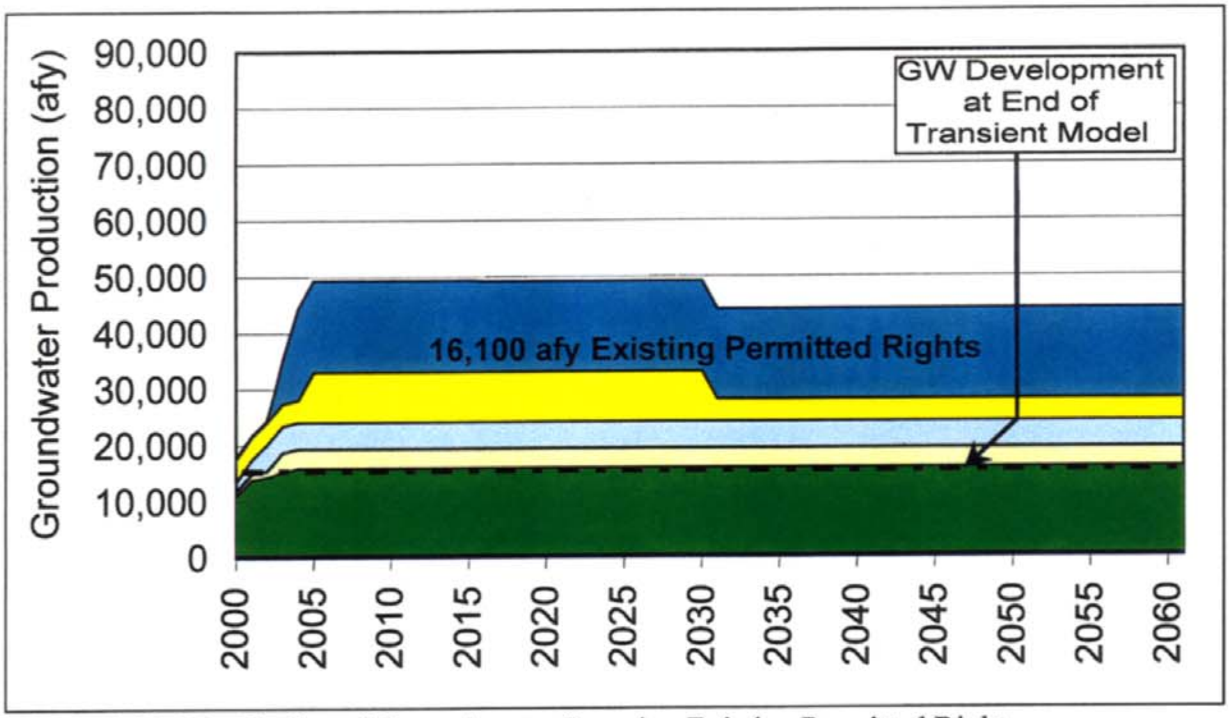


Figure 8-39 Distribution of Ground-water Pumping Existing Permitted Rights.

Legend	Coyote Springs	Garnet
	L. Meadow Valley Wash	Muddy Springs Area
	Black Mountains	Lower Moapa Valley

Note: Production from valley-fill and carbonate rocks.

pumped in three-year increments of 9,171 afy starting from the year 2017. In the first year (2017), the 9171 afy was divided among six wells sited within the Coyote Spring Valley. As in the previous simulation, all the wells were sited on CSI Property with majority of them within Lincoln County. None of them were sited within the Moapa Pauite Indian Reservation. Pumpage from six additional wells with a total duty of 9,171 afy was added in the second year (2018). The final increment of 9,171 afy was again divided among six wells in the third year. As in the first simulation, 7,500 afy was pumped out of MX-5 and 2,200 afy from two other SNWA wells in Garnet Valley. The simulation assumes that the pumpage will be distributed to the wells shown on **Figure 8-38**.

The representation of simulating LVVWD applications in the model is shown on **Figure 8-38**. **Figure 8-40** shows the geographic distribution of annual pumpage to regions within the modeled area.

8.3.2 Simulation Results

8.3.2.1 Existing Permitted Rights

Figure 8-41 through **Figure 8-49** and **Table 8-5** summarizes the simulation of existing permitted rights. **Figure 8-41** shows contours of computed ground-water elevation at the top of the carbonate aquifer for 2061. **Figure 8-42** shows contours of computed ground-water elevation at the ground-water table. **Figure 8-43** shows contours of computed change in ground-water elevation at the top of the carbonate aquifer for 2000-2061. **Figure 8-44** shows contours of computed change in ground-water elevation at the ground-water table. **Figure 8-45** through **Figure 8-47** shows hydrographs of computed streamflow, and **Figure 8-48** and **Figure 8-49** shows hydrographs of computed spring flows. **Table 8-5** lists the components of the ground-water budget for 2061.

As indicated on **Figure 8-45** through **Figure 8-49**, spring flows and streamflows in the simulation show a decline as a result of pumping existing permits. **Figure 8-43** and **Figure 8-44** also show a slight decline in simulated ground-water levels as a result of the specified future pumping. Within Coyote Springs Valley, the maximum water-level decline at the top of the carbonate is approximately 30 ft in 2061. At Muddy Springs, the water-level decline is <10 ft. At the western boundary of the modeled area, the water-level decline is approximately 2 ft in 2061. At the eastern boundary of the modeled area, the water-level decline is approximately 3 ft.

As indicated in **Table 8-5**, water-level declines at the model boundaries induce ground-water inflow to the modeled area. The boundary inflow during 2061 is 25,000 afy.

8.3.2.2 LVVWD Ground-Water Applications

Figure 8-50 through **Figure 8-58** and **Table 8-5** summarize the simulation for LVVWD applications. **Figure 8-50** shows contours of computed ground-water elevation at the top of the carbonate aquifer for 2061. **Figure 8-51** shows contours of computed ground-water elevation at the ground-water table. **Figure 8-52** shows contours of computed change in ground-water

Table 8-5. Water budgets for streams and hydrologic systems[1].

Budget Component	Historical Pumping / Diversions 1945	Historical Pumping / Diversions 2000	Existing Permits 2061	LVVWD Applications 2061
WATER BUDGETS FOR MEADOW VALLEY WASH AND MUDDY RIVER				
Inflows – Meadow Valley Wash				
• Streamflow at model boundary	10,000	10,000	10,000	10,000
• Ground-water inflows above Rox	11,000	9,000	9,000	8,000
• Ground-water inflows Rox to mouth	4,000	3,000	2,000	2,000
Total	**25,000**	**22,000**	**21,000**	**20,000**
Outflows – Meadow Valley Wash				
• ET above Rox[2]	21,000	20,000	19,000	18,000
• ET from Rox to mouth[2]	2,000	0	0	0
• Streamflow at mouth	2,000	2,000	2,000	2,000
Total	**25,000**	**22,000**	**21,000**	**20,000**
Inflows – Muddy River				
• Meadow Valley Wash streamflow at mouth	2,000	2,000	2,000	2,000
• Ground-water inflows above Moapa	38,000	31,000[3]	27,000[3]	26,000[3]
• Ground-water inflows Moapa to Glendale	6,000	6,000	4,000	4,000
• Ground-water inflows Glendale to Overton	7,000	7,000	6,000	6,000
Total	**53,000**	**46,000**	**39,000**	**38,000**
Outflows – Muddy River				
• ET above Moapa[2]	3,000	5,000	5,000	5,000
• ET Moapa to Glendale[2]	9,000	9,000	9,000	9,000
• ET Glendale to Overton[2]	25,000	25,000	20,000	19,000
• Streamflow at Overton	16,000	8,000	6,000	5,000
Total	**53,000**	**47,000**	**40,000**	**38,000**
HYDROLOGIC SYSTEM				
Inflows				
Ground-water underflow - Pahranagat Valley	28,000	28,000	28,000	28,000
Ground-water underflow - Delemar Valley	16,000	16,000	16,000	16,000
Ground-water underflow - Panaca Valley	17,000	17,000	17,000	17,000
Ground-water underflow - Clover Valley	9,000	9,000	9,000	9,000
Meadow Valley Wash streamflow at boundary	10,000	10,000	10,000	10,000
Boundary underflows	0	0	25,000	41,000
Precipitation recharge	37,000	37,000	37,000	37,000
Total	**117,000**	**117,000**	**142,000**	**158,000**
Outflows				
Ground-water pumpage	0	18,000	44,000	72,000
Surface-water outflow - Muddy River	16,000	8,000	6,000	5,000
Ground-water discharge to Colorado River	37,000	37,000	37,000	37,000
ET – Coyote Springs	1,000	1,000	1,000	1,000
ET – Kane Springs	1,000	1,000	1,000	1,000
ET – Rogers Springs	1,000	1,000	1,000	1,000
ET – Blue Point Springs	1,000	1,000	1,000	1,000
ET – Meadow Valley Wash above Rox	21,000	20,000	19,000	18,000
ET – Meadow Valley Wash below Rox	2,000	0	0	0
ET – Muddy River above Moapa	3,000	5,000	5,000	5,000
ET – Muddy River – Moapa to Glendale	9,000	9,000	9,000	9,000
ET – Muddy River – Glendale to Overton	25,000	25,000	20,000	19,000
Total	**117,000**	**126,000**	**144,000**	**169,000**
STORAGE CHANGE	**0**	**-9,000**	**-2,000**	**-11,000**

[1] See Figure 8-5 for definition of control volumes.
[2] ET includes consumption of diverted streamflow and riparian ground water.
[3] After-effects of diversions and ground-water pumping above Muddy River streamgaging station near Moapa.

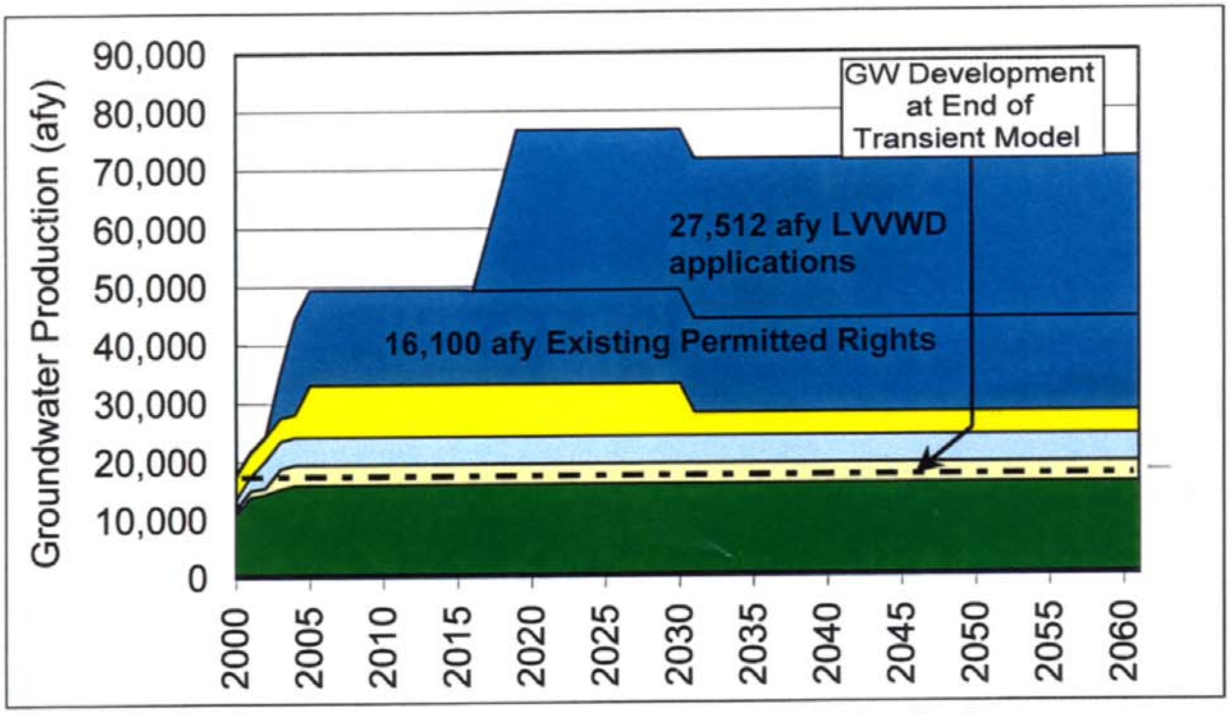


Figure 8-40 Distribution of Ground-water Pumping for LVVWD Applications.

Legend
- Coyote Springs
- L. Meadow Valley Wash
- Black Mountains
- Garnet
- Muddy Springs Area
- Lower Moapa Valley

Note: Production from valley-fill and carbonate rocks.

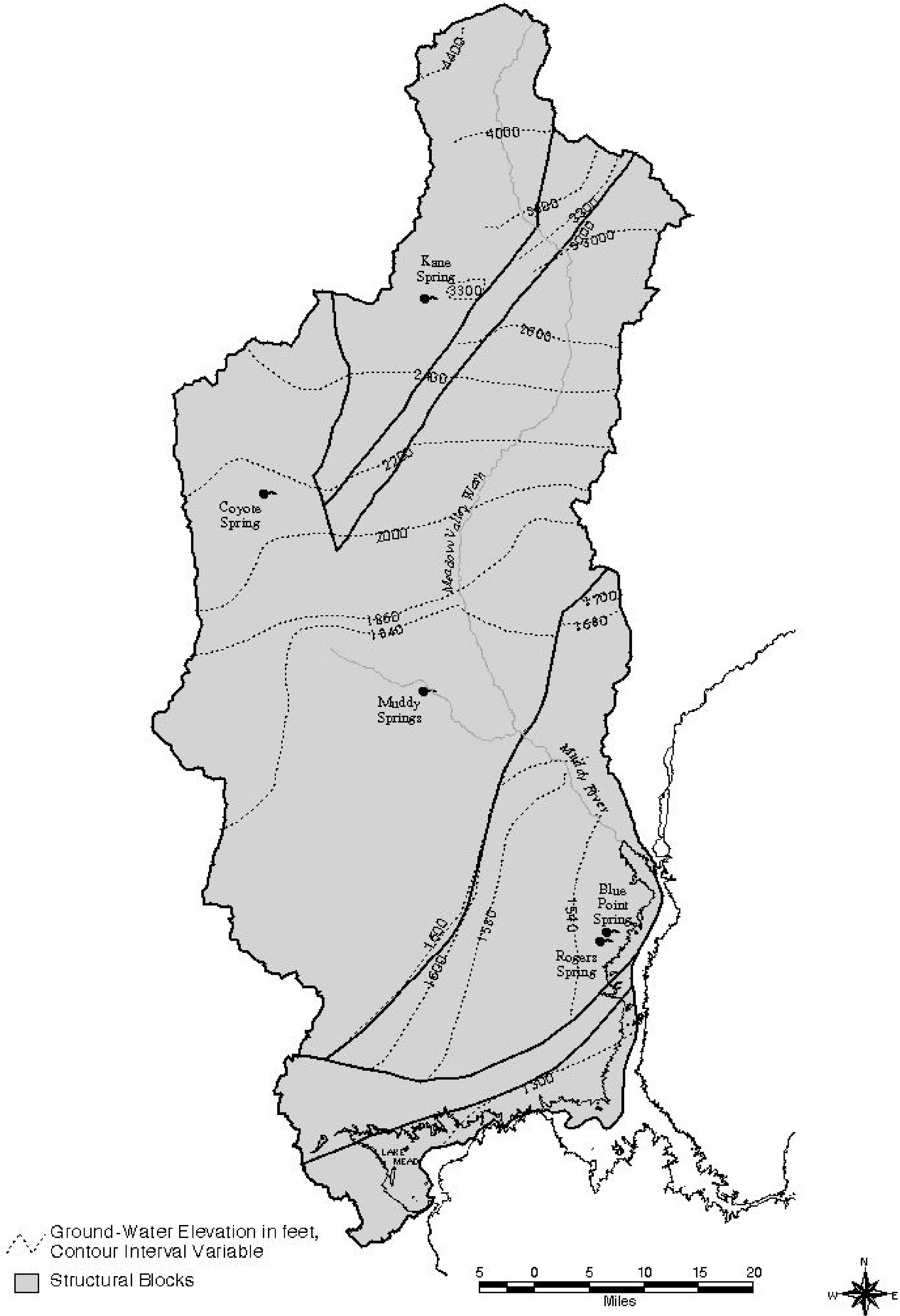


Figure 8-41. Simulated ground-water elevation at top of carbonate aquifer for existing permitted rights, 2061.

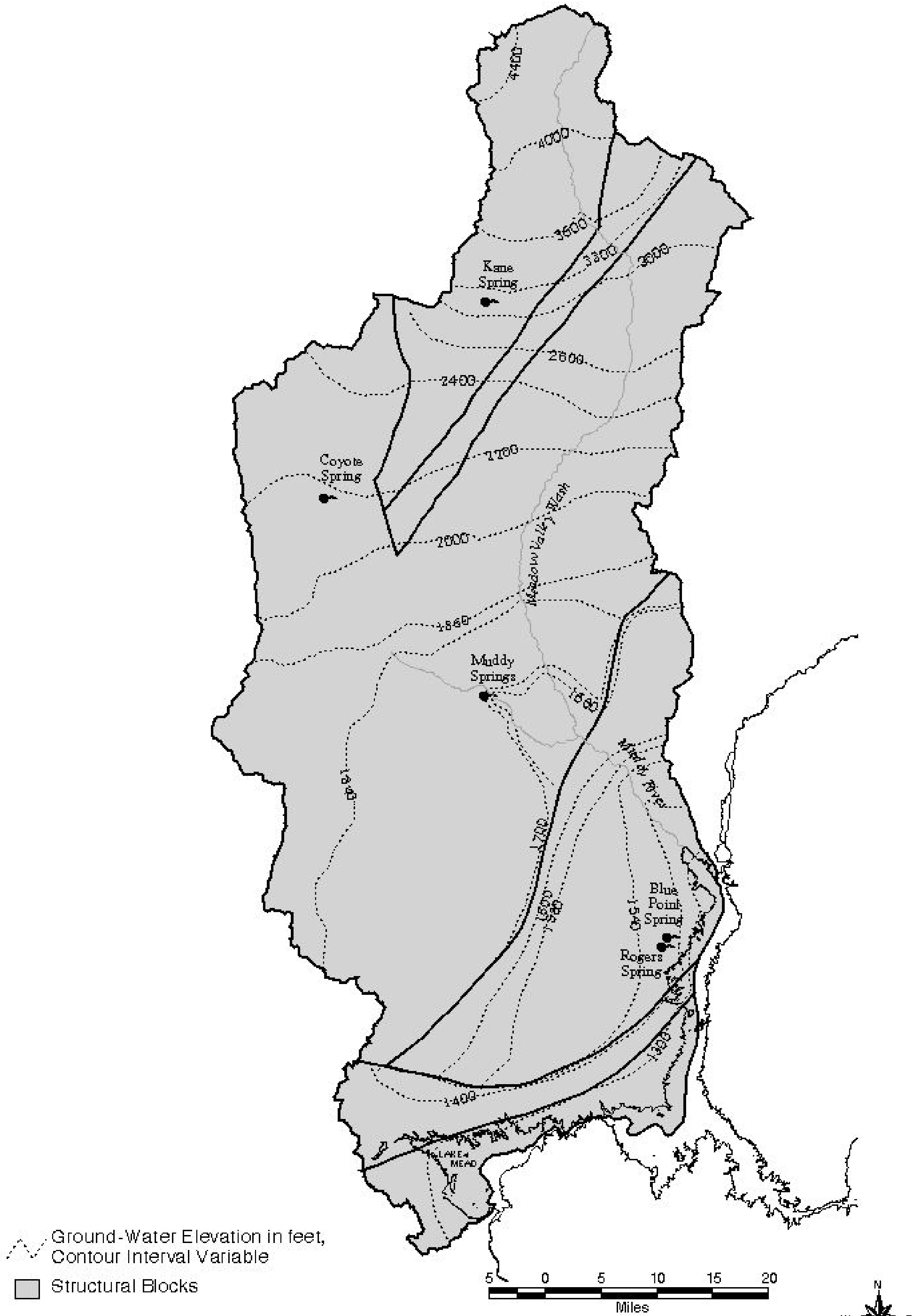


Figure 8-42. Simulated ground-water elevation at ground-water table for existing permitted rights, 2061.

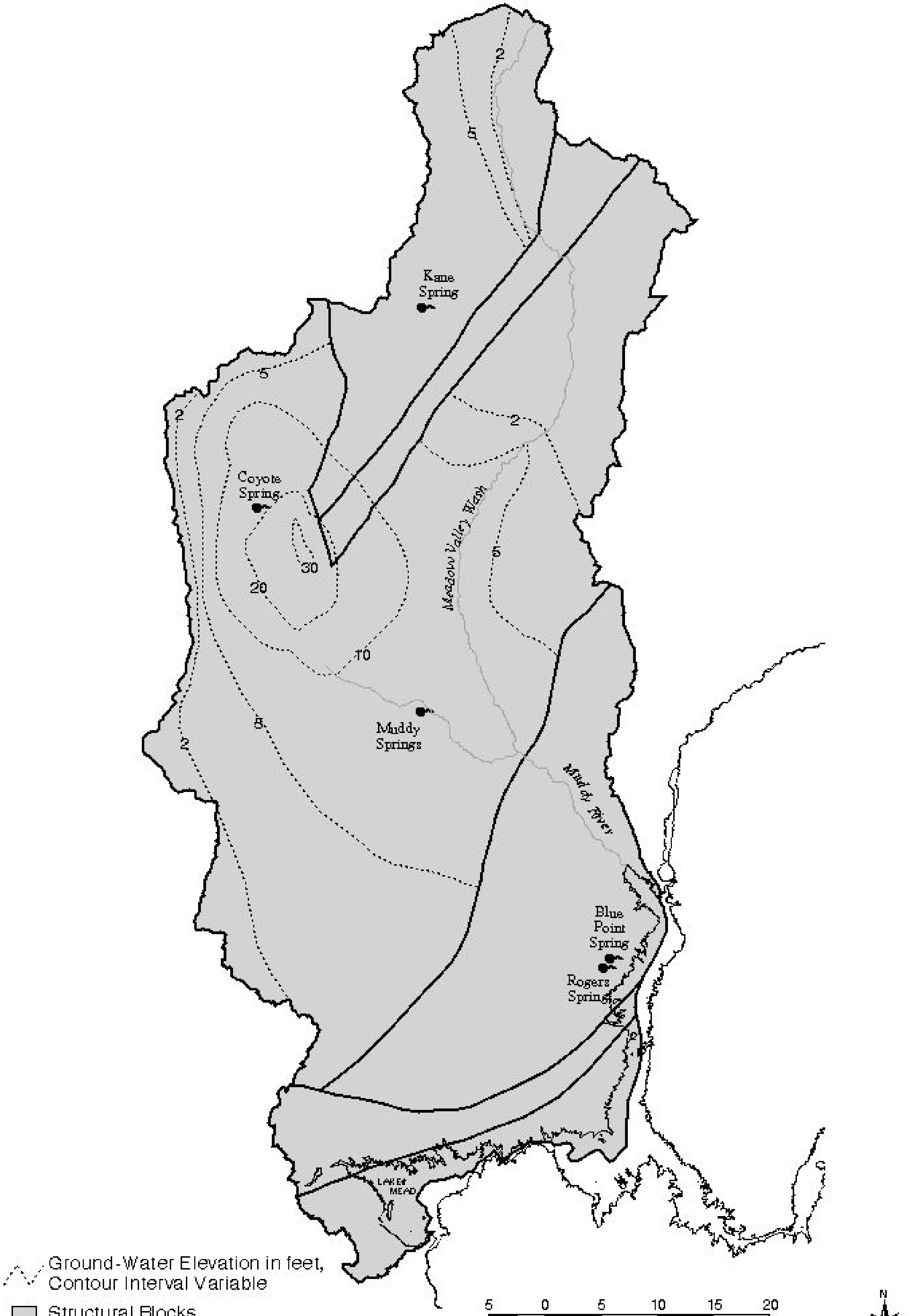


Figure 8-43. Simulated change in ground-water elevation at top of carbonate aquifer for existing permitted rights, 2000-2061.

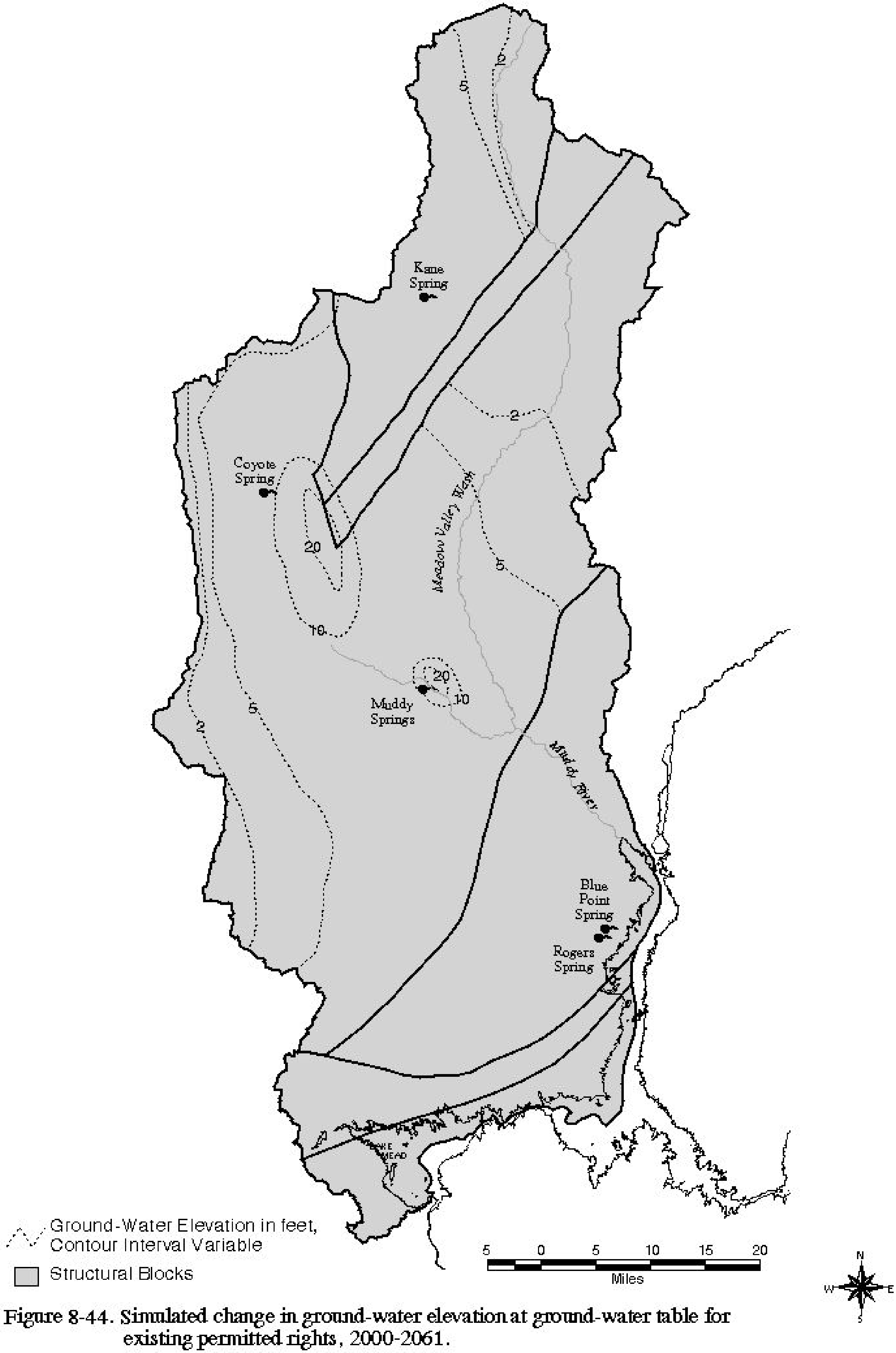


Figure 8-44. Simulated change in ground-water elevation at ground-water table for existing permitted rights, 2000-2061.

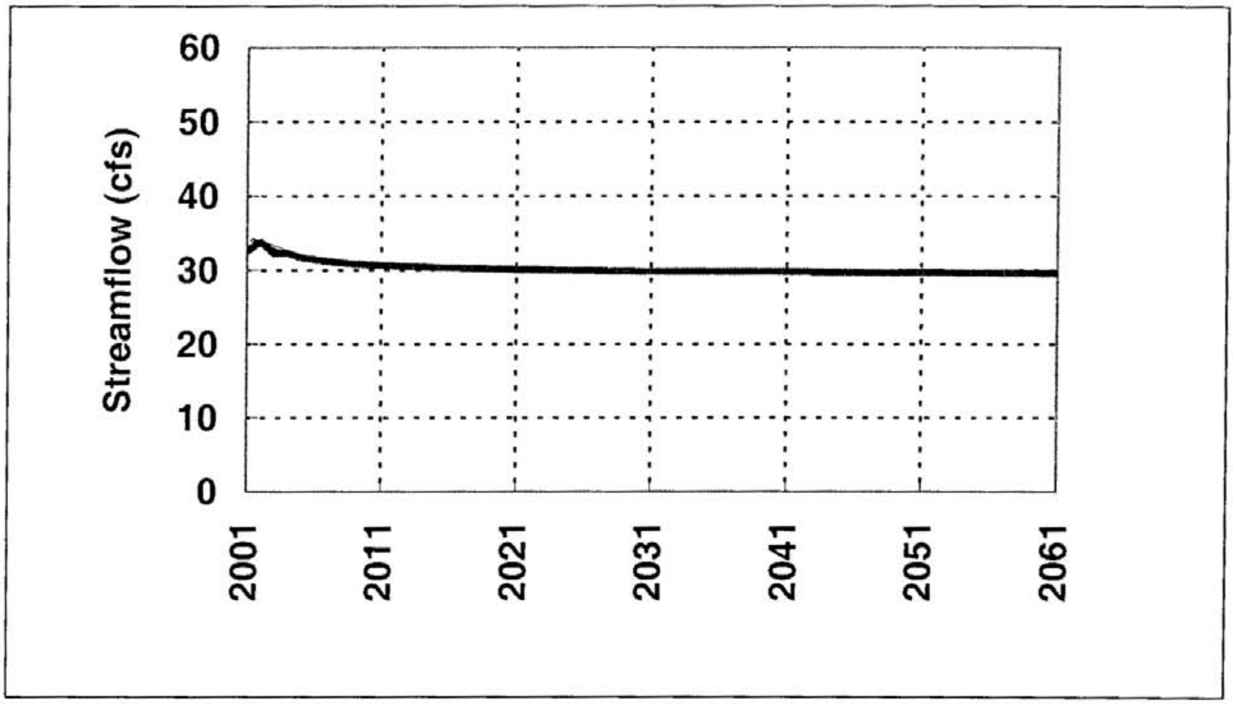


Figure 8-45 Simulated Muddy River Streamflow at Moapa Gage-Existing Permitted Rights.

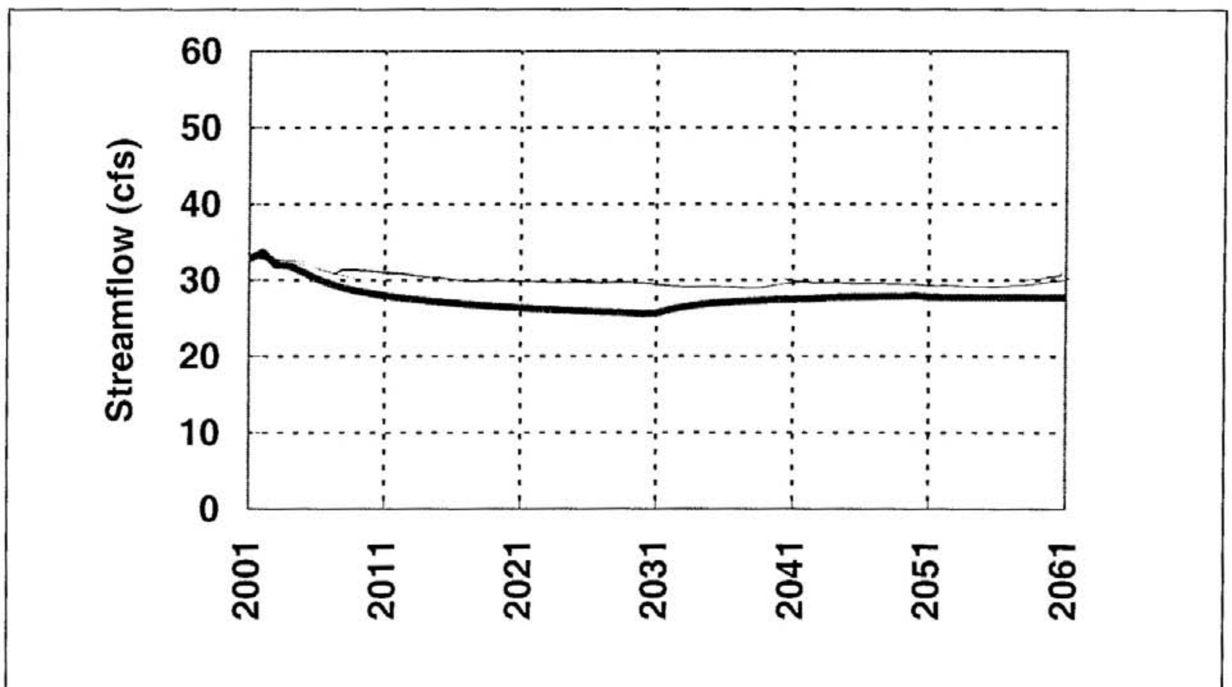


Figure 8-46 Simulated Muddy River Streamflow at Glendale Gage-Existing Permitted Rights.

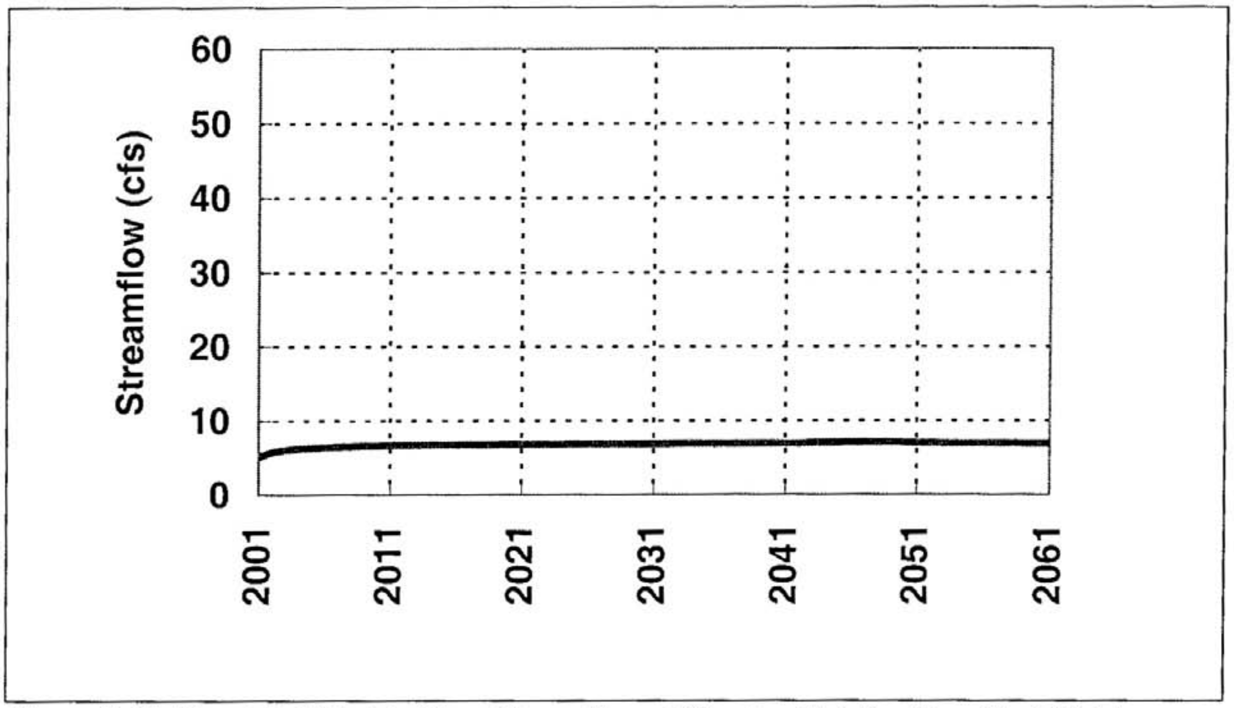


Figure 8-47 Simulated Muddy River Streamflow at Overton-Existing Permitted Rights.

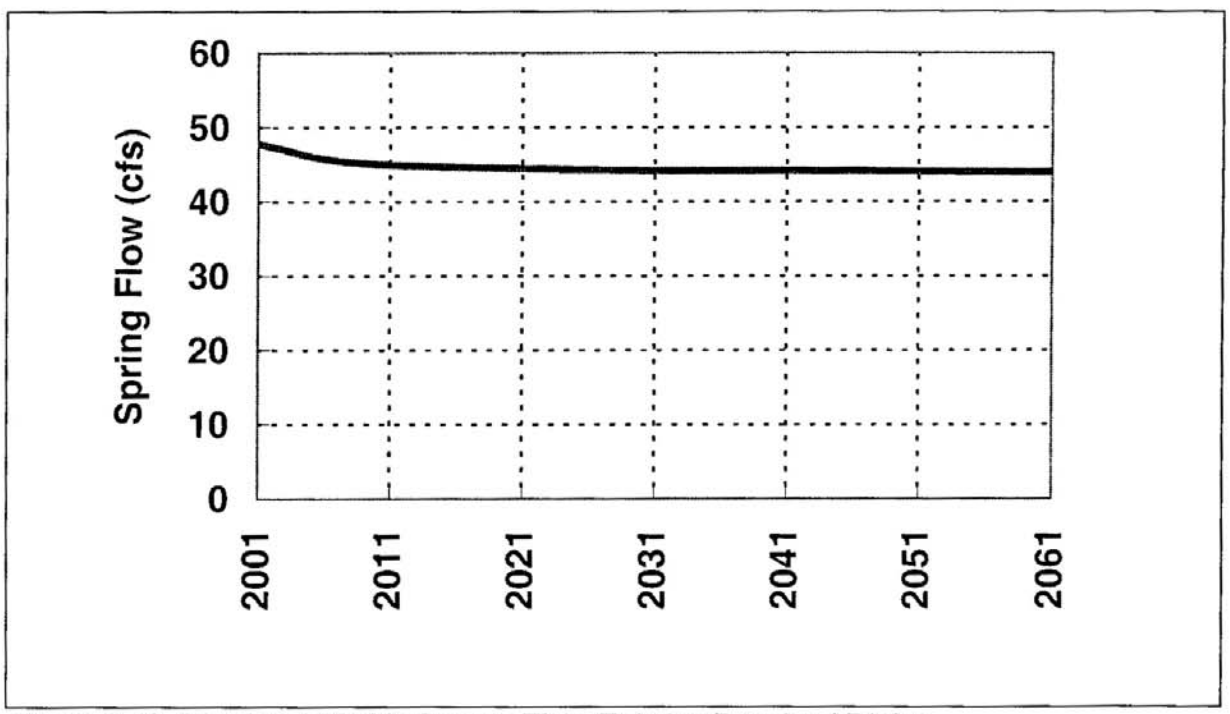


Figure 8-48 Simulated Muddy Springs Flow-Existing Permitted Rights.

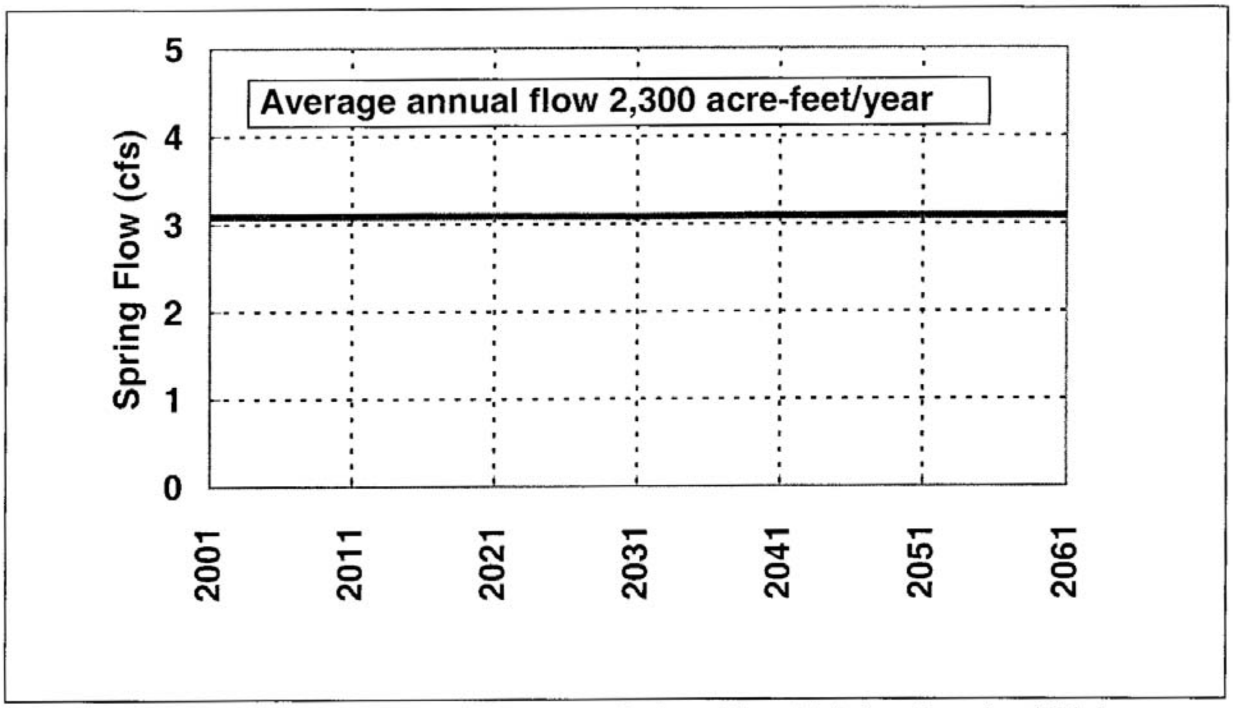


Figure 8-49 Simulated Rogers and Blue Point Springs Flow-Existing Permitted Rights. (represents North Shore Spring Complex).

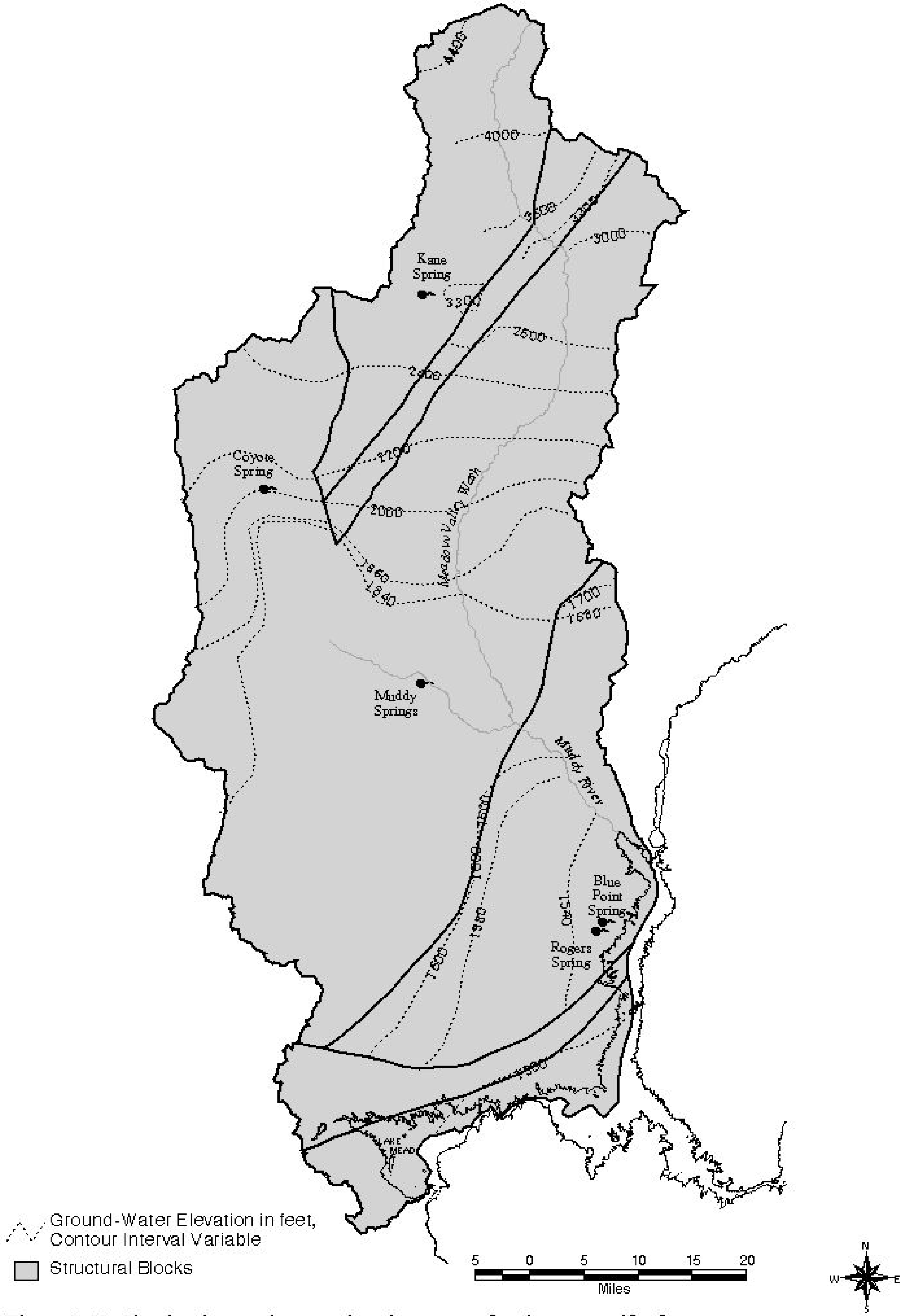


Figure 8-50. Simulated ground-water elevation at top of carbonate aquifer for LVVWD applications, 2061.

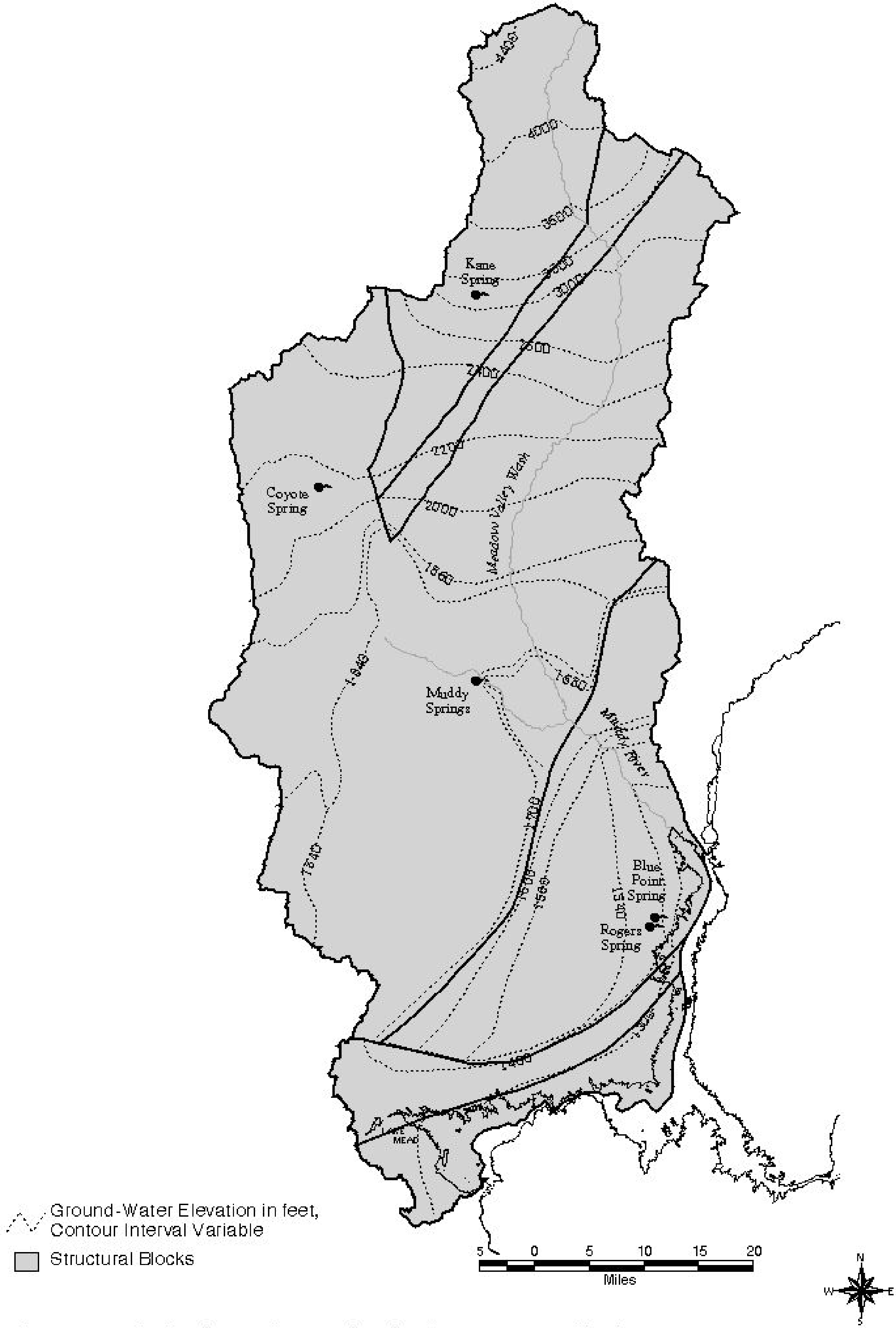


Figure 8-51. Simulated ground-water elevation for LVVWD applications, 2061.

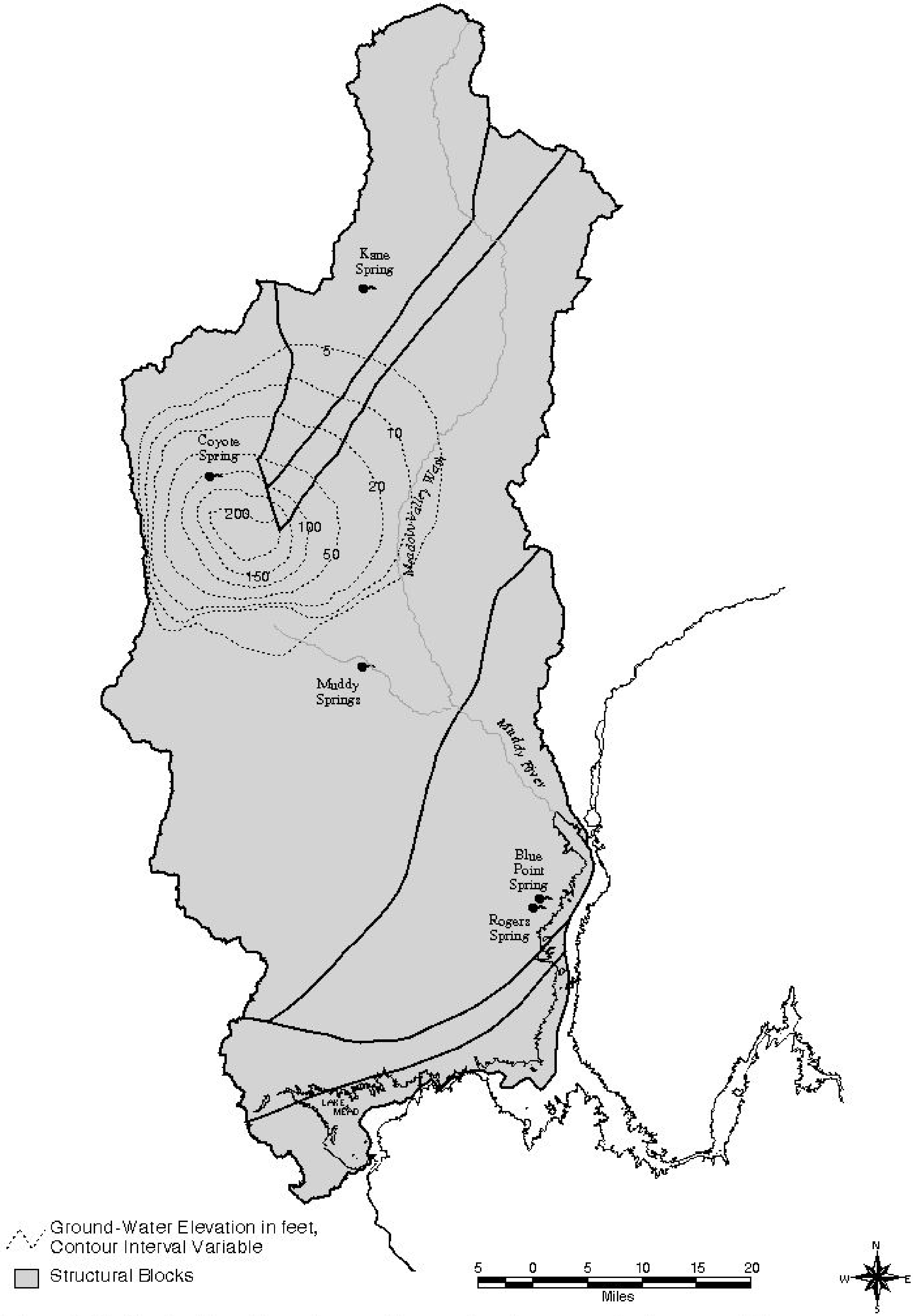


Figure 8-52. Simulated net change in ground-water elevation at top of carbonate aquifer in 2061 between existing permits and LVVWD applications.

elevation at the top of the carbonate aquifer in 2061 between existing permitted rights and LVVWD applications. **Figure 8-53** shows contours of computed change in ground-water elevation at the ground-water table in 2061 between existing permitted rights and LVVWD applications. **Figure 8-54** through **Figure 8-56** show hydrographs of computed streamflow, and **Figure 8-57** and **Figure 8-58** shows hydrographs of computed spring flows. **Table 8-5** lists the components of the ground-water budget for 2061.

As indicated on **Figure 8-54** through **Figure 8-58**, spring flows and streamflows in the simulation show a slight decline as a result of LVVWD applications compared to existing permitted rights. The Muddy Springs discharge shows a decrease from 44 to 41 cfs, but the Rogers Spring and Blue Point Springs discharges remain unchanged. Corresponding to the decrease at Muddy Springs, the Muddy River has a net decline in streamflow at the Moapa gage of approximately 2.5 cfs. The Muddy River streamflow near Glendale declines by approximately 3 cfs, and the decline of Muddy River streamflow at Overton is negligible (<0.1 cfs).

As indicated on **Figure 8-52** and **Figure 8-53**, ground-water levels in the simulation show a decline as a result of LVVWD applications compared to existing permitted rights. Within Coyote Spring Valley, the net water-level decline at the top of the carbonate aquifer is approximately 5 ft in 2061. At Muddy Springs, the net water-level decline at the top of the carbonate aquifer is approximately 2 ft. At the western boundary of the modeled area, the net water-level decline is 1 ft in 2061. At the eastern boundary of the modeled area, the net water-level decline is 2 ft.

As indicated in **Table 8-5**, water-level declines at the model boundaries induce ground-water inflow to the modeled area. The boundary inflow in year 2061 is approximately 41,000 afy.

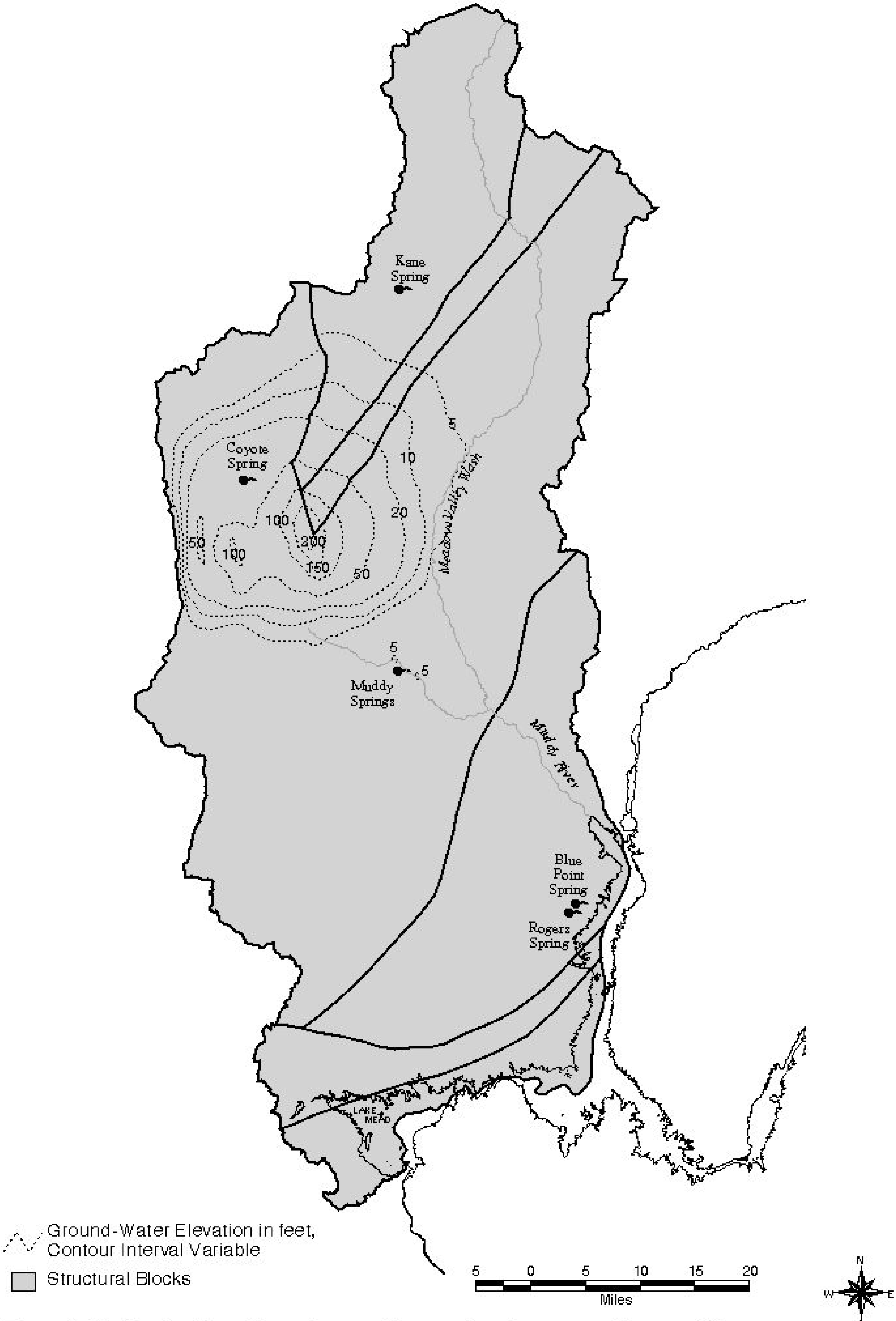


Figure 8-53. Simulated net change in ground-water elevation at ground-water table in 2061 between existing permits and LVVWD applications.

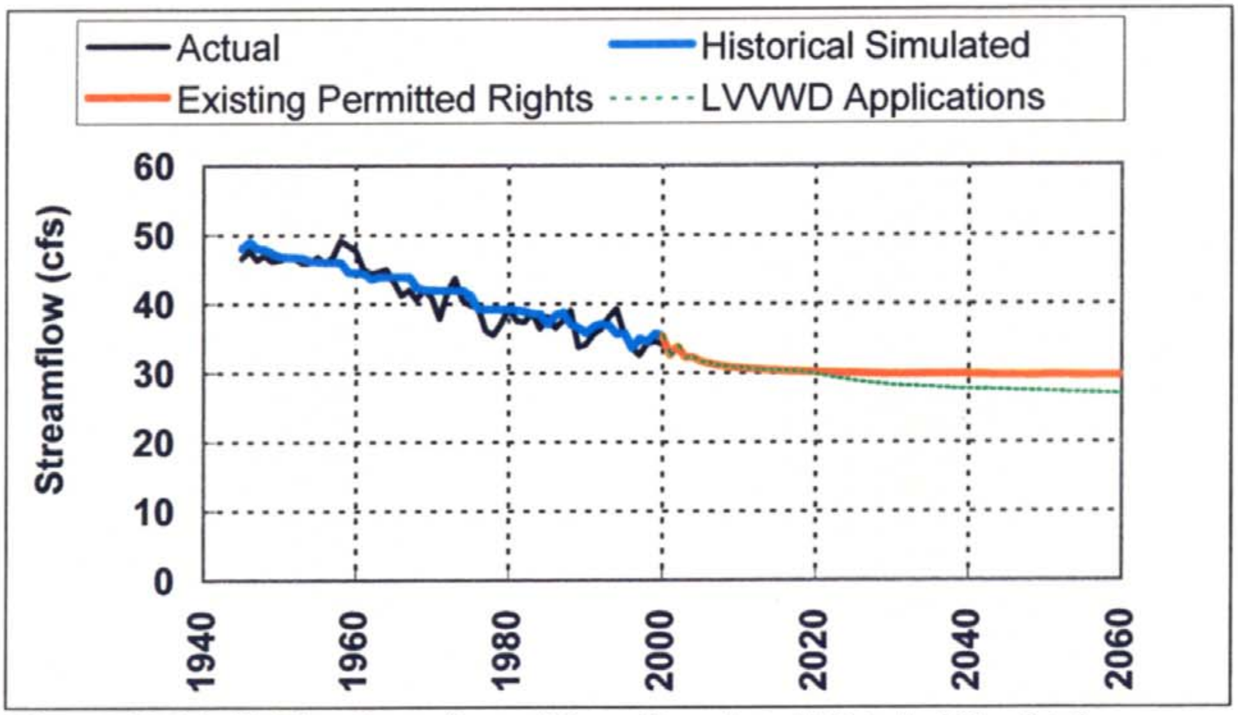


Figure 8-54 Muddy River Streamflow at Moapa Gage-Actual, Historical Simulated, Existing Permitted Rights, and LVVWD Applications.

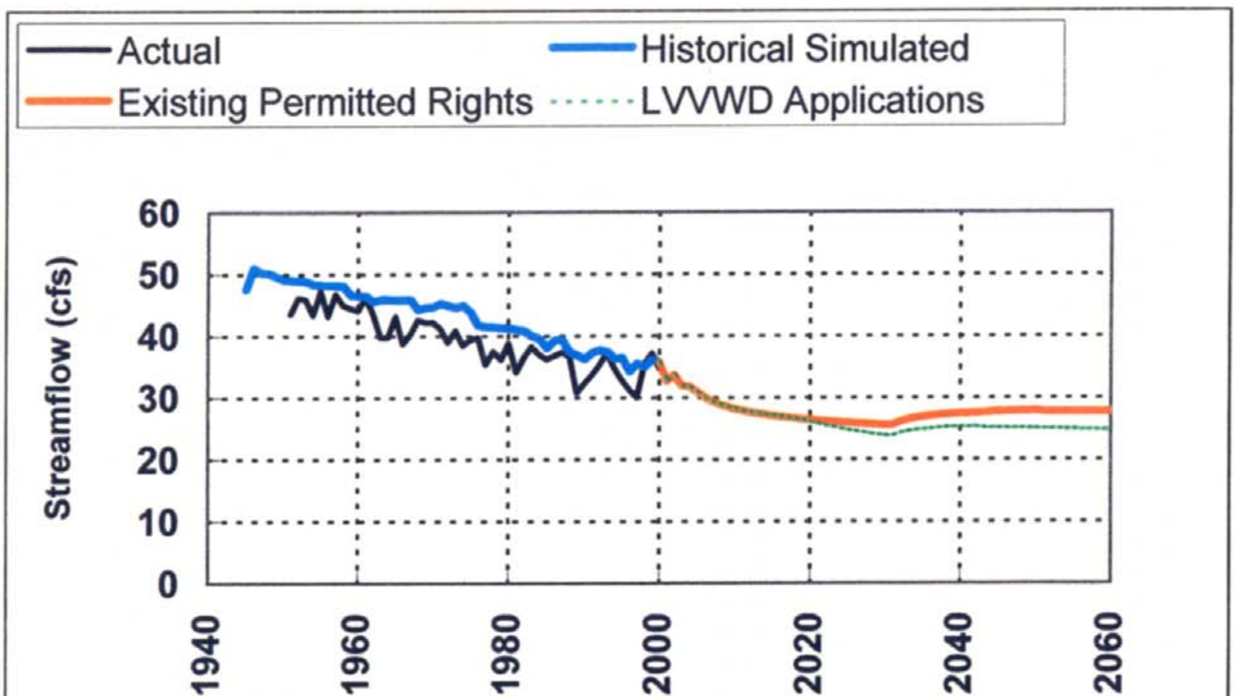


Figure 8-55 Muddy River Streamflow at Glendale Gage-Actual, Historical Simulated, Existing Permitted Rights, and LVVWD Applications.

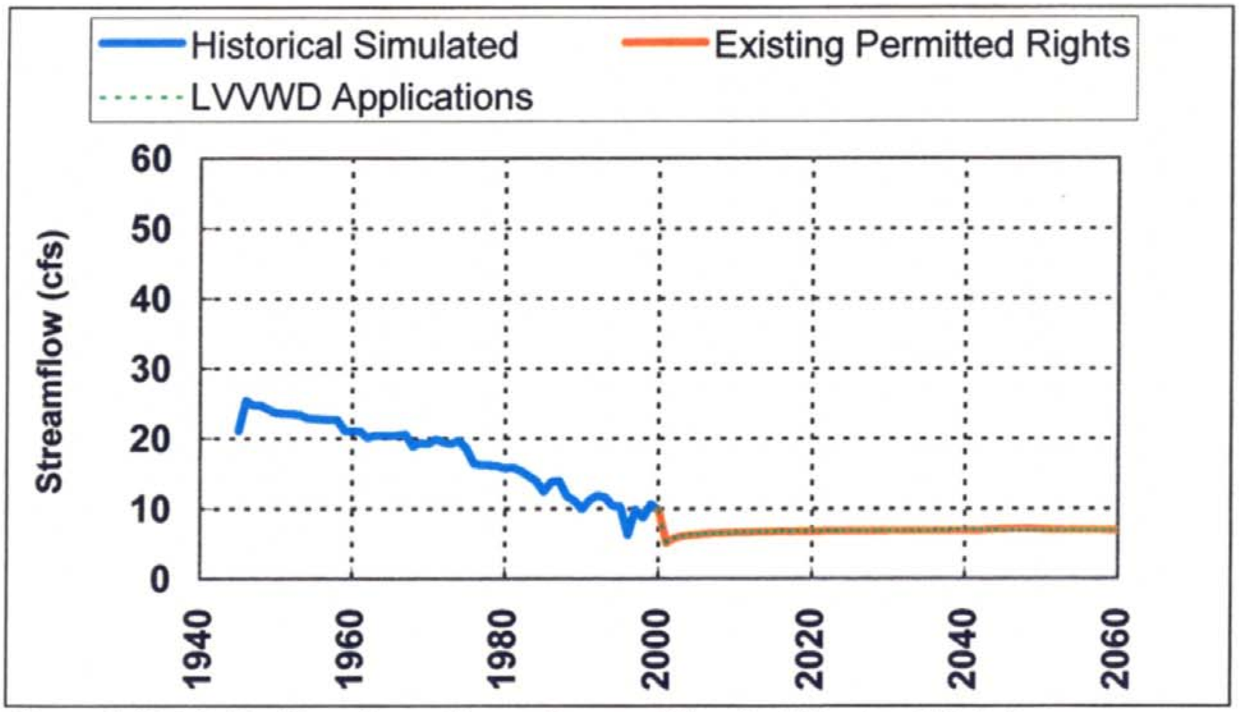


Figure 8-56 Muddy River Streamflow at Overton-Historical Simulated, Existing Permitted Rights, and LVVWD Applications.

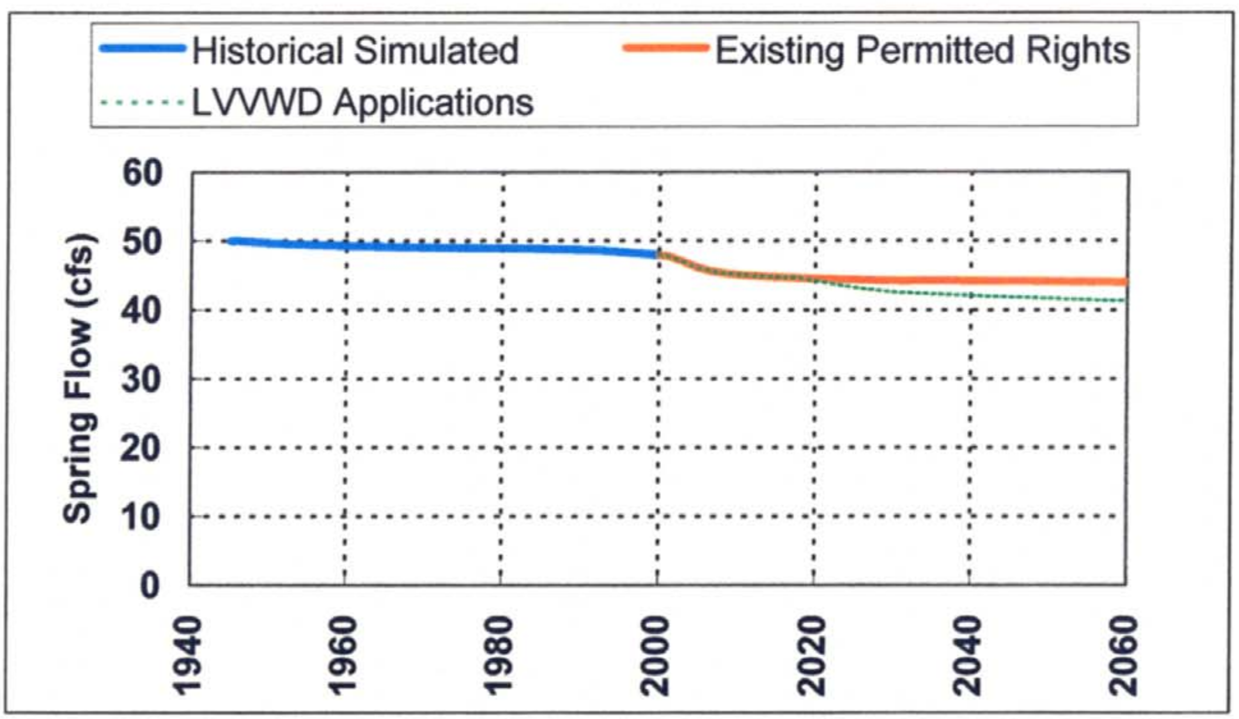


Figure 8-57 Muddy Springs Flow-Historical Simulated, Existing Permitted Rights, and LVVWD Applications.

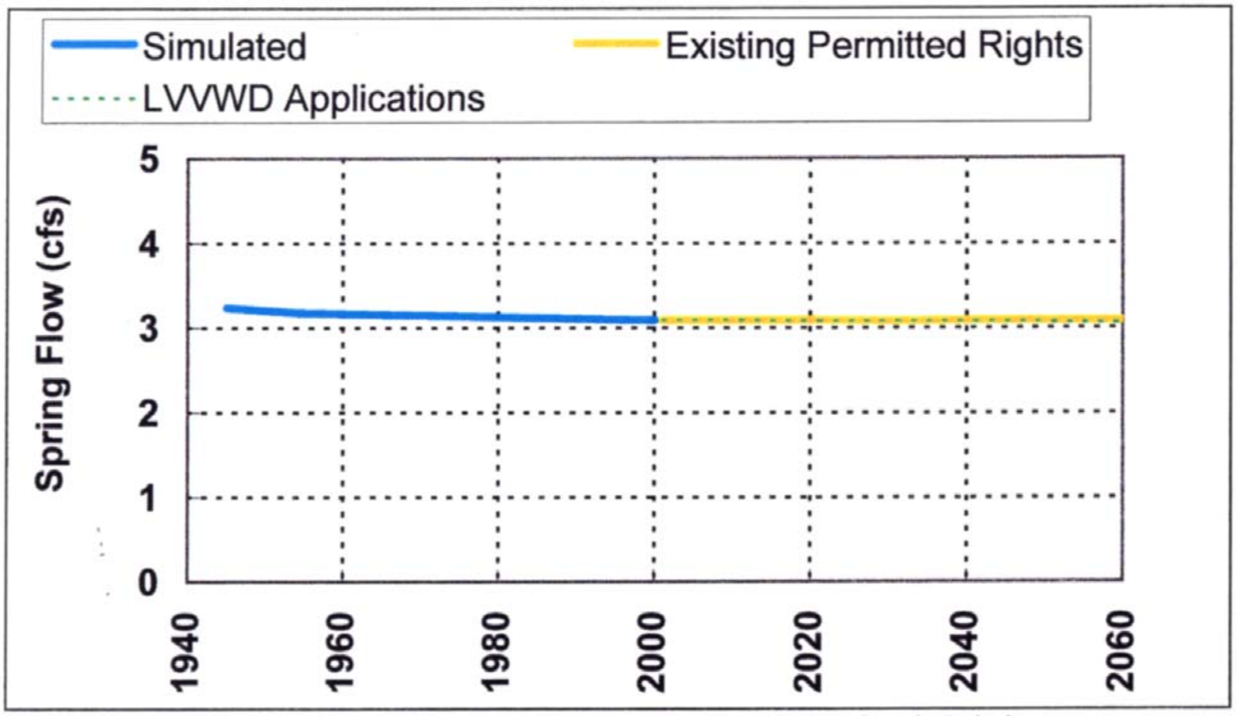


Figure 8-58 Rogers and Blue Point Springs Flow-Historical Simulated, Existing Permitted Rights and LVVWD Applications.

9 MONITORING

Timely and sound judgements regarding the effects and benefits of development of the regional carbonate aquifer can only be made through the use of monitoring combined with coordinated development. Extensive monitoring in the Muddy Springs Area and surrounding valleys is currently being conducted by NPC, MVWD, SNWA, and CSI. All these organizations have monitoring plans in place that require annual summaries to be submitted to the Nevada State Engineer for review. Monitoring is also being conducted by NDWR, USFS, USFWS, NPA, and the Moapa Band of Paiute Indians (MBPI). The parameters being monitored are ground-water levels, spring and streamflow discharges, and quantities of surface and ground-water diversions. **Table 9-1** outlines the number of wells and springs being monitored by each of these entities. This monitoring establishes a mechanism for all parties to better understand the complex aquifer system and protect vital water resources.

Ground-water development naturally occurs in stages due to capital investment of infrastructure and population growth. Development of existing and potential ground-water rights by LVVWD and SNWA will also occur in phases, with concurrent monitoring, modeling, and hydrogeologic investigations. However, the timing and quantities/volumes of these pumping stages will be variable, because future population growth and resulting water demand in the Las Vegas region and the I-15 corridor are not known at this time.

With so little actually known about causal relationships between pumping stresses, water level fluctuations, and spring discharge in the model area, monitoring is key to development of the carbonate aquifer system. LVVWD and SNWA as public agencies are committed to protecting the public interest and vital water resources in the model area.

Table 9-1. Summary of current ground-water and surface-water monitoring sites and data collected.

Area and Agency	Ground-Water Levels		Stream Flow	Diversion Amounts		
	Valley Fill	Carbonate	Spring/River	Springs	River	Wells
Upper Moapa Valley / Arrow Canyon						
NDWR (monthly)	6		5		2	12
NPC (continuous)	5	2			2	11
NPC (monthly)	6	1				
NPC (quarterly)			8			
MVWD (continuous)		2	4	2		2
USFWS (misc.)			5			
USGS (2 per year)			8			
USGS (continuous)[1]		1	4			
Black Mountains Area, California Wash, Garnet and Hidden Valleys						
MBPI (continuous)		6				
NPC (quarterly)		1				
NPS (monthly)		1?	1			
SNWA (quarterly)	2					
USGS (quarterly)	1					
Coyote Spring Valley						
SNWA (quarterly)	4	3				
USGS (continuous)		1				
USGS (quarterly)	4	3				
Lower Meadow Valley Wash / Lower Moapa Valley						
NDWR (monthly)						6
NPC (quarterly)	10					
USGS (continuous)			1			
Mesa/Weiser Wash						
NPC (quarterly)	2	2				

[1] *SNWA funds 50% of three of the USGS continuous gaging stations.*

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MVWD, 2000, Muddy Springs Area monitoring report, 10 p.
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Site reconnaissance conducted 4/30/01; SNWA, USGS, TNC

10 SUMMARY AND CONCLUSIONS

To support ground-water applications 54055 through 54059 (inclusive) filed by LVVWD for an annual duty of 27,512 af in Coyote Spring Valley an extensive hydrogeologic investigation was completed for the Colorado River Basin Province in Nevada, which includes all of the White River and Meadow Valley Flow Systems. Both of these systems are in hydrogeologic continuity with each other and are tributary to the Muddy River.

The water-resources budget for the model area, including Coyote Spring Valley where the applications are located, shows 117, 000 afy of inflow. The upper valleys in the White River and Meadow Valley Flow Systems contribute 44,000 afy and 36,000 afy respectively plus local recharge of 37,000 afy. This recharge is minor compared to the vast amount of water in storage in the alluvial and carbonate rock aquifers.

The analysis shows there is about 324,000 afy of ground-water recharge throughout the entire White River and Meadow Valley Flow Systems. This is slightly more than two times the amount estimated by previous investigators. Ground-water discharge through evapotranspiration is also much greater than previously estimated. Ground-water outflow from the two flow systems (the difference between recharge and discharge) is estimated at about 50,000 afy of which 10,000 to 20,000 afy is surface water in the Muddy River that actually flows into Lake Mead.

Previous studies demonstrate there is a wide range of values in the hydrologic components used to estimate natural recharge and discharge. There is also uncertainty in aquifer properties of the regional carbonate aquifer, and conceptual flow paths of this complex system are only vaguely known. These uncertainties are compounded by the lack of data over much of the area and when combined with natural variation in the hydrologic system make a definitive interpretation of the affects of ground-water development extremely difficult. Nevertheless, this study draws on all previous investigations and using the most recent data and interpretations refines estimates of the hydrogeology of the carbonate aquifer. With a better understanding of the surface- and ground-water hydrology, geology, and geochemistry a ground-water flow model was developed for the lower part of the White River and Meadow Valley Flow Systems to assess the potential affects of ground-water development of the carbonate aquifer in Coyote Spring Valley.

The model was calibrated (for the years 1945 to 2000) to measured water levels in the carbonate aquifer, spring flow of Muddy, Rogers, and Blue Point Springs, and flow in the Muddy River and Meadow Valley Wash. The calibrated model showed predicted water levels were within a few feet of observed levels and spring and river flows were matched within three percent.

During the transient simulations the model simulated a 2 cfs decline in the Muddy Springs from 1945 to 2000. However, water level and gage data collected over nearly the last 20 years does not support this simulated 2 cfs decline which means the model is conservative, slightly over predicting impacts to the ground-water system.

The most sensitive model parameter observed in model development is the value of specific storage. The range of plausible values, based on those found in the literature, vary from 1×10^{-5} to 1×10^{-7}. A value of 1×10^{-6} produced the best model calibration, and all the simulations were run with this value.

The calibrated model evaluated impacts to the ground-water system for a 61-year period. Existing ground-water pumpage of 18,000 afy is simulated in the model area plus additional permitted rights of 16,100 afy in Coyote Spring Valley, and another additional permitted 10,000 afy scattered throughout the model area for a total of 44,000 afy. Of this total 5,000 afy is utilized for a proposed power plant that is anticipated to decrease its use in 2031.

Future impacts due to the LVVWD applications in Coyote Springs Valley for the same time period has all of the permitted water pumped, 44,000 afy, plus ground-water applications filed by LVVWD in the amount of 27,512 afy for a total of about 72,000 afy. All of the pumpage for the LVVWD applications is on line in the first 20 years. The model predicts that the additional pumpage of the applications after 61 years results in: 1) A net water level decline of about 5 ft in Coyote Spring Valley, and 2) an additional 2 ft decline in water levels in the carbonate aquifer in the Muddy Springs area, which causes a decline in spring flow of about 2.5 cfs. This decrease in flow results in a similar decrease in the flow of the Muddy River. Rogers and Blue Point Springs remain unchanged.

Are these values realistic? If the hydrogeology is exactly as we have estimated the answer is yes, however, we know there is great variability in the hydrologic processes that control the movement of ground water and the associated recharge and discharge. These uncertainties suggest a staged approach to ground-water development of these applications that optimizes well locations based on ground-water exploration and aquifer testing. This program, coupled with a monitoring and mitigation plan, will provide insurance against undesirable impacts to the ground-water system.

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APPENDIX A

Appendix A, Part 1. Summary output of Altitude-Precipitation regressions using Excel software.

The four local altitude-precipitation relationships were created using the regression tool in the Excel software. Both altitude and precipitation were reported in feet. The independent variable was altitude and the dependent variable was precipitation.

Appendix A, Part 1, Table A-1. Summary of "General" altitude-precipitation relationship regression.

Regression Statistics	
Multiple R	0.886584
R Square	0.786031
Adjusted R Square	0.779345
Standard Error	0.208043
Observations	34

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0.084172	0.097407	0.86	0.393946
X Variable 1	0.000153	1.41E-05	10.84	3.02E-12
(P) Precipitation in feet = 0.000153 (A) Altitude in feet + 0.084				

Appendix A, Part 1, Table A-2. Summary of "Dry" (Group 1) altitude-precipitation relationship regression.

Regression Statistics	
Multiple R	0.963492
R Square	0.928317
Adjusted R Square	0.923837
Standard Error	0.088485
Observations	18

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0.042803	0.061857	0.691977	0.4988714
X Variable 1	0.000137	9.49E-06	14.3946	1.415E-10
(P) Precipitation in feet = 0.000137 (A) Altitude in feet + 0.0428				

APPENDIX A

Appendix A, Part 1, Table A-3. Summary of "Wet" (Group 2) altitude-precipitation relationship regression.

Regression Statistics	
Multiple R	0.929723
R Square	0.864386
Adjusted R Square	0.854699
Standard Error	0.181604
Observations	16

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0.250518	0.117663	2.129106	0.0514792
X Variable 1	0.000152	1.61E-05	9.446368	1.883E-07
(P) Precipitation in feet = 0.000152 (A) Altitude in feet + 0.2505				

Appendix A, Part 1, Table A-4. Summary of "WRV" altitude-precipitation relationship regression.

Regression Statistics	
Multiple R	0.981701
R Square	0.963736
Adjusted R Square	0.957692
Standard Error	0.07347
Observations	8

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-0.08728	0.093259	-0.93593	0.3854332
X Variable 1	0.000176	1.39E-05	12.62755	1.511E-05
(P) Precipitation in feet = 0.000176 (A) Altitude in feet - 0.087				

APPENDIX A

Appendix A, Part 2. Estimation of precipitation and natural recharge in the study area, by valley.

Altitude Interval	Local A-P[1] Relationship	Assumed Precipitation Rate[2]		Assumed Recharge Efficiency[3]	Area	Precipitation Totals	Natural Recharge Totals
Feet		inches	feet		acres	acre-feet	acre-feet
Long Valley							
6000-7000	WRV	12.7	1.06	0.0582	315,501	333,396	19,401
7000-8000	WRV	14.8	1.23	0.0889	93,202	114,892	10,213
8000-9000	WRV	16.9	1.41	0.1283	8,217	11,576	1,485
9000-10000	WRV	19.0	1.58	0.1774	46	73	13
Long Valley Total					**416,966**	**459,937**	**31,112**
Jakes Valley							
6000-7000	WRV	12.7	1.06	0.0582	147,842	156,227	9,091
7000-8000	WRV	14.8	1.23	0.0889	102,496	126,349	11,231
8000-9000	WRV	16.9	1.41	0.1283	20,673	29,123	3,737
9000-10000	WRV	19.0	1.58	0.1774	482	763	135
Jakes Valley Total					**271,493**	**312,462**	**24,194**
White River Valley							
5000-6000	WRV	10.6	0.88	0.0353	503,848	443,749	15,646
6000-7000	WRV	12.7	1.06	0.0582	325,682	344,155	20,027
7000-8000	WRV	14.8	1.23	0.0889	127,081	156,656	13,925
8000-9000	WRV	16.9	1.41	0.1283	46,897	66,064	8,476
9000-10000	WRV	19.0	1.58	0.1774	11,473	18,182	3,225
10000-11000	WRV	21.1	1.76	0.2500	1,839	3,237	809
11000-12000	WRV	23.2	1.94	0.2500	52	100	25
White River Valley Total					**1,016,871**	**1,032,143**	**62,133**
Garden Valley							
5000-6000	WRV	10.6	0.88	0.0353	177,408	156,247	5,509
6000-7000	WRV	12.7	1.06	0.0582	81,729	86,365	5,026
7000-8000	WRV	14.8	1.23	0.0889	37,964	46,799	4,160
8000-9000	WRV	16.9	1.41	0.1283	15,336	21,604	2,772
9000-10000	WRV	19.0	1.58	0.1774	4,949	7,842	1,391
10000-11000	WRV	21.1	1.76	0.2500	649	1,142	286
11000-12000	WRV	23.2	1.94	0.2500	21	40	10
Garden Valley Total					**318,055**	**320,039**	**19,153**
Coal Valley							
4000-5000	DRY	7.9	0.66	0.0159	50,893	33,553	534
5000-6000	DRY	9.6	0.80	0.0267	170,066	135,423	3,619
6000-7000	DRY	11.2	0.93	0.0414	62,580	58,406	2,415
7000-8000	DRY	12.8	1.07	0.0603	5,990	6,411	386
8000-9000	DRY	14.5	1.21	0.0839	469	567	48
Coal Valley Total					**289,998**	**234,361**	**7,002**
Cave Valley							
5000-6000	WRV	10.6	0.88	0.0353	25,855	22,771	803
6000-7000	WRV	12.7	1.06	0.0582	114,001	120,467	7,010
7000-8000	WRV	14.8	1.23	0.0889	69,058	85,129	7,567

APPENDIX A

Altitude Interval	Local A-P[1] Relationship	Assumed Precipitation Rate[2]		Assumed Recharge Efficiency[3]	Area	Precipitation Totals	Natural Recharge Totals
8000-9000	WRV	16.9	1.41	0.1283	17,409	24,524	3,147
9000-10000	WRV	19.0	1.58	0.1774	2,782	4,408	782
10000-11000	WRV	21.1	1.76	0.2500	650	1,145	286
Cave Valley Total					**229,755**	**258,445**	**19,595**
Pahroc Valley							
4000-5000	DRY	7.9	0.66	0.0159	61,728	40,697	647
5000-6000	DRY	9.6	0.80	0.0267	201,272	160,273	4,283
6000-7000	DRY	11.2	0.93	0.0414	54,632	50,988	2,109
7000-8000	DRY	12.8	1.07	0.0603	7,338	7,854	473
8000-9000	DRY	14.5	1.21	0.0839	319	385	32
Pahroc Valley Total					**325,289**	**260,197**	**7,545**
Dry Lake Valley							
4000-5000	DRY	7.9	0.66	0.0159	169,220	111,567	1,774
5000-6000	DRY	9.6	0.80	0.0267	275,992	219,772	5,874
6000-7000	DRY	11.2	0.93	0.0414	110,168	102,820	4,252
7000-8000	DRY	12.8	1.07	0.0603	15,753	16,861	1,016
8000-9000	DRY	14.5	1.21	0.0839	3,182	3,841	322
9000-10000	DRY	16.1	1.34	0.1128	102	137	15
Dry Lake Valley Total					**574,417**	**454,998**	**13,254**
Delamar Valley							
4000-5000	DRY	7.9	0.66	0.0159	102,703	67,712	1,077
5000-6000	DRY	9.6	0.80	0.0267	90,604	72,148	1,928
6000-7000	DRY	11.2	0.93	0.0414	33,844	31,587	1,306
7000-8000	DRY	12.8	1.07	0.0603	4,431	4,742	286
Delamar Valley Total					**231,582**	**176,189**	**4,597**
Pahranagat Valley							
3000-4000	DRY	6.3	0.52	0.0084	100,414	52,446	440
4000-5000	DRY	7.9	0.66	0.0159	231,352	152,530	2,426
5000-6000	DRY	9.6	0.80	0.0267	121,039	96,383	2,576
6000-7000	DRY	11.2	0.93	0.0414	35,356	32,998	1,365
7000-8000	DRY	12.8	1.07	0.0603	8,838	9,459	570
8000-9000	DRY	14.5	1.21	0.0839	313	378	32
Pahranagat Valley Total					**497,312**	**344,195**	**7,407**
Kane Springs Valley							
2000-3000	WET	7.6	0.63	0.0141	1,688	1,064	15
3000-4000	WET	9.4	0.78	0.0255	61,164	47,861	1,219
4000-5000	WET	11.2	0.93	0.0415	44,562	41,643	1,728
5000-6000	WET	13.0	1.09	0.0628	25,539	27,749	1,743
6000-7000	WET	14.9	1.24	0.0900	15,783	19,547	1,760
7000-8000	WET	16.7	1.39	0.1238	1,694	2,355	292
Kane Springs Valley Total					**150,429**	**140,218**	**6,757**
Coyote Spring Valley							
2000-3000	DRY	4.6	0.39	0.0036	132,184	50,931	185
3000-4000	DRY	6.3	0.52	0.0084	109,142	57,005	478
4000-5000	DRY	7.9	0.66	0.0159	67,259	44,344	705

APPENDIX A

Altitude Interval	Local A-P[1] Relationship	Assumed Precipitation Rate[2]		Assumed Recharge Efficiency[3]	Area	Precipitation Totals	Natural Recharge Totals
5000-6000	DRY	9.6	0.80	0.0267	51,624	41,108	1,099
6000-7000	DRY	11.2	0.93	0.0414	21,806	20,352	842
7000-8000	DRY	12.8	1.07	0.0603	7,908	8,464	510
8000-9000	DRY	14.5	1.21	0.0839	1,512	1,826	153
9000-10000	DRY	16.1	1.34	0.1128	186	249	28
Coyote Spring Valley Total					**391,621**	**224,278**	**4,000**
Muddy River Springs Area							
1000-2000	DRY	3.0	0.25	0.0011	13,427	3,334	4
2000-3000	DRY	4.6	0.39	0.0036	52,932	20,395	74
3000-4000	DRY	6.3	0.52	0.0084	19,294	10,077	84
4000-5000	DRY	7.9	0.66	0.0159	6,648	4,383	70
5000-6000	DRY	9.6	0.80	0.0267	239	190	5
Muddy River Springs Area Total					**92,541**	**38,380**	**237**
Lower Moapa Valley							
1000-2000	WET	5.7	0.48	0.0066	80,864	38,693	255
2000-3000	WET	7.6	0.63	0.0141	80,843	50,972	717
3000-4000	WET	9.4	0.78	0.0255	9,537	7,463	190
4000-5000	WET	11.2	0.93	0.0415	3,761	3,515	146
5000-6000	WET	13.0	1.09	0.0628	599	651	41
6000-7000	WET	14.9	1.24	0.0900	52	64	6
Lower Moapa Valley Total					**175,656**	**101,358**	**1,354**
Hidden Valley							
2000-3000	DRY	4.6	0.39	0.0036	20,275	7,812	28
3000-4000	DRY	6.3	0.52	0.0084	18,405	9,613	81
4000-5000	DRY	7.9	0.66	0.0159	7,162	4,722	75
5000-6000	DRY	9.6	0.80	0.0267	5,758	4,585	123
6000-7000	DRY	11.2	0.93	0.0414	833	777	32
7000-8000	DRY	12.8	1.07	0.0603	3	3	0
Hidden Valley Total					**52,435**	**27,512**	**339**
Garnet Valley							
1000-2000	DRY	3.0	0.25	0.0011	5,778	1,435	2
2000-3000	DRY	4.6	0.39	0.0036	68,111	26,243	95
3000-4000	DRY	6.3	0.52	0.0084	14,053	7,340	62
4000-5000	DRY	7.9	0.66	0.0159	8,228	5,425	86
5000-6000	DRY	9.6	0.80	0.0267	4,383	3,490	93
6000-7000	DRY	11.2	0.93	0.0414	1,412	1,317	54
7000-8000	DRY	12.8	1.07	0.0603	17	18	1
Garnet Valley Total					**101,981**	**45,268**	**393**
California Wash							
1000-2000	DRY	3.0	0.25	0.0011	51,402	12,763	14
2000-3000	DRY	4.6	0.39	0.0036	131,151	50,533	183
3000-4000	DRY	6.3	0.52	0.0084	20,818	10,873	91
4000-5000	DRY	7.9	0.66	0.0159	2,162	1,425	23
5000-6000	DRY	9.6	0.80	0.0267	17	14	0
California Wash Total					**205,550**	**75,608**	**311**

APPENDIX A

Altitude Interval	Local A-P[1] Relationship	Assumed Precipitation Rate[2]		Assumed Recharge Efficiency[3]	Area	Precipitation Totals	Natural Recharge Totals
Lake Valley							
5000-6000	WET	13.0	1.09	0.0628	99,543	108,154	6,794
6000-7000	WET	14.9	1.24	0.0900	186,091	230,473	20,752
7000-8000	WET	16.7	1.39	0.1238	51,929	72,207	8,939
8000-9000	WET	18.5	1.54	0.1647	13,279	20,483	3,373
9000-10000	WET	20.3	1.69	0.2500	2,847	4,824	1,206
10000-11000	WET	22.2	1.85	0.2500	558	1,030	257
Lake Valley Total					**354,246**	**437,170**	**41,320**
Patterson Valley							
4000-5000	GEN	9.3	0.77	0.0246	26	20	1
5000-6000	GEN	11.1	0.93	0.0404	121,199	112,190	4,536
6000-7000	GEN	12.9	1.08	0.0616	117,689	126,948	7,817
7000-8000	GEN	14.8	1.23	0.0887	23,894	29,429	2,610
8000-9000	GEN	16.6	1.38	0.1224	4,444	6,153	753
9000-10000	GEN	18.5	1.54	0.1632	178	274	45
Patterson Valley Total					**267,430**	**275,015**	**15,761**
Spring Valley							
5000-6000	GEN	11.1	0.93	0.0404	5,285	4,893	198
6000-7000	GEN	12.9	1.08	0.0616	101,315	109,286	6,729
7000-8000	GEN	14.8	1.23	0.0887	67,312	82,906	7,352
8000-9000	GEN	16.6	1.38	0.1224	11,013	15,249	1,866
9000-10000	GEN	18.5	1.54	0.1632	20	31	5
Spring Valley Total					**184,945**	**212,364**	**16,151**
Dry Valley							
4000-5000	GEN	9.3	0.77	0.0246	36	28	1
5000-6000	GEN	11.1	0.93	0.0404	39,384	36,457	1,474
6000-7000	GEN	12.9	1.08	0.0616	30,324	32,710	2,014
7000-8000	GEN	14.8	1.23	0.0887	6,128	7,547	669
8000-9000	GEN	16.6	1.38	0.1224	467	647	79
Dry Valley Total					**76,339**	**77,388**	**4,237**
Rose Valley							
5000-6000	GEN	11.1	0.93	0.0404	5,876	5,440	220
6000-7000	GEN	12.9	1.08	0.0616	1,770	1,910	118
Rose Valley Total					**7,647**	**7,349**	**338**
Eagle Valley							
5000-6000	GEN	11.1	0.93	0.0404	8,100	7,498	303
6000-7000	GEN	12.9	1.08	0.0616	20,763	22,397	1,379
7000-8000	GEN	14.8	1.23	0.0887	4,671	5,753	510
8000-9000	GEN	16.6	1.38	0.1224	924	1,280	157
Eagle Valley Total					**34,458**	**36,927**	**2,349**
Clover Valley							
4000-5000	GEN	9.3	0.77	0.0246	12,035	9,299	229
5000-6000	GEN	11.1	0.93	0.0404	149,551	138,435	5,597
6000-7000	GEN	12.9	1.08	0.0616	69,058	74,491	4,587
7000-8000	GEN	14.8	1.23	0.0887	1,320	1,626	144

APPENDIX A

Altitude Interval	Local A-P[1] Relationship	Assumed Precipitation Rate[2]		Assumed Recharge Efficiency[3]	Area	Precipitation Totals	Natural Recharge Totals
Clover Valley Total					**231,964**	**223,852**	**10,557**
Panaca Valley							
4000-5000	GEN	9.3	0.77	0.0246	51,990	40,171	988
5000-6000	GEN	11.1	0.93	0.0404	120,939	111,950	4,526
6000-7000	GEN	12.9	1.08	0.0616	41,111	44,345	2,731
7000-8000	GEN	14.8	1.23	0.0887	4,893	6,027	534
8000-9000	GEN	16.6	1.38	0.1224	1,419	1,965	240
9000-10000	GEN	18.5	1.54	0.1632	84	129	21
Panaca Valley Total					**220,435**	**204,587**	**9,041**
Lower Meadow Valley Wash							
1000-2000	WET	5.7	0.48	0.0066	32,791	15,690	103
2000-3000	WET	7.6	0.63	0.0141	111,757	70,462	991
3000-4000	WET	9.4	0.78	0.0255	175,275	137,153	3,493
4000-5000	WET	11.2	0.93	0.0415	124,533	116,376	4,830
5000-6000	WET	13.0	1.09	0.0628	109,876	119,380	7,499
6000-7000	WET	14.9	1.24	0.0900	48,781	60,415	5,440
7000-8000	WET	16.7	1.39	0.1238	2,711	3,769	467
8000-9000	WET	18.5	1.54	0.1647	1	1	0
Lower Meadow Valley Wash Total					**605,723**	**523,247**	**22,823**
Black Mountains Area							
1000-2000	DRY	3.0	0.25	0.0011	218,605	54,280	59
2000-3000	DRY	4.6	0.39	0.0036	159,897	61,608	224
3000-4000	DRY	6.3	0.52	0.0084	27,183	14,198	119
4000-5000	DRY	7.9	0.66	0.0159	2,975	1,961	31
5000-6000	DRY	9.6	0.80	0.0267	260	207	6
Black Mountains Area Total					**408,919**	**132,254**	**438**
Grand Total					**7,734,059**	**6,635,742**	**332,399**

[1] A-P = Altitude-Precipitation

[2] Precipitation calculated directly from mean altitude of 1,000 foot altitude intervals using one of the four local altitude-precipitation relationships listed in the second column and described in (Section 4.2, Precipitation)

[3] Recharge efficiency coefficient (percentage of precipitation that becomes natural recharge) was calculated from the estimate of precipitation in feet per year for the specific 1,000 foot altitude intervals by using the non-linear mathematical approximation ([$r_e = 0.05 (P)^{2.75}$] Donovan and Katzer, 2000, p. 1142), discussed in Section 4. 4. 2., of the Maxey-Eakin coefficients. Note 0.0100 = 1 percent.

APPENDIX B

B.1 BACKGROUND

Historically, ground-water development within the model boundary has generally been limited to areas located within the flood plains of the Muddy River and Lower Meadow Valley Wash in Lower Moapa Valley, Lower Meadow Valley Wash, and the Muddy River Springs area of the Upper Moapa Valley near the southeast portion of the model area. Ground water has principally been developed to supply water for agriculture in these areas. It has also been developed in the Muddy River Springs area to supply water to the Reid Gardner power-generating facility located in California Wash which is owned and operated by NPC. Pumping well locations in the area are depicted in **Figure B-1.** Until recently, there has been little to no ground-water development in the other basins comprising the remainder of the model area (Black Mountains, California Wash, Garnet Valley, Hidden Valley). However, since 1990, various commercial enterprises have been granted ground-water withdrawal permits within the Black Mountains Area, Garnet Valley, and Hidden Valley of which, only a few have been certified. The remaining sections of this appendix discuss sources of ground-water production data, methods used to compile the development history for each basin within the model boundary, and a summary of the development history and description of how the records were used in the flow model.

B.2 DATA SOURCES AND RECORD COMPILATION

Major sources of ground-water production data and information are DRI, NDWR, USGS, and various reports referenced in this appendix. Information was obtained in the form of published and unpublished documents and data sets. In addition, numerous interviews were conducted with representatives of the MVIC, MVWD, NDWR, and various consultants working within the boundaries of the model area.

Ground-water production data were compiled and transcribed into digital form for analysis and formatting such that they could be used as input into the ground-water flow model. Abstracts from the Water Rights Database administered by NDWR were used to identify permitted/certified ground-water rights. Information garnered from this process was used to construct possible ground-water production histories in areas where reported data are scarce. Much of the data for the Muddy Springs area was compiled from monitoring reports submitted to the Nevada State Engineer on behalf of MVWD and NPC. Ground-water production reports for selected wells located in the Black Mountains Area and Garnet Valley were acquired from NDWR and transcribed into digital form. Information garnered through interviews was incorporated. Land-use maps based on aerial photography and satellite imagery were developed for selected years in order to identify irrigated areas from which the magnitude of ground-water development could be approximated.

B.3 METHODS

A record of ground-water production for each basin within the model boundary was developed for the period 1945 to 2000 based on the data and informational sources noted in the previous section. Since few recorded data are available for the years prior to 1987, information garnered from literature review and the interview process, land-use maps, aerial photography, and satellite

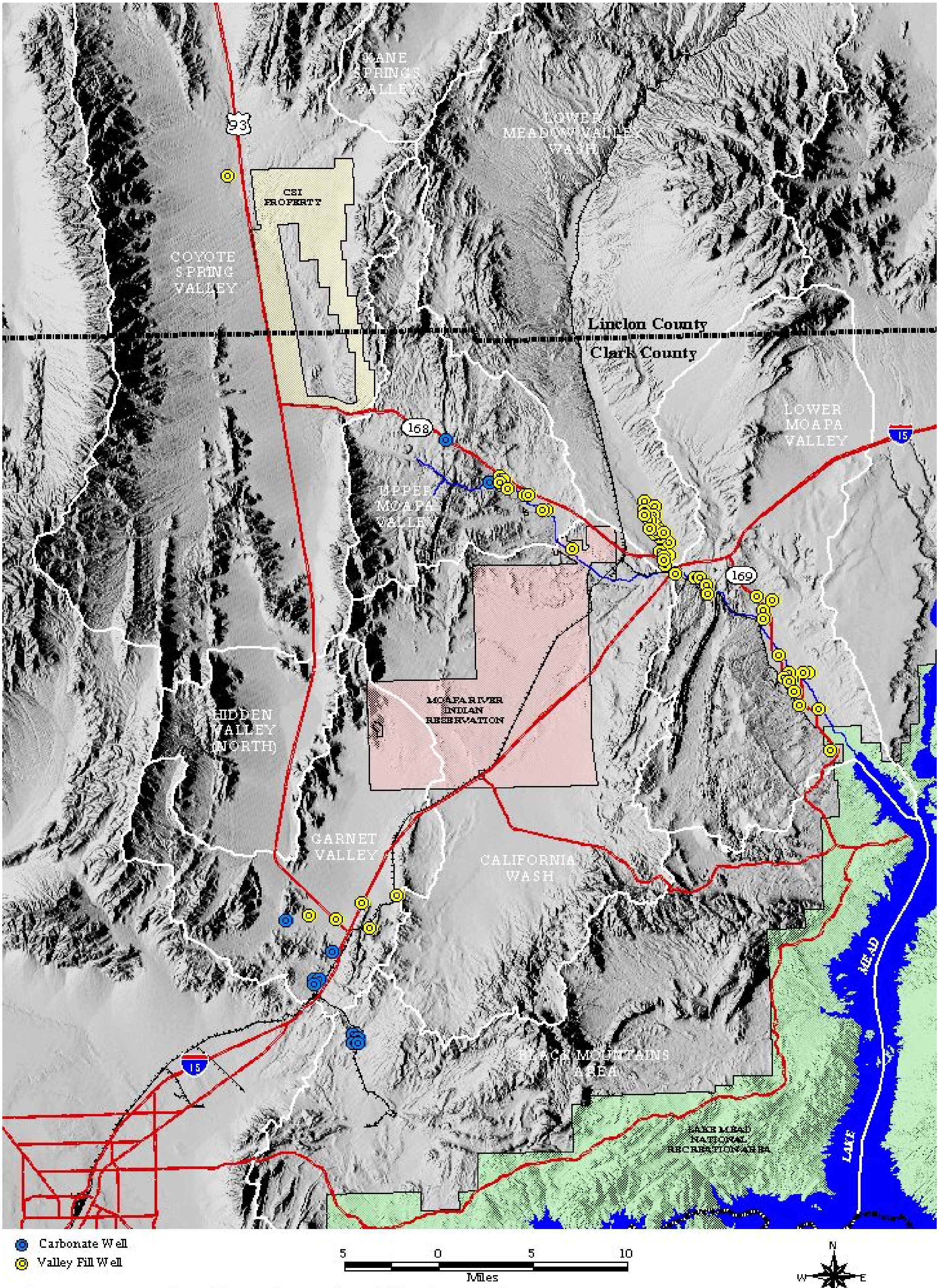


Figure B-1. Location of pumping wells within the model area.

imagery was relied upon to construct the records. The methods employed for each basin are discussed in detail in the following sections.

B.3.1 Black Mountains Area and Garnet Valley

Ground-water development in these basins began in earnest in the early 1990s to support various industrial and mining operations. The principal ground-water user in the Black Mountains Area is the Nevada Cogeneration Associates plant, and the principal users in Garnet Valley are the Chemical Lime Company, Georgia Pacific Corporation, Great Star Cement Corporation, and Republic Environmental Technologies. These users accounted for approximately 2,600 acre-feet of ground-water production in 2000.

Abstracts from NDWR's Water Rights Database were used to identify permitted rights within each basin. To construct the development history of these rights, ground-water production records were requested from NDWR. NDWR provided copies of these records for selected wells. For other wells that are known to exist in the area, information garnered from interviews with Mr. Robert Coache (Chief Engineer, NDWR) was used to estimate the extent to which the permitted rights have been developed.

B.3.2 California Wash, Coyote Spring and Hidden Valleys

California Wash, Coyote Spring and Hidden Valleys remain essentially undeveloped; however numerous ground-water permit applications have been filed with the Nevada State Engineer for proposed projects located within these basins. To date, no appreciable development has occurred.

B.3.3 Lower Meadow Valley Wash

In the southern section of Lower Meadow Valley Wash, ground water has historically been used for crop irrigation that has been generally confined to the flood plain of Lower Meadow Valley Wash. Based on interpretations of aerial photography acquired for year 2000, approximately 792 acres of cropland was irrigated in this section of the basin. Using a consumptive rate of 5 feet per acre, first published by Eakin (1964) for agriculture in the Muddy River Springs area, an estimated 3,960 acre-feet of ground water were applied in 2000. In order to distribute this quantity spatially, the volume was divided equally amongst permitted wells located on or near the irrigated fields. It was assumed that the consumptive use applied to the wells remained constant to the date the well was constructed.

In the early 1980s, NPC constructed wells at the southern tip of the basin in an effort to develop additional ground-water resources for use at their Reid Gardner facility. These wells were pumped extensively for a brief period in the early 1980s, coincident with the activation the fourth generating unit in 1983, but production was reduced in 1988 due to excessive declines in water levels and water quality (Mifflin, oral. commun. 03/2001). The annual ground-water production was reduced to approximately 310,000 gallons in 1989 as reported by Pohlmann et al. (1990, p.9). Only a negligible amount of ground water has been produced from these wells since 1990.

In the northern portions of Lower Meadow Valley Wash, above Farrier, agricultural uses are assumed to be supplied principally by surface water flowing in the wash. It is acknowledged that ground-water pumping occurs minimally in this area, but since records are non-existent or unavailable, it is assumed to be negligible for the purposes of this study.

B.3.4 Lower Moapa Valley

Records of ground-water production for this basin are either unavailable or do not exist, and therefore had to be estimated based on information garnered from the interview process. According to MVWD (03/2001, oral. commun.), ground-water development has generally been limited to selected wells located in the valley that have been used to supply water to meet peak agricultural demands during the summer months when diversions from the Muddy River have been either insufficient or untimely. Ground-water development was at its maximum between 1970 and the late-1980s, after which it began to decrease as agricultural lands were replaced with housing developments. This trend has continued to the present, and ground-water development is now much less prevalent.

The ground-water production record for this basin was developed based on an estimated consumptive use rate of 5-6 cfs for four months out of the year (MVWD, 03/2001, oral commun.). An average rate of 5.5 cfs equates to approximately 1,325 afy, which was distributed by dividing the volume equally amongst 21 permitted wells located in the valley in 1988. It was assumed that the consumptive use applied to the wells remained constant from the date the well was constructed. After 1988, the consumptive-use rate applied to each well was reduced to account for an observed increase in housing development and reduced irrigated acreage. It is assumed in the record that by 1991 the maximum consumptive use that occurred in the late-1980s had been reduced by 66 percent to account for changes in land use from agriculture to housing developments.

B.3.5 Muddy River Springs Area

Few records of ground-water production in the Muddy River Springs area existed prior to 1989 when Nevada Power Company first established their ground-water-monitoring program for the area. However, it is known that the first well was completed in the area in 1947 (NDWR Well Log Database) and it is assumed, for the purposes of this study, that little to no ground water had been developed prior to this time. After 1947, ground water was developed primarily for agricultural purposes. Eakin (1964) first estimated that 2,000 to 3,000 afy were used to irrigate 400 to 500 acres in the Muddy River Springs area prior to 1964. By 1965, NPC completed construction of its Reid Gardner facility and had acquired water rights in the Muddy River Springs area through the purchase of the Lewis wells. NPC continues to be the primary user of ground water in the area. For this report, data compilation focuses primarily on NPC and MVWD since they have been, and continue to be, the principal users of ground water in the area. It is acknowledged that there have been, and still are, other minor uses of ground water within the area. However, since these uses are small and no records exist to determine the exact amount, they were not accounted for in this study.

B.3.5.1 Nevada Power Company

Maxey et al. (1966) reported that NPC pumped 1,931 afy in 1962 and 1,681 afy in 1963 from their Lewis well field. They also reported that the total volume pumped in 1962 was the largest on record at that time, suggesting that although the area had been extensively developed for agricultural purposes, the annual production had not exceeded 1,931 afy prior to 1962. Ground-water production records for the period 1964 to 1986 either do not exist or are unavailable, and therefore had to be estimated.

Table B-1 provides data reported to the Nevada State Engineer by NPC for the period 1987 to 2000, and ground-water production estimates for the period 1945 to 1986. Included in **Table B-1** are reported NPC Muddy River diversions for the periods 1978 to 1985 (USGS, Water Resources Data for Nevada) and 1988 to 2000 (NPC), and estimated diversions for the periods 1965 to 1977 and 1986 to 1987.

The estimated values for NPC Muddy River diversions and ground-water production are based on an assumed total water demand related to the total generating capacity of the Reid Gardner facility. According to the 1994 NPC Re-filed Resource Plan, the facility's four generating units came on-line in 1965, 1968, 1976, and 1983 with the following generating capacities: No.1 110 megawatts (MW), No.2 110 MW, No.3 110 MW, and No.4 255 MW. The generating capacity of the Reid Gardner facility for the period 1989 to 2000 is estimated to have been 605 MW, during which time the average annual water use was 7,366 afy. This equates to approximately 12 acre-feet per megawatt generating capacity. Knowing the generating capacity and date each unit came on-line, this factor can then be used to estimate NPC's annual water demand for the period 1965 to 1986 by multiplying it by the generating capacity estimated for each year. NPC's annual ground-water demand can be approximated for this period by subtracting their annual surface-water diversions from their estimated annual water demand. This method takes into account typical facility operations and maintenance schedules.

Abstracts from NDWR's Water Rights Database were reviewed to develop a history of the ground-water and surface-water rights within the Muddy River Springs area. This information was used to distribute NPC's approximated annual ground-water demand to the wells listed in **Table B-1.**

B3.5.2 Moapa Valley Water District

MVWD has used ground water pumped from the Muddy River Springs area to supplement its spring diversions since 1986. In 1986, MVWD completed construction of water storage tanks and began pumping ground water from the MX-6 well to meet peak demand during four summer months (MVWD, 3/26/01, oral. commun.) MVWD estimates that from 1986 to 1992 the MX-6 well was pumped an average of 450 gpm, or approximately 245 afy. In January 1991, MVWD completed the Arrow Canyon well. Although, the well was pumped for hydraulic testing during 1991, it was not until 1992 that the well was pumped for water supply purposes. In 1992, MVWD estimates that an estimated 531 acre-feet was pumped from the well. **Table B-2** provides data reported by MVWD for the period 1993 to 2000. Included in **Table B-2** are estimates of annual ground-water withdrawals by MVWD from 1986 to 1992.

B.5 GROUND-WATER PRODUCTION DATA SET

The ground-water development history discussed in the preceding section was used to develop a data set for input into the ground-water flow model for the period 1945 to 2000. The data set is provided in **Table B-3.**

Table B-1. Estimated and reported NPC ground-water production in the Muddy River. Springs area for the period 1945 to 2000, in acre-feet per year

	NPC WATER DEMAND		SURFACE DIVERSIONS		NPC GROUND-WATER PRODUCTION				
YEAR	NPC GENERATING CAPACITY	ESTIMATED NPC WATER DEMAND[1]	MUDDY RIVER DIVERSION[2]	APPROX. NPC GROUNDWATER DEMAND[3]	BEHMER[4]	PERKINS[4]	LEWIS WELLS[5]	LDS WELLS[4]	LOWER MEADOW VALLEY WASH[6]
1945	0	0		*0*	*0*	*0*	*0*		0
1946	0	0		*0*	*0*	*0*	*0*		0
1947	0	0		*0*	*0*	*855*	*0*		0
1948	0	0		*0*	*0*	*855*	*0*		0
1949	0	0		*0*	*0*	*855*	*329*		0
1950	0	0		*0*	*0*	*855*	*658*		0
1951	0	0		*0*	*0*	*855*	*658*		0
1952	0	0		*0*	*0*	*855*	*658*		0
1953	0	0		*0*	*0*	*855*	*658*		0
1954	0	0		*0*	*0*	*855*	*987*		0
1955	0	0		*0*	*0*	*855*	*987*		0
1956	0	0		*0*	*0*	*855*	*987*		0
1957	0	0		*0*	*0*	*855*	*987*		0
1958	0	0		*0*	*0*	*855*	*987*		0
1959	0	0		*0*	*0*	*855*	*1316*		0
1960	0	0		*0*	*0*	*855*	*1316*		0
1961	0	0		*0*	*0*	*855*	*1316*		0
1962	0	0		*0*	*0*	*855*	**1931**		0
1963	0	0		*0*	*0*	*855*	**1681**		0
1964	0	0		*0*	*0*	*855*	*1645*		0
1965	110	*1320*	0	*1320*	*0*	*855*	*1645*		0
1966	110	*1320*	0	*1320*	*0*	*855*	*1645*		0
1967	110	*1320*	0	*1320*	*0*	*855*	*1645*		0
1968	220	*2640*	1200	*1440*	*0*	*855*	*1440*		0
1969	220	*2640*	2000	*640*	*0*	*855*	*640*		0
1970	220	*2640*	2000	*640*	*0*	*855*	*640*		0
1971	220	*2640*	2000	*640*	*0*	*855*	*640*		0
1972	220	*2640*	2000	*640*	*0*	*855*	*640*		0
1973	220	*2640*	2000	*640*	*0*	*855*	*640*		0
1974	220	*2640*	2000	*640*	*0*	*855*	*640*		0
1975	220	*2640*	2000	*640*	*200*	*855*	*500*		0
1976	330	*3960*	2900	*1060*	*300*	*855*	*800*		0
1977	330	*3960*	2900	*1060*	*300*	*855*	*800*		0
1978	330	*3960*	**2890**	*1070*	*300*	*855*	*800*		0
1979	330	*3960*	**2899**	*1061*	*300*	*855*	*800*		0
1980	330	*3960*	**2347**	*1613*	*400*	*855*	*1200*		0
1981	330	*3960*	**2805**	*1155*	*400*	*855*	*800*		0
1982	330	*3960*	**2752**	*1208*	*400*	*855*	*900*		*0*
1983	605	*7260*	**1885**	*5375*	*628*	*855*	*2400*		*2347*
1984	605	*7260*	**1720**	*5540*	*628*	*855*	*2400*		*2512*
1985	605	*7260*	**2731**	*4529*	*628*	*855*	*2400*		*1501*
1986	605	*7260*	2000	*5260*	*628*	*855*	*2400*		*1377*
1987	605	*7260*	3000	*4260*	**0**	**816**	**1188**	**300**	*1956*
1988	605	*7260*	**2164**	*5096*	**33**	**910**	**1524**	**1842**	*787*
1989	605	*7260*	**2012**	*5248*	**834**	**910**	**1679**	**1691**	**1**
1990	605	*7260*	**3526**	*3734*	**0**	**834**	**1476**	**1501**	**0**

Table B-1. Estimated and reported NPC ground-water production in the Muddy River. Springs area for the period 1945 to 2000, in acre-feet per year

	NPC WATER DEMAND		SURFACE DIVERSIONS		NPC GROUND-WATER PRODUCTION				
YEAR	NPC GENERATING CAPACITY	ESTIMATED NPC WATER DEMAND[1]	MUDDY RIVER DIVERSION[2]	APPROX. NPC GROUNDWATER DEMAND[3]	BEHMER[4]	PERKINS[4]	LEWIS WELLS[5]	LDS WELLS[4]	LOWER MEADOW VALLEY WASH[6]
1991	605	7260	3625	3635	319	910	1179	1309	0
1992	605	7260	2942	4318	0	777	1160	1413	0
1993	605	7260	2871	4389	138	910	1410	958	0
1994	605	7260	2462	4798	0	886	2075	1467	0
1995	605	7260	2950	4310	0	581	1299	1583	0
1996	605	7260	3219	4041	224	910	1522	2097	0
1997	605	7260	2494	4766	0	726	1195	2175	0
1998	605	7260	2296	4964	0	804	2259	2903	0
1999	605	7260	2585	4675	0	482	1876	2390	0
2000	605	7260	3063	4197	573	471	1736	4705	0

Note: Shaded cells represent estimated years in which well(s) was used for agricultural water supply based on abstracts from NDWR Water Rights Database

1. *Demand based on the average annual water demand per megawatt generating capacity during the period 1989 to 2000*
2. *Diversions for 1978 to 1985 reported by USGS; 1988 to 2000 reported by NPC*
3. *Approximated as the difference between the estimated water demand (1) and Muddy River diversion (2)*
4. *Data from 1987 to 2000 from NPC monitoring reports submitted to Nevada State Engineer's Office; 1945 to 1986 estimated data based abstracts from NDWR Water Rights Database*
5. *Data from 1962 and 1963 from Maxey et al. (1966); Data from 1987 to 2000 from NPC Hydrologic Impacts reports; stimated data based abstracts from NDWR Water Rights Database*
6. *Data from 1982 to 1988 estimated as the volume of water needed by NPC, in addition to other the sources, to meet their estimated water demand (1)*

Table B-2. Estimated and reported MVWD ground-water production in the Muddy River Springs area for the period 1986 to 2000, in acre-feet per year

Year	MX-6	Arrow Canyon	Total
1986	245	-	245
1987	245	-	245
1988	245	-	245
1989	245	-	245
1990	245	-	245
1991	245	0	245
1992	245	513	758
1993	141	1,204	1,345
1994	390	504	894
1995	374	304	678
1996	431	274	705
1997	307	501	808
1998	40	1,517	1,557
1999	145	2,434	2,579
2000	130	2,777	2,908

Sources: 1986 to 1992 estimates based on MVWD interviews (MVWD, oral commun., 03/2001)
1993 to 1996 NPC Hydrologic Impacts reports
1997 to 2000 MVWD Muddy Springs Area Monitoring Reports

Table B-3. Ground-water production data set as used in the ground-water flow model.

WELL_ID	OWNER/OPERATOR	UTM_X	UTM_Y	DATE COMPLETED	ELEV	HSU	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955
MUDDY SPRINGS AREA							0	0	855	855	1184	1513	1513	1513	1513	1842	1842
ARROW_CANYON	MVWD	701233	4067521	01/25/91	1875	C											
LEWIS-1	NEVADA POWER COMPANY	702136	4068021	05/16/49	1828	VF					329	329	329	329	329	329	329
LEWIS-3	NEVADA POWER COMPANY	702424	4067549	05/15/62	1827	VF											
LEWIS-2	NEVADA POWER COMPANY	702409	4067707	07/15/59	1821	VF											
LEWIS-5	NEVADA POWER COMPANY	702248	4067290	02/16/54	1822	VF										329	329
LEWIS-4	NEVADA POWER COMPANY	702104	4067418	06/07/50	1822	VF						329	329	329	329	329	329
LDS-WEST	NEVADA POWER COMPANY	702799	4066922	1986	1787	VF											
LDS-CENTRAL	NEVADA POWER COMPANY	704189	4066366	1986	1811	VF											
LDS-EAST	NEVADA POWER COMPANY	704537	4066400	1986	1715	VF											
MX-6	MVWD	697525	4071193	05/21/81	2275	C											
BEHMER	NEVADA POWER COMPANY	706031	4065080			VF											
NPC-PP	NEVADA POWER COMPANY	705735	4065016	06/16/88	1771	VF			855	855	855	855	855	855	855	855	855
LOWER MOAPA VALLEY							0	0	0	0	0	0	0	0	0	0	0
MV-2	NEVADA POWER COMPANY	716092	4061037	08/27/62	1538	VF											
73		718701	4059068	10/12/71	1524	VF											
MV-7	LEWIS, PAUL	719123	4059078	05/31/60	1552	VF											
MV-3	EWING, JAMES L	716113	4060205	02/15/80	1544	VF											
MV-5	C X PRODUCTS CORP	717002	4059425	11/26/73	1565	VF											
MV-9	LEWIS, PAUL R & PATRICIA	719735	4058477	01/11/75	1540	VF											
MV-10	LEWIS, PAUL R & PATRICIA	719755	4057676	01/11/75	1496	VF											
MV-12	LAS VEGAS CEMENT	724010	4057508	11/18/85	1500	VF											
MV-16	FAY, BOB	725237	4057139	07/15/80	1466	VF											
MV-13	STREET, KEVIN	724463	4056317	02/10/97	1431	VF											
MV-14	MOAPA VALLEY WATER CO	724484	4055516	04/24/67	1415	VF											
MV-21	ROBINSON, L H	725836	4052344	07/01/67	1367	VF											
MV-37	STRINGHAM, STANLEY	728364	4050807	02/12/78	1368	VF											
85		727941	4050795	03/21/74	1342	VF											
MV-29	HORN, ERIC	726937	4050183	03/18/67	1314	VF											
MV-26	MARSHAL, KARL	726723	4050763	02/11/76	1314	VF											
MV-23	SEBAUGH, FRANK	726311	4050352	02/27/76	1314	VF											
MV-28	METCALF, M B	726744	4049962	12/10/66	1314	VF											
MV-30	LAHM, ROBERT LEE & EVELYN	727188	4049172	05/05/73	1304	VF											
MV-33	PERKINS, W V	727643	4047950	09/26/74	1288	VF											
MV-40	MOAPA VALLEY DAIRY FARMS	729295	4047593	03/23/88	1250	VF											
MV-42	SIMPLOT SILICON PRODUCTS	730213	4043978	05/25/76	1292	VF											
37	MVWD-1	724484	4055516	04/24/67	1415	VF											
LOWER MEADOW VALLEY WASH							0	0	0	0	0	0	0	0	0	0	0
LMVW-72	NEVADA POWER COMPANY	715252	4063822	12/31/63	1564	VF											
LMVW-75	NEVADA POWER COMPANY	716086	4062240	09/30/81	1552	VF											
LMVW-76	NEVADA POWER COMPANY	716508	4062250	11/01/63	1541	VF											
LMVW-14	NEVADA POWER COMPANY	716514	4061048	08/27/62	1532	VF											
LMVW-34	LEWIS, PAUL	715669	4063031	11/1/1971	1573	VF											
LMVW-41	WHITNEY, R C	715684	4061428	11/13/1996	1545	VF											
135	PERKINS, ROBERT	708203	4061613	1/9/1975	1660	VF											
LMVW-49	MEADOW VALLEY FARMLAND IRR CO	714407	4065806	3/25/1988	1587	VF											
LMVW-50	MEADOW VALLEY FARMLAND IRR CO	715236	4065425	2/25/1988	1584	VF											
LMVW-53	SCHLARMAN, HENRY T	715659	4063432	4/23/1971	1566	VF											
LMVW-56	HENRIE, PAUL	714402	4065004	3/1/1969	1583	VF											
LMVW-57	MEADOW VALLEY FARMLAND IRR CO	715231	4064624	3/3/1988	1561	VF											
LMVW-60	LEWIS, PAUL	715679	4062630	2/12/1974	1577	VF											
LMVW-64	EMBRY, MILTON	715247	4063020	9/13/1974	1609	VF											
LMVW-66	LEAVITT, GARY & DIANE	716092	4061037	4/1/1974	1538	VF											
LMVW-67	STEWART, MARK	715669	4063031	11/1/1971	1573	VF											
LMVW-68	PERKINS, ROBERT	715237	4063421	9/28/1971	1586	VF											
LMVW-70	LEWIS, PAUL	716102	4060636	2/19/1974	1538	VF											
LMVW-71	MCKNIGHT, JAMES D	714820	4064212	3/1/1969	1564	VF											
LMVW-74	HENRIE, PAUL	714412	4064603	3/1/1969	1574	VF											
163	STEWART, MARK	716091	4063042	2/28/1977	1565	VF											
164	CUTLER, KEITH	714840	4063411	3/18/1970	1593	VF											
GARNET VALLEY							0	0	0	0	0	0	0	0	0	0	0
46	U S LIME	685798	4029433	06/17/71	2273	VF											
47	U S LIME	688174	4029084	07/22/71	2155	VF											
GV-KERR-1	KERR-MCGEE CHEMICAL CORP	683838	4028991	02/07/90	2405	C											
49	GEORGIA PACIFIC CORP	686317	4023833	10/23/92	2464	C											
50	GEORGIA PACIFIC CORP	686716	4023842	08/19/90	2415	C											
51	GEORGIA PACIFIC CORP	686326	4023432	09/30/86	2455	C											
GV-GSC-1	GREAT STAR CEMENT CORP	693337	4031201	03/30/87	2293	VF											
GV-USLIME-1	U S LIME	690310	4030549	09/13/63	2073	VF											
GV-ET-1	ENVIRONMENTAL TECHNOLOGIES	690982	4028343	03/23/89	2321	VF											
202	U S LIME	687850	4026300	06/01/99		C											
BLACK MOUNTAINS							0	0	0	0	0	0	0	0	0	0	0
60	BONNEVILLE ENERGY	689589	4019063	12/24/91	2485	C											
BM-BE-2	BONNEVILLE ENERGY	689997	4018671	12/30/91	2434	C											
BM-BE-3	BONNEVILLE ENERGY	689606	4018262	08/16/91	2391	C											
BM-BE-1	BONNEVILLE ENERGY	690006	4018271	06/12/90	2442	C											

Table B-3. Ground-water production data set as used in the ground-water flow model.

WELL_ID	OWNER/OPERATOR	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
MUDDY SPRINGS AREA		1842	1842	1842	2171	2171	2171	2786	2536	2500	2500	2500	2500	2295	1495	1495	1495	1495	1495
ARROW_CANYON	MVWD																		
LEWIS-1	NEVADA POWER COMPANY	329	329	329	329	329	329	386	336	329	329	329	329	288	128	128	128	128	128
LEWIS-3	NEVADA POWER COMPANY							386	336	329	329	329	329	288	128	128	128	128	128
LEWIS-2	NEVADA POWER COMPANY				329	329	329	386	336	329	329	329	329	288	128	128	128	128	128
LEWIS-5	NEVADA POWER COMPANY	329	329	329	329	329	329	386	336	329	329	329	329	288	128	128	128	128	128
LEWIS-4	NEVADA POWER COMPANY	329	329	329	329	329	329	386	336	329	329	329	329	288	128	128	128	128	128
LDS-WEST	NEVADA POWER COMPANY																		
LDS-CENTRAL	NEVADA POWER COMPANY																		
LDS-EAST	NEVADA POWER COMPANY																		
MX-6	MVWD																		
BEHMER	NEVADA POWER COMPANY																		
NPC-PP	NEVADA POWER COMPANY	855	855	855	855	855	855	855	855	855	855	855	855	855	855	855	855	855	855
LOWER MOAPA VALLEY		0	0	0	0	63	63	126	126	126	126	189	378	378	378	378	441	441	567
MV-2	NEVADA POWER COMPANY							63	63	63	63	63	63	63	63	63	63	63	63
73																	63	63	63
MV-7	LEWIS, PAUL					63	63	63	63	63	63	63	63	63	63	63	63	63	63
MV-3	EWING, JAMES L																		
MV-5	C X PRODUCTS CORP																		63
MV-9	LEWIS, PAUL R & PATRICIA																		
MV-10	LEWIS, PAUL R & PATRICIA																		
MV-12	LAS VEGAS CEMENT																		
MV-16	FAY, BOB																		
MV-13	STREET, KEVIN																		
MV-14	MOAPA VALLEY WATER CO												63	63	63	63	63	63	63
MV-21	ROBINSON, L H												63	63	63	63	63	63	63
MV-37	STRINGHAM, STANLEY																		
85																			
MV-29	HORN, ERIC												63	63	63	63	63	63	63
MV-26	MARSHAL, KARL																		
MV-23	SEBAUGH, FRANK																		
MV-28	METCALF, M B											63	63	63	63	63	63	63	63
MV-30	LAHM, ROBERT LEE & EVELYN																		63
MV-33	PERKINS, W V																		
MV-40	MOAPA VALLEY DAIRY FARMS																		
MV-42	SIMPLOT SILICON PRODUCTS																		
37	MVWD-1												0	0	0	0	0	0	0
LOWER MEADOW VALLEY WASH		0	0	0	0	0	0	0	0	0	0	0	0	0	660	880	1760	1760	1760
LMVW-72	NEVADA POWER COMPANY																		
LMVW-75	NEVADA POWER COMPANY																		
LMVW-76	NEVADA POWER COMPANY																		
LMVW-14	NEVADA POWER COMPANY																		
LMVW-34	LEWIS, PAUL																220	220	220
LMVW-41	WHITNEY, R C																		
135	PERKINS, ROBERT																		
LMVW-49	MEADOW VALLEY FARMLAND IRR CO																		
LMVW-50	MEADOW VALLEY FARMLAND IRR CO																		
LMVW-53	SCHLARMAN, HENRY T																220	220	220
LMVW-56	HENRIE, PAUL														220	220	220	220	220
LMVW-57	MEADOW VALLEY FARMLAND IRR CO																		
LMVW-60	LEWIS, PAUL																		
LMVW-64	EMBRY, MILTON																		
LMVW-66	LEAVITT, GARY & DIANE																		
LMVW-67	STEWART, MARK																220	220	220
LMVW-68	PERKINS, ROBERT																220	220	220
LMVW-70	LEWIS, PAUL																		
LMVW-71	MCKNIGHT, JAMES D														220	220	220	220	220
LMVW-74	HENRIE, PAUL														220	220	220	220	220
163	STEWART, MARK																		
164	CUTLER, KEITH															220	220	220	220
GARNET VALLEY		0	0	0	0	0	0	0	50	50	50	50	50	50	50	50	150	150	150
46	U S LIME																50	50	50
47	U S LIME																50	50	50
GV-KERR-1	KERR-MCGEE CHEMICAL CORP																		
49	GEORGIA PACIFIC CORP																		
50	GEORGIA PACIFIC CORP																		
51	GEORGIA PACIFIC CORP																		
GV-GSC-1	GREAT STAR CEMENT CORP																		
GV-USLIME-1	U S LIME								50	50	50	50	50	50	50	50	50	50	50
GV-ET-1	ENVIRONMENTAL TECHNOLOGIES																		
202	U S LIME																		
BLACK MOUNTAINS		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	BONNEVILLE ENERGY																		
BM-BE-2	BONNEVILLE ENERGY																		
BM-BE-3	BONNEVILLE ENERGY																		
BM-BE-1	BONNEVILLE ENERGY																		

Table B-3. Ground-water production data set as used in the ground-water flow model.

WELL_ID	OWNER/OPERATOR	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
MUDDY SPRINGS AREA		1495	1555	1955	1955	1955	1955	2455	2055	2155	3883	3883	3883	4128	2249	4554	5359
ARROW_CANYON	MVWD																
LEWIS-1	NEVADA POWER COMPANY	128	100	160	160	160	160	240	160	180	480	480	480	480	238	305	336
LEWIS-3	NEVADA POWER COMPANY	128	100	160	160	160	160	240	160	180	480	480	480	480	238	305	336
LEWIS-2	NEVADA POWER COMPANY	128	100	160	160	160	160	240	160	180	480	480	480	480	238	305	336
LEWIS-5	NEVADA POWER COMPANY	128	100	160	160	160	160	240	160	180	480	480	480	480	238	305	336
LEWIS-4	NEVADA POWER COMPANY	128	100	160	160	160	160	240	160	180	480	480	480	480	238	305	336
LDS-WEST	NEVADA POWER COMPANY															614	564
LDS-CENTRAL	NEVADA POWER COMPANY															614	564
LDS-EAST	NEVADA POWER COMPANY															614	564
MX-6	MVWD								0	0	0	0	0	245	245	245	245
BEHMER	NEVADA POWER COMPANY		200	300	300	300	300	400	400	400	628	628	628	628	0	33	834
NPC-PP	NEVADA POWER COMPANY	855	855	855	855	855	855	855	855	855	855	855	855	855	816	910	910
LOWER MOAPA VALLEY		819	819	1008	1008	1071	1071	1197	1197	1197	1197	1197	1260	1260	1260	1323	1102
MV-2	NEVADA POWER COMPANY	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	52
73		63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	52
MV-7	LEWIS, PAUL	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	52
MV-3	EWING, JAMES L							63	63	63	63	63	63	63	63	63	52
MV-5	C X PRODUCTS CORP	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	52
MV-9	LEWIS, PAUL R & PATRICIA	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	52
MV-10	LEWIS, PAUL R & PATRICIA	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	52
MV-12	LAS VEGAS CEMENT												63	63	63	63	52
MV-16	FAY, BOB							63	63	63	63	63	63	63	63	63	52
MV-13	STREET, KEVIN																
MV-14	MOAPA VALLEY WATER CO	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	52
MV-21	ROBINSON, L H	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	52
MV-37	STRINGHAM, STANLEY					63	63	63	63	63	63	63	63	63	63	63	52
85		63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	52
MV-29	HORN, ERIC	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	52
MV-26	MARSHAL, KARL			63	63	63	63	63	63	63	63	63	63	63	63	63	52
MV-23	SEBAUGH, FRANK			63	63	63	63	63	63	63	63	63	63	63	63	63	52
MV-28	METCALF, M B	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	52
MV-30	LAHM, ROBERT LEE & EVELYN	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	52
MV-33	PERKINS, W V	63	63	63	63	63	63	63	63	63	63	63	63	63	63	63	52
MV-40	MOAPA VALLEY DAIRY FARMS															63	52
MV-42	SIMPLOT SILICON PRODUCTS			63	63	63	63	63	63	63	63	63	63	63	63	63	52
37	MVWD-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LOWER MEADOW VALLEY WASH		2640	2860	2860	3080	3080	3080	3080	3080	3080	5427	5592	4581	4457	5036	4527	3874
LMVW-72	NEVADA POWER COMPANY										587	628	375	344	489	197	33
LMVW-75	NEVADA POWER COMPANY										587	628	375	344	489	197	33
LMVW-76	NEVADA POWER COMPANY										587	628	375	344	489	197	33
LMVW-14	NEVADA POWER COMPANY										587	628	375	344	489	197	33
LMVW-34	LEWIS, PAUL	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220
LMVW-41	WHITNEY, R C																
135	PERKINS, ROBERT		220	220	220	220	220	220	220	220	220	220	220	220	220	220	220
LMVW-49	MEADOW VALLEY FARMLAND IRR CO															220	220
LMVW-50	MEADOW VALLEY FARMLAND IRR CO															220	220
LMVW-53	SCHLARMAN, HENRY T	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220
LMVW-56	HENRIE, PAUL	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220
LMVW-57	MEADOW VALLEY FARMLAND IRR CO															220	220
LMVW-60	LEWIS, PAUL	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220
LMVW-64	EMBRY, MILTON	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220
LMVW-66	LEAVITT, GARY & DIANE	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220
LMVW-67	STEWART, MARK	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220
LMVW-68	PERKINS, ROBERT	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220
LMVW-70	LEWIS, PAUL	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220
LMVW-71	MCKNIGHT, JAMES D	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220
LMVW-74	HENRIE, PAUL	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220
163	STEWART, MARK				220	220	220	220	220	220	220	220	220	220	220	220	220
164	CUTLER, KEITH	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220	220
GARNET VALLEY		150	150	150	150	150	150	150	150	150	150	150	150	200	378	378	446
46	U S LIME	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
47	U S LIME	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
GV-KERR-1	KERR-MCGEE CHEMICAL CORP																
49	GEORGIA PACIFIC CORP																
50	GEORGIA PACIFIC CORP																
51	GEORGIA PACIFIC CORP													50	50	50	50
GV-GSC-1	GREAT STAR CEMENT CORP														178	178	178
GV-USLIME-1	U S LIME	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
GV-ET-1	ENVIRONMENTAL TECHNOLOGIES																68
202	U S LIME																
BLACK MOUNTAINS		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
60	BONNEVILLE ENERGY																
BM-BE-2	BONNEVILLE ENERGY																
BM-BE-3	BONNEVILLE ENERGY																
BM-BE-1	BONNEVILLE ENERGY																

Table B-3. Ground-water production data set as used in the ground-water flow model.

WELL_ID	OWNER/OPERATOR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
MUDDY SPRINGS AREA		4056	3963	4109	4762	5322	4142	5458	4904	7524	7327	10393
ARROW_CANYON	MVWD		0	513	1204	504	304	274	501	1517	2434	2777
LEWIS-1	NEVADA POWER COMPANY	295	236	232	282	415	260	304	239	452	375	275
LEWIS-3	NEVADA POWER COMPANY	295	236	232	282	415	260	304	239	452	375	468
LEWIS-2	NEVADA POWER COMPANY	295	236	232	282	415	260	304	239	452	375	317
LEWIS-5	NEVADA POWER COMPANY	295	236	232	282	415	260	304	239	452	375	427
LEWIS-4	NEVADA POWER COMPANY	295	236	232	282	415	260	304	239	452	375	249
LDS-WEST	NEVADA POWER COMPANY	500	437	471	319	489	528	699	725	968	797	2622
LDS-CENTRAL	NEVADA POWER COMPANY	500	437	471	319	489	528	699	725	968	797	967
LDS-EAST	NEVADA POWER COMPANY	500	437	471	319	489	528	699	725	968	797	1116
MX-6	MVWD	245	245	245	141	390	374	431	307	40	145	130
BEHMER	NEVADA POWER COMPANY	0	319	0	138	0	0	224	0	0	0	573
NPC-PP	NEVADA POWER COMPANY	834	910	777	910	886	581	910	726	804	482	471
LOWER MOAPA VALLEY		881	441	441	441	552	517	569	462	462	462	462
MV-2	NEVADA POWER COMPANY	42	21	21	21	21	21	21	21	21	21	21
73		42	21	21	21	21	21	21	21	21	21	21
MV-7	LEWIS, PAUL	42	21	21	21	21	21	21	21	21	21	21
MV-3	EWING, JAMES L	42	21	21	21	21	21	21	21	21	21	21
MV-5	C X PRODUCTS CORP	42	21	21	21	21	21	21	21	21	21	21
MV-9	LEWIS, PAUL R & PATRICIA	42	21	21	21	21	21	21	21	21	21	21
MV-10	LEWIS, PAUL R & PATRICIA	42	21	21	21	21	21	21	21	21	21	21
MV-12	LAS VEGAS CEMENT	42	21	21	21	21	21	21	21	21	21	21
MV-16	FAY, BOB	42	21	21	21	21	21	21	21	21	21	21
MV-13	STREET, KEVIN								21	21	21	21
MV-14	MOAPA VALLEY WATER CO	42	21	21	21	21	21	21	21	21	21	21
MV-21	ROBINSON, L H	42	21	21	21	21	21	21	21	21	21	21
MV-37	STRINGHAM, STANLEY	42	21	21	21	21	21	21	21	21	21	21
85		42	21	21	21	21	21	21	21	21	21	21
MV-29	HORN, ERIC	42	21	21	21	21	21	21	21	21	21	21
MV-26	MARSHAL, KARL	42	21	21	21	21	21	21	21	21	21	21
MV-23	SEBAUGH, FRANK	42	21	21	21	21	21	21	21	21	21	21
MV-28	METCALF, M B	42	21	21	21	21	21	21	21	21	21	21
MV-30	LAHM, ROBERT LEE & EVELYN	42	21	21	21	21	21	21	21	21	21	21
MV-33	PERKINS, W V	42	21	21	21	21	21	21	21	21	21	21
MV-40	MOAPA VALLEY DAIRY FARMS	42	21	21	21	21	21	21	21	21	21	21
MV-42	SIMPLOT SILICON PRODUCTS	42	21	21	21	21	21	21	21	21	21	21
37	MVWD-1	0	0	0	0	112	77	129	0	0	0	0
LOWER MEADOW VALLEY WASH		3740	3740	3740	3740	3740	3740	3960	3960	3960	3960	3960
LMVW-72	NEVADA POWER COMPANY	0	0	0	0	0	0	0	0	0	0	0
LMVW-75	NEVADA POWER COMPANY	0	0	0	0	0	0	0	0	0	0	0
LMVW-76	NEVADA POWER COMPANY	0	0	0	0	0	0	0	0	0	0	0
LMVW-14	NEVADA POWER COMPANY	0	0	0	0	0	0	0	0	0	0	0
LMVW-34	LEWIS, PAUL	220	220	220	220	220	220	220	220	220	220	220
LMVW-41	WHITNEY, R C							220	220	220	220	220
135	PERKINS, ROBERT	220	220	220	220	220	220	220	220	220	220	220
LMVW-49	MEADOW VALLEY FARMLAND IRR CO	220	220	220	220	220	220	220	220	220	220	220
LMVW-50	MEADOW VALLEY FARMLAND IRR CO	220	220	220	220	220	220	220	220	220	220	220
LMVW-53	SCHLARMAN, HENRY T	220	220	220	220	220	220	220	220	220	220	220
LMVW-56	HENRIE, PAUL	220	220	220	220	220	220	220	220	220	220	220
LMVW-57	MEADOW VALLEY FARMLAND IRR CO	220	220	220	220	220	220	220	220	220	220	220
LMVW-60	LEWIS, PAUL	220	220	220	220	220	220	220	220	220	220	220
LMVW-64	EMBRY, MILTON	220	220	220	220	220	220	220	220	220	220	220
LMVW-66	LEAVITT, GARY & DIANE	220	220	220	220	220	220	220	220	220	220	220
LMVW-67	STEWART, MARK	220	220	220	220	220	220	220	220	220	220	220
LMVW-68	PERKINS, ROBERT	220	220	220	220	220	220	220	220	220	220	220
LMVW-70	LEWIS, PAUL	220	220	220	220	220	220	220	220	220	220	220
LMVW-71	MCKNIGHT, JAMES D	220	220	220	220	220	220	220	220	220	220	220
LMVW-74	HENRIE, PAUL	220	220	220	220	220	220	220	220	220	220	220
163	STEWART, MARK	220	220	220	220	220	220	220	220	220	220	220
164	CUTLER, KEITH	220	220	220	220	220	220	220	220	220	220	220
GARNET VALLEY		496	497	547	549	553	549	542	523	578	717	952
46	U S LIME	50	50	50	50	50	50	50	50	50		
47	U S LIME	50	50	50	50	50	50	50	50	50		
GV-KERR-1	KERR-MCGEE CHEMICAL CORP	0	1	1	2	7	3	0	0	9	4	4
49	GEORGIA PACIFIC CORP			50	50	45	45					
50	GEORGIA PACIFIC CORP	50	50	50	50	65	65	145	126	131	149	150
51	GEORGIA PACIFIC CORP	50	50	50	50	40	40					
GV-GSC-1	GREAT STAR CEMENT CORP	178	178	178	178	178	178	178	178	178	178	178
GV-USLIME-1	U S LIME	50	50	50	50	50	50	50	50	50		
GV-ET-1	ENVIRONMENTAL TECHNOLOGIES	68	68	68	68	68	68	68	68	111	386	470
202	U S LIME										150	150
BLACK MOUNTAINS		0	0	582	1400	1563	1528	1613	1429	1408	1569	1693
60	BONNEVILLE ENERGY			194	350	391	382	403	357	352	392	423
BM-BE-2	BONNEVILLE ENERGY			194	350	391	382	403	357	352	392	423
BM-BE-3	BONNEVILLE ENERGY			194	350	391	382	403	357	352	392	423
BM-BE-1	BONNEVILLE ENERGY				350	391	382	403	357	352	392	423

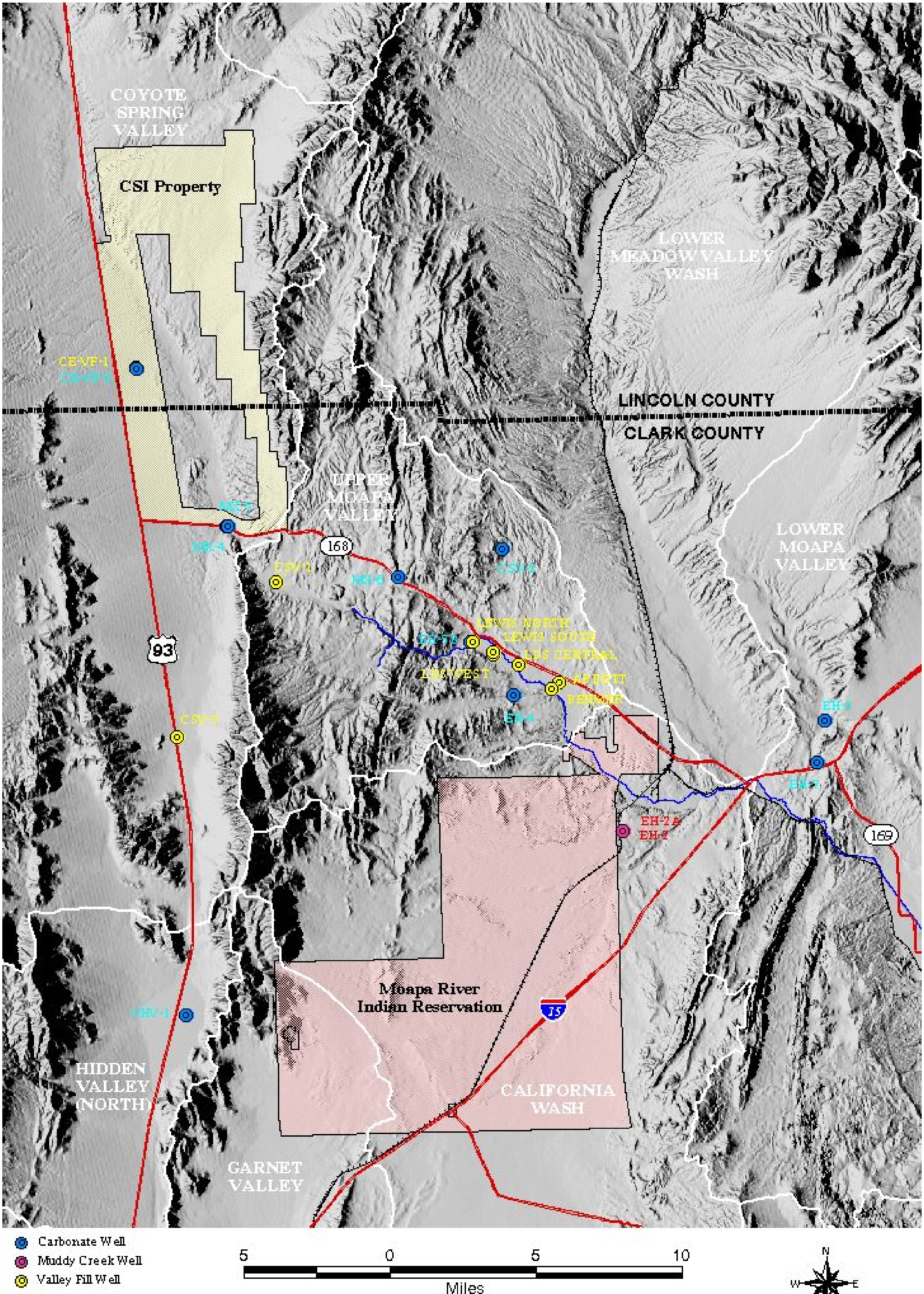


Figure C-1. Model area wells with greater than 5 years of water-level record.

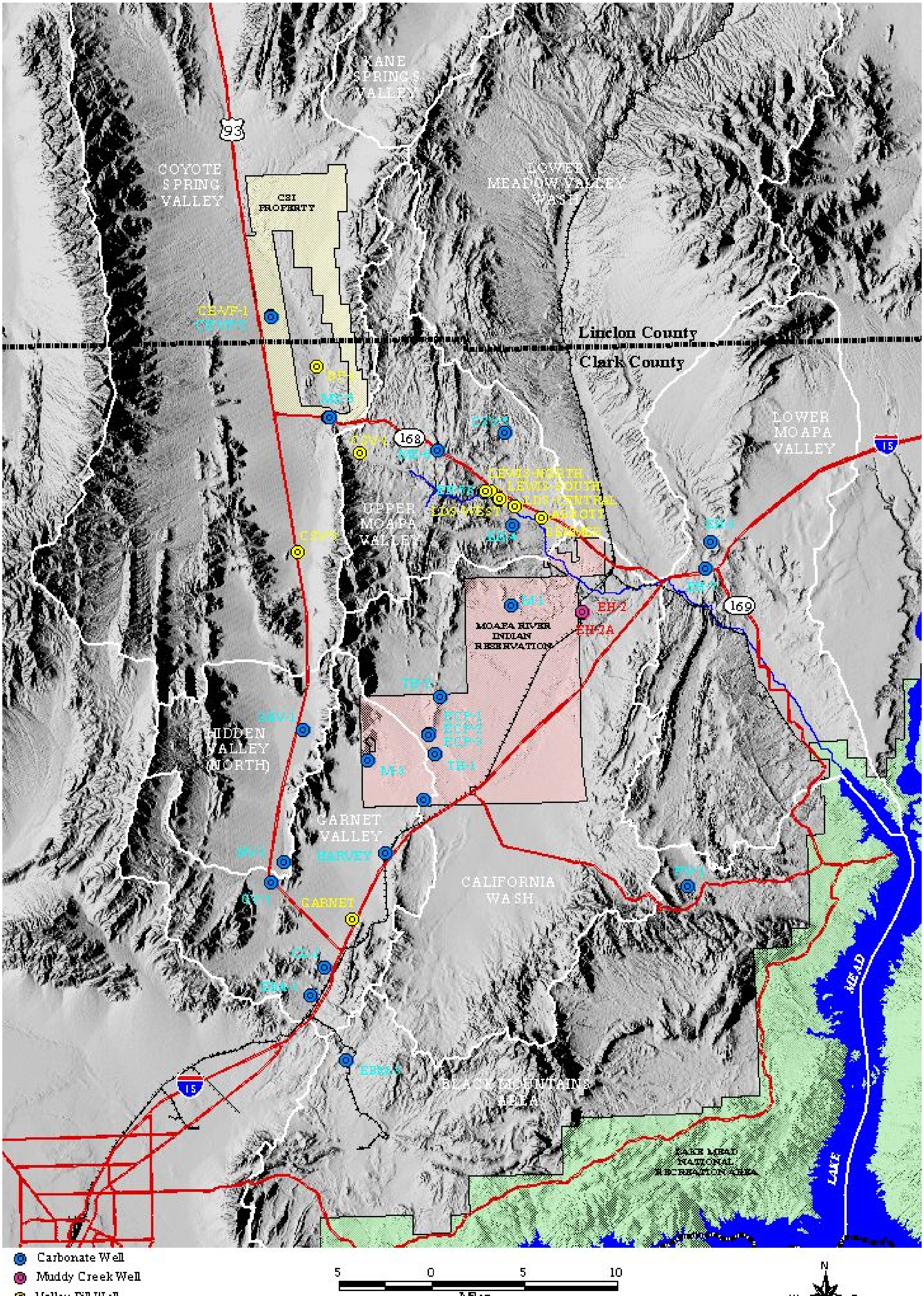
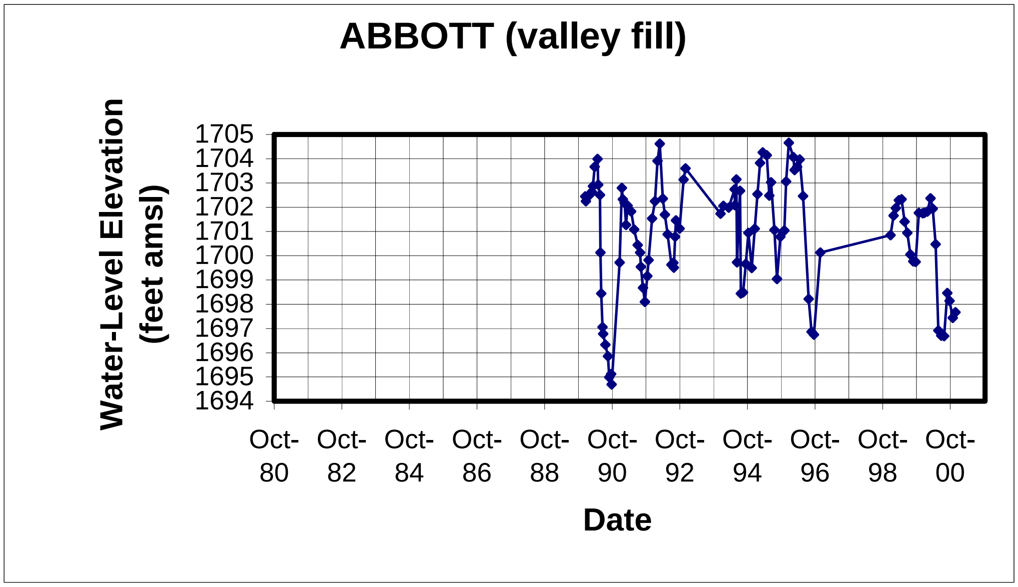
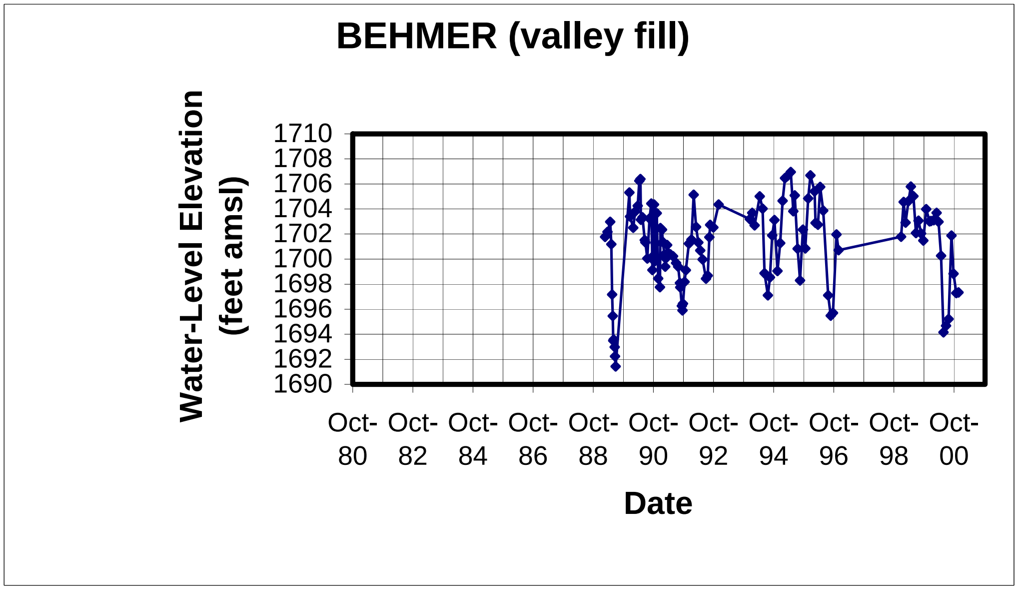


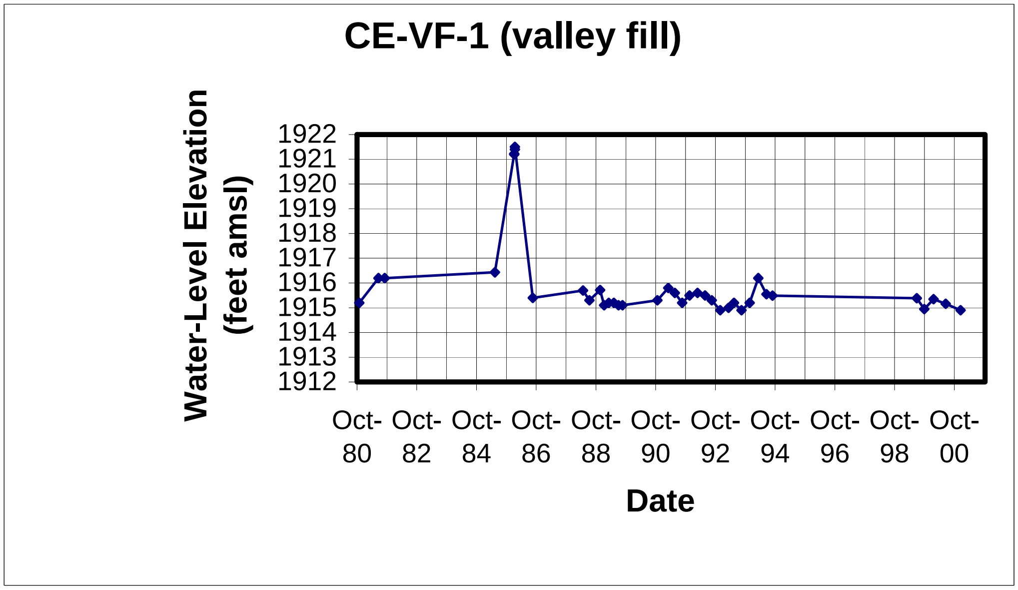
Figure C-2. Location of primary wells with significant water-level records.

APPENDIX C

Ground-water hydrographs of selected wells with greater than 5 years of record

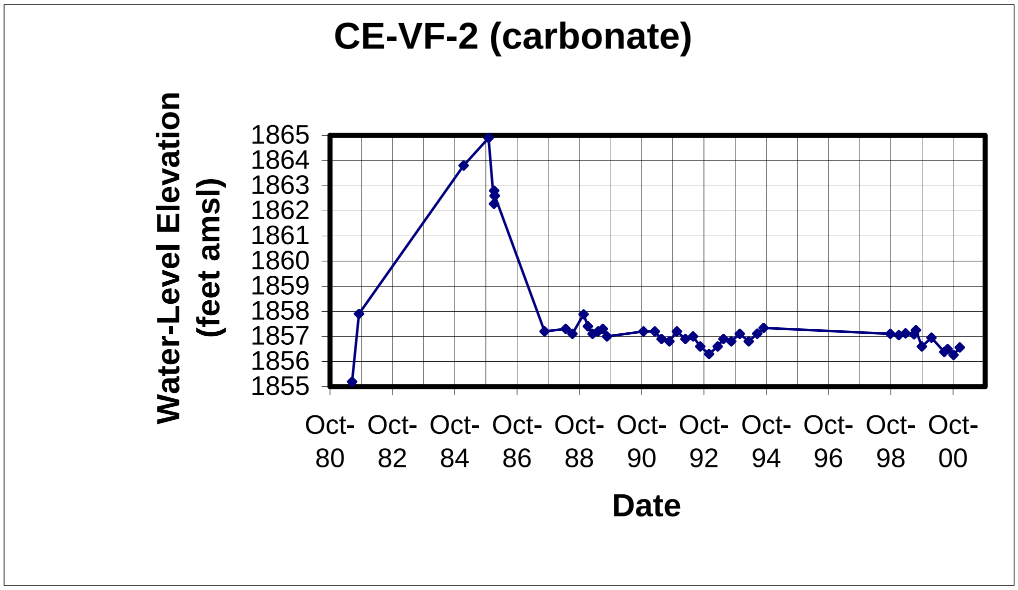


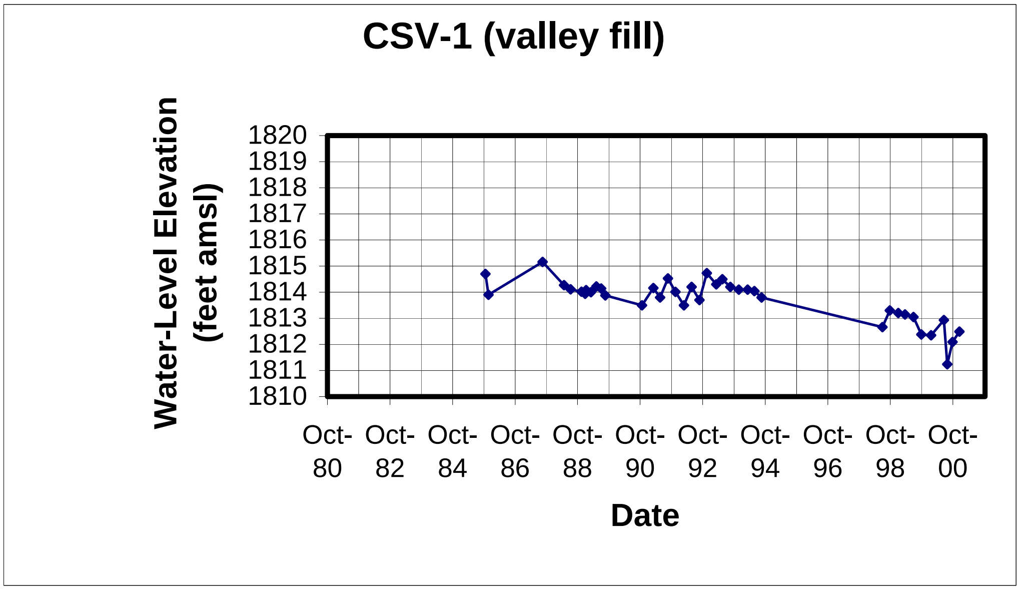


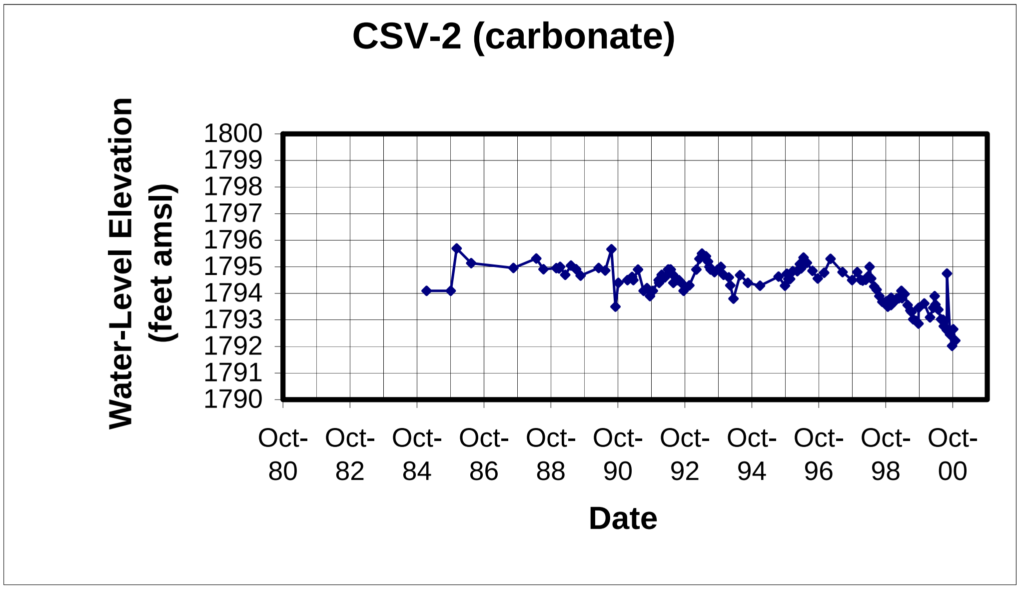


APPENDIX C

Ground-water hydrographs of selected wells with greater than 5 years of record

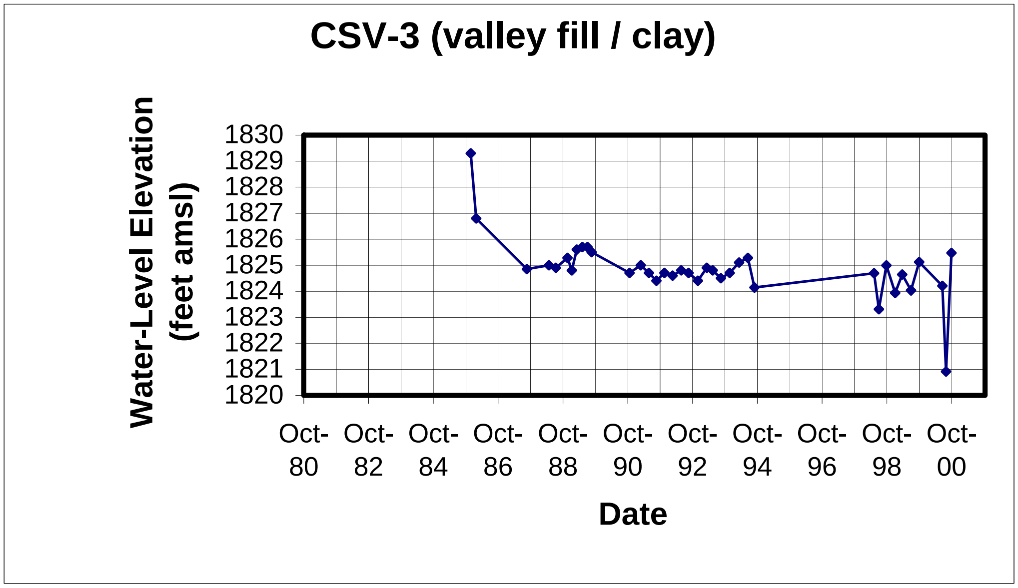


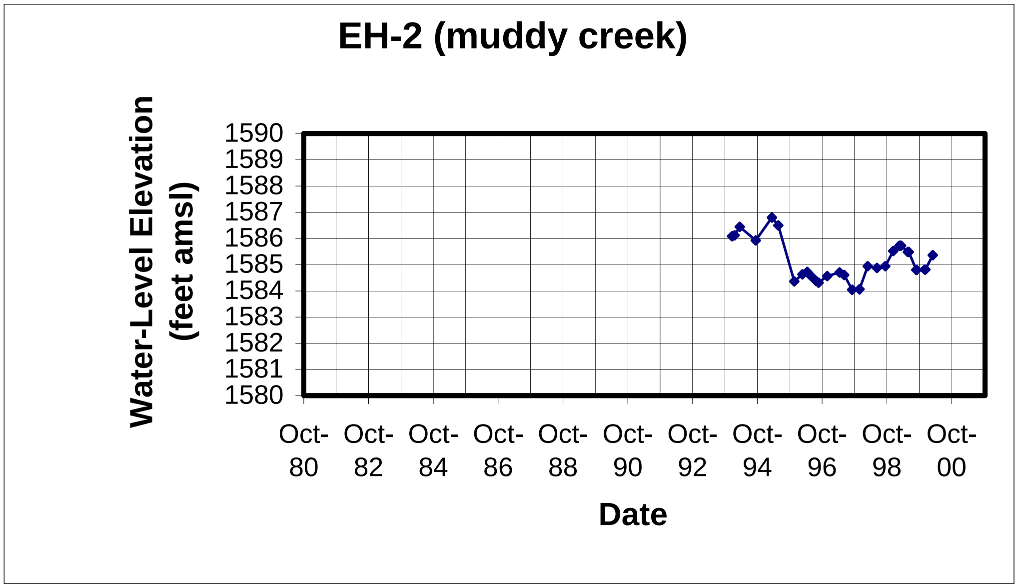


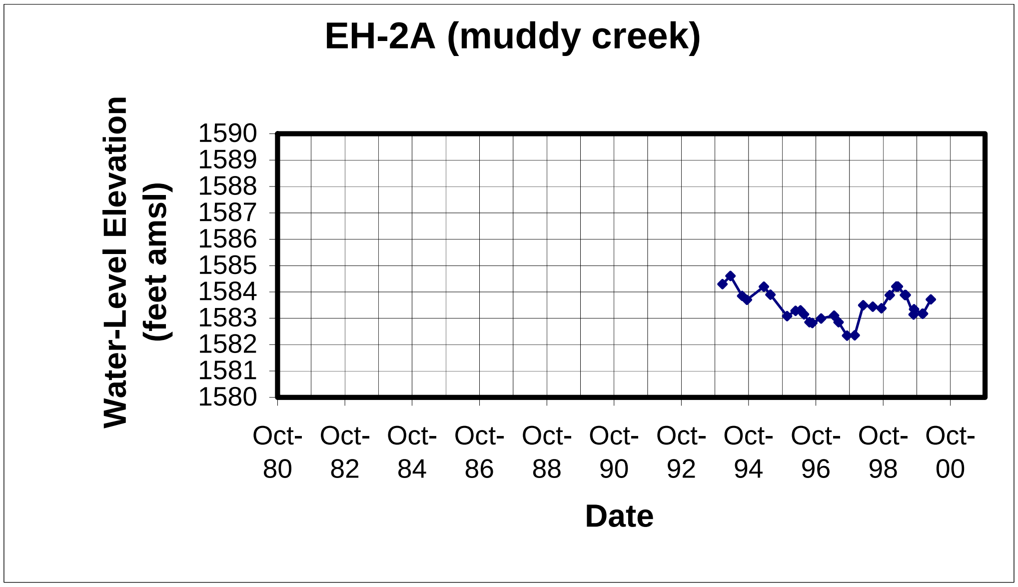


APPENDIX C

Ground-water hydrographs of selected wells with greater than 5 years of record

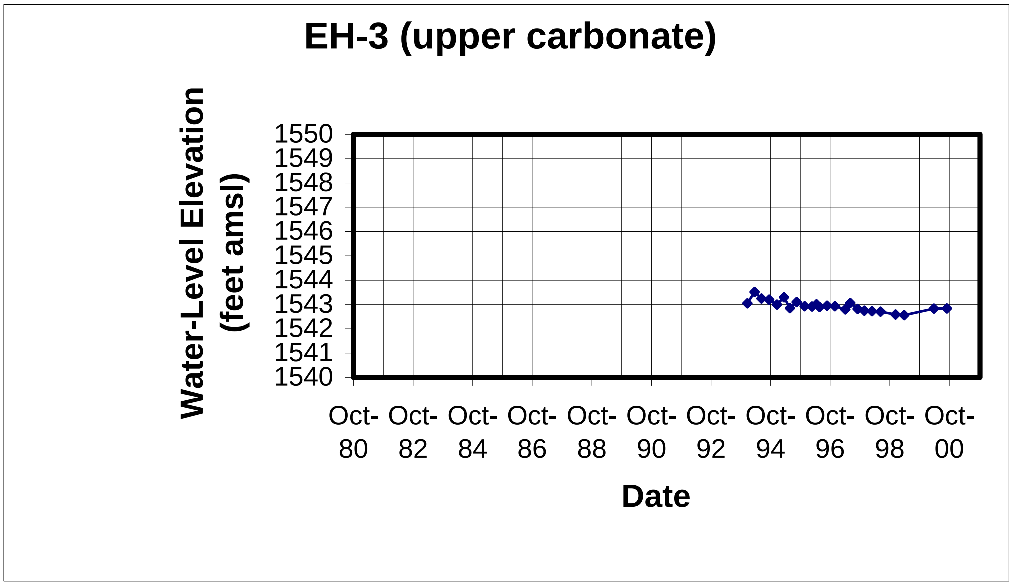


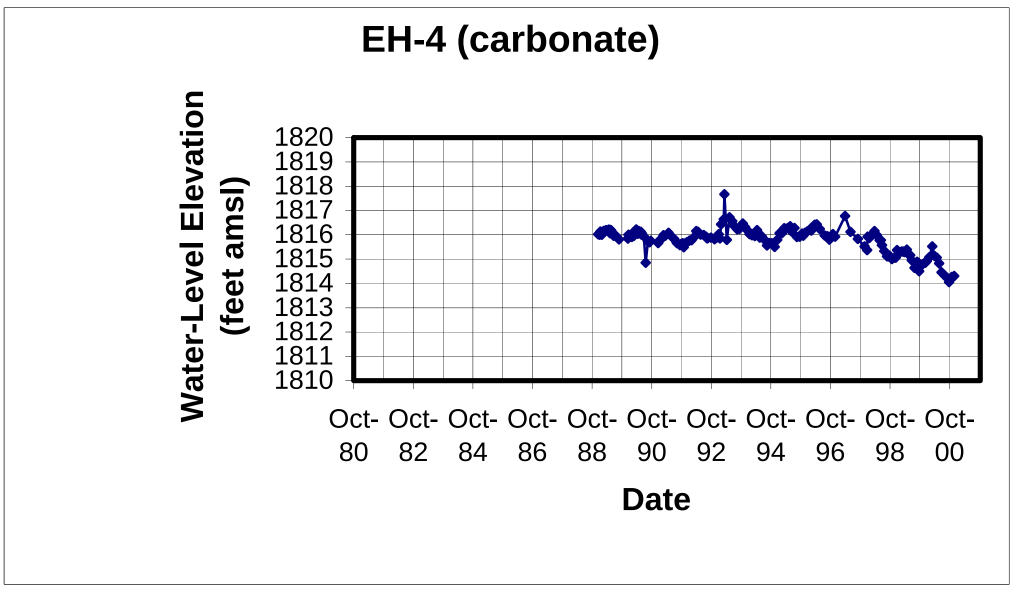


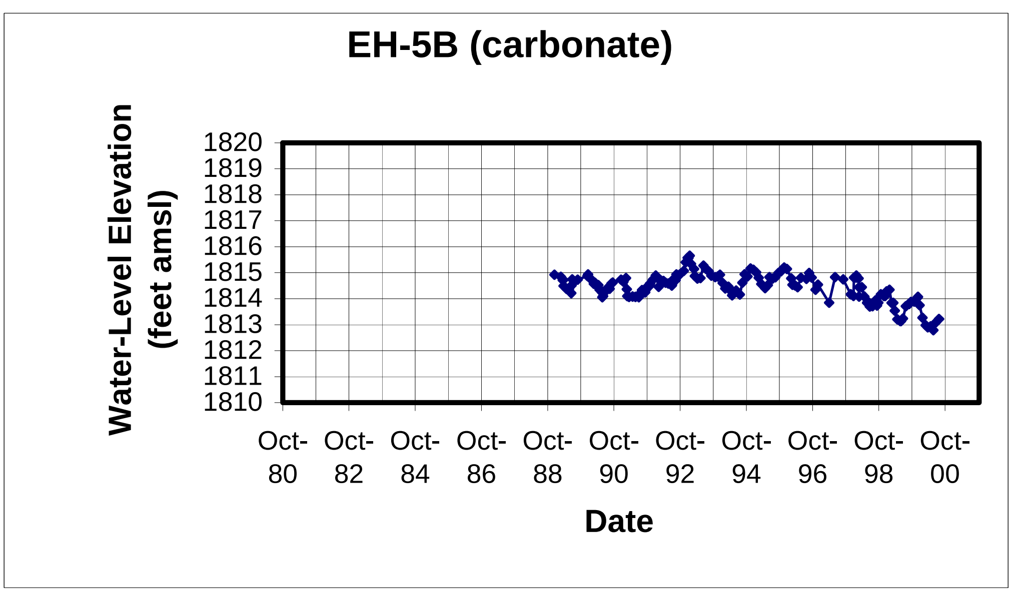


APPENDIX C

Ground-water hydrographs of selected wells with greater than 5 years of record

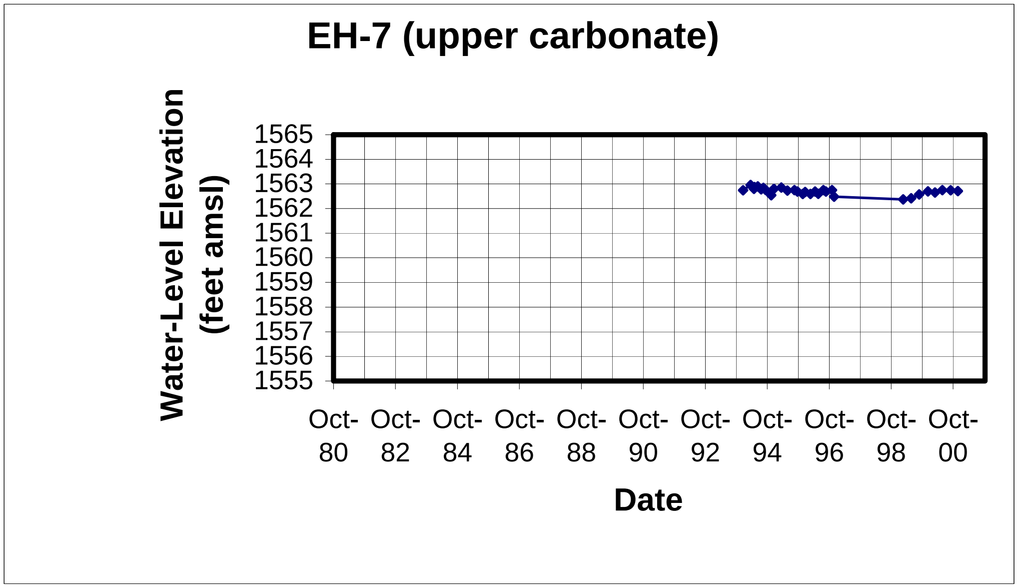


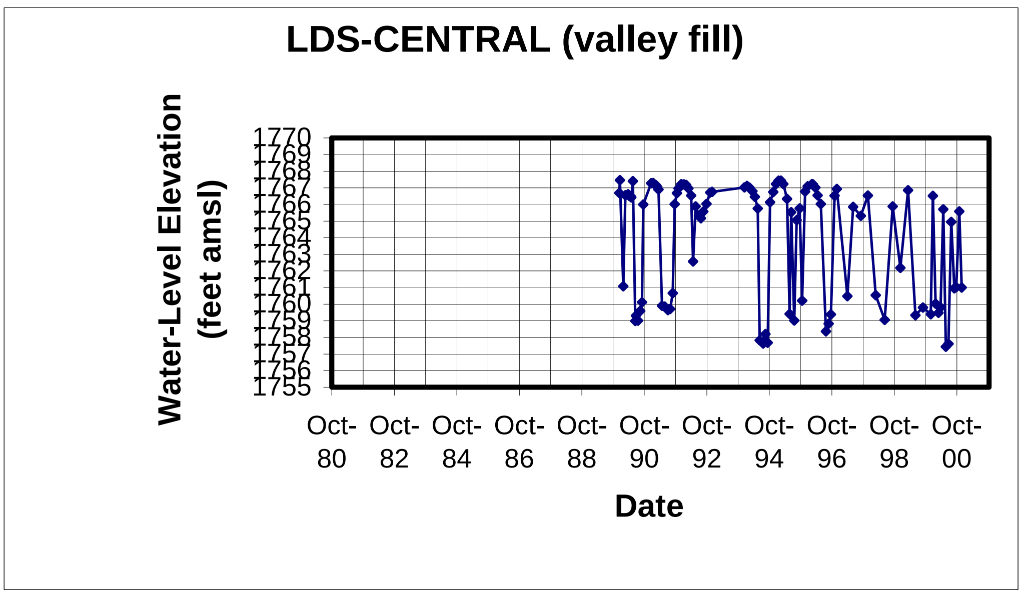


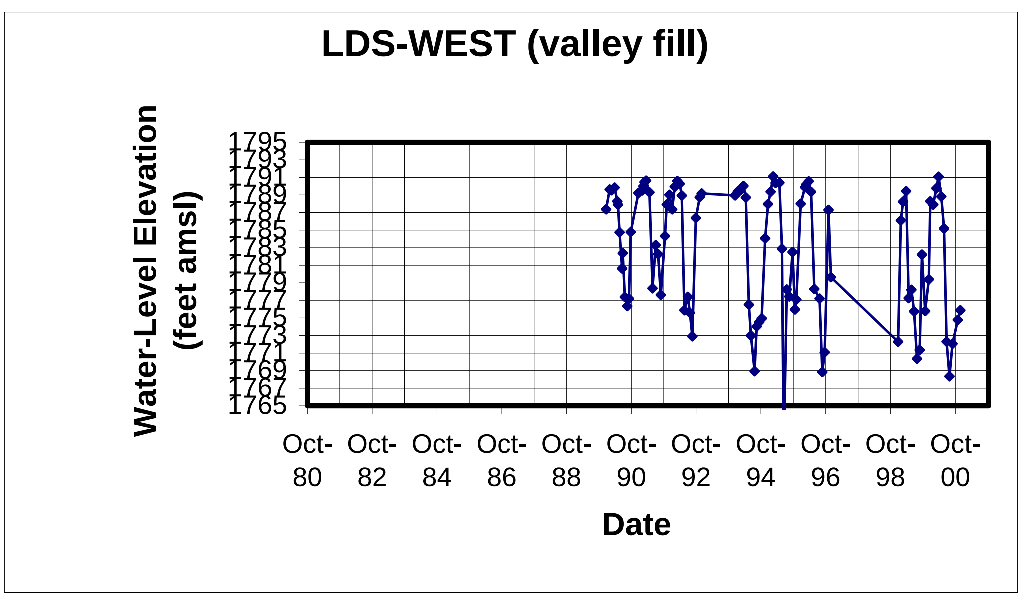


APPENDIX C

Ground-water hydrographs of selected wells with greater than 5 years of record

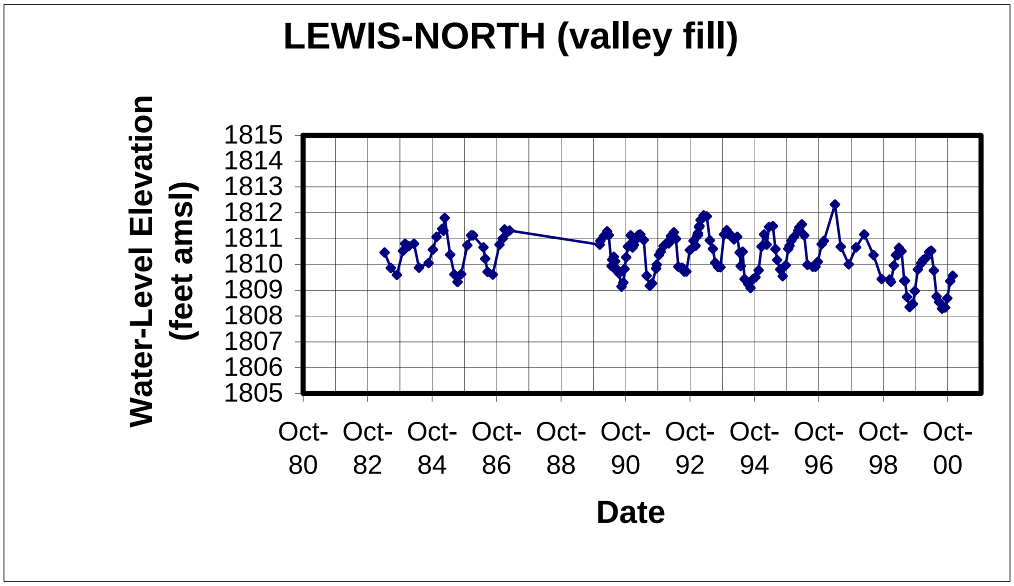


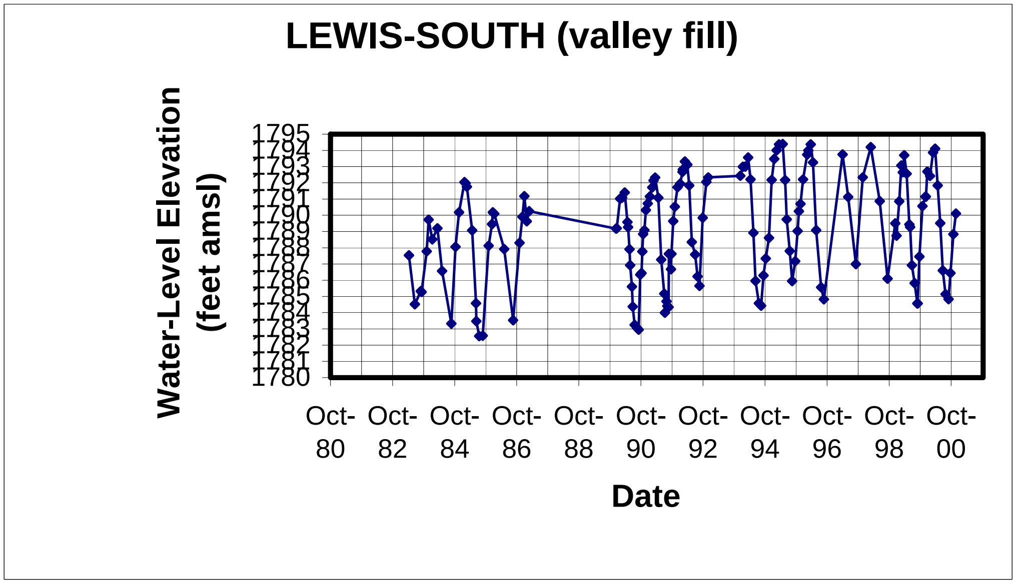


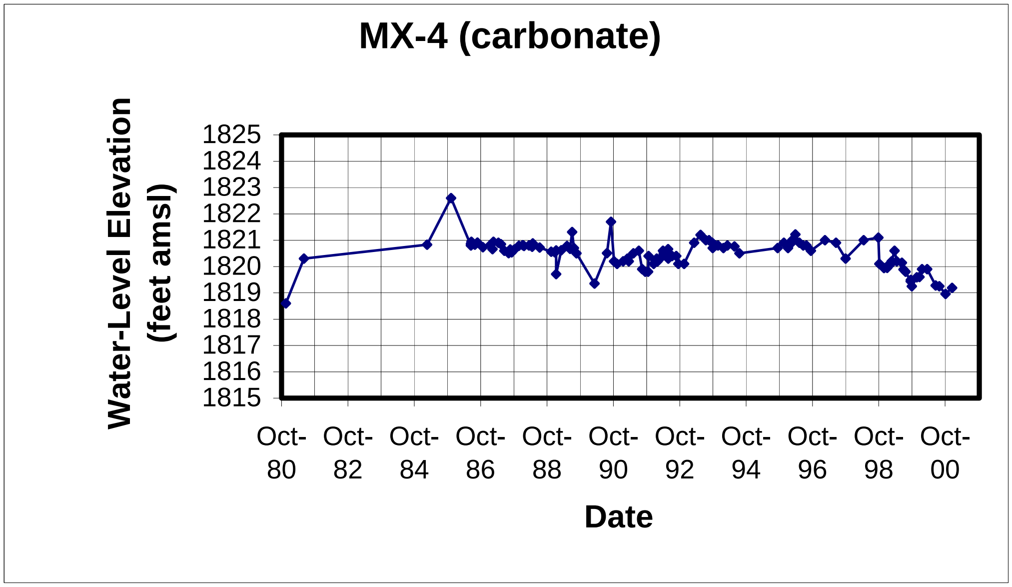


APPENDIX C

Ground-water hydrographs of selected wells with greater than 5 years of record

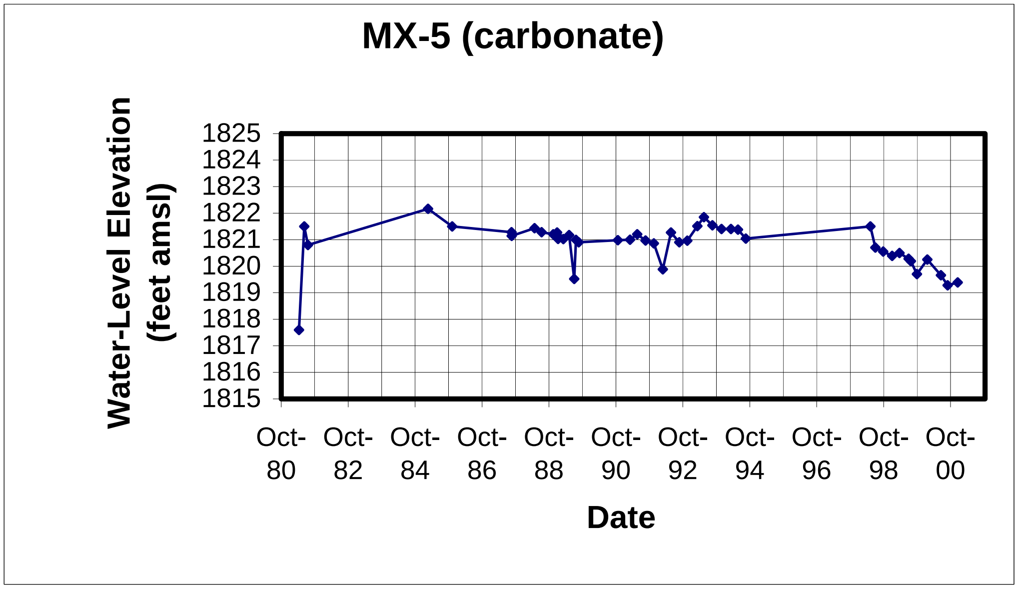


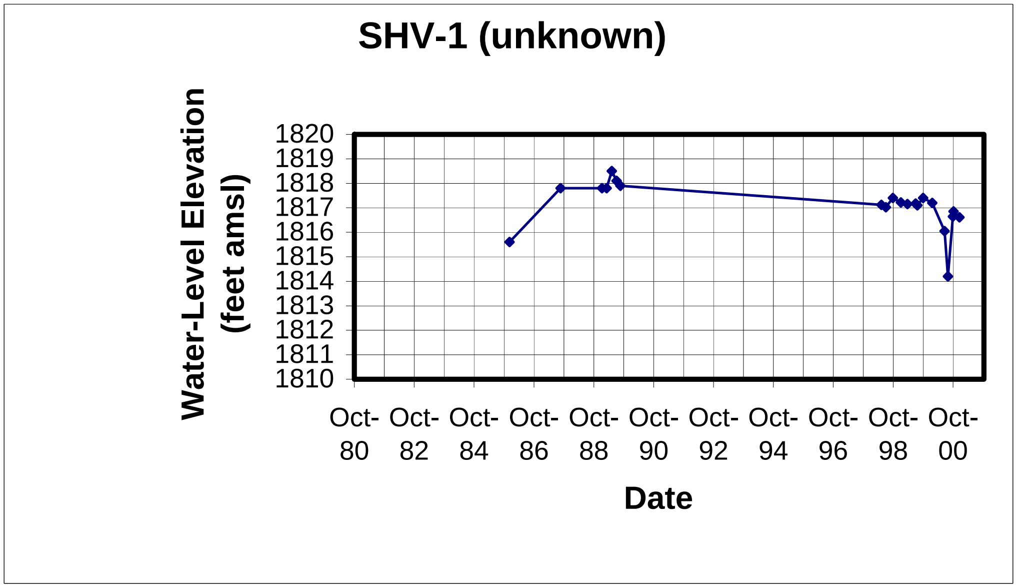




APPENDIX C

Ground-water hydrographs of selected wells with greater than 5 years of record





APPENDIX C

Table C-1. Well-Site Data

WELL_ID	ALIAS	OWNER/OPERATOR	HGU[1]	COMPLETION DATE	UTM EASTING[2] (m)	UTM NORTHING[2] (m)	ELEVATION (ft. amsl)	ELEVATION SOURCE[3]	WELL DEPTH (ft.)
ABBOTT	UM7	NPC	VF		706482	4065427	1710.83	NPC	
ACEVEDO		ACEVEDO, BEN	VF	10/30/99	729268	4045279	1273	NDWR	230
ARROW_CANYON		MVWD	C	01/25/91	701233	4067521	1875	USGS/GWSI	565
BEHMER	UM14	NPC	VF		706031	4065080	1715.77	NPC	
BM-BE-1		BONNEVILLE ENERGY	C	06/12/90	690006	4018271	2442	NDWR	1214
BM-BE-2		BONNEVILLE ENERGY	C	12/30/91	689997	4018671	2434	NDWR	960
BM-BE-3		BONNEVILLE ENERGY	C	08/16/91	689606	4018262	2391	NDWR	1241
BM-FARGO		FARGO PACIFIC	VF	5/10/1980	692376	4010399	1844	NDWR	950
BM-HEISEN-1		HEISEN, CHARLES	VF	8/4/1988	693487	4005336	1483	NDWR	440
BM-HEISEN-2		HEISEN, CHARLES	VF	11/10/1988	693478	4005737	1505	NDWR	320
BM-LIGHTFOOT-1		LIGHTFOOT, WILLIAM E	VF	11/6/1958	689739	4012191	1930	NDWR	240
BM-LIGHTFOOT-2		LIGHTFOOT, WILLIAM E	VF	10/18/1958	690608	4008973	1755	NDWR	130
BM-LIGHTFOOT-3		LIGHTFOOT, WILLIAM E	VF	9/20/1958	691204	4009171	1783	NDWR	146
BM-MARTIN		MARTIN, M B	VF	10/29/1994	693487	4005336	1483	NDWR	490
BM-ONC-1		OGLEBAY NORTON CORPORATION	VF	5/11/1995	702237.7	4010684	2110	NDWR	1291
BM-ONC-2		OGLEBAY NORTON CORPORATION	VF	5/27/1995	702247	4010283	2122	NDWR	1575
BM-SIMPLOT		SIMPLOT SILICIA PRODUCTS	VF	12/23/00	730121	4044013	1294	NDWR	203
BM-SITTON		SITTON, DORCUS	VF	11/18/1967	690138	4012200	1935	NDWR	200
CE-VF-1	365232114554401	CSI	VF	11/13/80	683135	4082805	2464.2	USGS/GWSI	714
CE-VF-2	365227114554401	CSI	C	12/15/80	683092	4082694	2466.9	USGS/GWSI	1221
CL-1		CHEM LIME	C		687748	4026564	2286.48	JOHNSON, C. et al., 2001	
CS-BUCKHORN		BUCKHORN LAND & CATTLE CO	VF	6/24/1970	678973	4095731	2573	NDWR	100
CS-GORDON		GORDON, TERRY	VF	7/11/1977	679139	4101902	2615	NDWR	500
CS-JBR		J B R ENVIRONMENTAL	VF	12/19/1996	676607	4091766	2776	NDWR	80
CSV-1	364601114514301	USGS	VF	10/16/85	690832	4070948	2158.6	USGS/GWSI	765
CSV-2	364650114432001	USGS	C	10/26/85	703269	4072746	2185.9	USGS/GWSI	478
CSV-3	364127114553001	USGS	VF	11/24/85	685386	4062380	2414.3	USGS/GWSI	780
CW-BLM-1		U S BUREAU OF LAND MANAGEMENT	VF	2/11/1949	705015.8	4042139	1976	NDWR	400
CW-BLM-2		U S BUREAU OF LAND MANAGEMENT	VF	6/17/1949	699863.7	4028081	2526	NDWR	860
CW-CLARK		CLARK, JIM	VF	7/1/1992	704617.7	4042130	1983	NDWR	680
CW-HALL		HALL, FRANK	VF	10/8/1967	702045.7	4038215	2109	NDWR	1550
CW-JONES		JONES, JOHN A	VF	12/6/1966	703286.8	4036271	2177	NDWR	500
CW-PEHLEN		PEHLEN, JACK	VF	7/3/1951	696908.3	4034150	2286	NDWR	583
CW-SCC		STEWART CONSTRUCTION CO	VF	4/24/1958	692211.1	4035863	2029	NDWR	550
DF-1	DUTCH FLAT	CSI	VF		687059	4078489	2223.6	SNWA	
EBA-1		GEORGIA PACIFIC	C	10/23/92	686513	4024108	2426.99	JOHNSON, C. et al., 2001	1598
EBM-3		NV COGEN	C		689602	4018535	2389.88	JOHNSON, C. et al., 2001	
ECP-1		CALPINE	C		696735	4046586	2233.55	JOHNSON, C. et al., 2001	1170
ECP-2		CALPINE	C		696726	4046738	2232.42	JOHNSON, C. et al., 2001	1228
ECP-3		CALPINE	C		696681	4046670	2243.63	JOHNSON, C. et al., 2001	1500
EH-2		NPC	MC	01/23/86	709965	4057216	1754	NPC	1960
EH-2A		NPC	MC		709947	4057235	1752	NPC	
EH-3	NORTH WEISER	NPC	C	02/25/86	721085	4063300	1739	NPC	793
EH-4	BATTLESHIP WASH	NPC	C	03/19/86	703929	4064736	1933.54	JOHNSON, C. et al., 2001	285
EH-5B		NPC	C	03/12/86	701569	4067619	1845.03	JOHNSON, C. et al., 2001	264

APPENDIX C

Table C-1. Well-Site Data

WELL_ID	ALIAS	OWNER/OPERATOR	HGU[1]	COMPLETION DATE	UTM EASTING[2] (m)	UTM NORTHING[2] (m)	ELEVATION (ft. amsl)	ELEVATION SOURCE[3]	WELL DEPTH (ft.)
EH-7	SOUTH WEISER	NPC	C	04/11/86	720660	4060990	1680	NPC	440
FW-1	VALLEY OF FIRE WELL	NV STATE PARKS	C	1/15/1985	719051	4033541	2358	NDWR	1140
GARNET		NDOT	VF		690107	4030729	2066	NDWR	500
GV-1	GARNET VALLEY	DRY LAKE LLC	C	05/05/00	683063	4033946	2692.7	JOHNSON, C. et al., 2001	1400
GV-ET-1		ENVIRONMENTAL TECHNOLOGIES	VF	03/23/89	690982	4028343	2321	NDWR	560
GV-GSC-1		GREAT STAR CEMENT CORP	VF	03/30/87	693337	4031201	2293	NDWR	736
GV-KERR-1		KERR-MCGEE CHEMICAL CORP	C	02/07/90	683838	4028991	2405	NDWR	1145
GV-NDOT		STATE OF NV HIGHWAY DEPT	VF	09/10/72	690107	4030729	2066	NDWR	500
GV-SSD-1		SILVER STATE DISPOSAL	MC	06/07/96	690594	4026732	2450	NDWR	1500
GV-SSD-2		SILVER STATE DISPOSAL	VF	06/21/97	692196	4027569	2449	NDWR	940
GV-USLIME-1		U S LIME	VF	09/13/63	690310	4030549	2073	NDWR	600
GV-USLIME-2		U S LIME	VF	07/22/71	688174	4029084	2155	NDWR	500
HARVEY WELL		NPC	C		692944	4036436		NPC	575
HV-1	HIDDEN VALLEY	DRY LAKE LLC	C	06/20/00	684198	4035619	2699.85	JOHNSON, C. et al., 2001	2480
HV-HLA		HARDING LAWSON ASSOCIATES	VF	9/19/1995	687444.7	4046581	2880	NDWR	70
KS-GEYSER		GEYSER RANCH	VF	1/10/1968	706511	4120722	3590	NDWR	200
LDS-CENTRAL	UM49	NPC	VF		704189	4066366	1769.58	NPC	
LDS-WEST	UM18	NPC	VF		702799	4066922	1807.34	NPC	
LEWIS-FARM		NPC	VF		702028	4067664	1827	NPC	
LEWIS-NORTH		NPC	VF		701668	4067676	1842.42	NPC	
LEWIS-SOUTH		NPC	VF		702800	4067061	1806.45	NPC	
LMVW-1		SUMMA CORPORATION	VF	10/27/1975	718268.5	4165282	4394	NDWR	180
LMVW-10		CALIENTE PUBLIC UTILITIES	VF	11/23/1953	719067.2	4165704	4386	NDWR	190
LMVW-11		BREEDLOVE, MILDRED	VF	12/1/1962	708398.1	4086134	1962	NDWR	105
LMVW-12		NPC	VF	9/30/1981	716513.7	4061048	1532	NDWR	171
LMVW-13		NPC	VF	5/6/1981	716528.4	4061449	1538	NDWR	175
LMVW-14		NPC	VF	8/27/1962	716513.7	4061048	1532	NDWR	480
LMVW-15		PULSIPHER, BILLY H & SUSAN	VF	4/4/1974	716091.6	4061037	1538	NDWR	105
LMVW-16		BUNKERVILLE WATER USERS ASSOC	VF	1/10/1952	755231.8	4080871	2361	NDWR	265
LMVW-17		STEWART WELLS CONSTRUCTION CO	VF	12/13/1961	718420.6	4061281	1653	NDWR	190
LMVW-18		SALT LAKE & LOS ANGELES RAILRO	VF	7/10/1980	709471.5	4076724	1753	NDWR	360
LMVW-19		VANKIRK, R S & RUTH	VF	11/13/1975	723303.5	4166033	4864	NDWR	115
LMVW-2		TENNELLE, JAMES B	VF	4/20/1979	714236.3	4157989	4189	NDWR	200
LMVW-20		ATLANTA GOLD & URANIUM CO	VF	8/8/1955	731591.1	4146887	5969	NDWR	550
LMVW-21		MATTHEWS, LESTER	VF	3/25/1974	724535.4	4115508	2657	NDWR	138
LMVW-22		REYNOLDS, PATRICK	VF	7/6/1982	721876.4	4166179	4443	NDWR	108
LMVW-23	NPC-HOLE21	NPC	VF	10/28/1980	715251.5	4063822	1564	NDWR	182
LMVW-24		BRADSHAW INC	VF	4/2/1976	724873.3	4116720	2678	NDWR	141
LMVW-25		BRADSHAW, JAMES W	VF	9/3/1962	721767.5	4133356	3278	NDWR	115
LMVW-26		CONAWAY, EMORY	VF	11/24/1959	718279.1	4164881	4362	NDWR	165
LMVW-27		SUMMA CORPORATION	VF	6/3/1974	718289.7	4164480	4358	NDWR	200
LMVW-28		SUMMA CORPORATION	VF	10/26/1973	717893.8	4163668	4327	NDWR	210
LMVW-29		CONAWAY, JOHN	VF	6/2/1949	718279.1	4164881	4362	NDWR	152
LMVW-3		SUMMA CORPORATION	VF	10/31/1974	717476.9	4163657	4321	NDWR	200
LMVW-30		WISEMAN, LYLE	VF	8/7/1976	713299.8	4146615	5368	NDWR	500

APPENDIX C

Table C-1.   Well-Site Data

WELL_ID	ALIAS	OWNER/OPERATOR	HGU[1]	COMPLETION DATE	UTM EASTING[2] (m)	UTM NORTHING[2] (m)	ELEVATION (ft. amsl)	ELEVATION SOURCE[3]	WELL DEPTH (ft.)
LMVW-31		NEVADA GIRLS TRAINING CENTER	VF	6/18/1976	723303.5	4166033	4864	NDWR	120
LMVW-32		SCHLARMAN, OLIVER	VF	11/30/1961	720683	4134314	3312	NDWR	120
LMVW-33		MCKENZIE, JOHN	VF	11/21/1975	723303.5	4166033	4864	NDWR	115
LMVW-34		LEWIS, PAUL	VF	11/1/1971	715668.8	4063031	1573	NDWR	117
LMVW-35		MEADOW VALLEY PROPERTIES	VF	8/20/1981	717132.6	4160872	4264	NDWR	127
LMVW-36		OLSON, ROBERT & MARY	VF	2/12/1968	721484	4166169	4485	NDWR	123
LMVW-37		LEWIS, PAUL	VF	2/26/1974	716091.6	4061037	1538	NDWR	194
LMVW-38		BREEDLOVE, C P	VF	6/1/1963	708358	4087768	1963	NDWR	120
LMVW-39		LEWIS, RON	VF	5/1/1982	716101.7	4060636	1538	NDWR	110
LMVW-4		SUMMA CORPORATION	VF	4/16/1975	717497.1	4162886	4322	NDWR	190
LMVW-40		BRADSHAW, DON	VF	11/6/1961	724840.3	4117953	2694	NDWR	150
LMVW-41		WHITNEY, R C	VF	11/13/1996	715684.4	4061428	1545	NDWR	168
LMVW-42		STUART, ROBERT B	VF	8/9/1995	709040.1	4079149	1794	NDWR	170
LMVW-43		LONGHORN CATTLE COMPANY	VF	8/21/1994	714653.5	4158000	4603	NDWR	102
LMVW-44		HENRIE, PAUL	VF	1/6/1973	714402.4	4065004	1583	NDWR	137
LMVW-45		CUTLER, KETH	VF	5/31/1985	715236.7	4063421	1586	NDWR	200
LMVW-46		STEWART, MARK	VF	4/9/1973	715668.8	4063031	1573	NDWR	150
LMVW-47		ROARING SPRINGS RANCH	VF	10/18/1986	710279.5	4077145	1788	NDWR	111
LMVW-48		GUINN, ROBERT	VF	5/13/1974	721950.5	4107728	2538	NDWR	105
LMVW-49		MEADOW VALLEY FARMLAND IRR CO	VF	3/25/1988	714407.1	4065806	1587	NDWR	134
LMVW-5		CONAWAY, JOHN	VF	6/9/1949	717146.7	4161273	4283	NDWR	108
LMVW-50		MEADOW VALLEY FARMLAND IRR CO	VF	2/25/1988	715236	4065425	1584	NDWR	162
LMVW-51		STUART, ROBERT B	VF	4/29/1988	709040.1	4079149	1794	NDWR	150
LMVW-52		MEADOW VALLEY FARMLAND IRR CO	VF	2/16/1987	716086.2	4062240	1552	NDWR	174
LMVW-53		SCHLARMAN, HENRY T	VF	4/23/1971	715658.8	4063432	1566	NDWR	112
LMVW-54		LEWIS, ROBERT & VIVIEN	VF	4/25/1974	715678.9	4062630	1577	NDWR	130
LMVW-55		MEADOW VALLEY FARM LANES	VF	3/9/1990	715231.4	4064624	1561	NDWR	142
LMVW-56		HENRIE, PAUL	VF	3/1/1969	714402.4	4065004	1583	NDWR	139
LMVW-57		MEADOW VALLEY FARMLAND IRR CO	VF	3/3/1988	715231.4	4064624	1561	NDWR	144
LMVW-58		HENRIE, PAUL	VF	1/2/1973	714412.4	4064603	1574	NDWR	158
LMVW-59		HOUSTMA, KEN	VF	11/7/1971	714839.7	4063411	1593	NDWR	200
LMVW-6		PIOCHE PUBLIC UTILITIES	VF	8/21/1965	718448.5	4165903	4524	NDWR	595
LMVW-60		LEWIS, PAUL	VF	2/12/1974	715678.9	4062630	1577	NDWR	206
LMVW-61		LEWIS, ROBERT C & VIVIAN	VF	4/5/1983	715678.9	4062630	1577	NDWR	135
LMVW-62		PAYTAS, PAUL	VF	12/25/1971	715246.8	4063020	1609	NDWR	255
LMVW-63		PERKINS, ROBERT	VF	3/26/1973	715236.7	4063421	1586	NDWR	125
LMVW-64		EMBRY, MILTON	VF	12/28/1971	715246.8	4063020	1609	NDWR	181
LMVW-65		CALLAHAN, RALPH V	VF	6/5/1976	716101.7	4060636	1538	NDWR	150
LMVW-66		LEAVITT, GARY & DIANE	VF	4/1/1974	716091.6	4061037	1538	NDWR	173
LMVW-67		STEWART, MARK	VF	11/1/1971	715668.8	4063031	1573	NDWR	117
LMVW-68		PERKINS, ROBERT	VF	9/28/1971	715236.7	4063421	1586	NDWR	117
LMVW-69		WRIGHT, LEONARD	VF	4/20/1971	714819.6	4064212	1564	NDWR	109
LMVW-7		OLSON, ROBERT & MARY	VF	3/7/1968	722293.2	4166191	4535	NDWR	115
LMVW-70		LEWIS, PAUL	VF	2/19/1974	716101.7	4060636	1538	NDWR	205
LMVW-71		MCKNIGHT, JAMES D	VF	3/1/1969	714819.6	4064212	1564	NDWR	112

APPENDIX C

Table C-1. Well-Site Data

WELL_ID	ALIAS	OWNER/OPERATOR	HGU[1]	COMPLETION DATE	UTM EASTING[2] (m)	UTM NORTHING[2] (m)	ELEVATION (ft. amsl)	ELEVATION SOURCE[3]	WELL DEPTH (ft.)
LMVW-72		NPC	VF	12/31/1963	715251.5	4063822	1564	NDWR	180
LMVW-73		FOLEY, RUSS	VF	1/5/1972	715658.8	4063432	1566	NDWR	141
LMVW-74		HENRIE, PAUL	VF	3/1/1969	714412.4	4064603	1574	NDWR	119
LMVW-75		NPC	VF	9/30/1981	716086.2	4062240	1552	NDWR	167
LMVW-76		NPC	VF	11/1/1963	716508.1	4062250	1541	NDWR	235
LMVW-77		BALLOW, JOE	VF	3/22/1973	714417.8	4063400	1610	NDWR	219
LMVW-78		COLE, JOE	VF	1/13/1973	714839.7	4063411	1593	NDWR	215
LMVW-79		STEELE, BOYD & WOOLEY, BOBBY F	VF	5/7/1971	715643.1	4065035	1574	NDWR	115
LMVW-8		CALIENTE PUBLIC UTILITIES	VF	3/5/1966	720247.4	4166537	4524	NDWR	195
LMVW-80	NPC-HOLE07	NPC	VF	10/23/1980	716528.4	4061449	1538	NDWR	204
LMVW-81	NPC-HOLE12	NPC	VF	10/26/1980	716508.1	4062250	1541	NDWR	204
LMVW-82	NPC-HOLE31	NPC	VF	11/7/1980	715684.4	4061428	1545	NDWR	104
LMVW-83		TENNILE, GEORGE	VF	1/26/1999	714226	4158390	4192	NDWR	130
LMVW-84	NPC-HOLE03	NPC	VF	10/14/1980	716936.6	4061027	1534	NDWR	204
LMVW-85	NPC-HOLE02	NPC	VF	10/16/1980	716946.7	4060627	1525	NDWR	160
LMVW-9		OLSON, ROBERT & MARY	VF	11/11/1965	722293.2	4166191	4535	NDWR	112
LMVW-PERKINS[4]			C		713096	4088869	2732	USGS DEM	
LMVW-TEXACO[4]			C		701232	4084759	3877	USGS DEM	
M-1		MOAPA PAIUTES	C		703851	4057823	1898.11	JOHNSON, C. et al., 2001	403
M-2		MOAPA PAIUTES	C		696307	4041041	2111.02	JOHNSON, C. et al., 2001	683
M-3		MOAPA PAIUTES	C		691446	4044464	2238.03	JOHNSON, C. et al., 2001	673
MV-1		HUGES, ROGER	VF	4/1/1983	715067.1	4044389	2673	NDWR	118
MV-10		LEWIS, PAUL R & PATRICIA	VF	1/11/1975	719755.2	4057676	1496	NDWR	135
MV-11		JENSEN, R M	VF	12/20/1959	719938.8	4058267	1507	NDWR	400
MV-12		LAS VEGAS CEMENT	VF	11/18/1985	724009.6	4057508	1500	NDWR	423
MV-13		STREET, KEVIN	VF	2/10/1997	724463.3	4056317	1431	NDWR	160
MV-14		MOAPA VALLEY WATER CO	VF	5/28/1967	724484.2	4055516	1415	NDWR	163
MV-15		ADAMS, LOUIS	VF	11/14/1957	724687.9	4055336	1410	NDWR	120
MV-16		FAY, BOB	VF	7/15/1980	725237.2	4057139	1466	NDWR	275
MV-17		LANGFORD, F H	VF	8/27/1966	725304.1	4055537	1415	NDWR	200
MV-18		CLARK COUNTY	VF	8/5/1973	725392.1	4053134	1375	NDWR	120
MV-19		LANGFORD, F H	VF	7/28/1958	725701.7	4055548	1446	NDWR	112
MV-2		NPC	VF	8/27/1962	716091.6	4061037	1538	NDWR	480
MV-20		WHITNEY, BERT N & ANNA C	VF	9/18/1971	725768.6	4053946	1403	NDWR	120
MV-21		ROBINSON, L H	VF	7/1/1967	725835.6	4052344	1367	NDWR	151
MV-22		WOOLSTON, ROBERT & IRENE	VF	9/13/1971	726155.7	4054357	1427	NDWR	120
MV-23		SEBAUGH, FRANK	VF	2/27/1976	726310.8	4050352	1314	NDWR	140
MV-24		CITY OF LOGANDALE	VF	11/21/1957	726415.8	4052976	1381	NDWR	100
MV-25		J R SIMPLOT CO	VF	3/31/1988	726672.3	4039443	1837	NDWR	525
MV-26		MARSHAL, KARL	VF	2/11/1976	726722.9	4050763	1314	NDWR	140
MV-27		BATES, D L	VF	8/26/1972	726733.5	4050363	1314	NDWR	143
MV-28		METCALF, M B	VF	12/10/1966	726744	4049962	1314	NDWR	140
MV-29		HORN, ERIC	VF	3/18/1967	726937.2	4050183	1314	NDWR	130
MV-3		EWING, JAMES L	VF	2/15/1980	716112.6	4060205	1544	NDWR	198
MV-30		LAHM, ROBERT LEE & EVELYN	VF	5/5/1973	727187.8	4049172	1304	NDWR	150

APPENDIX C

Table C-1. Well-Site Data

WELL_ID	ALIAS	OWNER/OPERATOR	HGU[1]	COMPLETION DATE	UTM EASTING[2] (m)	UTM NORTHING[2] (m)	ELEVATION (ft. amsl)	ELEVATION SOURCE[3]	WELL DEPTH (ft.)
MV-31		LONG, SIMON & BERNICE	VF	7/27/1982	727440.5	4052787	1418	NDWR	250
MV-32		RAMOS, MIKE	VF	3/26/1976	727585.6	4049182	1295	NDWR	150
MV-33		PERKINS, W V	VF	3/24/1978	727643.1	4047950	1288	NDWR	127
MV-34		PERKINS, W V	VF	3/24/1978	727691.2	4048013	1287	NDWR	220
MV-35		MCANICH, LEWIS	VF	7/22/1983	727884.2	4051997	1396	NDWR	120
MV-36		MATHIS, EARNEST G	VF	4/30/1977	728018.8	4048793	1285	NDWR	104
MV-37		STRINGHAM, STANLEY	VF	2/12/1978	728363.5	4050807	1368	NDWR	328
MV-38		ESTRADO, JUAN & SENAIDA	VF	4/29/1977	728452.2	4048403	1275	NDWR	104
MV-39		CLARK COUNTY	VF	5/19/1971	728646.2	4048594	1274	NDWR	120
MV-4		NEVADA SILICA CORP	VF		716544.8	4059815	1514	NDWR	150
MV-40		MOAPA VALLEY DAIRY FARMS	VF	3/23/1988	729294.9	4047593	1250	NDWR	145
MV-41		PERKINS, JACK	VF	2/23/1975	729670.6	4048436	1315	NDWR	242
MV-42		SIMPLOT SILICON PRODUCTS	VF	5/25/1976	730212.8	4043978	1292	NDWR	100
MV-43		U S NATIONAL PARK SERVICE	VF	6/26/1956	731965.8	4045444	1279	NDWR	300
MV-44		STEVENS, BERT	VF	2/4/1954	732009	4043841	1213	NDWR	106
MV-45		BUNKERVILLE WATER USERS ASSOC	VF	9/15/1960	755457.3	4070851	1744	NDWR	300
MV-5		C X PRODUCTS CORP	VF	11/26/1973	717001.9	4059425	1565	NDWR	360
MV-6		HESTER, CHARLIE	VF	1/14/1975	718655.5	4059868	1591	NDWR	200
MV-7		LEWIS, PAUL	VF	5/31/1960	719122.9	4059078	1552	NDWR	170
MV-8		STATE OF NEVADA	VF	4/3/1978	719443	4034784	2236	NDWR	500
MV-9		LEWIS, PAUL R & PATRICIA	VF	1/11/1975	719734.7	4058477	1540	NDWR	135
MV-UNKNOWN[4]			C		725591	4075915	2595	USGS DEM	
MX-4	364743114533101	CSI	C	11/20/80	688085	4074033	2172.6	USGS/GWSI	669
MX-5	364741114532801	SNWA	C	04/14/81	688166	4074024	2170	USGS/GWSI	628
MX-6	364604114471301	MVWD	C	05/21/81	697525	4071193	2274.6	USGS/GWSI	937
SHV-1	363308114553001	BLM	C		685831	4047059	2648.8	USGS/GWSI	920
TH-1		MOAPA PAIUTES	C		697237	4044962	2169.95	JOHNSON, C. et al., 2001	1100
TH-2		MOAPA PAIUTES	C		697687	4049913	2341.7	JOHNSON, C. et al., 2001	1198

1. HGU (hydrogeologic unit) designations: C = Carbonate Aquifer; VF = Valley Fill Aquifer; MC = Muddy Creek Formation

2. UTM Zone 11, NAD 27

3. Elevation sources: JOHNSON, C. et al., 2001 = Johnson et al., 2001, Hydrogeologic and groundwater modeling analyses for the Moapa Paiute Energy Center, 78 p.
NDWR = NDWR Well Log Database
NPC = Nevada Power Company
SNWA = Southern Nevada Water Authority
USGS DEM = USGS Seamless Digital Elevation Model
USGS/GWSI = USGS Ground-water Site Inventory Database

4. Site location from unpublished map by Buqo, T. (2001, oral commun.)

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
ABBOTT	UM7	01/04/90	1710.83	8.38	1702.45	M.D. MIFFLIN, MAY 1991
ABBOTT	UM7	01/12/90	1710.83	8.58	1702.25	M.D. MIFFLIN, MAY 1991
ABBOTT	UM7	02/20/90	1710.83	8.32	1702.51	M.D. MIFFLIN, MAY 1991
ABBOTT	UM7	03/16/90	1710.83	8.19	1702.64	M.D. MIFFLIN, MAY 1991
ABBOTT	UM7	03/28/90	1710.83	7.96	1702.87	M.D. MIFFLIN, MAY 1991
ABBOTT	UM7	04/16/90	1710.83	7.16	1703.67	M.D. MIFFLIN, MAY 1991
ABBOTT	UM7	05/18/90	1710.83	6.84	1703.99	M.D. MIFFLIN, MAY 1991
ABBOTT	UM7	05/25/90	1710.83	7.9	1702.93	M.D. MIFFLIN, MAY 1991
ABBOTT	UM7	06/12/90	1710.83	8.32	1702.51	M.D. MIFFLIN, MAY 1991
ABBOTT	UM7	06/18/90	1710.83	10.7	1700.13	M.D. MIFFLIN, MAY 1991
ABBOTT	UM7	06/26/90	1710.83	12.39	1698.44	M.D. MIFFLIN, MAY 1991
ABBOTT	UM7	07/10/90	1710.83	13.77	1697.06	M.D. MIFFLIN, MAY 1991
ABBOTT	UM7	07/18/90	1710.83	14.05	1696.78	M.D. MIFFLIN, MAY 1991
ABBOTT	UM7	08/10/90	1710.83	14.5	1696.33	M.D. MIFFLIN, MAY 1991
ABBOTT	UM7	09/07/90	1710.83	14.97	1695.86	M.D. MIFFLIN, MAY 1991
ABBOTT	UM7	09/20/90	1710.83	15.84	1694.99	M.D. MIFFLIN, MAY 1991
ABBOTT	UM7	10/12/90	1710.83	15.71	1695.12	M.D. MIFFLIN, MAY 1991
ABBOTT	UM7	10/16/90	1710.83	16.14	1694.69	M.D. MIFFLIN, MAY 1991
ABBOTT	UM7	01/11/91	1710.83	11.11	1699.72	M.D. MIFFLIN, MAY 1992
ABBOTT	UM7	02/05/91	1710.83	8.03	1702.80	M.D. MIFFLIN, MAY 1992
ABBOTT	UM7	02/14/91	1710.83	8.5	1702.33	M.D. MIFFLIN, MAY 1992
ABBOTT	UM7	03/06/91	1710.83	8.65	1702.18	M.D. MIFFLIN, MAY 1992
ABBOTT	UM7	03/21/91	1710.83	9.56	1701.27	M.D. MIFFLIN, MAY 1992
ABBOTT	UM7	04/08/91	1710.83	8.76	1702.07	M.D. MIFFLIN, MAY 1992
ABBOTT	UM7	05/16/91	1710.83	9	1701.83	M.D. MIFFLIN, MAY 1992
ABBOTT	UM7	06/18/91	1710.83	9.75	1701.08	M.D. MIFFLIN, MAY 1992
ABBOTT	UM7	07/25/91	1710.83	10.39	1700.44	M.D. MIFFLIN, MAY 1992
ABBOTT	UM7	08/20/91	1710.83	10.7	1700.13	M.D. MIFFLIN, MAY 1992
ABBOTT	UM7	08/29/91	1710.83	11.29	1699.54	M.D. MIFFLIN, MAY 1992
ABBOTT	UM7	09/20/91	1710.83	12.15	1698.68	M.D. MIFFLIN, MAY 1992
ABBOTT	UM7	10/11/91	1710.83	12.73	1698.10	M.D. MIFFLIN, MAY 1992
ABBOTT	UM7	11/06/91	1710.83	11.67	1699.16	M.D. MIFFLIN, MAY 1992
ABBOTT	UM7	11/20/91	1710.83	11.01	1699.82	M.D. MIFFLIN, MAY 1992
ABBOTT	UM7	12/27/91	1710.83	9.29	1701.54	M.D. MIFFLIN, MAY 1992
ABBOTT	UM7	01/27/92	1710.83	8.58	1702.25	M.D. MIFFLIN, APRIL 1993
ABBOTT	UM7	02/24/92	1710.83	6.92	1703.91	M.D. MIFFLIN, APRIL 1993
ABBOTT	UM7	03/20/92	1710.83	6.21	1704.62	M.D. MIFFLIN, APRIL 1993
ABBOTT	UM7	04/21/92	1710.83	8.47	1702.36	M.D. MIFFLIN, APRIL 1993
ABBOTT	UM7	05/13/92	1710.83	9.13	1701.70	M.D. MIFFLIN, APRIL 1993
ABBOTT	UM7	06/12/92	1710.83	9.95	1700.88	M.D. MIFFLIN, APRIL 1993
ABBOTT	UM7	07/23/92	1710.83	11.2	1699.63	M.D. MIFFLIN, APRIL 1993
ABBOTT	UM7	08/13/92	1710.83	11.12	1699.71	M.D. MIFFLIN, APRIL 1993
ABBOTT	UM7	08/18/92	1710.83	11.32	1699.51	M.D. MIFFLIN, APRIL 1993
ABBOTT	UM7	09/02/92	1710.83	10.05	1700.78	M.D. MIFFLIN, APRIL 1993
ABBOTT	UM7	09/10/92	1710.83	9.37	1701.46	M.D. MIFFLIN, APRIL 1993
ABBOTT	UM7	10/19/92	1710.83	9.71	1701.12	M.D. MIFFLIN, APRIL 1993
ABBOTT	UM7	12/01/92	1710.83	7.69	1703.14	M.D. MIFFLIN, APRIL 1993
ABBOTT	UM7	12/23/92	1710.83	7.23	1703.60	M.D. MIFFLIN, APRIL 1993
ABBOTT	UM7	01/05/94	1710.83	9.09	1701.74	KARL F. POHLMANN, JUNE 1995
ABBOTT	UM7	02/04/94	1710.83	8.77	1702.06	KARL F. POHLMANN, JUNE 1995
ABBOTT	UM7	04/03/94	1710.83	8.84	1701.99	KARL F. POHLMANN, JUNE 1995
ABBOTT	UM7	06/05/94	1710.83	8.09	1702.74	KARL F. POHLMANN, JUNE 1995
ABBOTT	UM7	06/09/94	1710.83	8.74	1702.09	KARL F. POHLMANN, JUNE 1995
ABBOTT	UM7	06/25/94	1710.83	7.68	1703.15	KARL F. POHLMANN, JUNE 1995
ABBOTT	UM7	07/02/94	1710.83	11.1	1699.73	KARL F. POHLMANN, JUNE 1995
ABBOTT	UM7	08/04/94	1710.83	8.15	1702.68	KARL F. POHLMANN, JUNE 1995
ABBOTT	UM7	08/12/94	1710.83	12.39	1698.44	KARL F. POHLMANN, JUNE 1995

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
ABBOTT	UM7	09/06/94	1710.83	12.34	1698.49	KARL F. POHLMANN, JUNE 1995
ABBOTT	UM7	10/04/94	1710.83	11.17	1699.66	KARL F. POHLMANN, JUNE 1995
ABBOTT	UM7	11/01/94	1710.83	9.89	1700.94	KARL F. POHLMANN, JUNE 1995
ABBOTT	UM7	12/08/94	1710.83	11.33	1699.5	KARL F. POHLMANN, JUNE 1995
ABBOTT	UM7	01/09/95	1710.83	9.72	1701.11	KARL F. POHLMANN, MAY 1996
ABBOTT	UM7	02/08/95	1710.83	8.29	1702.54	KARL F. POHLMANN, MAY 1996
ABBOTT	UM7	03/08/95	1710.83	7	1703.83	KARL F. POHLMANN, MAY 1996
ABBOTT	UM7	04/05/95	1710.83	6.57	1704.26	KARL F. POHLMANN, MAY 1996
ABBOTT	UM7	05/18/95	1710.83	6.69	1704.14	KARL F. POHLMANN, MAY 1996
ABBOTT	UM7	06/16/95	1710.83	8.35	1702.48	KARL F. POHLMANN, MAY 1996
ABBOTT	UM7	07/05/95	1710.83	7.8	1703.03	KARL F. POHLMANN, MAY 1996
ABBOTT	UM7	08/09/95	1710.83	9.77	1701.06	KARL F. POHLMANN, MAY 1996
ABBOTT	UM7	09/07/95	1710.83	11.79	1699.04	KARL F. POHLMANN, MAY 1996
ABBOTT	UM7	10/12/95	1710.83	10.05	1700.78	KARL F. POHLMANN, MAY 1996
ABBOTT	UM7	11/09/95	1710.83	9.85	1700.98	KARL F. POHLMANN, MAY 1996
ABBOTT	UM7	11/24/95	1710.83	9.79	1701.04	KARL F. POHLMANN, MAY 1996
ABBOTT	UM7	12/14/95	1710.83	7.77	1703.06	KARL F. POHLMANN, MAY 1996
ABBOTT	UM7	01/12/96	1710.83	6.17	1704.66	KARL F. POHLMANN, MARCH 1997
ABBOTT	UM7	03/01/96	1710.83	6.76	1704.07	KARL F. POHLMANN, MARCH 1997
ABBOTT	UM7	03/14/96	1710.83	7.29	1703.54	KARL F. POHLMANN, MARCH 1997
ABBOTT	UM7	04/11/96	1710.83	7.16	1703.67	KARL F. POHLMANN, MARCH 1997
ABBOTT	UM7	05/08/96	1710.83	6.86	1703.97	KARL F. POHLMANN, MARCH 1997
ABBOTT	UM7	06/14/96	1710.83	8.37	1702.46	KARL F. POHLMANN, MARCH 1997
ABBOTT	UM7	08/13/96	1710.83	12.61	1698.22	KARL F. POHLMANN, MARCH 1997
ABBOTT	UM7	09/13/96	1710.83	13.96	1696.87	KARL F. POHLMANN, MARCH 1997
ABBOTT	UM7	10/10/96	1710.83	14.08	1696.75	KARL F. POHLMANN, MARCH 1997
ABBOTT	UM7	12/18/96	1710.83	10.7	1700.13	KARL F. POHLMANN, MARCH 1997
ABBOTT	UM7	01/15/99	1710.83	9.98	1700.85	CONVERSE, 02/25/00
ABBOTT	UM7	02/16/99	1710.83	9.17	1701.66	CONVERSE, 02/25/00
ABBOTT	UM7	03/12/99	1710.83	8.86	1701.97	CONVERSE, 02/25/00
ABBOTT	UM7	04/15/99	1710.83	8.54	1702.29	CONVERSE, 02/25/00
ABBOTT	UM7	05/14/99	1710.83	8.5	1702.33	CONVERSE, 02/25/00
ABBOTT	UM7	06/15/99	1710.83	9.42	1701.41	CONVERSE, 02/25/00
ABBOTT	UM7	07/15/99	1710.83	9.89	1700.94	CONVERSE, 02/25/00
ABBOTT	UM7	08/16/99	1710.83	10.78	1700.05	CONVERSE, 02/25/00
ABBOTT	UM7	09/16/99	1710.83	11.06	1699.77	CONVERSE, 02/25/00
ABBOTT	UM7	10/12/99	1710.83	11.08	1699.75	CONVERSE, 02/25/00
ABBOTT	UM7	11/16/99	1710.83	9.06	1701.77	CONVERSE, 02/25/00
ABBOTT	UM7	12/28/99	1710.83	9.07	1701.76	CONVERSE, 02/25/00
ABBOTT	UM7	01/14/00	1710.83	9.06	1701.77	CONVERSE, 02/15/01
ABBOTT	UM7	02/15/00	1710.83	9.01	1701.82	CONVERSE, 02/15/01
ABBOTT	UM7	03/21/00	1710.83	8.46	1702.37	CONVERSE, 02/15/01
ABBOTT	UM7	04/14/00	1710.83	8.89	1701.94	CONVERSE, 02/15/01
ABBOTT	UM7	05/15/00	1710.83	10.36	1700.47	CONVERSE, 02/15/01
ABBOTT	UM7	06/14/00	1710.83	13.91	1696.92	CONVERSE, 02/15/01
ABBOTT	UM7	07/14/00	1710.83	14.12	1696.71	CONVERSE, 02/15/01
ABBOTT	UM7	08/15/00	1710.83	14.14	1696.69	CONVERSE, 02/15/01
ABBOTT	UM7	09/19/00	1710.83	12.37	1698.46	CONVERSE, 02/15/01
ABBOTT	UM7	10/13/00	1710.83	12.69	1698.14	CONVERSE, 02/15/01
ABBOTT	UM7	11/16/00	1710.83	13.39	1697.44	CONVERSE, 02/15/01
ABBOTT	UM7	12/15/00	1710.83	13.16	1697.67	CONVERSE, 02/15/01
ACEVEDO		10/30/99	1273.13	26	1247	NDWR
BEHMER	UM14	03/15/89	1715.77	14	1701.77	M.D. MIFFLIN, MAY 1991
BEHMER	UM14	04/14/89	1715.77	13.6	1702.17	M.D. MIFFLIN, MAY 1991
BEHMER	UM14	05/16/89	1715.77	12.8	1702.97	M.D. MIFFLIN, MAY 1991
BEHMER	UM14	05/31/89	1715.77	14.59	1701.18	M.D. MIFFLIN, MAY 1991
BEHMER	UM14	06/09/89	1715.77	18.59	1697.18	M.D. MIFFLIN, MAY 1991

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
BEHMER	UM14	06/16/89	1715.77	20.31	1695.46	M.D. MIFFLIN, MAY 1991
BEHMER	UM14	06/22/89	1715.77	22.28	1693.49	M.D. MIFFLIN, MAY 1991
BEHMER	UM14	06/28/89	1715.77	22.19	1693.58	M.D. MIFFLIN, MAY 1991
BEHMER	UM14	07/10/89	1715.77	22.79	1692.98	M.D. MIFFLIN, MAY 1991
BEHMER	UM14	07/14/89	1715.77	23.53	1692.24	M.D. MIFFLIN, MAY 1991
BEHMER	UM14	07/21/89	1715.77	24.34	1691.43	M.D. MIFFLIN, MAY 1991
BEHMER	UM14	01/04/90	1715.77	10.45	1705.32	KARL F. POHLMANN, JUNE 1991
BEHMER	UM14	01/12/90	1715.77	12.37	1703.4	KARL F. POHLMANN, JUNE 1991
BEHMER	UM14	02/20/90	1715.77	13.27	1702.5	KARL F. POHLMANN, JUNE 1991
BEHMER	UM14	03/16/90	1715.77	11.98	1703.79	KARL F. POHLMANN, JUNE 1991
BEHMER	UM14	04/16/90	1715.77	11.52	1704.25	KARL F. POHLMANN, JUNE 1991
BEHMER	UM14	05/04/90	1715.77	9.52	1706.25	KARL F. POHLMANN, JUNE 1991
BEHMER	UM14	05/18/90	1715.77	9.38	1706.39	KARL F. POHLMANN, JUNE 1991
BEHMER	UM14	05/25/90	1715.77	12.63	1703.14	KARL F. POHLMANN, JUNE 1991
BEHMER	UM14	06/12/90	1715.77	12.44	1703.33	KARL F. POHLMANN, JUNE 1991
BEHMER	UM14	07/10/90	1715.77	14.25	1701.52	KARL F. POHLMANN, JUNE 1991
BEHMER	UM14	07/18/90	1715.77	14.43	1701.34	KARL F. POHLMANN, JUNE 1991
BEHMER	UM14	08/10/90	1715.77	15.72	1700.05	KARL F. POHLMANN, JUNE 1991
BEHMER	UM14	09/07/90	1715.77	12.53	1703.24	KARL F. POHLMANN, JUNE 1991
BEHMER	UM14	09/27/90	1715.77	11.33	1704.44	KARL F. POHLMANN, JUNE 1991
BEHMER	UM14	10/11/90	1715.77	16.65	1699.12	KARL F. POHLMANN, JUNE 1991
BEHMER	UM14	10/16/90	1715.77	15.54	1700.23	KARL F. POHLMANN, JUNE 1991
BEHMER	UM14	10/30/90	1715.77	11.41	1704.36	KARL F. POHLMANN, JUNE 1991
BEHMER	UM14	11/08/90	1715.77	15.96	1699.81	KARL F. POHLMANN, JUNE 1991
BEHMER	UM14	11/19/90	1715.77	14.54	1701.23	KARL F. POHLMANN, JUNE 1991
BEHMER	UM14	12/03/90	1715.77	12.11	1703.66	KARL F. POHLMANN, JUNE 1991
BEHMER	UM14	12/20/90	1715.77	17.31	1698.46	KARL F. POHLMANN, JUNE 1991
BEHMER	UM14	01/11/91	1715.77	18	1697.77	M.D. MIFFLIN, MAY 1992
BEHMER	UM14	01/17/91	1715.77	13.3	1702.47	M.D. MIFFLIN, MAY 1992
BEHMER	UM14	02/05/91	1715.77	13.42	1702.35	M.D. MIFFLIN, MAY 1992
BEHMER	UM14	02/14/91	1715.77	14.41	1701.36	M.D. MIFFLIN, MAY 1992
BEHMER	UM14	03/06/91	1715.77	15.4	1700.37	M.D. MIFFLIN, MAY 1992
BEHMER	UM14	03/15/91	1715.77	16.38	1699.39	M.D. MIFFLIN, MAY 1992
BEHMER	UM14	03/21/91	1715.77	15.73	1700.04	M.D. MIFFLIN, MAY 1992
BEHMER	UM14	04/08/91	1715.77	14.65	1701.12	M.D. MIFFLIN, MAY 1992
BEHMER	UM14	05/16/91	1715.77	15.39	1700.38	M.D. MIFFLIN, MAY 1992
BEHMER	UM14	06/18/91	1715.77	15.54	1700.23	M.D. MIFFLIN, MAY 1992
BEHMER	UM14	07/25/91	1715.77	16.08	1699.69	M.D. MIFFLIN, MAY 1992
BEHMER	UM14	08/20/91	1715.77	16.38	1699.39	M.D. MIFFLIN, MAY 1992
BEHMER	UM14	09/09/91	1715.77	17.67	1698.10	M.D. MIFFLIN, MAY 1992
BEHMER	UM14	09/13/91	1715.77	18.02	1697.75	M.D. MIFFLIN, MAY 1992
BEHMER	UM14	10/03/91	1715.77	19.5	1696.27	M.D. MIFFLIN, MAY 1992
BEHMER	UM14	10/11/91	1715.77	19.86	1695.91	M.D. MIFFLIN, MAY 1992
BEHMER	UM14	10/17/91	1715.77	19.32	1696.45	M.D. MIFFLIN, MAY 1992
BEHMER	UM14	11/06/91	1715.77	17.58	1698.19	M.D. MIFFLIN, MAY 1992
BEHMER	UM14	11/20/91	1715.77	16.66	1699.11	M.D. MIFFLIN, MAY 1992
BEHMER	UM14	12/27/91	1715.77	14.54	1701.23	M.D. MIFFLIN, MAY 1992
BEHMER	UM14	01/27/92	1715.77	14.22	1701.55	M.D. MIFFLIN, APRIL 1993
BEHMER	UM14	02/24/92	1715.77	10.63	1705.14	M.D. MIFFLIN, APRIL 1993
BEHMER	UM14	03/24/92	1715.77	13.21	1702.56	M.D. MIFFLIN, APRIL 1993
BEHMER	UM14	04/21/92	1715.77	14.44	1701.33	M.D. MIFFLIN, APRIL 1993
BEHMER	UM14	05/13/92	1715.77	15.08	1700.69	M.D. MIFFLIN, APRIL 1993
BEHMER	UM14	06/12/92	1715.77	15.8	1699.97	M.D. MIFFLIN, APRIL 1993
BEHMER	UM14	07/23/92	1715.77	17.32	1698.45	M.D. MIFFLIN, APRIL 1993
BEHMER	UM14	08/13/92	1715.77	17.1	1698.67	M.D. MIFFLIN, APRIL 1993
BEHMER	UM14	09/02/92	1715.77	14.02	1701.75	M.D. MIFFLIN, APRIL 1993
BEHMER	UM14	09/10/92	1715.77	13.04	1702.73	M.D. MIFFLIN, APRIL 1993

APPENDIX C

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
BEHMER	UM14	10/19/92	1715.77	13.24	1702.53	M.D. MIFFLIN, APRIL 1993
BEHMER	UM14	12/23/92	1715.77	11.41	1704.36	M.D. MIFFLIN, APRIL 1993
BEHMER	UM14	01/05/94	1715.77	12.58	1703.19	KARL F. POHLMANN, JUNE 1995
BEHMER	UM14	02/04/94	1715.77	12.08	1703.69	KARL F. POHLMANN, JUNE 1995
BEHMER	UM14	03/04/94	1715.77	13.08	1702.69	KARL F. POHLMANN, JUNE 1995
BEHMER	UM14	05/06/94	1715.77	10.76	1705.01	KARL F. POHLMANN, JUNE 1995
BEHMER	UM14	06/09/94	1715.77	11.75	1704.02	KARL F. POHLMANN, JUNE 1995
BEHMER	UM14	07/02/94	1715.77	16.9	1698.87	KARL F. POHLMANN, JUNE 1995
BEHMER	UM14	08/12/94	1715.77	18.65	1697.12	KARL F. POHLMANN, JUNE 1995
BEHMER	UM14	09/06/94	1715.77	17.22	1698.55	KARL F. POHLMANN, JUNE 1995
BEHMER	UM14	10/04/94	1715.77	13.88	1701.89	KARL F. POHLMANN, JUNE 1995
BEHMER	UM14	11/01/94	1715.77	12.65	1703.12	KARL F. POHLMANN, JUNE 1995
BEHMER	UM14	12/08/94	1715.77	16.72	1699.05	KARL F. POHLMANN, JUNE 1995
BEHMER	UM14	01/09/95	1715.77	14.5	1701.27	KARL F. POHLMANN, MAY 1996
BEHMER	UM14	02/08/95	1715.77	11.12	1704.65	KARL F. POHLMANN, MAY 1996
BEHMER	UM14	03/08/95	1715.77	9.3	1706.47	KARL F. POHLMANN, MAY 1996
BEHMER	UM14	04/05/95	1715.77	9.15	1706.62	KARL F. POHLMANN, MAY 1996
BEHMER	UM14	05/18/95	1715.77	8.81	1706.96	KARL F. POHLMANN, MAY 1996
BEHMER	UM14	06/18/95	1715.77	11.95	1703.82	KARL F. POHLMANN, MAY 1996
BEHMER	UM14	07/05/95	1715.77	10.69	1705.08	KARL F. POHLMANN, MAY 1996
BEHMER	UM14	08/09/95	1715.77	14.95	1700.82	KARL F. POHLMANN, MAY 1996
BEHMER	UM14	09/07/95	1715.77	17.47	1698.3	KARL F. POHLMANN, MAY 1996
BEHMER	UM14	10/12/95	1715.77	13.42	1702.35	KARL F. POHLMANN, MAY 1996
BEHMER	UM14	11/09/95	1715.77	14.92	1700.85	KARL F. POHLMANN, MAY 1996
BEHMER	UM14	12/14/95	1715.77	10.93	1704.84	KARL F. POHLMANN, MAY 1996
BEHMER	UM14	01/12/96	1715.77	9.09	1706.68	KARL F. POHLMANN, MARCH 1997
BEHMER	UM14	03/01/96	1715.77	10.36	1705.41	KARL F. POHLMANN, MARCH 1997
BEHMER	UM14	03/14/96	1715.77	12.89	1702.88	KARL F. POHLMANN, MARCH 1997
BEHMER	UM14	04/11/96	1715.77	13.02	1702.75	KARL F. POHLMANN, MARCH 1997
BEHMER	UM14	05/08/96	1715.77	10.01	1705.76	KARL F. POHLMANN, MARCH 1997
BEHMER	UM14	06/14/96	1715.77	11.9	1703.87	KARL F. POHLMANN, MARCH 1997
BEHMER	UM14	08/13/96	1715.77	18.65	1697.12	KARL F. POHLMANN, MARCH 1997
BEHMER	UM14	09/13/96	1715.77	20.28	1695.49	KARL F. POHLMANN, MARCH 1997
BEHMER	UM14	10/10/96	1715.77	20.06	1695.71	KARL F. POHLMANN, MARCH 1997
BEHMER	UM14	11/22/96	1715.77	13.8	1701.97	KARL F. POHLMANN, MARCH 1997
BEHMER	UM14	12/18/96	1715.77	15.06	1700.71	KARL F. POHLMANN, MARCH 1997
BEHMER	UM14	01/15/99	1715.77	13.98	1701.79	CONVERSE, 02/25/00
BEHMER	UM14	02/16/99	1715.77	11.21	1704.56	CONVERSE, 02/25/00
BEHMER	UM14	03/12/99	1715.77	12.86	1702.91	CONVERSE, 02/25/00
BEHMER	UM14	04/15/99	1715.77	11.14	1704.63	CONVERSE, 02/25/00
BEHMER	UM14	05/14/99	1715.77	9.98	1705.79	CONVERSE, 02/25/00
BEHMER	UM14	06/14/99	1715.77	10.75	1705.02	CONVERSE, 02/25/00
BEHMER	UM14	07/15/99	1715.77	13.69	1702.08	CONVERSE, 02/25/00
BEHMER	UM14	08/16/99	1715.77	12.71	1703.06	CONVERSE, 02/25/00
BEHMER	UM14	09/16/99	1715.77	13.73	1702.04	CONVERSE, 02/25/00
BEHMER	UM14	10/12/99	1715.77	14.29	1701.48	CONVERSE, 02/25/00
BEHMER	UM14	11/16/99	1715.77	11.79	1703.98	CONVERSE, 02/25/00
BEHMER	UM14	12/28/99	1715.77	12.76	1703.01	CONVERSE, 02/25/00
BEHMER	UM14	01/14/00	1715.77	12.73	1703.04	CONVERSE, 02/15/01
BEHMER	UM14	02/15/00	1715.77	12.67	1703.1	CONVERSE, 02/15/01
BEHMER	UM14	03/21/00	1715.77	12.08	1703.69	CONVERSE, 02/15/01
BEHMER	UM14	04/14/00	1715.77	12.79	1702.98	CONVERSE, 02/15/01
BEHMER	UM14	05/15/00	1715.77	15.51	1700.26	CONVERSE, 02/15/01
BEHMER	UM14	06/14/00	1715.77	21.61	1694.16	CONVERSE, 02/15/01
BEHMER	UM14	07/14/00	1715.77	21.09	1694.68	CONVERSE, 02/15/01
BEHMER	UM14	08/15/00	1715.77	20.55	1695.22	CONVERSE, 02/15/01
BEHMER	UM14	09/19/00	1715.77	13.89	1701.88	CONVERSE, 02/15/01

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
BEHMER	UM14	10/13/00	1715.77	16.94	1698.83	CONVERSE, 02/15/01
BEHMER	UM14	11/16/00	1715.77	18.48	1697.29	CONVERSE, 02/15/01
BEHMER	UM14	12/12/00	1715.77	18.42	1697.35	CONVERSE, 02/15/01
BM-BE-1		06/12/90	2442.46	575	1867	NDWR
BM-BE-2		12/30/91	2434.21	608	1826	NDWR
BM-BE-3		08/16/91	2391.14	559	1832	NDWR
BM-FARGO		05/10/80	1844.35	137	1707	NDWR
BM-HEISEN-1		08/04/88	1483.37	155	1328	NDWR
BM-HEISEN-2		11/10/88	1505.27	150	1355	NDWR
BM-LIGHTFOOT-1		11/06/58	1930.28	40	1890	NDWR
BM-LIGHTFOOT-2		10/18/58	1754.62	20	1735	NDWR
BM-LIGHTFOOT-3		09/20/58	1783.48	14	1769	NDWR
BM-MARTIN		10/29/94	1483.37	180	1303	NDWR
BM-ONC-1		05/11/95	2109.93	344.09	1766	NDWR
BM-ONC-2		05/27/95	2121.92	549.55	1572	NDWR
BM-SIMPLOT		12/23/00	1293.85	25	1269	NDWR
BM-SITTON		11/18/67	1935.45	44	1891	NDWR
CE-VF-1	365232114554401	11/22/80	2464.20	549	1915.2	USGS
CE-VF-1	365232114554401	07/14/81	2464.20	548	1916.2	USGS
CE-VF-1	365232114554401	09/29/81	2464.20	548	1916.2	USGS
CE-VF-1	365232114554401	06/06/85	2464.20	547.77	1916.43	USGS
CE-VF-1	365232114554401	01/28/86	2464.20	542.98	1921.22	BERGER et al., 1988
CE-VF-1	365232114554401	01/29/86	2464.20	543	1921.2	USGS
CE-VF-1	365232114554401	02/05/86	2464.20	542.8	1921.4	USGS
CE-VF-1	365232114554401	02/06/86	2464.20	542.7	1921.5	USGS
CE-VF-1	365232114554401	09/13/86	2464.20	548.8	1915.4	USGS
CE-VF-1	365232114554401	05/17/88	2464.20	548.5	1915.7	USGS
CE-VF-1	365232114554401	08/04/88	2464.20	548.9	1915.3	USGS
CE-VF-1	365232114554401	12/13/88	2464.20	548.48	1915.72	USGS
CE-VF-1	365232114554401	01/31/89	2464.20	549.1	1915.1	USGS
CE-VF-1	365232114554401	03/28/89	2464.20	549	1915.2	USGS
CE-VF-1	365232114554401	05/30/89	2464.20	549	1915.2	USGS
CE-VF-1	365232114554401	07/26/89	2464.20	549.1	1915.1	USGS
CE-VF-1	365232114554401	09/12/89	2464.20	549.1	1915.1	USGS
CE-VF-1	365232114554401	11/13/90	2464.20	548.9	1915.3	USGS
CE-VF-1	365232114554401	03/26/91	2464.20	548.4	1915.8	USGS
CE-VF-1	365232114554401	06/13/91	2464.20	548.6	1915.6	USGS
CE-VF-1	365232114554401	09/12/91	2464.20	549	1915.2	USGS
CE-VF-1	365232114554401	12/10/91	2464.20	548.7	1915.5	USGS
CE-VF-1	365232114554401	03/18/92	2464.20	548.6	1915.6	USGS
CE-VF-1	365232114554401	06/17/92	2464.20	548.7	1915.5	USGS
CE-VF-1	365232114554401	09/08/92	2464.20	548.9	1915.3	USGS
CE-VF-1	365232114554401	12/21/92	2464.20	549.3	1914.9	USGS
CE-VF-1	365232114554401	03/31/93	2464.20	549.2	1915	USGS
CE-VF-1	365232114554401	06/07/93	2464.20	549	1915.2	USGS
CE-VF-1	365232114554401	09/07/93	2464.20	549.3	1914.9	USGS
CE-VF-1	365232114554401	12/15/93	2464.20	549	1915.2	USGS
CE-VF-1	365232114554401	03/31/94	2464.20	548	1916.2	USGS
CE-VF-1	365232114554401	07/07/94	2464.20	548.65	1915.55	USGS
CE-VF-1	365232114554401	09/20/94	2464.20	548.71	1915.49	USGS
CE-VF-1	365232114554401	07/19/99	2464.20	548.81	1915.39	SNWA
CE-VF-1	365232114554401	10/19/99	2464.20	549.25	1914.95	SNWA
CE-VF-1	365232114554401	02/09/00	2464.20	548.85	1915.35	SNWA
CE-VF-1	365232114554401	07/07/00	2464.20	549.04	1915.16	SNWA
CE-VF-1	365232114554401	01/05/01	2464.20	549.3	1914.9	SNWA
CE-VF-2	365227114554401	07/11/81	2466.90	611.7	1855.2	BERGER et al., 1988
CE-VF-2	365227114554401	09/29/81	2466.90	609	1857.9	USGS

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
CE-VF-2	365227114554401	02/05/85	2466.90	603.1	1863.8	USGS
CE-VF-2	365227114554401	11/25/85	2466.90	602	1864.9	USGS
CE-VF-2	365227114554401	01/28/86	2466.90	604.62	1862.28	BERGER et al., 1988
CE-VF-2	365227114554401	01/29/86	2466.90	604.1	1862.8	USGS
CE-VF-2	365227114554401	02/04/86	2466.90	604.3	1862.6	USGS
CE-VF-2	365227114554401	02/05/86	2466.90	604.3	1862.6	USGS
CE-VF-2	365227114554401	02/06/86	2466.90	604.3	1862.6	TUMBUSCH et al., 1996
CE-VF-2	365227114554401	09/13/87	2466.90	609.7	1857.2	USGS
CE-VF-2	365227114554401	05/17/88	2466.90	609.6	1857.3	USGS
CE-VF-2	365227114554401	08/04/88	2466.90	609.8	1857.1	USGS
CE-VF-2	365227114554401	12/13/88	2466.90	609.02	1857.88	USGS
CE-VF-2	365227114554401	01/31/89	2466.90	609.5	1857.4	USGS
CE-VF-2	365227114554401	03/28/89	2466.90	609.8	1857.1	USGS
CE-VF-2	365227114554401	05/30/89	2466.90	609.7	1857.2	USGS
CE-VF-2	365227114554401	07/26/89	2466.90	609.6	1857.3	USGS
CE-VF-2	365227114554401	09/12/89	2466.90	609.9	1857	USGS
CE-VF-2	365227114554401	11/13/90	2466.90	609.7	1857.2	USGS
CE-VF-2	365227114554401	03/26/91	2466.90	609.7	1857.2	USGS
CE-VF-2	365227114554401	06/13/91	2466.90	610	1856.9	USGS
CE-VF-2	365227114554401	09/12/91	2466.90	610.1	1856.8	USGS
CE-VF-2	365227114554401	12/10/91	2466.90	609.7	1857.2	USGS
CE-VF-2	365227114554401	03/18/92	2466.90	610	1856.9	USGS
CE-VF-2	365227114554401	06/17/92	2466.90	609.9	1857	USGS
CE-VF-2	365227114554401	09/08/92	2466.90	610.3	1856.6	USGS
CE-VF-2	365227114554401	12/21/92	2466.90	610.6	1856.3	USGS
CE-VF-2	365227114554401	03/31/93	2466.90	610.3	1856.6	USGS
CE-VF-2	365227114554401	06/07/93	2466.90	610	1856.9	USGS
CE-VF-2	365227114554401	09/07/93	2466.90	610.1	1856.8	USGS
CE-VF-2	365227114554401	12/15/93	2466.90	609.8	1857.1	USGS
CE-VF-2	365227114554401	03/31/94	2466.90	610.1	1856.8	USGS
CE-VF-2	365227114554401	07/07/94	2466.90	609.79	1857.11	USGS
CE-VF-2	365227114554401	09/20/94	2466.90	609.56	1857.34	USGS
CE-VF-2	365227114554401	10/16/98	2466.90	609.8	1857.1	SNWA
CE-VF-2	365227114554401	01/22/99	2466.90	609.85	1857.05	SNWA
CE-VF-2	365227114554401	04/12/99	2466.90	609.78	1857.12	SNWA
CE-VF-2	365227114554401	07/19/99	2466.90	609.82	1857.08	SNWA
CE-VF-2	365227114554401	08/12/99	2466.90	609.65	1857.25	USGS
CE-VF-2	365227114554401	10/19/99	2466.90	610.3	1856.6	SNWA
CE-VF-2	365227114554401	02/09/00	2466.90	609.95	1856.95	SNWA
CE-VF-2	365227114554401	07/07/00	2466.90	610.52	1856.38	SNWA
CE-VF-2	365227114554401	08/17/00	2466.90	610.4	1856.5	USGS
CE-VF-2	365227114554401	10/24/00	2466.90	610.64	1856.26	SNWA
CE-VF-2	365227114554401	01/05/01	2466.90	610.34	1856.56	SNWA
CL-1	CHEM LIME	05/21/99		471.1	1815.38	JOHNSON, C. et al., 2001
CS-BUCKHORN		06/24/70	2573.21	37	2536	NDWR
CS-GORDON		07/11/77	2614.82	360	2255	NDWR
CS-JBR		12/19/96	2776.18	72	2704	NDWR
CSV-1	364601114514301	11/11/85	2158.60	343.9	1814.7	BERGER et al., 1988
CSV-1	364601114514301	12/17/85	2158.60	344.7	1813.9	BERGER et al., 1988
CSV-1	364601114514301	09/11/87	2158.60	343.44	1815.16	BERGER et al., 1988
CSV-1	364601114514301	05/18/88	2158.60	344.33	1814.27	USGS
CSV-1	364601114514301	08/03/88	2158.60	344.49	1814.11	USGS
CSV-1	364601114514301	12/08/88	2158.60	344.58	1814.02	USGS
CSV-1	364601114514301	01/20/89	2158.60	344.66	1813.94	USGS
CSV-1	364601114514301	01/31/89	2158.60	344.52	1814.08	USGS
CSV-1	364601114514301	03/28/89	2158.60	344.6	1814	USGS
CSV-1	364601114514301	05/30/89	2158.60	344.38	1814.22	USGS

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
CSV-1	364601114514301	07/26/89	2158.60	344.46	1814.14	USGS
CSV-1	364601114514301	09/12/89	2158.60	344.72	1813.88	USGS
CSV-1	364601114514301	11/13/90	2158.60	345.1	1813.5	USGS
CSV-1	364601114514301	03/26/91	2158.60	344.44	1814.16	USGS
CSV-1	364601114514301	06/13/91	2158.60	344.8	1813.8	USGS
CSV-1	364601114514301	09/12/91	2158.60	344.07	1814.53	USGS
CSV-1	364601114514301	12/10/91	2158.60	344.59	1814.01	USGS
CSV-1	364601114514301	03/18/92	2158.60	345.1	1813.5	USGS
CSV-1	364601114514301	06/15/92	2158.60	344.4	1814.2	USGS
CSV-1	364601114514301	09/14/92	2158.60	344.9	1813.7	USGS
CSV-1	364601114514301	12/09/92	2158.60	343.87	1814.73	USGS
CSV-1	364601114514301	03/30/93	2158.60	344.3	1814.3	USGS
CSV-1	364601114514301	06/08/93	2158.60	344.1	1814.5	USGS
CSV-1	364601114514301	09/09/93	2158.60	344.4	1814.2	USGS
CSV-1	364601114514301	12/17/93	2158.60	344.5	1814.1	USGS
CSV-1	364601114514301	03/31/94	2158.60	344.5	1814.1	USGS
CSV-1	364601114514301	06/16/94	2158.60	344.56	1814.04	USGS
CSV-1	364601114514301	09/08/94	2158.60	344.8	1813.8	USGS
CSV-1	364601114514301	07/22/98	2158.60	345.94	1812.66	SNWA
CSV-1	364601114514301	10/16/98	2158.60	345.3	1813.3	SNWA
CSV-1	364601114514301	01/22/99	2158.60	345.4	1813.2	SNWA
CSV-1	364601114514301	04/12/99	2158.60	345.45	1813.15	SNWA
CSV-1	364601114514301	07/19/99	2158.60	345.55	1813.05	SNWA
CSV-1	364601114514301	10/19/99	2158.60	346.22	1812.38	SNWA
CSV-1	364601114514301	02/09/00	2158.60	346.25	1812.35	SNWA
CSV-1	364601114514301	07/07/00	2158.60	345.67	1812.93	SNWA
CSV-1	364601114514301	08/17/00	2158.60	347.36	1811.24	USGS
CSV-1	364601114514301	10/17/00	2158.60	346.51	1812.09	SNWA
CSV-1	364601114514301	01/05/01	2158.60	346.11	1812.49	SNWA
CSV-2	364650114432001	02/06/85	2185.90	391.8	1794.1	USGS
CSV-2	364650114432001	10/27/85	2185.90	391.8	1794.1	USGS
CSV-2	364650114432001	12/30/85	2185.90	390.21	1795.69	USGS
CSV-2	364650114432001	06/07/86	2185.90	390.76	1795.14	USGS
CSV-2	364650114432001	09/11/87	2185.90	390.94	1794.96	USGS
CSV-2	364650114432001	05/17/88	2185.90	390.59	1795.31	USGS
CSV-2	364650114432001	08/03/88	2185.90	390.99	1794.91	USGS
CSV-2	364650114432001	12/21/88	2185.90	390.95	1794.95	USGS
CSV-2	364650114432001	01/20/89	2185.90	390.96	1794.94	USGS
CSV-2	364650114432001	01/31/89	2185.90	390.9	1795	USGS
CSV-2	364650114432001	03/28/89	2185.90	391.2	1794.7	USGS
CSV-2	364650114432001	05/30/89	2185.90	390.85	1795.05	USGS
CSV-2	364650114432001	07/26/89	2185.90	390.99	1794.91	USGS
CSV-2	364650114432001	09/12/89	2185.90	391.23	1794.67	USGS
CSV-2	364650114432001	03/29/90	2185.90	390.94	1794.96	USGS
CSV-2	364650114432001	06/08/90	2185.90	391.04	1794.86	USGS
CSV-2	364650114432001	08/14/90	2185.90	390.24	1795.66	USGS
CSV-2	364650114432001	09/28/90	2185.90	392.4	1793.5	USGS
CSV-2	364650114432001	10/29/90	2185.90	391.5	1794.4	USGS
CSV-2	364650114432001	02/06/91	2185.90	391.4	1794.5	USGS
CSV-2	364650114432001	03/26/91	2185.90	391.28	1794.62	USGS
CSV-2	364650114432001	04/09/91	2185.90	391.4	1794.5	USGS
CSV-2	364650114432001	05/30/91	2185.90	391	1794.9	USGS
CSV-2	364650114432001	07/30/91	2185.90	391.8	1794.1	USGS
CSV-2	364650114432001	09/04/91	2185.90	391.7	1794.2	USGS
CSV-2	364650114432001	10/08/91	2185.90	392	1793.9	USGS
CSV-2	364650114432001	11/08/91	2185.90	391.8	1794.1	USGS
CSV-2	364650114432001	01/10/92	2185.90	391.4	1794.5	USGS

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
CSV-2	364650114432001	01/14/92	2185.90	391.5	1794.4	USGS
CSV-2	364650114432001	02/12/92	2185.90	391.2	1794.7	USGS
CSV-2	364650114432001	03/18/92	2185.90	391.3	1794.6	USGS
CSV-2	364650114432001	04/21/92	2185.90	391	1794.9	USGS
CSV-2	364650114432001	04/29/92	2185.90	391	1794.9	USGS
CSV-2	364650114432001	05/12/92	2185.90	391.1	1794.8	USGS
CSV-2	364650114432001	05/19/92	2185.90	391	1794.9	USGS
CSV-2	364650114432001	05/20/92	2185.90	391	1794.9	USGS
CSV-2	364650114432001	06/15/92	2185.90	391.2	1794.7	USGS
CSV-2	364650114432001	06/18/92	2185.90	391.5	1794.4	USGS
CSV-2	364650114432001	07/29/92	2185.90	391.4	1794.5	USGS
CSV-2	364650114432001	08/18/92	2185.90	391.4	1794.5	USGS
CSV-2	364650114432001	09/14/92	2185.90	391.5	1794.4	USGS
CSV-2	364650114432001	10/07/92	2185.90	391.8	1794.1	USGS
CSV-2	364650114432001	12/09/92	2185.90	391.6	1794.3	USGS
CSV-2	364650114432001	02/25/93	2185.90	391	1794.9	USGS
CSV-2	364650114432001	03/30/93	2185.90	390.6	1795.3	USGS
CSV-2	364650114432001	04/26/93	2185.90	390.4	1795.5	USGS
CSV-2	364650114432001	06/08/93	2185.90	390.5	1795.4	USGS
CSV-2	364650114432001	07/02/93	2185.90	390.7	1795.2	USGS
CSV-2	364650114432001	07/15/93	2185.90	390.9	1795	USGS
CSV-2	364650114432001	07/29/93	2185.90	391	1794.9	USGS
CSV-2	364650114432001	09/09/93	2185.90	391.1	1794.8	USGS
CSV-2	364650114432001	10/14/93	2185.90	391	1794.9	USGS
CSV-2	364650114432001	11/18/93	2185.90	390.9	1795	USGS
CSV-2	364650114432001	12/17/93	2185.90	391.2	1794.7	USGS
CSV-2	364650114432001	02/14/94	2185.90	391.3	1794.6	USGS
CSV-2	364650114432001	03/01/94	2185.90	391.6	1794.3	USGS
CSV-2	364650114432001	04/05/94	2185.90	392.1	1793.8	USGS
CSV-2	364650114432001	06/15/94	2185.90	391.21	1794.69	USGS
CSV-2	364650114432001	09/08/94	2185.90	391.5	1794.4	USGS
CSV-2	364650114432001	01/19/95	2187.20	392.91	1794.29	KARL F. POHLMANN, 1996
CSV-2	364650114432001	08/09/95	2187.20	392.57	1794.63	KARL F. POHLMANN, 1996
CSV-2	364650114432001	10/19/95	2187.20	392.91	1794.29	
CSV-2	364650114432001	11/09/95	2187.20	392.46	1794.74	KARL F. POHLMANN, 1996
CSV-2	364650114432001	11/24/95	2187.20	392.66	1794.54	KARL F. POHLMANN, 1996
CSV-2	364650114432001	12/14/95	2187.20	392.66	1794.54	KARL F. POHLMANN, 1996
CSV-2	364650114432001	01/12/96	2187.20	392.36	1794.84	KARL F. POHLMANN, MARCH 1997
CSV-2	364650114432001	03/01/96	2187.20	392.36	1794.84	KARL F. POHLMANN, MARCH 1997
CSV-2	364650114432001	03/14/96	2187.20	392.31	1794.89	KARL F. POHLMANN, MARCH 1997
CSV-2	364650114432001	03/29/96	2185.90	390.8	1795.1	USGS
CSV-2	364650114432001	04/11/96	2187.20	392.26	1794.94	KARL F. POHLMANN, MARCH 1997
CSV-2	364650114432001	05/08/96	2187.20	391.85	1795.35	KARL F. POHLMANN, MARCH 1997
CSV-2	364650114432001	06/14/96	2187.20	392.05	1795.15	KARL F. POHLMANN, MARCH 1997
CSV-2	364650114432001	08/13/96	2187.20	392.35	1794.85	KARL F. POHLMANN, MARCH 1997
CSV-2	364650114432001	10/10/96	2187.20	392.64	1794.56	KARL F. POHLMANN, MARCH 1997
CSV-2	364650114432001	12/18/96	2187.20	392.42	1794.78	KARL F. POHLMANN, MARCH 1997
CSV-2	364650114432001	02/26/97	2185.90	390.6	1795.3	USGS
CSV-2	364650114432001	07/08/97	2185.90	391.1	1794.8	USGS
CSV-2	364650114432001	10/20/97	2185.90	391.4	1794.5	USGS
CSV-2	364650114432001	12/15/97	2185.90	391.1	1794.8	USGS
CSV-2	364650114432001	01/21/98	2187.20	392.69	1794.51	MVWD, APRIL 1998
CSV-2	364650114432001	02/12/98	2187.20	392.72	1794.48	MVWD, APRIL 1998
CSV-2	364650114432001	03/18/98	2187.20	392.69	1794.51	MVWD, APRIL 1998
CSV-2	364650114432001	04/16/98	2187.20	392.54	1794.66	MVWD, APRIL 1998
CSV-2	364650114432001	04/28/98	2185.90	390.9	1795	USGS
CSV-2	364650114432001	05/15/98	2187.20	392.64	1794.56	MVWD, APRIL 1998

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
CSV-2	364650114432001	06/17/98	2187.20	392.94	1794.26	
CSV-2	364650114432001	07/14/98	2187.20	393.06	1794.14	
CSV-2	364650114432001	08/13/98	2187.20	393.3	1793.9	MVWD 1998
CSV-2	364650114432001	09/15/98	2187.20	393.52	1793.68	
CSV-2	364650114432001	10/15/98	2187.20	393.58	1793.62	
CSV-2	364650114432001	10/27/98	2185.90	392.2	1793.7	USGS
CSV-2	364650114432001	11/13/98	2187.20	393.7	1793.5	
CSV-2	364650114432001	12/16/98	2187.20	393.64	1793.56	MVWD 1998
CSV-2	364650114432001	12/17/98	2185.90	392.06	1793.84	USGS
CSV-2	364650114432001	01/15/99	2187.20	393.53	1793.67	CONVERSE, 02/25/00
CSV-2	364650114432001	01/15/99	2187.20	393.53	1793.67	
CSV-2	364650114432001	02/16/99	2187.20	393.4	1793.8	CONVERSE, 02/25/00
CSV-2	364650114432001	02/16/99	2187.20	393.4	1793.8	
CSV-2	364650114432001	03/12/99	2187.20	393.38	1793.82	CONVERSE, 02/25/00
CSV-2	364650114432001	03/12/99	2187.20	393.38	1793.82	MVWD 1998
CSV-2	364650114432001	04/08/99	2185.90	391.8	1794.1	USGS
CSV-2	364650114432001	04/15/99	2187.20	393.38	1793.82	CONVERSE, 02/25/00
CSV-2	364650114432001	05/14/99	2187.20	393.22	1793.98	CONVERSE, 02/25/00
CSV-2	364650114432001	06/15/99	2187.20	393.64	1793.56	CONVERSE, 02/25/00
CSV-2	364650114432001	07/15/99	2187.20	393.84	1793.36	CONVERSE, 02/25/00
CSV-2	364650114432001	07/28/99	2185.90	392.6	1793.3	USGS
CSV-2	364650114432001	08/16/99	2187.20	394.18	1793.02	CONVERSE, 02/25/00
CSV-2	364650114432001	09/16/99	2187.20	394.24	1792.96	CONVERSE, 02/25/00
CSV-2	364650114432001	10/12/99	2187.20	394.34	1792.86	CONVERSE, 02/25/00
CSV-2	364650114432001	10/14/99	2185.90	392.44	1793.46	USGS
CSV-2	364650114432001	12/13/99	2185.90	392.28	1793.62	USGS
CSV-2	364650114432001	02/15/00	2187.20	394.11	1793.09	CONVERSE, 02/15/01
CSV-2	364650114432001	03/21/00	2187.20	393.74	1793.46	CONVERSE, 02/15/01
CSV-2	364650114432001	04/05/00	2185.90	392	1793.9	USGS
CSV-2	364650114432001	04/14/00	2187.20	393.62	1793.58	CONVERSE, 02/15/01
CSV-2	364650114432001	05/15/00	2187.20	393.81	1793.39	CONVERSE, 02/15/01
CSV-2	364650114432001	06/14/00	2187.20	394.18	1793.02	CONVERSE, 02/15/01
CSV-2	364650114432001	07/07/00	2185.90	392.9	1793	USGS
CSV-2	364650114432001	07/14/00	2187.20	394.44	1792.76	CONVERSE, 02/15/01
CSV-2	364650114432001	08/15/00	2187.20	394.58	1792.62	CONVERSE, 02/15/01
CSV-2	364650114432001	08/17/00	2185.90	391.15	1794.75	USGS
CSV-2	364650114432001	09/19/00	2187.20	394.75	1792.45	CONVERSE, 02/15/01
CSV-2	364650114432001	10/13/00	2187.20	395.18	1792.02	CONVERSE, 02/15/01
CSV-2	364650114432001	10/24/00	2185.90	393.25	1792.65	USGS
CSV-2	364650114432001	11/16/00	2187.20	394.98	1792.22	CONVERSE, 02/15/01
CSV-3	364127114553001	12/20/85	2414.30	585	1829.3	USGS
CSV-3	364127114553001	02/19/86	2414.30	587.5	1826.8	USGS
CSV-3	364127114553001	09/13/87	2414.30	589.45	1824.85	USGS
CSV-3	364127114553001	05/18/88	2414.30	589.3	1825	USGS
CSV-3	364127114553001	08/04/88	2414.30	589.4	1824.9	USGS
CSV-3	364127114553001	12/13/88	2414.30	589.02	1825.28	USGS
CSV-3	364127114553001	01/31/89	2414.30	589.5	1824.8	USGS
CSV-3	364127114553001	03/28/89	2414.30	588.7	1825.6	USGS
CSV-3	364127114553001	05/30/89	2414.30	588.6	1825.7	USGS
CSV-3	364127114553001	07/26/89	2414.30	588.6	1825.7	USGS
CSV-3	364127114553001	09/12/89	2414.30	588.8	1825.5	USGS
CSV-3	364127114553001	11/13/90	2414.30	589.6	1824.7	USGS
CSV-3	364127114553001	03/19/91	2414.30	589.3	1825	USGS
CSV-3	364127114553001	06/18/91	2414.30	589.6	1824.7	USGS
CSV-3	364127114553001	09/12/91	2414.30	589.9	1824.4	USGS
CSV-3	364127114553001	12/10/91	2414.30	589.6	1824.7	USGS
CSV-3	364127114553001	03/11/92	2414.30	589.7	1824.6	USGS

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
CSV-3	364127114553001	06/17/92	2414.30	589.5	1824.8	USGS
CSV-3	364127114553001	09/08/92	2414.30	589.6	1824.7	USGS
CSV-3	364127114553001	12/21/92	2414.30	589.9	1824.4	USGS
CSV-3	364127114553001	03/31/93	2414.30	589.4	1824.9	USGS
CSV-3	364127114553001	06/07/93	2414.30	589.5	1824.8	USGS
CSV-3	364127114553001	09/07/93	2414.30	589.8	1824.5	USGS
CSV-3	364127114553001	12/15/93	2414.30	589.6	1824.7	USGS
CSV-3	364127114553001	03/31/94	2414.30	589.2	1825.1	USGS
CSV-3	364127114553001	07/07/94	2414.30	589.02	1825.28	USGS
CSV-3	364127114553001	09/20/94	2414.30	590.16	1824.14	USGS
CSV-3	364127114553001	05/29/98	2414.30	589.61	1824.69	SNWA
CSV-3	364127114553001	07/22/98	2414.30	590.99	1823.31	SNWA
CSV-3	364127114553001	10/16/98	2414.30	589.31	1824.99	SNWA
CSV-3	364127114553001	01/22/99	2414.30	590.36	1823.94	SNWA
CSV-3	364127114553001	04/12/99	2414.30	589.66	1824.64	SNWA
CSV-3	364127114553001	07/19/99	2414.30	590.27	1824.03	SNWA
CSV-3	364127114553001	10/19/99	2414.30	589.18	1825.12	SNWA
CSV-3	364127114553001	07/07/00	2414.30	590.1	1824.2	USGS
CSV-3	364127114553001	08/17/00	2414.30	593.39	1820.91	USGS
CSV-3	364127114553001	10/17/00	2416.90	591.43	1825.47	SNWA
CW-BLM-1		02/11/49	1975.62	340	1636	NDWR
CW-BLM-2		06/17/49	2526.24	825	1701	NDWR
CW-CLARK		07/01/92	1983.27	321	1662	NDWR
CW-HALL		10/08/67	2108.65	212	1897	NDWR
CW-JONES		12/06/66	2177.05	258	1919	NDWR
CW-PEHLEN		07/03/51	2286.37	160	2126	NDWR
CW-SCC		04/24/58	2028.63	272	1757	NDWR
DF-1	DUTCHFLAT	07/22/98	2223.60	164.63	2058.97	SNWA
DF-1	DUTCHFLAT	10/16/98	2223.60	164.45	2059.15	SNWA
DF-1	DUTCHFLAT	01/22/99	2223.60	164.65	2058.95	SNWA
DF-1	DUTCHFLAT	04/12/99	2223.60	164.5	2059.1	SNWA
DF-1	DUTCHFLAT	07/19/99	2223.60	164.51	2059.09	SNWA
DF-1	DUTCHFLAT	10/19/99	2223.60	164.73	2058.87	SNWA
DF-1	DUTCHFLAT	02/09/00	2223.60	164.22	2059.38	SNWA
DF-1	DUTCHFLAT	06/07/00	2223.60	164.49	2059.11	SNWA
DF-1	DUTCHFLAT	10/24/00	2223.60	163.72	2059.88	SNWA
DF-1	DUTCHFLAT	01/05/01	2223.60	164.46	2059.14	SNWA
EBA-1	GEORGIA PACIFIC	06/12/05		607	1819.99	JOHNSON, C. et al., 2001
EBM-3	NV COGEN	08/21/00		577.05	1812.83	JOHNSON, C. et al., 2001
ECP-1	CALPINE	12/05/00		417.94	1815.61	JOHNSON, C. et al., 2001
ECP-2	CALPINE	12/05/00		416.86	1815.56	JOHNSON, C. et al., 2001
ECP-3	CALPINE	12/05/00		428.53	1815.1	JOHNSON, C. et al., 2001
EH-2	EH-2	01/11/94	1754.00	167.92	1586.08	KARL F. POHLMANN, JUNE 1995
EH-2	EH-2	02/08/94	1754.00	167.88	1586.12	KARL F. POHLMANN, JUNE 1995
EH-2	EH-2	04/08/94	1754.00	167.56	1586.44	KARL F. POHLMANN, JUNE 1995
EH-2	EH-2	10/04/94	1754.00	168.08	1585.92	KARL F. POHLMANN, JUNE 1995
EH-2	EH-2	04/05/95	1754.00	167.2	1586.8	KARL F. POHLMANN, 1996
EH-2	EH-2	06/16/95	1754.00	167.5	1586.5	KARL F. POHLMANN, 1996
EH-2	EH-2	12/14/95	1754.00	169.64	1584.36	KARL F. POHLMANN, 1996
EH-2	EH-2	03/14/96	1754.00	169.37	1584.63	KARL F. POHLMANN, MARCH 1997
EH-2	EH-2	05/08/96	1754.00	169.28	1584.72	KARL F. POHLMANN, MARCH 1997
EH-2	EH-2	06/14/96	1754.00	169.42	1584.58	KARL F. POHLMANN, MARCH 1997
EH-2	EH-2	08/13/96	1754.00	169.62	1584.38	KARL F. POHLMANN, MARCH 1997
EH-2	EH-2	09/13/96	1754.00	169.69	1584.31	KARL F. POHLMANN, MARCH 1997
EH-2	EH-2	12/18/96	1754.00	169.44	1584.56	KARL F. POHLMANN, MARCH 1997
EH-2	EH-2	05/06/97	1754.00	169.3	1584.7	KLEINFELDER, 02/17/00
EH-2	EH-2	06/25/97	1754.00	169.4	1584.6	KLEINFELDER, 02/17/00

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
EH-2	EH-2	09/24/97	1754.00	169.96	1584.04	KLEINFELDER, 02/17/00
EH-2	EH-2	12/16/97	1754.00	169.94	1584.06	KLEINFELDER, 02/17/00
EH-2	EH-2	03/18/98	1754.00	169.06	1584.94	KLEINFELDER, 02/17/00
EH-2	EH-2	06/30/98	1754.00	169.13	1584.87	KLEINFELDER, 02/17/00
EH-2	EH-2	10/02/98	1754.00	169.06	1584.94	KLEINFELDER, 02/17/00
EH-2	EH-2	12/31/98	1754.00	168.48	1585.52	KLEINFELDER, 02/17/00
EH-2	EH-2	03/12/99	1754.00	168.28	1585.72	CONVERSE, 02/25/00
EH-2	EH-2	03/30/99	1754.00	168.28	1585.72	KLEINFELDER, 02/17/00
EH-2	EH-2	06/14/99	1754.00	168.52	1585.48	CONVERSE, 02/25/00
EH-2	EH-2	06/24/99	1754.00	168.52	1585.48	KLEINFELDER, 02/17/00
EH-2	EH-2	09/16/99	1754.00	169.2	1584.8	CONVERSE, 02/25/00
EH-2	EH-2	09/21/99	1754.00	169.2	1584.8	KLEINFELDER, 02/17/00
EH-2	EH-2	12/21/99	1754.00	169.19	1584.81	KLEINFELDER, 02/17/00
EH-2	EH-2	12/28/99	1754.00	169.19	1584.81	CONVERSE, 02/25/00
EH-2	EH-2	03/21/00	1754.00	168.64	1585.36	CONVERSE, 02/15/01
EH-2A	EH-2A	01/11/94	1752.00	167.7	1584.3	KARL F. POHLMANN, JUNE 1995
EH-2A	EH-2A	04/08/94	1752.00	167.39	1584.61	KARL F. POHLMANN, JUNE 1995
EH-2A	EH-2A	08/12/94	1752.00	168.15	1583.85	KARL F. POHLMANN, JUNE 1995
EH-2A	EH-2A	10/04/94	1752.00	168.3	1583.7	KARL F. POHLMANN, JUNE 1995
EH-2A	EH-2A	04/05/95	1752.00	167.8	1584.2	KARL F. POHLMANN, 1996
EH-2A	EH-2A	06/16/95	1752.00	168.1	1583.9	KARL F. POHLMANN, 1996
EH-2A	EH-2A	12/14/95	1752.00	168.92	1583.08	KARL F. POHLMANN, 1996
EH-2A	EH-2A	03/14/96	1752.00	168.72	1583.28	KARL F. POHLMANN, MARCH 1997
EH-2A	EH-2A	05/08/96	1752.00	168.7	1583.3	KARL F. POHLMANN, MARCH 1997
EH-2A	EH-2A	06/14/96	1752.00	168.85	1583.15	KARL F. POHLMANN, MARCH 1997
EH-2A	EH-2A	08/13/96	1752.00	169.15	1582.85	KARL F. POHLMANN, MARCH 1997
EH-2A	EH-2A	09/13/96	1752.00	169.18	1582.82	KARL F. POHLMANN, MARCH 1997
EH-2A	EH-2A	12/18/96	1752.00	169.01	1582.99	KARL F. POHLMANN, MARCH 1997
EH-2A	EH-2A	05/06/97	1752.00	168.9	1583.1	KLEINFELDER, 02/17/00
EH-2A	EH-2A	06/25/97	1752.00	169.15	1582.85	KLEINFELDER, 02/17/00
EH-2A	EH-2A	09/24/97	1752.00	169.66	1582.34	KLEINFELDER, 02/17/00
EH-2A	EH-2A	12/16/97	1752.00	169.65	1582.35	KLEINFELDER, 02/17/00
EH-2A	EH-2A	03/18/98	1752.00	168.51	1583.49	KLEINFELDER, 02/17/00
EH-2A	EH-2A	06/30/98	1752.00	168.56	1583.44	KLEINFELDER, 02/17/00
EH-2A	EH-2A	10/02/98	1752.00	168.62	1583.38	KLEINFELDER, 02/17/00
EH-2A	EH-2A	12/31/98	1752.00	168.12	1583.88	KLEINFELDER, 02/17/00
EH-2A	EH-2A	03/12/99	1752.00	167.79	1584.21	CONVERSE, 02/25/00
EH-2A	EH-2A	03/30/99	1752.00	167.79	1584.21	KLEINFELDER, 02/17/00
EH-2A	EH-2A	06/14/99	1752.00	168.11	1583.89	CONVERSE, 02/25/00
EH-2A	EH-2A	06/24/99	1752.00	168.11	1583.89	KLEINFELDER, 02/17/00
EH-2A	EH-2A	09/16/99	1752.00	168.86	1583.14	CONVERSE, 02/25/00
EH-2A	EH-2A	09/21/99	1752.00	168.66	1583.34	KLEINFELDER, 02/17/00
EH-2A	EH-2A	12/21/99	1752.00	168.83	1583.17	KLEINFELDER, 02/17/00
EH-2A	EH-2A	12/28/99	1752.00	168.83	1583.17	CONVERSE, 02/25/00
EH-2A	EH-2A	03/21/00	1752.00	168.28	1583.72	CONVERSE, 02/15/01
EH-3	NORTH WEISER	01/11/94	1739.00	195.95	1543.05	KARL F. POHLMANN, JUNE 1995
EH-3	NORTH WEISER	04/08/94	1739.00	195.48	1543.52	KARL F. POHLMANN, JUNE 1995
EH-3	NORTH WEISER	07/02/94	1739.00	195.75	1543.25	KARL F. POHLMANN, JUNE 1995
EH-3	NORTH WEISER	10/04/94	1739.00	195.8	1543.2	KARL F. POHLMANN, JUNE 1995
EH-3	NORTH WEISER	01/09/95	1739.00	196	1543	KARL F. POHLMANN, 1996
EH-3	NORTH WEISER	04/05/95	1739.00	195.7	1543.3	KARL F. POHLMANN, 1996
EH-3	NORTH WEISER	06/16/95	1739.00	196.15	1542.85	KARL F. POHLMANN, 1996
EH-3	NORTH WEISER	09/07/95	1739.00	195.9	1543.1	KARL F. POHLMANN, 1996
EH-3	NORTH WEISER	12/14/95	1739.00	196.07	1542.93	KARL F. POHLMANN, 1996
EH-3	NORTH WEISER	03/14/96	1739.00	196.08	1542.92	KARL F. POHLMANN, MARCH 1997
EH-3	NORTH WEISER	05/08/96	1739.00	195.99	1543.01	KARL F. POHLMANN, MARCH 1997
EH-3	NORTH WEISER	06/14/96	1739.00	196.1	1542.9	KARL F. POHLMANN, MARCH 1997

APPENDIX C

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
EH-3	NORTH WEISER	09/13/96	1739.00	196.05	1542.95	KARL F. POHLMANN, MARCH 1997
EH-3	NORTH WEISER	12/18/96	1739.00	196.07	1542.93	KARL F. POHLMANN, MARCH 1997
EH-3	NORTH WEISER	04/25/97	1739.00	196.2	1542.8	KLEINFELDER, 02/17/00
EH-3	NORTH WEISER	06/25/97	1739.00	195.94	1543.06	KLEINFELDER, 02/17/00
EH-3	NORTH WEISER	09/24/97	1739.00	196.18	1542.82	KLEINFELDER, 02/17/00
EH-3	NORTH WEISER	12/15/97	1739.00	196.25	1542.75	KLEINFELDER, 02/17/00
EH-3	NORTH WEISER	03/18/98	1739.00	196.27	1542.73	KLEINFELDER, 02/17/00
EH-3	NORTH WEISER	06/30/98	1739.00	196.29	1542.71	KLEINFELDER, 02/17/00
EH-3	NORTH WEISER	12/31/98	1739.00	196.41	1542.59	KLEINFELDER, 02/17/00
EH-3	NORTH WEISER	04/15/99	1739.00	196.44	1542.56	CONVERSE, 02/25/00
EH-3	NORTH WEISER	04/14/00	1739.00	196.17	1542.83	CONVERSE, 02/15/01
EH-3	NORTH WEISER	09/20/00	1739.00	196.16	1542.84	CONVERSE, 02/15/01
EH-4	BATTLESHIP WASH	01/06/89	1932.77	116.75	1816.02	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	01/25/89	1932.77	116.77	1816	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	02/03/89	1932.77	116.64	1816.13	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	02/21/89	1932.77	116.77	1816	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	03/09/89	1932.77	116.66	1816.11	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	03/17/89	1932.77	116.61	1816.16	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	04/07/89	1932.77	116.6	1816.17	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	04/14/89	1932.77	116.58	1816.19	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	05/02/89	1932.77	116.59	1816.18	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	05/16/89	1932.77	116.56	1816.21	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	05/19/89	1932.77	116.62	1816.15	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	05/31/89	1932.77	116.7	1816.07	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	06/09/89	1932.77	116.57	1816.2	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	06/16/89	1932.77	116.6	1816.17	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	07/10/89	1932.77	116.75	1816.02	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	07/14/89	1932.77	116.81	1815.96	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	07/21/89	1932.77	116.8	1815.97	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	08/16/89	1932.77	116.83	1815.94	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	09/19/89	1932.77	116.96	1815.81	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	01/04/90	1932.77	116.93	1815.84	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	01/12/90	1932.77	116.77	1816	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	02/20/90	1932.77	116.86	1815.91	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	03/16/90	1932.77	116.82	1815.95	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	03/28/90	1932.77	116.62	1816.15	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	04/16/90	1932.77	116.55	1816.22	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	05/04/90	1932.77	116.73	1816.04	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	05/18/90	1932.77	116.62	1816.15	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	05/25/90	1932.77	116.7	1816.07	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	06/12/90	1932.77	116.65	1816.12	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	06/18/90	1932.77	116.76	1816.01	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	06/26/90	1932.77	116.72	1816.05	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	07/18/90	1932.77	116.83	1815.94	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	08/10/90	1932.77	116.92	1814.85	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	09/07/90	1932.77	117.03	1815.74	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	09/27/90	1932.77	117.08	1815.69	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	10/10/90	1932.77	117.02	1815.75	M.D. MIFFLIN, MAY 1991
EH-4	BATTLESHIP WASH	01/11/91	1932.77	117.11	1815.66	M.D. MIFFLIN, MAY 1992
EH-4	BATTLESHIP WASH	02/05/91	1932.77	116.97	1815.80	M.D. MIFFLIN, MAY 1992
EH-4	BATTLESHIP WASH	02/14/91	1932.77	116.95	1815.82	M.D. MIFFLIN, MAY 1992
EH-4	BATTLESHIP WASH	03/15/91	1932.77	116.79	1815.98	M.D. MIFFLIN, MAY 1992
EH-4	BATTLESHIP WASH	03/21/91	1932.77	116.81	1815.96	M.D. MIFFLIN, MAY 1992
EH-4	BATTLESHIP WASH	04/08/91	1932.77	116.81	1815.96	M.D. MIFFLIN, MAY 1992
EH-4	BATTLESHIP WASH	05/17/91	1932.77	116.69	1816.08	M.D. MIFFLIN, MAY 1992
EH-4	BATTLESHIP WASH	06/18/91	1932.77	116.82	1815.95	M.D. MIFFLIN, MAY 1992
EH-4	BATTLESHIP WASH	07/25/91	1932.77	116.94	1815.83	M.D. MIFFLIN, MAY 1992

APPENDIX C

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
EH-4	BATTLESHIP WASH	08/20/91	1932.77	117.06	1815.71	M.D. MIFFLIN, MAY 1992
EH-4	BATTLESHIP WASH	08/29/91	1932.77	117.12	1815.65	M.D. MIFFLIN, MAY 1992
EH-4	BATTLESHIP WASH	10/03/91	1932.77	117.2	1815.57	M.D. MIFFLIN, MAY 1992
EH-4	BATTLESHIP WASH	10/11/91	1932.77	117.18	1815.59	M.D. MIFFLIN, MAY 1992
EH-4	BATTLESHIP WASH	10/17/91	1932.77	117.15	1815.62	M.D. MIFFLIN, MAY 1992
EH-4	BATTLESHIP WASH	11/06/91	1932.77	117.12	1815.65	M.D. MIFFLIN, MAY 1992
EH-4	BATTLESHIP WASH	11/20/91	1932.77	117.28	1815.49	M.D. MIFFLIN, MAY 1992
EH-4	BATTLESHIP WASH	11/26/91	1932.77	117.13	1815.64	M.D. MIFFLIN, MAY 1992
EH-4	BATTLESHIP WASH	12/27/91	1932.77	117.08	1815.69	M.D. MIFFLIN, MAY 1992
EH-4	BATTLESHIP WASH	01/27/92	1932.77	117.01	1815.76	M.D. MIFFLIN, APRIL 1993
EH-4	BATTLESHIP WASH	02/24/92	1932.77	116.99	1815.78	M.D. MIFFLIN, APRIL 1993
EH-4	BATTLESHIP WASH	03/24/92	1932.77	116.87	1815.90	M.D. MIFFLIN, APRIL 1993
EH-4	BATTLESHIP WASH	04/21/92	1932.77	116.62	1816.15	M.D. MIFFLIN, APRIL 1993
EH-4	BATTLESHIP WASH	05/13/92	1932.77	116.65	1816.12	M.D. MIFFLIN, APRIL 1993
EH-4	BATTLESHIP WASH	06/12/92	1932.77	116.76	1816.01	M.D. MIFFLIN, APRIL 1993
EH-4	BATTLESHIP WASH	07/22/92	1932.77	116.78	1815.99	M.D. MIFFLIN, APRIL 1993
EH-4	BATTLESHIP WASH	08/18/92	1932.77	116.85	1815.92	M.D. MIFFLIN, APRIL 1993
EH-4	BATTLESHIP WASH	09/02/92	1932.77	116.92	1815.85	M.D. MIFFLIN, APRIL 1993
EH-4	BATTLESHIP WASH	09/10/92	1932.77	116.91	1815.86	M.D. MIFFLIN, APRIL 1993
EH-4	BATTLESHIP WASH	10/19/92	1932.77	116.89	1815.88	M.D. MIFFLIN, APRIL 1993
EH-4	BATTLESHIP WASH	12/01/92	1932.77	116.95	1815.82	M.D. MIFFLIN, APRIL 1993
EH-4	BATTLESHIP WASH	12/23/92	1932.77	116.9	1815.87	M.D. MIFFLIN, APRIL 1993
EH-4	BATTLESHIP WASH	01/13/93	1932.77	116.78	1815.99	M.D. MIFFLIN, APRIL 1994
EH-4	BATTLESHIP WASH	01/21/93	1932.77	116.75	1816.02	M.D. MIFFLIN, APRIL 1994
EH-4	BATTLESHIP WASH	02/05/93	1932.77	116.92	1815.85	M.D. MIFFLIN, APRIL 1994
EH-4	BATTLESHIP WASH	02/19/93	1932.77	116.34	1816.43	M.D. MIFFLIN, APRIL 1994
EH-4	BATTLESHIP WASH	03/24/93	1932.77	116.13	1816.64	M.D. MIFFLIN, APRIL 1994
EH-4	BATTLESHIP WASH	04/02/93	1932.77	115.1	1817.67	M.D. MIFFLIN, APRIL 1994
EH-4	BATTLESHIP WASH	04/30/93	1932.77	116.98	1815.79	M.D. MIFFLIN, APRIL 1994
EH-4	BATTLESHIP WASH	06/03/93	1932.77	116.05	1816.72	M.D. MIFFLIN, APRIL 1994
EH-4	BATTLESHIP WASH	07/07/93	1932.77	116.21	1816.56	M.D. MIFFLIN, APRIL 1994
EH-4	BATTLESHIP WASH	08/02/93	1932.77	116.42	1816.35	M.D. MIFFLIN, APRIL 1994
EH-4	BATTLESHIP WASH	09/03/93	1932.77	116.54	1816.23	M.D. MIFFLIN, APRIL 1994
EH-4	BATTLESHIP WASH	10/01/93	1932.77	116.53	1816.24	M.D. MIFFLIN, APRIL 1994
EH-4	BATTLESHIP WASH	11/12/93	1932.77	116.31	1816.46	M.D. MIFFLIN, APRIL 1994
EH-4	BATTLESHIP WASH	12/10/93	1932.77	116.45	1816.32	M.D. MIFFLIN, APRIL 1994
EH-4	BATTLESHIP WASH	01/05/94	1932.77	116.58	1816.19	KARL F. POHLMANN, JUNE 1995
EH-4	BATTLESHIP WASH	02/04/94	1932.77	116.74	1816.03	KARL F. POHLMANN, JUNE 1995
EH-4	BATTLESHIP WASH	03/04/94	1932.77	116.79	1815.98	KARL F. POHLMANN, JUNE 1995
EH-4	BATTLESHIP WASH	04/08/94	1932.77	116.82	1815.95	KARL F. POHLMANN, JUNE 1995
EH-4	BATTLESHIP WASH	05/06/94	1932.77	116.58	1816.19	KARL F. POHLMANN, JUNE 1995
EH-4	BATTLESHIP WASH	05/19/94	1932.77	116.74	1816.03	KARL F. POHLMANN, JUNE 1995
EH-4	BATTLESHIP WASH	06/09/94	1932.77	116.89	1815.88	KARL F. POHLMANN, JUNE 1995
EH-4	BATTLESHIP WASH	07/02/94	1932.77	116.83	1815.94	KARL F. POHLMANN, JUNE 1995
EH-4	BATTLESHIP WASH	08/12/94	1932.77	117	1815.77	KARL F. POHLMANN, JUNE 1995
EH-4	BATTLESHIP WASH	09/06/94	1932.77	117.21	1815.56	KARL F. POHLMANN, JUNE 1995
EH-4	BATTLESHIP WASH	10/04/94	1932.77	117.11	1815.66	KARL F. POHLMANN, JUNE 1995
EH-4	BATTLESHIP WASH	11/01/94	1932.77	117.12	1815.65	KARL F. POHLMANN, JUNE 1995
EH-4	BATTLESHIP WASH	12/08/94	1932.77	117.27	1815.5	KARL F. POHLMANN, JUNE 1995
EH-4	BATTLESHIP WASH	01/09/95	1932.77	116.98	1815.79	KARL F. POHLMANN, 1996
EH-4	BATTLESHIP WASH	02/08/95	1932.77	116.7	1816.07	KARL F. POHLMANN, 1996
EH-4	BATTLESHIP WASH	03/08/95	1932.77	116.7	1816.07	KARL F. POHLMANN, 1996
EH-4	BATTLESHIP WASH	04/05/95	1932.77	116.5	1816.27	KARL F. POHLMANN, 1996
EH-4	BATTLESHIP WASH	05/18/95	1932.77	116.49	1816.28	KARL F. POHLMANN, 1996
EH-4	BATTLESHIP WASH	06/16/95	1932.77	116.42	1816.35	KARL F. POHLMANN, 1996
EH-4	BATTLESHIP WASH	07/05/95	1932.77	116.64	1816.13	KARL F. POHLMANN, 1996
EH-4	BATTLESHIP WASH	08/09/95	1932.77	116.49	1816.28	KARL F. POHLMANN, 1996

APPENDIX C

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
EH-4	BATTLESHIP WASH	09/07/95	1932.77	116.86	1815.91	KARL F. POHLMANN, 1996
EH-4	BATTLESHIP WASH	10/12/95	1932.77	116.85	1815.92	KARL F. POHLMANN, 1996
EH-4	BATTLESHIP WASH	11/09/95	1932.77	116.72	1816.05	KARL F. POHLMANN, 1996
EH-4	BATTLESHIP WASH	11/24/95	1932.77	116.81	1815.96	KARL F. POHLMANN, 1996
EH-4	BATTLESHIP WASH	12/14/95	1932.77	116.69	1816.08	KARL F. POHLMANN, 1996
EH-4	BATTLESHIP WASH	01/12/96	1932.77	116.63	1816.14	M.D. MIFFLIN, JANUARY 1997
EH-4	BATTLESHIP WASH	03/01/96	1932.77	116.6	1816.17	M.D. MIFFLIN, JANUARY 1997
EH-4	BATTLESHIP WASH	03/14/96	1932.77	116.45	1816.32	M.D. MIFFLIN, JANUARY 1997
EH-4	BATTLESHIP WASH	04/11/96	1932.77	116.36	1816.41	M.D. MIFFLIN, JANUARY 1997
EH-4	BATTLESHIP WASH	05/08/96	1932.77	116.34	1816.43	M.D. MIFFLIN, JANUARY 1997
EH-4	BATTLESHIP WASH	06/14/96	1932.77	116.53	1816.24	M.D. MIFFLIN, JANUARY 1997
EH-4	BATTLESHIP WASH	08/13/96	1932.77	116.8	1815.97	M.D. MIFFLIN, JANUARY 1997
EH-4	BATTLESHIP WASH	09/13/96	1932.77	116.83	1815.94	M.D. MIFFLIN, JANUARY 1997
EH-4	BATTLESHIP WASH	10/10/96	1932.77	116.97	1815.8	KARL F. POHLMANN, MARCH 1997
EH-4	BATTLESHIP WASH	11/22/96	1932.77	116.74	1816.03	KARL F. POHLMANN, MARCH 1997
EH-4	BATTLESHIP WASH	12/18/96	1932.77	116.85	1815.92	KARL F. POHLMANN, MARCH 1997
EH-4	BATTLESHIP WASH	04/20/97	1932.77	116	1816.77	KLEINFELDER, 02/17/00
EH-4	BATTLESHIP WASH	06/26/97	1932.77	116.65	1816.12	KLEINFELDER, 02/17/00
EH-4	BATTLESHIP WASH	09/24/97	1932.77	116.94	1815.83	KLEINFELDER, 02/17/00
EH-4	BATTLESHIP WASH	12/15/97	1932.77	117.25	1815.52	KLEINFELDER, 02/17/00
EH-4	BATTLESHIP WASH	01/15/98	1932.77	117.4	1815.37	MVWD 1999
EH-4	BATTLESHIP WASH	01/21/98	1932.77	116.85	1815.92	MVWD 1999
EH-4	BATTLESHIP WASH	02/12/98	1932.77	116.9	1815.87	MVWD 1999
EH-4	BATTLESHIP WASH	03/18/98	1932.77	116.75	1816.02	KLEINFELDER, 02/17/00
EH-4	BATTLESHIP WASH	03/18/98	1932.77	116.75	1816.02	MVWD 1999
EH-4	BATTLESHIP WASH	04/16/98	1932.77	116.62	1816.15	MVWD 1999
EH-4	BATTLESHIP WASH	05/15/98	1932.77	116.79	1815.98	MVWD 1999
EH-4	BATTLESHIP WASH	06/17/98	1932.77	116.99	1815.78	MVWD 1999
EH-4	BATTLESHIP WASH	07/01/98	1932.77	116.99	1815.78	KLEINFELDER, 02/17/00
EH-4	BATTLESHIP WASH	07/14/98	1932.77	117.2	1815.57	MVWD 1999
EH-4	BATTLESHIP WASH	08/13/98	1932.77	117.44	1815.33	MVWD 1999
EH-4	BATTLESHIP WASH	09/15/98	1932.77	117.66	1815.11	MVWD 1999
EH-4	BATTLESHIP WASH	10/02/98	1932.77	117.66	1815.11	KLEINFELDER, 02/17/00
EH-4	BATTLESHIP WASH	10/15/98	1932.77	117.63	1815.14	MVWD 1999
EH-4	BATTLESHIP WASH	11/13/98	1932.77	117.77	1815	MVWD 1999
EH-4	BATTLESHIP WASH	12/16/98	1932.77	117.71	1815.06	MVWD 1999
EH-4	BATTLESHIP WASH	12/31/98	1932.77	117.71	1815.06	KLEINFELDER, 02/17/00
EH-4	BATTLESHIP WASH	01/15/99	1932.77	117.4	1815.37	CONVERSE, 02/25/00
EH-4	BATTLESHIP WASH	02/16/99	1932.77	117.48	1815.29	CONVERSE, 02/25/00
EH-4	BATTLESHIP WASH	03/12/99	1932.77	117.46	1815.31	CONVERSE, 02/25/00
EH-4	BATTLESHIP WASH	03/30/99	1932.77	117.46	1815.31	KLEINFELDER, 02/17/00
EH-4	BATTLESHIP WASH	04/15/99	1932.77	117.48	1815.29	CONVERSE, 02/25/00
EH-4	BATTLESHIP WASH	05/14/99	1932.77	117.38	1815.39	CONVERSE, 02/25/00
EH-4	BATTLESHIP WASH	06/15/99	1932.77	117.61	1815.16	CONVERSE, 02/25/00
EH-4	BATTLESHIP WASH	06/24/99	1932.77	117.61	1815.16	KLEINFELDER, 02/17/00
EH-4	BATTLESHIP WASH	07/15/99	1932.77	117.82	1814.95	CONVERSE, 02/25/00
EH-4	BATTLESHIP WASH	08/16/99	1932.77	118.13	1814.64	CONVERSE, 02/25/00
EH-4	BATTLESHIP WASH	09/16/99	1932.77	117.89	1814.88	CONVERSE, 02/25/00
EH-4	BATTLESHIP WASH	09/21/99	1932.77	117.89	1814.88	KLEINFELDER, 02/17/00
EH-4	BATTLESHIP WASH	10/12/99	1932.77	118.27	1814.5	CONVERSE, 02/25/00
EH-4	BATTLESHIP WASH	11/16/99	1932.77	118.01	1814.76	CONVERSE, 02/25/00
EH-4	BATTLESHIP WASH	12/21/99	1932.77	117.92	1814.85	KLEINFELDER, 02/17/00
EH-4	BATTLESHIP WASH	12/28/99	1932.77	117.92	1814.85	CONVERSE, 02/25/00
EH-4	BATTLESHIP WASH	01/14/00	1932.77	117.85	1814.92	CONVERSE, 02/15/01
EH-4	BATTLESHIP WASH	02/15/00	1932.77	117.69	1815.08	CONVERSE, 02/15/01
EH-4	BATTLESHIP WASH	03/21/00	1932.77	117.25	1815.52	CONVERSE, 02/15/01
EH-4	BATTLESHIP WASH	04/14/00	1932.77	117.63	1815.14	CONVERSE, 02/15/01

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
EH-4	BATTLESHIP WASH	05/15/00	1932.77	117.71	1815.06	CONVERSE, 02/15/01
EH-4	BATTLESHIP WASH	06/14/00	1932.77	117.95	1814.82	CONVERSE, 02/15/01
EH-4	BATTLESHIP WASH	07/14/00	1932.77	118.32	1814.45	CONVERSE, 02/15/01
EH-4	BATTLESHIP WASH	08/15/00	1932.77	118.43	1814.34	CONVERSE, 02/15/01
EH-4	BATTLESHIP WASH	09/19/00	1932.77	118.54	1814.23	CONVERSE, 02/15/01
EH-4	BATTLESHIP WASH	10/13/00	1932.77	118.71	1814.06	CONVERSE, 02/15/01
EH-4	BATTLESHIP WASH	11/16/00	1932.77	118.51	1814.26	CONVERSE, 02/15/01
EH-4	BATTLESHIP WASH	12/15/00	1932.77	118.47	1814.3	CONVERSE, 02/15/01
EH-5B		01/06/89	1842.69	27.91	1814.78	M.D. MIFFLIN, MAY 1991
EH-5B		03/17/89	1842.69	27.83	1814.86	M.D. MIFFLIN, MAY 1991
EH-5B		04/07/89	1842.69	27.76	1814.93	M.D. MIFFLIN, MAY 1991
EH-5B		04/14/89	1842.69	27.77	1814.92	M.D. MIFFLIN, MAY 1991
EH-5B		04/17/89	1842.69	27.77	1814.92	M.D. MIFFLIN, MAY 1991
EH-5B		05/16/89	1842.69	27.85	1814.84	M.D. MIFFLIN, MAY 1991
EH-5B		05/19/89	1842.69	27.98	1814.71	M.D. MIFFLIN, MAY 1991
EH-5B		06/09/89	1842.69	27.97	1814.72	M.D. MIFFLIN, MAY 1991
EH-5B		06/16/89	1842.69	28.2	1814.49	M.D. MIFFLIN, MAY 1991
EH-5B		07/10/89	1842.69	28.3	1814.39	M.D. MIFFLIN, MAY 1991
EH-5B		07/14/89	1842.69	28.32	1814.37	M.D. MIFFLIN, MAY 1991
EH-5B		07/21/89	1842.69	28.33	1814.36	M.D. MIFFLIN, MAY 1991
EH-5B		08/16/89	1842.69	28.32	1814.37	M.D. MIFFLIN, MAY 1991
EH-5B		09/19/89	1842.69	28.48	1814.21	M.D. MIFFLIN, MAY 1991
EH-5B		01/04/90	1842.69	28.18	1814.51	M.D. MIFFLIN, MAY 1991
EH-5B		01/12/90	1842.69	27.95	1814.74	M.D. MIFFLIN, MAY 1991
EH-5B		02/20/90	1842.69	28.02	1814.67	M.D. MIFFLIN, MAY 1991
EH-5B		03/16/90	1842.69	27.96	1814.73	M.D. MIFFLIN, MAY 1991
EH-5B		03/28/90	1842.69	27.82	1814.87	M.D. MIFFLIN, MAY 1991
EH-5B		04/16/90	1842.69	27.76	1814.93	M.D. MIFFLIN, MAY 1991
EH-5B		05/04/90	1842.69	27.97	1814.72	M.D. MIFFLIN, MAY 1991
EH-5B		05/18/90	1842.69	28.12	1814.57	M.D. MIFFLIN, MAY 1991
EH-5B		05/25/90	1842.69	28.08	1814.61	M.D. MIFFLIN, MAY 1991
EH-5B		06/12/90	1842.69	28.19	1814.5	M.D. MIFFLIN, MAY 1991
EH-5B		06/18/90	1842.69	28.17	1814.52	M.D. MIFFLIN, MAY 1991
EH-5B		06/26/90	1842.69	28.35	1814.34	M.D. MIFFLIN, MAY 1991
EH-5B		07/18/90	1842.69	28.35	1814.34	M.D. MIFFLIN, MAY 1991
EH-5B		08/10/90	1842.69	28.44	1814.25	M.D. MIFFLIN, MAY 1991
EH-5B		09/07/90	1842.69	28.63	1814.06	M.D. MIFFLIN, MAY 1991
EH-5B		09/27/90	1842.69	28.59	1814.1	M.D. MIFFLIN, MAY 1991
EH-5B		10/10/90	1842.69	28.42	1814.27	M.D. MIFFLIN, MAY 1991
EH-5B		01/11/91	1842.69	28.3	1814.39	M.D. MIFFLIN, MAY 1992
EH-5B		01/25/91	1842.69	28.31	1814.38	M.D. MIFFLIN, MAY 1992
EH-5B		02/05/91	1842.69	28.11	1814.58	M.D. MIFFLIN, MAY 1992
EH-5B		03/06/91	1842.69	28.07	1814.62	M.D. MIFFLIN, MAY 1992
EH-5B		03/15/91	1842.69	27.96	1814.73	M.D. MIFFLIN, MAY 1992
EH-5B		03/21/91	1842.69	27.99	1814.70	M.D. MIFFLIN, MAY 1992
EH-5B		04/08/91	1842.69	28.04	1814.65	M.D. MIFFLIN, MAY 1992
EH-5B		05/17/91	1842.69	27.9	1814.79	M.D. MIFFLIN, MAY 1992
EH-5B		06/18/91	1842.69	28.33	1814.36	M.D. MIFFLIN, MAY 1992
EH-5B		07/25/91	1842.69	28.59	1814.10	M.D. MIFFLIN, MAY 1992
EH-5B		07/26/91	1842.69	28.62	1814.07	M.D. MIFFLIN, MAY 1992
EH-5B		08/01/91	1842.69	28.61	1814.08	M.D. MIFFLIN, MAY 1992
EH-5B		08/20/91	1842.69	28.62	1814.07	M.D. MIFFLIN, MAY 1992
EH-5B		08/29/91	1842.69	28.63	1814.06	M.D. MIFFLIN, MAY 1992
EH-5B		10/03/91	1842.69	28.55	1814.14	M.D. MIFFLIN, MAY 1992
EH-5B		10/11/91	1842.69	28.52	1814.17	M.D. MIFFLIN, MAY 1992
EH-5B		10/17/91	1842.69	28.5	1814.19	M.D. MIFFLIN, MAY 1992
EH-5B		11/06/91	1842.69	28.36	1814.33	M.D. MIFFLIN, MAY 1992

APPENDIX C

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
EH-5B		11/20/91	1842.69	28.45	1814.24	M.D. MIFFLIN, MAY 1992
EH-5B		11/26/91	1842.69	28.34	1814.35	M.D. MIFFLIN, MAY 1992
EH-5B		12/27/91	1842.69	28.27	1814.42	M.D. MIFFLIN, MAY 1992
EH-5B		01/27/92	1842.69	28.24	1814.45	M.D. MIFFLIN, APRIL 1993
EH-5B		02/24/92	1842.69	28.19	1814.50	M.D. MIFFLIN, APRIL 1993
EH-5B		02/28/92	1842.69	28.11	1814.58	M.D. MIFFLIN, APRIL 1993
EH-5B		03/20/92	1842.69	27.96	1814.73	M.D. MIFFLIN, APRIL 1993
EH-5B		04/21/92	1842.69	27.8	1814.89	M.D. MIFFLIN, APRIL 1993
EH-5B		05/13/92	1842.69	27.93	1814.76	M.D. MIFFLIN, APRIL 1993
EH-5B		06/12/92	1842.69	28.24	1814.45	M.D. MIFFLIN, APRIL 1993
EH-5B		07/22/92	1842.69	27.98	1814.71	M.D. MIFFLIN, APRIL 1993
EH-5B		07/23/92	1842.69	28.01	1814.68	M.D. MIFFLIN, APRIL 1993
EH-5B		08/05/92	1842.69	28.08	1814.61	M.D. MIFFLIN, APRIL 1993
EH-5B		08/18/92	1842.69	28.11	1814.58	M.D. MIFFLIN, APRIL 1993
EH-5B		09/02/92	1842.69	28.19	1814.50	M.D. MIFFLIN, APRIL 1993
EH-5B		09/10/92	1842.69	28.16	1814.53	M.D. MIFFLIN, APRIL 1993
EH-5B		10/19/92	1842.69	27.96	1814.73	M.D. MIFFLIN, APRIL 1993
EH-5B		12/01/92	1842.69	27.93	1814.76	M.D. MIFFLIN, APRIL 1993
EH-5B		12/23/92	1842.69	27.98	1814.71	M.D. MIFFLIN, APRIL 1993
EH-5B		01/13/93	1842.69	27.76	1814.93	M.D. MIFFLIN, APRIL 1994
EH-5B		01/21/93	1842.69	27.75	1814.94	M.D. MIFFLIN, APRIL 1994
EH-5B		02/05/93	1842.69	27.62	1815.07	M.D. MIFFLIN, APRIL 1994
EH-5B		02/19/93	1842.69	27.29	1815.4	M.D. MIFFLIN, APRIL 1994
EH-5B		03/24/93	1842.69	27.12	1815.57	M.D. MIFFLIN, APRIL 1994
EH-5B		04/02/93	1842.69	27.13	1815.56	M.D. MIFFLIN, APRIL 1994
EH-5B		04/30/93	1842.69	27.04	1815.65	M.D. MIFFLIN, APRIL 1994
EH-5B		06/03/93	1842.69	27.35	1815.34	M.D. MIFFLIN, APRIL 1994
EH-5B		07/07/93	1842.69	27.55	1815.14	M.D. MIFFLIN, APRIL 1994
EH-5B		08/02/93	1842.69	27.82	1814.87	M.D. MIFFLIN, APRIL 1994
EH-5B		09/03/93	1842.69	27.92	1814.77	M.D. MIFFLIN, APRIL 1994
EH-5B		10/01/93	1842.69	27.9	1814.79	M.D. MIFFLIN, APRIL 1994
EH-5B		11/12/93	1842.69	27.42	1815.27	M.D. MIFFLIN, APRIL 1994
EH-5B		12/10/93	1842.69	27.54	1815.15	M.D. MIFFLIN, APRIL 1994
EH-5B		01/05/94	1842.69	27.64	1815.05	KARL F. POHLMANN, JUNE 1995
EH-5B		02/04/94	1842.69	27.81	1814.88	KARL F. POHLMANN, JUNE 1995
EH-5B		03/04/94	1842.69	27.86	1814.83	KARL F. POHLMANN, JUNE 1995
EH-5B		04/08/94	1842.69	27.84	1814.85	KARL F. POHLMANN, JUNE 1995
EH-5B		05/06/94	1842.69	27.77	1814.92	KARL F. POHLMANN, JUNE 1995
EH-5B		05/19/94	1842.69	28.09	1814.6	KARL F. POHLMANN, JUNE 1995
EH-5B		06/09/94	1842.69	28.3	1814.39	KARL F. POHLMANN, JUNE 1995
EH-5B		07/02/94	1842.69	28.23	1814.46	KARL F. POHLMANN, JUNE 1995
EH-5B		08/12/94	1842.69	28.4	1814.29	KARL F. POHLMANN, JUNE 1995
EH-5B		09/09/94	1842.69	28.56	1814.13	KARL F. POHLMANN, JUNE 1995
EH-5B		10/04/94	1842.69	28.44	1814.25	KARL F. POHLMANN, JUNE 1995
EH-5B		11/04/94	1842.69	28.38	1814.31	KARL F. POHLMANN, JUNE 1995
EH-5B		12/08/94	1842.69	28.53	1814.16	KARL F. POHLMANN, JUNE 1995
EH-5B		01/09/95	1842.69	28.08	1814.61	KARL F. POHLMANN, 1996
EH-5B		02/08/95	1842.69	27.75	1814.94	KARL F. POHLMANN, 1996
EH-5B		03/08/95	1842.69	27.84	1814.85	KARL F. POHLMANN, 1996
EH-5B		04/05/95	1842.69	27.53	1815.16	KARL F. POHLMANN, 1996
EH-5B		05/18/95	1842.69	27.58	1815.11	KARL F. POHLMANN, 1996
EH-5B		06/16/95	1842.69	27.68	1815.01	KARL F. POHLMANN, 1996
EH-5B		07/05/95	1842.69	27.89	1814.8	KARL F. POHLMANN, 1996
EH-5B		08/09/95	1842.69	28.13	1814.56	KARL F. POHLMANN, 1996
EH-5B		09/07/95	1842.69	28.29	1814.4	KARL F. POHLMANN, 1996
EH-5B		10/12/95	1842.69	28.17	1814.52	KARL F. POHLMANN, 1996
EH-5B		11/09/95	1842.69	27.86	1814.83	KARL F. POHLMANN, 1996

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
EH-5B		11/24/95	1842.69	27.92	1814.77	KARL F. POHLMANN, 1996
EH-5B		12/14/95	1842.69	27.87	1814.82	KARL F. POHLMANN, 1996
EH-5B		01/12/96	1842.69	27.7	1814.99	M.D. MIFFLIN, JANUARY 1997
EH-5B		03/01/96	1842.69	27.64	1815.05	M.D. MIFFLIN, JANUARY 1997
EH-5B		03/14/96	1842.69	27.56	1815.13	M.D. MIFFLIN, JANUARY 1997
EH-5B		04/11/96	1842.69	27.49	1815.2	M.D. MIFFLIN, JANUARY 1997
EH-5B		05/08/96	1842.69	27.55	1815.14	M.D. MIFFLIN, JANUARY 1997
EH-5B		06/14/96	1842.69	27.91	1814.78	M.D. MIFFLIN, JANUARY 1997
EH-5B		08/13/96	1842.69	28.16	1814.53	M.D. MIFFLIN, JANUARY 1997
EH-5B		09/13/96	1842.69	28.18	1814.51	M.D. MIFFLIN, JANUARY 1997
EH-5B		10/10/96	1842.69	28.25	1814.44	KARL F. POHLMANN, MARCH 1997
EH-5B		11/22/96	1842.69	27.89	1814.8	KARL F. POHLMANN, MARCH 1997
EH-5B		12/18/96	1842.69	27.93	1814.76	KARL F. POHLMANN, MARCH 1997
EH-5B		04/21/97	1842.69	27.7	1814.99	KLEINFELDER, 02/17/00
EH-5B		06/26/97	1842.69	27.88	1814.81	KLEINFELDER, 02/17/00
EH-5B		09/24/97	1842.69	28.35	1814.34	KLEINFELDER, 02/17/00
EH-5B		12/16/97	1842.69	28.15	1814.54	KLEINFELDER, 02/17/00
EH-5B		01/15/98	1842.69	28.84	1813.85	MVWD 1999
EH-5B		01/21/98	1842.69	27.86	1814.83	MVWD 1999
EH-5B		02/12/98	1842.69	27.95	1814.74	MVWD 1999
EH-5B		02/16/98	1842.69	28.52	1814.17	MVWD 1999
EH-5B		03/12/98	1842.69	28.58	1814.11	MVWD 1999
EH-5B		03/18/98	1842.69	27.88	1814.81	KLEINFELDER, 02/17/00
EH-5B		03/18/98	1842.69	27.88	1814.81	MVWD 1999
EH-5B		04/16/98	1842.69	27.8	1814.89	MVWD 1999
EH-5B		05/15/98	1842.69	27.91	1814.78	MVWD 1999
EH-5B		06/14/98	1842.69	28.61	1814.08	MVWD98
EH-5B		06/17/98	1842.69	28.25	1814.44	MVWD 1999
EH-5B		07/01/98	1842.69	28.25	1814.44	KLEINFELDER, 02/17/00
EH-5B		07/14/98	1842.69	28.61	1814.08	MVWD 1999
EH-5B		08/13/98	1842.69	28.85	1813.84	MVWD 1999
EH-5B		09/15/98	1842.69	28.83	1813.86	MVWD 1999
EH-5B		10/02/98	1842.69	28.83	1813.86	KLEINFELDER, 02/17/00
EH-5B		10/15/98	1842.69	28.99	1813.7	MVWD 1999
EH-5B		11/13/98	1842.69	28.98	1813.71	MVWD 1999
EH-5B		12/16/98	1842.69	28.75	1813.94	MVWD 1999
EH-5B		12/31/98	1842.69	28.95	1813.74	KLEINFELDER, 02/17/00
EH-5B		01/15/99	1842.69	28.84	1813.85	CONVERSE, 02/25/00
EH-5B		02/16/99	1842.69	28.52	1814.17	CONVERSE, 02/25/00
EH-5B		03/12/99	1842.69	28.58	1814.11	CONVERSE, 02/25/00
EH-5B		03/30/99	1842.69	28.58	1814.11	KLEINFELDER, 02/17/00
EH-5B		04/15/99	1842.69	28.41	1814.28	CONVERSE, 02/25/00
EH-5B		05/14/99	1842.69	28.35	1814.34	CONVERSE, 02/25/00
EH-5B		06/15/99	1842.69	28.85	1813.84	CONVERSE, 02/25/00
EH-5B		06/24/99	1842.69	28.85	1813.84	KLEINFELDER, 02/17/00
EH-5B		07/15/99	1842.69	29.15	1813.54	CONVERSE, 02/25/00
EH-5B		08/16/99	1842.69	29.48	1813.21	CONVERSE, 02/25/00
EH-5B		09/16/99	1842.69	29.55	1813.14	CONVERSE, 02/25/00
EH-5B		09/21/99	1842.69	29.55	1813.14	KLEINFELDER, 02/17/00
EH-5B		10/12/99	1842.69	29.45	1813.24	CONVERSE, 02/25/00
EH-5B		11/16/99	1842.69	28.98	1813.71	CONVERSE, 02/25/00
EH-5B		12/21/99	1842.69	28.89	1813.8	KLEINFELDER, 02/17/00
EH-5B		12/28/99	1842.69	28.89	1813.8	CONVERSE, 02/25/00
EH-5B		01/14/00	1842.69	28.81	1813.88	CONVERSE, 02/15/01
EH-5B		02/15/00	1842.69	28.8	1813.89	CONVERSE, 02/15/01
EH-5B		03/21/00	1842.69	28.65	1814.04	CONVERSE, 02/15/01
EH-5B		04/14/00	1842.69	28.62	1814.07	CONVERSE, 02/15/01

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
EH-5B		05/15/00	1842.69	28.94	1813.75	CONVERSE, 02/15/01
EH-5B		06/14/00	1842.69	29.42	1813.27	CONVERSE, 02/15/01
EH-5B		07/14/00	1842.69	29.71	1812.98	CONVERSE, 02/15/01
EH-5B		08/15/00	1842.69	29.79	1812.9	CONVERSE, 02/15/01
EH-5B		09/19/00	1842.69	29.75	1812.94	CONVERSE, 02/15/01
EH-5B		10/13/00	1842.69	29.9	1812.79	CONVERSE, 02/15/01
EH-5B		11/16/00	1842.69	29.59	1813.1	CONVERSE, 02/15/01
EH-5B		12/15/00	1842.69	29.47	1813.22	CONVERSE, 02/15/01
EH-7	SOUTH WEISER	01/11/94	1680.00	117.26	1562.74	KARL F. POHLMANN, JUNE 1995
EH-7	SOUTH WEISER	04/08/94	1680.00	117.04	1562.96	KARL F. POHLMANN, JUNE 1995
EH-7	SOUTH WEISER	05/19/94	1680.00	117.2	1562.8	KARL F. POHLMANN, JUNE 1995
EH-7	SOUTH WEISER	05/25/94	1680.00	117.13	1562.87	KARL F. POHLMANN, JUNE 1995
EH-7	SOUTH WEISER	07/02/94	1680.00	117.1	1562.9	KARL F. POHLMANN, JUNE 1995
EH-7	SOUTH WEISER	08/12/94	1680.00	117.22	1562.78	KARL F. POHLMANN, JUNE 1995
EH-7	SOUTH WEISER	09/06/94	1680.00	117.16	1562.84	KARL F. POHLMANN, JUNE 1995
EH-7	SOUTH WEISER	10/04/94	1680.00	117.25	1562.75	KARL F. POHLMANN, JUNE 1995
EH-7	SOUTH WEISER	12/08/94	1680.00	117.46	1562.54	KARL F. POHLMANN, JUNE 1995
EH-7	SOUTH WEISER	01/09/95	1680.00	117.2	1562.8	KARL F. POHLMANN, 1996
EH-7	SOUTH WEISER	04/05/95	1680.00	117.15	1562.85	KARL F. POHLMANN, 1996
EH-7	SOUTH WEISER	06/16/95	1680.00	117.27	1562.73	KARL F. POHLMANN, 1996
EH-7	SOUTH WEISER	09/07/95	1680.00	117.25	1562.75	KARL F. POHLMANN, 1996
EH-7	SOUTH WEISER	10/12/95	1680.00	117.31	1562.69	KARL F. POHLMANN, 1996
EH-7	SOUTH WEISER	12/14/95	1680.00	117.41	1562.59	KARL F. POHLMANN, 1996
EH-7	SOUTH WEISER	01/12/96	1680.00	117.33	1562.67	KARL F. POHLMANN, MARCH 1997
EH-7	SOUTH WEISER	03/14/96	1680.00	117.41	1562.59	KARL F. POHLMANN, MARCH 1997
EH-7	SOUTH WEISER	05/08/96	1680.00	117.31	1562.69	KARL F. POHLMANN, MARCH 1997
EH-7	SOUTH WEISER	06/14/96	1680.00	117.4	1562.6	KARL F. POHLMANN, MARCH 1997
EH-7	SOUTH WEISER	08/13/96	1680.00	117.25	1562.75	KARL F. POHLMANN, MARCH 1997
EH-7	SOUTH WEISER	09/13/96	1680.00	117.31	1562.69	KARL F. POHLMANN, MARCH 1997
EH-7	SOUTH WEISER	11/22/96	1680.00	117.25	1562.75	KARL F. POHLMANN, MARCH 1997
EH-7	SOUTH WEISER	12/18/96	1680.00	117.52	1562.48	KARL F. POHLMANN, MARCH 1997
EH-7	SOUTH WEISER	03/12/99	1680.00	117.63	1562.37	CONVERSE, 02/25/00
EH-7	SOUTH WEISER	06/14/99	1680.00	117.58	1562.42	CONVERSE, 02/25/00
EH-7	SOUTH WEISER	09/16/99	1680.00	117.43	1562.57	CONVERSE, 02/25/00
EH-7	SOUTH WEISER	12/28/99	1680.00	117.3	1562.7	CONVERSE, 02/25/00
EH-7	SOUTH WEISER	03/21/00	1680.00	117.35	1562.65	CONVERSE, 02/15/01
EH-7	SOUTH WEISER	06/15/00	1680.00	117.25	1562.75	CONVERSE, 02/15/01
EH-7	SOUTH WEISER	09/20/00	1680.00	117.26	1562.74	CONVERSE, 02/15/01
EH-7	SOUTH WEISER	12/15/00	1680.00	117.29	1562.71	CONVERSE, 02/15/01
GARNET		10/23/97	2066.00	282.8	1783.20	SNWA
GARNET		11/28/97	2066.00	283.58	1782.42	SNWA
GARNET		01/05/98	2066.00	281.88	1784.12	SNWA
GARNET		04/09/98	2066.00	278.56	1787.44	SNWA
GARNET		05/29/98	2066.00	282.71	1783.29	SNWA
GARNET		06/11/98	2066.00	275.05	1790.95	SNWA
GARNET		07/01/98	2066.00	275.62	1790.38	SNWA
GARNET		08/19/98	2066.00	283.4	1782.60	SNWA
GARNET		01/22/99	2066.00	283.4	1782.60	SNWA
GARNET		04/12/99	2066.00	282.7	1783.30	SNWA
GARNET		08/06/99	2066.00	283.77	1782.23	SNWA
GARNET		10/19/99	2066.00	284.15	1781.85	SNWA
GARNET		06/09/00	2066.00	283.84	1782.16	SNWA
GARNET		01/05/01	2066.00	284.5	1781.50	SNWA
GV-1	DRY LAKE LLC	06/04/00	2692.70	880.5	1812.2	JOHNSON, C. et al., 2001
GV-ET-1		03/23/89	2321.41	453	1868	NDWR
GV-GSC-1		03/30/87	2293.41	485	1808	NDWR
GV-KERR-1		02/07/90	2404.60	578	1827	NDWR

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
GV-NDOT		09/10/72	2066.37	240	1826	NDWR
GV-SSD-1		06/07/96	2450.12	645	1805	NDWR
GV-SSD-2		06/21/97	2449.17	610	1839	NDWR
GV-USLIME-1		09/13/63	2073.16	230	1843	NDWR
GV-USLIME-2		07/22/71	2155.33	338	1817	NDWR
HARVEY WELL		04/15/99	2066.80	253.79	1813.01	CONVERSE, 02/25/00
HARVEY WELL		06/14/99	2066.80	253.91	1812.89	CONVERSE, 02/25/00
HARVEY WELL		09/16/99	2066.80	254.43	1812.37	CONVERSE, 02/25/00
HARVEY WELL		12/28/99	2066.80	254.19	1812.61	CONVERSE, 02/25/00
HARVEY WELL		03/21/00	2066.80	254.1	1812.7	CONVERSE, 02/15/01
HARVEY WELL		06/15/00	2066.80	254.35	1812.45	CONVERSE, 02/15/01
HARVEY WELL		08/09/00	2066.80	254.8	1812	CONVERSE, 02/15/01
HARVEY WELL		08/15/00	2066.80	254.85	1811.95	CONVERSE, 02/15/01
HARVEY WELL		09/19/00	2066.80	254.84	1811.96	CONVERSE, 02/15/01
HARVEY WELL		12/15/00	2066.80	254.82	1811.98	CONVERSE, 02/15/01
HV-1	DRY LAKE LLC	05/10/00		882.5	1817.35	JOHNSON, C. et al., 2001
HV-HLA		09/19/95	2879.97	46	2834	NDWR
KS-GEYSER		01/10/68	3590.13	55	3535	NDWR
LDS-CENTRAL	UM49	01/04/90	1769.58	2.89	1766.69	M.D. MIFFLIN, MAY 1991
LDS-CENTRAL	UM49	01/12/90	1769.58	2.12	1767.46	M.D. MIFFLIN, MAY 1991
LDS-CENTRAL	UM49	02/20/90	1769.58	8.5	1761.08	M.D. MIFFLIN, MAY 1991
LDS-CENTRAL	UM49	03/16/90	1769.58	3.02	1766.56	M.D. MIFFLIN, MAY 1991
LDS-CENTRAL	UM49	04/16/90	1769.58	2.96	1766.62	M.D. MIFFLIN, MAY 1991
LDS-CENTRAL	UM49	05/04/90	1769.58	3.08	1766.5	M.D. MIFFLIN, MAY 1991
LDS-CENTRAL	UM49	05/18/90	1769.58	3.09	1766.49	M.D. MIFFLIN, MAY 1991
LDS-CENTRAL	UM49	05/25/90	1769.58	3.16	1766.42	M.D. MIFFLIN, MAY 1991
LDS-CENTRAL	UM49	06/12/90	1769.58	2.18	1767.4	M.D. MIFFLIN, MAY 1991
LDS-CENTRAL	UM49	07/10/90	1769.58	10.59	1758.99	M.D. MIFFLIN, MAY 1991
LDS-CENTRAL	UM49	07/18/90	1769.58	10.27	1759.31	M.D. MIFFLIN, MAY 1991
LDS-CENTRAL	UM49	08/10/90	1769.58	10.57	1759.01	M.D. MIFFLIN, MAY 1991
LDS-CENTRAL	UM49	09/07/90	1769.58	9.98	1759.6	M.D. MIFFLIN, MAY 1991
LDS-CENTRAL	UM49	09/27/90	1769.58	9.46	1760.12	M.D. MIFFLIN, MAY 1991
LDS-CENTRAL	UM49	10/12/90	1769.58	3.58	1766	M.D. MIFFLIN, MAY 1991
LDS-CENTRAL	UM49	01/11/91	1769.58	2.3	1767.28	M.D. MIFFLIN, MAY 1992
LDS-CENTRAL	UM49	02/05/91	1769.58	2.29	1767.29	M.D. MIFFLIN, MAY 1992
LDS-CENTRAL	UM49	03/06/91	1769.58	2.42	1767.16	M.D. MIFFLIN, MAY 1992
LDS-CENTRAL	UM49	03/21/91	1769.58	2.51	1767.07	M.D. MIFFLIN, MAY 1992
LDS-CENTRAL	UM49	04/06/91	1769.58	2.68	1766.90	M.D. MIFFLIN, MAY 1992
LDS-CENTRAL	UM49	05/16/91	1769.58	9.68	1759.90	M.D. MIFFLIN, MAY 1992
LDS-CENTRAL	UM49	06/18/91	1769.58	9.72	1759.86	M.D. MIFFLIN, MAY 1992
LDS-CENTRAL	UM49	07/25/91	1769.58	9.94	1759.64	M.D. MIFFLIN, MAY 1992
LDS-CENTRAL	UM49	08/20/91	1769.58	9.87	1759.71	M.D. MIFFLIN, MAY 1992
LDS-CENTRAL	UM49	09/20/91	1769.58	8.92	1760.66	M.D. MIFFLIN, MAY 1992
LDS-CENTRAL	UM49	10/11/91	1769.58	3.56	1766.02	M.D. MIFFLIN, MAY 1992
LDS-CENTRAL	UM49	11/06/91	1769.58	2.9	1766.68	M.D. MIFFLIN, MAY 1992
LDS-CENTRAL	UM49	11/26/91	1769.58	2.61	1766.97	M.D. MIFFLIN, MAY 1992
LDS-CENTRAL	UM49	12/27/91	1769.58	2.36	1767.22	M.D. MIFFLIN, MAY 1992
LDS-CENTRAL	UM49	01/27/92	1769.58	2.37	1767.21	M.D. MIFFLIN, APRIL 1993
LDS-CENTRAL	UM49	02/24/92	1769.58	2.41	1767.17	M.D. MIFFLIN, APRIL 1993
LDS-CENTRAL	UM49	03/20/92	1769.58	2.61	1766.97	M.D. MIFFLIN, APRIL 1993
LDS-CENTRAL	UM49	04/21/92	1769.58	3.04	1766.54	M.D. MIFFLIN, APRIL 1993
LDS-CENTRAL	UM49	05/13/92	1769.58	7.01	1762.57	M.D. MIFFLIN, APRIL 1993
LDS-CENTRAL	UM49	06/12/92	1769.58	3.7	1765.88	M.D. MIFFLIN, APRIL 1993
LDS-CENTRAL	UM49	07/23/92	1769.58	4.24	1765.34	M.D. MIFFLIN, APRIL 1993
LDS-CENTRAL	UM49	08/13/92	1769.58	4.41	1765.17	M.D. MIFFLIN, APRIL 1993
LDS-CENTRAL	UM49	09/10/92	1769.58	4	1765.58	M.D. MIFFLIN, APRIL 1993
LDS-CENTRAL	UM49	10/19/92	1769.58	3.54	1766.04	M.D. MIFFLIN, APRIL 1993

APPENDIX C

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
LDS-CENTRAL	UM49	12/01/92	1769.58	2.86	1766.72	M.D. MIFFLIN, APRIL 1993
LDS-CENTRAL	UM49	12/23/92	1769.58	2.82	1766.76	M.D. MIFFLIN, APRIL 1993
LDS-CENTRAL	UM49	01/05/94	1769.58	2.55	1767.03	KARL F. POHLMANN, JUNE 1995
LDS-CENTRAL	UM49	02/04/94	1769.58	2.46	1767.12	KARL F. POHLMANN, JUNE 1995
LDS-CENTRAL	UM49	03/04/94	1769.58	2.56	1767.02	KARL F. POHLMANN, JUNE 1995
LDS-CENTRAL	UM49	04/08/94	1769.58	2.78	1766.8	KARL F. POHLMANN, JUNE 1995
LDS-CENTRAL	UM49	05/06/94	1769.58	3.12	1766.46	KARL F. POHLMANN, JUNE 1995
LDS-CENTRAL	UM49	06/09/94	1769.58	3.82	1765.76	KARL F. POHLMANN, JUNE 1995
LDS-CENTRAL	UM49	07/02/94	1769.58	11.75	1757.83	KARL F. POHLMANN, JUNE 1995
LDS-CENTRAL	UM49	08/12/94	1769.58	11.95	1757.63	KARL F. POHLMANN, JUNE 1995
LDS-CENTRAL	UM49	09/06/94	1769.58	11.38	1758.2	KARL F. POHLMANN, JUNE 1995
LDS-CENTRAL	UM49	10/04/94	1769.58	11.9	1757.68	KARL F. POHLMANN, JUNE 1995
LDS-CENTRAL	UM49	11/01/94	1769.58	3.45	1766.13	KARL F. POHLMANN, JUNE 1995
LDS-CENTRAL	UM49	12/08/94	1769.58	2.83	1766.75	KARL F. POHLMANN, JUNE 1995
LDS-CENTRAL	UM49	01/09/95	1769.58	2.35	1767.23	KARL F. POHLMANN, 1996
LDS-CENTRAL	UM49	02/08/95	1769.58	2.15	1767.43	KARL F. POHLMANN, 1996
LDS-CENTRAL	UM49	03/08/95	1769.58	2.15	1767.43	KARL F. POHLMANN, 1996
LDS-CENTRAL	UM49	04/05/95	1769.58	2.35	1767.23	KARL F. POHLMANN, 1996
LDS-CENTRAL	UM49	05/18/95	1769.58	3.24	1766.34	KARL F. POHLMANN, 1996
LDS-CENTRAL	UM49	06/16/95	1769.58	10.17	1759.41	KARL F. POHLMANN, 1996
LDS-CENTRAL	UM49	07/05/95	1769.58	4.04	1765.54	KARL F. POHLMANN, 1996
LDS-CENTRAL	UM49	08/09/95	1769.58	10.56	1759.02	KARL F. POHLMANN, 1996
LDS-CENTRAL	UM49	09/07/95	1769.58	4.52	1765.06	KARL F. POHLMANN, 1996
LDS-CENTRAL	UM49	10/12/95	1769.58	3.81	1765.77	KARL F. POHLMANN, 1996
LDS-CENTRAL	UM49	11/09/95	1769.58	9.37	1760.21	KARL F. POHLMANN, 1996
LDS-CENTRAL	UM49	12/14/95	1769.58	2.8	1766.78	KARL F. POHLMANN, 1996
LDS-CENTRAL	UM49	01/12/96	1769.58	2.48	1767.1	KARL F. POHLMANN, MARCH 1997
LDS-CENTRAL	UM49	03/01/96	1769.58	2.36	1767.22	KARL F. POHLMANN, MARCH 1997
LDS-CENTRAL	UM49	03/14/96	1769.58	2.37	1767.21	KARL F. POHLMANN, MARCH 1997
LDS-CENTRAL	UM49	04/11/96	1769.58	2.56	1767.02	KARL F. POHLMANN, MARCH 1997
LDS-CENTRAL	UM49	05/08/96	1769.58	3.03	1766.55	KARL F. POHLMANN, MARCH 1997
LDS-CENTRAL	UM49	06/14/96	1769.58	3.55	1766.03	KARL F. POHLMANN, MARCH 1997
LDS-CENTRAL	UM49	08/13/96	1769.58	11.21	1758.37	KARL F. POHLMANN, MARCH 1997
LDS-CENTRAL	UM49	09/13/96	1769.58	10.75	1758.83	KARL F. POHLMANN, MARCH 1997
LDS-CENTRAL	UM49	10/10/96	1769.58	10.2	1759.38	KARL F. POHLMANN, MARCH 1997
LDS-CENTRAL	UM49	11/22/96	1769.58	3.05	1766.53	KARL F. POHLMANN, MARCH 1997
LDS-CENTRAL	UM49	12/18/96	1769.58	2.65	1766.93	KARL F. POHLMANN, MARCH 1997
LDS-CENTRAL	UM49	04/21/97	1769.58	9.1	1760.48	KLEINFELDER, 02/17/00
LDS-CENTRAL	UM49	06/26/97	1769.58	3.72	1765.86	KLEINFELDER, 02/17/00
LDS-CENTRAL	UM49	09/24/97	1769.58	4.26	1765.32	KLEINFELDER, 02/17/00
LDS-CENTRAL	UM49	12/16/97	1769.58	3.04	1766.54	KLEINFELDER, 02/17/00
LDS-CENTRAL	UM49	03/18/98	1769.58	9.04	1760.54	KLEINFELDER, 02/17/00
LDS-CENTRAL	UM49	07/01/98	1769.58	10.52	1759.06	KLEINFELDER, 02/17/00
LDS-CENTRAL	UM49	10/02/98	1769.58	3.7	1765.88	KLEINFELDER, 02/17/00
LDS-CENTRAL	UM49	12/31/98	1769.58	7.4	1762.18	KLEINFELDER, 02/17/00
LDS-CENTRAL	UM49	03/30/99	1769.58	2.72	1766.86	KLEINFELDER, 02/17/00
LDS-CENTRAL	UM49	06/24/99	1769.58	10.24	1759.34	KLEINFELDER, 02/17/00
LDS-CENTRAL	UM49	09/21/99	1769.58	9.78	1759.8	KLEINFELDER, 02/17/00
LDS-CENTRAL	UM49	12/22/99	1769.58	10.19	1759.39	KLEINFELDER, 02/17/00
LDS-CENTRAL	UM49	01/14/00	1769.58	3.06	1766.52	CONVERSE, 02/15/01
LDS-CENTRAL	UM49	02/15/00	1769.58	9.55	1760.03	CONVERSE, 02/15/01
LDS-CENTRAL	UM49	03/21/00	1769.58	10.1	1759.48	CONVERSE, 02/15/01
LDS-CENTRAL	UM49	04/14/00	1769.58	9.77	1759.81	CONVERSE, 02/15/01
LDS-CENTRAL	UM49	05/15/00	1769.58	3.87	1765.71	CONVERSE, 02/15/01
LDS-CENTRAL	UM49	06/14/00	1769.58	12.14	1757.44	CONVERSE, 02/15/01
LDS-CENTRAL	UM49	07/14/00	1769.58	11.96	1757.62	CONVERSE, 02/15/01
LDS-CENTRAL	UM49	08/15/00	1769.58	4.63	1764.95	CONVERSE, 02/15/01

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
LDS-CENTRAL	UM49	09/19/00	1769.58	8.63	1760.95	CONVERSE, 02/15/01
LDS-CENTRAL	UM49	10/13/00	1769.58	8.56	1761.02	CONVERSE, 02/15/01
LDS-CENTRAL	UM49	11/16/00	1769.58	3.99	1765.59	CONVERSE, 02/15/01
LDS-CENTRAL	UM49	12/15/00	1769.58	8.58	1761	CONVERSE, 02/15/01
LDS-WEST	UM18	01/12/90	1807.34	19.98	1787.36	M.D. MIFFLIN, MAY 1991
LDS-WEST	UM18	02/20/90	1807.34	17.71	1789.63	M.D. MIFFLIN, MAY 1991
LDS-WEST	UM18	03/16/90	1807.34	17.81	1789.53	M.D. MIFFLIN, MAY 1991
LDS-WEST	UM18	04/16/90	1807.34	17.49	1789.85	M.D. MIFFLIN, MAY 1991
LDS-WEST	UM18	05/18/90	1807.34	19.07	1788.27	M.D. MIFFLIN, MAY 1991
LDS-WEST	UM18	05/25/90	1807.34	19.44	1787.9	M.D. MIFFLIN, MAY 1991
LDS-WEST	UM18	06/12/90	1807.34	22.6	1784.74	M.D. MIFFLIN, MAY 1991
LDS-WEST	UM18	07/10/90	1807.34	26.71	1780.63	M.D. MIFFLIN, MAY 1991
LDS-WEST	UM18	07/18/90	1807.34	24.96	1782.38	M.D. MIFFLIN, MAY 1991
LDS-WEST	UM18	08/10/90	1807.34	29.95	1777.39	M.D. MIFFLIN, MAY 1991
LDS-WEST	UM18	09/07/90	1807.34	31	1776.34	M.D. MIFFLIN, MAY 1991
LDS-WEST	UM18	09/27/90	1807.34	30.16	1777.18	M.D. MIFFLIN, MAY 1991
LDS-WEST	UM18	10/16/90	1807.34	22.55	1784.79	M.D. MIFFLIN, MAY 1991
LDS-WEST	UM18	01/11/91	1807.34	18.12	1789.22	M.D. MIFFLIN, MAY 1992
LDS-WEST	UM18	02/25/91	1807.34	17.82	1789.52	M.D. MIFFLIN, MAY 1992
LDS-WEST	UM18	03/06/91	1807.34	17.36	1789.98	M.D. MIFFLIN, MAY 1992
LDS-WEST	UM18	03/21/91	1807.34	16.88	1790.46	M.D. MIFFLIN, MAY 1992
LDS-WEST	UM18	04/08/91	1807.34	16.72	1790.62	M.D. MIFFLIN, MAY 1992
LDS-WEST	UM18	05/16/91	1807.34	18.04	1789.30	M.D. MIFFLIN, MAY 1992
LDS-WEST	UM18	06/18/91	1807.34	28.97	1778.37	M.D. MIFFLIN, MAY 1992
LDS-WEST	UM18	07/25/91	1807.34	24.05	1783.29	M.D. MIFFLIN, MAY 1992
LDS-WEST	UM18	08/20/91	1807.34	25.08	1782.26	M.D. MIFFLIN, MAY 1992
LDS-WEST	UM18	09/20/91	1807.34	29.72	1777.62	M.D. MIFFLIN, MAY 1992
LDS-WEST	UM18	11/06/91	1807.34	23.02	1784.32	M.D. MIFFLIN, MAY 1992
LDS-WEST	UM18	11/26/91	1807.34	19.43	1787.91	M.D. MIFFLIN, MAY 1992
LDS-WEST	UM18	12/27/91	1807.34	18.31	1789.03	M.D. MIFFLIN, MAY 1992
LDS-WEST	UM18	01/27/92	1807.34	19.98	1787.36	M.D. MIFFLIN, APRIL 1993
LDS-WEST	UM18	02/24/92	1807.34	17.41	1789.93	M.D. MIFFLIN, APRIL 1993
LDS-WEST	UM18	03/24/92	1807.34	16.75	1790.59	M.D. MIFFLIN, APRIL 1993
LDS-WEST	UM18	04/21/92	1807.34	17.05	1790.29	M.D. MIFFLIN, APRIL 1993
LDS-WEST	UM18	05/13/92	1807.34	18.41	1788.93	M.D. MIFFLIN, APRIL 1993
LDS-WEST	UM18	06/12/92	1807.34	31.46	1775.88	M.D. MIFFLIN, APRIL 1993
LDS-WEST	UM18	07/22/92	1807.34	29.94	1777.40	M.D. MIFFLIN, APRIL 1993
LDS-WEST	UM18	08/13/92	1807.34	31.76	1775.58	M.D. MIFFLIN, APRIL 1993
LDS-WEST	UM18	09/10/92	1807.34	34.44	1772.90	M.D. MIFFLIN, APRIL 1993
LDS-WEST	UM18	10/19/92	1807.34	20.95	1786.39	M.D. MIFFLIN, APRIL 1993
LDS-WEST	UM18	12/01/92	1807.34	18.58	1788.76	M.D. MIFFLIN, APRIL 1993
LDS-WEST	UM18	12/23/92	1807.34	18.16	1789.18	M.D. MIFFLIN, APRIL 1993
LDS-WEST	UM18	01/05/94	1807.34	18.39	1788.95	KARL F. POHLMANN, JUNE 1995
LDS-WEST	UM18	02/04/94	1807.34	17.94	1789.4	KARL F. POHLMANN, JUNE 1995
LDS-WEST	UM18	03/04/94	1807.34	17.83	1789.51	KARL F. POHLMANN, JUNE 1995
LDS-WEST	UM18	04/08/94	1807.34	17.32	1790.02	KARL F. POHLMANN, JUNE 1995
LDS-WEST	UM18	05/06/94	1807.34	18.63	1788.71	KARL F. POHLMANN, JUNE 1995
LDS-WEST	UM18	06/09/94	1807.34	30.83	1776.51	KARL F. POHLMANN, JUNE 1995
LDS-WEST	UM18	07/02/94	1807.34	34.35	1772.99	KARL F. POHLMANN, JUNE 1995
LDS-WEST	UM18	08/12/94	1807.34	38.4	1768.94	KARL F. POHLMANN, JUNE 1995
LDS-WEST	UM18	09/06/94	1807.34	33.3	1774.04	KARL F. POHLMANN, JUNE 1995
LDS-WEST	UM18	10/04/94	1807.34	32.8	1774.54	KARL F. POHLMANN, JUNE 1995
LDS-WEST	UM18	11/01/94	1807.34	32.4	1774.94	KARL F. POHLMANN, JUNE 1995
LDS-WEST	UM18	12/08/94	1807.34	23.26	1784.08	KARL F. POHLMANN, JUNE 1995
LDS-WEST	UM18	01/09/95	1807.34	19.38	1787.96	KARL F. POHLMANN, 1996
LDS-WEST	UM18	02/08/95	1807.34	17.97	1789.37	KARL F. POHLMANN, 1996
LDS-WEST	UM18	03/08/95	1807.34	16.24	1791.1	KARL F. POHLMANN, 1996

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
LDS-WEST	UM18	04/05/95	1807.34	16.96	1790.38	KARL F. POHLMANN, 1996
LDS-WEST	UM18	05/18/95	1807.34	16.94	1790.4	KARL F. POHLMANN, 1996
LDS-WEST	UM18	06/16/95	1807.34	24.48	1782.86	KARL F. POHLMANN, 1996
LDS-WEST	UM18	07/05/95	1807.34	48	1759.34	KARL F. POHLMANN, 1996
LDS-WEST	UM18	08/09/95	1807.34	29.1	1778.24	KARL F. POHLMANN, 1996
LDS-WEST	UM18	09/07/95	1807.34	29.9	1777.44	KARL F. POHLMANN, 1996
LDS-WEST	UM18	10/12/95	1807.34	24.84	1782.5	KARL F. POHLMANN, 1996
LDS-WEST	UM18	11/09/95	1807.34	31.38	1775.96	KARL F. POHLMANN, 1996
LDS-WEST	UM18	11/24/95	1807.34	30.25	1777.09	KARL F. POHLMANN, 1996
LDS-WEST	UM18	01/12/96	1807.34	19.33	1788.01	KARL F. POHLMANN, MARCH 1997
LDS-WEST	UM18	03/01/96	1807.34	17.46	1789.88	KARL F. POHLMANN, MARCH 1997
LDS-WEST	UM18	03/14/96	1807.34	17.17	1790.17	KARL F. POHLMANN, MARCH 1997
LDS-WEST	UM18	04/11/96	1807.34	16.79	1790.55	KARL F. POHLMANN, MARCH 1997
LDS-WEST	UM18	05/08/96	1807.34	17.99	1789.35	KARL F. POHLMANN, MARCH 1997
LDS-WEST	UM18	06/14/96	1807.34	29.05	1778.29	KARL F. POHLMANN, MARCH 1997
LDS-WEST	UM18	08/13/96	1807.34	30.14	1777.2	KARL F. POHLMANN, MARCH 1997
LDS-WEST	UM18	09/13/96	1807.34	38.5	1768.84	KARL F. POHLMANN, MARCH 1997
LDS-WEST	UM18	10/10/96	1807.34	36.25	1771.09	KARL F. POHLMANN, MARCH 1997
LDS-WEST	UM18	11/22/96	1807.34	20.04	1787.3	KARL F. POHLMANN, MARCH 1997
LDS-WEST	UM18	12/18/96	1807.34	27.7	1779.64	KARL F. POHLMANN, MARCH 1997
LDS-WEST	UM18	01/15/99	1807.34	35.05	1772.29	CONVERSE, 02/25/00
LDS-WEST	UM18	02/16/99	1807.34	21.22	1786.12	CONVERSE, 02/25/00
LDS-WEST	UM18	03/12/99	1807.34	19.1	1788.24	CONVERSE, 02/25/00
LDS-WEST	UM18	04/15/99	1807.34	17.89	1789.45	CONVERSE, 02/25/00
LDS-WEST	UM18	05/14/99	1807.34	30.08	1777.26	CONVERSE, 02/25/00
LDS-WEST	UM18	06/14/99	1807.34	29.14	1778.2	CONVERSE, 02/25/00
LDS-WEST	UM18	07/15/99	1807.34	31.59	1775.75	CONVERSE, 02/25/00
LDS-WEST	UM18	08/16/99	1807.34	36.98	1770.36	CONVERSE, 02/25/00
LDS-WEST	UM18	09/16/99	1807.34	35.99	1771.35	CONVERSE, 02/25/00
LDS-WEST	UM18	10/12/99	1807.34	25.12	1782.22	CONVERSE, 02/25/00
LDS-WEST	UM18	11/16/99	1807.34	31.55	1775.79	CONVERSE, 02/25/00
LDS-WEST	UM18	12/28/99	1807.34	27.95	1779.39	CONVERSE, 02/25/00
LDS-WEST	UM18	01/14/00	1807.34	19.06	1788.28	CONVERSE, 02/15/01
LDS-WEST	UM18	02/15/00	1807.34	19.44	1787.9	CONVERSE, 02/15/01
LDS-WEST	UM18	03/21/00	1807.34	17.58	1789.76	CONVERSE, 02/15/01
LDS-WEST	UM18	04/14/00	1807.34	16.26	1791.08	CONVERSE, 02/15/01
LDS-WEST	UM18	05/15/00	1807.34	18.52	1788.82	CONVERSE, 02/15/01
LDS-WEST	UM18	06/14/00	1807.34	22.16	1785.18	CONVERSE, 02/15/01
LDS-WEST	UM18	07/14/00	1807.34	35.04	1772.3	CONVERSE, 02/15/01
LDS-WEST	UM18	08/15/00	1807.34	38.98	1768.36	CONVERSE, 02/15/01
LDS-WEST	UM18	09/19/00	1807.34	35.27	1772.07	CONVERSE, 02/15/01
LDS-WEST	UM18	11/16/00	1807.34	32.56	1774.78	CONVERSE, 02/15/01
LDS-WEST	UM18	12/15/00	1807.34	31.47	1775.87	CONVERSE, 02/15/01
LEWIS-FARM		01/05/94	1827.00	24.4	1802.60	KARL F. POHLMANN, JUNE 1995
LEWIS-FARM		02/04/94	1827.00	24.35	1802.65	KARL F. POHLMANN, JUNE 1995
LEWIS-FARM		03/04/94	1827.00	24.6	1802.40	KARL F. POHLMANN, JUNE 1995
LEWIS-FARM		04/08/94	1827.00	24.17	1802.83	KARL F. POHLMANN, JUNE 1995
LEWIS-FARM		05/06/94	1827.00	27.54	1799.46	KARL F. POHLMANN, JUNE 1995
LEWIS-FARM		05/19/94	1827.00	27.96	1799.04	KARL F. POHLMANN, JUNE 1995
LEWIS-FARM		06/09/94	1827.00	28.16	1798.84	KARL F. POHLMANN, JUNE 1995
LEWIS-FARM		07/02/94	1827.00	28.16	1798.84	KARL F. POHLMANN, JUNE 1995
LEWIS-FARM		08/12/94	1827.00	28.14	1798.86	KARL F. POHLMANN, JUNE 1995
LEWIS-FARM		09/06/94	1827.00	28.17	1798.83	KARL F. POHLMANN, JUNE 1995
LEWIS-FARM		10/04/94	1827.00	28.04	1798.96	KARL F. POHLMANN, JUNE 1995
LEWIS-FARM		11/01/94	1827.00	28.02	1798.98	KARL F. POHLMANN, JUNE 1995
LEWIS-FARM		12/08/94	1827.00	27.24	1799.76	KARL F. POHLMANN, JUNE 1995
LEWIS-FARM		01/09/95	1827.00	25	1802.00	KARL F. POHLMANN, JUNE 1996

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
LEWIS-FARM		02/08/95	1827.00	24.06	1802.94	KARL F. POHLMANN, JUNE 1996
LEWIS-FARM		03/08/95	1827.00	26.68	1800.32	KARL F. POHLMANN, JUNE 1996
LEWIS-FARM		04/05/95	1827.00	23.59	1803.41	KARL F. POHLMANN, JUNE 1996
LEWIS-FARM		05/18/95	1827.00	23.55	1803.45	KARL F. POHLMANN, JUNE 1996
LEWIS-FARM		06/16/95	1827.00	27.34	1799.66	KARL F. POHLMANN, JUNE 1996
LEWIS-FARM		07/05/95	1827.00	27.82	1799.18	KARL F. POHLMANN, JUNE 1996
LEWIS-FARM		08/09/95	1827.00	27.97	1799.03	KARL F. POHLMANN, JUNE 1996
LEWIS-FARM		09/07/95	1827.00	28.04	1798.96	KARL F. POHLMANN, JUNE 1996
LEWIS-FARM		10/12/95	1827.00	27.34	1799.66	KARL F. POHLMANN, JUNE 1996
LEWIS-FARM		10/19/95	1827.00	27.14	1799.86	KARL F. POHLMANN, JUNE 1996
LEWIS-NORTH	UM45	05/05/83	1842.42	31.96	1810.46	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	07/14/83	1842.42	32.56	1809.86	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	09/21/83	1842.42	32.83	1809.59	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	11/30/83	1842.42	31.9	1810.52	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	12/23/83	1842.42	31.62	1810.80	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	02/03/84	1842.42	31.71	1810.71	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	04/03/84	1842.42	31.62	1810.80	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	05/29/84	1842.42	32.55	1809.87	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	09/14/84	1842.42	32.37	1810.05	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	11/02/84	1842.42	31.85	1810.57	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	12/14/84	1842.42	31.35	1811.07	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	02/15/85	1842.42	31.04	1811.38	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	03/01/85	1842.42	31.12	1811.30	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	03/16/85	1842.42	30.62	1811.80	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	05/17/85	1842.42	32.05	1810.37	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	07/02/85	1842.42	32.81	1809.61	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	08/07/85	1842.42	33.1	1809.32	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	09/18/85	1842.42	32.8	1809.62	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	11/26/85	1842.42	31.68	1810.74	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	01/08/86	1842.42	31.3	1811.12	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	01/31/86	1842.42	31.3	1811.12	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	05/29/86	1842.42	31.76	1810.66	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	06/17/86	1842.42	32.2	1810.22	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	07/14/86	1842.42	32.71	1809.71	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	09/11/86	1842.42	32.82	1809.60	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	11/26/86	1842.42	31.66	1810.76	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	12/31/86	1842.42	31.42	1811.00	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	01/23/87	1842.42	31.07	1811.35	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	02/20/87	1842.42	31.17	1811.25	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	03/19/87	1842.42	31.11	1811.31	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-NORTH	UM45	01/04/90	1842.42	31.66	1810.76	KARL F. POHLMANN, JUNE 1991
LEWIS-NORTH	UM45	01/12/90	1842.42	31.51	1810.91	KARL F. POHLMANN, JUNE 1991
LEWIS-NORTH	UM45	02/20/90	1842.42	31.32	1811.10	KARL F. POHLMANN, JUNE 1991
LEWIS-NORTH	UM45	03/16/90	1842.42	31.26	1811.16	KARL F. POHLMANN, JUNE 1991
LEWIS-NORTH	UM45	03/28/90	1842.42	31.14	1811.28	KARL F. POHLMANN, JUNE 1991
LEWIS-NORTH	UM45	04/16/90	1842.42	31.29	1811.13	KARL F. POHLMANN, JUNE 1991
LEWIS-NORTH	UM45	05/18/90	1842.42	32.49	1809.93	KARL F. POHLMANN, JUNE 1991
LEWIS-NORTH	UM45	05/25/90	1842.42	32.24	1810.18	KARL F. POHLMANN, JUNE 1991
LEWIS-NORTH	UM45	06/12/90	1842.42	32.13	1810.29	KARL F. POHLMANN, JUNE 1991
LEWIS-NORTH	UM45	06/26/90	1842.42	32.3	1810.12	KARL F. POHLMANN, JUNE 1991
LEWIS-NORTH	UM45	07/10/90	1842.42	32.59	1809.83	KARL F. POHLMANN, JUNE 1991
LEWIS-NORTH	UM45	07/18/90	1842.42	32.68	1809.74	KARL F. POHLMANN, JUNE 1991
LEWIS-NORTH	UM45	08/10/90	1842.42	32.77	1809.65	KARL F. POHLMANN, JUNE 1991
LEWIS-NORTH	UM45	09/07/90	1842.42	33.28	1809.14	KARL F. POHLMANN, JUNE 1991
LEWIS-NORTH	UM45	09/27/90	1842.42	33.13	1809.29	KARL F. POHLMANN, JUNE 1991
LEWIS-NORTH	UM45	10/11/90	1842.42	32.6	1809.82	KARL F. POHLMANN, JUNE 1991
LEWIS-NORTH	UM45	10/30/90	1842.42	32.15	1810.27	KARL F. POHLMANN, JUNE 1991

APPENDIX C

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
LEWIS-NORTH	UM45	11/19/90	1842.42	31.73	1810.69	KARL F. POHLMANN, JUNE 1991
LEWIS-NORTH	UM45	12/03/90	1842.42	31.69	1810.73	KARL F. POHLMANN, JUNE 1991
LEWIS-NORTH	UM45	12/20/90	1842.42	31.3	1811.12	KARL F. POHLMANN, JUNE 1991
LEWIS-NORTH	UM45	01/11/91	1842.42	31.77	1810.65	M.D. MIFFLIN, MAY 1992
LEWIS-NORTH	UM45	01/25/91	1842.42	31.67	1810.75	M.D. MIFFLIN, MAY 1992
LEWIS-NORTH	UM45	02/05/91	1842.42	31.5	1810.92	M.D. MIFFLIN, MAY 1992
LEWIS-NORTH	UM45	03/06/91	1842.42	31.35	1811.07	M.D. MIFFLIN, MAY 1992
LEWIS-NORTH	UM45	03/21/91	1842.42	31.28	1811.14	M.D. MIFFLIN, MAY 1992
LEWIS-NORTH	UM45	04/08/91	1842.42	31.26	1811.16	M.D. MIFFLIN, MAY 1992
LEWIS-NORTH	UM45	05/17/91	1842.42	31.48	1810.94	M.D. MIFFLIN, MAY 1992
LEWIS-NORTH	UM45	06/18/91	1842.42	32.86	1809.56	M.D. MIFFLIN, MAY 1992
LEWIS-NORTH	UM45	07/25/91	1842.42	33.25	1809.17	M.D. MIFFLIN, MAY 1992
LEWIS-NORTH	UM45	08/20/91	1842.42	33.16	1809.26	M.D. MIFFLIN, MAY 1992
LEWIS-NORTH	UM45	10/03/91	1842.42	32.58	1809.84	M.D. MIFFLIN, MAY 1992
LEWIS-NORTH	UM45	10/11/91	1842.42	32.43	1809.99	M.D. MIFFLIN, MAY 1992
LEWIS-NORTH	UM45	11/06/91	1842.42	32.06	1810.36	M.D. MIFFLIN, MAY 1992
LEWIS-NORTH	UM45	11/26/91	1842.42	31.93	1810.49	M.D. MIFFLIN, MAY 1992
LEWIS-NORTH	UM45	12/27/91	1842.42	31.71	1810.71	M.D. MIFFLIN, MAY 1992
LEWIS-NORTH	UM45	01/27/92	1842.42	31.61	1810.81	M.D. MIFFLIN, APRIL 1993
LEWIS-NORTH	UM45	02/24/92	1842.42	31.61	1810.81	M.D. MIFFLIN, APRIL 1993
LEWIS-NORTH	UM45	02/28/92	1842.42	31.52	1810.90	M.D. MIFFLIN, APRIL 1993
LEWIS-NORTH	UM45	03/20/92	1842.42	31.32	1811.10	M.D. MIFFLIN, APRIL 1993
LEWIS-NORTH	UM45	03/24/92	1842.42	31.33	1811.09	M.D. MIFFLIN, APRIL 1993
LEWIS-NORTH	UM45	03/25/92	1842.42	31.37	1811.05	M.D. MIFFLIN, APRIL 1993
LEWIS-NORTH	UM45	04/21/92	1842.42	31.18	1811.24	M.D. MIFFLIN, APRIL 1993
LEWIS-NORTH	UM45	05/13/92	1842.42	31.42	1811.00	M.D. MIFFLIN, APRIL 1993
LEWIS-NORTH	UM45	05/15/92	1842.42	31.44	1810.98	M.D. MIFFLIN, APRIL 1993
LEWIS-NORTH	UM45	06/12/92	1842.42	32.51	1809.91	M.D. MIFFLIN, APRIL 1993
LEWIS-NORTH	UM45	07/22/92	1842.42	32.55	1809.87	M.D. MIFFLIN, APRIL 1993
LEWIS-NORTH	UM45	07/23/92	1842.42	32.57	1809.85	M.D. MIFFLIN, APRIL 1993
LEWIS-NORTH	UM45	08/05/92	1842.42	32.59	1809.83	M.D. MIFFLIN, APRIL 1993
LEWIS-NORTH	UM45	08/13/92	1842.42	32.66	1809.76	M.D. MIFFLIN, APRIL 1993
LEWIS-NORTH	UM45	08/18/92	1842.42	32.7	1809.72	M.D. MIFFLIN, APRIL 1993
LEWIS-NORTH	UM45	09/10/92	1842.42	32.7	1809.72	M.D. MIFFLIN, APRIL 1993
LEWIS-NORTH	UM45	10/19/92	1842.42	31.87	1810.55	M.D. MIFFLIN, APRIL 1993
LEWIS-NORTH	UM45	12/01/92	1842.42	31.51	1810.91	M.D. MIFFLIN, APRIL 1993
LEWIS-NORTH	UM45	12/23/92	1842.42	31.7	1810.72	KARL F. POHLMANN, APRIL 1994
LEWIS-NORTH	UM45	12/23/92	1842.42	31.7	1810.72	M.D. MIFFLIN, APRIL 1993
LEWIS-NORTH	UM45	01/13/93	1842.42	31.3	1811.12	KARL F. POHLMANN, APRIL 1994
LEWIS-NORTH	UM45	01/19/93	1842.42	31.21	1811.21	KARL F. POHLMANN, APRIL 1994
LEWIS-NORTH	UM45	01/20/93	1842.42	31.29	1811.13	KARL F. POHLMANN, APRIL 1994
LEWIS-NORTH	UM45	02/01/93	1842.42	30.98	1811.44	KARL F. POHLMANN, APRIL 1994
LEWIS-NORTH	UM45	02/05/93	1842.42	30.93	1811.49	KARL F. POHLMANN, APRIL 1994
LEWIS-NORTH	UM45	02/19/93	1842.42	30.7	1811.72	KARL F. POHLMANN, APRIL 1994
LEWIS-NORTH	UM45	03/24/93	1842.42	30.52	1811.90	KARL F. POHLMANN, APRIL 1994
LEWIS-NORTH	UM45	04/02/93	1842.42	30.56	1811.86	KARL F. POHLMANN, APRIL 1994
LEWIS-NORTH	UM45	04/30/93	1842.42	30.56	1811.86	KARL F. POHLMANN, APRIL 1994
LEWIS-NORTH	UM45	06/03/93	1842.42	31.49	1810.93	KARL F. POHLMANN, APRIL 1994
LEWIS-NORTH	UM45	07/07/93	1842.42	31.82	1810.60	KARL F. POHLMANN, APRIL 1994
LEWIS-NORTH	UM45	08/02/93	1842.42	32.36	1810.06	KARL F. POHLMANN, APRIL 1994
LEWIS-NORTH	UM45	09/03/93	1842.42	32.52	1809.90	KARL F. POHLMANN, APRIL 1994
LEWIS-NORTH	UM45	10/01/93	1842.42	32.53	1809.89	KARL F. POHLMANN, APRIL 1994
LEWIS-NORTH	UM45	11/12/93	1842.42	31.26	1811.16	KARL F. POHLMANN, APRIL 1994
LEWIS-NORTH	UM45	12/10/93	1842.42	31.1	1811.32	KARL F. POHLMANN, APRIL 1994
LEWIS-NORTH	UM45	01/05/94	1842.42	31.26	1811.16	KARL F. POHLMANN, JUNE 1995
LEWIS-NORTH	UM45	02/04/94	1842.42	31.32	1811.10	KARL F. POHLMANN, JUNE 1995
LEWIS-NORTH	UM45	03/04/94	1842.42	31.45	1810.97	KARL F. POHLMANN, JUNE 1995

APPENDIX C

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
LEWIS-NORTH	UM45	04/08/94	1842.42	31.35	1811.07	KARL F. POHLMANN, JUNE 1995
LEWIS-NORTH	UM45	05/06/94	1842.42	31.96	1810.46	KARL F. POHLMANN, JUNE 1995
LEWIS-NORTH	UM45	05/19/94	1842.42	32.49	1809.93	KARL F. POHLMANN, JUNE 1995
LEWIS-NORTH	UM45	06/09/94	1842.42	31.93	1810.49	KARL F. POHLMANN, JUNE 1995
LEWIS-NORTH	UM45	07/02/94	1842.42	32.99	1809.43	KARL F. POHLMANN, JUNE 1995
LEWIS-NORTH	UM45	08/12/94	1842.42	33.18	1809.24	KARL F. POHLMANN, JUNE 1995
LEWIS-NORTH	UM45	09/06/94	1842.42	33.33	1809.09	KARL F. POHLMANN, JUNE 1995
LEWIS-NORTH	UM45	10/04/94	1842.42	33	1809.42	KARL F. POHLMANN, JUNE 1995
LEWIS-NORTH	UM45	11/01/94	1842.42	32.92	1809.50	KARL F. POHLMANN, JUNE 1995
LEWIS-NORTH	UM45	12/08/94	1842.42	32.65	1809.77	KARL F. POHLMANN, JUNE 1995
LEWIS-NORTH	UM45	01/09/95	1842.42	31.73	1810.69	KARL F. POHLMANN, JUNE 1996
LEWIS-NORTH	UM45	02/08/95	1842.42	31.26	1811.16	KARL F. POHLMANN, JUNE 1996
LEWIS-NORTH	UM45	03/08/95	1842.42	31.66	1810.76	KARL F. POHLMANN, JUNE 1996
LEWIS-NORTH	UM45	04/05/95	1842.42	30.97	1811.45	KARL F. POHLMANN, JUNE 1996
LEWIS-NORTH	UM45	05/18/95	1842.42	30.94	1811.48	KARL F. POHLMANN, JUNE 1996
LEWIS-NORTH	UM45	06/16/95	1842.42	31.83	1810.59	KARL F. POHLMANN, JUNE 1996
LEWIS-NORTH	UM45	07/05/95	1842.42	32.25	1810.17	KARL F. POHLMANN, JUNE 1996
LEWIS-NORTH	UM45	08/09/95	1842.42	32.62	1809.80	KARL F. POHLMANN, JUNE 1996
LEWIS-NORTH	UM45	09/07/95	1842.42	32.88	1809.54	KARL F. POHLMANN, JUNE 1996
LEWIS-NORTH	UM45	10/12/95	1842.42	32.46	1809.96	KARL F. POHLMANN, JUNE 1996
LEWIS-NORTH	UM45	11/09/95	1842.42	31.82	1810.60	KARL F. POHLMANN, JUNE 1996
LEWIS-NORTH	UM45	11/24/95	1842.42	31.7	1810.72	KARL F. POHLMANN, JUNE 1996
LEWIS-NORTH	UM45	12/14/95	1842.42	31.5	1810.92	KARL F. POHLMANN, JUNE 1996
LEWIS-NORTH	UM45	01/12/96	1842.42	31.36	1811.06	KARL F. POHLMANN, MARCH 1997
LEWIS-NORTH	UM45	03/01/96	1842.42	31.11	1811.31	KARL F. POHLMANN, MARCH 1997
LEWIS-NORTH	UM45	03/14/96	1842.42	30.99	1811.43	KARL F. POHLMANN, MARCH 1997
LEWIS-NORTH	UM45	04/11/96	1842.42	30.87	1811.55	KARL F. POHLMANN, MARCH 1997
LEWIS-NORTH	UM45	05/08/96	1842.42	31.3	1811.12	KARL F. POHLMANN, MARCH 1997
LEWIS-NORTH	UM45	06/14/96	1842.42	32.44	1809.98	KARL F. POHLMANN, MARCH 1997
LEWIS-NORTH	UM45	08/13/96	1842.42	32.51	1809.91	KARL F. POHLMANN, MARCH 1997
LEWIS-NORTH	UM45	09/13/96	1842.42	32.51	1809.91	KARL F. POHLMANN, MARCH 1997
LEWIS-NORTH	UM45	10/10/96	1842.42	32.32	1810.10	KARL F. POHLMANN, MARCH 1997
LEWIS-NORTH	UM45	11/22/96	1842.42	31.64	1810.78	KARL F. POHLMANN, MARCH 1997
LEWIS-NORTH	UM45	12/18/96	1842.42	31.51	1810.91	KARL F. POHLMANN, MARCH 1997
LEWIS-NORTH	UM45	04/21/97	1842.42	30.1	1812.32	KLEINFELDER, FEBRUARY 2000
LEWIS-NORTH	UM45	06/26/97	1842.42	31.74	1810.68	KLEINFELDER, FEBRUARY 2000
LEWIS-NORTH	UM45	09/24/97	1842.42	32.42	1810.00	KLEINFELDER, FEBRUARY 2000
LEWIS-NORTH	UM45	12/16/97	1842.42	31.76	1810.66	KLEINFELDER, FEBRUARY 2000
LEWIS-NORTH	UM45	03/18/98	1842.42	31.26	1811.16	KLEINFELDER, FEBRUARY 2000
LEWIS-NORTH	UM45	07/01/98	1842.42	32.06	1810.36	KLEINFELDER, FEBRUARY 2000
LEWIS-NORTH	UM45	10/02/98	1842.42	32.99	1809.43	KLEINFELDER, FEBRUARY 2000
LEWIS-NORTH	UM45	12/31/98	1842.42	33.01	1809.41	KLEINFELDER, FEBRUARY 2000
LEWIS-NORTH	UM45	01/15/99	1842.42	33.1	1809.32	CONVERSE, 02/25/00
LEWIS-NORTH	UM45	02/16/99	1842.42	32.47	1809.95	CONVERSE, 02/25/00
LEWIS-NORTH	UM45	03/12/99	1842.42	32.06	1810.36	CONVERSE, 02/25/00
LEWIS-NORTH	UM45	03/30/99	1842.42	32.06	1810.36	KLEINFELDER, FEBRUARY 2000
LEWIS-NORTH	UM45	04/15/99	1842.42	31.78	1810.64	CONVERSE, 02/25/00
LEWIS-NORTH	UM45	05/14/99	1842.42	31.91	1810.51	CONVERSE, 02/25/00
LEWIS-NORTH	UM45	06/15/99	1842.42	33.06	1809.36	CONVERSE, 02/25/00
LEWIS-NORTH	UM45	06/24/99	1842.42	33.06	1809.36	KLEINFELDER, FEBRUARY 2000
LEWIS-NORTH	UM45	07/15/99	1842.42	33.68	1808.74	CONVERSE, 02/25/00
LEWIS-NORTH	UM45	08/16/99	1842.42	34.07	1808.35	CONVERSE, 02/25/00
LEWIS-NORTH	UM45	09/16/99	1842.42	33.95	1808.47	CONVERSE, 02/25/00
LEWIS-NORTH	UM45	09/21/99	1842.42	33.95	1808.47	KLEINFELDER, FEBRUARY 2000
LEWIS-NORTH	UM45	10/12/99	1842.42	33.45	1808.97	CONVERSE, 02/25/00
LEWIS-NORTH	UM45	11/16/99	1842.42	32.62	1809.80	CONVERSE, 02/25/00
LEWIS-NORTH	UM45	12/21/99	1842.42	32.37	1810.05	KLEINFELDER, FEBRUARY 2000

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
LEWIS-NORTH	UM45	12/28/99	1842.42	32.37	1810.05	CONVERSE, 02/25/00
LEWIS-NORTH	UM45	01/14/00	1842.42	32.25	1810.17	CONVERSE, 02/15/01
LEWIS-NORTH	UM45	02/15/00	1842.42	32.18	1810.24	CONVERSE, 02/15/01
LEWIS-NORTH	UM45	03/21/00	1842.42	31.94	1810.48	CONVERSE, 02/15/01
LEWIS-NORTH	UM45	04/14/00	1842.42	31.89	1810.53	CONVERSE, 02/15/01
LEWIS-NORTH	UM45	05/15/00	1842.42	32.66	1809.76	CONVERSE, 02/15/01
LEWIS-NORTH	UM45	06/14/00	1842.42	33.66	1808.76	CONVERSE, 02/15/01
LEWIS-NORTH	UM45	07/14/00	1842.42	33.88	1808.54	CONVERSE, 02/15/01
LEWIS-NORTH	UM45	08/15/00	1842.42	34.13	1808.29	CONVERSE, 02/15/01
LEWIS-NORTH	UM45	09/19/00	1842.42	34.09	1808.33	CONVERSE, 02/15/01
LEWIS-NORTH	UM45	10/13/00	1842.42	33.73	1808.69	CONVERSE, 02/15/01
LEWIS-NORTH	UM45	11/16/00	1842.42	33.07	1809.35	CONVERSE, 02/15/01
LEWIS-NORTH	UM45	12/15/00	1842.42	32.86	1809.56	CONVERSE, 02/15/01
LEWIS-SOUTH	UM43	05/05/83	1806.45	18.92	1787.53	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	07/14/83	1806.45	21.94	1784.51	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	09/21/83	1806.45	21.12	1785.33	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	09/30/83	1806.45	21.18	1785.27	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	11/30/83	1806.45	18.67	1787.78	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	12/23/83	1806.45	16.72	1789.73	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	02/03/84	1806.45	17.93	1788.52	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	04/03/84	1806.45	17.25	1789.20	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	05/29/84	1806.45	19.88	1786.57	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	09/14/84	1806.45	23.13	1783.32	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	11/02/84	1806.45	18.39	1788.06	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	12/13/84	1806.45	16.27	1790.18	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	02/15/85	1806.45	14.41	1792.04	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	03/01/85	1806.45	14.48	1791.97	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	03/16/85	1806.45	14.7	1791.75	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	05/17/85	1806.45	17.38	1789.07	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	07/02/85	1806.45	21.88	1784.57	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	07/05/85	1806.45	22.98	1783.47	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	08/07/85	1806.45	23.89	1782.56	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	09/18/85	1806.45	23.87	1782.58	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	11/26/85	1806.45	18.33	1788.12	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	01/06/86	1806.45	17	1789.45	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	01/14/86	1806.45	16.27	1790.18	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	01/31/86	1806.45	16.36	1790.09	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	05/29/86	1806.45	18.53	1787.92	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	09/11/86	1806.45	22.92	1783.53	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	11/26/86	1806.45	18.15	1788.30	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	12/31/86	1806.45	16.55	1789.90	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	01/23/87	1806.45	15.28	1791.17	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	02/20/87	1806.45	16.82	1789.63	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	03/20/87	1806.45	16.2	1790.25	M.D. MIFFLIN, FEBRUARY 1989
LEWIS-SOUTH	UM43	01/04/90	1806.45	17.27	1789.18	KARL F. POHLMANN, JUNE 1991
LEWIS-SOUTH	UM43	01/12/90	1806.45	17.25	1789.20	KARL F. POHLMANN, JUNE 1991
LEWIS-SOUTH	UM43	02/20/90	1806.45	15.43	1791.02	KARL F. POHLMANN, JUNE 1991
LEWIS-SOUTH	UM43	03/16/90	1806.45	15.36	1791.09	KARL F. POHLMANN, JUNE 1991
LEWIS-SOUTH	UM43	04/16/90	1806.45	15.05	1791.40	KARL F. POHLMANN, JUNE 1991
LEWIS-SOUTH	UM43	05/18/90	1806.45	16.87	1789.58	KARL F. POHLMANN, JUNE 1991
LEWIS-SOUTH	UM43	05/25/90	1806.45	17.18	1789.27	KARL F. POHLMANN, JUNE 1991
LEWIS-SOUTH	UM43	06/12/90	1806.45	18.54	1787.91	KARL F. POHLMANN, JUNE 1991
LEWIS-SOUTH	UM43	06/18/90	1806.45	19.53	1786.92	KARL F. POHLMANN, JUNE 1991
LEWIS-SOUTH	UM43	07/10/90	1806.45	20.84	1785.61	KARL F. POHLMANN, JUNE 1991
LEWIS-SOUTH	UM43	07/18/90	1806.45	22.08	1784.37	KARL F. POHLMANN, JUNE 1991
LEWIS-SOUTH	UM43	08/10/90	1806.45	23.2	1783.25	KARL F. POHLMANN, JUNE 1991
LEWIS-SOUTH	UM43	09/07/90	1806.45	23.39	1783.06	KARL F. POHLMANN, JUNE 1991

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
LEWIS-SOUTH	UM43	09/27/90	1806.45	23.5	1782.95	KARL F. POHLMANN, JUNE 1991
LEWIS-SOUTH	UM43	10/16/90	1806.45	20.11	1786.34	KARL F. POHLMANN, JUNE 1991
LEWIS-SOUTH	UM43	10/30/90	1806.45	20.01	1786.44	KARL F. POHLMANN, JUNE 1991
LEWIS-SOUTH	UM43	11/08/90	1806.45	18.68	1787.77	KARL F. POHLMANN, JUNE 1991
LEWIS-SOUTH	UM43	11/19/90	1806.45	17.61	1788.84	KARL F. POHLMANN, JUNE 1991
LEWIS-SOUTH	UM43	12/03/90	1806.45	17.37	1789.08	KARL F. POHLMANN, JUNE 1991
LEWIS-SOUTH	UM43	12/20/90	1806.45	16.13	1790.32	KARL F. POHLMANN, JUNE 1991
LEWIS-SOUTH	UM43	01/11/91	1806.45	15.73	1790.72	M.D. MIFFLIN, MAY 1992
LEWIS-SOUTH	UM43	02/05/91	1806.45	15.3	1791.15	M.D. MIFFLIN, MAY 1992
LEWIS-SOUTH	UM43	03/06/91	1806.45	14.74	1791.71	M.D. MIFFLIN, MAY 1992
LEWIS-SOUTH	UM43	03/21/91	1806.45	14.31	1792.14	M.D. MIFFLIN, MAY 1992
LEWIS-SOUTH	UM43	04/08/91	1806.45	14.13	1792.32	M.D. MIFFLIN, MAY 1992
LEWIS-SOUTH	UM43	05/16/91	1806.45	15.37	1791.08	M.D. MIFFLIN, MAY 1992
LEWIS-SOUTH	UM43	06/18/91	1806.45	19.18	1787.27	M.D. MIFFLIN, MAY 1992
LEWIS-SOUTH	UM43	07/25/91	1806.45	21.28	1785.17	M.D. MIFFLIN, MAY 1992
LEWIS-SOUTH	UM43	08/01/91	1806.45	22.46	1783.99	M.D. MIFFLIN, MAY 1992
LEWIS-SOUTH	UM43	08/20/91	1806.45	21.76	1784.69	M.D. MIFFLIN, MAY 1992
LEWIS-SOUTH	UM43	08/29/91	1806.45	22.04	1784.41	M.D. MIFFLIN, MAY 1992
LEWIS-SOUTH	UM43	09/13/91	1806.45	22.11	1784.34	M.D. MIFFLIN, MAY 1992
LEWIS-SOUTH	UM43	09/17/91	1806.45	18.83	1787.62	M.D. MIFFLIN, MAY 1992
LEWIS-SOUTH	UM43	10/11/91	1806.45	19.77	1786.68	M.D. MIFFLIN, MAY 1992
LEWIS-SOUTH	UM43	10/17/91	1806.45	18.83	1787.62	M.D. MIFFLIN, MAY 1992
LEWIS-SOUTH	UM43	11/06/91	1806.45	16.81	1789.64	M.D. MIFFLIN, MAY 1992
LEWIS-SOUTH	UM43	11/26/91	1806.45	15.93	1790.52	M.D. MIFFLIN, MAY 1992
LEWIS-SOUTH	UM43	12/27/91	1806.45	14.73	1791.72	M.D. MIFFLIN, MAY 1992
LEWIS-SOUTH	UM43	01/27/92	1806.45	14.51	1791.94	M.D. MIFFLIN, APRIL 1993
LEWIS-SOUTH	UM43	02/24/92	1806.45	13.77	1792.68	M.D. MIFFLIN, APRIL 1993
LEWIS-SOUTH	UM43	02/28/92	1806.45	13.62	1792.83	M.D. MIFFLIN, APRIL 1993
LEWIS-SOUTH	UM43	03/24/92	1806.45	13.13	1793.32	M.D. MIFFLIN, APRIL 1993
LEWIS-SOUTH	UM43	04/21/92	1806.45	13.33	1793.12	M.D. MIFFLIN, APRIL 1993
LEWIS-SOUTH	UM43	05/13/92	1806.45	14.62	1791.83	M.D. MIFFLIN, APRIL 1993
LEWIS-SOUTH	UM43	06/12/92	1806.45	18.1	1788.35	M.D. MIFFLIN, APRIL 1993
LEWIS-SOUTH	UM43	07/22/92	1806.45	18.87	1787.58	M.D. MIFFLIN, APRIL 1993
LEWIS-SOUTH	UM43	08/18/92	1806.45	20.21	1786.24	M.D. MIFFLIN, APRIL 1993
LEWIS-SOUTH	UM43	09/10/92	1806.45	20.79	1785.66	M.D. MIFFLIN, APRIL 1993
LEWIS-SOUTH	UM43	10/19/92	1806.45	16.6	1789.85	M.D. MIFFLIN, APRIL 1993
LEWIS-SOUTH	UM43	12/01/92	1806.45	14.4	1792.05	M.D. MIFFLIN, APRIL 1993
LEWIS-SOUTH	UM43	12/23/92	1806.45	14.12	1792.33	M.D. MIFFLIN, APRIL 1993
LEWIS-SOUTH	UM43	01/05/94	1806.45	14.02	1792.43	KARL F. POHLMANN, JUNE 1995
LEWIS-SOUTH	UM43	02/04/94	1806.45	13.46	1792.99	KARL F. POHLMANN, JUNE 1995
LEWIS-SOUTH	UM43	03/04/94	1806.45	13.45	1793.00	KARL F. POHLMANN, JUNE 1995
LEWIS-SOUTH	UM43	04/08/94	1806.45	12.89	1793.56	KARL F. POHLMANN, JUNE 1995
LEWIS-SOUTH	UM43	05/06/94	1806.45	14.24	1792.21	KARL F. POHLMANN, JUNE 1995
LEWIS-SOUTH	UM43	06/09/94	1806.45	17.53	1788.92	KARL F. POHLMANN, JUNE 1995
LEWIS-SOUTH	UM43	07/02/94	1806.45	20.49	1785.96	KARL F. POHLMANN, JUNE 1995
LEWIS-SOUTH	UM43	08/12/94	1806.45	21.88	1784.57	KARL F. POHLMANN, JUNE 1995
LEWIS-SOUTH	UM43	09/06/94	1806.45	22.02	1784.43	KARL F. POHLMANN, JUNE 1995
LEWIS-SOUTH	UM43	10/04/94	1806.45	20.15	1786.30	KARL F. POHLMANN, JUNE 1995
LEWIS-SOUTH	UM43	11/01/94	1806.45	19.11	1787.34	KARL F. POHLMANN, JUNE 1995
LEWIS-SOUTH	UM43	12/08/94	1806.45	17.84	1788.61	KARL F. POHLMANN, JUNE 1995
LEWIS-SOUTH	UM43	01/09/95	1806.45	14.27	1792.18	KARL F. POHLMANN, JUNE 1996
LEWIS-SOUTH	UM43	02/08/95	1806.45	12.97	1793.48	KARL F. POHLMANN, JUNE 1996
LEWIS-SOUTH	UM43	03/08/95	1806.45	12.44	1794.01	KARL F. POHLMANN, JUNE 1996
LEWIS-SOUTH	UM43	04/05/95	1806.45	12.08	1794.37	KARL F. POHLMANN, JUNE 1996
LEWIS-SOUTH	UM43	05/18/95	1806.45	12.06	1794.39	KARL F. POHLMANN, JUNE 1996
LEWIS-SOUTH	UM43	06/16/95	1806.45	14.28	1792.17	KARL F. POHLMANN, JUNE 1996
LEWIS-SOUTH	UM43	07/05/95	1806.45	16.7	1789.75	KARL F. POHLMANN, JUNE 1996

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
LEWIS-SOUTH	UM43	08/09/95	1806.45	18.65	1787.80	KARL F. POHLMANN, JUNE 1996
LEWIS-SOUTH	UM43	09/07/95	1806.45	20.5	1785.95	KARL F. POHLMANN, JUNE 1996
LEWIS-SOUTH	UM43	10/12/95	1806.45	19.28	1787.17	KARL F. POHLMANN, JUNE 1996
LEWIS-SOUTH	UM43	11/09/95	1806.45	17.42	1789.03	KARL F. POHLMANN, JUNE 1996
LEWIS-SOUTH	UM43	11/24/95	1806.45	16.2	1790.25	KARL F. POHLMANN, JUNE 1996
LEWIS-SOUTH	UM43	12/14/95	1806.45	15.75	1790.70	KARL F. POHLMANN, JUNE 1996
LEWIS-SOUTH	UM43	01/12/96	1806.45	14.24	1792.21	KARL F. POHLMANN, MARCH 1997
LEWIS-SOUTH	UM43	03/01/96	1806.45	12.71	1793.74	KARL F. POHLMANN, MARCH 1997
LEWIS-SOUTH	UM43	03/14/96	1806.45	12.45	1794.00	KARL F. POHLMANN, MARCH 1997
LEWIS-SOUTH	UM43	04/11/96	1806.45	12.08	1794.37	KARL F. POHLMANN, MARCH 1997
LEWIS-SOUTH	UM43	05/08/96	1806.45	13.19	1793.26	KARL F. POHLMANN, MARCH 1997
LEWIS-SOUTH	UM43	06/14/96	1806.45	17.37	1789.08	KARL F. POHLMANN, MARCH 1997
LEWIS-SOUTH	UM43	08/13/96	1806.45	20.88	1785.57	KARL F. POHLMANN, MARCH 1997
LEWIS-SOUTH	UM43	09/13/96	1806.45	21.63	1784.82	KARL F. POHLMANN, MARCH 1997
LEWIS-SOUTH	UM43	04/21/97	1806.45	12.7	1793.75	KLEINFELDER, FEBRUARY 2000
LEWIS-SOUTH	UM43	06/26/97	1806.45	15.33	1791.12	KLEINFELDER, FEBRUARY 2000
LEWIS-SOUTH	UM43	09/24/97	1806.45	19.46	1786.99	KLEINFELDER, FEBRUARY 2000
LEWIS-SOUTH	UM43	12/15/97	1806.45	14.12	1792.33	KLEINFELDER, FEBRUARY 2000
LEWIS-SOUTH	UM43	03/18/98	1806.45	12.25	1794.20	KLEINFELDER, FEBRUARY 2000
LEWIS-SOUTH	UM43	07/01/98	1806.45	15.58	1790.87	KLEINFELDER, FEBRUARY 2000
LEWIS-SOUTH	UM43	10/02/98	1806.45	20.35	1786.10	KLEINFELDER, FEBRUARY 2000
LEWIS-SOUTH	UM43	12/31/98	1806.45	16.95	1789.50	KLEINFELDER, FEBRUARY 2000
LEWIS-SOUTH	UM43	01/15/99	1806.45	17.71	1788.74	CONVERSE, 02/25/00
LEWIS-SOUTH	UM43	02/16/99	1806.45	15.59	1790.86	CONVERSE, 02/25/00
LEWIS-SOUTH	UM43	03/12/99	1806.45	13.38	1793.07	CONVERSE, 02/25/00
LEWIS-SOUTH	UM43	03/30/99	1806.45	13.8	1792.65	KLEINFELDER, FEBRUARY 2000
LEWIS-SOUTH	UM43	04/15/99	1806.45	12.75	1793.70	CONVERSE, 02/25/00
LEWIS-SOUTH	UM43	05/14/99	1806.45	13.89	1792.56	CONVERSE, 02/25/00
LEWIS-SOUTH	UM43	06/15/99	1806.45	17.02	1789.43	CONVERSE, 02/25/00
LEWIS-SOUTH	UM43	06/24/99	1806.45	17.17	1789.28	KLEINFELDER, FEBRUARY 2000
LEWIS-SOUTH	UM43	07/15/99	1806.45	19.53	1786.92	CONVERSE, 02/25/00
LEWIS-SOUTH	UM43	08/16/99	1806.45	20.63	1785.82	CONVERSE, 02/25/00
LEWIS-SOUTH	UM43	09/16/99	1806.45	21.89	1784.56	CONVERSE, 02/25/00
LEWIS-SOUTH	UM43	09/21/99	1806.45	21.89	1784.56	KLEINFELDER, FEBRUARY 2000
LEWIS-SOUTH	UM43	10/12/99	1806.45	18.99	1787.46	CONVERSE, 02/25/00
LEWIS-SOUTH	UM43	11/16/99	1806.45	15.89	1790.56	CONVERSE, 02/25/00
LEWIS-SOUTH	UM43	12/22/99	1806.45	15.31	1791.14	KLEINFELDER, FEBRUARY 2000
LEWIS-SOUTH	UM43	12/28/99	1806.45	15.31	1791.14	CONVERSE, 02/25/00
LEWIS-SOUTH	UM43	01/14/00	1806.45	13.75	1792.70	CONVERSE, 02/15/01
LEWIS-SOUTH	UM43	02/15/00	1806.45	14.03	1792.42	CONVERSE, 02/15/01
LEWIS-SOUTH	UM43	03/21/00	1806.45	12.58	1793.87	CONVERSE, 02/15/01
LEWIS-SOUTH	UM43	04/14/00	1806.45	12.35	1794.10	CONVERSE, 02/15/01
LEWIS-SOUTH	UM43	05/15/00	1806.45	14.62	1791.83	CONVERSE, 02/15/01
LEWIS-SOUTH	UM43	06/14/00	1806.45	16.94	1789.51	CONVERSE, 02/15/01
LEWIS-SOUTH	UM43	07/14/00	1806.45	19.85	1786.60	CONVERSE, 02/15/01
LEWIS-SOUTH	UM43	08/15/00	1806.45	21.31	1785.14	CONVERSE, 02/15/01
LEWIS-SOUTH	UM43	09/19/00	1806.45	21.62	1784.83	CONVERSE, 02/15/01
LEWIS-SOUTH	UM43	10/13/00	1806.45	20.01	1786.44	CONVERSE, 02/15/01
LEWIS-SOUTH	UM43	11/16/00	1806.45	17.62	1788.83	CONVERSE, 02/15/01
LEWIS-SOUTH	UM43	12/15/00	1806.45	16.35	1790.10	CONVERSE, 02/15/01
LMVW-1		10/27/75	4393.71	30	4364	NDWR
LMVW-10		11/23/53	4386.40	14	4372	NDWR
LMVW-11		12/01/62	1961.66	11	1951	NDWR
LMVW-12		09/30/81	1532.45	20	1512	NDWR
LMVW-13		05/06/81	1537.60	19	1519	NDWR
LMVW-14		08/27/62	1532.45	17	1515	NDWR
LMVW-15		04/04/74	1537.60	18	1520	NDWR

APPENDIX C

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
LMVW-16		01/10/52	2361.19	170	2191	NDWR
LMVW-17		12/13/61	1653.13	16	1637	NDWR
LMVW-18		07/10/80	1753.01	50	1703	NDWR
LMVW-19		11/13/75	4863.89	10	4854	NDWR
LMVW-2		04/20/79	4188.98	10	4179	NDWR
LMVW-20		08/08/55	5969.19	210	5759	NDWR
LMVW-21		03/25/74	2657.48	25	2632	NDWR
LMVW-22		07/06/82	4442.57	24	4419	NDWR
LMVW-23		10/28/80	1564.10	29.4	1535	NDWR
LMVW-24		04/02/76	2678.39	33	2645	NDWR
LMVW-25		09/03/62	3278.09	20	3258	NDWR
LMVW-26		11/24/59	4361.62	26	4336	NDWR
LMVW-27		06/03/74	4358.30	13	4345	NDWR
LMVW-28		10/26/73	4327.45	7	4320	NDWR
LMVW-29		06/02/49	4361.62	34	4328	NDWR
LMVW-3		10/31/74	4320.86	8	4313	NDWR
LMVW-30		08/07/76	5367.74	86	5282	NDWR
LMVW-31		06/18/76	4863.89	12	4852	NDWR
LMVW-32		11/30/61	3311.82	21	3291	NDWR
LMVW-33		11/21/75	4863.89	15	4849	NDWR
LMVW-34		11/01/71	1573.42	19	1554	NDWR
LMVW-35		08/20/81	4263.76	36	4228	NDWR
LMVW-36		02/12/68	4485.25	21	4464	NDWR
LMVW-37		02/26/74	1537.60	22	1516	NDWR
LMVW-38		06/01/63	1962.74	22	1941	NDWR
LMVW-39		05/01/82	1537.60	21	1517	NDWR
LMVW-4		04/16/75	4322.13	5	4317	NDWR
LMVW-40		11/06/61	2694.48	51	2643	NDWR
LMVW-41		11/13/96	1544.56	67	1478	NDWR
LMVW-42		08/09/95	1794.24	55	1739	NDWR
LMVW-43		08/21/94	4603.28	21	4582	NDWR
LMVW-44		01/06/73	1583.24	21	1562	NDWR
LMVW-45		05/31/85	1585.69	55	1531	NDWR
LMVW-46		04/09/73	1573.42	42	1531	NDWR
LMVW-47		10/18/86	1787.97	80	1708	NDWR
LMVW-48		05/13/74	2538.31	14	2524	NDWR
LMVW-49		03/25/88	1586.54	30	1557	NDWR
LMVW-5		06/09/49	4283.41	15	4268	NDWR
LMVW-50		02/25/88	1583.55	30	1554	NDWR
LMVW-51		04/29/88	1794.24	12	1782	NDWR
LMVW-52		02/16/87	1551.72	30	1522	NDWR
LMVW-53		04/23/71	1566.33	20	1546	NDWR
LMVW-54		04/25/74	1577.21	20	1557	NDWR
LMVW-55		03/09/90	1560.57	20	1541	NDWR
LMVW-56		03/01/69	1583.24	23	1560	NDWR
LMVW-57		03/03/88	1560.57	30	1531	NDWR
LMVW-58		01/02/73	1573.51	24	1550	NDWR
LMVW-59		11/07/71	1592.54	28	1565	NDWR
LMVW-6		08/21/65	4523.83	93	4431	NDWR
LMVW-60		02/12/74	1577.21	22	1555	NDWR
LMVW-61		04/05/83	1577.21	22	1555	NDWR
LMVW-62		12/25/71	1608.72	64	1545	NDWR
LMVW-63		03/26/73	1585.69	34	1552	NDWR
LMVW-64		12/28/71	1608.72	28	1581	NDWR
LMVW-65		06/05/76	1537.60	55	1483	NDWR
LMVW-66		04/01/74	1537.60	18	1520	NDWR
LMVW-67		11/01/71	1573.42	19	1554	NDWR

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
LMVW-68		09/28/71	1585.69	20	1566	NDWR
LMVW-69		04/20/71	1563.77	19	1545	NDWR
LMVW-7		03/07/68	4535.13	29	4506	NDWR
LMVW-70		02/19/74	1537.60	22	1516	NDWR
LMVW-71		03/01/69	1563.77	18	1546	NDWR
LMVW-72		12/31/63	1564.10	23	1541	NDWR
LMVW-73		01/05/72	1566.33	31	1535	NDWR
LMVW-74		03/01/69	1573.51	20	1554	NDWR
LMVW-75		09/30/81	1551.72	25	1527	NDWR
LMVW-76		11/01/63	1541.49	20	1521	NDWR
LMVW-77		03/22/73	1609.78	76	1534	NDWR
LMVW-78		01/13/73	1592.54	61	1532	NDWR
LMVW-79		05/07/71	1573.59	20	1554	NDWR
LMVW-8		03/05/66	4524.20	18	4506	NDWR
LMVW-80		10/23/80	1537.60	20.4	1517	NDWR
LMVW-81		10/26/80	1541.49	24	1517	NDWR
LMVW-82		11/07/80	1544.56	27	1518	NDWR
LMVW-83		01/26/99	4191.54	35	4157	NDWR
LMVW-84		10/14/80	1534.19	15.4	1519	NDWR
LMVW-85		10/16/80	1525.37	15.44	1510	NDWR
LMVW-9		11/11/65	4535.13	36	4499	NDWR
M-1		12/04/00		82.28	1815.83	JOHNSON, C. et al., 2001
M-2		12/04/00		298.05	1812.97	JOHNSON, C. et al., 2001
M-3		12/04/00		423	1815.03	JOHNSON, C. et al., 2001
MV-1		04/01/83	2672.68	21	2652	NDWR
MV-10		01/11/75	1496.05	40	1456	NDWR
MV-11		12/20/59	1507.44	30	1477	NDWR
MV-12		11/18/85	1499.73	165	1335	NDWR
MV-13		02/10/97	1430.77	35	1396	NDWR
MV-14		05/28/67	1415.38	22	1393	NDWR
MV-15		11/14/57	1409.60	21	1389	NDWR
MV-16		07/15/80	1466.09	47	1419	NDWR
MV-17		08/27/66	1414.81	17	1398	NDWR
MV-18		08/05/73	1375.34	20	1355	NDWR
MV-19		07/28/58	1446.48	5	1441	NDWR
MV-2		08/27/62	1537.60	17	1521	NDWR
MV-20		09/18/71	1402.80	48	1355	NDWR
MV-21		07/01/67	1366.77	10	1357	NDWR
MV-22		09/13/71	1427.44	65	1362	NDWR
MV-23		02/27/76	1314.45	12	1302	NDWR
MV-24		11/21/57	1381.01	22	1359	NDWR
MV-25		03/31/88	1836.69	174	1663	NDWR
MV-26		02/11/76	1314.45	12	1302	NDWR
MV-27		08/26/72	1314.45	25	1289	NDWR
MV-28		12/10/66	1314.45	6	1308	NDWR
MV-29		03/18/67	1314.45	12	1302	NDWR
MV-3		02/15/80	1544.45	33	1511	NDWR
MV-30		05/05/73	1304.38	3	1301	NDWR
MV-31		07/27/82	1418.04	85	1333	NDWR
MV-32		03/26/76	1295.29	7	1288	NDWR
MV-33		03/24/78	1288.29	8	1280	NDWR
MV-34		03/24/78	1286.86	6	1281	NDWR
MV-35		07/22/83	1396.11	70	1326	NDWR
MV-36		04/30/77	1285.02	18	1267	NDWR
MV-37		02/12/78	1367.63	61	1307	NDWR
MV-38		04/29/77	1275.08	20	1255	NDWR
MV-39		05/19/71	1273.57	2	1272	NDWR

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
MV-4			1514.04	10	1504	NDWR
MV-40		03/23/88	1249.89	6	1244	NDWR
MV-41		02/23/75	1314.89	10	1305	NDWR
MV-42		05/25/76	1291.63	23	1269	NDWR
MV-43		06/26/56	1279.47	83	1196	NDWR
MV-44		02/04/54	1212.75	67	1146	NDWR
MV-45		09/15/60	1744.35	180	1564	NDWR
MV-5		11/26/73	1564.64	8	1557	NDWR
MV-6		01/14/75	1591.26	14	1577	NDWR
MV-7		05/31/60	1551.80	12	1540	NDWR
MV-8		04/03/78	2236.47	336	1900	NDWR
MV-9		01/11/75	1539.93	40	1500	NDWR
MX-4	364743114533101	12/12/80	2172.60	354	1818.6	BERGER et al., 1988
MX-4	364743114533101	06/28/81	2172.60	352.3	1820.3	BERGER et al., 1988
MX-4	364743114533101	03/14/85	2172.60	351.77	1820.83	BERGER et al., 1988
MX-4	364743114533101	12/04/85	2172.60	350	1822.6	BERGER et al., 1988
MX-4	364743114533101	07/09/86	2172.60	351.8	1820.8	USGS
MX-4	364743114533101	07/10/86	2172.60	351.74	1820.86	USGS
MX-4	364743114533101	07/14/86	2172.60	351.66	1820.94	USGS
MX-4	364743114533101	08/20/86	2172.60	351.77	1820.83	USGS
MX-4	364743114533101	09/18/86	2172.60	351.69	1820.91	USGS
MX-4	364743114533101	11/17/86	2172.60	351.87	1820.73	USGS
MX-4	364743114533101	02/10/87	2172.60	351.77	1820.83	USGS
MX-4	364743114533101	03/03/87	2172.60	351.94	1820.66	USGS
MX-4	364743114533101	03/13/87	2172.60	351.66	1820.94	USGS
MX-4	364743114533101	05/07/87	2172.60	351.7	1820.9	USGS
MX-4	364743114533101	06/03/87	2172.60	351.75	1820.85	USGS
MX-4	364743114533101	07/10/87	2172.60	352	1820.6	USGS
MX-4	364743114533101	08/27/87	2172.60	352.09	1820.51	USGS
MX-4	364743114533101	09/11/87	2172.60	351.99	1820.61	TUMBUSCH et al., 1996
MX-4	364743114533101	09/13/87	2172.60	351.95	1820.65	TUMBUSCH et al., 1996
MX-4	364743114533101	09/30/87	2172.60	352.06	1820.54	USGS
MX-4	364743114533101	10/29/87	2172.60	351.95	1820.65	USGS
MX-4	364743114533101	12/18/87	2172.60	351.81	1820.79	USGS
MX-4	364743114533101	01/29/88	2172.60	351.79	1820.81	USGS
MX-4	364743114533101	02/12/88	2172.60	351.82	1820.78	USGS
MX-4	364743114533101	04/07/88	2172.60	351.8	1820.8	USGS
MX-4	364743114533101	05/12/88	2172.60	351.85	1820.75	USGS
MX-4	364743114533101	05/18/88	2172.60	351.72	1820.88	USGS
MX-4	364743114533101	08/03/88	2172.60	351.88	1820.72	USGS
MX-4	364743114533101	12/08/88	2172.60	352.04	1820.56	USGS
MX-4	364743114533101	01/17/89	2172.60	352.06	1820.54	USGS
MX-4	364743114533101	01/30/89	2172.60	351.99	1820.61	USGS
MX-4	364743114533101	01/31/89	2172.60	352.89	1819.71	USGS
MX-4	364743114533101	03/28/89	2172.60	351.98	1820.62	USGS
MX-4	364743114533101	05/30/89	2172.60	351.82	1820.78	USGS
MX-4	364743114533101	07/03/89	2172.60	351.93	1820.67	USGS
MX-4	364743114533101	07/26/89	2172.60	351.29	1821.31	USGS
MX-4	364743114533101	08/14/89	2172.60	351.9	1820.7	USGS
MX-4	364743114533101	09/12/89	2172.60	352.1	1820.5	USGS
MX-4	364743114533101	03/29/90	2172.60	353.25	1819.35	USGS
MX-4	364743114533101	08/14/90	2172.60	352.09	1820.51	USGS
MX-4	364743114533101	09/27/90	2172.60	350.9	1821.7	USGS
MX-4	364743114533101	10/29/90	2172.60	352.4	1820.2	USGS
MX-4	364743114533101	12/03/90	2172.60	352.5	1820.1	USGS
MX-4	364743114533101	02/07/91	2172.60	352.4	1820.2	USGS
MX-4	364743114533101	03/26/91	2172.60	352.3	1820.3	USGS

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
MX-4	364743114533101	04/09/91	2172.60	352.4	1820.2	USGS
MX-4	364743114533101	05/30/91	2172.60	352.1	1820.5	USGS
MX-4	364743114533101	07/30/91	2172.60	352	1820.6	USGS
MX-4	364743114533101	09/05/91	2172.60	352.7	1819.9	USGS
MX-4	364743114533101	10/08/91	2172.60	352.8	1819.8	USGS
MX-4	364743114533101	11/08/91	2172.60	352.8	1819.8	USGS
MX-4	364743114533101	11/14/91	2172.60	352.2	1820.4	USGS
MX-4	364743114533101	01/10/92	2172.60	352.5	1820.1	USGS
MX-4	364743114533101	02/12/92	2172.60	352.3	1820.3	USGS
MX-4	364743114533101	02/21/92	2172.60	352.4	1820.2	USGS
MX-4	364743114533101	03/18/92	2172.60	352.3	1820.3	USGS
MX-4	364743114533101	04/21/92	2172.60	352	1820.6	USGS
MX-4	364743114533101	04/29/92	2172.60	352.1	1820.5	USGS
MX-4	364743114533101	05/12/92	2172.60	352.1	1820.5	USGS
MX-4	364743114533101	06/15/92	2172.60	351.94	1820.66	USGS
MX-4	364743114533101	06/18/92	2172.60	352.3	1820.3	USGS
MX-4	364743114533101	07/29/92	2172.60	352.2	1820.4	USGS
MX-4	364743114533101	09/14/92	2172.60	352.2	1820.4	USGS
MX-4	364743114533101	10/07/92	2172.60	352.5	1820.1	USGS
MX-4	364743114533101	12/09/92	2172.60	352.5	1820.1	USGS
MX-4	364743114533101	03/30/93	2172.60	351.7	1820.9	USGS
MX-4	364743114533101	06/08/93	2172.60	351.4	1821.2	USGS
MX-4	364743114533101	08/04/93	2172.60	351.6	1821	USGS
MX-4	364743114533101	09/09/93	2172.60	351.6	1821	USGS
MX-4	364743114533101	10/14/93	2172.60	351.7	1820.9	USGS
MX-4	364743114533101	10/19/93	2172.60	351.9	1820.7	USGS
MX-4	364743114533101	11/10/93	2172.60	351.8	1820.8	USGS
MX-4	364743114533101	11/18/93	2172.60	351.8	1820.8	USGS
MX-4	364743114533101	12/17/93	2172.60	351.8	1820.8	USGS
MX-4	364743114533101	02/14/94	2172.60	351.9	1820.7	USGS
MX-4	364743114533101	03/31/94	2172.60	351.8	1820.8	USGS
MX-4	364743114533101	06/16/94	2172.60	351.84	1820.76	USGS
MX-4	364743114533101	08/09/94	2172.60	352.1	1820.5	USGS
MX-4	364743114533101	10/04/95	2172.60	351.9	1820.7	USGS
MX-4	364743114533101	12/12/95	2172.60	351.7	1820.9	USGS
MX-4	364743114533101	01/19/96	2172.60	351.8	1820.8	USGS
MX-4	364743114533101	01/26/96	2172.60	351.9	1820.7	USGS
MX-4	364743114533101	03/05/96	2172.60	351.7	1820.9	USGS
MX-4	364743114533101	03/12/96	2172.60	351.6	1821	USGS
MX-4	364743114533101	04/16/96	2172.60	351.38	1821.22	USGS
MX-4	364743114533101	05/31/96	2172.60	351.7	1820.9	USGS
MX-4	364743114533101	07/11/96	2172.60	351.8	1820.8	USGS
MX-4	364743114533101	08/15/96	2172.60	351.8	1820.8	USGS
MX-4	364743114533101	10/04/96	2172.60	352	1820.6	USGS
MX-4	364743114533101	03/07/97	2172.60	351.6	1821	USGS
MX-4	364743114533101	07/08/97	2172.60	351.7	1820.9	USGS
MX-4	364743114533101	10/20/97	2172.60	352.3	1820.3	USGS
MX-4	364743114533101	05/07/98	2172.60	351.6	1821	USGS
MX-4	364743114533101	10/16/98	2172.60	351.5	1821.1	SNWA
MX-4	364743114533101	10/27/98	2172.60	352.5	1820.1	USGS
MX-4	364743114533101	12/17/98	2172.60	352.66	1819.94	USGS
MX-4	364743114533101	01/22/99	2172.60	352.65	1819.95	SNWA
MX-4	364743114533101	02/19/99	2172.60	352.5	1820.1	USGS
MX-4	364743114533101	03/02/99	2172.60	352.5	1820.1	USGS
MX-4	364743114533101	03/11/99	2172.60	352.4	1820.2	USGS
MX-4	364743114533101	04/12/99	2172.60	352	1820.6	SNWA
MX-4	364743114533101	05/07/99	2172.60	352.4	1820.2	USGS

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
MX-4	364743114533101	07/02/99	2172.60	352.46	1820.14	USGS
MX-4	364743114533101	07/19/99	2172.60	352.71	1819.89	SNWA
MX-4	364743114533101	08/12/99	2172.60	352.8	1819.8	USGS
MX-4	364743114533101	10/07/99	2172.60	353.16	1819.44	USGS
MX-4	364743114533101	10/08/99	2172.60	353.11	1819.49	USGS
MX-4	364743114533101	10/19/99	2172.60	353.35	1819.25	SNWA
MX-4	364743114533101	12/13/99	2172.60	353.01	1819.59	USGS
MX-4	364743114533101	01/11/00	2172.60	353	1819.6	USGS
MX-4	364743114533101	02/09/00	2172.60	352.7	1819.9	SNWA
MX-4	364743114533101	04/05/00	2172.60	352.7	1819.9	USGS
MX-4	364743114533101	07/07/00	2172.60	353.32	1819.28	SNWA
MX-4	364743114533101	08/17/00	2172.60	353.35	1819.25	USGS
MX-4	364743114533101	10/24/00	2172.60	353.64	1818.96	SNWA
MX-4	364743114533101	01/05/01	2172.60	353.41	1819.19	SNWA
MX-5	364741114532801	05/06/81	2170.00	352.4	1817.6	BERGER et al., 1988
MX-5	364741114532801	07/04/81	2170.00	348.5	1821.5	BERGER et al., 1988
MX-5	364741114532801	08/13/81	2170.00	349.2	1820.8	BERGER et al., 1988
MX-5	364741114532801	03/14/85	2170.00	347.84	1822.16	BERGER et al., 1988
MX-5	364741114532801	12/03/85	2170.00	348.5	1821.5	BERGER et al., 1988
MX-5	364741114532801	09/11/87	2170.00	348.72	1821.28	BERGER et al., 1988
MX-5	364741114532801	09/13/87	2170.00	348.86	1821.14	BERGER et al., 1988
MX-5	364741114532801	05/18/88	2170.00	348.57	1821.43	TUMBUSCH et al., 1996
MX-5	364741114532801	08/03/88	2170.00	348.72	1821.28	TUMBUSCH et al., 1996
MX-5	364741114532801	12/08/88	2170.00	348.8	1821.2	TUMBUSCH et al., 1996
MX-5	364741114532801	01/20/89	2170.00	348.73	1821.27	TUMBUSCH et al., 1996
MX-5	364741114532801	01/30/89	2170.00	348.97	1821.03	TUMBUSCH et al., 1996
MX-5	364741114532801	01/31/89	2170.00	348.88	1821.12	TUMBUSCH et al., 1996
MX-5	364741114532801	03/28/89	2170.00	348.98	1821.02	TUMBUSCH et al., 1996
MX-5	364741114532801	05/30/89	2170.00	348.83	1821.17	TUMBUSCH et al., 1996
MX-5	364741114532801	07/26/89	2170.00	350.48	1819.52	TUMBUSCH et al., 1996
MX-5	364741114532801	08/14/89	2170.00	349.01	1820.99	TUMBUSCH et al., 1996
MX-5	364741114532801	09/12/89	2170.00	349.1	1820.9	TUMBUSCH et al., 1996
MX-5	364741114532801	11/13/90	2170.00	349.02	1820.98	TUMBUSCH et al., 1996
MX-5	364741114532801	03/26/91	2170.00	349	1821	TUMBUSCH et al., 1996
MX-5	364741114532801	06/13/91	2170.00	348.8	1821.2	TUMBUSCH et al., 1996
MX-5	364741114532801	09/12/91	2170.00	349.03	1820.97	TUMBUSCH et al., 1996
MX-5	364741114532801	12/10/91	2170.00	349.14	1820.86	TUMBUSCH et al., 1996
MX-5	364741114532801	03/18/92	2170.00	350.12	1819.88	TUMBUSCH et al., 1996
MX-5	364741114532801	06/15/92	2170.00	348.73	1821.27	TUMBUSCH et al., 1996
MX-5	364741114532801	09/14/92	2170.00	349.1	1820.9	TUMBUSCH et al., 1996
MX-5	364741114532801	12/09/92	2170.00	349.04	1820.96	TUMBUSCH et al., 1996
MX-5	364741114532801	03/30/93	2170.00	348.49	1821.51	TUMBUSCH et al., 1996
MX-5	364741114532801	06/08/93	2170.00	348.15	1821.85	TUMBUSCH et al., 1996
MX-5	364741114532801	09/09/93	2170.00	348.46	1821.54	TUMBUSCH et al., 1996
MX-5	364741114532801	12/17/93	2170.00	348.6	1821.4	TUMBUSCH et al., 1996
MX-5	364741114532801	03/31/94	2170.00	348.6	1821.4	TUMBUSCH et al., 1996
MX-5	364741114532801	06/16/94	2170.00	348.62	1821.38	TUMBUSCH et al., 1996
MX-5	364741114532801	09/08/94	2170.00	348.96	1821.04	TUMBUSCH et al., 1996
MX-5	364741114532801	05/29/98	2170.00	348.5	1821.5	SNWA
MX-5	364741114532801	07/22/98	2170.00	349.3	1820.7	SNWA
MX-5	364741114532801	10/16/98	2170.00	349.45	1820.55	SNWA
MX-5	364741114532801	01/22/99	2170.00	349.61	1820.39	SNWA
MX-5	364741114532801	04/12/99	2170.00	349.5	1820.5	SNWA
MX-5	364741114532801	07/19/99	2170.00	349.72	1820.28	SNWA
MX-5	364741114532801	08/13/99	2170.00	349.81	1820.19	USGS
MX-5	364741114532801	10/19/99	2170.00	350.3	1819.7	SNWA
MX-5	364741114532801	02/09/00	2170.00	349.75	1820.25	SNWA

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
MX-5	364741114532801	07/07/00	2170.00	350.34	1819.66	SNWA
MX-5	364741114532801	09/17/00	2170.00	350.72	1819.28	SNWA
MX-5	364741114532801	01/05/01	2170.00	350.61	1819.39	SNWA
MX-6	364604114471301	06/03/81	2274.60	458	1816.6	BERGER et al., 1988
MX-6	364604114471301	06/06/81	2274.60	457	1817.6	BERGER et al., 1988
MX-6	364604114471301	07/11/81	2274.60	457.4	1817.2	BERGER et al., 1988
MX-6	364604114471301	08/11/81	2274.60	457.8	1816.8	BERGER et al., 1988
MX-6	364604114471301	03/14/85	2274.60	457.37	1817.23	BERGER et al., 1988
MX-6	364604114471301	06/18/85	2274.60	457.34	1817.26	BERGER et al., 1988
MX-6	364604114471301	09/11/87	2274.60	459.16	1815.44	BERGER et al., 1988
MX-6	364604114471301	09/13/87	2274.60	459.47	1815.13	BERGER et al., 1988
MX-6	364604114471301	08/03/88	2274.60	457.63	1816.97	USGS
MX-6	364604114471301	12/08/88	2274.60	461.96	1812.64	USGS
MX-6	364604114471301	01/20/89	2274.60	457.77	1816.83	USGS
MX-6	364604114471301	01/31/89	2274.60	457.95	1816.65	USGS
MX-6	364604114471301	03/28/89	2274.60	457.7	1816.9	USGS
MX-6	364604114471301	05/30/89	2274.60	457.66	1816.94	USGS
MX-6	364604114471301	03/18/92	2274.60	458.1	1816.5	USGS
MX-6	364604114471301	06/15/92	2274.60	457.8	1816.8	USGS
MX-6	364604114471301	09/14/92	2274.60	458.2	1816.4	USGS
MX-6	364604114471301	12/09/92	2274.60	458.3	1816.3	USGS
MX-6	364604114471301	03/30/93	2274.60	457.5	1817.1	USGS
MX-6	364604114471301	12/17/93	2274.60	457.9	1816.7	USGS
MX-6	364604114471301	10/18/95	2274.60	457.8	1816.8	USGS
MX-6	364604114471301	01/16/96	2274.60	457.7	1816.9	USGS
MX-6	364604114471301	02/01/96	2274.60	459	1815.6	USGS
MX-6	364604114471301	04/01/96	2274.60	440	1834.6	USGS
MX-6	364604114471301	12/31/96	2274.60	459	1815.6	USGS
MX-6	364604114471301	01/31/97	2274.60	458.9	1815.7	USGS
MX-6	364604114471301	02/28/97	2274.60	458.5	1816.1	USGS
MX-6	364604114471301	04/01/97	2274.60	458.8	1815.8	USGS
MX-6	364604114471301	05/01/97	2274.60	508	1766.6	USGS
MX-6	364604114471301	06/02/97	2274.60	507	1767.6	USGS
MX-6	364604114471301	07/01/97	2274.60	508	1766.6	USGS
MX-6	364604114471301	08/01/97	2274.60	507	1767.6	USGS
MX-6	364604114471301	09/02/97	2274.60	507	1767.6	USGS
MX-6	364604114471301	11/03/97	2274.60	459.4	1815.2	USGS
MX-6	364604114471301	12/31/97	2274.60	460	1814.6	USGS
MX-6	364604114471301	06/01/98	2274.60	460	1814.6	USGS
MX-6	364604114471301	12/31/98	2274.60	460	1814.6	USGS
MX-6	364604114471301	02/01/99	2274.60	516	1758.6	USGS
MX-6	364604114471301	03/01/99	2274.60	516	1758.6	USGS
MX-6	364604114471301	04/01/99	2274.60	459	1815.6	USGS
MX-6	364604114471301	04/30/99	2274.60	459	1815.6	USGS
MX-6	364604114471301	06/01/99	2274.60	460	1814.6	USGS
MX-6	364604114471301	07/01/99	2274.60	459	1815.6	USGS
MX-6	364604114471301	08/02/99	2274.60	461	1813.6	USGS
MX-6	364604114471301	09/01/99	2274.60	459	1815.6	USGS
MX-6	364604114471301	10/01/99	2274.60	461	1813.6	USGS
MX-6	364604114471301	10/29/99	2274.60	461	1813.6	USGS
MX-6	364604114471301	12/01/99	2274.60	461	1813.6	USGS
MX-6	364604114471301	12/30/99	2274.60	461	1813.6	USGS
MX-6	364604114471301	02/01/00	2274.60	461	1813.6	USGS
MX-6	364604114471301	03/01/00	2274.60	461	1813.6	USGS
MX-6	364604114471301	04/03/00	2274.60	461	1813.6	USGS
MX-6	364604114471301	05/02/00	2274.60	461	1813.6	USGS
MX-6	364604114471301	06/01/00	2274.60	461	1813.6	USGS

Table C-2. Depth-to-Water Measurement Data

WELL ID	ALIAS	DATE	MP ELEVATION (ft. amsl)	DTW (ft.)	WL ELEV (ft. amsl)	DATA SOURCE[1]
MX-6	364604114471301	06/29/00	2274.60	475	1799.6	USGS
MX-6	364604114471301	07/31/00	2274.60	479	1795.6	USGS
MX-6	364604114471301	08/31/00	2274.60	484	1790.6	USGS
MX-6	364604114471301	09/29/00	2274.60	484	1790.6	USGS
MX-6	364604114471301	10/26/00	2274.60	461	1813.6	USGS
MX-6	364604114471301	11/30/00	2274.60	461	1813.6	USGS
SHV-1	363308114553001	12/30/85	2648.80	833.2	1815.6	BERGER et al., 1988
SHV-1	363308114553001	09/13/87	2648.80	831	1817.8	BERGER et al., 1988
SHV-1	363308114553001	01/31/89	2648.80	831	1817.8	USGS
SHV-1	363308114553001	03/28/89	2648.80	831	1817.8	USGS
SHV-1	363308114553001	05/30/89	2648.80	830.3	1818.5	USGS
SHV-1	363308114553001	07/26/89	2648.80	830.7	1818.1	USGS
SHV-1	363308114553001	09/12/89	2648.80	830.9	1817.9	USGS
SHV-1	363308114553001	05/29/98	2648.80	831.68	1817.12	SNWA
SHV-1	363308114553001	07/22/98	2648.80	831.78	1817.02	SNWA
SHV-1	363308114553001	10/16/98	2648.80	831.4	1817.4	SNWA
SHV-1	363308114553001	01/22/99	2648.80	831.58	1817.22	SNWA
SHV-1	363308114553001	04/12/99	2648.80	831.65	1817.15	SNWA
SHV-1	363308114553001	07/19/99	2648.80	831.63	1817.17	SNWA
SHV-1	363308114553001	08/12/99	2648.80	831.7	1817.1	USGS
SHV-1	363308114553001	10/19/99	2648.80	831.4	1817.4	SNWA
SHV-1	363308114553001	02/09/00	2648.80	831.6	1817.2	SNWA
SHV-1	363308114553001	07/07/00	2648.80	832.75	1816.05	SNWA
SHV-1	363308114553001	08/17/00	2648.80	834.6	1814.2	USGS
SHV-1	363308114553001	10/17/00	2648.80	832.16	1816.64	SNWA
SHV-1	363308114553001	10/24/00	2648.80	831.95	1816.85	SNWA
SHV-1	363308114553001	01/05/01	2648.80	832.19	1816.61	SNWA
TH-1		12/01/00		354.83	1815.12	JOHNSON, C. et al., 2001
TH-2		12/01/00		526.15	1815.55	JOHNSON, C. et al., 2001
xtal-2		08/21/00		256.34		JOHNSON, C. et al., 2001

1. NDWR - NDWR Well Log Database
   SNWA - Southern Nevada Water Authority Records
   USGS - USGS Ground-Water Site Inventory Database

ERRATA TO:

WATER RESOURCES AND GROUND-WATER MODELING IN THE WHITE RIVER AND MEADOW VALLEY FLOW SYSTEMS
CLARK, LINCOLN, NYE AND WHITE PINE COUNTIES, NEVADA

by
Las Vegas Valley Water District
June 2001

1) Table of Contents

Revision: Corrected table of contents to match body of document

2) Figure 6-1. Generalized ground-water recharge, evapotranspiration, and inter-basin flow of the White River and Meadow Valley Flow Systems, units in thousands of acre-feet per year**.**

Revision: Ground-water outflow from: Jakes Valley = 35,000 afy, Coyote Spring Valley to Upper Moapa Valley = 37,000 afy, and California Wash to Lower Moapa Valley = 41,000 afy

3) Table 8-4. Hydraulic properties assigned to hydrogeologic units and faults.

Revision: Corrected values for K_x and K_y for material 28 (Carbonate Rocks, Upper Moapa Subarea (South)). Correct values are $2.00x10^{+1}$.

4) Figures 8-26, 8-27, 8-28, 8-29, 8-30, 8-45, 8-46, 8-47, 8-48, 8-49, 8-54, 8-55, 8-56, 8-57, and 8-58.

Revision: Charts revised to reflect minor changes in model output as a result of correcting the placement of two well locations used to pump existing permitted rights in Lower Meadow Valley Wash and Lower Moapa Valley. The revision does not change the relative differences between the compared variables or change the conclusions stated in the report.

5) Appendix B Added list of reference inadvertently excluded in report.

6) Appendix C Added list of reference inadvertently excluded in report.

GENERALIZED GEOLOGIC MAP OF MODEL AREA WITH CROSS-SECTIONS

Data Sources: Longwell et al., 1965
Tschanz and Pampeyan, 1970
Ekren et al., 1977
Page, 1992
Page and Pampeyan, 1996
Schmidt et al., 1996
Page, 1998

GENERALIZED HYDROGEOLOGIC MAP OF MODEL AREA WITH CROSS-SECTIONS

Plate 2